Approved

Chapter 4

WATER QUALITY

APPROVED ASSESSMENT REPORT
for the
Grey Sauble Source Protection Area

October 15, 2015

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Approved ASSESSMENT REPORT
for the
Grey Sauble Source Protection Area

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4.0 Water Quality

4.0.1 Guide to Chapter

This chapter describes the risk to water quality for all drinking water systems listed in the Terms of Reference. It lists activities that may pose a threat to raw water quality sources for these systems. Also included are tables that describe the number of occurrences where these activities exist or have the potential to exist.

This chapter is separated into two parts. The first part explains the methods used to identify vulnerable areas and the vulnerability scoring of these areas; methods for the identification of significant threats to drinking water quality and drinking water issues that have worrisome water quality measurements at the well or intake. The second section of this chapter applies these methods to each drinking water system in this Source Protection Area (SPA). The systems are in order by municipality and separated by groundwater and surface water systems.

For each municipality, some general data on population and land use is given. Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge Areas (SGRAs) are then broadly located within each municipality. Each drinking water system is described separately and information is given on the well/intake including the area that influences the well/intake and its vulnerability, and the drinking water threats and issues identified for the system. Finally, significant drinking water threats were summarized for each municipality.

Numbering of Tables and Maps

The second part of this chapter contains a large number of tables and maps, which contain data on each municipality and each drinking water system. There are a total of nine maps for each municipality and between six and thirteen maps for each drinking water system. Each drinking water system also has a set of data tables. This report includes eight municipalities, 10 groundwater systems and six surface water systems with eight intakes.

The maps for each municipality are given in Table 4.0.1.

Coding for Maps by Municipality

Each map has a code that contains the chapter (4), the municipality and the map number.
For example, Map 4.1.M3 is in chapter 4, for municipality 1 (Municipality of Northern Bruce Peninsula) and shows the HVA vulnerability.

Coding for Tables and Maps of Drinking Water Systems

To facilitate review, coding is used for all tables and maps associated with municipalities and drinking water systems. They have the following format:

Chapter.Municipality.DrinkingWaterSystem.Number

Further, drinking water systems are numbered within the municipality by occurrence and by type, either groundwater (G) or surface water (S). For example, the first drinking water system from groundwater in a municipality is coded G1, the second surface water system is coded S2, and so on. The final number describes the content of each map or table and is shown in Table 4.0.2.

TABLE 4.0.1 – Maps for each Municipality

	Maps
Municipality	
Number	*Content*
M1	Aquifer Susceptibility (ISI)
M2	HVA/SGRA Extent
M3	HVA Vulnerability
M5	Impervious surfaces for HVAs/SGRAs
M6	HVA Managed lands
M7	HVA Livestock Density (Nutrient Units)

Two Examples for Coding in Drinking Water Systems

Map 4.4.G2.3 is a map in chapter 4 for municipality 4 (Township of Georgian Bluffs); it is the second groundwater drinking water system in the municipality (Shallow Lake) and the content is the "Vulnerability Score of Wellhead Protection Area and Transport Pathways". This system is described in section 4.2.4.2.2.

Table 4.6.S1.2b is a table in chapter 4 for municipality 6 (Municipality of Meaford); it is the first surface water drinking water system in the municipality (Meaford PUC Water Treatment Plant) and the content is the "Source Vulnerability Score". This system is described in section 4.2.6.2.1.

TABLE 4.0.2 – Maps and Tables for each Drinking Water System

Maps		***Tables***	
Drinking Water System from Groundwater			
Number	Content	Number	Content
1	WHPA Delineation	1	Description of Drinking Water System
2	WHPA with Aerial Photo	2a	Impervious Surfaces
3	WHPA Vulnerability Score	2b	Managed Lands and Nutrient Units
4	Impervious Surfaces for WHPA	2c	WHPA-E Vulnerability (if applicable)
5	Managed Lands	3	Drinking Water Threats by Activity
6	Livestock Density (Nutrient Units)	4	Summary of Significant Threats
		5	Issues and Conditions
Drinking Water System from Surface Water			
Number	Content	Number	Content

1	Intake Protection Zone Components	1	Description of Drinking Water System
2	IPZ Delineation	1b	Managed Lands, Nutrient Units and Impervious Surfaces
3	IPZ with Aerial Photo	2a	Area Vulnerability Score
4	IPZ Vulnerability Scores	2b	Source Vulnerability Score
5	Impervious Surfaces for IPZ	2c	Vulnerability Score of IPZ
6	Managed Lands	3	Drinking Water Threats by Activity
7	Livestock Density (Nutrient units)	4	Summary of Significant Threats
8	Events-based Area	5	Issues and Conditions
9	Events-based Area Policy Components		

4.1 Background and Methodology

4.1.1 Overview on the Regulatory Context

This chapter portrays how the legislation and rules apply to the Grey Sauble Source Protection Area. Under the *Clean Water Act, 2006*, the drinking water sources that must be assessed in a Source Protection Area are wells and surface water intakes that serve municipal drinking water systems for major residential developments as well as any systems elevated by the Director of the Conservation and Source Protection Branch of the Ministry of the Environment, Conservation and Parks (MECP). All these systems must be in the Terms of Reference. Vulnerable areas are delineated and the degree of vulnerability scored. For each vulnerable area, those activities and conditions that pose a significant risk to the drinking water are identified.

Vulnerable Areas

Drinking water sources can be impaired by the entry of contaminants. The areas where the potential for contamination is greatest require the highest level of protection. To focus the resources used for Drinking Water Source Protection to the greatest risks, the *Clean Water Act, 2006,* defines four types of vulnerable areas:

- **Highly vulnerable aquifers** (HVAs) are groundwater aquifers that can easily be contaminated from land area above these aquifers.
- **Significant groundwater recharge areas** (SGRAs) are areas that are particularly important for the replenishment of groundwater aquifers. Here, it is desirable to regulate or monitor drinking water threats that may affect the quantity of recharge entering an aquifer or its quality.
- **Intake protection zones** (IPZs) are areas in the vicinity of surface water intakes. Intake protection zones are composed of an in-water (or offshore) component and an on-land (or onshore) component that drains into the offshore component.
- **Wellhead protection areas** (WHPAs) are areas within aquifers that provide water to municipal drinking water wells. Within these areas it is desirable to regulate or monitor drinking water threats.

The Technical Rules (Ontario Ministry of the Environment, Conservation and Parks). Technical Rules: Assessment Report made under s. 107, *Clean Water Act, 2006*) indicate how to delineate each type of vulnerable area and how to assess the degree of vulnerability within each area. The *Clean Water Act* (Regulation 287/07) describes 22 drinking water threats, which are listed in Section 4.1.5.2 of this report. As an Addendum to O. Reg. 287/07, the Tables of Drinking Water Threats provide details on specific circumstances for each threat as well as the vulnerability score that would be applicable in order to consider an activity a significant, moderate or low threat.

Vulnerability Scoring in Vulnerable Areas

Each location within a vulnerable area is assigned a specific vulnerability score that ranges between two (lowest vulnerability) and ten (highest vulnerability). This score takes into account the time needed for a contaminant to travel to the drinking water intake or well and the specific characteristics of each location.
For groundwater, these characteristics are determined by the amount of protection that the soil or overburden on top of the aquifer provides. The score also takes into account artificial transport pathways for contaminants, such as wells, or aggregate pits.

For surface water intakes, the vulnerability score takes into account water mixing and flow directions in the water. The vulnerability score of a surface water intake combines the characteristics of the onshore component and its land use and the intrinsic vulnerability of the water body prescribed by the Technical Rules.

Activities and Conditions

The *Clean Water Act, 2006* distinguishes two sources of risk, referred to as activities and conditions, which may jeopardize the quality of drinking water sources. Activities include ongoing and future land uses while conditions refer to situations where contamination occurs due to historical activities. This contamination can occur in surface water, groundwater, soil, or sediment. Every existing or potential land use in a vulnerable area (an activity) is further analyzed to determine the level of risk it poses to drinking water sources.

Threats, Issues and Events

The *Clean Water Act, 2006* describes three basic approaches to determine the risk level of an activity or condition: the threat-based approach, the issue-based approach and the events-based approach.
The **threats-based approach** determines the risk of contamination of a water source based on the vulnerability score within a vulnerable area and the hazard rating of a contaminant/pathogen that is associated with a land use activity. Activities can become “significant” threats even if no negative impact on the drinking water source was recorded.

To apply the **issues-based approach,** the deterioration of water quality of a drinking water source must be demonstrated from measured data. If such deterioration is confirmed for a well or at a surface water intake, and the problem is found to be anthropogenic, a “Drinking Water Quality Issue” can be declared. The local source protection committee decided on thresholds for the determination of an issue for both contaminants and pathogen (SPC Jan 23, 2009, Technical

Report 7c, Development of water quality standards for issues evaluation). If an issue was identified in the raw water, then the area that contributes to this issue must be delineated. All activities that contribute to the exceeded threshold are identified and regarded as significant.

The **events-based approach** is reserved for continuous or discrete activities (such as accidents) that occur under extreme weather conditions, such as storms, strong precipitation events or droughts. Any activity or condition that poses a significant risk in such an extreme event must be individually identified.

Under the events-based approach, the activity or condition can be located outside of vulnerable areas as delineated under the threats-based approach. However, scientific justification is required indicating that the contaminant or pathogen can be transported to the intake or well during an extreme event (Technical Rule 68), and that the concentration of that contaminant can cause an interruption of normal operation of the drinking water system. An IPZ-3 may be delineated to capture these additional locations. The area within which individual activities are designated significant threats during an extreme event is called the events-based area for surface water systems.

For surface water intakes in this SPR, the events-based approach can be applied to Type A intakes (Great Lakes) or any other system defined in Technical Rule 68. IPZ-3s for all Great Lakes intakes do not have vulnerability scores and the threats-based approach using threats assessments is not used in this case. For such intakes, the procedure to identify a significant threat requires that modelling, or an equivalent analysis that was accepted by MECP, demonstrates the activity can cause the deterioration of the source of drinking water (Technical Rule 130).

Types of Threats and Risk Rating

Threats are classified into three groups: **chemical**s, **pathogen**s and dense non-aqueous phase liquids (**DNAPLs**). For each activity or condition that may pose a drinking water threat, one of four risk ratings is assigned; none, low, moderate or significant. Each activity that is designated a significant threat must be addressed in the source protection plan, and the *Clean Water Act, 2006* provides more restrictive tools for development of these significant threat policies. For drinking water threats that have a risk rating of low or moderate, the source protection plan may also include policies, although with less restrictive measures available through the *Clean Water Act, 2006*.

Risk rating under the threats-based approach is based on rules that take into account: the category of the threat (chemical, pathogen or DNAPLs, see Section 4.1.5); the hazard rating of the contaminant; the water source (ground water or surface water); the vulnerable area (highly vulnerable aquifer, significant groundwater recharge area, wellhead protection area, and intake protection zone); the vulnerability at the location of the activity; and the circumstances of a specific land use (an ongoing or future activity, or a condition from historic land uses). A detailed description of risk rating is given in Section 4.1.5.

Hazard and risk ratings are built into the Tables of Drinking Water Threats and online Threats Tool that provide a vulnerability score that is high enough for an activity/circumstance to be designated a threat. Property owners can identify potential risks on their property by the procedure outlined in Section 4.1.5.7.

Risk rating is not used under the issues-based approach or the events-based approach. The issues-based approach is reserved for situations where contamination is already observed and the events-based approach requires specific analysis for each activity.

4.1.2 Vulnerable Areas: Delineation Methods

4.1.2.1 The Intrinsic Vulnerability of Groundwater

Aquifer vulnerability is an important characteristic used to delineate highly vulnerable aquifers and to score vulnerability in wellhead protection areas, significant recharge areas, and the onshore component of intake protection zones.

Intrinsic Susceptibility Index (ISI)
Intrinsic Susceptibility Index (ISI) is a calculated value that estimates the susceptibility of groundwater resources to contamination. The susceptibility of an aquifer to contamination can be correlated to the rate of infiltration of water from the ground surface to the aquifer. This susceptibility can be evaluated at a regional scale using the ISI.

ISI mapping is available for the entire planning region from a number of county groundwater studies, including: Grey and Bruce (2003); Huron (2003); Dufferin (2003); and, Wellington (2006). These studies were undertaken with funding from MECP and utilized a standardized methodology for determining ISI. However, minor modifications to the ISI calculations were incorporated to account for local geological conditions. As a result, minor discrepancies exist along the edges of these mapping products. Wellington County used an alternate yet equivalent methodology (Aquifer Vulnerability Index (AVI) method).

ISI mapping begins by assigning an ISI value to each well within the Water Well Information System (WWIS) for the study area. This is accomplished by summing the product of the thickness of each unit (b) in the well log with a corresponding K-factor (see Watershed Characterization Report 2008, Appendix E), as represented in the equation below.

$$ISI = \sum_i \; b_i \bullet K_{Fi}$$

where:

- i = the number of geologic units recorded in the water well record (borehole)
- b = the thickness of each geologic unit recorded in the water well record
- K_F = the Generic Representative Permeability, or K-Factor for each unit (see MOE Technical Terms of Reference for Groundwater Studies 2001/2002, Schedule C)

The ISI was calculated at each well from the ground surface to the water table for any unconfined aquifer, or from the ground surface to the top of any confined aquifer.

In identified karst areas (caves, sinkholes, sinking streams, sinking lakes, and karst pavement) ISI was adjusted and assigned a high susceptibility value.

Groundwater Vulnerability Level

Within the uppermost aquifer system, areas of low, medium and high susceptibility were identified using the MECP susceptibility classes (low: ISI >80; medium: 30 < ISI < 80; and high: ISI < 30; see WHI 2003, p. 6).

4.1.2.2 Delineating Highly Vulnerable Aquifers

The areas above aquifers that were designated as having high intrinsic susceptibility are considered Highly Vulnerable Aquifers for the purposes of source protection planning.

4.1.2.3 Delineating Significant Groundwater Recharge Areas

Significant groundwater recharge areas were delineated using the water budget tools (see Chapter 3.13, as part of the Water Quantity Stress Assessment). Groundwater recharge was estimated by evaluating surficial geology (soil types and thickness, permeability) and land cover within a hydrologic model. Areas with annual average recharge above 115% of the annual mean recharge for the SPA were designated SGRAs.

For details on the delineation of SGRAs and a discussion on limitations and data gaps, see Chapter 3.13.

4.1.2.4 Delineating Intake Protection Zones (IPZs)

There are nine active surface water systems within the planning region, five of which are in the Grey Sauble Source Protection Area. The source of water for all intakes is Lake Huron except Ruhl Lake, a small inland water body that supplies the Town of Hanover (Saugeen Valley Source protection area). The locations of the Great Lakes intakes in the Grey Sauble Source Protection Area are East Linton, Owen Sound, Meaford, Thornbury, and Wiarton.

Intake protection zones (IPZs) define areas of vulnerability for each intake. Each is composed of an offshore (Lake Huron) and an onshore (land) component. The offshore component of an IPZ reflects the flow, direction and speed of lake and river currents. The onshore component of an IPZ is generated to identify areas on the land surface where surface water runs off into water bodies that form part offshore.

Offshore Components

Consultants with coastal modelling expertise were selected to undertake the delineation of the offshore component of IPZs. All modelling work and in-water delineation of IPZs was peer reviewed. Delineation of intake protection zones followed the Technical Rules: Assessment Report to the *Clean Water Act* (2009), Part IV.3 and Part IV.4.

The offshore component of IPZ-1 for a Type A intake is defined as a circle with a radius of 1 km around the intake as per the Technical Rules. The IPZ-1 was centered on the intake crib. Where the IPZ-1 abutted land it was extended inland 120 m or to the Conservation Authority's regulation limit, whichever is greater (see discussion below).

Delineation of the offshore component of IPZ-2 is based on two factors: the time required to shut down the water treatment facility in the event of a spill; and, the distance that the contaminant could be transported during that time. This time-of-travel (ToT) was defined by the MECP after consulting with operators and is set at a minimum of 2 hours.

An understanding of the direction and velocity of currents within the water body is required to define the distance and direction that the contaminant may be transported. In the Great Lakes, currents at the lakebed, where the intake is often located, frequently flow in the opposite direction from currents at the lake surface. The currents also vary over time and are dependent on wind conditions. A numerical model, calibrated against field measurements, is the most defensible and practical approach to define an IPZ-2. This type of model allows us to evaluate and understand the flow patterns around the intake under a range of conditions.

Numerical modelling was undertaken to delineate the offshore component of the IPZ-2 within the Great Lakes. For Georgian Bay intakes, the hydrodynamic modelling package Delft 3D was used to develop an interim West Georgian Bay Model (WGBM) with a grid size that varies from 70 m close to the shoreline and in areas of complex bathymetry to 2.5 km in the open lake. The boundary conditions (levels and currents) in the open lake were extracted from the Lake Huron Operational Forecast System (LHOFS).

The model was run for two periods of three weeks each, which included several storms documented in 2003. The open boundary conditions for the Delft3D model were defined with the currents and water levels extracted from LHOFS. The model was run in reverse mode with neutrally buoyant particles introduced at the intake. Particles were tracked in reverse mode over a 2-hour period, defined by the WTP operators as the required time to shut down the plant in the event of a spill or threat to the drinking water. The composite areal extent of these particles, based on eight wind scenarios was taken to represent the offshore component of the IPZ-2.

Data from the climate station with the longest period of record, Environment Canada's Wiarton Airport, was used in the extreme value analysis. Hourly meteorological data from the National Data Buoy Centre South Lake Huron Monitoring Buoy date from 1981. This data set includes large gaps, especially in the winter season when the monitoring equipment is removed from the lake. Hourly wind speed and direction data from Wiarton Airport date from 1953 and include the winter season.

Eight constant wind directions are used to estimate the range of variability of currents, as shown in Table 4.1.1. Wind data from the closest measurement station was evaluated for the intensity of a 10-year return period; winds from a constant direction over the full model period was assumed (Stantec, 2009). Finally, the model was calibrated and validated with Acoustic Doppler Current Profiler (ADCP) measurements from three deployments by the MOECC in Lake Huron from May 16, 2003 to November 27, 2003 as part of the Great Lakes Nearshore Monitoring Program (Stantec, 2009).

TABLE 4.1.1 – Directional 10-Year Return Period Wind Speeds at Wiarton Airport

Direction	***Direction From (deg)***	***10-year overland wind speed (m/s)***	***10-year overwater wind speed (m/s)***
North	360	13.4	17.3

Northeast	45	15	19.2
East	90	16	20.3
Southeast	135	13.7	17.6
South	180	17.6	22.2
Southwest	225	19.5	24.4
West	270	18.9	23.7
Northwest	315	14.3	18.3
All directions	all	20.6	25.7

Onshore Components

According to the MECP Technical Rules, the offshore IPZ must be extended onshore. The watershed component of the IPZ is extended along watercourse and subsidiary branches within the 2-hour time-of-travel (Stantec 2009, Phase 1 Technical Addendum). For the offshore component of the IPZ, including the tributaries that fall into the 2-hour ToT, an onshore offset is delineated from each bank. Areas that include constructed pathways are added if their outlets are within the 2-hour ToT.

Storm Sewer Networks

Areas that can deteriorate water quality of the intake by draining into the storm sewer network must be added to the intake protection zone 2, if the time-of-travel to the intake is two hours or less.

In areas where only storm sewer networks were provided, outfall locations and the digital elevation model were used to estimate the extent of the catchment area. Due to the small size of all of these storm sewersheds (maximum length 2 km or less), the entire storm sewer catchment areas were included in the onshore component of the IPZ-2.

In the event storm sewer outfalls, networks, or catchments were listed as data gaps, the onshore component of IPZ-2 was delineated using aerial photography and watershed boundaries. In this instance developed areas were included in their entirety; with consideration given to the watershed boundaries.

Tile Drains

All tile drains were assumed to discharge either directly, or through other tile drain networks, to municipal drains or watercourses. Where tile drainage existed next to a municipal drain or watercourse and the municipal drain or watercourse was included in the IPZ-2, the IPZ-2 was extended to include the adjacent tile drained areas, as well as all other tile drain areas that, using the DEM, were assumed to contribute water to that water body (Stantec, 2009).

The onshore component of IPZ-2 is a setback of the greater of 120 m or regulatory limits set by the local Conservation Authority under Ontario Regulation 97/04 - Regulations for Development, Interference with Wetlands and Alterations to Shorelines and Watercourses, also known as the Generic Regulation Limit.

Data sources for onshore delineation are summarized in Table 4.1.2.

Knowledge Limitations and Data Gaps of IPZ Delineation

The uncertainty of the data sources incorporates an analysis of data variability, quality, relevance, and the spatial resolution of the data.

The data variability refers to the level of consistency among the different datasets reviewed. If a multitude of independent but consistent sources are used for delineation, then level of uncertainty is probably low.

The data quality refers to the accuracy of the data assessed based on the origins of the information. Federal and provincial data are assumed to have a high accuracy level due to regulated quality control measures in place, therefore has an associated high-level of certainty. Other data sources that provide interpretations of data are not considered to have an equal certainty level.

The relevance of the data refers to the applicability of the information to the study area. Site specific and local information is assumed to represent the area well therefore it has a high level of certainty. Unavailable or non-site-specific data lowers this certainty and generally requires that assumptions be made.

TABLE 4.1.2 – Input Data for Onshore Delineation of Intake Protection Zones

Digital Elevation Model	The Provincial Digital Elevation Model (DEM) V.2.0, with 10 m horizontal resolution and 5 m vertical resolution, was obtained from Land Information Ontario (LIO) as a GIS dataset. This dataset was used to infer storm sewer catchments where discrete boundaries were not available and to identify elevation of land as part of the overland flow analysis.
Drawings of Storm Sewer Systems	The lower tier municipalities in the study areas were asked to provide drawings of their storm sewer systems where available. This dataset was complemented with its derivative flow direction grid to delineate watersheds for watercourses within the study areas and to characterize overland flow.
Watercourse Mapping	In accordance with Technical Rule 56, the Water Virtual Flow (WVF) and Water Poly Segment (WPS) datasets were available from the Ministry of Natural Resources and Forestry (MNRF) and were used to identify surface water bodies, including rivers and creeks, within all study areas.
Constructed Drains	Obtained from LIO, the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) constructed drain dataset was reviewed to identify closed drains located within the study areas. The dataset indicated that no closed drains were located within the WTP study areas.
Tile Drainage Area Mapping	Tile drainage mapping provided by OMAFRA was used to identify the extent of the tile drainage areas in the onshore extent of the study areas.
Water Treatment Plant Operator Supplemental Interviews	In September 2009, Stantec conducted interviews with operations staff for the study area WTPs. Operators identified problems and concerns that they have experienced with plant operations in relation to the water supply and quality. The interviews provided some information on treatment challenges, raw water quality,

	treatment concerns, and potential sources of contamination. Some data gaps in the interviews exist where information was not available.
Aerial Photography	Southwestern Ontario Orthophotography Project (SWOOP) imagery captured in 2006 by First Base Solutions has 30 cm resolution and was used for general mapping purposes, to identify surface features and to delineate storm sewer catchments of the study areas.

Spatial resolution of data and the number and data points available impacts the quality of the model. For example, the number of time series available to calibrate and validate the models used for delineating the IPZs – ranging from climate stations, wind data and flow currents – is relatively low and a core reason for the high uncertainty rating. A larger number of data points would improve the certainty of the analysis.

Modelling uncertainty relates to the ability of the model to accurately depict the flow processes in the hydrological system. The model and employed methods were assessed for each component and overall uncertainties were assigned. While separation of the modelling components is not identified in the Technical Rules, uncertainties have been assessed independently for the purpose of clarity as part of this report.

The extent of the onshore component depends on the residual ToT as determined through in-water modelling. The accuracy of the onshore delineations is limited by the certainty of the in-water modelling.

The 120 m setback and regulatory limits for the onshore component are determined with high certainty. The certainty of the watershed boundaries, storm sewer sheds and tile drained areas each depend on separate data sources, the uncertainty of these data sources directly impact the analysis. Digital data are not available for the exact location of storm sewer shed outfalls or the location of tile drainage outfalls. Finally, many rural developed areas that do not have storm sewers use surface drains (ditches) for the discharge of surface runoff. Data on these surface transport pathways are not available.

Delineation of Intake Protection Zone 3

The modelling completed by Baird & Associates (Baird) for our region's Intake Protection Zone-3 (IPZ-3) and events-based delineation and significant threat identification for local intakes continues on from previous studies completed by Baird. The previous studies, as well as the current study, are included as appendices to this report.

The hydrodynamic models used in the IPZ-3 study were developed in the previous phases. The methodology used is outlined in the 2009 Ministry of the Environment and Climate Change (MOECC) Technical Bulletin: Delineation of Intake Protection Zone 3 Using the Event Based Approach. The steps completed were as follows:

- Selection of extreme events

- Selection of spill scenarios based on identified activities of concern
- Calculation of the dilution in spill concentrations from the spill location to the intake
- Determining whether the spill would constitute a drinking water threat at the intake (concentrations exceeding the Ontario Drinking Water Quality Standard (ODWQS) were used in this case)
- Desktop analysis of additional spills
- Recommendations to support IPZ-3 delineation

Modelling

In 2011, the study to complete the supporting modelling for use in defining the IPZ-3 areas *Numerical Modelling in Support of IPZ-3 Delineation, Saugeen, Grey Sauble, Northern Bruce Peninsula* was completed. The following data were used during the study (Baird 2012);

- **Joint Probability Analysis** modelling scenarios based on a combination of wind storm and tributary flow events meeting the definition of an "extreme event" as defined in MOE (2009a).
- **Hydrodynamic Model Runs for Medium-Scale Models**, including the East Lake Huron Model (ELHM) and West Georgian Bay Model (WBGM). The model results provide the boundary conditions for the nested model runs.
- **Hydrodynamic Model Runs for Nested Models** including Kincardine, Southampton, Owen Sound and Meaford. A total of 4 combined scenarios were run for each nested model.

As stated in the Technical Rules, an IPZ-3 must be delineated for type A intakes, where modelling or other methods demonstrate that contaminants released during an extreme event may be transported to the intake. The extreme events that would be most likely to transport a contaminant to the intakes in this region are tributary flows and wind on Lake Huron.
Joint probability and persistence analysis were used to model the extreme events, based on a previous source water studies (Baird, 2012).

The 100-year joint probability events were selected to include the mean and 2-year return period flow events, the return periods of the corresponding wind speeds are shown in Table 4.1.3 (Baird, 2013). For additional information, refer to Baird (2012).

TABLE 4.1.3 – Model Scenarios with Combined 100-Year Return Period

	East Lake Huron Model		West Georgian Bay Model			
	Southampton and Kincardine Models		Owen Sound Model		Meaford Model	
	NE Wind	SW Wind	NNE Wind	SSW Wind	NW Wind	SE Wind
Wind Storm Duration	36 hrs	43 hrs	111 hrs	43 hrs	49 hrs	74 hrs
Mean Flow	50-Yr Wind (23.7 m/s)	50-Yr Wind (27.3 m/s)	50-Yr Wind (18.9 m/s)	50-Yr Wind (27.3 m/s)	50-Yr Wind (21.1 m/s)	50-Yr Wind (20.4 m/s)
2 Year Flow	0.5-Yr Wind (12.6 m/s)	0.5-Yr Wind (18.9 m/s)	1-Yr Wind (13.9 m/s)	1-Yr Wind (20.2 m/s)	1-Yr Wind (13.4 m/s)	1-Yr Wind (12.3 m/s)

Recommendations for scenarios were developed based on a threats analysis and 38 scenarios were chosen; however, only ten were selected for modelling (see Table 4.1.4). The remaining scenarios were evaluated using a desktop analytical assessment.

The spill scenarios chosen included fuel tanks and waste water treatment plants. E. coli was the chosen contaminant for the waste water treatment plants. As the ODWQS for e. coli is 0 cfu/100 mL, the operator for the R.H. Neath Water Treatment Plant (Owen Sound) was consulted and it was decided that the recreational standard of 100 cfu/100 mL would be used. Benzene was chosen to be the substance of concern for gas fuel spills because the ODWQS for benzene is low (0.005 mg/L). Diesel contains 0.07% ethylbenzene and only 0.03% benzene; therefore, ethylbenzene was selected as the substance of concern for diesel fuel spills. The objective standard is 0.0024 mg/L for ethylbenzene, set in Table 4 under section 3.2 of the *Technical Support Document for Ontario Drinking-water Quality Standards, Objectives and Guidelines* (2003).

The DELWAQ model was used to model the advection and dispersion of the spills (Baird, 2013). More than one model run was required for some spill scenarios in order to properly evaluate the response for different wind and flow combinations. For example, the Owen Sound marina fuel spill had four different model runs completed in order to include all combinations of two wind conditions and two flow conditions. Additionally, some model runs evaluated more than one intake. For example, the Owen Sound and East Linton intakes are within the same model domain so one model run was used to assess the impact on both intakes.

To be conservative, the Owen Sound Waste Water Treatment Plant release rate was based on the largest bypass event in 2013 (7,546,000 L spill over 21 hours). A conservative approach was adopted and assumptions were made regarding the fuel spills. Marina fuel tanks were assigned a duration of 1 hour; however, the larger fuel tanks at Bruce Power were given a duration of 3 hours (see Table 4.1.5). It was also assumed that there was no evaporation before the fuel entered the water when, in reality, some of the fuel will be lost to evaporation before entering the receiving water and additional evaporation from the surface of the water during the slick phase would occur. In addition, portion will diffuse into the water column to a maximum concentration equal to the equilibrium concentration of the substance in water (Baird, 2013);

- The literature suggests that water in contact with gasoline with about 2% (by weight) benzene will have an equilibrium concentration of dissolved benzene of approximately 58 mg/L. However, maximum concentrations of field samples tend not to exceed 0.2 times the equilibrium saturation unless free product was taken with the sample (Bruce, Miller and Hockman, 1991). Therefore it is reasonable to assume that the equilibrium concentration of benzene is about 12 mg/L in the receiving water.
- The solubility of ethylbenzene varies in accordance with the presence of other petroleum products. The pure compound solubility of ethylbenzene in water is 180 mg/L, while when in diesel fuel its solubility is 0.18 mg/L (Potter, 1993).

TABLE 4.1.4 – Modelled Spill Scenarios

Spill#	Spill Location	Spill Description	Substance	Volume	Contaminant
1	Owen Sound	Sewage Pumping Station Bypass	E. coli	7,546,000 L	E. coli time series
2	Owen Sound	Marina Fuel	Gasoline	15,000 L	1.5% Benzene
3	Meaford	Marina Fuel	Gasoline	4,500 L	1.5% Benzene
4	Southampton	Bruce Power Fuel Tank	Diesel	750,111 L	0.07% Ethylbenzene
5	Southampton	Marina Fuel	Gasoline	22,500 L	1.5% Benzene
6	Kincardine	Bruce Power Fuel Tank	Diesel	750,111 L	0.07% Ethylbenzene
7	Kincardine	Marina Fuel	Gasoline	15,000 L	1.5% Benzene
8	Lion's Head	Marina Fuel	Gasoline	10,000 L	1.5% Benzene
9	Wiarton	Marina Fuel	Gasoline	10,000 L	1.5% Benzene
10	Thornbury	Marina Fuel	Gasoline	15,000 L	1.5% Benzene

The model runs determined that no exceedance of ODWQS was predicted for the spill scenarios related to the fuel tanks at the Bruce Nuclear Power Plant, the Owen Sound sewage pumping station or the marinas in East Linton and Thornbury. However, for the Meaford, Southampton (New), Southampton (Old), Kincardine, Lion's Head, and Wiarton intakes, the model predicted the concentration of benzene would exceed the ODWQS of 0.005 mg/L. At Owen Sound, the predicted concentration of benzene at the lakebed (0.005 mg/L) equaled the ODWQS, while the predicted concentration at the surface (0.004 mg/L) was just below the ODWQS. Taking into consideration the accuracy of the model, this was considered as a predicted exceedance (Baird, 2013). Figure 4.1.1 shows the pollutograph for the Lion's Head marina spill, which represents a snapshot of the dispersion during the moment of highest concentration at the intake.
In 2017 the Ontario Drinking Water Quality Standard (ODWQS) for benzene was reduced from 0.005 mg/L to 0.001 mg/L. Model predictions for East Linton Intake completed in 2011 demonstrated possible exceedance of the new standard for benzene, therefore resulting in the need to delineate a new Event-based area (EBA) for the East Linton Intake. It is important to note that the other existing EBAs are delineated using the previous ODWQS (0.005 mg/l) and these remain valid under the new ODWQS since the new standard is more stringent.

TABLE 4.1.5 – Model Run Results

Run#	Spill#	Intakes Evaluated	Spill Description	Contaminant	Wind Direction	Flow Return Period	Spill Duration	Spill Volume
1	1	Owen Sound and East Linton	Sewage Pumping Station Bypass	E. coli Time series	SSW	2 Year	21 hr	7,546,000 L
2					NNW			
3	2	Owen Sound and East Linton	Marina Fuel	1.5% Benzene	SSW	2 Year	1 hr	15,000 L
4					NNE			
5					SSW	Mean	1 hr	
6					NNE			
7	3	Meaford	Marina Fuel	1.5% Benzene	SE	2 Year	1 hr	4,500 L
8						Mean		
9	10	Thornbury	Marina Fuel	1.5% Benzene	SE	2 Year	1 hr	15,000 L
10						Mean		
11	5	Southampton (New) & (Old)	Marina Fuel	1.5% Benzene	SW	2 Year	1 hr	22,500 L
12	7	Kincardine	Marina Fuel	1.5% Benzene	SW	2 Year	1 hr	15,000 L
13	8	Lion's Head	Marina Fuel	1.5% Benzene	SSW	2 Year	1 hr	10,000 L
14	9	Wiarton	Marina Fuel	1.5% Benzene	SSW	2 Year	1 hr	10,000 L
15	4	Southampton (New) & (Old)	Bruce Power Fuel Tank	0.07% Ethylbenzene	SW	2 Year	3 hr	750,111 L
16	6	Kincardine	Bruce Power Fuel Tank	0.07% Ethylbenzene	NE	2 Year	3 hr	750,111 L

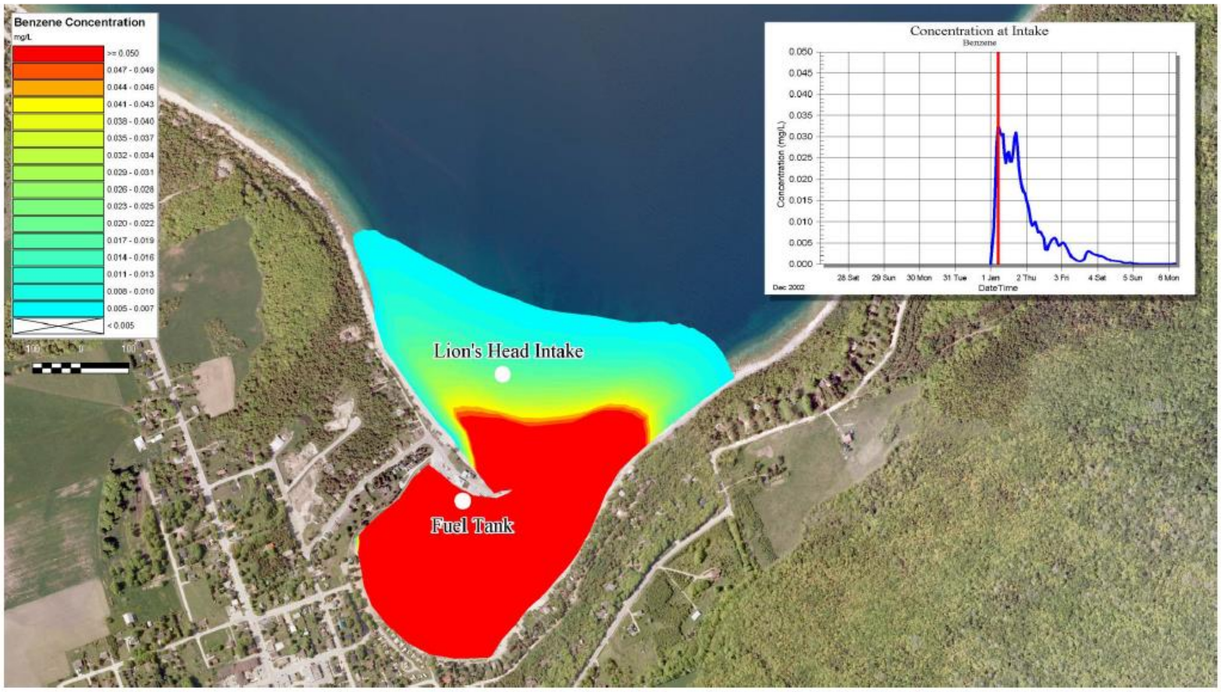

Figure 4.1.1 – Pollutograph for Lion's Head Marina Spill (Baird, 2013)

For limitations on spill modelling, see section 3.6 of *IPZ-3 Modelling for Indentification of Significant Threats Saugeen, Grey Sauble, Northern Bruce Peninsula Region* (Baird, 2013).

Desktop Assessment

The computer model results of spill scenarios generated in the Baird report were used as a basis for a desktop analysis of other potential spill locations. The Baird report contained important pieces of information about the spill scenarios: the volume spilled; the concentration of contaminant; the on-land distance from the spill and along drainage pathways to the outfall at the lakeshore, if applicable; the in-lake distance between the outfall of the spill and the municipal drinking water intake; and the resulting concentration of contaminate in lake water at the intake.

Both fuel and sewage spills were analytically evaluated using the desktop assessment method. The spills modelled using the desktop method all required a flow path from the spill to the lake, as all were located inland. Drainage paths were assumed to follow either storm sewer drains or roadside ditches with a speed of 1 m/s. Baird completed sensitivity testing and determined that reducing the flow speed to 0.3 m/s resulted in a slightly lower assumed concentration at the intake (Baird, 2013), however, whether or not an exceedance was predicted was not affected. While in the drainage path, it was assumed that spill would begin to evaporate. The volume of the spill remaining once the path reached the shoreline was determined using the evaporation rates shown in Figure 4.1.2 and Table 4.1.6. The evaporation rates shown are generally consistent with fresh water, for the purposes of this analysis (Baird, 2013).

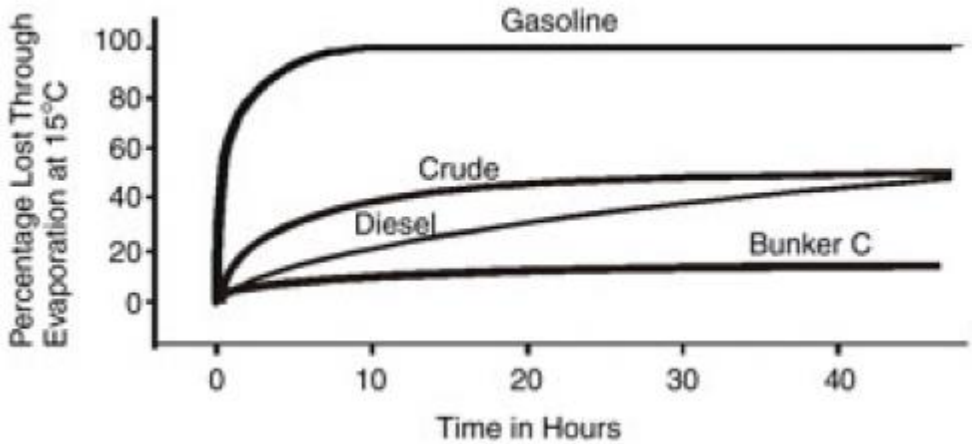

Figure 4.1.2 – Percent Fuel Lost Through Evaporation over Time (Committee on Oil in the Sea 2003)

TABLE 4.1.6 – Percentage of Fuel Lost Through Evaporation over Time Digitized and Interpolated from Committee on Oil in the Sea (2003)

Time (minutes)	% of benzene evaporated	% of benzene remaining	On-land distance factor
0	0	100	1.00
15	42	58	0.58
30	54	46	0.46
60	67	33	0.33
90	73	27	0.27
120	78	22	0.22
150	82	18	0.18
180	85	15	0.15
240	91	9	0.09
300	96	4	0.04
360	98.6	1.4	0.014
420	99.5	0.5	0.005
480	99.7	0.3	0.003

To determine the final concentration at the intake, an estimated dilution factor was applied for the in-water distance, calculated as factor of the modelled spill per linear metre from the shoreline to the intake, as illustrated by Figure 4.1.3. For the spill scenarios considered in the desktop study, this dilution factor was applied to the in-water travel distance and concentration at the shore to estimate the concentration at the intake. The final concentration was then compared to the ODWQS and checked for exceedance (Baird, 2013).

Figure 4.1.3 – Assumed Drainage and In-water Travel Paths for Desktop Assessment

Desktop analysis done by Baird determined that none of the possible sewage spill scenarios resulted in a predicted exceedance at the intake. Fuel spill exceedances were predicted for Lion's Head, Wiarton, Owen Sound, Meaford, Southampton and Kincardine (Table 4.1.7).

Using the methodology provided by Baird, Source Protection staff examined other points in and around the existing IPZ-2 to determine where to delineate the events-based area (EBA). If the EBA fell outside the existing IPZ-2, an IPZ-3 was delineated. If an area regulated by the Conservation Authority went beyond the IPZ-2 and EBA, an IPZ-3 was delineated. Upon consultation with the MECP, it was determined that not only would a concentration at the intake be calculated, but also a minimum volume required to cause and exceedance. The computer model scenario results were used to predict values from other spill locations by applying three factors:

> **Volume factor**: The volume of benzene released in a spill is directly proportional to the quantity of the spill. If the volume of the spill scenario is greater than the computer modelled scenario, then the volume factor is greater than 1.0. Where the spill scenario volume is less than the computer modelled scenario, the volume factor is less than 1.0. The volume factor is 1.0 where volumes for the two scenarios are equivalent.

TABLE 4.1.7 – Flow Speed Sensitivity Testing and Exceedance Results

Spill#	Spill Location	Descripti	Substance	Volume	Contaminant	Inland Drainage Path Length (m)	In-lake Minimum Distance to Intake (m)	Estimated Concentration at Intake Flows (1 m/s)
11	Lion's Head	Fuel	Gasoline	50,000 L	1.5%Benzene	0	514	**0.098 mg/L**
12	Wiarton	Fuel	Gasoline	50,000 L	1.5%Benzene	836	1,573	**0.041 mg/L**
13	Wiarton	Av. Fuel	Kerosene	50,000 L	0.31% Naphthalene	1043	1,367	**0.012 mg/L**
14	Owen Sound	Fuel	Gasoline	10,000 L	1.5%Benzene	0	1,462	**0.004 mg/L**
	East Linton						6,581	**0.001 mg/L**
15	Owen Sound	Fuel	Gasoline	50,000 L	1.5%Benzene	234	2,840	**0.011 mg/L**
	East Linton						7,959	**0.004 mg/L**
16	Owen Sound	Fuel	Gasoline	50,000 L	1.5%Benzene	3,342	714	**0.019 mg/L**
	East Linton						5,833	**0.002 mg/L**
17	Owen Sound	Fuel	Gasoline	50,000 L	1.5%Benzene	1,355	2,296	**0.011 mg/L**
	East Linton						7,415	**0.003 mg/L**
18	Owen Sound	Fuel	Gasoline	50,000 L	1.5%Benzene	136	3,387	**0.009 mg/L**
	East Linton						8,506	**0.004 mg/L**
19	Owen Sound	Fuel	Gasoline	50,000 L	1.5%Benzene	198	3,375	**0.009 mg/L**
	East Linton						8,494	**0.004 mg/L**
20	Owen Sound	Fuel	Gasoline	50,000 L	1.5%Benzene	1,401	2,225	**0.011 mg/L**
	East Linton						7,344	**0.003 mg/L**
21	Owen Sound	Fuel	Gasoline	50,000 L	1.5%Benzene	1,269	2,225	**0.011 mg/L**
	East Linton						7,344	**0.003 mg/L**
22	Meaford	Fuel	Gasoline	50,000 L	1.5%Benzene	3,357	6,038	**0.026 mg/L**
23	Meaford	Fuel	Gasoline	50,000 L	1.5%Benzene	0	1,700	**0.209 mg/L**
24	Meaford	Fuel	Gasoline	50,000 L	1.5%Benzene	234.5	1,426	**0.239 mg/L**
25	Meaford	Fuel	Gasoline	50,000 L	1.5%Benzene	46.5	2,186	**0.161 mg/L**
26	Meaford	Fuel	Gasoline	50,000 L	1.5%Benzene	1,222	261	**1.083 mg/L**
27	Thornbury	Fuel	Gasoline	50,000 L	1.5%Benzene	284	1,493	**0.003 mg/L**
28	Kincardine	Fuel	Gasoline	50,000 L	1.5%Benzene	691	739	**0.253 mg/L**
29	Kincardine	Fuel	Gasoline	50,000 L	1.5%Benzene	660	4,266	**0.044 mg/L**
30	Kincardine	Fuel	Gasoline	50,000 L	1.5%Benzene	391	900	**0.220 mg/L**
31	Southampton (New)	Fuel	Gasoline	50,000 L	1.5% Benzene	464	3,064	**0.018 mg/L**

On-land distance factor: Fuel, such as gasoline, does evaporate over time with the resultant decrease in the amount of the contaminant, in this case benzene. An evaporation curve was used to determine the proportion of material that would be remaining after a given amount of time of moving downstream to the lake (see Figure 4.1.2). The measured in-land distance was multiplied by an estimated velocity of the water to give the time of travel and then the time of travel was compared to the evaporation curve to give the percent material remaining. The proportion remaining became the on-land distance factor (values range from 1.0 down to 0.0). For example, if the spill location was 600 metres from the outfall, it would take 10 minutes of travel and 85% of the original material would remain; therefore the on-land distance factor would be 0.85. Values are near 1.0 where the spill scenario location is close to the lake and decrease as the upstream distance becomes greater. Values approach 0.0 after 8 hours of travel time.

In-lake distance factor: Since the spill scenario may not reach the same outfall location as the computer modelled scenario, it is necessary to account for the difference in dilution of the spill as it moves in the lake. The distance from the spill outfall location to the municipal water intake was measured and compared to the measurement for the computer modelled spill. There is an inverse relationship for the in-lake distance, meaning that if a spill is closer to the intake then the concentration of benzene would remain higher. For example, if the spill outfall location was 1000 metres from the intake and the computer modelled location was 2000 metres, then the in-lake distance factor would be 2.0. If the outfall for the spill scenario location is closer to the intake than the computer modelled scenario, then the in-lake distance factor is greater than 1.0. Where the distance to the intake from the outfall for the spill scenario is farther than the computer modelled scenario, the in-lake distance factor is less than 1.0. The in-lake distance factor is 1.0 where the in-lake distance for the two scenarios are equivalent.

Calculations

The concentration of benzene at the intake resulting from a spill can be derived for virtually any point in proximity to the intake and computer modelled spill location. The following formula is used:

$$\text{Benzene concentration at intake from spill scenario (mg/L)} = \text{Benzene concentration at intake from computer modelled scenario (mg/L)} \times \text{Volume factor} \times \text{On-land distance factor} \times \text{In-lake distance factor}$$

where: Volume factor

$$= \frac{\text{Volume of spill scenario}}{\text{Volume of computer modelled scenario}}$$

On-land distance factor	=	Proportion of benzene remaining after evaporation considered for the amount of time travelled

$$\text{In-lake distance factor} = \frac{\text{Distance to intake for computer modelled scenario}}{\text{Distance to intake from outfall of spill scenario}}$$

The concentration formula was used to derive a second formula for determining the minimum volume of a spill that would result in an exceedance of the water quality objective for benzene. The Ontario Drinking Water Quality Standard for benzene is 0.005 mg/L. (If water the intake was to have a concentration of 0.005 mg/L or greater of benzene, then the water quality would be adversely affected and the activity causing this event would be considered a significant drinking water threat.) The calculations used to delineate the East Linton EBA follows the same methodology as the other EBA's, with the exception of using the updated Ontario Drinking Water Quality Standard for benzene of 0.001 mg/L as the exceedance threshold to determine if a given spill volume would be considered a significant drinking water threat.

The formula for calculating the minimum volume of the spill is:

$$\text{Volume of spill scenario} = \frac{\text{Benzene concentration at intake of 0.005 mg/L for spill scenario} \times \text{Volume of computer modelled scenario}}{\text{Benzene concentration at intake for computer modelled scenario (mg/L)} \times \text{On-land distance factor} \times \text{In-lake distance factor}}$$

The effect of the three factors on the resulting concentration at the intake can be illustrated by the following example. Information from the Baird modelling report (Baird, 2013) indicates that a spill near the mouth of the Penetangore River in Kincardine (15,000 L spilled at a site on the lakeshore and the in-lake distance to the intake of 1149 metres) would result in a benzene concentration at the Kincardine intake of 0.055 mg/L. If the spill volume from the same location was doubled, then the calculated concentration would double to 0.110 mg/L. If the spill volume was the same, but the spill location was 1000 metres in-land, then the calculated concentration would decrease because of evaporation to a value of 0.031 mg/L. In addition the information for these two locations could be used to calculate the spill volume necessary to have a concentration of 0.005 mg/L. The location near the river mouth would have a spill volume of 1400 L and the location 1000 metres in-land from the shoreline would have a higher value at 2500L.

Points were then re-evaluated using this method to determine the minimum volumes that cause exceedance of the standards to deteriorate the water quality. These volumes were used to delineate events based areas where certain fuel activities have been identified as significant drinking water threats. Source protection plan will/would include policies to address these significant threats (Figure 4.1.4).

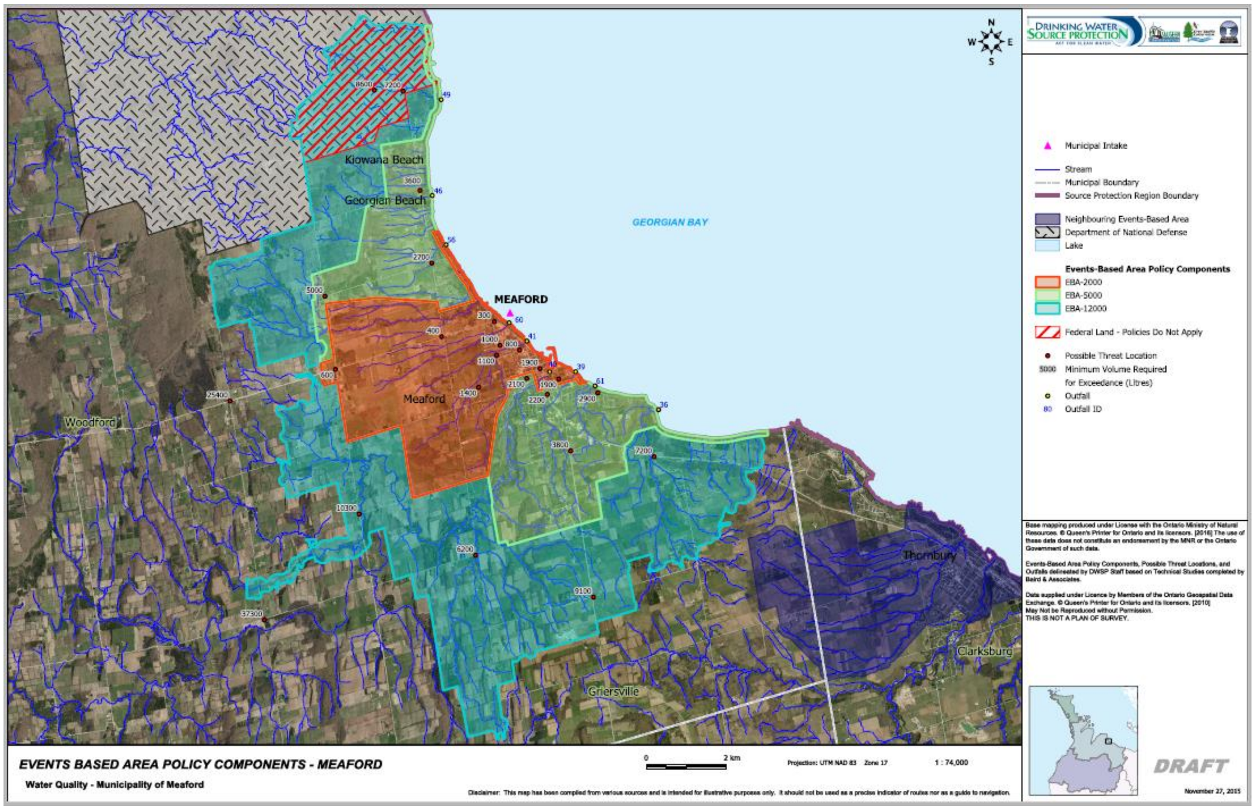

Figure 4.1.4 – Events-based Policy Area for Meaford Intake

4.1.2.5 Delineating Wellhead Protection Areas (WHPAs)

Wellhead Protection Areas (WHPAs)

A wellhead protection area, or WHPA, is the two-dimensional projection onto the ground surface of the three-dimensional volume of groundwater that is pumped from a well field. In other words, it is the area above the aquifer from which groundwater is drawn into the well in a certain time frame under a defined pumping rate.

WHPAs themselves are composed of a number of zones that reflect the time required for water to move to the well from different areas of the aquifer. These zones are called time of travel capture zones. Zones were identified as the 100 metre radius, 2-year, 5-year, and 25-year time-of-travel limits. This delineation only considers the time-of-travel within the aquifer and ignores the time-of-travel from the ground surface to the aquifer.

WHPAs were originally generated for the study area as part of the MOECC Groundwater Studies completed for Huron, Bruce, Grey, and Dufferin Counties in 2003 and for Wellington County in 2006. Additional work was undertaken between 2006 and 2009 by the Source Protection program for wellheads when additional information had become available or the circumstances of the well had changed.

Following the Technical Rules, these time-of-travel (ToT) capture zones were applied to all municipal groundwater supplies within the study area as part of the MOECC groundwater studies. The time-of-travel zones as per Technical Rule 51 are:

- WHPA-A: 100 metre radius
- WHPA-B: 2-year ToT capture zone that is not within WHPA-A
- WHPA-C: 5-year ToT capture zone that is not within WHPAs A or B
- WHPA-D: The capture zone where ToT is less than 25 years and not within WHPAs A, B or C
- WHPA-E: For GUDI wells, the 2-hour ToT within the surface water body influencing the well

The WHPA is the composite of WHPA-A, B, C, and D. If the well is under the direct influence of surface water, a WHPA-E is required.

Wells are called under the direct influence of surface water (GUDI) if a hydrogeological study indicates that surface water can rapidly enter into a well or if pathogens expected in surface water are present in the well.

For wells classified as GUDI, an additional protection zone, WHPA-E, must be delineated. This zone contains the 2-hour ToT within the surface water body affecting the well. The delineation method for WHPA-E closely follows that of intake protection zone 2 (IPZ-2). Furthermore, if the water quality of this well shows contamination that can be neither attributed to the total capture zone (WHPAs A-D) nor the surface water in the vicinity (WHPA-E), then a larger contributing area of the influencing surface water may be delineated, called WHPA-F.

The size and shape of all groundwater WHPAs A-D largely depends on the amount of water being pumped, the permeability of the aquifer from which it is being pumped, and the overall regional hydraulic gradient. Large WHPAs occur in areas where there are high gradients, areas with high permeability, areas with bedrock fractures and areas where large volumes of water are being pumped.

It is important to note that an increased pumping rate, perhaps due to new development, will increase the size of a WHPA and alter its shape. However, a conservative pumping rate was assumed, which is a projection of the average pumping rate into the future, assuming continued population growth at the current rate (2001 and 2006 data) and current water use.

Methodology

Delineation of wellhead protection areas is accomplished through the application of numerical groundwater models. The physical relationships governing the movement of groundwater can be incorporated into numerical models to simulate the existing groundwater flow system. Once calibrated, this model can be used to determine the pathways of groundwater in the aquifer and to calculate the travel time between any two points along those path lines.

ToT capture zones for municipal wells are calculated by releasing many particles into the model that originate in a circle around the well, and running the model in reverse. These capture zone results form the basis for delineating WHPAs for the municipal well.

Knowledge Limitations and Data Gaps of WHPA Delineation

WHPAs produced from numerical models incorporate a number of assumptions, input parameters and boundary conditions. Each model is a representation of the area surrounding the municipal well, and this representation has been simplified to facilitate model development in all cases. The WHPA modelling results represent the best estimate of the actual area which contributes to the well.

As additional information about the hydrogeology becomes available, the numerical models will be revised and WHPAs will be re-evaluated. Furthermore, the taking of water will be different in the future as communities grow and additional groundwater wells are developed.

One important limitation is that the capture zones are projected to ground surface, which does not reflect the time required for water to travel from ground surface to the aquifer. This is particularly true when the wells that are being evaluated pump water from a deep aquifer that is overlain with fine-grain sediments, such as silts and clays. Especially in karst terrains, the applicability of the conventional numerical groundwater models should be re-evaluated due to the high permeability of these aquifers.

4.1.2.6 Identification of Transport Pathways to Groundwater

The intrinsic vulnerability of an aquifer can increase by any land use activity or feature that disturbs the surface above the aquifer or artificially enhances flow to that aquifer. These transport pathways, or short circuits, can be either natural or constructed (CRA 2009). Natural pathways, such as fracturing and karsts features, are already considered within the regional ISI/AVI mapping. Constructed transport pathways are human-made features or open pathways through the ground that have the potential to increase the vulnerability of a drinking water source to contamination.

Preliminary identification of transport pathways was completed through aerial photo interpretation. Properties and areas of interest were identified from the 2006/2007 photos in a GIS environment. Properties located in the WHPA were also visited as part of a larger effort to evaluate drinking water threats throughout the region. As part of these visits, routine questions were asked of the property owners about the location and condition of any wells on the property. The results of these site visits were entered and stored in a geo-referenced database, facilitating review as part of the transport pathways review.

In this source protection region, transport pathways can be grouped into several categories, namely: pits and quarries; private wells; urban areas; and, private well clusters. Detailed methodology and consideration of these areas are outlined below. In assigning transport pathway adjustments, the hydrogeology of the site and the condition of the pathway were considered, as well as the cumulative impact of transport pathways.

Pits and Quarries

Pits and quarries were primarily identified through aerial photography. Where prudent, these operations were examined by a roadside or windshield survey in order to ascertain the type of operations. There are relatively few pits and quarries in the Region. Where they exist, and dependent on their depth with respect to the water table, aquifer vulnerability was adjusted from low to moderate or high, or from moderate to high.

Private Wells

Private wells were first identified using the WWIS. Additional information was gathered from site visits carried out as part of this review, and stewardship programs to determine if any upgrades had occurred since 2006.

Wells that were not in compliance with existing regulations were identified as being potential conduits for water that increase the vulnerability of the aquifer locally. Vulnerability scores were adjusted in the vicinity of the well, and were adjusted a maximum of one level (i.e. low to moderate; or moderate to high).

Additionally, several properties for which no well record exists, nor any well obvious by site inspection, yet have structures which require water were identified. In these cases, vulnerability scores were adjusted for the property and were elevated a maximum of one level.

Urban Areas and Private Well Clusters

Urban areas inside WHPAs were delineated based on aerial photography. These areas warrant special consideration as potential areas for transport pathway adjustments under Technical Rule 41 (3) as the cumulative effects of a high density of abandoned historic wells are common. Although these areas today are serviced by a municipal well, most were historically serviced by private wells. Additionally, the age of these wells precludes the existence of a record for the wells.

The historical servicing of these urban areas was reviewed, and the areas themselves visited to determine if former private wells could be in existence. Where this information indicates that wells are in existence and are substantially non-compliant, vulnerability scores were adjusted for the areas, and were adjusted a maximum of one level.

4.1.2.7 Delineating Wellhead Protection Area E (GUDI wells only)

The wellhead protection area E (WHPA-E) is delineated for groundwater wells that receive water from aquifers under the direct influence of surface water (GUDI). The Technical Rules lay out the methodology to delineate WHPA-Es and for threats-based risk assessment. Specifically, Part V.3 Technical Rule 47(5) defines how a surface water body shall be identified that is most likely to influence the well. From this point of interaction, the Technical Rules prescribe to follow the rules for surface water intakes (see 4.1.2.4). Following the threats-based approach to water quality risk assessment, vulnerability scores are then assigned to these surface water bodies. Activities on properties located within the WHPA-E may be considered a threat to the drinking water source.

The first step requires the identification of a point of interaction (POI), which is the point within a surface water body where interaction with the groundwater aquifer is most likely. Unless a specific water body was pointed out in the engineering reports and inspection reports, the closest point within a water body was identified.

From the POI, the 2-hour ToT must be delineated. If the POI is located in a surface water body that is sufficiently large, the delineation of the WHPA-E requires the computation of the two-hour ToT considering streamflow velocity, for example using open channel modelling. In cases where surface water bodies were very small, the WHPA-E was extended to the full surface water body. This is the case where, during any 2-year return period runoff event, water from any location in the surface water body can reach the point of interaction with the GUDI well in less than two hours.

With the availability of new and more accurate data, particularly a new digital elevation model available for some areas, Source Protection staff undertook a review of the WHPA-E delineations fall of 2013. It was determined that eight (Tobermory, Oliphant, Huron Woods, Foreman, Pottawatomi, Kimberley, Markdale and Neustadt) included the full extent of nearby watersheds and therefore did not need to be redelineated. Staff undertook work to redelineate the remaining seven WHPA-Es (Amabel-Sauble, Winburk, Tara, Chatsworth, Walters Falls, Chepstow and Durham) using updated methodology.

Updated WHPA-E Methodology

Southwestern Ontario Orthophotography Project 2010 (SWOOP 2010) raw imagery data obtained as part of the Ontario Geospatial Data Exchange was used to create 1 metre digital elevation models (DEMs) using BAE Systems SOCET GXP software. SWOOP 2010 aerial imagery was also used to update watercourse line work and water body polygons.

Velocities were calculated and used to represent a section of stream using the following steps:

a) Streams were broken up into sections at intersections of tributaries and where the characteristics of the stream looked unique on the aerial imagery. The 1 m DEM was used to collect cross-sections in 3D stereo viewing. Any spikes in the profile data were smoothed out where it looked like the software had problems with water reflectance or highly wooded sections.

b) Slopes running along the stream were calculated for representative sections using elevation values off the 1 m DEM. They were calculated using the standard equation for slope; change in height divided by change in distance. The elevation values were collected just beside the visible water surface on the bank so that water reflectance errors would not be an issue. The distance used was the stream length.

c) Roughness values were determined using previous fieldwork photographs and a reference catalogue in the Conveyance Estimation System software. The roughness value depends on the characteristics of the streambed, bank and floodplain. For example, gravel, clay, reeds, trees, etc. will all influence the velocity at which water in the stream will flow.

d) The stream profile, slope and roughness data was all put into modeling software called the Conveyance Estimation System. The resulting output from this is an average velocity (m/s) versus elevation (m) graph for each stream profile. The velocity value used is taken at the elevation of the top of the bank simulating the worst-case scenario of water levels rising to fill the streambed.

The velocity and stream distance for each stream section was used to calculate a portion of an hour of travel time. This was used to go upstream until a 2-hour ToT was reached from the POI.

The following components were then created in order to delineate the WHPA-E:

a) A 120 m buffer was applied to the stream network reaching 2 hours upstream from the well. This buffer was cut in a straight line across the POI because downstream of the well does not need to be included.

b) Conservation Authority regulation limit polygons that intersect the 120 m buffer are included. Some cuts were made for these when they extended significantly past the end of the 2 Hour ToT. Meander belt polygons that continued past were often cut across the end of a property representing tile drainage just past the end of the 120 m buffer. Wetland polygons that extended significantly past were often cut along the edge of the nearest crossing road past the end of the 120 m buffer. The Saugeen Valley Conservation Authority does not have regulation limits outside of populated areas so, when absent, the hazard lands polygons were used instead (part of Durham and for Chepstow).

c) Tile drainage was included by taking agricultural properties that are touching the 120 m buffer and including those that look like they have fields that could be in production and could therefore have tile drainage. Any wooded areas larger than one hectare were cut out.

All of these components were then combined to form the WHPA-E delineation. Any holes smaller than one hectare were removed, as they were the result of imperfect alignment of the components. During review by the MECP these small holes were determined to be negligible in segmenting the area of flow towards the water body.

4.1.2.8 Delineating Wellhead Protection Area F (GUDI wells only)

In this source protection area, no WHPA-F has been delineated.

4.1.3 Vulnerability Scoring in Vulnerable Areas

4.1.3.1 Vulnerability of Highly Vulnerable Aquifers (HVAs)

According to the Technical Rules, highly vulnerable aquifer areas outside of Wellhead Protection Areas are assigned a vulnerability score of six.

4.1.3.2 Vulnerability of Significant Groundwater Recharge Areas (SGRAs)

Vulnerability scoring within the significant groundwater recharge areas was completed by combining the aquifer vulnerability mapping with the significant groundwater recharge areas. Significant groundwater recharge areas that have high intrinsic susceptibility (coincident with highly vulnerable aquifers) were given a score of six. Significant groundwater recharge areas that have moderate and low intrinsic susceptibility were given vulnerability scores of four and two respectively. As per the 2021 Amendments to the Technical Rules, vulnerability scoring for significant groundwater recharge areas was removed.

4.1.3.3 Vulnerability of Drinking Water Systems that use Groundwater

To determine the vulnerability of groundwater wells, the map of a wellhead protection area (WHPA) is combined with the intrinsic groundwater vulnerability. This intrinsic vulnerability is expressed with the Intrinsic Vulnerability Index and its susceptibility classes (ISI see Section 4.1.2.1). Aquifer susceptibility can be low, medium and high.

In accordance with Part VII.3, Technical Rule 83, WHPA vulnerability scores can range from two, for low vulnerability, to ten, for high vulnerability (see Table 4.1.8). Based on the combination of the WHPA maps and the intrinsic groundwater susceptibility, scores were generated across each WHPA. The resulting scores provide an indication of how likely it is that contamination from drinking water quality threats can reach a well (i.e., surface or near surface sources of contamination within the WHPA). Typically, vulnerability scores are higher closer to the well.

TABLE 4.1.8 – Vulnerability Scoring in Wellhead Protection Areas (WHPA)

WHPA Protection Zone	***Intrinsic Groundwater Vulnerability***		
	High	***Medium***	***Low***
WHPA-A: 100 m radius	10	10	10
WHPA-B: 2-year ToT	10	8	6
WHPA-C: 5-year ToT	8	6	4
WHPA-D: 25-year ToT	6	4	2

4.1.3.4 Vulnerability Adjustment for Transport Pathways

Transport pathways are features resulting from human activities that have removed layers of material that provide natural protection to pumped aquifers. These features, which include gravel pits, quarries and improperly constructed wells have the potential to allow the rapid movement of contaminants from the ground surface into these aquifers. The location, density and likelihood of these features to impact the aquifers was evaluated for all WHPAs (see Section 4.1.2.6). As a result of this evaluation, ISI/AVI index mapping values were increased in areas where potential impacts were considered possible in accordance with the Technical Rules (Part IV.1, Technical Rules 39 to 41).

4.1.3.5 Vulnerability of Drinking Water Systems that use Surface Water

The vulnerability score is based on the attributes of the intake such as distance from shore and depth, the type of water body, the physical characteristics of the environment, and the influences on source water. It is essentially qualitative, based on scores assigned to the contributing factors. Vulnerability scores are derived for each intake protection zone.

A vulnerability score is assigned to each IPZ-1, IPZ-2 and each area of an IPZ-3 that is associated with a Type C or Type D intake. It is calculated by combining the Area Vulnerability

Factor (Part VIII.2, Technical Rule 92), which depends on the IPZ zoning, and the Source Vulnerability Factor (Part VIII.3, Technical Rule 95), which describes the inherent vulnerability of the intake.

Vulnerability Score = Area Vulnerability Factor x Source Vulnerability Factor

This formula does not take into consideration the biological, chemical or physical properties of potential contaminants. The vulnerability score, area vulnerability factor and the source vulnerability factor are unit-less.

The Technical Rules outline applicable vulnerability scoring for intakes in all types of surface water sources. The water treatment plants (WTPs) located on Lake Huron, which includes Georgian Bay, are classified as Type A (Great Lakes) intakes.

The Technical Rules provide the sub factors required to assess the area vulnerability factor and source vulnerability factors. The criteria to evaluate and weigh the sub factors are not provided in the Technical Rules; therefore, a methodology has been developed in the form of a decision matrix.

The area vulnerability factor, the source vulnerability factor and their sub-factors are considered and discussed below.

Area Vulnerability Factor

The Area Vulnerability Factor for IPZ-1 is set by the Technical Rules and is always ten (Part VIII.2, Technical Rule 88). The area vulnerability factor for IPZ-2 must be assigned a whole number ranging from seven to nine (Technical Rule 89) and it must consider the following factors (for detailed description on how each of these is computed, see (Stantec, 2009, Phase 1 Technical Addendum):

1. The percentage of land within IPZ-2
2. The land cover, soil type, permeability of the land, and the slope of any setbacks
3. The hydrological and hydro-geological conditions in the area that contribute water to the area through transport pathways

The area vulnerability factor score is the average of these components.

Source Vulnerability Factor

The Source Vulnerability Factor ranges from 0.5 to 1.0 and must take into consideration the depth of the intake from the top of the water surface, the distance of the intake from land and the number of recorded drinking water issues related to the intake. The source vulnerability factor score is then the average of these three components. The values set out in the Technical Rules are shown below in Table 4.1.9. (Part VIII.3, Technical Rule 92(3)).

TABLE 4.1.9 – Source Vulnerability Factor of an Intake Protection Zone 2 (IPZ-2)

Intake Type	*Source Vulnerability Factor*
A (Great Lakes)	0.5 to 0.7
B (connecting channels)	0.7 to 0.9
C (rivers)	0.9 or 1
D (others)	0.8 to 1

4.1.3.6 Vulnerability Scoring for Groundwater Systems Under the Direct Influence of Surface Water (WHPA-E)

Vulnerability scoring for wellhead protection area E (WHPA-E) associated with wells under the direct influence of surface water follows the procedure outlined for intake protection zones (Section 4.1.3.5). Separate scores are determined for the area vulnerability, which contributes runoff to the surface water, and the source vulnerability at the well itself, which measures the likelihood that contamination enters from the surface water body into the well. Both factors are then multiplied together.

Area vulnerability was determined as described for intake protection zones, taking into account: the percentage of land within the WHPA-E; land characteristics, such as the land cover, soil type, permeability of the land, and the slope of any setbacks; and the hydrological and hydro-geological conditions in the area that contribute water to the area through transport pathways.

To determine the source vulnerability factor, groundwater systems under the direct influence of surface water (GUDI) are best described as Type D (other) systems. The source vulnerability score is 0.8 (low), 0.9 (moderate) and 1.0 (high).

4.1.3.7 Limitations of Vulnerability Scoring

Vulnerability scoring of all vulnerable areas is limited by the accumulative effect of its three components:

- Limitations of the aquifer vulnerability and intrinsic susceptibility (see section 4.1.2.1), which is the basis for vulnerability scoring;
- Uncertainty regarding the spatial extent of the vulnerable areas (see section 4.1.2.2-5, and 4.1.2.7); and
- Limitations related to the identification of transport pathways in groundwater (see section 4.1.2.6) and as part of the onshore component of the intake protection zone (see section 4.1.2.4), which lead to an adjustment of the vulnerability score.

4.1.4 Managed Lands, Livestock Density and Impervious Surfaces

Managed lands are lands to which nutrients are applied. Managed lands can be categorized into two groups: agricultural managed land and non-agricultural managed land (definition in Technical Rule 1(1)). Agricultural managed land includes areas of cropland, fallow and improved pasture that may receive nutrients. Non-agricultural managed land includes golf courses, sports fields, lawns, and other grassed areas that may receive nutrients, which is primarily commercial fertilizer. Determining the location and percentage of managed lands, the location of agricultural managed lands and the calculation of livestock density can determine whether the application of agricultural source material (ASM), non-agricultural source material (NASM) and commercial fertilizers are significant threats within a vulnerable area.

Livestock density is determined by "dividing the nutrient units generated in each area by the number of acres of agricultural managed land in that area where agricultural source material is applied" (Technical Rules 16(10)).

4.1.4.1 Managed Lands and Methodology

A proposed methodology for calculating the percentage of managed lands and livestock density for the application of ASM, NASM and commercial fertilizers was outlined in an MOECC Technical Bulletin (2009b).

Agricultural Managed Lands
For each agricultural parcel within a wellhead protection area (WHPA), the percentage of managed land was estimated, based on review of aerial photography, as the total area that is cropped plus the area devoted to animal land use. The portion of the property within the WHPA was estimated using the MPAC parcel layer and the DWSP delineation of the WHPA. The total area of agricultural lands within a vulnerable area is calculated by adding all agricultural parcels within the vulnerable area, weighted with the percentage of each property that is managed.

Each agricultural parcel within an intake protection zone (IPZ), highly vulnerable aquifer (HVA) or significant groundwater recharge area (SGRA) was evaluated using the same rules. For intake protection zones, only the onshore component of the IPZ was taken into consideration.

Non-Agricultural Managed Lands

Non-agricultural properties considered managed lands include municipal parks, sport complexes, large school playgrounds, ski hills, golf courses and residential lawns. To determine the areas of residential lawn within a vulnerable area, only 55% of their original parcels size was considered. The full parcel size was used for all non-residential, non-agricultural managed land parcels, such as municipal parks and golf courses.

Input Data for Managed Lands

- MPAC parcel fabric
- DWSP delineated layer of Recreation Polygons consisting of golf courses, ski hills and sports complexes, digitized from aerial photography
- SOLRIS (Southern Ontario Land Resource Information System) "Built-Up Areas"

Separating Areas with Elevated Vulnerability

Agricultural and non-agricultural managed lands were computed for each vulnerable area but only those areas with an elevated vulnerability score were further considered, as well as the total size of each vulnerable area. For WHPAs, this threshold is a vulnerability score of six or more. For IPZs, this threshold is 4.2 or more. For HVAs, only the areas with a vulnerability of six were considered. Areas identified with an elevated vulnerability were then added by each sub area to create one score for each WHPA-A, WHPA-B, WHPA-C, WHPA-D, IPZ-1 and IPZ-2, and HVA. These areas were used for all further computations.

Calculations of managed lands used to determine water quality risks in HVAs remain valid with the removal of SGRA scores given the fact that the same threshold vulnerability of six or more was used for both areas.

Calculation of Managed Lands Percentage

For each vulnerable area WHPA-A, WHPA-B, WHPA-C, WHPA-D, IPZ-1 and IPZ-2, the percentage of managed lands was computed by dividing the hectares of managed lands by the hectares in the vulnerable area zone and multiplying by 100.

4.1.4.2 Livestock Density and Methodology

The calculation of livestock density within vulnerable areas (WHPAs, IPZs, SGRAs, and HVAs) uses the index nutrient units per acre (NU/acre), using only the area of agricultural managed lands as a denominator. Separate scores were computed for WHPA-A, WHPA-B, WHPA-C, WHPA-D, IPZ-1 and IPZ-2. The same areas with elevated vulnerability were used as previously described for managed lands.

Nutrient Units Estimate for Agricultural Parcels with Barns

To determine the nutrient units, each parcel of land that intersects the vulnerable areas was assessed for the presence of a livestock barn. The size of the barn was used as a surrogate for the number of livestock and the amount of nutrients that could be generated by the livestock on that farm. The description in the MPAC farm code was initially used to screen for the livestock parcels to determine the livestock type.

Livestock housing areas were estimated for barns on these parcels. Partial coverage of building footprints was available for the study area, but where data gaps existed, the buildings on parcels having a farm code were measured based on 2006 air photos.

Each type of livestock has its own nutrient unit conversion factor to determine the number of animals that generate 1 NU. For instance, one beef cow produces 1 NU and requires 100 square feet or nine square metres of living space in a barn, so the relationship for beef barns is 100 ft^2/NU. The ratio assumes that the capacity of each livestock barn is at maximum capacity in order to generate, or have the potential to generate, that amount of nutrients.

The number of animals on each parcel was determined using Table 4.1.10. The NU value was multiplied by the NU conversion factor to generate the number of animals on each parcel.

The distinction between beef cow and beef feeders was made based on a visual review of the property; pasture areas are consistent with beef cow production and livestock yards are consistent with beef feeders. NU was then multiplied by the appropriate conversion factor as each parcel was reviewed. The chart information was extracted and condensed from the memorandum that contains Technical Bulletins supplied by the Ministry of the Environment and Climate Change (MOECC, 2009b).

Through air photo interpretation, the type of livestock housed in each barn was determined and the area of the housing was measured. A table included in the technical memorandum provided by the MECP summarizes the relationship between barn area, livestock type and nutrient units generated, see Table 4.1.11. To determine the total number of nutrient units per farm the following calculation was made for each parcel; multiplying the area of the barn by the nutrient unit per area ratio.

TABLE 4.1.10 – Nutrient Unit Conversion Factors for Poultry, Cattle and Swine and Other Types of Livestock

Livestock Category	***Description***	***NU Conversion Factor***	***Animal Conversion Factor***
Cattle	Beef cow	1 animal/NU	1
	Beef feeder	3 animals/NU	3
	Dairy	2 animals/NU	2
Swine	Average	8 animals/NU	8
Sheep	Average	12 animals/NU	12
Other	Horse	1 animal/NU	1
	Goat	8 animals/NU	8

Source: Technical Bulletin: Managed Lands and Livestock Density, Table 2 *(MOECC, 2009b)*

TABLE 4.1.11 – Barn/Nutrient Unit Relationship

Livestock Type	***Nutrient Units per Barn Area [m²/NU]***	***Nutrient Units per Barn Area [ft²/NU]***
Dairy	11	120
Beef	9	100
Swine	7	70
Horse	26	275
Sheep	14	150
Goat	19	200
Chickens	25	267
Turkeys	24	260
Fur	223	2400
Mixed	13	140

Source: Technical Bulletin: Managed Lands and Livestock Density, Table 1 (MOECC, 2009b)

Nutrient Units Estimate for Agricultural Parcels without Barns

For pastures located within agricultural parcels located within vulnerable areas that do not contain a barn, it is assumed these are used as permanent pastures.

The percentage of each agricultural parcel used as livestock pastures was estimated using 2006 aerial photography. The number of nutrient units was estimated using the area of the parcel, multiplied by the percentage used as livestock pastures in order to derive the total nutrient units per parcel. For each hectare, a nutrient unit count of 1.5 NU/hectare was assumed. (OMAFRA, 2000).

Calculation of Livestock Density

For each vulnerable area (SGRA and HVA within each municipality, WHPA-A, WHPA-B, WHPA-C, WHPA-D, IPZ-1 and IPZ-2), the nutrient units within the vulnerable area were estimated by summing all nutrient units for each parcel weighted with the portion of each parcel that is located within the vulnerable area. The total nutrient unit value within each vulnerable area was then divided by the total area of agricultural managed lands in acres within that vulnerable area. Livestock density is given as nutrient units per acre of agricultural managed land.

For WHPAs, IPZs, and HVAs, livestock density was computed for all areas that have a vulnerability score of six or higher. For WHPAs, the nutrient unit per acre values were calculated for each zone and vulnerability score. If values landed in the same category for two or more contiguous areas within a zone, they were merged. For IPZs, one average value was computed for each zone within vulnerable area onshore, regardless of any other borders, such as municipalities and source protection areas. For HVAs, the average value was computed separately for each municipality.

Calculations of livestock density used to determine water quality risks in HVAs remain valid with the removal of SGRA scores given the fact that the same threshold vulnerability of six or more was used for both areas.

Input Data for Livestock Density

- MPAC parcel fabric (improved by DWSP using SWOOP imagery and windshield survey)
- WHPA delineation
- IPZ delineation
- HVA delineation
- SGRA delineation

Knowledge Limitations and Data Gaps for Managed Lands and Livestock Density

The property code and farm operation code values used to identify a candidate parcel is a single descriptor assigned by MPAC during the generation of the tax assessment record. It does not necessarily represent the current land use activities on each property.

None of the data used as input for the analysis was verified in the field. A quantitative estimate of data accuracy is not known; therefore, the results should be considered approximate. The input data layers used to identify the non-managed land areas (wetlands, water bodies, wooded areas) have spatial and content accuracies of varied and unknown degrees. The provincial data are intended to represent a 1:10,000 scale of hardcopy mapping.

The data layers were acquired from Land Information Ontario and represent the best available data for their thematic content at the time of analysis.

The values of nutrient unit per square metre of livestock type were generated by the Ontario Ministry of Agriculture, Food and Rural Affairs. The values are meant to approximate the maximum potential nutrient unit production for the size of the livestock barn structure. The livestock nutrient unit calculations were not field verified and; therefore, the results should be considered approximate.

The estimation of barn size was also approximate, as air photo interpretation cannot decipher between areas of the barn that house livestock and areas that do not. Also, the ability to determine whether the barn had one storey or two storeys was impossible through air photo interpretation and all barns were assumed to be single storey. Interpretation of the imagery was done to the best of the interpreter’s ability.

Verification of the livestock type and size of actual livestock housing area is suggested for more accurate results.

4.1.4.3 Percentage of Impervious Surfaces for Vulnerable Areas

The Technical Rules define the total impervious surface area as the surface area of all highways and other impervious land surfaces used for vehicular traffic and parking, as well as all pedestrian paths (Definitions in Technical Rules, August 2009).

The percentage of impervious surface was calculated for one square kilometre grid cells under the guidance provided by section 16(11) of the amended Technical Rules (August 2009). The SWOOP one km tile grid was used.

To estimate the impervious surface area, the land cover classification data from the Southern Ontario Interim Landcover (SIL) was used. This continuous grid data has 1,000 x 1,000 metre cells and contains impervious surfaces as well as roads and highway transportation routes. Pedestrian paths and parking areas where road salt is probably applied regularly are not distinguished from other impervious surfaces such as roofs. For the purpose of estimating the “total impervious surface area” as defined above, all impervious land surfaces were assumed as areas with the potential for road salt application, weighing the size of a typical house against the length of driveways, pedestrian paths and parking spaces on each property. Table 4.1.12 provides a list of the input data used in evaluating impervious surfaces.

TABLE 4.1.12 – Input Data for Impervious Surfaces in Vulnerable Areas

Data Input	*Description*	*Source*	*Purpose*
Areas with potential for road salt application (vectorized raster)	The Southern Ontario Interim Landcover (SIL) is a composite of the best available datasets depicting land classes that have been merged to formulate an updated seamless land cover for southern Ontario (MNRF Frequently Asked Questions)	Ontario Ministry of Natural Resources and Forestry (MNRF)	Continuous 1,000 x 1,000 metre cells that represent surface areas with build-up areas, transportation, agricultural, and other rural land uses
1 km x 1 km	For the full source protection region, a one km grid that corresponded to the one km SWOOP 2006 tiles was used	Own data	Impervious Surfaces
Vulnerable areas (WHPA, IPZ , HVA, SGRA)	Wellhead Protection Area, Intake Protection Zone, Highly Vulnerable Aquifer, and Significant Groundwater Recharge Area polygons	Own data	Boundary of reporting unit

The percentage was computed by assigning a value of one to all cells that are roads or impervious areas, adding the area in each grid cell and dividing it by the cell size. The percentage value was classified into four intervals, as defined in the provincial tables of drinking water threats:

1	0 % – <1%
2	1% – <8%
3	8% – < 80%
4	>= 80%

As per amendments to the 2021 Technical Rules, the option to change impervious surface area calculations where salt handling and storage activities could be considered a significant risk at 30% for Wellhead Protection Areas with a vulnerability score of 10, 6% for Intake Protection Zones (IPZ) with a score of 10 and 8% for IPZ with a score of 9 or 10. Salt application and storage threat policies in the amendment Source Protection Plan were assessed based on these changes to impervious surface area calculations. Furthermore, this change to the Technical Rules permits the calculation of percent impervious surface area in a vulnerable area as a whole, or in a sub-area within the vulnerable area, where the road salt is applied.

4.1.4.4 Implications of Managed Lands, Livestock Density and Impervious Surface Percentage for Risk Level Analysis

The risk rating of some activities takes into account the percentage of managed land, the livestock density and the percentage of impervious surfaces within each farm unit.

The Table of Drinking Water Threats considers the intensity of farm operations for risk rating. The assessment level is either related to the full vulnerable area, especially if the risk accumulates, or to the specific farm. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard is considered on the basis of the livestock density on a farm unit. The percentage of managed lands and livestock density on a vulnerable area basis is considered for: the application of agricultural source material to land; the application of non-agricultural source material to land; and the application of commercial fertilizer.

The percentage of impervious surfaces on a vulnerable area basis is considered in the risk rating for the application of road salt.

4.1.5 Drinking Water Quality Threats: Threats-Based Approach

4.1.5.1 Legal Requirements for Assessing Drinking Water Quality Threats

The *Clean Water Act, 2006* (O.Reg. 287/07 s. 13) provides a list of information that is to be included in the Assessment Report. As described in previous sections, areas were identified where activities may be considered drinking water threats (Section 4.1.2). For these vulnerable areas, the vulnerability was scored (Section 4.1.3) and managed lands as well as livestock density were estimated (Section 4.1.4). The following section of text describes how the Technical Rules determine the threat level of activities and conditions.

According to subsection 13 (1) (6), the assessment report is to include:

> "For each vulnerable area identified under clause 15 (2) (d) or (e) of the Act,
>
> i. the number of locations at which a person is engaging in an activity listed under subclause 15(2)(g)(i) of the Act that is or would be a significant drinking water threat, and
>
> ii. the number of locations at which a condition listed under subclause 15(2)(g)(ii) of the Act is a significant drinking water threat." (O.Reg 287/07)

It is specified further in the Technical Rule 9(1), which requires:

> e) "the number of locations at which an activity that is a significant drinking water threat is being engaged in, and
>
> f) the number of locations at which a condition resulting from a past activity is a significant drinking water threat." (Technical Rules)

Direction provided by the MECP for interpreting these rules advised that the word "is" in subclause i or ii (above) should be interpreted to mean where an activity is currently known to occur. The wording "would be" (see above) should be interpreted to refer to a situation where infrastructure is in place to allow an activity to occur. In some cases, these are or would be threats were inferred, not based on site specific information collected from a property survey, and based only on a review of available records, land use assessment data, aerial photographs, and information collected from windshield surveys.

Further, the Technical Rules define how to identify an activity, either from those prescribed by the province in the Table of Drinking Water Threats (Part XI.2, Technical Rule 118.1) or as new activity (Part XI.2, Technical Rule 119-125). For every activity that is prescribed by the province, the Table of Drinking Water Threats specifies many circumstances and assigns a threat rating to each of those circumstances dependent on the vulnerable area and its vulnerability score.

The Technical Rules Part XI.3 defines when conditions that result from historic land uses are considered a drinking water threat and shall be listed (see section 4.1.5.6).

4.1.5.2 List of Activities that May Pose Drinking Water Threats

The *Clean Water Act, 2006* defines activities and land uses that can potentially threaten drinking water sources. These are identified in O.Reg. 287/07, s. 1.1(1) as shown in Table 4.1.13 below, and are referred to as Prescribed Drinking Water Threats. The Source Protection Committee can identify further activities specific to this Source Protection Region that are not part of the prescribed list of threats and submit them to MECP for approval.

Based on such a request, MECP added two activities as local threats in this Source Protection Region related to the storage and handling of Tritium, communicated in letter dated January 26, 2011 to the SPC (see Table 4.1.14). Under the events-based approach, these activities were evaluated and found not to be a significant drinking water threat. No further threats have been identified by the Saugeen, Grey Sauble, and Northern Bruce Peninsula Source Protection Committee.

TABLE 4.1.13 – List of Prescribed Drinking Water Threats in Ontario Regulation 287/07, Section 1.1(1)

ID	Legal Name	Short Name*
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	Waste disposal site
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats, or disposes of sewage.	Sewage systems - Collection, storage, transmittance, treatment, or disposal
3	The application of agricultural source material to land.	Agricultural source material - Application to land
4	The storage of agricultural source material.	Agricultural source material - Storage
5	The management of agricultural source material. **	Management Of Agricultural Source Material - Aquaculture
6	The application of non-agricultural source material to land.	Non-agricultural source material - Application to land
7	The handling and storage of non-agricultural source material.	Non-agricultural source material - Handling and storage
8	The application of commercial fertilizer to land.	Commercial fertilizer - Application to land
9	The handling and storage of commercial fertilizer.	Commercial fertilizer - Handling and storage
10	The application of pesticide to land.	Pesticide - Application to land
11	The handling and storage of pesticide.	Pesticide - Handling and storage
12	The application of road salt.	Road salt – Application
13	The handling and storage of road salt.	Road salt - Handling and storage
14	The storage of snow.	Snow – Storage
15	The handling and storage of fuel.	Fuel - Handling and storage
16	The handling and storage of a dense non-aqueous phase liquid.	Dense non-aqueous phase liquid - Handling and storage

ID	Legal Name	Short Name*
17	The handling and storage of an organic solvent.	Organic solvent - Handling and storage
18	The management of runoff that contains chemicals used in the de-icing of aircraft.	De-icing chemicals - Runoff from airports
19	An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.	Water takings without returning the water to the same water body
20	An activity that reduces the recharge of an aquifer.	An activity that reduces the recharge of an aquifer
21	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.	Pastures or other farm-animal yards - Livestock grazing
22	The establishment and operation of a liquid hydrocarbon pipeline	Liquid hydrocarbon pipeline

* *The short name is used in drinking water threat tables for all drinking water systems.*
** Prescribed Activity No. 5 (“The management of agricultural source material”) is only associated with the threat subcategory of aquaculture, which is not a significant threat occurring in any vulnerable area of this assessment report.

TABLE 4.1.14 – List of Local Drinking Water Threats as requested by the Source Protection Committee and approved by MECP

Legal Name	Circumstances
The storage and handling of Tritium	• The above grade handling of tritium in tanks and facilities that are not required to report to the NPRI • A spill of the tritium may result in the presence of tritium in groundwater or surface water
The storage and handling of Tritium	• The above grade handling of tritium in tanks and facilities that are required to report to the NPRI • A spill of the tritium may result in the presence of tritium in groundwater or surface water

* *The National Pollutant Release Inventory (NPRI) is Canada's legislated, publicly accessible inventory of pollutant releases (to air, water and land), disposals and transfers for recycling.*

4.1.5.3 Risk Scoring within the Threats-Based Approach

Risk Rating and Risk Score

Within the threat-based approach, a risk rating is attributed to each activity or condition that may pose a drinking water threat. The risk rating has four categories: none, low, moderate, and significant. To determine this risk level, a risk score is first calculated for each activity that takes into account the vulnerability of the water source in the vulnerable area and the hazard rating of a specific activity using the following formula:

RISK SCORE = AREA VULNERABILITY SCORE x HAZARD RATING

The rules for hazard rating differ between (existing or future) activities and conditions that result from historic land uses.

It is pointed out again that hazard and risk rating is built into the Tables of Drinking Water Threats and the circumstances therein which provide a vulnerability score that is high enough for an activity or a circumstance to be deemed a threat.

Hazard Rating for Activities

To determine the risk level of existing or future activities, specific circumstances are specified for each activity. Threats are classified into three groups: chemicals, pathogens and dense non-aqueous phase liquids (DNAPLs). For all prescribed activities, the Ministry of the Environment Conservation and Parks provides Tables of Drinking Water Threats (2021) in which a hazard rating is assigned for a list of circumstances, with differences in hazard ratings.

For chemical threats, the table lists details such as the substance, the quantity of this substance, the vulnerable area, and the vulnerability score of the vulnerable area. Finally, the hazard rating is defined and the risk rating is listed for each vulnerable area and vulnerability score. Chemical threats can exist in any vulnerable area, but the risk rating decreases with lower vulnerability scores.

DNAPL threats are a sub-category of chemical threats. Due to their adverse transport behaviour in groundwater aquifers as well as their high toxicity and persistence, the risk rating for these chemicals is significant at any quantity if the vulnerability score is at least four and the activity is located in a WHPA-A, B or C. In other areas, risk rating is the same as for chemical threats.

Pathogen threat ratings take a similar approach; however, the circumstances do not specify minimum storage or application quantities for pathogen threats. To account for relatively short survival times of pathogens, the risk rating is none if the time-of-travel from the activity to the intake or well exceeds two years. Thus, pathogen threats can only exist in WHPAs A and B and when surface water can influence the intake in IPZs 1, 2, 3 and in WHPAs E and F).

Hazard Rating for Conditions that Result from Historic Land Uses

The Source Protection Committee may also identify conditions that constitute a risk to drinking water sources. Conditions include contaminated lands that have either been abandoned or are still in use, sediments, groundwater, surface water, or other media that pose a threat to drinking water quality. The Source Protection Committee has not identified any high-risk conditions within highly vulnerable areas.

As per Technical Rule 139, the hazard rating of a condition from historic land use is:

- Ten (10) if there is evidence that the situation causes contamination outside of the property
- Ten (10) if the condition is located on a property where a well, intake or monitoring well exists or is planned and included in the Terms of Reference
- Six (6) in any other case.

4.1.5.4 Inventory of Activities that Pose Drinking Water Threats

As result of the low vulnerability scores of all Great Lakes IPZs, none of these include activities that score high enough to rate significant in this SPR. Significant threats identified in this study, therefore all refer to groundwater supply systems.

To identify significant threats to a drinking water supply in each vulnerable area, the following procedure was followed (CRA, 2009):

- Activities prescribed in Ontario Regulation 287/07, Section 1.1(1) were listed (Table 4.1.5).
- For each property, the land use was defined using the Municipal Property Assessment Corporation (MPAC) property codes.
- Each property in a WHPA was associated with a North American Industrial Classification System (NAICS) code. This analysis started with the MPAC property code, which was cross-checked with aerial photography and windshield surveys.
- Each NAICS code was associated with a list of prescribed threats. This was accomplished using the Ministry of the Environment and Climate Change's Threats Lookup Table (LUT v6.1), which associates threats to NAICS codes and vice versa.
- This threats inventory was stored in a central geospatial database and each record was linked to a location.

Each record in the threat inventory was spatially associated with vulnerability score areas and circumstances with a geospatial reference (such as parcel area, percent managed lands, etc.) in order to derive a list of activities that are coupled with their circumstances based on vulnerability scoring areas. Pathogens can only be a threat within the WHPA-A and WHPA-B; therefore, only scoring from six to ten in these zones is applicable. Chemical threats were assessed within the 25-year time-of-travel zone where the vulnerability score was higher than four, since a risk score greater than 40 is needed for a threat to be a significant, moderate or low drinking water threat. DNAPL activities are always considered significant drinking water threats within WHPA-A, WHPA-B and WHPA-C for groundwater systems. They also have the potential to represent a low to moderate drinking water threat within WHPA-D with a vulnerability score of six. DNAPL threats were reported separately from the other pathogen and chemical threats.

Given the level of information we have for each land use activity, the worst-case scenario was assumed for all other circumstances identified in the MECP's Table of Drinking Water Threats when assigning threat categories. Storage and handling quantities were also assumed (based on the worst-case scenario), as was the type of storage, such as above or below ground surface. In some instances, volume and quantity values were reported in available databases and the appropriate circumstance was applied.

Threat 2 as per O.Reg 287/07 s. 1(1) is the establishment, operation or maintenance of a system that collects, stores, transmits, treats, or disposes of sewage. This activity is further categorized into several sub categories, each of which is associated with separate quantity circumstances; septic system holding tank, storage of sewage (e.g. treatment plant tanks), industrial effluent discharges, sanitary sewers and related pipes, septic systems, sewage treatment plant bypass discharges to surface water, sewage treatment plant effluent discharges (including lagoons), combined sewer discharge from stormwater outlets to surface water, and the discharge of untreated stormwater from a stormwater retention pond.

Properties with private septic systems count as a pathogen threat if located within WHPA A or WHPA B and as a chemical threat if the vulnerability score is 10. If private properties are connected to sanitary sewer lines, then the connecting line from the house to the municipal sewer line also counts as a potential threat in these areas. For chemical threats, the quantity is assumed to be far below the significance threshold.

For residential properties, the potential for heating-related fuel storage was assumed. Also, the sub category Waste Disposal Site - Storage of wastes described under the definition of hazardous waste and the prescribed activity the handling and storage of a dense non-aqueous phase liquid were left as is since both are independent of the quantity of the material. Among others, this waste storage sub category deals with chemicals such as cadmium, lead, mercury, and selenium, which are often used in batteries. It also covers herbicides such as 2,4-Dichlorophenoxyacetic acid (2,4-D) and Trichlorophenoxyacetic acid-2,4,5, the disposal of which is not regulated elsewhere.

DNAPLs (dense non-aqueous phase liquids) are heavier than water and do not dissolve or mix with it. As a result, DNAPLs can quickly enter groundwater aquifers, especially along transport pathways. They form persistent lenses at the bottom of an aquifer and are difficult to monitor or remediate. Many DNAPLs are highly toxic and carcinogenic, such as Dioxane-1,4 and other polycyclic aromatic hydrocarbons (PAHs), tetrachloroethylene (PCE), trichloroethylene or other chemicals that degrade to it, and vinyl chloride or other chemicals that degrade to vinyl chloride. DNAPLs are used as coolants, as organic solvents for degreasing and dry cleaning and as paint strippers and spot removers. These widely used and highly hazardous chemicals may be not only be used in industrial facilities but they may be used and disposed of on every residential property.

The circumstances and assumptions, under which an activity in the list of threats is significant, moderate or low, were recorded in the database for future reference. Site visits may be warranted in areas where the potential for a significant drinking water threat was identified in order to verify the circumstance that triggers the activity as significant (CRA, 2009).

Further to identifying areas within vulnerable areas as significant, moderate or low drinking water quality threats, Technical Rule 9 of the Technical Rules and Section 13(1)(6) of O. Reg. 287/07 requires that the number of locations where an activity has the potential to be a significant drinking water threat be inventoried and reported.

These tables are given for each drinking water system and eventually separated by vulnerable area.

Definition of land uses

- Residential - includes single and multi-family residential units, seasonal dwellings, mobile homes, and residences with commercial/industrial use buildings.
- Farm Residential - includes parcels used for agricultural purposes with residential occupation [i.e., house(s)]. Agricultural land use class includes both cash crop and livestock operations.
- Agricultural - includes parcels used strictly for agricultural purposes with no residential occupation (i.e., no house). Agricultural land use class includes both cash crop and livestock operations.
- Commercial - includes all land uses associated with retail or commercial operations, including parking areas, shopping centres, offices, banks, restaurants, gas stations, hotels, motels, lodges, resorts, and campgrounds.
- Industrial - includes all land uses associated with industrial operations, including manufacturing, warehousing and aggregate extraction.
- Institutional - includes schools, day care centres, retirement/nursing homes, hospitals, correction facilities, and places of worship.
- Recreational - includes sports complexes, community halls, amusement parks, golf courses, ski resorts, marinas, casinos, and other recreational facilities.
- Vacant Land - includes all vacant residential, commercial, and industrial lands, undeveloped properties, and park lands.
- Transportation Corridors - includes all roadways and undesignated parcels.
- Other - includes all municipal or other government related buildings and infrastructure, such as ambulance and police stations, fire halls, post offices, military buildings, and airports.

Textbox 1: From Municipal Property Assessment Corporation (MPAC) data of land uses

All groundwater systems that were assessed by Conestoga-Rovers followed the methodology outlined here. For a detailed description, please see the original studies cited for each drinking water system.

For the Revised Assessment Report, threats verification work was done by DWSP staff. Windshield surveys were done of all properties within the WHPA-A, B and C to determine whether waste, DNAPL or fuel storage threats were warranted.

A DNAPL storage and a DNAPL handling threat were given to those properties whose land use suggested there might by DNAPLs on the premises; hardware stores, antiques dealers and woodshops, car dealers or garages, restaurants, all municipal/ institutional properties such as hospitals, churches and schools, and any residential properties that look like they might repair cars or do wood working or furniture restoration. All the remaining properties in the WHPA-A, B or C were flagged with “Possible DNAPL threat”.

All properties with a vulnerability score of 10 where fuel could be stored were assumed to have fuel storage threats, unless the windshield survey determined otherwise. DWSP staff also sent out fuel surveys to all properties that could not be eliminated as fuel threats from the windshield surveys. The response rate was about 36%. All remaining properties received a fuel storage threat.

All waste threats were removed as no properties were found to warrant one.

The local threat storage and handling of Tritiated Deuterium (Tritium), as described in the Director's opinion regarding the addition of the operation of the Nuclear Generating Station where nuclear reactions are being moderated by deuterium (Heavy Water) in any quantity (January 26, 2011), could result in low or moderate drinking water threats in WHPAs A-E and IPZs 1-3.

4.1.5.5 Confidence in List of Activities that Pose Significant Drinking Water Threats

Threats evaluation and the assignment of risk ratings are determined through Regulations and the Technical Rules. On a practical basis, the enumeration of threats is based on land use classification. Thus, a number of sources of uncertainty are applicable to the enumeration of threats, namely: assigning a NAICS land use code to each property; translating this NAICS code into an "is or would be" threat based on local infrastructure; and, determining the quantity of a hazardous material that poses this threat.

Land use identification is limited by the accuracy of information obtained from property owners, windshield surveys and the land use information of the MPAC database. A total of approximately 12,000 threats were evaluated within the Source Protection Region, usually with more than one potential prescribed drinking water threat associated with each property. Of all land use activities that resulted in the identification of moderate or significant threats, only 20% were confirmed by property owners (21% of all significant and 14% of the all moderate threats). Additionally, approximately 60% of all threats were identified based on the MPAC property code alone. The remaining Land Use Activities were derived from the EcoLog database, from both aerial photos and windshield surveys or from aerial photos alone.

Confidence levels for the threats enumeration are assumed high if threats are linked to sewers due to the quality and availability of the data. Land use classifications, and the derived threats, were also assigned "high certainty" if property owners were consulted and the activity was confirmed. For all other data sources used to identify the threat, confidence is determined to be moderate. In cases where the threat rating was based on MPAC codes in conjunction with aerial photography a low confidence level was assigned. In general, approximately half of all threats were given a low confidence rating.

Given the multiple sources of data used to enumerate threats and the confidence in those sources, the overall confidence for the enumeration of significant threats is considered to be low.

The threats verification windshield and fuel surveys increase the confidence in determining both land use and existing activities. This increases the confidence in the delineation of threats to a moderate.

4.1.5.6 Conditions from Historical Land Uses

Conditions are defined as drinking water threats in relation to water quality that result from past activities (in accordance with Part XI.). Drinking Water Threats Analysis, Part I.2, 2(4) requires that such conditions be listed. Further, Part I.2, 8(5) requires the identification of "….those areas where conditions that result from past activities….are significant, moderate or low drinking water threats in accordance with Part XI.5" (Technical Rules).

The Source Protection Committee must identify any condition that results from historic land uses of which it is aware. Conditions must be located within vulnerable areas: intake protection zones; wellhead protection areas; highly vulnerable areas; and, significant recharge areas. A risk score must be computed for these conditions based on the vulnerability score of the area and the hazard rating of the specific site, following the rules described in Section 4.1.5.3.

The objective of the Source Protection Plan is to reduce the risk level of the drinking water threats identified in this Assessment Report. For every significant threat, the *Clean Water Act* requires the SPC to develop policies that reduce the risk rating to a point where they are no longer significant. The SPC may also develop policies for moderate and low drinking water threats.

4.1.5.6.1 Conditions Related to Groundwater Systems

Types of Contaminants and Concentration Limits

The Technical Rules: Assessment Report identifies the types of situations when contamination from historic land uses may be considered a condition. Conditions that result from a historic land uses and include the following situations within a vulnerable area related to groundwater (highly vulnerable aquifers, and wellhead protection areas):

1. the presence of any single mass of *non-aqueous phase liquid*,
2. the presence of a contaminant in groundwater if the contaminant
    - is listed in Table 2 of the *Soil, Ground Water and Sediment Standards* and
    - is present at a concentration that *exceeds the potable groundwater standard* set out for the contaminant in that Table and
3. the presence of a contaminant in sediment if the contaminant
    - is listed in Table 1 of the *Soil, Ground Water and Sediment Standards* and
    - is present at a *concentration that exceeds the sediment standard* set out for the contaminant in that Table.

Information Used to Identify Conditions of Historical Land Uses

To identify conditions that may pose drinking water threats, existing information was screened to determine those locations where contaminants are present and, if applicable, their concentration exceeds the relevant standards. Three sources of information were used for the preliminary identification of locations of concern; information provided by the Ministry of the Environment and Climate Change, municipal technical reports and studies, and observations from stakeholders, consultants and the public.

The Ecolog Environmental Risk Information Services (ERIS) database reports were evaluated for existing databases on spills and contamination. Ecolog records from the Occurrence Reporting Information System (1988-2002) were also reviewed to identify reported spills and occurrences within each WHPA that have the potential to contaminant groundwater.

Observations were made through the use of windshield surveys and/or property visits in the year 2006 to confirm the existing and past land uses stated within the 2008 Municipal Property Assessment Corporation (MPAC) parcel information. Air photo interpretation was also used. In general, the locations of historic gasoline stations, automotive repair shops, abandoned pits, hardware stores, dry cleaners, air strips, and mills were identified within nine of the WHPAs in this study. Furthermore, concerns from members of the Source Protection Committee, being local experts, were incorporated.

Summary of Studies Done and Preliminary Findings

As identified in the CRA 2009 report, CRA is unaware of any existing groundwater conditions resulting from these past activities or spills that have caused the deterioration of drinking water in any of the systems listed in the Terms of Reference.
Ecolog records from the Occurrence Reporting Information System (1988-2002) were examined for spills or contaminations. Based on the analysis of this data, no contaminated sites were identified in the Grey Sauble Source Protection Area that meets the tests in Technical Rule 126, and therefore, become conditions that can be identified as drinking water threats.

4.1.5.6.2 Conditions Related to Surface Water Intakes

Types of Contaminants and Concentration Limits

The Technical Rules: Assessment Report identifies the types of situations when contamination from historic land uses may be considered a condition. Conditions that result from historic land uses include the following situations within a vulnerable area related to surface water (intake protection zone):

1. the presence of any single mass of more than 100 litres of one or more *dense non-aqueous phase liquids* in surface water,
2. the presence of a contaminant in surface soil in a surface water intake protection zone if the contaminant
   - is listed in Table 4 of the *Soil, Ground Water and Sediment Standards* and
   - is present at a concentration that exceeds the *surface soil standard for industrial/ commercial/community property use* set out for the contaminant in that Table and
3. the presence of a contaminant in sediment if the contaminant
   - is listed in Table 1 of the *Soil, Ground Water and Sediment Standards* and
   - is present at a concentration that exceeds the *sediment standard* set out for the contaminant in that Table.

Summary of Studies Done and Preliminary Findings

For the identification and risk rating of conditions, a preliminary review of data made available by the Ministry of the Environment and Climate Change and other sources was undertaken, as part of the Threats and Risk Assessment. Stantec Consulting Limited was the primary consultant for this study (Stantec 2009 - Phase 2 Report). For this assessment report, only the preliminary review was finalized. Risk rating could not be performed because no data were available to provide evidence whether the situation causes contamination outside of the property or not.

Environment Canada (EC) report Sediment Quality in Canadian Lake Huron Tributaries: A Screening – Level Survey (Burniston *et al.*, 2006) detailed sediment data sampled at tributaries discharging into the Kincardine, Southampton (Primary Intake), East Linton, Meaford, and Thornbury WTP vulnerable areas. Tributaries discharging into the Lion's Head, R.H. Neath, and Wiarton WTP vulnerable areas were not sampled as part of this report. Additional sediment data for these areas were unavailable.

Following Technical Rule 126 (5), the sample data from the tributaries discharging into the WTP vulnerable areas were compared to Table 1 of the Soil, Ground Water and Sediment Standards for Use under Part XV.1 of the *Environmental Protection Act, 1999*. During this screening, the following parameters exceeded sediment standards in one or more location: Chromium (total), Nickel and Copper.

In attempts to further identify the presence of conditions within the IPZs, the following sources were reviewed:

- Provincial Brownfield Sites Registry (MOE, 2009c); and
- The Federal Contaminated Inventory (TBCS, 2009).

Based on this analysis of this data, no contaminated sites were identified in the Grey Sauble Source Protection Area in these databases. No contamination meets the tests in Technical Rule 126, and therefore, become conditions that can be identified as drinking water threats.

4.1.5.7 Identifying Specific Circumstances for Drinking Water Threats

This section outlines the procedure to identify whether or not a land use activity on a property poses a risk to drinking water sources and is thus considered a drinking water threat under the threats-based approach. This is done using a risk rating of that activity, taking into account the type of the vulnerable area, the vulnerability score at the location where the activity is or would be carried out, and specific circumstances of the activity. Note that activities can also be associated with significant risk levels under the issues-based approach, Section 4.1.6. and under the events-based approach, Section 4.1.7. See Section 4.1.1 for a summary.

Activities, conditions, vulnerable area type, and vulnerability scores are combined in the Table of Drinking Water Threats (2021) by the Ministry of the Environment, Conservation and Parks. This table lists activities and circumstances, and sets out hazard scores and risk levels. It is important for all property owners to identify which activities that are or could be carried out on their property can pose threats to drinking water sources. To determine where an activity is a significant, moderate, or low threat, and the circumstances that make them significant, moderate, or low, requires a person to look at the vulnerability scores for an area, and then look through the Table of Drinking Water Threats to determine whether an activity or a circumstance is significant, moderate, or low in any given area.

The MECP also provides a tool to support property owners and practitioners, the Tables of Drinking Water Threats and online Threats Tool. Tables of Drinking Water Threats for Pathogens and Chemicals lists all activities and circumstances for a specific vulnerable area, vulnerability score, type of contaminant (Chemical/DNAPL/Pathogen), and threat level (low/moderate/significant). It also specifies the type of contaminant (Chemical/DNAPL/Pathogen), the vulnerable area, the vulnerability score, and the significance level. For example, one table pinpoints all activities or circumstances that are or would be significant chemical threats in a WHPA-B where the vulnerability score at one location is eight.

. This Table also contains the circumstances for: highly vulnerable aquifers (Table 4.1.15); wellhead protection areas (Table 4.1.5.16); and surface water bodies (intake protection zones and WHPA-Es, Table 4.1.5.17). Furthermore, the Threats Tool is separated into two categories: chemical\and pathogen threats, and are also separated by risk level (low, moderate, significant).

Procedure to Identify Activities and Circumstances that are or would be Significant at a Location

The Threats Tool and the vulnerability maps can be used in combination with the Ministry of the Environment, Conservation and Park'sTables of Drinking Water Threats to determine the types of activities that would be deemed a significant, moderate and low drinking water threat in each area.

A four-step procedure is used to identify specific circumstances under which an activity is considered a drinking water threat:

1. Identify the vulnerable zone that the property is in using either the municipal maps M1 (HVA, SGRA) or the maps for each drinking water system (for example WHPA-A or C, IPZ-1 or 2).
2. Identify the vulnerability score of that location using the vulnerability maps.
3. Determine the name of the circumstance you need, using the reference tables in this section.
4. Download the Tables of Drinking Water Threats and online Threats Tool posted by the MECP (see below). The table lists all activities and circumstances of the specified threat rating (significant, moderate, low) for a particular vulnerable area with a certain vulnerability score. This table will exactly define under which circumstances a risk is designated as a low, moderate or significant threat.

https://www.ontario.ca/page/tables-drinking-water-threats

TABLE 4.1.15 – Reference Tables of Drinking Water Threats for Pathogens and Chemicals for areas within Highly Vulnerable Aquifers (HVA)

Highly Vulnerable Aquifers					
Threat	*Zone*	*Vulnerability Score*	*Threat Level Possible*		
			Significant	*Moderate*	*Low*
Chemical and DNAPL	**HVA**	6			
		<6			
Pathogen		2 – 6			

TABLE 4.1.16 – Reference Tables of Drinking Water Threats for Pathogens and Chemicals for areas within the Capture Zones of Wells (WHPA A-D)

Wellhead Protection Area (WHPA) A-D					
Threat	*Zone*	*Vulnerability Score*	*Threat Level Possible*		
			Significant	*Moderate*	*Low*
Chemical	**WHPA A, B, C, C1**	10			
		8			
		6			
		<6			
		<4.2			
Pathogen	**WHPA-A, B**	10			
		8			
		6			
	WHPA-C, C1, D	2 – 8			
DNAPL	**WHPA A, B, C, C1**	4 – 10			
	WHPA-D	6			
		<6			

TABLE 4.1.17 – Reference Tables of Drinking Water Threats for Pathogens and Chemicals for areas within the Intake Protection Zones (IPZ) and along Surface Water Bodies that Influence Wells (WHPA-E)

Intake Protection Zones (IPZ) and WHPA-E					
Threat	*Zone*	*Vulnerability Score*	*Threat Level Possible*		
			Significant	*Moderate*	*Low*
Chemical and DNAPL	**IPZ-1, IPZ-2, IPZ-3, WHPA-E**	8 – 10			
		6 – 7.2			
		4.2 – 5.6			

Pathogen	**IPZ-1, IPZ-2, IPZ-3, WHPA-E**	8 – 10			
		6 – 7.2			
		4.2-5.6			

4.1.6 Drinking Water Quality and the Issues-Based Approach

A Drinking Water Quality Issue is defined as the deterioration of water quality of a drinking water source. This deterioration of water quality must be measured in raw water directly at a drinking water source or at a monitoring well related to the system. An example of an issue would be the contamination of an aquifer with gasoline that threatens to exceed drinking water standards. Another example could be an unusually high occurrence of anthropogenic bacteria (human or animal) or nitrates within a lake that is a municipal drinking water source. If such an issue was identified at a well or an intake, activities that cause the water quality deterioration must be identified. The Source Protection Committee must then consider policies to mitigate such an issue.

Technical Rule 114 states that the Source Protection Committee can define an issue at an intake or well that is listed in the Terms of Reference (Technical Rule 114(1) and (2)) and at other drinking water systems that are *not* listed in the Terms of Reference (Technical Rule 114(3)).

On January 23, 2009, the Source Protection Committee passed a motion to approve thresholds for microbiological, chemical and radionuclide parameters as well as for aesthetic objectives and operational guidelines (memo “Development of Water Quality Thresholds for Issues Evaluation”, also listed in Appendix I):

- For chemical and radionuclide parameters, 50% of the Maximum Acceptable Concentration was adopted, as defined in Table 2 and 3 of Ontario Regulation 169/03.
- For aesthetic objectives and operational guidelines, Table 4 Ontario Regulation 169/03 was adopted.
- For microbial parameters, a standard of 0 cfu/100 mL total coliforms and *E. coli* was adopted. It was acknowledged that these thresholds are neither realistic for GUDI wells nor for surface water intakes, so further investigation is needed for systems where these thresholds are flagged.

These thresholds were developed with input from municipal water treatment plant operators, and correspond to thresholds which require an increase in the frequency of monitoring under the *Safe Drinking Water Act, 2002* and associated regulations. If a measurement of raw water at a drinking water intake or well exceeds, or threatens to exceed, one of these standards, further investigation is required to confirm the deterioration of water quality. As part of these analyses, existing data are compiled and reviewed to identify any exceedances or trends in water quality data.

In the case of a municipal drinking water system, operators and operation managers are contacted and a recommendation to the SPC is expected. After notification, the SPC can formally adopt a drinking water quality issue, taking into account the threshold values identified by the SPC (Jan 23, 2009, Technical Report 7c) and the recommendations of the operator and other local knowledge.

If such an issue was defined accordingly and it "*is the result of, or partially the result of, anthropogenic causes*", then Technical Rule 115 lists the information that must be compiled:

"(1) The parameter or pathogen concerned.

(2) The surface water intake, well or monitoring well at which the presence of the parameter or pathogen has occurred.

(3) The area within a vulnerable area where activities, conditions that result from past activities, and naturally occurring conditions may contribute to the parameter or pathogen and this area shall be identified as the "issue contributing area", and;

(4) The identification of the drinking water threats listed….that contribute or may contribute to the parameter or pathogen of concern". (Technical Rules)

All activities that contribute to an issue identified under Technical Rule 114(1) or (2) are automatically considered significant drinking water threats.

If an issue was identified in the raw water of a *municipal drinking water system* (or any other system listed in the Terms of Reference), it is discussed in Section 4.2 - Risk Assessment by Municipality. In this source protection area, no issues related to municipal systems were declared.

For *non-municipal drinking water systems*, no issues have been identified under Rule 114(3). Public Health Units are undertaking risk assessments of all small drinking water systems, and through that process may identify possible issues for a future Assessment Report. If such issue is identified under Technical Rule 114(3) and it is at least partly anthropogenic, these activities will automatically be moderate drinking water threats.

4.1.7 Drinking Water Quality and the Events-Based Approach

If modelling of an extreme event shows that a contaminant could reach an intake, an area known as an IPZ-3 will be delineated, composed of the land area that drains into the surface water body, allowing contaminant to reach the intake (Technical Rule 68). The on land area must include 120 m setback from the high water mark along the shoreline, or the regulation limit, whichever is greater (Technical Rule 68(2)).

Once the IPZ-3 is delineated, an events-based area (EBA) can be determined for each intake. This area allows potential significant drinking water threats to be identified. Using modelling and other forms of analysis, any area that is determined could cause an exceedance of contaminant at the intake can be included. The identification of activities as significant drinking water threats is done under Technical Rule 130.

4.1.8 Uncertainty of Vulnerable Area Delineation and Vulnerability Scoring

Uncertainty related to the identification of significant groundwater recharge areas (SGRAs) is discussed in Chapter 3, Section 3.14.3. Uncertainty related to the delineation of highly vulnerable aquifers (HVAs) is fully related to data limitations of the Intrinsic Vulnerability Index (ISI), which is addressed in Section 4.1.2.1. This section discusses uncertainty related to wellhead protection areas of groundwater systems and to intake protection zones of surface water systems.

4.1.8.1 Uncertainty in the Assessment of Groundwater Systems

Vulnerability Uncertainty

The Technical Rules: Assessment Report (*Clean Water Act, 2006*) requires an assessment of uncertainty as part of the vulnerability assessment. The uncertainty assessment seeks to provide a qualitative summary of data and analyzes reliability as performed during the study. Uncertainty associated with a vulnerability assessment can be attributed to a number of factors including:

- Density of input data
- Quality and reliability of data
- Assumptions made when reducing or synthesizing data

The evaluation of uncertainty conducted as part of this study involves the following components:

- An evaluation of the uncertainty of the delineation of the WHPAs
- An evaluation of the uncertainty of the determination of aquifer vulnerability
- Assignment of an aggregate uncertainty rating for each water system

Uncertainty Related to the Location and Extent of Wellhead Protection Areas

WHPA delineation was originally completed for all systems through the use of a MODFLOW groundwater model as part of the Grey Bruce Groundwater Study (2003). The models were completed based on a number of simplifying assumptions that incorporate some level of uncertainty dependent on the nature, spatial distribution and density of available data. WHPAs were updated using new projected pumping rates for all systems where significant increases were projected. Existing models were updated by Schlumberger Water Services (formerly Waterloo Hydrogeologic Inc.) as part of 2008 studies completed by Conestoga-Rovers and Associates (2008) and Genivar (2010). A new WHPA, using the existing model, was developed for Tara Well No. 4, which did not have a WHPA delineated previously.

In all cases, groundwater models were calibrated to represent steady state conditions in the aquifer using static water levels from available water well records (with a normalized root-mean-square error for the calibration within the acceptable limits of less than 10% for numerical models). The model calibration results were compared to reported pumping tests at the wells and showed a reasonable fit to the observed groundwater conditions recorded in the tests. Stream flow data was also used for calibration. The calibration process found that the hydraulic conductivities of the geological units, simulated flow pattern within the bedrock aquifer, and modeled base flows are in agreement with site specific information.

Uncertainties within the model are associated with limitations in the availability of subsurface information and can be related to projected variability in the aquifer properties (e.g. hydraulic conductivity, porosity) or uncertainties with the conceptual model (e.g. groundwater-surface water interactions, location of flow boundaries, recharge rates, continuity in aquitards, direction of regional groundwater flow). To account for some of these uncertainties, hydrogeological parameters were adjusted and multiple particle-tracking simulations were run in order to develop a more robust WHPA. Based on known variations in hydraulic properties, this approach does not adequately address the issue of uncertainty as it is known that slight variations of aquifer properties (hydraulic conductivity, effective porosity, observed water levels, etc.) may impact the shape and orientation of the capture zones.

In WHPAs that have relatively low pumping rates, therefore small cones of depression, the shape of the WHPA is largely determined by regional groundwater flow. These tend to produce elongated, thin WHPAs in which more accurate observed water levels could cause dramatic changes in the orientation of the WHPA. Similarly, slight changes in effective porosity and hydraulic conductivity can dramatically alter the size of WHPAs for wells with higher pumping rates.

Although the calibration results were good for all models, the potential for dramatic changes in the shape and orientation of WHPAs due to slight variations in aquifer properties suggests that uncertainty should be considered high for the WHPA delineation.

Uncertainty of Vulnerability Assessment

Vulnerability assessment was completed using the Intrinsic Susceptibility Index (ISI) mapping developed by WHI (2003). The ISI calculation was based on an empirical formula provided by the Ministry of the Environment and Climate Change for completion of groundwater studies (MOECC, 2001). Detailed descriptions of the methodology and associated assumptions for these calculations are included in the Grey and Bruce County Groundwater Study (WHI, 2003).

The ISI mapping utilized existing well records within the Water Well Information System (WWIS). These records were screened to remove wells with poor locations based on location codes provided in the WWIS. ISI was calculated on a well–to-well basis and kriging methodology was used to interpolate between individual wells. The resultant mapping provided was a grid with 200 x 200 metre squares.

It is important to understand the limitations of the ISI mapping when assessing the uncertainty of the aquifer vulnerability mapping of a given WHPA. Although ISI mapping is a well-documented and accepted methodology in Ontario for assessing aquifer vulnerability, it does have a number of limitations including:

- ISI mapping is intended to be viewed and interpreted on a regional scale and is not intended to be interpreted on a property or site-specific scale.
- The primary source of data for calculating ISI is the WWIS, which is known to have several deficiencies in both the lack of records for existing wells and in the location of the existing records.
- ISI does not take into account hydrogeological properties of aquifers, which may make them more or less susceptible.
- ISI is interpolated between known data points and does not take into account geological features or boundaries that may be the cause of significant differences between the points.

With these limitations in mind, ISI is a useful tool in evaluating the overall susceptibility of a given aquifer at a regional scale. However, ISI should not be substituted for comprehensive site-specific investigation.

Based on these facts, the uncertainty of the aquifer vulnerability mapping can be considered low on a regional scale. However, on a WHPA scale, the ISI mapping can be highly sensitive to relatively few data points and should be considered highly uncertain as a result. Additionally, due to the interpolation methodology and the resultant coarse resolution of the ISI mapping, the uncertainty of the aquifer vulnerability mapping on a property scale must be considered high. Despite the inherent uncertainty associated with applying ISI at the WHPA and property scales, the ISI mapping is likely reasonable in areas where the geology, and thus ISI, is consistent and predictable. Alternatively, ISI is least reasonable in areas with highly variable geology and ISI values.

Uncertainty Ratings

The Technical Guidance outlines that each vulnerable area should be assigned an uncertainty of high or low to identify where information gaps exist. This process will assist in addressing data quality problems in future source water protection planning.

Table 4.1.18 summarizes the uncertainty assigned to the WHPAs in the Grey Sauble Source Protection Area.

TABLE 4.1.18 – Uncertainty Assessment and Results – Grey Sauble SPA

Uncertainty Type	***WHPAs***	***Steady-State***
WHPA Delineation	High	High
Aquifer Vulnerability Mapping (ISI)	High	High
Overall – Vulnerability Scores	High	High

Uncertainty for the WHPAs in the Grey Sauble Source Protection Area are summarized as follows:

- Due to the potential changes in the shape of the WHPAs based on slight variations of aquifer properties, the uncertainty of the WHPAs is high.
- Due to the reliability of the WWIS, the interpolation methodology and the coarse resolution of the ISI mapping, the uncertainty of the aquifer vulnerability mapping at the WHPA scale is high.

The uncertainty of the vulnerability scores for the WHPAs, which are developed from the WHPA delineation and the ISI mapping, can be considered high.

4.1.8.2 Uncertainty in the Assessment of Great Lakes Surface Water Systems

The Technical Rules have outlined five uncertainty factors to be considered in determining the uncertainty level for IPZ delineations and vulnerability scores. Not all of the five factors apply to both the delineation uncertainty and the vulnerability uncertainty prescribed to each IPZ; however each factor as it pertains to the IPZ uncertainty analysis is addressed in the appropriate section.

Data

The uncertainty relating to the data sources incorporates an analysis of; variability, quality, and relevance of the data. The Technical Rules prescribe an analysis of the distribution of the data as well; however distribution of the datasets is not relevant in delineation as delineation utilizes the most current available data.

The variability of data relates to the number of datasets reviewed for information. Multiple sources of data relating to the parameters used in vulnerability scoring and delineation produce a low level of uncertainty. For the delineation of the in-water IPZ using numerical modelling, multiple sources of data were not available for any of the systems. Therefore, a high level of uncertainty must be assigned to the variability of data.

The quality of data is related to the accuracy of the data assessed based upon the origins of the information. Federal and provincial data are assumed to have a high level of accuracy due to regulated quality control measures in place and therefore have an associated high level of confidence at the scale that was originally intended for their interpretation. Datasets that describe regulation limits and other legislative boundaries are assumed to have a high level of accuracy. Data sources that provide interpretations of the data are not considered to have an equal confidence level. For all surface water systems, data were gathered from provincial and municipal sources and by the Conservation Authorities. A high level of confidence in the quality of the data was established based on the assumption that adequate quality control programs are in place for these sources.

The relevance of the data relates to the applicability of the information to the study area. Site-specific and local information is assumed to represent the area well and therefore has an associated high level of confidence. Unavailable or non-site-specific data lowers the confidence and generally requires assumptions to be made. The majority of available datasets used in the delineation of all IPZs were relevant to the study area; however due to the availability of data, some alternative datasets were required to be used.

For the models of the Georgian Bay intakes, Acoustic Doppler Current Profiler (ADCP) data were not available and parameters were used from the calibrated Lake Huron model. It is important to note that the processes in the semi-enclosed bay of Owen Sound and Wiarton are quite different from the Lake Huron sites for which ADCP data were used. A low level of confidence has been established for the relevance of the data used in the in-water delineation.

Stream flow discharge data were obtained from Environment Canada. Velocities were not available for most rivers and tributaries. Side-slopes and cross-width measurements were needed to calculate the velocity and up-tributary extent of all watercourses. These data were obtained from 2006 Aerial Photography. In most cases, tributary cross-section data were limited to the information supplied in the bathymetry dataset. Much of the bathymetry data are not recent. For many locations this is not an issue, as the bathymetry has not changed significantly, however it may be an issue at some locations including river mouths and locations that are more dynamic. Due to the lack of any additional upstream bathymetry, it was assumed that upstream river cross-sections were the same as the river mouth. Catchment area extents were not available and were estimated using the Provincial DEM, watershed boundaries and the location of the developed area based on 2006 aerial photography.

Data on sediment load, especially during storm events, are not available. Also, measurement on water currents was taken under mild weather conditions, so that these data are only relevant for a limited range of weather conditions.

Storm sewer networks were provided for some systems; however the locations of outfalls were inferred. More detailed storm sewer network information would decrease the uncertainty related to data relevance. Tile drainage data provided by the province is generally regarded as incomplete and thus a high uncertainty was assigned. The problem of increased mixing due to negatively buoyant plumes also translates to discharges from storm sewers and runoff from drainage and other transport pathways.

Distribution of data as it pertains to the vulnerability uncertainty analysis relates to the time series available for a dataset. A greater distribution of data provides a lower level of uncertainty in the analysis.

Reasonable assumptions were made to determine the delineation of the in–water and onshore extent for all surface water systems located within the Great Lakes. If data were incomplete, then it was automatically high.

The uncertainty is high for all the datasets used.

Modelling

<u>Overview</u>

Modelling uncertainty relates to the ability of the model to accurately depict the flow processes in the hydrological system. The IPZ-2 has two components; in-water and onshore. Isolated methods were used to delineate each component. The model and employed methods were assessed for each component, and overall uncertainties were assigned. While separation of the modelling components is not identified in the Technical Rules, uncertainties have been assessed independently for the purpose of clarity as part of this report. In-water modelling determines the residual ToT and therefore the extents of the onshore delineations calculated for each Great Lakes system. The accuracy of the onshore delineations are dependent upon the confidence of the in-water modelling. Therefore despite the confidence in the onshore delineation, the confidence in the tributary extents is limited to the confidence in the in-water delineations.

The Delft3D hydrodynamic model was used to evaluate current velocities in the vicinity of all Great Lakes intakes in this region. The following data were obtained, analyzed, and used in the model calibration, processes evaluation, and model runs undertaken to delineate the in-water IPZ-2:

- Bathymetry;
- Water levels;
- Recorded and modelled wind data; and
- Measured currents and tributary flows.

The Lake Huron Operational Forecast System was used to define the boundary conditions for area modelled with the Delft3D modelling software.

On the Lake Huron shore, the Delft3D model was calibrated with measured current data from three ADCPs deployed by the MOECC in Lake Huron from May 16, 2003 to November 27, 2003.
In Georgian Bay, measured calibration data for the Delft3D model was not available, so parameters determined for the Lake Huron shore model was also used there.

<u>Particle Tracking and Area Delineation</u>
Reverse particle tracking with a 10-year return was used to delineate the in-water IPZ-2, and neutrally buoyant particles were introduced at the intake to provide a site-specific representation of the lake processes about the intake. There was a significant difference between the particle tracking results for surface and bottom released particles at this site. The most conservative results were used to delineate the IPZ-2.

Datasets employed in the model run were obtained from federal and provincial sources (i.e. Canadian Hydrographic Service (CHS), National Oceanic and Atmospheric Administration (NOAA), and Great Lakes Environmental Research Laboratory (GLERL)) and have an associated high level of confidence.

Forward particle tracking methods were used with the model runs to evaluate site specific processes and conditions that increase the risk of contamination at the intake. The forward particle tracking results include output for model runs extending beyond the 2-hour limit used for the IPZ-2 delineations. The identification and understanding of the processes that are impacting each site improves the level of confidence in the delineation.

Near-Shore Currents
Currents inshore of the surf zone are complex and are not well defined by existing numerical models. However, it is recognized that there is potential for currents in the surf zone to transport a contaminant in an offshore direction from the shoreline. This methodology was used to define the shore connection for the IPZ-2s and travel time isopleths. This methodology is assumed appropriate; however it presents a limitation in the model with an associated level of uncertainty.

If stream flow discharges are denser than the receiving water body, then negatively buoyant (hyperpycnal) river plumes result. Especially in conditions of the Great Lakes, these are common because the salinity difference between river discharge and the receiving water body is very small. For example during spring, when lake and river waters are near the temperature of maximum fresh water density (4°C), then relatively warm river discharge is often denser than the colder receiving lake water. Groundwater discharge may also create river water that is colder than lake water, especially when lakeshores are shallow. Furthermore, density of discharging water increases drastically with sediment load, especially after erosive precipitation events (Churchill et al., 2003). Negatively buoyant river plumes that are caused by sediment load were not considered in the model, because data on sediment load, especially during storm events, is not available.

Conclusion on Modelling Uncertainty
As directed in the Technical Rules, an uncertainty rating of high or low must be assigned to the level of uncertainty associated with hydrodynamic modelling. Regardless of the high level of confidence associated with the model input data, provisions must be made to include uncertainty associated with the model application and limitations of model outputs. A high level of uncertainty is associated with the methodology of in-water IPZ-2 delineations and therefore for all Great Lakes models.

Quality Assurance and Quality Control (QA/QC)

Quality assurance (QA) and quality control (QC) measures were applied to model outputs and calculations of all Great Lakes surface water delineations. Delineations were reviewed and the confidence in the data, models, and calculations used in the delineation was assessed to be low for the Great Lakes systems.

QA/QC measures were also applied to the sub-factor outputs for the vulnerability analysis. Vulnerability factors were reviewed throughout the analysis process and as such the confidence in the data and the calculations used in the vulnerability analysis were assessed for the Great Lakes systems and is low.

Calibration and Validation

Calibration and validation of the modelling of the in-water and onshore components of the delineations were reviewed for the uncertainty analysis. If the in-water modelling and onshore calculations were calibrated using site-specific data of a reasonable time series and the outputs of the model were validated with actual measurements, a low level of uncertainty was assigned.

Overall, the uncertainty associated to the calibration and validation of the models and methods used in the delineation of Great Lake Intakes is high.

Accuracy of the Vulnerability Factors

Accuracy of the area and source vulnerability factors is dependent on the data used in the factor analysis. The confidence in the density, extent, distribution, and relevance of data concerning the intake system, water quality records and shoreline, and onshore features is considered. A high level of confidence in the supporting data relates to high confidence in the accuracy of the vulnerability factors. The accuracy of the vulnerability factors was assessed for each Great Lakes system separately.

Uncertainty of the Events-based Area and IPZ-3

The limitations of the delineation of intake protection zones and events based areas with regards to the events-based delineations are outlined by Baird in their 2013 report.

Modelling

Modelling was used to determine whether a spill under the conditions set out in the model would result in a predicted exceedance. The approach used is consistent with the methodologies outlined in MOE (2009b). However, there were limitations to modelling. Time and budget limited the number of model runs that could be completed for each event, and a limited number of events could be modelled. Due to the lack of data, many assumptions were made, including spill duration and spill volume. In Georgian Bay, data related to lake currents were incomplete. Further, the DELWAQ modelling software does not account for some of the physical processes with regards to fuel evaporation and dispersal, therefore it was assumed that no evaporation took place once the spill entered the water.

Desktop Analysis

The desktop analysis done was used to evaluate whether spills that occurred inland would reach the intake within the two hour time-of-travel or a bit longer and cause a predicted exceedance, as prescribed in the technical rules 68 and 130. Where a spill, outside IPZ-1 and IPZ-2, caused deterioration of the water quality, an IPZ-3 was delineated. For the desktop assessment done by Baird, all scenarios were evaluated based on the distance to the lake, and then used the spill scenarios that were modelled to estimate the dilution of the chemical parameter. Therefore, all limitations for the modelling apply to the desktop analysis. Additionally, flow speed was assumed to be 1 m/s, with no accounting for roughness, vegetation, travel slope and other factors that might contribute or reduce the flow speed. Further, the inherent simplicity in the linear modelling method used for the inland spill locations creates high uncertainty. Finally, advection with limited mixing of benzene in water was the only mechanism used for transportation was assumed in the drainage path, no evaporation was assumed in the lake and absorption into groundwater and soil were not considered.

Summary of Uncertainty Considerations

The uncertainty sub-factors results are displayed in Table 4.1.19. For all Great Lakes systems, these factors are equal. For IPZ-1, uncertainty in the area delineation rating is low, because it is fully prescribed by the Technical Rules. The rating of the IPZ-2 delineation is high, partly because of uncertainties embedded within the numerical modelling itself, and partly because the data required for validating these models has high uncertainty. The ratings of the IPZ-3 and EBA are high due to the previously stated uncertainty of the modelling. Further, the ratings are high for the desktop assessment due to the use of linear modelling and the many unknowns that were assumed, such as flow speed, dilution and a full understanding of the lake current circulations at a larger scale.

The overall uncertainty related to the vulnerability of the intake protection zones is high.

TABLE 4.1.19 – Uncertainty Rating for Great Lakes Intakes (Type A)

Uncertainty Component	***Consideration Factor***	***IPZ-1 Rating***	***IPZ-2 Rating***	***IPZ-3 Rating***	***EBA Component Rating***
Delineation of the surface water intake protection zones.	*Data*	*Low*	*High*	*High*	*High*
	Modelling	*n/a*	*High*	*High*	*High*
	QA/QC	*Low*	*Low*	*High*	*High*
	Calibration and validation	*n/a*	*High*	*High*	*High*
	Overall	**Low**	**High**	**High**	**High**
The assessment of the **Vulnerability** of the intake protection zones	*Data*	*Low*	*High*	*n/a*	*n/a*
	QA/QC	*Low*	*Low*	*n/a*	*n/a*
	Accuracy of the vulnerability factors	*Low*	*Low*	*n/a*	*n/a*
	Overall	**Low**	**Low**	**n/a**	**n/a**

n/a – (not applicable) modelling is not required for the delineation of the IPZ-1.

4.1.8.3 Uncertainty in the Assessment of WHPA-Es

Identification of Point of Interaction

The point of interaction between the surface water and the well was not known in most GUDI systems in this source protection area. Thus, Technical Rule 47(5a) was applied and the point closest to the well was identified. The hydrological uncertainty of this approach is high.

Hydraulic Analysis

<u>Data</u>
Data uncertainty mainly impacts the total upstream extent of the WHPA-E. Implications from this uncertainty can be managed with relative ease, if a moderately conservative approach to delineation is chosen.

Table 4.1.20 summarizes input data, method to obtain these, and data uncertainty.

TABLE 4.1.20 – Data used for Hydraulic Modelling of WHPA-E

Input Data	Method	Uncertainty
Streamflow Analysis		**High**
Watershed Area	*GIS Watershed analysis*	*Low*
Flow station measurements	*Time series of 20 flow stations*	*Low*
Flow Quantity at flow stations, 2-year return period	*Streamflow Frequency Analysis using Log-Pearson Type 3 distribution*	*Low*
Flow Quantity at location of river	*Regression model*	*High*
Flow Velocity Hydraulic Analysis		**High**
Characteristic ground surface profile (cross section)	Selected, characteristic cross sections identified based on GIS aerial photography and field visit. Cross section derived from digital elevation model; stream bed corrected based on measurement data. However, total number of data points low*	High
Characteristic river slope	Slope averaged from local slope and reach-averaged slope.	High
Characteristic roughness	Determined with CES library based on field visit. Upper and lower error interval quantified.	High

* *Uncertainty is increased for this variable.*

Modelling and Calibration

The CES model is based on the Reynolds-Averaged Navier-Stokes (RANS) equations estimates the depth-averaged velocity distribution across the river cross section and also allows estimating the reach-averaged flow velocity, as given by Manning's equation. In addition, this equation automatically takes into account the flow regime (super and sub critical), based on the Froude number. These details are derived directly from the Navier-Stokes equation and require no additional inputs.

However, along river processes such as backwater effects are disregarded in both the CES and the Manning approach. If such effects are relevant, especially in rivers with large heterogeneity of the cross section profile and elevation, the methodological uncertainty is high. Also, methodological uncertainty is high in wetland areas, above limestone bedrocks or in small creeks that have large variation of flow quantity over the year.

As mentioned in Section 4.1.2.7, empirical data for calibration under high flow condition is not available. Thus, uncertainty related to calibration and validation is high.

In consequence, the uncertainty associated with the delineation of the 2-hour time-of-travel is high if modelling is required. In cases where the point of interaction is located in a very small surface water bodies, this uncertainty is low.

Overall Uncertainty of WHPA-E Delineation
The uncertainty of the WHPA-E delineation impacts those properties at the tail end of the WHPA-E. The overall uncertainty of the time-of-travel distance and WHPA-E area delineation is the cumulative effect of our knowledge on the point of interaction, the data uncertainty, and the methodological uncertainty.

In addition, the hydraulic uncertainty related to the identification of the point of interaction between the surface water body and the well is high unless determined with a tracer study, which was not feasible in any system.

The transport pathways (agricultural tile drainage) was assumed.

GUDI Drinking Water Systems with Particular Difficulties
During modelling for some systems, particular difficulties were encountered, which are summarized in the following table. Priority is highest for the first system (Kimberley) and successively lower in each row.

Uncertainty of Vulnerability Rating

Area Vulnerability
Area vulnerability rating is very robust. While sub factors are varying, the overall area vulnerability is moderate for all systems. Thus, the uncertainty attributed to the area vulnerability factor is considered low.

Source Vulnerability
Source vulnerability varies considerably among wells, ranging from low to high. Data used for source vulnerability rating is the distance to surfacing karst, the overburden thickness and the casing depth.

Due to the relevant impact of data uncertainty on the overall vulnerability rating, uncertainty related to source vulnerability is high for all systems.

TABLE 4.1.21 – Limitations on GUDI Delineations

System	Limitations	Recommendation
Kimberley Spring	The two springs located within the Niagara Escarpment are strongly influenced by surface water. Due to the prevalence of sink holes in this area and as described in Section 8.9.3, an	Extend the WHPA-E delineation to several points of interactions, which includes the catchment area of several sink holes within the WHPA A-D and

	alternative delineation of WHPA-E based on precautionary principle is suggested.	also two hour Time-of-Travel in the Woodhouse Creek.
Tara	River is strongly heterogeneous, frequently shifting from deep, wide sections to shallow and relatively narrow sections. With variable flow conditions, wetlands and flood lines further impact flow velocity.	A model with more detailed resolution of cross sections, as well as the capability to consider backwater effects, is recommended. This requires a different type of modelling software, e.g. HEC-RAS.
Winburk/Amabel	The drainage behaviour of the two inland lakes (Carson Lake and Silver Lake) is unclear and seems to be variable over time. In most incidences, these lakes seem to recharge groundwater while under strong rainfall conditions, they discharge into the creek that influences the Winburk, and joins the Sauble River.	It is recommended to assess the drainage behaviour of these lakes after strong precipitation/runoff events.
Walters Falls	The streams are dominated by wide wetlands on top of limestone bedrock. During normal flow conditions, many of these streams don't carry any water. During the spring fleshet, wetlands are pronounced, forming beds with rapid flow.	An in-depth study of this stream system is recommended.

Accumulative Uncertainty

Taking into account all uncertainties mentioned, the accumulative uncertainty related to WHPA-E threats analysis is high for all systems.

More detailed consideration factors to determine the uncertainty for all systems in this source protection area are given in Table 4.1.22.

TABLE 4.1.22 – Uncertainty Rating for WHPA-Es

Uncertainty Component	**Delineation** of the wellhead protection area E			The assessment of the **Vulnerability** of the wellhead protection area E		
Consideration Factor		*Hydraulic Analysis*	**Over all**	*Area Vulnerability*	*Source Vulnerability*	**Over all**

	Point of inter-action	*Data*	*Mod elling*	*Calibration*		*Data*	*Method*	*Data*	*Method*	
Amabel School	*High*	*High*	*High*	*High*	**High**	*High*	*Low*	*High*	*High*	**High**
Winburk	*High*	*High*	*High*	*High*	**High**	*High*	*Low*	*High*	*High*	**High**
Chatsworth 1 & 2	*High*	*High*	*High*	*High*	**High**	*High*	*Low*	*High*	*High*	**High**
Foreman	*High*	*High*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**
Huron Woods 1&2	*High*	*High*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**
Huron Woods 6	*High*	*High*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**
Kimberley Spring 1 & 2	*High*	*High*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**
Oliphant Well Supply	*High*	*High*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**
Pottawatomi 2	*High*	*High*	*High*	*High*	**High**	*High*	*Low*	*High*	*High*	**High**
Shallow Lake 2&3	*High*	*High*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**
Tara 2 & 3	*High*	*High*	*High*	*High*	**High**	*High*	*Low*	*High*	*High*	**High**
Walters Falls 1&2	*High*	*High*	*High*	*High*	**High**	*High*	*Low*	*High*	*High*	**High**

4.2 Risk Assessment by Municipality: Threats and Issues

4.2.1 Municipality of Arran-Elderslie

The Municipality of Arran-Elderslie is located in central Bruce County along the eastern boundary separating Grey and Bruce Counties. It is included in two Source Protection Areas: Grey Sauble SPA and Saugeen Valley SPA. In 2016, the population was 6,803, which was an increase of 0.8% from 2006 (Statistics Canada, 2016b). Arran-Elderslie is located in the heart of Bruce County, close to many major tourist destinations. The Municipality contains three main towns: Chesley (population 1,880), Tara (population 905) and Paisley (population 1,033). Smaller villages include Dobbinton, Invermay, Arkwright, and Burgoyne.

Tara is the only municipal drinking water system located within this municipality in this SPA. The community has a large residential municipal groundwater system (GUDI) with three supply wells that serve Tara.

The community of Chesley also has a large residential municipal groundwater system with two supply wells to serve Chesley. Drinking water from the Arran-Elderslie Drinking Water System (Chesley) also supplies Paisley via a 17 km pipeline. However, the Arran-Elderslie DWS is located in the Saugeen Valley SPA. Please refer to the Assessment Report for the Saugeen Valley Source Protection Area. No new drinking water systems are planned.

Looking at agricultural land use in Arran-Elderslie, 355 farms manage a total land area of 42,885 ha (average farm size 121 ha), out of which 53.9% are cropped according to the Agricultural Census (Statistics Canada, 2006a). From this cropped area, alfalfa and other fodder crops take up 12.7% of the land, soybeans take up 12.4% and other crops (corn, wheat, etc.) take up 17.5%. In Arran-Elderslie the total livestock density is 0.17 nutrient units per acre. According to the same census, there are 30,000 chickens on 47 farms (Statistics Canada, 2006a). The total number of cattle is 45,331 (4% dairy, remainder beef) on 272 farms. Further, there are no pigs, 2,805 sheep, 510 horses, and 747 goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.1.M1.

4.2.1.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.1.M2 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this Municipality. The southern part of the Municipality that lies in the Saugeen Valley Source Protection Area, is characterized by thick overburdens with lower conductivity so that groundwater aquifers are mostly shielded against contamination and recharge. The overburden in the north-western tip of the Municipality is characterized by glaciolacustrine deposits, which contain sand and some silt. These areas are considered significant groundwater recharge areas. Other small SGRAs are scattered throughout the Municipality, partly of the same glaciolacustrine origin (including parts of the Chesley WHPA) and partly from ice-contact stratified drift. The north-easterly part of the Municipality, between Dobbinton and Tara, has low overburden thickness, which is typical of large parts of the Sauble River watershed and Bruce Peninsula underlain by the Guelph formation bedrock. These areas

are designated highly vulnerable aquifers. Large parts of the combined WHPA-D of Tara Wells 2 and 3 are both HVAs and SGRAs.
All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.1.M3).

For the portion of this municipality located in GSSPA, the total area of SGRAs is 30.2 km^2 and the total area of HVAs is 43.1 km^2. For the purposes of calculating managed lands and livestock density, only the portion of the SGRAs where the vulnerability score is 6 are used in the calculations. The percentage of managed lands located within the SGRAs and HVAs is 40-80%. The livestock density is less than 0.5 NU/acre. Only 1-8% of all surfaces in SGRAs and HVAs are classified as impervious (Table 4.2.1.1).

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

TABLE 4.2.1.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Municipality of Arran-Elderslie

SGRA	Total Area of SGRA	30.2 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	43.1 km^2
	Managed Land and Livestock Density	ML% >80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

4.2.1.2 Groundwater Municipal Systems

4.2.1.2.1 Tara Drinking Water System

Until recently, the community of Tara was served by two drilled wells identified as Well No. 2 and Well No. 3. In 2007, a third well, Well No. 4, was installed and was added as supply well in 2009. Tara Wells No. 2 and 3 are located in the eastern portion of the community of Tara on the west side of the Sauble River. These wells are located approximately 400 metres apart and each is associated with its own pump house. The associated water supply system is classified as a large municipal residential system (Genivar 2010).

Well No. 2 was drilled in 1958, installed in 1960 (MOECC, 2009f) and has a depth of 118.6 metres (MOECC, 2009f). Bedrock at the well location was reportedly encountered at a depth of approximately 8.8 metres. The bedrock was reportedly overlaid by predominantly stony till with a stratum of sand and gravel encountered between 4.3 and 4.9 metres depth. The well record indicates that the water-producing zones are bedrock layers at depths of approximately 79 and 110 metres. In 2002, the casing was updated from 15.9 m to 72 metres to improve the protection against water intrusions through fractures (Genivar, 2010). For treatment, the pump house uses primary ultraviolet (UV) disinfection, a chlorination system and cartridge filtration (MOECC, 2009f).

Well No. 3 was drilled and installed in 1978 with a depth of 119 metres. It is located in the direct vicinity of the pump house. Bedrock at the well location was reportedly encountered at a depth of approximately 2.4 metres and overlaid by predominantly clayey soils. The well record indicates that the water-producing zones are bedrock layers at depths of approximately 75 and 96 metres (Genivar, 2010).

Wells No. 2 and No. 3 were assumed GUDI wells until a study was completed and a report was submitted in January 2004 (Henderson and Paddon, 2004a; 2004b). Initially, this study confirmed that the wells were not GUDI. Later in March 2004, the Engineer submitted additional information revealing that Well No. 3 tested positive for coliform bacteria on two accounts and thus should be treated as a GUDI well subject to full treatment (MOECC, 2006). It was then overdrilled to an 8 inch casing and lined the same year, as an attempt to achieve a secure groundwater source. This attempt failed and Well No. 3 remains classified as GUDI (MOECC, 2009f).

The newest Well No. 4 was drilled in 2006 with a depth of 22.8 m. It is screened in the interval 19.8 to 22.8 m and draws water from the Guelph limestone aquifer. The average flow rate is 171.6 cubic metres per day (m^3/d) for Tara Well No. 2 and 270.5 m^3/d for Tara Well No. 3 (2003 Grey Bruce Groundwater Study, in Genivar 2010). Detailed analysis shows that the combined rate fluctuates between 328.4 and 442.1 m^3/d with an estimated flow rate of 511.1 m^3/d in the year 2021. However, the flows have shifted between the two production wells and are expected to shift further with new Well No. 4 (Genivar, 2010).

TABLE 4.1.G1.1 – Description of the Drinking Water System and Wells

Well Name	Tara No. 2	Tara No. 3	Tara No. 4
Drinking Water System ID	220002627		
Drinking Water System Classification	Large Municipal Residential System		
SPA of Well and Vulnerable Area (WHPA)	Grey Sauble SPA		
Northing/Easting	4925018.4 / 488655.6	4924676.1 / 488534.9	4925549.1 / 488249.5
Year Constructed	1958	1978	2007
Well Depth	118.6 m	119 m	25.9 m
Uncased Interval	72 - 118.6 m	70 - 119 m	19.8 - 22.8 m
Aquifer	Guelph/Amabel limestone	Guelph/Amabel limestone	Guelph limestone
GUDI	No	Yes	No
Number of Users Served	841 persons		
Design Capacity (CoA)	982.08 m^3/day	1414.1952 m^3/day	852 m^3/day
Permitted Rate (PTTW)	426.2 m^3/day	457.9 m^3/day	852 m^3/day
Average Annual Usage*	171.6 m^3/day	270.5 m^3/day	n/a
Modelled Pumping Rate	198.4 m^3/day	312.7 m^3/day	340 m^3/day
Treatment	Chlorination and cartridge filtration	UV, chlorination and cartridge filtration	Chlorination and cartridge filtration

** Genivar, 2010*

A wellhead protection area (WHPA) for the Tara System was first developed as part of the Grey Bruce Groundwater Study (WHI, 2003). This initial WHPA was developed for the wells No. 2 and No. 3. The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates and the addition of Well No. 4 as part of the Municipality of Arran-Elderslie Groundwater Vulnerability Study (Genivar 2010).

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.1.G1.2a and shown on Map 4.1.G1.4. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. For the purposes of calculating managed lands and livestock density, only the portion of the WHPA with a vulnerability score of 6 or more was used in the calculations. The results are listed in Table 4.1.G1.2b and shown on Maps 4.1.G1.5 and 4.1.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.1.G1.2a – Impervious Surfaces

General	Code for WHPA	TARA_2_3	TARA_4
	Total Area [hectare]	334.93	75.08
Impervious Surfaces Area [ha]	0 % – <1%	211.53	0.00
	1% – <8%	81.68	58.73
	8% – < 80%	41.72	16.36
	Larger or equal than 80%	-	-

Note: Total areas relate to the full WHPA, even if located in other municipalities

TABLE 4.1.G1.2b – Managed Land and Livestock Density

WHPA_NAME	TARA_2_3 and TARA_4										
Well Name	No.2			No.3			No.2 &3	No.4			
Zone	A	B	C	A	B	C	D	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5-1.0	<0.5	0.5-1.0	<0.5	<0.5
% Managed Lands (<40%, 40-80%, >80%)	<40%	40-80%	>80%	<40%	40-80%	>80%	>80%	40-80%	>80%	>80%	>80%

Wellhead Protection Area

WHPA A-D

The wellhead protection area (WHPA) was estimated following the methodology described in Section 4.1.2.5. The capture zones extend predominantly in an easterly direction to a maximum distance of approximately 3.7 kilometres from the wells. The WHPA-D (25-year capture zone) crosses the Grey Bruce County Line and extends approximately 1000 metres into the Township of Georgian Bluffs in Grey County (Genivar, 2010). A second WHPA for Tara Well No. 4 extends south-east of the well for 3.3 kilometres. WHPAs A and B extend 2.8 kilometres with land uses including commercial, residential, and agricultural. WHPAs C and D extend 0.5 kilometres from WHPAs A and B having residential and agricultural land. Land use is predominantly residential in the vicinity of the wells and agricultural in WHPAs C and D (Map 4.1.G1.1).

Municipal parcel mapping for Tara Wells No. 2 and 3 identified eighty-six (86) separate land parcels that are located partially or fully within the identified WHPA, and sixty-nine (69) for Well No. 4. In addition to these land parcels, the WHPA also contains transportation corridors associated with road allowances and undesignated property associated with the river corridor (Well Nos. 2 and 3: Genivar 2010, Well No. 4: DWSP staff).

<u>WHPA-E</u>
WHPA-E was delineated in the surface water body that influences this GUDI well. The Tara Well No. 3 is located 50 metres from the Sauble River and its floodplain. Under flood conditions, areas are not only affected within the town of Tara but also further upstream. The WHPA-E extends 4.8 km in the upstream direction of the river flow. It includes all tributaries within the 2-hour ToT. A 120 metre setback or the regulation limit, and areas with agricultural tile drainage were added (for details, see Section 4.1.2.7).

Map 4.1.G1.2 shows the borders of all zones of the WHPA overlaid on aerial photography.

Transport Pathways

The vulnerability of the WHPA must be increased if pathways exist that transport contaminants from the surface into the aquifer that is a source for drinking water (see Section 4.1.2.6), unless the vulnerability is already rated "high".

No transport pathway adjustments were made to aquifer vulnerability in the bulk of the Tara WHPA. Existing properties are either on municipal services, or have wells that are in compliance with existing standards. Aquifer vulnerability was adjusted for one property, located on the northern edge of the WHPA for Well No. 4, as it is suspected of having a well that is out of compliance with existing standards.

Vulnerability

<u>WHPA A-D</u>
The intrinsic susceptibility index for the Tara wells is shown on Map 4.1.M1. The area is protected to a degree by the surficial geology, which is at minimum partially composed of fine grained materials. Quaternary geology mapping indicated that the larger part of the WHPA, especially around the wells, is underlain by fine-textured surficial deposits (identified as stony, sandy silt till) with some fluvial deposits from the nearby Sauble River in the upper soil layer (Genivar 2010). Bedrock has been encountered at depths as low as 2.5 m in the area, and the resultant aquifer vulnerability is high to moderate for this reason.

After overlaying the intrinsic susceptibility index (Map 4.1.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.1.3 for detail). Nearly all of WHPAs A, B and C and the majority of WHPA D are areas of high aquifer vulnerability. A small portion of WHPA D has medium vulnerability, as shown on Map 4.1.G1.3.

<u>WHPA-E</u>
The total vulnerability of the WHPA-E associated with Tara Well No. 3 is comparatively high (8.0). This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.1.G1.2c). The area vulnerability describes the propensity of the on-land area to contribute runoff (percentage of land, land characteristics and transport pathways), which is 8 (moderate). The source vulnerability score describes the likelihood that the surface water transports contaminants to the well and is 1.0 (high).

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.3 for details).

TABLE 4.1.G1.2c – Vulnerability of WHPA-E Associated with the Tara DWS

Name of WHPA	TARA_2_3	
DWIS_ID	220002627	
Area (Total), hectares	949.26	
Vulnerability (Total)	**8.0**	
Source Vulnerability	**1.0**	
SV - Distance to surfacing karst [m]	> 500 m	0.8
SV - Overburden Protection	6.97 m	1.0
Area Vulnerability **	**8 (8.25)**	
AV - Percent Land: Score	**9**	
AV - Percentage of Land	> 70%	9
AV - Land Characteristics	**7.75**	
Land Cover *	Mainly vegetated	7
Soil Type	Silty loam and sandy loam	8
Soil Permeability *	High permeability	7
Setback Slope [%]	8.3%	9
AV Transport Pathways	**8.0**	
Tile Drainage [% of land area]	80.3%	9
Storm Catchment	< 33%	7
Number of Watercourses/1,000 ha	3-6	8

** Area disregarded if classified "Not categorized"*
*** The Area Vulnerability Score is rounded to full number.*

Threats and Risks

Land uses and activities within the wellhead protection area were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

<u>WHPA A-D</u>
There are 13 significant drinking water threats in the Tara (Wells No. 2 and 3) wellhead protection area A-D. These threats include 6 activities related to the potential for pathogen contamination, 7 activities related to contamination with hazardous chemicals and 0 activities related to DNAPLs. The total number of properties with threats is 6 (see detailed Table 4.1.G1.3a and summary Table 4.1.G1.4).

There are 35 significant drinking water threats in the Tara (Well No. 4) wellhead protection area A-D. These threats include 25 activities related to the potential for pathogen contamination, 10 activities related to contamination with hazardous chemicals and 0 activities related to DNAPLs. The total number of properties with threats is 12 (see detailed Table 4.1.G1.3b and summary Table 4.1.G1.4).

<u>WHPA-E</u>
With surface water influencing the Tara Well No. 3, WHPA-E was delineated. The vulnerability score of this WHPA-E is 8.0, and chemical and pathogen threats can be significant (see Section 4.1.5.7). For chemical threats, no activity in this area meets the quantity circumstances defined in Provincial Table 22 - CIPZWE8S. Some activities that discharge sewage (as defined in Provincial Table 48 - PIPZWE8S) would be considered pathogen threats, but none were identified in this area. Agricultural activities that have the potential to contaminate surface water with pathogens (as defined in Provincial Table 48 - PIPZWE8S) were identified, associated with the handling, storage and application of agricultural source material and non-agricultural source material, as well as with livestock. A total of 33 activities were identified in this area as significant threats to drinking water sources (Table 4.1.G1.3c).

<u>Moderate and Low Threats</u>
Moderate and low threats are not counted individually. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

Quality of Raw Water at the Well

After the well casings of Wells No. 2 and 3 were upgraded in 2002, the Ontario Drinking Water Quality Standards were not exceeded for the chemical parameters routinely tested for and included in the annual reports. Nitrate concentrations in the samples from Wells No. 2 and 3 were typically less than 1 mg/L. No volatile organic carbons were detected in annual samples (Genivar, 2010).

TABLE 4.1.G1.3a – Tara Wells No. 2 and 3: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL threats)

Prescribed Threat **WHPA: TARA_2_3** *For full legal name of prescribed threat, see Table 4.1.5*		**Land Use Category**									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land										
4	Agricultural source material – Storage	2									**2**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage	2									**2**
8	Commercial fertilizer - Application to land	1									**1**
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
12	Road Salt – Application		1								**1**
13	Road Salt – Handling and Storage		1								**1**
14	Snow – Storage										
15	Fuel - Handling and storage										
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards - Livestock grazing	1									**1**
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
1	Untreated septage - Application to land										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land	2									**2**
4	Agricultural source material – Storage	2									**2**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards - Livestock grazing	1									**1**

TABLE 4.1.G1.3b – Tara Well No. 4: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL threats)

Prescribed Threat WHPA: TARA_4 *For full legal name of prescribed threat, see Table 4.1.5*		Land Use Category									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal	1									**1**
3	Agricultural source material - Application to land	5									**5**
4	Agricultural source material – Storage	6									**6**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
8	Commercial fertilizer - Application to land	4									**4**
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land	1									**1**
11	Pesticide - Handling and storage										
12	Road Salt – Application		1								**1**
13	Road Salt – Handling and Storage		1								**1**
14	Snow – Storage										
15	Fuel - Handling and storage							1			**1**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards	3									**3**
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
1	Untreated septage - Application to land										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal	1									**1**
3	Agricultural source material - Application to land	5									**5**
4	Agricultural source material – Storage	6									**6**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards	3									**3**

TABLE 4.1.G1.3c – Tara: Significant Drinking Water Threats Associated with the WHPA-E (all land use activities identified are agricultural)

Prescribed Threat Name *For full legal name of prescribed threat, see Table 4.1.5*			TARA_2_3
	PATHOGENS		
1	Untreated septage – Application to land		0
3	Agricultural source material - Application to land		11
4	Agricultural source material – Storage		6
6	Non-agricultural source material - Application to land		
7	Non-agricultural source material - Handling and storage		
21	Pastures or other farm-animal yards - Livestock	Grazing and pasturing	8
21	Pastures or other farm-animal yards - Livestock	Yards and confinement	8
	Grand Total		**33**

TABLE 4.1.G1.4 – Tara WHPA: Summary of Significant Drinking Water Threats

	Number of "are or would be significant" threats				Number of *properties* with "are or would be significant" threats			
WHPA A-D	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
TARA 2, 3	8	0	5	13	6	0	0	6
TARA 4	12	0	23	35	11	0	1	12
WHPA E								
TARA 3			33	33	15			15

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality of the well in its existing configuration, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.1.G1.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.1.G1.5 – Tara: Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	**Threat**
None	None

4.2.1.3 Surface Water Municipal Systems

No municipal drinking water systems that use surface water exist in this municipality.

4.2.2 The Blue Mountains

The Blue Mountains is located on the shores of Georgian Bay, extending from west of Thornbury to east of Craigleith. It is part of Grey County and in the Grey Sauble Source Protection Area as well as the Nottawasaga Valley Source Protection Area, which is not in this Source Protection Region. In 2016, the population was 7,025, which was an increase of 2.9% from 2006. The Blue Mountains has extensive shoreline development. The main towns are Thornbury (population 1,771) and Craigleith. Smaller villages include Clarksburg, Slabtown, Heathcote, Ravenna, Red Wing, and Kolapore. One surface water intake serves The Blue Mountains and it is located in Thornbury. No new drinking water systems are planned.

The west pier in Thornbury is east of the water intake and extends 115 m from shore out into the lake to form the western limits of the harbour. The end of the pier has a rubble mound extension for entrance protection to the harbour. The pier is a parallel steel sheet pile wall with a concrete deck. The eastern limit of the harbour has taken its shape from a spit of sand and boulders that formed along the west bank of the Beaver River. This spit naturally extends west to enclose the harbour.

The Thornbury small craft harbour is home to numerous recreational vessels and an occasional tugboat. There is no commercial activity at the Thornbury harbour. Occasional commercial activity occurs far offshore for vessels heading to Midland, which is in excess of 37 km from Thornbury. The former commercial harbour at Collingwood is 18.5 km southeast of Thornbury. The Thornbury Marina is managed by the Town and has capacity for 195 recreational vessels (OMOA, 2007) including transient vessels.

Looking at agricultural land use in Blue Mountains, 140 farms manage a total land area of 10,786 ha (average farm size 77 ha) of which 64.2% are cropped according to the Agricultural Census (Statistics Canada 2006). From this cropped area, alfalfa and other fodder crops take up 11% of the land, soybeans take up 14% and other crops (corn, apple, etc.) take up 21.6%. The total livestock density is 0.03 nutrient units per acre in the Town. In 2006, only 11 farms reported chickens (numbers disclosed, Agricultural Census 2006). The total number of cattle is 2,350 (7% dairy, remainder beef) on 42 farms. Further, there are no pigs, 665 sheep, 234 horses, and 32 goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.2.M1.

4.2.2.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.2.M2 indicates the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. Large portions of The Blue Mountains are influenced by the Niagara Escarpment. These areas and the surrounding areas are HVAs due to very thin overburden and karstic nature of the surfacing Amabel formation. From the town of Thornbury south to Red Wing and also around Ravenna, a relatively thick layer of sandy silt protects the aquifer. All karstic areas on top of the escarpment, as well as sand deposits at its bottom, are designated SGRAs. Further, the gravely deposits towards the mouth of the Beaver River and Indian Creek are SGRAs. These extend into the intake protection zone of Thornbury's municipal intake.
All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.2.M3).

The portion of this municipality that lies within this SPA has a total area of SGRAs of 78.2 km^2 and a total area of HVAs of 165.5 km^2. For the purposes of calculating managed lands and livestock density, only the portion of the SGRAs where the vulnerability score is 6 are used in the calculations. The percentage of managed lands located within the SGRAs and HVAs is 40-80%. The livestock density is less than 0.5 NU/acre. Only 1-8% of all surfaces in SGRAs and HVAs are classified as impervious (Table 4.2.2.1).

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

TABLE 4.2.2.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Town of The Blue Mountains

SGRA	Total Area of SGRA	78.2 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	165.5 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

4.2.2.2 Groundwater Municipal Systems

No municipal drinking water systems that use groundwater exist in this municipality.

4.2.2.3 Surface Water Municipal Systems

4.2.2.3.1 Thornbury Drinking Water System

The Town of Thornbury is located on the southwest of Georgian Bay, within the Manitoulin-Lake Simcoe ecoregion (Environment Canada, 2005). Its municipal water system draws water through a surface intake from Georgian Bay, classified as a Type A (Great Lakes) Intake.

The Thornbury DWS is located on the western shore of Nottawasaga Bay in Georgian Bay. It is a large municipal residential system that services an approximate population of 11,389 within Thornbury and surrounding area (Clarksburg, Camperdown and Lora Bay) via a 747 m^3 water tower. The Thornbury DWS partly services the Craigleith area via the Arrowhead Booster Pumping Station, which supplies water to twin in-ground storage tanks with a combined capacity of 5,000 m^3 (MOECC, 2005). Craigleith also receives water from Collingwood via the Collingwood Connection Booster Pumping Station at a rate of 2,500 m^3 daily.

The 600 mm diameter raw water intake extends approximately 430 m into Nottawasaga Bay (Georgian Bay) with twin 1.1 m diameter intake bells. The depth of the top of the intake crib is reported at 6.7 m, at a lake depth of 8.9 m (Stantec 2009, Phase 1 Technical Addendum). The intake piping splits just prior to the WTP into two separate pipes feeding the raw water clear well. The intake capacity is 20,000 m^3/day.

TABLE 4.2.S1.1 – Description of the Drinking Water System

Intake Name	**Thornbury WTP intake**
Drinking Water System ID	220001762
Drinking Water System Classification	Large Municipal Residential System
Intake Type	A (Great Lakes)
SPA of Intake and Vulnerable Area (IPZ)	Grey Sauble
Northing/Easting of Intake	543391.29 / 4935663.13
Intake Pipe Length	430 m
Lake Depth at Intake*	8.9 m
Depth of Top of Intake Crib*	6.7 m
Number of Users Served	14953
Intake Capacity	20000 m3/day
Average Usage	3007 m3/day
Maximum Usage	5273 m3/day

** Elevations measured from plan & profile drawings (Ainley, November 1978) and converted to International Great Lakes Datum 1985 by comparing recorded water levels with historical information from US Army Corps of Engineers (in Stantec 2009, Phase 1 Technical Addendum).*

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.2.S1.1b and shown on Map 4.2.S1.5. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. The results are listed in Table 4.2.S1.1b and shown on Maps 4.2.S1.6 and 4.2.S1.7. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.2.S1.1b – Managed Land, Livestock Density and Impervious Surfaces

General	IPZ ID	THORNBURY
	Area Total [hectare]	4321.58
	Area Offshore [hectare]	1579.47
	Area Onshore [hectare]	2732.61
IPZ 1 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	21.72
	Livestock Density [NU/Acre]	0.00
	Managed Land Area [hectare]	3.38
	% Managed Lands	15.58
	Category	**ML% <40%, NU/acre <0.5**
IPZ 2 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	0.00
	Livestock Density [NU/Acre]	0
	Managed Land Area [hectare]	0.00
	% Managed Lands	0
	Category	**ML% <40%, NU/acre <0.5**
Impervious Surface: Area per category [hectare]	0 % – <1%	403.42
	1% – <8%	1526.33
	8% – < 80%	802.65
	Larger or equal than 80%	0.00

Note: All areas relate to the full IPZ including other municipalities.

Intake Protection Zone

The Thornbury Drinking Water System uses raw water from an intake located in Georgian Bay and is classified as a Great Lakes (Type A) intake. For the in-water portion of the IPZ-1 of a Type A intake, the Technical Rules prescribe to delineate the IPZ as a circle with a radius of 1,000 meters from the entry point where raw water enters the drinking water system (see Section 4.1.2.6 for details). Where the IPZ-1 abutted land and was not impacted by a riverine or transport pathway, it was extended 120 m inland as this was greater than the area of the regulation limit (Stantec 2009, Phase 1 Technical Addendum). The Little Beaver River and the Beaver River, with associated stormwater collection and emergency and permanent sanitary outfalls to Nottawasaga Bay, are within one km of the Thornbury water treatment plant and intake. The shoreline length of this zone is approximately 1,700 m. The area of IPZ-1 is 0.2 km^2 onshore and 2.5 km^2 offshore, totalling to 2.7 km^2.

IPZ-2, as delineated with hydrodynamic modelling, extends 7,000 m to the northwest of the intake, 4,300 m to the southeast and 1,600 m into Georgian Bay, thus covering a lake area of 15.9 km^2 offshore. There are several watercourses draining into this area, including Beaver River, Little Beaver Creek, Indian Brook, and many that are not named.

The Beaver River plume crosses the intake, bringing watershed sediments and urban contaminants under easterly winds, which causes turbidity spikes in the raw water. The Little Beaver River is also a storm drain that collects stormwater from shoreline developments and discharges into Nottawasaga Bay at the east side of the WTP. A sanitary pumping station with emergency bypass is also located on the shore immediately south of the WTP. Because the confluence of Little Beaver Creek and Beaver River is located close to the intake, the IPZ-2 Zone extends along these rivers for 14.2 km and 9.2 km respectively. Where the IPZ-2 abutted land and was not impacted by a riverine or transport pathway, it was extended 120 m inland as this was greater than the area of the regulation limit (Stantec 2009, Phase 1 Technical Addendum). The IPZ-2 was extended to the small reservoir behind Thornbury Dam (at Bridge Street) and includes all tributaries before Haine's Dam.

The full IPZ, including upland areas, is shown on Map 4.2.S1.1 and on Map 4.2.S1.2 with underlying aerial photography. Including transport pathways, the size of the onshore area of the IPZ-2 is 25.6 km^2 totalling to 41.5 km^2 with the in-water component.

An IPZ-3 and an EBA were delineated for based on modelled spill scenarios and desktop assessment. Using the methodology described in section 4.1.2.4, minimum volumes that would result in exceedances were determined for locations distributed throughout Thornbury and around the IPZ-2. Volumes ranged from 38,800 L to 92,600 L and were split into two EBA categories (see map 4.1.S1.1.9);

- 50,000 L and greater
- 100,00 L and greater

Storm Sewer Systems and Transport Pathways

The onshore component of the intake protection zone includes properties that drain into storm sewersheds within a 2-hour ToT, and other transport pathways (Section 4.1.2.6).

Overland flow, natural streams and rivers, and storm sewers and drains are all present within the study area. Various storm sewer and drain outfalls are located on the shoreline at Thornbury to convey captured surface drainage to Nottawasaga Bay. Those areas that are located less than the 2 hour time-of-travel were added to the intake protection zone according to the Technical Rules (see Section 4.1.2.6 – Onshore Components). There are 633 ha of tile drainage area within the IPZ-2 located in numerous locations surrounding the study area tributaries (Map 4.2.S1.1).

The storm sewer networks located along the Lora Bay shoreline and the shoreline west of the intake extending from Kenwood Drive to Peel Street, as well as areas along Bay Street West, Bay Street East, Bruce Street North, and Bruce Street South, were included in their entirety if outlet plumes impact the in-water IPZs. A 116 ha storm sewershed located along the Lora Bay shoreline and the shoreline west of the intake extending from Kenwood Drive to Peel Street, as well as areas along Bay Street West, Bay Street East, Bruce Street North, and Bruce Street South, were included in their entirety in the IPZ-2 (Stantec 2009, Phase 1 Technical Addendum).

Inliers are small areas that are fully enclosed within IPZ onshore components. Following the method outlined in Section 4.1.2.4, inliers with areas less than 10 ha were added to the IPZ without further study, while the existence of preferential pathways (ditches, storm sewers) were confirmed in inliers with larger spatial extent.

Vulnerability

Vulnerability of the protection zone of the surface water intake was delineated following the methodology described in Section 4.1.3.5. Two factors measuring the vulnerability of the area and of the raw water source are computed separately and then multiplied with each other.

<u>Area Vulnerability Factor</u>
The area vulnerability factor for IPZ-1 is ten, as prescribed by the Technical Rules. For IPZ-2, the area vulnerability factor is 8, which is determined by averaging the percentage of land, land characteristics and transport pathways sub-factors (Table 4.2.S1.2a).

<u>Percentage of Land</u>
The % land sub factor has been divided equally between the three ranges outlined in the Technical Rules (< 33% = 7, 33% – 66% = 8, > 66% = 9). The Thornbury DWS has approximately 65% land area and therefore the % land sub factor has a score of 8.

<u>Land Characteristics</u>
The land characteristic sub factor has the components; land cover, soil type, permeability, and slope. The land characteristics sub factor can be derived from the average of the ratings for the four components.

Land Cover The land cover rating ranges from seven to nine and has been divided into; mainly vegetated (7), mixed vegetated and developed (8) and mainly developed (9). Land in the upland portion of the IPZ-2 is primarily comprised of mainly vegetated areas. Based on the available SOLRIS GIS dataset, the land cover type is 72% agricultural fields, parks, vegetation and natural landscapes (e.g. cliffs, prairies, etc). Therefore, a land cover component rating of 7 was prescribed for the Thornbury DWS.

Soil Type The soil type rating ranges from seven to nine and has been divided into; sandy soils (7), silty sand soils (8), and clay soils (9). Soils along the IPZ-1 and IPZ-2 shoreline are mainly sand with good drainage, with small pockets of silty clay with imperfect drainage. Soils within the upland IPZ-2 are mainly sand, silty clay loam and clay with good drainage, with areas of silty clay, silt loam and sand with imperfect drainage. The soil type component rating is 7.

Permeability The permeability rating ranges from seven to nine and has been divided into; highly permeable (> 66% = 7), moderately permeable (33% to 66% = 8), and largely impervious (< 33% = 9). The upland area of the Thornbury DWS is

2,521 ha of land with 247 ha (10%) of impervious cover (90% pervious). The impervious land cover was determined using SOLRIS (2009) information. Therefore, the permeability component rating is 7.

Setback Slope The setback slope rating ranges from seven to nine and has been divided equally into; < 2% slope (7), 2% to 5% (8), and > 5% (9). The slope of the study area ranged from 1.5% to 9.5%, with the majority of the slopes being > 5%, and contained steep Nipissing Ridge slopes. This was determined using OBM contours. These area features may increase runoff directly to the lake within the vulnerable zone. The slope component rating is 9.

Land Characteristics (Summary) The resulting land characteristics sub factor, calculated using an averaged equal representation of each component listed above is 7.5.

Transport Pathways

The transport pathway sub factor has the components; storm catchment areas, storm outfalls, watercourses and drains, and tile drained areas.

Storm Catchment Areas The storm catchment areas are rated based on the percent of land area that is drained by a storm sewer system. The rating ranges from seven to nine and has been divided equally into; < 33% area (7), 33% to 66% area (8) and > 66% area (9). Storm catchment areas were unavailable for the Thornbury DWS study area. Storm catchments were assumed based on available storm sewer network and the area of the developed land. The upland area was determined to be 5% (116 ha) storm sewer drained. The area of the developed land was based on 2006 SWOOP data and resulted in a component rating of 7.

Storm Outfalls, Watercourses and Drains For the purpose of rating the number of storm outfalls, watercourses and drains, a standardized method was applied to the data. The number of outfalls, watercourses and drains per 1,000 ha of land was calculated for the Thornbury WTP IPZ-2 using the MOECC’s Water Virtual Flow – Seamless Provincial Data Set (MNRF, 2008), as well as storm sewer networks provided by the Town of The Blue Mountains. The rating range has been set for 0-3/1,000 ha in the zone at 7, 4 to 7/1,000 ha in the zone at 8 and > 7/1,000 ha in the zone at 9. Fourteen watercourses and 10 outfalls discharge into Georgian Bay within the IPZ-2 giving a calculated 10 outfalls *per* 1,000 ha of land. This resulted in a sub factor of 9. It should be noted that watercourses and outfalls that discharge into the alongshore extent of the IPZ-1 were not considered in this calculation as it is used for the determination of the IPZ-2 vulnerability factor only.

Tile Drained Area Tile drained area is based on the percent land artificially drained as indicated by the Tile Drainage Areas GIS dataset (OMAFRA, 2009). The rating ranges from seven to nine and has been divided into; < 33% area (7), 33% to 66% area (8), and > 66% area (9). The area of land that is characterized as tile drainage areas in the Thornbury upland IPZ-2 is 598 ha (24%). Therefore, a component rating of 7 has been assigned.

Transport Pathways (Summary) The resulting transport pathways sub factor, calculated using an averaged equal representation of the components listed above is 7.7.

The area vulnerability factor is determined by averaging an equal representation of the % land, land characteristics, and transport pathways sub factors. The resulting area factor rating for the Thornbury IPZ-2 is 8 (Stantec 2009, Phase 1 Technical Addendum).

Source Vulnerability Factor

The source vulnerability factor for the Thornbury intake is a combined rating of intake characteristics (depth, length of pipe) and past water quality concerns. The intake crib depth is 6.7 m and thus, its vulnerability sub score is 0.5. The Thornbury intake is located approximately 430 m from the shoreline (Stantec 2009, Phase 1 Technical Addendum) and at a depth that potentially would not be impacted by water column mixing. With consideration given to the local hydrodynamic conditions, within the wave breaking zone, the sub factor is 0.6. A supplementary review of available raw water data to established water quality standards was undertaken. The review identified no apparent water quality concerns relating to the ODWQS listed chemical parameters and their respective MACs or IMACs. Also taking into account pathogen occurrence, water quality concerns are classified as low and only scored 0.5.

The source vulnerability factor is determined by averaging the above listed sub factors. The source factor rating for the Thornbury IPZ is 0.5 (Table 4.2.S1.2b).

Resulting Vulnerability of the Intake Protection Zone

The resulting vulnerability for IPZ-1 is six and for IPZ-2 is 4.8 (Table 4.2.S1.2c).

TABLE 4.2.S1.2a – Area Vulnerability Factor for the Thornbury Intake

Area Vulnerability Factor Rating *(Rounded average of percentage of land, land characteristics and transport pathways)*	8
Percentage of Land	8
Land Characteristics	7.5
Land Cover	7
Soil Type	7
Permeability	7
Setback Slope	9
Transport Pathways	7.7
Storm Catchment Areas *(less than 33%)*	7
Storm Outfalls, Watercourses, Drains (The number of storm outfalls, watercourses and drains per 1,000 ha is larger than 7)	9
Tile Drained Area (less than 33 %)	7

TABLE 4.2.S1.2b – Source Vulnerability Factor for the Thornbury Intake

Sub Factor	Score
Intake Depth	0.5
Length of Pipe (offshore)	0.6
Recorded Water Quality	0.5
Source Vulnerability Factor	0.5

TABLE 4.2.S1.2c – Vulnerability Score of the Thornbury Intake Protection Zone (IPZ)

Intake Type	Area Vulnerability Factor		Source Vulnerability Factor	Vulnerability Score	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
A (Great Lakes)	10	8	0.5	5	4

Uncertainty Rating

The uncertainty rating for the area delineation of IPZ-1 is low, because rules are prescribed by the Technical Rules.

Numerical modelling and the delineation of on-land areas was peer reviewed. However, the uncertainty rating for the delineation of IPZ-2 is high, partly because of uncertainties embedded within the numerical modelling itself, and partly because the data required for validating these models has high uncertainty (for details, see Section 4.1.7.2).

Threats and Risks

Land uses and activities within the intake protection zone were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

Table 4.2.S1.4 indicates that no surface water threats are rated at a "significant" level for DNAPLs or pathogens. The vulnerability score for Great Lakes intakes (both IPZ-1 and IPZ-2) is always smaller than eight. However, moderate threats were identified in the vulnerable area (Stantec 2009, Phase 2 Report). Three existing significant drinking water threats were identified through events-based modelling (see detailed Table 4.2.S1.3 and summary Table 4.2.S1.4).

TABLE 4.2.S1.3 – Thornbury IPZ: Significant Drinking Water Threats for Events-based Area

Prescribed Threat **IPZ: THORNBURY** *For full legal name of prescribed threat, see Table 4.1.5*		Land use Category									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
	CHEMICALS										
15	Fuel - Handling and storage		3								**3**

<u>Moderate and Low Threats</u>

Moderate and low threats are not counted individually. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

TABLE 4.2.S1.4 – Thornbury IPZ: Significant Drinking Water Threats for Chemical, Pathogen and DNAPLs

	Number of "are or would be significant" threats			
IPZ Name	Pathogen	Chemical	DNAPL	Total
Thornbury	0	3	0	3

Quality of Raw Water at the Intake

Raw water quality data at the intake available for this assessment was minimal. Provincial drinking water quality standards were not exceeded in treated drinking water in 2004 and 2005. From 2003-2005, *E. coli* was detected in just over 9% of the raw water samples at the Thornbury intake. Given the ubiquity of bacteria, including *E.coli*, in surface waters and their relatively low concentrations when present in Thornbury raw water and the ability of the water treatment plant to successfully treat this pathogen, presence of these bacteria does not represent an imminent threat to the water supply.

Raw water datasets with an array of non-microbiological parameters were not available; therefore, references to the drinking water treatment plant's annual reports were made. The annual reports included results for sampling inorganic and organic parameters from treated water. Since WTPs do not specifically target the removal of metals and pesticides, these treated results give some insight into the state of the raw source water. The ODWQS were not exceeded for inorganics or organics at the Thornbury WTP according to the latest available annual reports.

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.2.S1.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.2.S1.5 – Thornbury: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.3 Township of Chatsworth

The Township of Chatsworth is located in the heart of Grey County. It is partially within the Grey Sauble Source Protection Area and partially within the Saugeen Valley Source Protection Area. In 2016, the population was 6,630, which was an increase of 2.6% from 2006. Essentially a rural community, the Township of Chatsworth gets it character from the farmlands and forests surrounding it. Agriculture is the most predominant industry in the Township. There are numerous sawmills in the Township, some operated by the Amish community. The main towns are Chatsworth (population 522) and Desboro (population 200). Smaller villages include Massie, Holland Centre, Berkeley, Walters Falls and Mooresburg. One residential municipal groundwater system serves the village of Chatsworth and one residential municipal groundwater system serves the village of Walters Falls. No new drinking water systems are planned.

Looking at agricultural land use in Chatsworth, 375 farms manage a total land area of 28,879 ha (average farm size 77 ha) of which 49.3% are cropped according to the Agricultural Census (Statistics Canada, 2006a). From this cropped area, alfalfa and other fodder crops take up 16.8% of the land, soybeans take up 6.8%, barley takes up 6.6%, and other crops take up (corn, wheat, etc.) 7.7%. The total livestock density in Chatsworth is 0.07 nutrient units per acre. According to the same census, there are 36,000 chickens on 78 farms (Statistics Canada, 2006a). The total number of cattle is 16,405 (8% dairy, remainder beef) on 244 farms. Further, there are no pigs, 3,711 sheep, 941 horses, and 2,012 goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.3.M1.

4.2.3.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.3.M2 portrays the locations of highly vulnerable aquifers (HVAS) and significant groundwater recharge areas (SGRAs) in this municipality. The elevated eastern portion of this municipality located near Holland Centre is an important headwater for the North Saugeen River, the Sydenham River and the Bighead River. The glaciofluvial deposits cover the triangle between Chesley, Walters Falls and Markdale, all just beyond the municipal limits. Their high permeability, the hummocky topography and the interlaying wetlands make most of this triangle an SGRA.

Most of the Municipality is an HVA because of the thin and permeable overburden with the exception of the southeast. The southeast contains a ridge that starts southwest of Chatsworth and stretches 1.5 km north of Mooresburg and marks the watershed divide between the Sydenham and the Sauble Rivers to the north and the North Saugeen River to the south. Northwest of Mooresburg at Peabody, the Snake Creek has its source and the divide continues between this creek and the North Saugeen River. This watershed divide is characterized by thicker overburden that protects the groundwater aquifer. Other aquifers that are not highly vulnerable stretch between Holford and Glascott as well as east of Kinghurst.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.3.M3).

For the portion of this municipality located in GSSPA, the total area of SGRAs is 96.93 km^2 and the total area of HVAs is 223 km^2. The percentage of managed lands located within the SGRAs and HVAs is 40-80%. The livestock density is less than 0.5 NU/acre. Only 1-8% of all surfaces in SGRAs and HVAs are classified as impervious (Table 4.2.3.1).

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

TABLE 4.2.3.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Township of Chatsworth

SGRA	Total Area of SGRA	96.93 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	223.0 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

4.2.3.2 Groundwater Municipal Systems

4.2.3.2.1 Chatsworth Drinking Water System

The Chatsworth drinking water system services approximately 567 people with 189 connections. The town is currently served by two drilled wells, identified as Well No. 1 and Well No. 2. The wells are approximately six metres apart and are currently located within a single pump house and water treatment building. The wells are located on the southeast side of the village, approximately 250 metres east of Highway 10 and 140 metres east of the Spey River. The associated water supply system is classified as a large municipal residential system. Both wells were installed in 1983 on behalf of the Village of Chatsworth. Below the casings, the wells were completed as nominal 200 millimetre (8-inch) diameter open holes in the bedrock, with Well No. 1 extending to a depth of approximately 31.7 metres and Well No. 2 extending to a depth of approximately 19.2 metres (Genivar, 2009a). Approximately 2.7 to 2.9 metres of predominantly clayey soil reportedly overlays the bedrock at the well locations. Bedrock geology mapping indicates that the upper bedrock in the vicinity of the Chatsworth wells consists of Guelph Formation dolostone and the Chatsworth municipal wells penetrate the Guelph, Amabel and Fossil Hill formations (see Genivar, 2009a).

Each well is equipped with pumping equipment capable of pumping at 529.8 L/min. Well No. l and Well No. 2 are equally rated at 569.0 L/min and are not meant to run simultaneously. The pump house that houses the wells is located on Part Lot 5, Concession 1 East, East Garafraxa Road in the former Township of Holland (MOECC, 2009e).

The Chatsworth water system has been categorized as GUDI due to episodic bacterial contamination and the relatively thin layer of protective overburden in the area. In their engineering report, Henderson, Paddon & Associates Ltd. (2000) determined some influence of surface water on groundwater, arguing with the vicinity to Spey River and the total lack of overburden protection along this river. Sampling confirmed this conclusion, with occasional counts of *E. coli*. However, adequate treatment systems are installed. The water is first disinfected with ultraviolet and then treated with sodium hypochlorite (MOECC, 2009e).

A wellhead protection area (WHPA) for the Chatsworth System was first developed as part of the Grey Bruce Groundwater Study (WHI, 2003). The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates, accounting for projected future growth as part of the Township of Chatsworth Groundwater Vulnerability Study (Genivar, 2009a).

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.3.G1.2a and shown on Map 4.3.G1.4. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. For the purposes of calculating managed lands and livestock density, only the portion of the WHPA with a vulnerability score of 6 or more was used in the calculations. The results are listed in Table 4.3.G1.2b and shown on Maps 4.3.G1.5 and 4.3.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.3.G1.1 – Description of the Drinking Water System and Wells

Well Name	Chatsworth No. 1	Chatsworth No. 2
Drinking Water System ID	210003011	
Drinking Water System Classification	Large Municipal Residential System	
SPA of Well and Vulnerable Area (WHPA)	Grey Sauble SPA	
Northing/Easting	4922112.2 / 508878.2	4922116.3 / 508881.7
Year Constructed	1983	1983
Well Depth	31.7 m	19.2 m
Uncased Interval	5 - 31.7 m	5.4 - 19.2 m
Aquifer	Guelph Formation bedrock	Guelph Formation bedrock
GUDI	Yes	Yes
Number of Users Served	540 persons	
Design Capacity (CoA)	not known	not known
Permitted Rate (PTTW)	818 m^3/day	
Average Annual Usage *	230 m^3/day	
Modelled Pumping Rate	155 m^3/day	155 m^3/day
Treatment	Filtration, UV disinfection, sodium hypochlorite for primary and secondary disinfection	

** Year 2000-2006 (Genivar, 2009)*

TABLE 4.3.G1.2a – Impervious Surfaces

General	Code for WHPA	CHATSWORTH_1_2
	Total Area [hectare]	150.72
Impervious Surfaces Area [ha]	0 % – <1%	60.76
	1% – <8%	74.17
	8% – < 80%	15.79
	Larger or equal than 80%	-

Note: Total areas relate to the full WHPA, even if located in other municipalities

TABLE 4.3.G1.2b – Managed Land and Livestock Density

WHPA_NAME	**CHATSWORTH_1_2**		
Well Name	No. 1&2	No. 1&2	No. 1&2
Zone	A	B	C
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5
% Managed Lands (<40%, 40-80%, >80%)	>80%	>80%	>80%

Wellhead Protection Area

The wellhead protection area (WHPA) was estimated following the methodology described in Section 4.1.2.5. The capture zones extend predominantly in a northeast direction to a maximum distance of approximately 3000 metres from the municipal wells, with Congers Creek flowing through WHPA-B (Genivar, 2009a). Land use is residential and agricultural. WHPA-C is all agricultural and forested land (Map 4.3.G1.1).

Hazard lands, which constitute approximately 16 per cent of the WHPA, are primarily associated with the Spey River located just west of the municipal wells and a marshy area shown to be located near the intersection of Massie Road and Concession 2 in the northeast portion of the WHPA (Genivar, 2009a).

Municipal parcel mapping for the vicinity of the Chatsworth wells identified twenty nine (29) separate land parcels located partially or wholly within the identified WHPA. In addition to these land parcels, the WHPA also contains transportation corridors associated with road allowances (Genivar, 2009a).

WHPA-E was delineated in the surface water body that influences these GUDI wells. The closest surface water body to the Chatsworth Wells No. 1 and No. 2 is the Spey River. To identify the points of interaction, Technical Rule 47(5a) was applied and the points closest to the wells were identified. For both wells, the points of interaction are located within the WHPA-B, 135 metres north-west of the well in the Spey River. The WHPA-E extends upstream direction of the river flow. It includes all tributaries within the 2-hour ToT. A 120 metre setback or the regulation limit, and areas with agricultural tile drainage were added (for details, see Section 4.1.2.7).

Map 4.3.G1.2 shows the borders of all zones of the WHPA overlaid on aerial photography.

Transport Pathways

The vulnerability of the WHPA must be increased if pathways exist that transport contaminants from the surface into the aquifer that is a source for drinking water (see Section 4.1.2.6), unless the vulnerability is already rated “high”.

No transport pathway adjustments were made to aquifer vulnerability in the Chatsworth WHPA. Existing properties are either on municipal services, or have wells that are in compliance with existing standards.

Vulnerability

The intrinsic susceptibility index for the Chatsworth wells is shown on Map 4.3.M1. The bedrock aquifer in this area is considered to be highly susceptible to contamination primarily due to the thin overburden overlying the bedrock.

<u>WHPA A-D</u>
After overlaying the intrinsic susceptibility index (Map 4.3.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.1.3 for detail). The vulnerability is shown on Map 4.3.G1.3. WHPA-A and WHPA-B of the wellhead protection area contains areas of both high and medium aquifer vulnerability and WHPA-C contains areas of high, medium and low vulnerability.

<u>WHPA-E</u>
The total vulnerability of the WHPA-E associated with the Chatsworth Wells (No. 1 and 2) is comparatively high (8.0). This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.3.G1.2c). The area vulnerability describes the propensity of the on-land area to contribute runoff (percentage of land, land characteristics and transport pathways), which is 8 (moderate) for both wells. The source vulnerability score describes the likelihood that the surface water transports contaminants to the well and is 1.0 (high) for both wells due to lack of overburden protection. Uncertainty for WHPA-E delineation is high (see Section 4.1.7.3 for details).

TABLE 4.3.G1.2c – Vulnerability of WHPA-E Associated with the Chatsworth DWS

Name of WHPA	**CHATSWORTH_1_2**	
DWIS_ID	210003011	
Area (Total), hectares	396.14	
Vulnerability (Total)	**8.0**	
Source Vulnerability	**1.0**	
SV - Distance to surfacing Karst [m]	> 500 m	0.8
SV - Overburden Protection	5.67 m	1.0
Area Vulnerability **	**8 (8.14)**	
AV - Percent Land: Score	**9**	
AV - Percentage of Land	> 70%	9
AV - Land Characteristics	**7.75**	
Land Cover *	Mainly vegetated	7
Soil Type	Moderate loam and organic	8
Soil Permeability *	Highly permeable	7
Setback Slope [%]	13.9%	9
AV Transport Pathways	**7.67**	
Tile Drainage [% of land area]	19%	7
Storm Catchment	< 33%	7
Number of Watercourses/1,000 ha	< 7	9

** Area disregarded if classified "Not categorized"*
*** The Area Vulnerability Score is rounded to full number.*

Threats and Risks

Land uses and activities within the wellhead protection area were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions on how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

WHPA A-D
There are 20 significant drinking water threats in the Chatsworth (Wells No. 1 and 2) wellhead protection area A-D. These threats include 9 activities related to the potential for pathogen contamination, 11 activities related to contamination with hazardous chemicals and no activities related to DNAPLs. The total number of properties with threats is four, all of which are agricultural land uses (see detailed Table 4.3.G1.3 and summary Table 4.3.G1.4).

Among other agricultural activities, the potential for application of agricultural source material and commercial fertilizer to lands within the WHPA was identified. According to the Tables of Drinking Water Threats, application of pesticide to properties in WHPAs A and B with an area of one hectare or larger can also result in a significant chemical threat.

WHPA-E
With surface water influencing the Chatsworth Wells No. 1 and 2, a WHPA-E was delineated. The vulnerability score of this WHPA-E is 8.0, and chemical and pathogen threats can be significant (see Section 4.1.5.7). For chemical threats, no activity in this area meets the quantity circumstances defined in Provincial Table 22: CIPZWE8S. Some activities that discharge sewage (as defined in Provincial Table 48:PIPZWE8S) would be considered pathogen threats, but none were identified in this area. Agricultural activities that have the potential to contaminate surface water with pathogens (as defined in Provincial Table 48: PIPZWE8S) were identified, associated with the handling, storage and application of agricultural source material and non-agricultural source material, as well as with livestock. A total of 4 activities were identified in this area as significant threats to drinking water sources (Table 4.3.G1.3c).

Moderate and Low Threats
Moderate and low threats are not counted individually. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

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TABLE 4.3.G1.3 – Chatsworth: Significant Drinking Water Threats by Activity and Land Use in WHPA A-C (Chemical, Pathogen and DNAPL threats)

Prescribed Threat **WHPA: CHATSWORTH_1_2** *For full legal name of prescribed threat, see Table 4.1.5*		**Land Use Category**									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land	3									**3**
4	Agricultural source material - Storage	2									**2**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
8	Commercial fertilizer - Application to land										
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
12	Road Salt – Application		1								**1**
13	Road Salt – Handling and Storage		1								**1**
14	Snow - Storage										
15	Fuel - Handling and storage										
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards	4									**4**
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
1	Untreated septage - Application to land										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land	3									**3**
4	Agricultural source material - Storage	2									**2**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards	4									**4**

TABLE 4.3.G1.3 – Chatsworth: Significant Drinking Water Threats Associated with the WHPA-E (all land use activities identified are agricultural)

	Prescribed Threat Name *For full legal name of prescribed threat, see Table 4.1.5*		**CHATSWORTH_1_2**
	PATHOGENS		
1	Untreated septage – Application to land		0
3	Agricultural source material - Application to land		2
4	Agricultural source material - Storage		1
6	Non-agricultural source material - Application to land		0
7	Non-agricultural source material - Handling and storage		0
21	Pastures or other farm-animal yards - Livestock	Grazing and pasturing	1
21	Pastures or other farm-animal yards - Livestock	Yards and confinement	0
	Grand Total		**4**

TABLE 4.3.G1.4 – Chatsworth WHPA: Summary of Significant Drinking Water Threats

CHATSWORTH _1_2	**Number of “are or would be significant” threats**				**Number of *properties* with “are or would be significant” threats**			
	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	11	0	9	20	4	0	0	4
WHPA E			4	4	4			4

Quality of Raw Water at the Well

Annual reports for Wells No. 1 and 2 for the years 2004 through 2008, prepared by the Township under O.Reg. 170/03, were reviewed in conjunction with this assessment. These annual reports indicate that both total coliform and *E. coli* bacteria were detected in raw water samples from Wells No. 1 and 2 in each of these years. These results were consistent with the findings of the Engineer's Report (Genivar, 2009a).

The Ontario Drinking Water Quality Standards were not exceeded for the chemical parameters routinely tested for and included in the annual reports. Genivar noted that the nitrate concentrations in the samples from Wells No.1 and 2 were relatively low, typically on the order of 1 mg/l or less. The annual reports did not provide turbidity results for raw water samples. Reported turbidity results on the treated water from the continuous monitors were less than 0.1 NTU. The reports indicated that the water was treated with a 5-micron cartridge filter and disinfected with a UV treatment system (primary) and chlorination (secondary).

In summary, available water quality data for Wells No. 1 and 2 indicated the ongoing occurrence of *E. coli* and total coliform in the raw water. However, because this situation was previously identified and is addressed in the current operation of the water supplies, it was interpreted that this does not constitute a drinking water issue as defined in the Technical Rules. No other potential drinking water issues were identified for Chatsworth Wells No. 1 and 2.

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.3.G1.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.3.G1.5 – Chatsworth: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.3.2.2 Walters Falls Drinking Water System

The community of Walters Falls is currently served by two drilled wells, identified as Well No. 1 and Well No. 2. This distribution system has approximately 45 service connections and supplies water to residences in the hamlet of Walters Falls.

According to the engineering report, the system is under the direct influence of surface water (GUDI). Both wells are categorized as GUDI systems, largely due to fluctuating water quality and episodic bacterial contamination, and the minimum treatment requirement is removal/inactivation of *Cryptosporidium*, *Giardia* and viruses using chemically assisted filtration. The Walters Falls Drinking Water System has equivalent accepted treatment, which are cartridge filtration, UV and chlorination (MOECC, 2009g). Analytical results obtained from the well and from Walters Creek at the Mill Pond were analyzed for various chemical and physical parameters and similar results were obtained, suggesting the creek is having an influence on the well water supply (MOECC, 2009g).

TABLE 4.3.G2.1 – Description of the Drinking Water System and Wells

Well Name	Walters Falls No. 1	Walters Falls No. 2
Drinking Water System ID	220007034	
Drinking Water System Classification	Small Municipal Residential System	
SPA of Well and Vulnerable Area (WHPA)	Grey Sauble SPA	
Northing/Easting	4926006.5 / 523605.5	4926021.9 / 523621.2
Year Constructed	not known	not known
Well Depth	42.7 m	42.7 m
Uncased Interval	7.3 - 42.7 m	8.2 - 42.7 m
Aquifer	Fractured zone	Fractured zone
GUDI	Yes	Yes
Number of Users Served	100	conjunctive
Design Capacity (CoA)	656.64 m^3/day	656.64 m^3/day
Permitted Rate (PTTW)	795 m^3/day	795 m^3/day
Average Usage	40.2 m^3/day 0	conjunctive
Modelled Pumping Rate	51.5 m^3/day	51.5 m^3/day
Treatment	Cartridge filter, ultraviolet primary and 6 % sodium hypochlorite secondary disinfection.	

A wellhead protection area (WHPA) for the Walters Falls DWS was first developed as part of the Grey Bruce Groundwater Study (WHI, 2003). The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates as part of the Township of Chatsworth Groundwater Vulnerability Study (Genivar, 2009a). These pumping rates have been increased to account for projected future growth, and although they represent a large increase on a percentage basis, they do not represent large actual increases.

The two wells are spaced approximately 25 metres apart and are located on the same property within a fenced compound at locations northeast and southwest of the associated pump house and water treatment building. The wells are located on the southeast side of the community, north of the intersection of Grey Road 29 and Deviation Road. The wells are located approximately 170 metres west of the boundary between the Township of Chatsworth and the Municipality of Grey Highlands. The associated water supply system is classified as a small municipal residential system.

Both wells were installed in 1989 on behalf of the Township of Holland. Below the casings, the wells were completed as nominal 200 millimetre (8-inch) diameter open holes in the bedrock, with both wells extending to a depth of approximately 42.7 metres. Approximately 6.7 to 7.3 metres of predominantly clayey soil reportedly overlays the bedrock at the well locations. Bedrock geology mapping indicated that the upper bedrock in the vicinity of the Walters Falls wells are the Amabel formation dolostone but the wells also penetrate the Fossil Hill, Cabot Head and Queenston formations.

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.3.G2.2a and shown on Map 4.3.G2.4. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. For the purposes of calculating managed lands and livestock density, only the portion of the WHPA with a vulnerability score of 6 or more was used in the calculations. The results are listed in Table 4.3.G2.2b and shown on Maps 4.3.G2.5 and 4.3.G2.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.3.G2.2a – Impervious Surfaces

General	Code for WHPA	WALTERS_FALLS_1_2
	Total Area [hectare]	48.76
Impervious Surfaces Area [ha]	0 % – <1%	0.00
	1% – <8%	41.57
	8% – < 80%	7.19
	Larger or equal than 80%	-

Note: Total areas relate to the full WHPA, even if located in other municipalities

TABLE 4.3.G2.2b – Managed Land and Livestock Density

WHPA_NAME	WALTERS_FALLS_1_2			
Well Name	No. 1&2	No. 1&2	No. 1&2	No. 1&2
Zone	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	0.5-1.0
% Managed Lands (<40%, 40-80%, >80%)	40-80%	>80%	>80%	>80%

Wellhead Protection Area

The wellhead protection area (WHPA) was estimated following the methodology described in Section 4.1.2.5. It extends predominantly in an easterly direction, to a maximum distance of approximately 1200 metres from the municipal wells (Map 4.3.G2.1). WHPA-A is the 100 metre circle around the well and WHPA-B is a 50 metre semi-circle extending to the east of WHPA-A. The area for the capture zones is 3.6 ha for the 100 m radius of WHPA-A, 3.7 ha for WHPA-B, 8.1 ha for WHPA-C, and 48.7 ha for WHPA-D, which is the full 25-year ToT capture zone. Part of the capture zone falls within the Niagara Escarpment Plan area.

Municipal parcel mapping for the vicinity of the Walters Falls wells identified twelve separate properties that are located partially or fully within the identified WHPA. In addition to these properties, the WHPA also contains transportation corridors associated with road allowances.

WHPA-E was delineated in the surface water body that influences this GUDI well. Walters Creek and Mills Pond are identified as influencing both of the municipal wells (MOECC, 2003b), and the point of interaction was identified within Mills Pond. The WHPA-E extends upstream and includes all tributaries within the 2-hour ToT. A 120 metre setback or the regulation limit, and areas with agricultural tile drainage were added (for details, see Section 4.1.2.7).

Map 4.3.G2.2 shows the borders of all zones of WHPA overlaid on aerial photography.

Transport Pathways

The vulnerability of the WHPA must be increased if pathways exist that transport contaminants from the surface into the aquifer that is a source for drinking water (see Section 4.1.2.6), unless the vulnerability is already rated “high”.

The entire WHPA is situated within an area previously identified as having high groundwater vulnerability, primarily as a result of relatively thin overburden and the occurrence of bedrock outcrops. As a result, there was no potential to increase the rating of the aquifer vulnerability based on the presence of transport pathways.

No transport pathway adjustments were made to aquifer vulnerability in the Walters Falls WHPA. Existing properties have wells that are in compliance with existing standards.

Vulnerability

The intrinsic susceptibility index for the Walters Falls wells, and for the complete municipality, is shown on Map 4.3.M1. The entirety of WHPAs A-D are located within an area identified as having high groundwater vulnerability. This is primarily due to thin overburden and exposed bedrock in the area.

After overlaying the intrinsic susceptibility index (Map 4.3.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.1.3 for detail). The vulnerability is shown on Map 4.3.G2.3.

WHPA-E

The total vulnerability of the WHPA-E associated with the Walters Falls well is comparatively high (8.0). This score was determined by multiplying the area vulnerability score with the source vulnerability score (Table 4.3.G2.2c). This score was determined by multiplying the area vulnerability score with the source vulnerability score (Table 4.3.G2.2c). The area vulnerability describes the propensity of the on-land area to contribute runoff (percentage of land, land characteristics and transport pathways), which is 8 (moderate). The source vulnerability score describes the likelihood that the surface water transports contaminants to the well and is 1.0 (high) due to karst exposure.

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.3 for details).

Threats and Risks

Land uses and activities within the wellhead protection area were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

WHPA A-D

There are 4 significant drinking water threats in the Walters Falls (Wells No. 1 and 2) wellhead protection area A-D. These threats include 1 activities related to the potential for pathogen contamination and 3 activities related to contamination with hazardous chemicals. The total number of properties with threats is three (see detailed Table 4.3.G2.3a,b and summary Table 4.3.G2.4).

WHPA-E

With surface water influencing the Walters Falls Wells No. 1 and 2, a WHPA-E was delineated. The vulnerability score of this WHPA-E is 8.0, and chemical and pathogen threats can be significant (see Section 4.1.5.7). For chemical threats, no activity in this area meets the quantity circumstances defined in Provincial Table22: CIPZWE8S. Some activities that discharge sewage (as defined in Provincial Table 24: PIPZWE8S) would be considered pathogen threats, but none were identified in this area. Agricultural activities that have the potential to contaminate surface water with pathogens (as defined in Provincial Table 48: PIPZWE8S) were identified, associated with the handling, storage and application of agricultural source material and non-agricultural source material, as well as with livestock. A total of 1 activity was identified in this area as significant threats to drinking water sources (Table 4.3.G2.3b).

TABLE 4.3.G2.2c – Vulnerability of WHPA-E Associated with the Walters Falls DWS

Name of WHPA	**WALTERS_FALLS_1_2**	
DWIS_ID	220007034	
Area (Total), hectares	461.82	
Vulnerability (Total)	**8.0**	
Source Vulnerability	**1.0**	
SV - Distance to surfacing karst [m]	< 250 m	1
SV - Overburden Protection	1.03 m	1.0
Area Vulnerability **	**8 (8.03)**	
AV - Percent Land: Score	**9**	
AV - Percentage of Land	> 70%	9
AV - Land Characteristics	**7.75**	
Land Cover *	Mainly vegetated	7
Soil Type	Moderate loam and organic	8
Soil Permeability *	Highly permeable	7
Setback Slope [%]	12.7%	9
AV Transport Pathways	**7.33**	
Tile Drainage [% of land area]	36%	8
Storm Catchment	< 33%	7
Number of Watercourses/1,000 ha	0-3	7

** Area disregarded if classified "Not categorized"*
*** The Area Vulnerability Score is rounded to full number*

<u>Moderate and Low Threats</u>

Moderate and low threats are not counted individually. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

TABLE 4.3.G2.3a – Walters Falls: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL threats)

Prescribed Threat **WHPA: WALTERS_FALLS_1_2** *For full legal name of prescribed threat, see Table 4.1.5*		**Land Use Category**									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land	1									**1**
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
8	Commercial fertilizer - Application to land										
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
14	Snow - Storage										
15	Fuel - Handling and storage						1				**1**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
1	Untreated septage - Application to land										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								1		**1**
3	Agricultural source material - Application to land	1									**1**
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards										

TABLE 4.3.G2.3b – Walters Falls: Significant Drinking Water Threats Associated with the WHPA-E (all land use activities identified are agricultural)

Prescribed Threat Name *For full legal name of prescribed threat, see Table 4.1.5*			**WALTERS_FALLS_1_2**
	PATHOGENS		
1	Untreated septage – Application to land		0
3	Agricultural source material - Application to land		0
4	Agricultural source material - Storage		0
6	Non-agricultural source material - Application to land		0
7	Non-agricultural source material - Handling and storage		0
21	Pastures or other farm-animal yards - Livestock	Grazing and pasturing	1
21	Pastures or other farm-animal yards - Livestock	Yards and confinement	0
	Grand Total		**1**

TABLE 4.3.G2.4 – Walters Falls WHPA: Summary of Significant Drinking Water Threats

WALTERS FALLS _1_2	**Number of “are or would be significant” threats**				**Number of properties with “are or would be significant” threats**			
	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	3	0	1	4	1	1	1	3
WHPA-E			1	1	1			1

Quality of Raw Water at the Well

Annual reports for Wells No. 1 and 2 were prepared by the Township under O.Reg. 170/03, for the years 2004 to 2008. These were reviewed in conjunction with this assessment. These annual reports indicate that total coliform bacteria were detected in raw water samples from Wells No. 1 and 2 in each of these years. *E. coli* bacteria were detected in samples from Well No. 2 in each of these years and in samples from Well No. 1 in 2006, 2007 and 2008. The more recent test results indicate the ongoing occurrence of total coliform and *E. coli* bacteria in the raw water samples from Wells No. 1 and 2, and are consistent with the findings of the Engineer's Report (Genivar, 2009a).

With the exception of turbidity, the Ontario Drinking Water Quality Standards were not exceeded for the chemical parameters routinely tested for and included in the annual reports. Reported nitrate concentrations in the annual reports for 2004 to 2008 ranged from 2.01 to 3.26 mg/L for nine separate sample results and did not indicate an increasing trend (Genivar, 2009a).

In summary, available water quality data for Wells No. 1 and 2 indicate the ongoing occurrence of *E. coli* and total coliform in the raw water. However, because this situation was previously identified and is addressed in the current operation of the water supplies, it was interpreted that this does not constitute a drinking water issue as defined in the Technical Rules. No other potential drinking water issues were identified for Walters Falls Wells No. 1 and 2.

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.3.G2.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.3.G2.5 – Walters Falls: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.3.3 Surface Water Municipal Systems

No municipal drinking water systems that use surface water exist in this municipality.

4.2.4 Township of Georgian Bluffs

The Township of Georgian Bluffs borders the City of Owen Sound to the south, west and north. The Township is located in the northwest part of the County of Grey, entirely in the Grey Sauble Source Protection Area. The Georgian Bay shoreline surrounds the Township to the east and north. The Township has a mix of urban, rural and agricultural land including commercial/industrial development and several defined settlement areas, as well as many recreation areas. In 2016, the population was 10,479, a decrease of 0.3% from 2006. The main towns are Shallow Lake (population 487) and Kilsyth (population 100). Smaller settlement areas include Keady, Rockford, Springmount, Jackson, Balmy Beach, and Clavering.

The Township of Georgian Bluffs is currently operating a total of three separate municipal water supply systems, of which two are groundwater based and one is surface water based. The current groundwater based systems include the Pottawatomi Village Water Treatment Plant and the Shallow Lake Water Treatment Plant, both of which are designated as GUDI. The surface water based system is the East Linton Water Treatment Plant. No new drinking water systems are planned. A second surface water system, Presqu'ile has recently been decommissioned but is included in this report because it appears in the approved Terms of Reference document.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.4.M1.

4.2.4.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.4.M2 indicates the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. With negligible exceptions, the complete Township of Georgian Bluffs is designated an HVA because of permeable and thin overburdens and surfacing karst, especially along the Niagara Escarpment.

Significant groundwater recharge areas in Georgian Bluffs are mostly associated with surfacing karst. Geologically, these are associated with the Amabel formation on top of the Niagara Escarpment and with the Clinton/Cataract Group below the Escarpment. A large number of wetlands on top of the Escarpment are connected to groundwater through karstic bedrock, which makes it difficult to determine the wetland areas that are actually fed by groundwater and that feed into the groundwater as recharge. It is probable that these wetlands are connected to groundwater and function both as recharge/discharge areas, depending on the time of the year, precipitation and groundwater level. As such, wetland areas around Shallow Lake, the Long Swamp Complex and the Sydenham River Lowlands should be regarded with care because the temporal and spatial resolution of data is insufficient for final delineation. Also, the lakeshore areas between Balmy Beach and Kemble are SGRAs because of their karstic nature.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.4.M3).

In this municipality, the total area of SGRAs is 148.6 km^2 and the total area of HVAs is 549.2 km^2. The percentage of managed lands located within the SGRAs and HVAs is 40-80%. The livestock density is less than 0.5 NU/acre. Only 1-8% of all surfaces in SGRAs and HVAs are classified as impervious (Table 4.2.4.1).

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

TABLE 4.2.4.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Township of Georgian Bluffs

SGRA	Total Area of SGRA	155.1km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces average)	1-8 %
HVA	Total Area of HVA	549.2 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

4.2.4.2 Groundwater Municipal Systems

4.2.4.2.1 Pottawatomi Village Water Treatment Plant

The Pottawatomi Village Water Treatment Plant is located west of the City of Owen Sound in the Township of Georgian Bluffs. It is comprised of two bedrock wells that were both constructed in 1987: Well No. 1, a capped standby well, and Well No. 2, the current operating well. Well No. 2 is 54.8 metres (m) deep and is cased to a depth of 29.5 m. This well is located in a subdivision on the west side of Owen Sound, 600 meters north of Highway 21.

The geology of the Pottawatomi Well No. 2, as derived from well records, indicates a thin 1.8 m overburden of permeable sand, underlain by 27.5 m of soft clay and rock. Beneath this, the well is drilled into a series of bedrock formations. Presumably, between 29.3 to 38.4 m exists of the limestone Manitoulin formation, which is labelled as Blue rock shale in the well log. From 38.4 to 54.8 m, the well encounters the blue and red series of the Queenston shale formations. Both of these formations contribute water to the well (Henderson and Paddon, 1987).

A GUDI assessment has not been completed therefore this well was given GUDI status. In this well, turbidity levels tend to rise following precipitation events, suggesting pronounced surface water influence (MOECC, 2005b). Also, the distance of the well to the Pottawatomi River is below the GUDI criteria. However, an earlier Engineer's Report for the Pottawatomi Village Well Supply (Gamsby and Mannerow, 2001a) indicated that there is no significant potential for microbiological contamination.

TABLE 4.4.G1.1 – Description of the Drinking Water System and Wells

Well Name	Pottawatomi No. 2
Drinking Water System ID	220008319
Drinking Water System Classification	Small Municipal Residential System
SPA of Well and Vulnerable Area (WHPA)	Grey Sauble SPA
Northing/Easting	4934735.8 / 502387.4
Year Constructed	1987
Well Depth	> 55 m
Uncased Interval	29.5 - 54.8 m
Aquifer	Manitoulin bedrock
GUDI	Yes
Number of Users Served	50
Design Capacity (CoA)	170 m^3/day
Permitted Rate (PTTW)	93 m^3/day
Average Usage *	25 m^3/day
Modelled Pumping Rate	29 m^3/day
Treatment	Cartridge filtration (5 micron), UV disinfection (3 Hallet UV Pure Model 30 units), chlorination sodium hypochlorite) and iron sequestering (sodium silicate)

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A wellhead protection area (WHPA) for the Pottawatomi well was first developed as part of the Grey Bruce Groundwater Study (WHI 2003). The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates based on projected population growth as part of the Round 1 Technical Study for the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region (CRA 2007).

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.4.G1.2a and shown on Map 4.4.G1.4. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. For the purposes of calculating managed lands and livestock density, only the portion of the WHPA with a vulnerability score of 6 or more was used in the calculations. The results are listed in Table 4.4.G1.2b and shown on Maps 4.4.G1.5 and 4.4.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.4.G1.2a – Impervious Surfaces

General	Code for WHPA	POTTAWATOMI_2
	Total Area [hectare]	10.04
Impervious Surfaces Area [ha]	0 % – <1%	0.00
	1% – <8%	4.32
	8% – < 80%	5.72
	Larger or equal than 80%	-

Note: Total areas relate to the full WHPA, even if located in other municipalities

TABLE 4.4.G1.2b – Managed Land and Livestock Density

WHPA_NAME	**POTTAWATOMI_2**			
Well Name	No. 2	No. 2	No. 2	No. 2
Zone	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	>1.0
% Managed Lands (<40%, 40-80%, >80%)	<40%	<40%	<40%	>80%

Wellhead Protection Area

The wellhead protection area (WHPA) was estimated following the methodology described in Section 4.1.2.5. The WHPA for the Pottawatomi system is the second smallest WHPA investigated under this study (Map 4.4.G1.1). It extends west of the well 800 metres. WHPAs A and B are all residential properties. WHPAs C and D consist of residential and agricultural land.

A WHPA-E was delineated in the surface water body that influences this GUDI well. To identify the point of interaction, the surface water body closest to the well was identified, a small, temporary creek north of the well. Another point of interaction was indicated by the Engineering study for the Pottawatomi River. The WHPA-E extends 5.2 km in the upstream direction of the river into the Long Swamp, and includes all tributaries within the two-hour ToT. A 120 metre setback or the regulation limit, and areas with agricultural tile drainage were added (for details, see Section 4.1.2.7).

Map 4.4.G1.2 shows the borders of all zones of the WHPA overlaid on aerial photography.

Transport Pathways

The vulnerability of the WHPA must be increased if pathways exist that transport contaminants from the surface into the aquifer that is a source for drinking water (see Section 4.1.2.6), unless the vulnerability is already rated “high”.

No transport pathway adjustments were made to aquifer vulnerability in the Pottawatomi WHPA. Existing properties are either on municipal services, or have wells that are in compliance with existing standards. However, aquifer vulnerability in this area is already high.

Vulnerability

<u>WHPA A-D</u>
The WHPA for the Pottawatomi system is located in an area of medium to high intrinsic susceptibility, as shown in the regional scale intrinsic susceptibility index mapping (Map 4.4.M1), which is likely a result of the presence of a thin, coarse grained overburden material in the area. Vulnerability decreases with distance from the supply well, which is located in the village. The village, located in WHPAs A and B, is on individual septic systems to treat and discharge waste water.

After overlaying the intrinsic susceptibility index (Map 4.4.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.1.3 for detail). The vulnerability is shown in Map 4.4.G1.3. The vulnerability in zone D, which represents 60% of the total WHPA, scores a six due to the high ISI index. However, according to the Engineer's Report (Gamsby and Mannerow, 2001a), the presence of 25.6 to 27.4 m of sandy, stony clay overburden in the vicinity of the well, which overlies the shale aquifer, likely provides some degree of natural protection for the aquifer.

<u>WHPA-E</u>
The total vulnerability of the WHPA-E associated with the Pottawatomi well is moderate (7.2). This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.4.G1.2c). The area vulnerability describes the propensity of the on-land area to contribute runoff (percentage of land, land characteristics and transport pathways), which is 8 (moderate). The source vulnerability score describes the likelihood that the surface water transports contaminants to the well and is 0.9 (moderate).

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.3 for details).

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TABLE 4.4.G1.2c – Vulnerability of WHPA-E Associated with the Pottawatomi DWS

Name of WHPA	POTTAWATOMI_2	
DWIS_ID	220008319	
Area (Total), hectares	442.18	
Vulnerability (Total)	**7.2**	
Source Vulnerability	**0.9**	
SV - Distance to surfacing karst [m]	>500m	0.8
SV - Overburden Protection	14.94 m	0.9
Area Vulnerability	**8 (8.2)**	
AV - Percent Land: Score	**9**	
AV - Percentage of Land	> 70%	9
AV - Land Characteristics	**8.0**	
Land Cover*	40% Agricultural, 10% Developed, 60% Natural	7.5
Soil Type	15.5% diamicton, 31.6% organic deposits, 18.7% bedrock, 11.5% sand,	8.0
Soil Permeability *	1.8% A, 6.5% B, 39.7% C, 52% D	8.6
Slope [%]	2.5%	8.0
AV Transport Pathways	**7.7**	
Tile Drainage [% of land area]	0.9%	7
Storm Catchment	None	7
Number of Watercourses/1,000 ha	9.0	

** Area disregarded if classified "Not categorized"*
*** The Area Vulnerability Score is rounded to full number. In brackets, value rounded to 1 digit is shown.*

Threats and Risks

Land uses and activities within the wellhead protection area were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

WHPA A-D

There are 26 significant drinking water threats in the Pottawatomi (Well No. 2) wellhead protection area A-D. These threats include 13 activities related to the potential for pathogen contamination and 13 activities related to contamination with hazardous chemicals. The total number of properties with threats is 13, all of which are residential (see detailed Table 4.4.G1.3 and summary Table 4.4.G1.4).

The land surrounding the well is all residential properties. The significant threats for zones A and B for the Pottawatomi WHPA include sewage system and storage of fuel. WHPAs C and D are located in agricultural land and there are no significant threats within these capture zones. However, these areas were considered for the computation of managed lands and nutrient units.

WHPA-E
The vulnerability of this WHPA-E is 7.2, so the risk level of any activity cannot exceed "moderate".

Moderate and Low Threats
Moderate and low threats are not counted individually. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

Quality of Raw Water at the Well

According to the operators, the raw water of the Pottawatomi well, which extracts groundwater from the Manitoulin dolostone and the Queenston shale, at times has elevated levels of iron and hardness above the aesthetical drinking water standards (MOECC, 2003a, ODWQS, Table 4). This is typical for such aquifers and is dealt with by treatment (iron sequestration, micro filtration).

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TABLE 4.4.G1.3 – Pottawatomi: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen threats. No DNAPL threats)

Prescribed Threat **WHPA: POTTAWATOMI_2** *For full legal name of prescribed threat, see Table 4.1.5*		**Land Use Category**									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site								13		**13**
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land										
6	Non-agricultural source material - Application to land										
8	Commercial fertilizer - Application to land										
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
14	Snow - Storage										
15	Fuel - Handling and storage										
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards - Livestock grazing										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								13		**13**
3	Agricultural source material - Application to land										
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards - Livestock grazing										

TABLE 4.4.G1.4 – Pottawatomi WHPA: Summary of Significant Drinking Water Threats

	Number of "are or would be significant" threats				Number of *properties* with "are or would be significant" threats			
POTTAWATOMI 2	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	13	0	13	26	0	13	0	13
WHPA-E				0				0

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.4.G1.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.4.G1.5 – Pottawatomi: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.4.2.2 Shallow Lake Water Treatment Plant

The Shallow Lake Water Treatment Plant is located in the former Village of Shallow Lake in the Township of Georgian Bluffs and is comprised of two bedrock wells: Well No. 2, constructed in 1996, and Well No. 3, constructed in 1999. Both wells are located northeast of Shallow Lake, two kilometres east of Bruce Road 10 and 500 metres south of Hwy 6. Well No. 1, a reserve well, was disconnected from the system in 1999. Well No. 2 is 46.9 m deep and is cased to a depth of 21.3 m. Well No. 3 is 61 m deep and is cased to a depth of 15.2 m.

According to the Engineer's Report (Gamsby and Mannerow, 2001b), Shallow Lake Well Nos. 2 and 3 draw water from a fractured bedrock aquifer in an area of karst topography. Due to the relatively meagre thickness of this layer and the presence of water-filled depressions in the WHPA, windows through the confining layer are expected to exist. Bedrock at these well locations is limestone of the Guelph and Amabel formations as well as Fossil Hill limestone. At the bottom of the drilled holes, the Shallow Lake wells encounter shale from the Cabot Head formation.

The raw water quality is generally poor, both bacteriologically and chemically, and has been confirmed GUDI due to the presence of high turbidity, total coliform, and Dissolved Oxygen – concentration in the raw water supply (Gamsby and Mannerow, 2001b).

TABLE 4.4.G2.1 – Description of the Drinking Water System and Wells

Well Name	Shallow Lake No. 2	Shallow Lake No. 3
Drinking Water System ID	220009096	
Drinking Water System Classification	Large Municipal Residential System	
SPA of Well and Vulnerable Area (WHPA)	Grey Sauble SPA	
Northing/Easting	4940744.5 / 491418.4	4940679.8 / 491272.1
Year Constructed	1996	1999
Well Depth	61 m	49.9 m
Uncased Interval	15.2 - 61 m	21.3 - 49.9 m
Aquifer	Guelph/Amabel, Fossil Hill	
GUDI	Yes	Yes
Number of Users Served	500	conjunctive
Design Capacity (CoA)	696.384 m^3/day	696.384 m^3/day
Permitted Rate (PTTW)	696 m^3/day	696 m^3/day
Average Usage	260 m^3/day	conjunctive m^3/day
Modelled Pumping Rate	175 m^3/day	175 m^3/day
Treatment	Iron and manganese removal, Conventional filtration, Sodium hypochlorite Chlorination	

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A wellhead protection area (WHPA) for the Shallow Lake wells was first developed as part of the Grey Bruce Groundwater Study (WHI, 2003). The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates to account for proposed future pumping rates as part of the Round 1 Technical Study for the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region (CRA, 2007).

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.4.G2.2a and shown on Map 4.4.G2.4. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. For the purposes of calculating managed lands and livestock density, only the portion of the WHPA with a vulnerability score of 6 or more was used in the calculations. The results are listed in Table 4.4.G2.2b and shown on Maps 4.4.G2.5 and 4.4.G2.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.4.G2.2a – Impervious Surfaces

General	Code for WHPA	SHALLOW LAKE
	Total Area [hectare]	59.25
Impervious Surfaces Area [ha]	0 % – <1%	0.00
	1% – <8%	1.44
	8% – < 80%	57.81
	Larger or equal than 80%	0.00

TABLE 4.4.G2.2b – Managed Land and Livestock Density

WHPA_NAME	**SHALLOW LAKE_2_3**			
Well Name	No. 2_3	No. 2_3	No. 2_3	No. 2_3
Zone	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	<0.5
% Managed Lands (<40%, 40-80%, >80%)	<40%	<40%	<40%	40-80%

Wellhead Protection Area

The wellhead protection area (WHPA) was estimated following the methodology described in Section 4.1.2.5. The Shallow Lake WHPA is located in a rural area east of the built up area around the shores of Shallow Lake (Map 4.4.G2.1). The WHPA for Shallow Lake is egg-shaped and it extends northeast and southwest of the wells. The land use in WHPAs A and B is woodland. WHPAs C and D have industrial, residential and agricultural properties.

WHPA-E was delineated in the surface water body that influences these GUDI wells. The closest surface water to the Shallow Lake wells are wetland areas without surface water drainage in an area dominated by karst. To identify the points of interaction, Technical Rule 47(5a) was applied and the points closest to the wells were identified within these wetlands. The WHPA-E includes the wetland and a drainage channel into this wetland, both within the two-hour ToT. A 120 metre setback was added (for details, see Section 4.1.2.7).

Map 4.4.G2.2 shows the borders of all zones of WHPA overlaid on aerial photography.

Transport Pathways

The vulnerability of the WHPA must be increased if pathways exist that transport contaminants from the surface into the aquifer that is a source for drinking water (see Section 4.1.2.6), unless the vulnerability is already rated “high”.

No transport pathway adjustments were made to aquifer vulnerability in the Shallow Lake WHPA. This area is under heavy influence to surface water and aquifer vulnerability is very high. It is unlikely that any of the wells would increase the vulnerability of the aquifer being exploited by the municipal well.

Vulnerability

<u>WHPA A-D</u>
The Shallow Lake wells draw water from a fractured bedrock aquifer in an area of karst topography. Thus, at the regional scale, the area exhibits a high intrinsic susceptibility index due to the thin overburden and karstic conditions in the area (Map 4.4.M1).

After overlaying the intrinsic susceptibility index (Map 4.4.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.1.3 for detail). The vulnerability is shown on Map 4.4.G2.3. Overall, the Shallow Lake WHPA is moderately vulnerable to surface (or near surface) contamination, with 60% of the total area scoring between five and seven.

<u>WHPA-E</u>
The total vulnerability of the WHPA-E associated with the Shallow Lake wells is comparatively high (8.0). This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.4.G2.2c). The area vulnerability describes the propensity of the on-land area to contribute runoff (percentage of land, land characteristics and transport pathways), which is 8 (moderate). The source vulnerability score describes the likelihood that the surface water transports contaminants to the well and is 1.0 (high) due to its vicinity to karst.

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.3 for details).

TABLE 4.4.G2.2c – Vulnerability of WHPA-E Associated with the Shallow Lake DWS

Name of WHPA	**SHALLOWLAKE_2_3**	
DWIS_ID	220009096	
Area (Total), hectares	25.76	
Vulnerability (Total)	**8.0**	
Source Vulnerability	**1.0**	
SV - Distance to surfacing karst [m]	<250m	1
SV - Overburden Protection	4.26 m	1.0
Area Vulnerability	**8 (8.1)**	
AV - Percent Land: Score	**9**	
AV - Percentage of Land	> 70%	9
AV - Land Characteristics	**7.6**	
Land Cover*	50% Agricultural, 10% Developed, 50% Natural	7.6
Soil Type	20.2% diamicton, 35.2% gravel, 44.6% sand,	7.1
Soil Permeability *	100% B,	7.7
Slope [%]	4.2%	8.0
AV Transport Pathways	**7.7**	
Tile Drainage [% of land area]	0.0%	7
Storm Catchment	None	7
Number of Watercourses/1,000 ha	9.0	

** Area disregarded if classified "Not categorized"*
*** The Area Vulnerability Score is rounded to full number. In brackets, value rounded to 1 digit is shown*

Threats and Risks

Land uses and activities within the wellhead protection area were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

WHPA A-D
There are no significant drinking water threats for this system (see detailed Table 4.4.G2.3).

WHPA-E
With surface water influencing the Shallow Lake wells, a WHPA-E was delineated. The vulnerability score of this WHPA-E is 8.0, and chemical and pathogen threats can be significant (see Section 4.1.5.7). For chemical threats, no activity in this area meets the quantity circumstances defined in Provincial Table 22: CIPZWE8S. Some activities that discharge sewage (as defined in Provincial Table 48: PIPZWE8S) would be considered pathogen threats,

but none were identified in this area. Agricultural activities have the potential to contaminate surface water with pathogens (as defined in Provincial Table 48: PIPZWE8S), if they engage in activities such as the handling, storage and application of agricultural source material and non-agricultural source material, as well as with livestock. No pathogen threats were identified in this WHPA-E, and the total number of significant threats associated with the WHPA-E is zero.

Moderate and Low Threats

Moderate and low threats are not counted individually. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

Quality of Raw Water at the Well

According to the Engineer's Report (Gamsby and Mannerow, 2001b), Shallow Lake Well Nos. 2 and 3 draw water from a fractured bedrock aquifer in an area of karst topography. The raw water quality is generally poor, both bacteriologically and chemically, and has been confirmed groundwater under the direct influence of surface water (GUDI) due to the presence of high turbidity, total coliform and dissolved organic carbon (DOC) in the raw water supply.

TABLE 4.4.G2.4 – Shallow Lake WHPA: Summary of Significant Drinking Water Threats

	Number of “are or would be significant” threats				**Number of *properties* with “are or would be significant” threats**			
SHALLOW LAKE 2&3	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	0	0	0	0	0	0	0	0
WHPA-E				0				0

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.4.G2.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.4.G2.5 – Shallow Lake: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.4.3 Surface Water Municipal Systems

4.2.4.3.1 Presqu’ile Water Treatment Plant

The Owner decommissioned the Presqu’ile WTP for treatment on January 11, 2011. The Presqu’ile connections now receive their treated drinking water from the East Linton WTP.

4.2.4.3.2 East Linton Water Treatment Plant

The East Linton Water Treatment Plant (WTP) currently services approximately 321 connections. The area is in Phase 1 of a planned development that will result in the addition of 557 equivalent residential units. In the future, it is expected that once Phase 2 of the expansion is completed, the WTP would service up to 1,500 equivalent residential units. In February 2011 the Presqu’ile drinking water system's distribution was connected to the East Linton WTP's distribution (MOECC, 2011b). It is classified as Great Lakes (Type A) intake for a large municipal residential system.

The East Linton WTP facility uses a treatment process involving chemically assisted coagulation, flocculation, dual media filtration, ultraviolet disinfection, and chlorine disinfection. Treated and backwash water pumped from the site are sent to an in-ground reservoir. Backwash water is collected and decanted to a percolation lagoon. Standby power is available for the treatment plant but not provided for the low lift pumping station. Chemicals used in the treatment process include polyaluminum chloride as a coagulation agent and sodium hypochlorite for disinfection purposes. The facility is categorized as a large municipal drinking water system.

The intake for the East Linton WTP is located at 44.6433° latitude and 80.9297° longitude. The intake crib has an approximate depth of 4.3 m, at a lake depth of 4.9 m. The approved intake capacity is 786 m^3/day.

Managed Land, Livestock Density and Impervious Surfaces

Following the methodology outlined in Section 4.1.4, the percentage of managed land, the livestock density (nutrient units per acre) and the percentage of impervious surfaces was computed for each wellhead protection area. Computation results are listed in Table 4.4.S2.1b and in Maps 4.4.S2.4, 5 and 6.

The East Linton WTP intake protection zone is classified as an area where the percentage of managed land of the vulnerable area are at least 40%, but not more than 80% and the livestock density is less than 0.5 NU/acre. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.4.S2.1 – Description of the Drinking Water System

Intake Name	**East Linton WTP intake**
Drinking Water System ID	220007659
Drinking Water System Classification	Large Municipal Residential System
Intake Type	A (Great Lakes)
SPA of Intake and Vulnerable Area (IPZ)	Grey Sauble
Northing/Easting of Intake	505574.99 / 4943329.2
Intake Pipe Length*	170 m
Lake Depth at Intake *	4.9 m
Depth of Top of Intake Crib *	4.3 m
Number of Users Served	900
Intake Capacity	786 m^3/day
Average Annual Usage**	175 m^3/day
Maximum Usage**	444 m^3/day

** Elevations measured from plan & profile drawings (Gamsby and Mannerow, April 20, 1993) and converted to International Great Lakes Datum 1985 (IGLD 85) by comparing recorded water levels with historical information from US Army Corps of Engineers (Stantec 2009, Phase 1 Technical Addendum)*
*** MOECC, 2009h*

Intake Protection Zone

The East Linton Drinking Water System uses raw water from an intake located in Georgian Bay and is classified as a Great Lakes (Type A) intake. For the in-water portion of the IPZ-1 of a Type A intake, the Technical Rules prescribe to delineate the IPZ as a circle with a radius of 1000 meters from the entry point where raw water enters the drinking water system (see Section 4.1.2.4, Offshore component). Where the IPZ-1 abutted land and was not impacted by a riverine or transport pathway, it extended 120 m inland as it was greater than the area of the regulation limit (Stantec 2009, Phase 1 Technical Addendum). For IPZ-1, the onshore area is 0.2 km^2 and the offshore area 1.8 km^2. The shoreline of IPZ-1 is nearly 2,000 m long.

The East Linton IPZ-2 extends 3,652 m north of the intake, 4,522 m south of the intake and 1,000 m offshore at its furthest point. Where the IPZ-2 abutted land and was not impacted by a riverine or transport pathway, it extended inland 120 m as this was generally greater than the area of the regulation limit. Where the regulation limit was greater than the 120 m setback, the regulation limit was used (Stantec 2009, Phase 1 Technical Addendum). The shoreline of IPZ-2 is approximately 8,700 m long. The up-tributary extent of Indian Creek, as well as seven other unnamed water courses, falls within the 2-hour ToT contour of the intake. Depending on the confluence point, the up-tributary distance varies, taking up to 4.7 km with the appropriate setback (Stantec 2009, Phase 1 Technical Addendum).
For IPZ-2, the resulting onshore area is 3.7 km^2 and the offshore area 6.2 km^2. The full IPZ is shown on Map 4.4.S2.2 and on Map 4.4.S2.3 with underlying aerial photography.

TABLE 4.4.S2.1b – Managed Land, Livestock Density and Impervious Surfaces

General	IPZ ID	EAST_LINTON
	Area Total [hectare]	993.73
	Area Offshore [hectare]	612.59
	Area Onshore [hectare]	381.13
IPZ 1 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	24.75
	Livestock Density [NU/Acre]	0.29
	Managed Land Area [hectare]	4.72
	% Managed Lands	19.07
	Category	**ML% <40%, NU/acre <0.5**
IPZ 2 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	289.30
	Livestock Density [NU/Acre]	0.14
	Managed Land Area [hectare]	289.30
	% Managed Lands	65.35
	Category	**ML% 40%-80%, NU/acre <0.5**
Impervious Surface: Area per category [hectare]	0 % – <1%	33.59
	1% – <8%	200.71
	8% – < 80%	233.04
	Larger or equal than 80%	0.00

Note: All areas relate to the full IPZ including other municipalities.

An IPZ-3 and an EBA were delineated for based on modelled spill scenarios and desktop assessment. Using the methodology described in section 4.1.2.4, minimum volumes that would result in exceedances were determined for locations distributed around the East Linton IPZ-2. Spill locations were selected based on pathways restricted to the East Linton intake so as not overlap with the existing EBA boundaries for the Owen Sound intake. Volumes ranged from 2,500 L to 10,000 L and were split into three EBA categories (see map 4.4.S2.9);

- 2,500 L and greater
- 5,000 L and greater
- 10,000 L and greater

Storm Sewer Systems and Transport Pathways

The onshore component of the intake protection zone includes properties that drain into storm sewersheds within a 2-hour ToT, and other transport pathways (Section 4.1.2.6). No storm sewer systems are known to exist in this area, and no other transport pathways were identified (Stantec 2009, Phase 1 Technical Addendum).

Inliers are small areas that are fully enclosed within IPZ onshore components. Following the method outlined in Section 4.1.2.4, inliers with areas less than 10 ha were added to the IPZ without further study, while the existence of preferential pathways (ditches, storm sewers) were confirmed in inliers with larger spatial extent.

Vulnerability

Vulnerability of the protection zone of the surface water intake was delineated following the methodology described in Section 4.1.3.5. Two factors measuring the vulnerability of the area and of the raw water source are computed separately and then multiplied with each other.

Area Vulnerability Factor

The area vulnerability factor for IPZ-1 is ten, as prescribed by the Technical Rules. For IPZ-2, the area vulnerability factor is determined by averaging, with equal weighting, the percentage of land, land characteristics and transport pathways sub factors (Table 4.4.S2.2a).

TABLE 4.4.S2.2a – Area Vulnerability Factor for the East Linton Intake

Area Vulnerability Factor Rating *(Rounded average of percentage of land, land characteristics and Transport Pathways)*	**8**
Percentage of Land	8
Land Characteristics	7.8
Land Cover	8
Soil Type	8
Permeability	7
Setback Slope	8
Transport Pathways	7.7
Storm Catchment Areas *(less than 33%)*	7
Storm Outfalls, Watercourses, Drains (The number of storm outfalls, watercourses and drains per 1000 ha is larger than 7)	9
Tile Drained Area (less than 33 %)	7

Percentage of Land

The % land sub factor has been divided equally between the three ranges outlined in the Technical Rules (< 33% = 7, 33% – 66% = 8, > 66% = 9). The East Linton WTP has approximately 43% land area and therefore the % land sub factor has a score of 8.

Land Characteristics

The land characteristic sub factor has the components; land cover, soil type, permeability, and slope. The land characteristics sub factor can be derived from the average of the ratings for the four components.

Land Cover The land cover rating ranges from seven to nine and has been divided into; mainly vegetated (7), mixed vegetated and developed (8) and mainly developed (9). Land in the upland portion of the IPZ-2 is primarily comprised of mixed vegetative and developed areas. Based on the available SOLRIS GIS dataset, the land cover type is 57% agricultural fields, parks, vegetation and natural landscapes (e.g. cliffs, prairies, etc). Therefore, a land cover component rating of 8 was prescribed for the East Linton WTP.

Soil Type The soil type rating ranges from seven to nine and has been divided into; sandy soils (7), silty clay soils (8), and clay soils (9). The majority of the upland IPZ-2 area consists of silty clay with moderate drainage, with small portions of clay loam and Breypen with poor and imperfect drainage along the southern shoreline of the IPZ-2. The soil type component rating is 8.

Permeability The permeability rating ranges from seven to nine and has been divided into; highly permeable (> 66% = 7), moderately permeable (33% to 66% = 8), and largely impervious (< 33% = 9). The upland area of the East Linton WTP is 338 ha of land with 80 ha (24%) of impervious cover, (76% pervious). The impervious land cover was determined using SOLRIS (2009) information. Therefore, the permeability component rating is 7.

Setback Slope The setback slope rating ranges from seven to nine and has been divided equally into; < 2% slope (7), 2% to 5% (8), and > 5% (9). The slope of the study area ranges from 2.4% to 4.5%. This was determined using OBM contours. The slope component rating is 8.

Land Characteristics (Summary) The resulting land characteristics sub factor, calculated using an averaged equal representation of each component listed above is 7.8.

Transport Pathways

The transport pathway sub factor has the components; storm catchment areas, storm outfalls, watercourses and drains, and tile drained areas.

Storm Catchment Areas The storm catchment areas are rated based on the percent of land area that is drained by a storm sewer system. The rating ranges from seven to nine and has been divided equally into; < 33% area (7), 33% to 66% area (8) and > 66% area (9). Storm sewer catchment areas and networks were unavailable for the East Linton WTP study area. Based on the percent of impervious land cover (24%), it was assumed that a storm sewer network did not exist for the study area. This resulted in a component rating of 7.

Storm Outfalls, Watercourses and Drains For the purpose of rating the number of storm outfalls, watercourses and drains, a standardized method was applied to the data. The number of outfalls, watercourses and drains per 1,000 ha of land was calculated for the East Linton WTP IPZ-2 using the WVF Provincial Dataset. The rating range has been set for 0-3/1,000 ha in the zone at 7, 4 to 7/1,000 ha in the zone at 8 and > 7/1,000 ha in the zone at 9. There are eight watercourses within the upland IPZ-2 giving calculated 24 outfalls *per* 1,000 ha of land. This resulted in a sub factor of 9.

Tile Drained Area Tile drained area is based on the percent land artificially drained as indicated by the Tile Drainage Areas GIS dataset (OMAFRA, 2009). The rating ranges from seven to nine and has been divided into; < 33% area (7), 33% to 66% area (8), and > 66% area (9). There are no tile drained areas in the East Linton WTP upland IPZ-2 and therefore a component rating of 7 has been assigned.

The area vulnerability factor is determined by averaging an equal representation of the % land, land characteristics, and transport pathways sub factors. The resulting area factor rating for the East Linton IPZ-2 is 8.

<u>Source Vulnerability Factor</u>
The source vulnerability factor for the East Linton intake is a combined rating of intake characteristics (depth, length of pipe) and past water quality concerns. The intake crib depth is 4.3 m and; therefore, its vulnerability sub score is 0.6. The East Linton intake is located approximately 130 m from the shoreline and the sub factor is 0.7. No water quality concerns were found relating the ODWQS listed chemical parameters and their respective MACs or IMACs. Further, microbiological tests gave relatively low concentrations of ubiquitous bacteria so the resulting sub factor for recorded water quality concerns is 0.5 (Stantec 2009, Phase 1 Technical Addendum).

The source vulnerability factor is determined by averaging the above listed sub factors. The source factor rating for the East Linton IPZ is 0.6 (Table 4.4.S2.2b).

TABLE 4.4.S2.2b – Source Vulnerability Factor for the East Linton Intake

Sub Factor	Score
Intake Depth	0.6
Length of Pipe (offshore)	0.7
Recorded Water Quality	0.5
Source Vulnerability Factor	0.6

<u>Resulting Vulnerability of the Intake Protection Zone</u>
The resulting vulnerability for IPZ-1 is six and for IPZ-2 is 4.8 (Table 4.4.S2.2c).

TABLE 4.4.S2.2c – Vulnerability Score of the East Linton Intake Protection Zone (IPZ)

Intake Type	Area Vulnerability Factor		Source Vulnerability Factor	Vulnerability Score	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
A (Great Lakes)	10	8	0.6	6	4.8

Uncertainty Rating

The uncertainty rating for the area delineation of IPZ-1 is low, because rules are prescribed by the Technical Rules.

Numerical modelling and the delineation of on-land areas was peer reviewed. However, the uncertainty rating for the delineation of IPZ-2 is high, partly because of uncertainties embedded within the numerical modelling itself, and partly because the data required for validating these models has high uncertainty (for details, see Section 4.1.7.2).

Threats and Risks

Land uses and activities within the intake protection zone were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

Table 4.4.S2.4 indicates that 1 activity for this surface water intake are rated at a "significant" level of risk, for chemicals within the East Linton Events-Based Area for fuel storage and handling The vulnerability score for Great Lakes intakes (both IPZ-1 and IPZ-2) is always smaller than eight. However, moderate threats were identified in the vulnerable area (Stantec 2009, Phase 2 Report).

<u>Moderate and Low Threats</u>
Moderate and low threats are not counted individually. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

TABLE 4.4.S2.4 – East Linton IPZ: Significant Drinking Water Threats for Chemical, Pathogen and DNAPLs

	Number of "are or would be significant" threats			
IPZ Name	Pathogen	Chemical	DNAPL	Total
East Linton	0	1	0	1

<u>Threats from Other Systems</u>
One existing significant drinking water threat for Georgian Bluffs was identified through events-based modelling for the Wiarton intake. (see detailed Table 4.4.8.1 and summary Table 4.4.8.2).

TABLE 4.4.8.1 – Wiarton IPZ: Significant Drinking Water Threats for Events-based Area (Georgian Bluffs)

Prescribed Threat IPZ: WIARTON *For full legal name of prescribed threat, see Table 4.1.5*		Land use Category									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
	CHEMICALS										
15	Fuel - Handling and storage						1				**1**

TABLE 4.4.8.2 – Wiarton IPZ: Significant Drinking Water Threats for Chemical, Pathogen and DNAPLs (Georgian Bluffs)

	Number of "are or would be significant" threats			
IPZ Name	Pathogen	Chemical	DNAPL	Total
Wiarton	0	1	0	1

Quality of Raw Water at the Intake

See Source Vulnerability.

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.4.S2.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.4.S2.5 – East Linton: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.5 Municipality of Grey Highlands

The Municipality of Grey Highlands is situated in Grey County. The Beaver Valley, waterfalls, the Bruce Trail, the Niagara Escarpment, the Osprey Bluffs, and the Saugeen and Beaver Rivers are key features.

The municipality is located within the jurisdiction of three source protection areas and two source protection regions: portions are located in the Grey Sauble SPA and in the Saugeen Valley SPA, which are both located in the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region. A portion also is within the Nottawasaga Valley SPA, which is in the South Georgian Bay Lake Simcoe Source Protection Region.

In 2016, the population was 9,804, which was an increase of 3.3% from 2006. The main towns are Markdale (population 1,433) and Flesherton (population 617). Smaller settlement areas are Feversham, Rocklyn, Kimberley, and Eugenia. Agriculture is one of the largest industries in Grey Highlands. Farms range from small and family-owned to large and highly-automated.

The two municipal drinking water systems in Grey Highlands are the Markdale Well Supply, servicing the former Village of Markdale (see Assessment Report of Saugeen Valley SPA), and the Kimberley-Amik-Talisman Well Supply, servicing the Kimberly and Amik subdivisions and Talisman Ski Resort (Grey Sauble SPA). The Feversham Water system, which serviced the Beaver Heights Subdivision, has been decommissioned. No new drinking water systems are planned.

Looking at agricultural land use in Grey Highlands, 507 farms manage a total land area of 46,897 ha (average farm size 92 ha), of which 54.7% are cropped according to the Agricultural Census (Statistics Canada, 2006a). From this cropped area, alfalfa and other fodder crops take up 13.4% of the land, barley takes up 9.3% and other crops (corn, wheat, etc.) take up 14%.The total livestock density is 0.08 nutrient units per acre. According to the same census, there are 61,000 chickens on 76 farms (Statistics Canada, 2006a). The total number of cattle is 26,142 (9% dairy, remainder beef) on 337 farms. Further, there are 13,905 pigs, 4086 sheep, 1,133 horses, and 272 goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.5.M1.

4.2.5.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.5.M2 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. Its landscape is dominated by the Niagara Escarpment's karstic bedrock and the Beaver Valley's silty till. The karst bedrock surfaces are only in a few areas and are considered SGRA. The overburden is generally quite thin and permeable across this municipality, which makes most parts of it an HVA; however, an exception is the thicker overburden located south of Maxwell and around Wareham and the area east of Ceylon. Many areas around the Beaver River above the escarpment are also SGRAs, especially around the Eugenia Lake Wetlands.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.5.M3).

The portion of this municipality that lies within the Grey Sauble SPA has a total area of SGRAs of 110.1 km^2 and a total area of HVAs of 429.8 km^2. The percentage of managed lands located within the SGRAs and HVAs is 40-80%. The livestock density is less than 0.5 NU/acre. Only 1-8% of all surfaces in SGRAs and HVAs are classified as impervious (Table 4.2.4.1).

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

TABLE 4.2.5.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Municipality of Grey Highlands in this Source Protection Region

SGRA	Total Area of SGRA	110.1 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	429.8 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

4.2.5.2 Groundwater Municipal Systems

4.2.5.2.1 Kimberley-Amik-Talisman Well Supply

Lands designated by the Niagara Escarpment Commission (NEC) as Escarpment Natural Areas and Escarpment Protection Areas surround the Kimberly-Amik-Talisman water supply system. The area contains a mixture of land uses, such as recreational, residential, agricultural, and natural forests. The Kimberley-Amik-Talisman Water System is located in the former Hamlet of Kimberley and is comprised of two bedrock springs: Spring No. 1 and Spring No. 2. Both springs are located close to each other, north of the village of Kimberley. The springs flow from the vertical bedrock face of the Niagara Escarpment at the bottom of the Guelph/Amabel formation.

In 1988, the individual water supply systems of the Hamlet of Kimberley, the Amik Subdivision and the Talisman Ski Resort (including recreational and residential areas) were amalgamated into one.

Both springs of this DWS are considered GUDI, due to variability in water quality. According to operators, turbidity varies rapidly over time, especially after precipitation events. However, the drinking water system uses extensive treatment. Depending on measured turbidity levels, raw water can either be directed into the treatment plant or into the pre-sedimentation tanks. If turbidity levels exceed 75 NTU, raw water is entirely drawn from the pre-sedimentation tanks. Low lift pumps are utilized to pump the water from the pre-sedimentation tanks to the treatment building (MOECC, 2009i).

A wellhead protection area (WHPA) for the Kimberley-Amik-Talisman springs was first developed as part of the Grey Bruce Groundwater Study (WHI, 2003). The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates to account for projected future growth as part of the Round 1 Technical Study for the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region (CRA 2007). It should be noted that there is no pumping system for the springs, and that they are flowing springs, only a portion of which is directed to the water treatment plant. As a result, the modelled rate for the development of the WHPA is significantly higher than the outlined usage for the system.

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in TABLE 4.5.G1.2a and shown on Map 4.5.G1.4. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. For the purposes of calculating managed lands and livestock density, only the portion of the WHPA with a vulnerability score of 6 or more was used in the calculations. The results are listed in Table 4.5.G1.2b and shown on Maps 4.5.G1.5 and 4.5.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.5.G1.1 – Description of the Drinking Water System and Wells

Well Name	Spring 1	Spring 2
Drinking Water System ID	*220007070*	
Drinking Water System Classification	*Large Municipal Residential System*	
SPA of Well and Vulnerable Area (WHPA)	*Grey Sauble SPA*	
Northing/Easting	4915612.3 / 535357.1	4915681.1 / 535386.2
Year Constructed	approx 1950	approx 1950
Well Depth	(not applicable)	(not applicable)
Uncased Interval	(not applicable)	(not applicable)
Aquifer	Natural spring in Amabel Formation (Bedrock)	Natural spring in Amabel Formation (Bedrock)
GUDI	Yes	Yes
Number of Users Served	350	conjunctive
Design Capacity (CoA)	1185 m^3/day	1185 m^3/day
Permitted Rate (PTTW)	1184 m^3/day	1184 m^3/day
Average Usage	282 m^3/day	conjunctive
Modelled Pumping Rate	3800 m^3/day	3800 m^3/day
Treatment	Conventional filtration and chlorination (sodium hypochlorite)	

** CRA Phase I, Round 1 Report 2007*

TABLE 4.5.G1.2a – Impervious Surfaces

General	Code for WHPA	KIMBERLEY_SPRING_1_2
	Total Area [hectare]	144.58
Impervious Surfaces Area [ha]	0 % – <1%	46.32
	1% – <8%	72.04
	8% – < 80%	26.22
	Larger or equal than 80%	-

Note: Total areas relate to the full WHPA, even if located in other municipalities

TABLE 4.5.G1.2b – Managed Land and Livestock Density

WHPA_NAME	KIMBERLEY_SPRING_1_2			
Well Name	No. 1_2	No. 1_2	No. 1_2	No. 1_2
Zone	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	0.5-1.0	0.5-1.0	<0.5	<0.5
% Managed Lands (<40%, 40-80%, >80%)	<40%	>80%	>80%	>80%

Wellhead Protection Area

The wellhead protection area (WHPA) was estimated following the methodology described in Section 4.1.2.5.

After reviewing flow data for the Kimberley treatment system and completing a site visit of the springs, it was determined that the WHI 2003 study had used only the treatment system flows and not the total spring flow.

A portion of the spring flow is diverted to the Kimberley water treatment facility. The flow rate was determined by taking base flow measurements from each spring after a minimum three days of dry weather. In addition, it was noted that the modelled location of the spring was significantly (i.e., > 200 m) offset from the surveyed location.

The WHPA extends southwest 2.5 kilometres from the wells (Map 4.5.G1.1). The land use in WHPAs A and B include a ski resort, woodland and agricultural land. WHPAs C and D contain Wodehouse Creek, agricultural land and residential properties. The 25-year ToT capture zone for the Kimberley springs WHPA has a total land area of approximately 1.45 km^2. The land within the 25-year ToT capture zone consists of residential, commercial, forested, and agricultural lands. Tributaries and small wetland complexes associated with the Beaver River traverse throughout the WHPA, which influences the shape of the capture zone boundaries.
The WHPAs within the Municipality of Grey Highlands are variable with respect to their intrinsic vulnerability to surface (or near surface) contamination. The Kimberley WHPA is located on the west side of the Beaver River valley in a steeply sloping area associated with the Niagara Escarpment.

WHPA-E was delineated in the surface water body that influences these GUDI springs. To identify the points of interaction, Technical Rule 47(5a) was applied and the points closest to the wells were identified. The closest surface water to the springs is the creeks created by the springs. Also, the creek on top of the escarpment was added to the WHPA-E. The WHPA-E extends 0.7 km east of the spring within the 2-hour ToT. A 120 metres setback was added (for details, see Section 4.1.2.7).

However, due to the existence of numerous sink holes on top of the escarpment and strong karst influence, the uncertainty associated with this WHPA-E is very high. Woodhouse Creek, which drains wet areas north-west of the WHPA and passes through WHPA-C, has the potential to impact water quality but conclusive evidence does not exist.

Map 4.5.G1.2 shows the borders of all zones of WHPA overlaid on aerial photography.

Transport Pathways

The vulnerability of the WHPA must be increased if pathways exist that transport contaminants from the surface into the aquifer that is a source for drinking water (see Section 4.1.2.6), unless the vulnerability is already rated “high”.

A few private septic systems and water wells are mapped in parcels that intersect WHPAs C and D; however, no well clusters were identified within the WHPA boundaries. Also, intrinsic aquifer susceptibility is already considered high.

No transport pathway adjustments were made to aquifer vulnerability in the Kimberley-Amik-Talisman WHPA. Existing properties have wells that are in compliance with existing standards.

Vulnerability

WHPA A-D
Intrinsic susceptibility mapping shows the area surrounding the WHPA boundaries is designated with high susceptibility (Map 4.5.M1), which is likely a result of the thin overburden material overlying the bedrock aquifer and the presence of karst topography, which is representative of the face of the Niagara Escarpment.

After overlaying the intrinsic susceptibility index (Map 4.5.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.1.3 for detail). The vulnerability is shown on Map 4.5.G1.3. The Kimberley WHPA has a relatively high vulnerability. In areas outside WHPA-A, vulnerability typically decreases with distance from the well from a vulnerability score of ten to a score of 6.

WHPA-E
The total vulnerability of the WHPA-E associated with the two Kimberley-Amik-Talisman springs is comparatively high (8.0) for both springs. This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.5.G1.2c). The area vulnerability describes the propensity of the on-land area to contribute runoff (percentage of land, land characteristics and transport pathways), which is 8 (moderate) for both springs. The source vulnerability score describes the likelihood that the surface water transports contaminants to the well and is 1.0 (high) for both springs, which are located within the karst formation of the Niagara escarpment.

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.3 for details).

Threats and Risks

Land uses and activities within the wellhead protection area were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

TABLE 4.5.G1.2c – Vulnerability of WHPA-E Associated with the Kimberley-Amik-Talisman DWS

Name of WHPA	**KIMBERLEY_SPRING_1_2**	
DWIS_ID	220007070	
Area (Total), hectares	23.12	
Vulnerability (Total)	**8.0**	
Source Vulnerability	**1.0**	
SV - Distance to surfacing karst [m]	<250m	1
SV - Overburden Protection	12.25 m	0.9
Area Vulnerability	**8 (8.3)**	
AV - Percent Land: Score	**9**	
AV - Percentage of Land	> 70%	9
AV - Land Characteristics	**8.2**	
Land Cover*	70% Agricultural, 10% Developed, 20% Natural	7.9
Soil Type	86.1% diamicton	7.6
Soil Permeability *	99.9% C, 0.1% D	8.3
Slope [%]	12.0%	9.0
AV Transport Pathways	**7.7**	
Tile Drainage [% of land area]	0.0%	7
Storm Catchment	None	7
Number of Watercourses/1,000 ha	9.0	

** Area disregarded if classified "Not categorized"*
*** The Area Vulnerability Score is rounded to full number. In brackets, value rounded to 1 digit is shown.*

WHPA A-D

There are 24 significant drinking water threats in the Kimberley Spring (Spring Nos. 1 and 2) for wellhead protection areas A-D. These threats include 12 activities related to the potential for pathogen contamination and 12 activities related to contamination with hazardous chemicals. The total number of properties with threats is three, all of which are agricultural (see detailed Table 4.5.G1.3a and summary Table 4.5.G1.4).

The wells are surrounded by woodland and agricultural land. Significant threats are in zone B of the WHPA, large parts of which are cropped. Land use activities may include the application of pesticide, agricultural or non-agricultural source material to land. Also, manure may result in pathogens in the source water. However, this GUDI well has treatment facilities to handle these. There are no significant threats in zones C or D for the Kimberley WHPA.

WHPA-E

With surface water influencing the Kimberley springs, a WHPA-E was delineated. The vulnerability score of this WHPA-E is 8.0, and chemical and pathogen threats can be significant (see Section 4.1.5.7). For chemical threats, no activity in this area meets the quantity circumstances defined in Provincial Table 22: CIPZWE8S. Some activities that discharge sewage (as defined in Provincial Table 48: PIPZWE8S) would be considered pathogen threats, but none were identified in this area. Agricultural activities that have the potential to contaminate surface water with pathogens (as defined in Provincial Table 48: PIPZWE8S) were identified, associated with the handling, storage and application of agricultural source material and non-agricultural source material, as well as with livestock. No pathogen threats were identified in this WHPA-E, and the total number of significant threats in the WHPA-E is zero. Significant threats previously identified in the WHPA-E have been allocated to the WHPA-A.

Moderate and Low Threats

Moderate and low threats are not counted individually. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

Quality of Raw Water at the Well

The water of Kimberley Springs has been used as drinking water since early settlement times. According to operators, its quality fluctuates with rainfall conditions. Under dry conditions, the springs are fed by the Guelph/Amabel aquifer. During rainfalls, precipitation water percolates through the karstic terrain and mixes into the aquifer. The spring water sometimes has high iron and hardness levels, which is typical for the groundwater aquifer. Sometimes the spring water also shows surface water characteristics with high levels of turbidity and water colour during percolation events. Treatment at the Kimberley-Amik-Talisman well supply includes conventional filtration and chlorination, including ion removal. Equipment for pH adjustment and taste and odour removal (powdered activated carbon) is also installed at the plant, but it is not used. Instead, operators use storage schemes to overcome short-term turbidity events.

Approved

TABLE 4.5.G1.3a – Kimberley-Amik-Talisman: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen, DNAPL threats)

Prescribed Threat **WHPA: KIMBERLEY_SPRING_1_2** *For full legal name of prescribed threat, see Table 4.1.5*		**Land use Category**									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land	3									**3**
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
8	Commercial fertilizer - Application to land	3									**3**
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land	3									**3**
11	Pesticide - Handling and storage										
14	Snow - Storage										
15	Fuel - Handling and storage										
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards	3									**3**
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
1	Untreated septage - Application to land										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land	3									**3**
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards	3									**3**

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.5.G1.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.5.G1.4 – Kimberley-Amik-Talisman WHPA: Summary of Significant Drinking Water Threats

	Number of "are or would be significant" threats				**Number of *properties* with "are or would be significant" threats**			
KIMBERLEY SPRING 1 &2	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	12	0	12	24	3	0	0	3
WHPA-E				0				0

TABLE 4.5.G1.5 – Kimberley-Amik-Talisman: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.5.3 Surface Water Municipal Systems

No municipal drinking water systems that use surface water exist in this municipality.

4.2.6 Municipality of Meaford

The Municipality of Meaford is located in Grey County completely in the Grey Sauble Source Protection Area. Key features include kilometres of Georgian Bay shoreline, the Niagara Escarpment, the Bighead River and tributaries, the Bruce and Georgian Trails, substantial forests, rolling valleys, and large wetland areas. In 2016, the population was 10,991, which was an increase of 0.4% from 2006. Seasonal residents add to the population during peak periods. The main town is Meaford (population 4,524). Smaller villages include Leith, Annan, Bognor, and Woodford.

The one municipal drinking water system is an intake located in the town of Meaford. No new drinking water systems are planned.

Agricultural land use in Meaford includes 316 farms that manage a total land area of 26,811 ha (average farm size 85 ha), of which 52.9% are cropped according to the Agricultural Census (Statistics Canada, 2006a). Of these cropped farms, alfalfa and other fodder crops take up 17.9% of the land, soybeans take up 5%, barley takes up 4.3%, and other crops (corn, wheat, etc.) take up 6.1%. In the Municipality of Meaford, the total livestock density is 0.06 nutrient units per acre. In 2006, only 33 farms reported chickens (numbers disclosed, Agricultural Census, 2006a). The total number of cattle is 12,164 (9% dairy, remainder beef) on 184 farms. Further, there are 234 pigs, 3,719 sheep, 526 horses, and 189 goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.6.M1.

4.2.6.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.6.M2 shows the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. Most SGRAs are associated with surfacing karst, especially along the Niagara Escarpment. Beach sand areas and other low karst areas are SGRA. All of these areas are also highly vulnerable aquifers. Areas with sandy till, which covers most of the west portion of this municipality, are also designated HVA. The till generally has a fine texture in lowland areas and a coarse texture in higher areas.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.6.M3).

In this municipality, the total area of SGRAs is 182.57 km^2 and the total area of HVAs is 450.7 km^2. The percentage of managed lands located within the SGRAs and HVAs is 40-80%. The livestock density is less than 0.5 NU/acre. Only 1-8% of all surfaces in SGRAs and HVAs are classified as impervious (Table 4.2.6.1).

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

TABLE 4.2.6.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Municipality of Meaford

SGRA	Total Area of SGRA	182.57 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	450.7 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

4.2.6.2 Groundwater Municipal Systems

No municipal drinking water systems that use groundwater exist in this municipality.

4.2.6.3 Surface Water Municipal Systems

4.2.6.3.1 Meaford PUC Water Treatment Plant

The Meaford WTP is a Great Lakes (Type A) intake that is located on Nottawasaga Bay. It services approximately 4,800 people and is classified as a large municipal residential system, under Ontario Regulation 170/03, with a rated capacity of the treatment plan of 26,848 m^3/day.

The treatment process includes two filter beds with multimedia and backwash troughs, a flash mixer, gas chlorination disinfection, ultraviolet disinfection, and backwash wastewater treatment. The filter backwash wastewater system consists of a surge tank, a treatment clarifier and an injection of sodium metabisulphate for dechlorination. Treated backwash wastewater is discharged into the storm sewer system. Chemicals used in the treatment process include polyaluminum chloride, sodium metabisulphate and chlorine gas (Stantec 2008, Phase 1 Report).

The raw water intake is located at a northing of 531614.37 and an easting of 4940904.72. It is a concrete pipe approximately 265 m in length and 750 mm in diameter. The intake crib, located at the end of the intake pipe, is protected by gabion baskets in approximately 4.1 m of water, with a lake depth of 5.7 m (Stantec 2009, Phase 1 Technical Addendum). A chlorine dosing system for zebra mussel control exists at the inlet of the raw water intake crib (Stantec 2008, Phase 1 Report).

TABLE 4.6.S1.1 – Description of the Drinking Water System

Intake Name	Meaford WTP Intake
Drinking Water System ID	210000176
Drinking Water System Classification	Large Municipal Residential System
Intake Type	A (Great Lakes)
SPA of Intake and Vulnerable Area (IPZ)	Grey Sauble
Northing/Easting of Intake	531614.37 / 4940904.72
Intake pipe length	265 m
Lake Depth at Intake *	5.7 m
Depth of Top of Intake Crib *	4.1 m
Number of users served	4800
Intake Capacity	not known
Average Usage	1748 m^3/day
Maximum Usage	2259 m^3/day

** Elevations measured from plan & profile drawings (Philips & Roberts, Mar 1959) and converted to International Great Lakes Datum 1985 (IGLD 85) by comparing recorded water levels with historical information from US Army Corps of Engineers (in Stantec 2009, Phase 1 Technical Addendum)*

Managed Land, Livestock Density and Impervious Surfaces

Following the methodology outlined in Section 4.1.4, the percentage of managed land, the livestock density (nutrient units per acre) and the percentage of impervious surfaces were computed for each wellhead protection area. Computation results are listed in Table 4.6.S1.1b and in Maps 4.6.S1.4, 5 and 6.

The Meaford WTP intake protection zone is classified as an area where the percentage of managed land of the vulnerable area are at least 40%, but not more than 80% and the livestock density is less than 0.5 NU/acre. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.6.S1.1b – Managed Land, Livestock Density and Impervious Surfaces

General	IPZ ID	MEAFORD
	Area Total [hectare]	3996.70
	Area offshore [hectare]	1182.68
	Area onshore [hectare]	2794.34
IPZ 1 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	24.02
	Livestock Density [NU/Acre]	0.00
	Managed Land Area [hectare]	4.39
	% Managed Lands	18.28
	Category	**ML% <40%, NU/acre <0.5**
IPZ 2 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	2770.32
	Livestock Density [NU/Acre]	0.16
	Managed Land Area [hectare]	1892.51
	% Managed Lands	68.31
	Category	**ML% 40%-80%, NU/acre <0.5**
Impervious Surface: Area per category [hectare]	0 % – <1%	703.99
	1% – <8%	969.13
	8% – < 80%	1120.79
	Larger or equal than 80%	0.00

Note: All areas relate to the full IPZ including other municipalities.

Intake Protection Zone

The Meaford WTP uses raw water from an intake located in eastern Lake Huron (Georgian Bay) and it is classified as Great Lakes (Type A) intake. For the in-water portion of the IPZ-1 of a Type A intake, the Technical Rules prescribe to delineate the IPZ as a circle with a radius of 1,000 metres from the entry point where raw water enters the drinking water system (see Section 4.1.2.4, Offshore component). Where the IPZ-1 abutted land and was not impacted by a riverine or transport pathway, it was extended 120 m inland as it was greater than the area of the regulation limit (Stantec 2009, Phase 1 Technical Addendum). The shoreline of IPZ-1 is nearly 2,000 m long. For IPZ-1, the onshore area is 0.2 km^2 and the offshore area of 2.0 km^2.

The IPZ-2 extends 5.4 km east of the intake, 3.6 km west of the intake and 1.6 km offshore at its furthest point. Where the IPZ-2 abutted land and was not impacted by a riverine or transport pathway, it was extended inland 120 m or to the area of the Regulation Limit, whichever was greater (Stantec 2009, Phase 1 Technical Addendum). At Workmans Creek, it was extended to meet the area set forth by the regulation limit. The shoreline of IPZ-2 is approximately 10 km long.

The Bighead River enters Georgian Bay and the IPZ approximately 1,600 m from the intake, outside of IPZ-1. The up-stream extent that was added to IPZ-2 has a length of 3.6 km. Other creek outlets include Centreville Creek (9.6 km), Meaford Creek (7.2 km), Workmans Creek (2.0 km), and twelve other unnamed creeks. The 120 m bank setback was applied along the up-tributary extent of each watercourse. For IPZ-2, the resulting onshore area is 24.5 km^2 and the offshore area of 12.5 km^2.

The full IPZ is shown on Map 4.6.S1.2 and on Map 4.6.S1.3 with underlying aerial photography.

An IPZ-3 and an EBA were delineated for based on modelled spill scenarios and desktop assessment. Using the methodology described in section 4.1.2.4, minimum volumes that would result in exceedances were determined for locations distributed throughout Meaford and around the IPZ-2. Volumes ranged from 300 L to 11,600 L and were split into three EBA categories (see map 4.1.S1.1.9);

- 2,000 L and greater
- 5,000 L and greater
- 12,000 L and greater

Storm Sewer Systems and Transport Pathways

The onshore component of the intake protection zone includes properties that drain into storm sewersheds within a 2-hour ToT, and other transport pathways (Section 4.1.2.6).

The IPZ includes storm sewer network and tile drain network, based on data provided by the Municipality and the inferred location of a total of 51storm sewer outfalls (Stantec 2008, Phase 1 Report). Those areas that are located less than 2-hour time-of-travel were added to the intake protection zone according to the Technical Rules (the method is described in Section 4.1.2.6 – Onshore Components). The resulting area is shown on Map 4.6.S1.1.

Vulnerability

Vulnerability of the protection zone of the surface water intake was delineated following the methodology described in Section 4.1.3.5. Two factors measuring the vulnerability of the area and of the raw water source are computed separately and then multiplied with each other.

<u>Area Vulnerability Factor</u>
The area vulnerability factor for IPZ-1 is ten, as prescribed by the Technical Rules. For IPZ-2, the area vulnerability factor is determined by averaging the percentage of land, land characteristics and transport pathways sub factors (Table 4.6.S1.2a).

<u>Percentage of Land</u>
The % land sub factor has been divided equally between the three ranges outlined in the Technical Rules (< 33% = 7, 33% – 66% = 8, > 66% = 9). The Meaford WTP has approximately 71% land area and therefore the % land sub factor has a score of 9.

<u>Land Characteristics</u>
The land characteristic sub factor has the components; land cover, soil type, permeability, and slope. The land characteristics sub factor can be derived from the average of the ratings for the four components.

Land Cover The land cover rating ranges from seven to nine and has been divided into; mainly vegetated (7), mixed vegetated and developed (8) and mainly developed (9). Land in the upland portion of the IPZ-2 is primarily comprised of agriculture, natural areas, and the community of Meaford. Based on the available SOLRIS GIS dataset, the land cover type is 84% natural green areas and agricultural fields. Therefore, a land cover component rating of 7 was prescribed for the Meaford WTP.

Soil Type The soil type rating ranges from seven to nine and has been divided into; sandy soils (7), silty sand soils (8), and clay soils (9). The soils of the upland IPZ-2 are identified as silty clay loam (Agriculture and Agri-Food Canada, 1983b). These soils are described as having imperfect drainage and a soil type component rating of 8 has been assigned to the Meaford WTP.

Permeability The permeability rating ranges from seven to nine and has been divided into; highly permeable (> 66% = 7), moderately permeable (33% to 66% = 8), and largely impervious (< 33% = 9). The upland area of the Meaford WTP is 2,430 ha of land with 383 ha (16%) of impervious cover (84% pervious). The impervious land cover was determined using SOLRIS (2009) information. Therefore, the permeability component rating is 7.

Setback Slope The setback slope rating ranges from seven to nine and has been divided equally into; < 2% slope (7), 2% to 5% (8), and > 5% (9). The topography of the Meaford WTP upland IPZ-2 is characterized by the Bighead Valley Physiographic Region, which is described as a valley with unique depositional effects of ice, as the shoulders, sides, and floor of the valley are covered with drumlins (Chapman and Putman, 1966 in Stantec 2009, Phase 1 Technical Addendum). The slope of the study area ranges from 1.2% to 4.0%. This was determined using OBM contours. As a conservative approach, the greatest slope value (4.0%) was used to assign the component rating. These area features may increase runoff directly to the lake within the vulnerable zone. The slope component rating is 8.

Land Characteristics (Summary) The resulting land characteristics sub factor, calculated using an averaged equal representation of each component listed above is 7.5.

Transport Pathways

The transport pathway sub factor has the components; storm catchment areas, storm outfalls, watercourses and drains, and tile drained areas.

Storm Catchment Areas Storm catchment areas are rated based on the percent of land area that is drained by a storm sewer system. The rating ranges from seven to nine and has been divided equally into; < 33% area (7), 33% to 66% area (8) and > 66% area (9). Storm sewer catchment areas and outfalls were unavailable for the Meaford WTP study area; however, the storm sewer networks were provided. Storm sewer catchments were assumed based on the storm sewer networks and the area of the developed land. The upland area was determined to be 8% (185 ha) storm sewer drained. The area of development was based upon South Western Ontario Orthophotography Project, (SWOOP, 2006) data provided by GSCA. This resulted in a component rating of 7.

Storm Outfalls, Watercourses and Drains For the purpose of rating the number of storm outfalls, watercourses and drains, a standardized method was applied to the data. The number of outfalls per 1,000 ha of land was calculated for the Meaford WTP IPZ-2 using WVF Provincial Dataset. The rating range has been set for 0-3/1,000 ha in the zone at 7, 4 to 7/1,000 ha in the zone at 8 and > 7/1,000 ha in the zone at 9. Fifty one transport pathways and 16 watercourses were determined to discharge into Georgian Bay within the IPZ-2 giving a calculated 28 outfalls *per* 1,000 ha of land. This resulted in a sub factor of 9.

Tile Drained Area Tile drained area is based on the percent land artificially drained as indicated by the Tile Drainage Areas GIS dataset (OMAFRA, 2009). The rating ranges from seven to nine and has been divided into; < 33% area (7), 33% to 66% area (8), and > 66% area (9). The area of the Meaford WTP upland IPZ-2 that is tile drained is 437 ha (18%) tile, therefore a component rating of 7 has been assigned.

Transport Pathways (Summary) The resulting transport pathways sub factor, calculated using an averaged equal representation of the components listed above is 7.7.

The area vulnerability factor is determined by averaging an equal representation of the % land, land characteristics, and transport pathways sub factors. The resulting area factor rating for the Meaford IPZ-2 is 8.

<u>Source Vulnerability Factor</u>
The source vulnerability factor for the Meaford intake is a combined rating of intake characteristics (depth, length of pipe) and past water quality concerns. The intake crib depth is 4.1 m and its vulnerability sub score is 0.6. The Meaford intake is located approximately 265 m from the shoreline and the sub factor is 0.7. No water quality concerns relating to the ODWQS listed chemical parameters and their respective MACs or IMACs were noted. Given that bacteria, including *E. coli*, are normally ubiquitous at low levels in raw surface water supplies from multiple non-human sources and the levels are relatively low in the data record for the Meaford WTP, there appears to be no immediate concern for bacterial presence in the WTP raw water supply. Based on the available data, there were no recorded drinking water issues resulting in a sub factor of 0.5. (Stantec 2009, Phase 1 Technical Addendum).

The source vulnerability factor is determined by averaging the above listed sub factors. The source factor rating for the Meaford IPZ is 0.6 (Table 4.6.S1.2b).

<u>Resulting Vulnerability of the Intake Protection Zone</u>
The resulting vulnerability for IPZ-1 is six and for IPZ-2 is 4.8 (Table 4.6.S1.2c).

TABLE 4.6.S1.2a – Area Vulnerability Factor for the Meaford Intake

Area Vulnerability Factor Rating *(Rounded average of percentage of land, land characteristics and Transport Pathways)*	**8**
Percentage of Land	9
Land Characteristics	7.5
Land Cover	7
Soil Type	8
Permeability	7
Setback Slope	8
Transport Pathways	7.7
Storm Catchment Areas *(less than 33%)*	7
Storm Outfalls, Watercourses, Drains (The number of storm outfalls, watercourses and drains per 1000 ha is larger than 7)	7
Tile Drained Area (less than 33 %)	9

TABLE 4.6.S1.2b – Source Vulnerability Factor for the Meaford Intake

Sub Factor	Score
Intake Depth	0.6
Length of Pipe (offshore)	0.7
Recorded Water Quality	0.5
Source Vulnerability Factor	0.6

TABLE 4.6.S1.2c – Vulnerability Score of the Meaford Intake Protection Zone (IPZ)

Intake Type	Area Vulnerability Factor		Source Vulnerability Factor	Vulnerability Score	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
A (Great Lakes)	10	8	0.6	6	4.8

Uncertainty Rating

The uncertainty rating for the area delineation of IPZ-1 is low, because rules are prescribed by the Technical Rules.

Numerical modelling and the delineation of on-land areas was peer reviewed. However, the uncertainty rating for the delineation of IPZ-2 is high, partly because of uncertainties embedded within the numerical modelling itself, and partly because the data required for validating these models has high uncertainty (for details, see Section 4.1.7.2).

Threats and Risks

Land uses and activities within the intake protection zone were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

Table 4.6.S1.4 indicates that no surface water threats are rated at a “significant” level for DNAPLs or pathogens. The vulnerability score for Great Lakes intakes (both IPZ-1 and IPZ-2) is always smaller than eight. However, moderate threats were identified in the vulnerable area (Stantec 2009, Phase 2 Report). Nine existing significant drinking water threats were identified through events-based modelling (see detailed Table 4.6.S1.3 and summary Table 4.6.S1.4).

TABLE 4.6.S1.3 – Meaford IPZ: Significant Drinking Water Threats for Events-based Area

Prescribed Threat IPZ: MEAFORD *For full legal name of prescribed threat, see Table 4.1.5*		Land use Category									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
	CHEMICALS										
15	Fuel - Handling and storage		7				2				**9**

<u>Moderate and Low Threats</u>

Moderate and low threats are not counted individually even if identified. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

TABLE 4.6.S1.4 – Meaford IPZ: Significant Drinking Water Threats for Chemical, Pathogen and DNAPLs

	Number of "are or would be significant" threats			
IPZ Name	Pathogen	Chemical	DNAPL	Total
Meaford	0	9	0	9

Quality of Raw Water at the Intake

At the Meaford intake, the geometric mean of microbial concentrations microbial cell counts is ten cfu/100 ml for total coliform, and 2.8 for *E. coli*. These levels are amongst the lowest of all Great Lakes intakes in this source protection region. Also, no other water quality parameter can justify concern.

Drinking Water Issues and Condition

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.6.S1.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.6.S1.5 – Meaford: Issues and Conditions

Drinking Water Issue	Parameter
None	None
Drinking Water Condition	**Threat**
None	None

4.2.7 City of Owen Sound

Owen Sound is the largest urban community in Grey County and in this Source Protection Region. The City of Owen Sound is located on the southern shore of Georgian Bay within the Grey Sauble Source Protection Area. In 2016, the population was 21,341, which was a decrease of 2% from 2006. The City is home to a magnificent harbour and bay, two winding rivers, tree-lined streets, and an extensive parks system. The tree-covered hillsides and ravines are home to a wide variety of flora and fauna. There is one municipal drinking water system in the City of Owen Sound, which is a surface water intake. No new drinking water systems are planned.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.7.M1.

4.2.7.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.7.M2 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. Nearly the entire City of Owen Sound is a HVA and only a few forest bands were designated as SGRA.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.7.M3).

In this municipality, the total area of SGRAs is 1.8 km^2 and the total area of HVAs is 20.7 km^2. The percentage of managed lands located within the SGRAs and HVAs is less than 40%. The livestock density is less than 0.5 NU/acre. Only 1-8% of all surfaces in SGRAs and HVAs are classified as impervious (Table 4.2.7.1).

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

TABLE 4.2.7.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the City of Owen Sound

SGRA	Total Area of SGRA	1.8 km^2
	Managed Land and Livestock Density	ML% <40%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	20.7 km^2
	Managed Land and Livestock Density	ML% <40%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

4.2.7.2 Groundwater Municipal Systems

No municipal drinking water systems that use groundwater exist in this municipality.

4.2.7.3 Surface Water Municipal Systems

4.2.7.3.1 R.H. Neath Water Treatment Plant (Owen Sound)

The R.H. Neath WTP is a large municipal residential drinking water system that services a population of approximately 22,000 people in Owen Sound as well as a small area to the north that lies within the Municipality of Meaford. The rated capacity of the drinking water system is 27,300 m^3/day. The treatment process includes raw water screening, pre-chlorination for zebra mussel control, flash mixing, coagulation/flocculation, and post-chlorination for disinfection, ultraviolet disinfection, and fluoridation. Chemicals used in the treatment process include gaseous chlorine, hydrofluorosilic acid, polyaluminum chloride, and aluminum chlorohydrate (Stantec 2008, Phase 1 Report).

This Great Lakes (Type A) intake at the R.H. Neath WTP is located at a northing of 505436.59 and an easting of 4938152.75, at a measured depth of the intake crib of 11.3 m and a lake depth of 12.3 m. The intake is a 900 mm diameter intake pipe with a bellmouth inlet extending 670 m from the intake structure to the low lift pump station screening chamber. It has a 50 mm diameter line for delivery of chlorine solution to a diffuser at the bellmouth inlet for zebra mussel control (Stantec 2008, Phase 1 Report).

The major coastal structures that exist within the study area are related to the commercial harbour in Owen Sound and the Owen Sound Marina. To the northwest of the Owen Sound harbour is the breakwater protection for the Owen Sound Marina. An adjacent smaller area of the marina exists outside the breakwaters to the north and is protected behind separate rubble mound structures.

There are two larger rivers that discharge into Owen Sound harbour at the City of Owen Sound: the Sydenham River and the Pottawatomi River. The catchment area of these two rivers covers approximately 285 km^2 of land to the south and the west of the city. The Sydenham River enters the Owen Sound lowlands via Inglis Falls. The Pottawatomi River meanders through swamps located west of the city before it arrives in the lowland area of Owen Sound via Jones Falls and then empties into the bay of Owen Sound. Additionally, two minor watercourses also impact the water quality of Owen Sound: Bothwell Creek, which drains into the bay north of Owen Sound at Leith, and the Indian River, which drains into Owen Sound at Balmy Beach, across the bay from the R.H. Neath WTP intake.

TABLE 4.7.S1.1 – Description of the Drinking Water System

Intake Name	Owen Sound RH Neath WTP Intake
Drinking Water System ID	220001799
Drinking Water System Classification	Large Municipal Residential System
Intake Type	A (Great Lakes)
SPA of Intake and Vulnerable Area (IPZ)	Grey Sauble
Northing/Easting of Intake	505436.59 / 4938152.75
Intake pipe length	670 m
Lake Depth at Intake *	12.3 m
Depth of Top of Intake Crib *	11.3 m
Number of users served	21,000
Intake Capacity	not known
Average Annual Usage**	12,190 m^3/day
Maximum Usage**	17,253 m^3/day

** Elevations measured from plan & profile drawings (MacLaren, Dec 1967) and converted to International Great Lakes Datum 1985 (IGLD 85) by comparing recorded water levels with historical information from US Army Corps of Engineers (in Stantec 2009, Phase 1 Technical Addendum)*
*** Flow data from R. H. Neath Plant Water Treatment*

Managed Land, Livestock Density and Impervious Surfaces

Following the methodology outlined in Section 4.1.4, the percentage of managed land, the livestock density (nutrient units per acre) and the percentage of impervious surfaces were computed for each wellhead protection area. Computation results are listed in Table 4.7.S1.1b and in Maps 4.7.S1.4, 5 and 6.

The R.H. Neath WTP Intake Protection Zone is classified as an area where the percentage of managed land of the vulnerable area are less than 40% and the livestock density is less than 0.5 NU/acre. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

Intake Protection Zone

The R. H. Neath WTP uses raw water from an intake located in eastern Lake Huron (Georgian Bay). It is classified as Great Lakes Type A intake. For the in-water portion of the IPZ-1 of a Type A intake, the Technical Rules prescribe to delineate the IPZ as a circle with a radius of 1,000 metres from the entry point where raw water enters the drinking water system (see Section 4.1.2.4, Offshore component). Where the IPZ-1 abutted land and was not impacted by a riverine or transport pathway, it was extended 120 m inland as it was greater than the area of the regulation limit (Stantec 2009, Phase 1 Technical Addendum). The shoreline length of IPZ 1 is approximately 1,800 m along the west side of the bay and it does touch the west side of the bay in some areas. For IPZ-1, the onshore area is 0.2 km^2 and the offshore area is 2.6 km^2.

Approved

TABLE 4.7.S1.1b – Managed Land, Livestock Density and Impervious Surfaces

General	IPZ ID	OWEN_SOUND
	Area Total [hectare]	1902.94
	Area offshore [hectare]	604.78
	Area onshore [hectare]	1288.56
IPZ 1 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	22.51
	Livestock Density [NU/Acre]	0.00
	Managed Land Area [hectare]	1.86
	% Managed Lands	8.24
	Category	**ML% <40%, NU/acre <0.5**
IPZ 2 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	0.00
	Livestock Density [NU/Acre]	0
	Managed Land Area [hectare]	0.00
	% Managed Lands	0
	Category	**ML% <40%, NU/acre <0.5**
Impervious Surface: Area per Category [hectare]	0 % – <1%	1.10
	1% – <8%	59.51
	8% – < 80%	1041.67
	Larger or equal than 80%	186.20

Note: All areas relate to the full IPZ including other municipalities.

The in-water IPZ-2 occupies the most southern base of the Owen Sound bay and it reaches both the east and west shorelines. The most western point reaches the shoreline 1,300 m from the intake, and the most eastern point reaches the shoreline 3,100 m from the intake. Where the IPZ-2 abutted land and was not impacted by riverine or transport pathways, it was extended inland 120 m as this was greater than the area of the regulation limit (Stantec 2009, Phase 1 Technical Addendum).

The model was inspected and stormwater sewersheds were updated. Due to low spatial resolution and also due to neglect of buoyancy effects from temperature and sediment load, spatially confined plumes within the area of the harbour and the mouth of Pottawatomi River are not represented in the model. To account for these observed phenomena, the in-water area was extended to include the harbour up to Owen Sound Mill Dam and the Pottawatomi River mouth.

The delineation of the upland component of the IPZ-1 and IPZ-2 was completed using the methodology outlined in Section 4.1.2.4 (Onshore components). The upland component of the IPZ-1 includes the abutted shoreline setbacks whereas the upland component of the IPZ-2 incorporates features that may contribute water to the intake: watercourses; municipal drains; storm sewer networks; and tile drained areas. Also included in the upland IPZ-2 are the appropriate bank setbacks for watercourses and/or municipal drain (Stantec 2009, Phase 1 Technical Addendum). The up-tributary extent of the Kenny Drain and 15 unnamed drains are part of the 2-hour ToT contour of the intake. The maximum length of one tributary is 6,700 m.

A small creek that discharges into Georgian Bay in Balmy Beach, directly south of County Rd 17, is not part of the IPZ-2. It is located at the extreme ends of the IPZ-2 of two drinking water systems, the R.H. Neath WTP and the East Linton WTP. The time-of-travel at this location is at the 2-hour mark. Extending the IPZ-2 up the creek would be taking it beyond the 2-hour mark.

The onshore area of the IPZ-2 is 7.0 km^2 and the offshore area 6.1 km^2. The full IPZ is shown on Map 4.7.S1.2 and on Map 4.7.S1.3 with underlying aerial photography.

An IPZ-3 and an EBA were delineated for based on modelled spill scenarios and desktop assessment. Using the methodology described in section 4.1.2.4, minimum volumes that would result in exceedances were determined for locations distributed throughout Owen Sound and around the IPZ-2. Volumes ranged from 8,700 L to 46,500 L and were split into three EBA categories (see map 4.1.S1.1.9);

- 15,000 L and greater
- 25,000 L and greater
- 50,000 L and greater

Storm Sewer Systems and Transport Pathways

The onshore component of the intake protection zone includes properties that drain into storm sewersheds within a 2-hour ToT, and other transport pathways (Section 4.1.2.4).

Storm sewer networks, including storm sewer outfall locations and catchment areas, were provided by the City of Owen Sound. This data may not include the full extent of the study area and, where information was incomplete, 2006 aerial photography was used to include catchment areas of the storm sewer network to be included in the onshore IPZ-2 in its entirety, based on the area of the developed land (Stantec 2008, Phase 1 Report). Also, technical reports on stormwater were considered. The areas east of 3rd Ave West around Brook's Creek were also added. Also, stormwater sewers in the Sydenham Heights industrial park east of the city were revised and extended. In downtown, those storm sewers that drain into Sydenham River between the harbour and Mills Dam were also added up to the Niagara Escarpment.

Those areas that are located less than 2-hour time-of-travel were added to the intake protection zone according to the Technical Rules (see Section 4.1.2.4 – Onshore Components). Transport pathways are shown on Map 4.7.S1.1.

Inliers are small areas that are fully enclosed within IPZ onshore components. Following the method outlined in Section 4.1.2.4, inliers with areas less than 10 ha were added to the IPZ without further study, while the existence of preferential pathways (ditches, storm sewers) were confirmed in inliers with larger spatial extent.

Vulnerability

Vulnerability of the protection zone of the surface water intake was delineated following the methodology described in Section 4.1.3.5. Two factors measuring the vulnerability of the area and of the raw water source are computed separately and then multiplied with each other.

Area Vulnerability Factor
The area vulnerability factor for IPZ-1 is ten, as prescribed by the Technical Rules. For IPZ-2, the area vulnerability factor is 8, which is determined by averaging the percentage of land, land characteristics and transport pathways sub factors (Table 4.7.S1.2a).

Percentage of Land
The % land sub factor has been divided equally between the three ranges outlined in the Technical Rules (< 33% = 7, 33% – 66% = 8, > 66% = 9). The R.H. Neath WTP has approximately 64% land area and therefore the % land sub factor has a score of 8.

Land Characteristics
The land characteristic sub factor has the components; land cover, soil type, permeability, and slope. The land characteristics sub factor can be derived from the average of the ratings for the four components.

Land Cover The land cover rating ranges from seven to nine and has been divided into; mainly vegetated (7), mixed vegetated and developed (8) and mainly developed (9). Land in the upland portion of the IPZ-2 is primarily comprised of natural areas and the City of Owen Sound. Based on the available SOLRIS GIS dataset, the land cover type is 7% forested areas, 35% natural areas and green space, and 58% developed land. Therefore, a land cover component rating of 9 was prescribed for the R.H. Neath WTP.

Soil Type The soil type rating ranges from seven to nine and has been divided into; sandy soils (7), silty sand soils (8), and clay soils (9). There are two main soil types identified in the upland IPZ-2, the Saugeen series and the Tecumseh series. The Saugeen series is the characteristic soil east of Owen Sound and is comprised of silty clay loam (Gillespie and Richards, 1954). To the west of Owen Sound, Tecumseh series soil type is comprised of high lime sands (Agriculture and Agri-Food Canada, 1983b). Both soil types are imperfectly drained, therefore, a soil type component rating of 8 has been assigned for the study area.

Permeability The permeability rating ranges from seven to nine and has been divided into; highly permeable (> 66% = 7), moderately permeable (33% to 66% = 8), and largely impervious (< 33% = 9). The upland area of the R.H. Neath WTP is 672 ha of land with 376 ha (58%) of impervious cover (42% pervious). The impervious land cover was determined using SOLRIS (2009) information. Therefore, the permeability component rating is 8.

Setback Slope The setback slope rating ranges from seven to nine and has been divided equally into; < 2% slope (7), 2% to 5% (8), and > 5% (9). The topography of the R.H. Neath WTP upland IPZ-2 is described as moderately sloping topography with a steep eastern ridge, characteristic of the Cape Rich steps rock formation. The slope of the study area ranges from 1.5% to 4.5%. This was determined using OBM contours. As a conservative approach, the greatest slope range (4.5%) was used to assign the component rating. These area features may increase runoff directly to the lake within the vulnerable zone. The slope component rating is 8.

Land Characteristics (Summary) The resulting land characteristics sub factor, calculated using an averaged equal representation of each component listed above is 8.3.

Transport Pathways

The transport pathway sub factor has the components: storm catchment areas, storm outfalls, watercourses and drains, and tile drained areas.

Storm Catchment Areas Storm catchment areas are rated based on the percent of land area that is drained by a storm sewer system. The rating ranges from seven to nine and has been divided equally into; < 33% area (7), 33% to 66% area (8) and > 66% area (9). The upland area was determined to be 46% (296 ha) storm sewer drained. This resulted in a component rating of 8.

Storm Outfalls, Watercourses and Drains For the purpose of rating the number of storm outfalls, watercourses and drains, a standardized method was applied to the data. The number of outfalls per 1,000 ha of land was calculated for the R.H. Neath WTP IPZ-2 using the WVF Provincial Dataset. The rating range has been set for 0-3/1,000 ha in the zone at 7, 4 to 7/1,000 ha in the zone at 8 and > 7/1,000 ha in the zone at 9. Fifteen storm sewers and fourteen watercourses discharge into Owen Sound the IPZ-2 giving a calculated 43 outfalls *per* 1,000 ha of land. This resulted in a sub factor of 9.

Tile Drained Area Tile drained area is based on the percent land artificially drained as indicated by the Tile Drainage Areas GIS dataset (OMAFRA, 2009). The rating ranges from seven to nine and has been divided into; < 33% area (7), 33% to 66% area (8), and > 66% area (9). There are no tile drained areas in the R.H. Neath WTP upland IPZ-2 and therefore a component rating of 7 has been assigned.

Transport Pathways (Summary) The resulting transport pathways sub factor, calculated using an averaged equal representation of the components listed above is 8.

The area vulnerability factor is determined by averaging an equal representation of the % land, land characteristics, and transport pathways sub factors. The resulting area factor rating for the Owen Sound IPZ-2 is 8.

Source Vulnerability Factor
The source vulnerability factor for the Owen Sound Intake is a combined rating of intake characteristics (depth, length of pipe) and past water quality concerns. The intake crib depth is 11.3 m and its vulnerability sub score is 0.5. The Owen Sound intake is located approximately 670 m from the shoreline and the sub factor is 0.5. No water quality concerns relating the ODWQS listed chemical parameters and their respective MACs or IMACs are evident. Given that bacteria, including *E.coli*, are normally ubiquitous at low levels in raw surface water supplies from multiple non-human sources and the levels are relatively low in the data record for the R.H. Neath WTP, there appears to be no immediate concern for their presence in the WTP raw water supply. However, the R.H. Neath WTP is located approximately one km from the Owen Sound Waste Water Treatment Plant (WWTP), which is a potential source of bacteria and chemical pollutants to the source water. The operating authority is to report all bypasses from the WWTP and the West Side Pump Station to the MOECC, the Grey Bruce Health Unit and the WTP. Records indicate that this is being done. Also, on occasion, elevated nitrates were reported at the intake (Stantec 2009, Phase 1 Technical Addendum). The resulting sub factor for recorded water quality concerns is 0.5 (Stantec 2009, Phase 1 Technical Addendum).

The source vulnerability factor is determined by averaging the above listed sub factors. The source factor rating for the Owen Sound IPZ is 0.5 (Table 4.7.S1.2b).

Resulting Vulnerability of the Intake Protection Zone
The resulting vulnerability for IPZ-1 is five and for IPZ-2 is four (Table 4.7.S1.2c).

TABLE 4.7.S1.2a – Area Vulnerability Factor for the R. H. Neath Intake

Area Vulnerability Factor Rating *(Rounded average of percentage of land, land characteristics and transport pathways)*	**8**
Percentage of Land	8
Land Characteristics	8.3
Land Cover	9
Soil Type	8
Permeability	8
Setback Slope	8
Transport Pathways	8
Storm Catchment Areas (more than 33% but less than 66 %)	8
Storm Outfalls, Watercourses, Drains (The number of storm outfalls, watercourses and drains per 1,000 ha is larger than 7)	9
Tile Drained Area (less than 33 %)	7

TABLE 4.7.S1.2b – Source Vulnerability Factor for the R. H. Neath Intake

Sub Factor	Score
Intake Depth	0.5
Length of Pipe (offshore)	0.5
Recorded Water Quality	0.5
Source Vulnerability Factor	0.5

TABLE 4.7.S1.2c – Vulnerability Score of the R. H. Neath Intake Protection Zone (IPZ)

Intake Type	Area Vulnerability Factor		Source Vulnerability Factor	Vulnerability Score	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
A (Great Lake)	10	8	0.5	5	4

Uncertainty Rating

The uncertainty rating for the area delineation of IPZ-1 is low, because rules are prescribed by the Technical Rules.

Numerical modelling and the delineation of on-land areas was peer reviewed. However, the uncertainty rating for the delineation of IPZ-2 is high, partly because of uncertainties embedded within the numerical modelling itself, and partly because the data required for validating these models has high uncertainty (for details, see Section 4.1.7.2).

Threats and Risks

Land uses and activities within the intake protection zone were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

Table 4.7.S1.4 indicates that no surface water threats are rated at a “significant” level for DNAPLs or pathogens. The vulnerability score for Great Lakes intakes (both IPZ-1 and IPZ-2) is always smaller than eight. However, moderate threats were identified in the vulnerable area (Stantec 2009, Phase 2 Report). 12 existing significant drinking water threats were identified through events-based modelling (see detailed Table 4.7.S1.3 and summary Table 4.7.S1.4).

TABLE 4.7.S1.3 – Owen Sound IPZ: Significant Drinking Water Threats for Events-based Area

Prescribed Threat **IPZ: OWEN SOUND** *For full legal name of prescribed threat, see Table 4.1.5*		Land use Category									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
	CHEMICALS										
15	Fuel - Handling and storage		11				1				**12**

<u>Moderate and Low Threats</u>
Moderate and low threats are not counted individually even if identified. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

TABLE 4.7.S1.4 – R. H. Neath IPZ: Significant Drinking Water Threats for Chemical, Pathogen and DNAPLs

IPZ Name	**Number of "are or would be significant" threats**			
	Pathogen	Chemical	DNAPL	Total
Owen Sound	0	12	0	12

Quality of Raw Water at the Intake

The R. H. Neath WTP gets its water supply from Georgian Bay. Samples have been collected from 1990 to 2005 and range from one to 11 samples per year. Levels for lead, total phosphorus and turbidity were observed and exceeded. Lead values were near or above the maximum acceptable concentration (MAC) of one ug/L in four of the 16 years samples were collected. Total phosphorus concentrations exceeded the PWQO of 0.03 mg/L in two of 16 years that were sampled, and turbidity levels were near or above one FTU in 11 of the 16 years sampled.

The Owen Sound Spring Supply Treatment Plant is no longer in operation but existing water quality data was examined. The water supply is groundwater and samples were collected from 1990 to 1995. The number of samples collected ranged from two to 11 samples per year. Hardness was the only parameter that had values that exceeded the operational guideline of 80-100 mg/L of calcium carbonate every year sampling occurred.

See Source Vulnerability.

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.7.S1.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.7.S1.5 – R. H. Neath: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.8 Town of South Bruce Peninsula

The Town of South Bruce Peninsula is a lower tier municipality in the County of Bruce located in the southern portion of the Bruce Peninsula. To the west, Lake Huron confines the Town of South Bruce Peninsula. To the northeast, the town is bordered by Georgian Bay and to the southeast by the Township of Georgian Bluffs. In January 1999, the Town of Wiarton was amalgamated with the surrounding municipalities of the Township of Albemarle, Township of Amabel and the Village of Hepworth to form this municipality.

The majority of the Town of South Bruce Peninsula lies within the Grey Sauble Source Protection Area. A small northerly portion of the municipality lies in the Northern Bruce Peninsula Source Protection Area, and a small southerly portion lies within the Saugeen Valley Source Protection Area. In 2006, the population was 8,416, which was an increase of 0% from 2006. The main towns are Wiarton (population 2,349), Sauble Beach (population 2,000 permanent, plus thousands seasonally) and Hepworth. Smaller settlement areas are Colpoys Bay, Oliphant and Allenford. The Town of South Bruce Peninsula has a strong tourism sector along the Lake Huron shoreline in the summer and cross country skiing in the winter. The second largest sector is agriculture, with livestock and crop production comprising the main farming activities. The quality gravel deposits throughout the region have also ensured a thriving aggregate industry.

The Town of South Bruce Peninsula previously operated eleven separate municipal water supply systems, ten of which were groundwater-based and one was surface water based, Wiarton. In 2008, these systems were rearranged into five groundwater systems: Foreman Water Works at Chesley Lake, Huron Woods Water Supply Works south of Silver Lake, Amabel-Sauble Water Treatment Plant and Distribution System (includes Winburk) in the northern end of Sauble Beach, and Oliphant Water System in Oliphant, which was previously called Fiddlehead.

Six of the groundwater systems within the central portion of Sauble Beach area were scheduled for decommissioning and were tied into a newly developed groundwater system at the Amabel-Sauble School in May 2009. It should be noted that all of these systems were listed as potential GUDI wells and a number of them had problems with fluoride, iron, turbidity, bacteria, and sodium. The well for the Winburk Water Works will be maintained as a backup well to the new Amabel-Sauble system. This new system is tied into the six former distribution systems (Winburk/Fedy, Thompson, Gremik, Trask, Forbes, and Robins) that were located in the central portion of Sauble Beach area.

Two groundwater systems to the south, Foreman Water Works and Huron Woods Water Supply Works, remain separate and operational. Two former systems to the north were decommissioned: the Fiddlehead Water Plant on January 23, 2009 and Cammidge & Collins Water Works on April 22, 2009. The area is now tied into a newly developed system at the Fiddlehead location, referred to as the Oliphant Water System. The two wells at Amabel-Sauble School and one well at Oliphant are new wells and were not investigated under the 2003 Grey Sauble groundwater studies program.

Agricultural land use in South Bruce Peninsula includes 147 farms covering a total land area of 21,628 ha (average farm size 147 ha), of which 33.5% are cropped according to the Agricultural

Census (Statistics Canada, 2006a). Of this cropped area, alfalfa and other fodder crops take up 39.4% of the land, barley takes up 4.2% and other crops (corn, wheat, etc.) take up 7.6%. For South Bruce Peninsula, the total livestock density is 0.05 nutrient units per acre. According to the same census, there are 1,087 chickens on 14 farms (Statistics Canada, 2006a). The total number of cattle is 12,746 (only beef) on 101 farms. Further, there are no pigs, no sheep, 382 horses, and no goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.8.M1.

4.2.8.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.8.M2 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this Municipality. All of the northern part of this Municipality is designated HVA as a result of thin and permeable overburden. Only below the transection of Huron Woods and Allenford is the vulnerability of aquifers low, thus offering relevant protection. Regarding recharge, the sandy glaciolacustrine shallow water deposits between Hepworth and Sauble Beach and the sandy strip east of the lakeshore of Lake Huron, with a width of 1-3 km, is designated a SGRA.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.8.M3).

In this municipality, the total area of SGRAs is 132.6 km^2 and the total area of HVAs is 434.1 km^2. The percentage of managed lands located within the SGRAs and HVAs is 40-80%. The livestock density is less than 0.5 NU/acre. Only 1-8% of all surfaces in SGRAs and HVAs are classified as impervious (Table 4.2.8.1).

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions on how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

TABLE 4.2.8.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Town of South Bruce Peninsula

SGRA	Total Area of SGRA	132.6 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	434.1 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

4.2.8.2 Groundwater Municipal Systems

4.2.8.2.1 Oliphant Water System

The Oliphant Water System is located near the community of Oliphant about 8 km north of Sauble Beach. The Oliphant Water Works is presently comprised of two bedrock wells. One well was constructed in 1971 and a second well was constructed in July of 2002. The Oliphant (also known as Fiddlehead) Well No. 1 is 27.4 m deep and the Oliphant No. 2 is 36.6 m deep. Oliphant Well No. 1 is the main production well with Oliphant Well No. 2 as back up. The wells are located in the town of Oliphant, 300 metres east of Lake Huron and 11.5 kilometres west of Wiarton.

In the area surrounding the two Oliphant wells, the overburden thickness ranges between 5 and 7 metres and karstic bedrock is surfacing in several locations. Glaciolacustrine shoreline deposits mainly consist of coarse sand with high permeability, which is loamy around the nearby Spry Lake. Data on the area serviced with drinking water and sewer exist in paper form but digital data is not available to DWSP at this moment.

Both Oliphant wells are considered GUDI, and were declared GUDI without study by the Municipality. However, several adverse bacteriological incidences were reported. In the year 2003, three incidences of bacteriological contamination of the raw water were identified (MOECC, 2004). In the same year, one increased level of turbidity was reported (> 1 NTU).

TABLE 4.8.G1.1 – Description of the Drinking Water System and Wells

Well Name	Fiddlehead No. 1	Fiddlehead No. 2
Drinking Water System ID	220007695	
Drinking Water System Classification	Small Municipal Residential System	
SPA of Well and Vulnerable Area (WHPA)	Grey Sauble SPA	
Northing/Easting	4953551.3 / 478287.8	4953564.2 / 478296.1
Year Constructed	1971	2003
Well Depth	27.4 m	36.6 m
Uncased Interval	10.7 - 27.4 m	15.2 - 36.6 m
Aquifer	Limestone bedrock (Amabel formation)	
GUDI	Yes	Yes
Number of Users Served	33	
Design Capacity (CoA)	417 m^3/day	417 m^3/day
Permitted Rate (PTTW)	329 m^3/day	329 m^3/day
Average Usage*	11.61 m^3/day	9.28 m^3/day
Modelled Pumping Rate	329 m^3/day	329 m^3/day
Treatment	UV and a chlorination system (sodium hypochlorite and ammonia) capable of providing secondary disinfection	

* *CRA Phase I, Round 1 Report 2007*

A wellhead protection area (WHPA) for the Oliphant Water System was first developed as part of the Grey Bruce Groundwater Study (WHI, 2003). The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates as part of the Round 1 Technical Study for the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region (CRA, 2007).

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.8.G1.2a and shown on Map 4.8.G1.4. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. For the purposes of calculating managed lands and livestock density, only the portion of the WHPA with a vulnerability score of 6 or more was used in the calculations. The results are listed in Table 4.8.G1.2b and shown on Maps 4.8.G1.5 and 4.8.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.8.G1.2a – Impervious Surfaces

General	Code for WHPA	OLIPHANT
	Total Area [hectare]	28.10
Impervious surfaces Area [ha]	0 % – <1%	0.00
	1% – <8%	23.74
	8% – < 80%	0.00
	Larger or equal than 80%	0.00

Note: Total areas relate to the full WHPA, even if located in other municipalities

TABLE 4.8.G1.2b – Managed Land and Livestock Density

WHPA_NAME	**OLIPHANT**			
Well name	Fiddlehead 1_2	Fiddlehead 1_2	Fiddlehead 1_2	Fiddlehead 1_2
Zone	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	<0.5
% Managed Lands (<40%, 40-80%, >80%)	<40%	<40%	<40%	<40%

Wellhead Protection Area

The wellhead protection area (WHPA) was estimated following the methodology described in Section 4.1.2.5. It extends east of the well 1.3 kilometres (Map 4.8.G1.1). WHPAs A, B, C, and D are residential and woodland. The 25-year ToT capture zone for the Oliphant WHPA encompasses a total land area of approximately 0.28 km^2. The WHPA is short and thin due to the low pumping rate of the wells, resulting in protection zones that generally overlap each other. The most easterly portion of the WHPA approaches but does not reach Spry Lake.

A WHPA-E was delineated in the surface water body that influences these GUDI wells. The closest surface water to the Fiddlehead well is a wetland mostly within the WHPA. To identify the points of interaction, Technical Rule 47(5a) was applied and two points within the wetland were identified, 300 metres north east of the wells. A 120 metre setback or the regulation limit was added. The small WHPA-E has an area of seven hectares and extends outside to the north of the WHPA-B (for details, see Section 4.1.2.7).

Map 4.8.G1.2 shows the borders of all zones of WHPA overlaid on aerial photography.

Transport Pathways

The vulnerability of the WHPA must be increased if pathways exist that transport contaminants from the surface into the aquifer that is a source for drinking water (see Section 4.1.2.6), unless the vulnerability is already rated “high”.

No transport pathway adjustments were made to aquifer vulnerability in the Oliphant WHPA. Existing properties are either on municipal services, or have wells that are in compliance with existing standards.

Vulnerability

<u>WHPA A-D</u>
The high intrinsic susceptibility index in the area is likely due to the presence of highly permeable overburden material (e.g., sand), which lays directly over the limestone aquifer, and the lack of low permeability materials (e.g., clay) within the overburden materials to protect the aquifer.

After overlaying the intrinsic susceptibility index (Map 4.8.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.1.3 for detail). The vulnerability is shown on Map 4.8.G1.3.

The adjusted vulnerability scores within the Town of South Bruce Peninsula WHPAs are variable among and between WHPAs. The intrinsic vulnerability (Map 4.8.M1) is high in the Oliphant WHPA, with 85% of the 25 year-ToT capture zone designated as highly vulnerable (adjusted vulnerability scores between 8 and 10). The Oliphant WHPA is characterized by a relatively large zone B located within an area where the aquifer has a high intrinsic susceptibility index (i.e., overburden materials provide little aquifer protection) and land use around the well is dominated by low-density residential areas with private wells and individual septic systems to treat and discharge waste water.

<u>WHPA-E</u>
The total vulnerability of the WHPA-E associated with the Oliphant wells is comparatively high (8.0). This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.8.G1.2c). The area vulnerability describes the propensity of the on-land area to contribute runoff (percentage of land, land characteristics and transport pathways), which is 8 (moderate) for both wells. The source vulnerability score describes the likelihood that the surface water transports contaminants to the well and is 1.0 (high) for both wells, due to lack of overburden protection.

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.3 for details).

TABLE 4.8.G1.2c – Vulnerability of WHPA-E Associated with the Oliphant Water System

Name of WHPA	OLIPHANT	
DWIS_ID	220007695	
Area (Total), hectares	7.72	
Vulnerability (Total)	**8.0**	
Source Vulnerability	**1.0**	
SV - Distance to surfacing karst [m]	>500m	0.8
SV - Overburden Protection	4.89 m	1.0
Area Vulnerability	**8 (8.1)**	
AV - Percent Land: Score	**9**	
AV - Percentage of Land	> 70%	9
AV - Land Characteristics	**7.6**	
Land Cover*	100% Natural	7.0
Soil Type	100% sand,	7.0
Soil Permeability *	100% C,	8.3
Slope [%]	3.5%	8.0
AV Transport Pathways	**7.7**	
Tile Drainage [% of land area]	0.0%	7
Storm Catchment	None	7
Number of Water Courses/1000 ha	9.0	

** Area disregarded if classified "Not categorized"*
*** The Area Vulnerability Score is rounded to full number. In brackets, value rounded to 1 digit is shown.*

Threats and Risks

Land uses and activities within the wellhead protection area were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

WHPA A-D
There are 35 significant drinking water threats in the Oliphant wellhead protection area A-D. These threats include 17 activities related to the potential for pathogen contamination and 18 activities related to contamination with hazardous chemicals. The total number of properties with threats is 18 (see detailed Table 4.8.G1.3 and summary Table 4.8.G1.4).

The land surrounding the wells is deemed residential and woodland. The significant threats are located in WHPAs A and B. WHPA-B is highly vulnerable and is almost as large as WHPAs C and D. Except for the pumping station of the well itself, all other activities associated with potentially significant threats are residential and include sewage system, storage of fuel and waste disposal.

WHPA-E
With surface water influencing the Oliphant wells, a WHPA-E was delineated. The vulnerability score of this WHPA-E is 8.0, and chemical and pathogen threats can be significant (see Section 4.1.5.7). For chemical threats, no activity in this area meets the quantity circumstances defined in Provincial Table 22: CIPZWE8S. Some activities that discharge sewage (as defined in Provincial Table 48: PIPZWE8S) would be considered pathogen threats, but none were identified in this area. Agricultural activities have the potential to contaminate surface water with pathogens (as defined in Provincial Table 48: PIPZWE8S), if they engage in activities such as the handling, storage and application of agricultural source material and non-agricultural source material, as well as with livestock. No pathogen threats were identified in this WHPA-E, and the total number of significant threats in the WHPA-E is zero.

Moderate and Low Threats
Moderate and low threats are not counted individually even if identified. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

Quality of Raw Water at the Well

Water from the Oliphant wells is rich in Dissolved Organic Carbons and Dissolved Organic Solids as result of the connection of the karstic Amabel aquifer with surface waters. It also contains high iron content, which is attributed to natural occurrences (operator statement).

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TABLE 4.8.G1.3 – Oliphant: Significant Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL threats)

Prescribed Threat **WHPA: OLIPHANT** *For full legal name of prescribed threat, see Table 4.1.5*		**Land Use Category**									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal						1		16		**17**
3	Agricultural source material - Application to land										
6	Non-agricultural source material - Application to land										
8	Commercial fertilizer - Application to land										
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
14	Snow – Storage										
15	Fuel - Handling and storage						1				**1**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards - Livestock grazing										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal						1		16		**17**
3	Agricultural source material - Application to land										
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards - Livestock grazing										

TABLE 4.8.G1.4 – Oliphant WHPA: Summary of Significant Drinking Water Threats

	Number of "are or would be significant" threats				Number of *properties* with "are or would be significant" threats			
OLIPHANT	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	18	0	17	35	0	17	1	18
WHPA-E				0				0

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.8.G1.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.8.G1.5 – Oliphant: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.8.2.2 Amabel-Sauble Drinking Water System

The Amabel-Sauble Drinking Water System is owned by the Town of South Bruce Peninsula. It was formed in 2009 by tying the seven former distribution systems within the central portion of Sauble Beach area into a single system. These former systems were Gremik, Thompson, Trask, Forbes, Winburk, Fedy, and Robins. Only the Winburk well is maintained as a backup well to this new system. Even though the well and its supply remain as an intact system, it is inspected with the Amabel-Sauble system and thus classified as part of it. Therefore, the Winburk system is described within this section.

This system is comprised of two operating bedrock wells: PW1 and PW2. The wells are located on the grounds of an elementary school in the north east part of Sauble Beach, 200 metres east of Sauble Falls Parkway and 1.5 kilometres inshore of Lake Huron. PW1 was drilled in June 1994 and is located on Lot 31, Concession D. PW2 was drilled in the summer of 2002 and is located approximately 34.5 m south of PW1.

Well PW1 was drilled to a depth of 102.1 m with 2.3 m of sand with clay and stones from 7.3 m to 17.6 m. From 17.6 m (58') to 99.1 m is shown as limestone (dolostone) before blue shale and red shale are encountered. Water was found at 29.3 m, 64.3 m and 97.8 m in the Guelph Amabel Bedrock Formation. Well PW1 was cased to a depth of 20.0 m into the bedrock (CRA, 2003). The well record for the well PW2 shows sand from ground surface to 7.0 m and clay and stones from 7.0 m to 16.2 m. From 16.2 m to 102.4 m is limestone (dolostone) of the Guelph Amabel Formation. A water bearing zone was found at 25.9 m in accordance with a video log of the well (CRA, 2003) and also at 44.5 m and 81.7 m. This well was cased and grouted to a depth of 19.0 m, which is 1.5 m into the bedrock.

The Winburk well is located in the north east part of Sauble Beach, 800 metres east of Sauble Falls Parkway and 1.8 kilometres inshore of Lake Huron. The well is located in a well pit at the former site of the Winburk DWS. It was constructed in 1977 and has steel casing (MOECC, 2009d). Its overburden consists of approximately 15 m of sand with approximately 8 m of clay and stones underneath (Henderson and Paddon, 2003a). Due to problems with pathogens in this well (WHI 2003), the area immediately surrounding the Winburk well appears to have a connection between the surface and confined bedrock aquifer, which may be a result of a high density of up-gradient deep bedrock wells of unknown integrity. The former Fedy and Forbes wells have not been decommissioned and remain as monitoring wells. The other wells were decommissioned.

All wells of this DWS are considered GUDI, due to variability in groundwater quality. Both Amabel-Sauble School wells derive their water supply from the fractured dolostone bedrock of the Guelph-Amabel formation. While they were originally believed to be well protected by overburden (CRA, 2003), new water quality results indicate surface water influence. The classification was recently changed and is now GUDI (Genivar, 2009b). The wells are equipped with a submersible pump, rated at 4 l/sec pump raw water to the new treatment plant. This plant is equipped with secondary UV disinfection and adequate to handle microbial contamination at levels that are typical for GUDI wells.

The former Winburk well, in which water quality shows strong influence from the overburden, was assumed GUDI without further studies.

The Amabel-Sauble Water Treatment Plant houses treatment equipment consisting of an iron removal system, a chlorination system for disinfection, an additional UV disinfection system, a residual management system, and standby power. The iron removal system consists of two pressure vessels containing anthracite and catalytic media. The disinfection system consists of three pumps each with a dedicated duty, one pump is used for iron and manganese oxidation, the second pump is used to chlorinate treated water after UV disinfection prior to water entering the clear well and the third pump is used for post chlorination. The additional disinfection system consists of one filter cartridge housing precedent to the one UV disinfection unit. This additional disinfection unit is only needed when the former Winburk well is being used because it is deemed a GUDI well and requires additional disinfection (MOECC, 2009d).

TABLE 4.8.G2.1 – Description of the Drinking Water System and Wells

Well Name	Amabel PW1	Amabel PW2	Winburk
Drinking Water System ID	220007917		
Drinking Water System Classification	Large Municipal Residential System		
SPA of Well and Vulnerable Area (WHPA)	Grey Sauble SPA		
Northing/Easting	4944164.6 / 479776.3	4944133.5 / 479790.4	4943742.3 / 480235.8
Year Constructed	1994	2002	1977
Well Depth	102.1 m	105.5 m	87 m
Uncased Interval	20 - 102.1 m	18 - 105.5 m	? - 87 m
Aquifer	Guelph/Amabel, little Queenston shale	Guelph/Amabel, little Queenston shale	Overburden, Guelph/Amabel
GUDI	No	No	Yes
Number of Users Served	< 730 persons		
Design Capacity (CoA)	not known	not known	262.1 m^3/day
Permitted Rate (PTTW)	687 m^3/day	687 m^3/day	262 m^3/day
Average Annual Usage**	not known	not known	33.65 m^3/day
Modelled Pumping Rate	344 m^3/day	344 m^3/day	262 m^3/day
Treatment	iron removal system, a disinfection system, an additional disinfection system, residual management system and standby power		Backup well; additional filter cartridge housing prior to the one UV disinfection

** New treatment plant, data not available*
*** CRA Phase I, Round 1 Report 2007*

Data on the area serviced with drinking water and sewer exist in paper form but digital data is not available to DWSP at this time. The distribution system trunk watermains were constructed on Sauble Falls Parkway, Woodland Crescent, 6th Street North, 3rd Avenue North, 9th Street

North, 2nd Avenue North, D-Line, Jewel Bridge Road, Deer Trail Road, and Martin Drive in Sauble Beach. There are fire hydrants on the trunk mains as well as two air release valve chambers. A raw watermain from the former Winburk pump house to the new Amabel-Sauble Water Treatment Plant was installed from Bunnyview Drive to the D-Line (MOECC, 2009d).

A wellhead protection area (WHPA) for the Amabel-Sauble DWS was first developed as part of the Grey Bruce Groundwater Study (WHI, 2003). The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates as part of the Round 1 Technical Study for the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region (CRA, 2007).

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.8.G2.2a and shown on Map 4.8.G2.4. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. For the purposes of calculating managed lands and livestock density, only the portion of the WHPA with a vulnerability score of 6 or more was used in the calculations. The results are listed in Table 4.8.G2.2b and shown on Maps 4.8.G2.5 and 4.8.G2.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.8.G2.2a – Impervious Surfaces

General	Code for WHPA	**AMABEL_SCHOOL**	**WINBURK**
	Total Area [hectare]	43.10	29.57
Impervious Surfaces Area [ha]	0 % – <1%	1.61	0.00
	1% – <8%	41.45	29.57
	8% – < 80%	0.04	0.00
	Larger or equal than 80%	-	-

Note: Total areas relate to the full WHPA, even if located in other municipalities

TABLE 4.8.G2.2b – Managed Land and Livestock Density

WHPA_NAME	**AMABEL-SAUBLE**							
Well Name	AMABEL_SCHOOL_1_2				WINBURK			
Zone	A	B	C	D	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	0.5-1.0	<0.5	<0.5	<0.5	<0.5
% Managed Lands (<40%, 40-80%, >80%)	<40%	<40%	<40%	40-80%	<40%	<40%	>80%	>80%

Wellhead Protection Area

Amabel-Sauble School Wells
The wellhead protection area (WHPA) was estimated following the methodology described in Section 4.1.2.5. It extends southeast (Map 4.8.G2.1) from the well. WHPAs A and B extend 700 metres and include Amabel-Sauble School and a residential area. WHPAs C and D extend 2.7 kilometres and encompass the Sauble River as well as a variety of other land uses including residential, forest and farmland. The 25-year ToT capture zone for this WHPA encompasses a total land area of approximately 0.43 km^2. Land use within the 25-year ToT capture zone consists of institutional, residential and commercial, within the Sauble Beach area, and mining (aggregate), forested/wetland and agricultural to the east. WHPAs C and D intersect the Sauble River and the associated Bannister Swamp wetland complex.

A WHPA-E was delineated in the surface water body that influences these GUDI wells. The closest surface water to the Amabel School wells PW1 and PW2 is the Sauble River, which passes north of Jewel Bridge. The specific point of interaction is not known for the Amabel-Sauble school wells. Thus, Technical Rule 47(5a) was applied and the point closest to the well was identified. The point of interaction for wells PW1 and PW2 is located outside of their WHPA A-D, approximately 300 metres north-east in the Sauble River and 35 metres beyond the WHPA. It includes all tributaries within the 2-hour ToT. A 120 metres setback or the regulation limit, and areas with agricultural tile drainage were added (for details, see Section 4.1.2.7).

Map 4.8.G2.2 shows the borders of all zones of WHPA overlaid on aerial photography.

Winburk Well
The Winburk WHPA is located just south of the Amabel-Sauble WHPA and is similar in characteristics. The WHPA extends southeast from the well. WHPAs A and B are 800 metres in length and the Sauble River flows through these zones. WHPAs C and D are largely woodland, with a small section consisting of agricultural land. The Winburk WHPA encompasses a total land area of approximately 0.30 km^2. Land use within the 25-year ToT zone consists of residential, commercial, forested, and agricultural lands. WHPA C includes the Sauble River and the associated Bannister Swamp wetland complex. The wetland complex drains into the Sauble River via a municipal drain.

A WHPA-E was delineated in the surface water body that influences this GUDI well. The specific point of interaction is not known for the Winburk well. Thus, Technical Rule 47(5a) was applied and the point closest to the well was identified. The Winburk point of interaction is located in a small creek 530 metres south of the well, before it discharges into Sauble River. This creek connects to and drains the swampy floodplain surrounding Carson Lake and Silver Lake, both located behind an elevated sandy stretch behind Sauble Beach. This creek is generally small but can swell significantly if the water level of the two groundwater-fed inland lakes rises. The WHPA-E extends upstream from the point of interaction and includes parts of the Banister Swamp and minor tributaries to the wetland north of Carson Lake. A 120 metres setback or the regulation limit, and areas with agricultural tile drainage were added (for details, see Section 4.1.2.7).

Map 4.8.G2.2 shows the borders of all zones of WHPA overlaid on aerial photography.

Transport Pathways

The vulnerability of the WHPA must be increased if pathways exist that transport contaminants from the surface into the aquifer that is a source for drinking water (see Section 4.1.2.6), unless the vulnerability is already rated "high".

Aquifer Vulnerability was adjusted one level to account for transport pathways in the urban area within the Amabel-Sauble and Winburk WHPAs. This adjustment was based on the documented existence of wells that are out of compliance with existing standards. Areas where aquifer vulnerability was adjusted are shown in Map 4.8.G2.3.

Vulnerability

<u>WHPA A-D</u>

The high intrinsic susceptibility index in the area (Map 4.8.M.1) is caused by the presence of highly permeable sandy overburden directly overlying the limestone aquifer. Geologic cross-sections indicate the presence of a clay layer above the limestone bedrock surface in the vicinity of the Amabel-Sauble School wells; however, with less than three meters, the layer is relatively thin in some areas within the WHPA and likely discontinuous (CRA 2009, Phase I Technical study).

After overlaying the intrinsic susceptibility index (Map 4.8.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.1.3 for detail). The vulnerability is shown on Map 4.8.G2.3.

The intrinsic susceptibility of the groundwater aquifer (Map 4.8.M1) is considerably higher in the Amabel-Sauble and Winburk WHPAs, which have over 84% of their total area designated as high vulnerability (adjusted vulnerability scores between 8 and 10). The Amabel-Sauble and the Winburk WHPA are characterized by a relatively large 2-year ToT WHPA- B. They are located within an area where the aquifer has a high intrinsic susceptibility index (i.e. overburden materials provide little aquifer protection).

<u>WHPA-E</u>

The total vulnerability of the WHPA-E associated with the Amabel-Sauble School wells (PW1, PW2) is comparatively high (8.0), as is the vulnerability of the WHPA-E of the Winburk well (8.0). This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.1.3.6). The area vulnerability describes the propensity of the on-land area to contribute runoff (percentage of land, land characteristics and transport pathways), which is 8, moderate, for both WHPA-E areas) with the source vulnerability score (1.0, high, for both wells).

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.3 for details).

TABLE 4.8.G2.2c – Vulnerability of WHPA-E Associated with the Amabel-Sauble DWS

Name of WHPA	AMABEL_SCHOOL		WINBURK	
DWIS_ID	220007917		220007917	
Area (Total), hectares	1420.20		445.49	
Vulnerability (Total)	**8.0**		**8.0**	
Source Vulnerability	**1.0**		**1.0**	
SV - Distance to surfacing karst [m]	< 250 m	1	< 250 m	1
SV - Overburden Protection	23.93 m	0.9	26 m	0.9
Area Vulnerability **	**8 (8.06)**		**8 (7.75)**	
AV - Percent Land: Score	**9**		**9**	
AV - Percentage of Land	> 70%	9	> 70%	9
AV - Land Characteristics	**7.5**		**7.25**	
Land Cover*	Mainly vegetated	7	Mainly vegetated	7
Soil Type	Moderately coarse sandy loam and organic	8	Moderately coarse sandy loam and organic,	8
Soil Permeability *	< 33%	7	< 33%	7
Setback Slope [%]	4.4%	8	1.2%	7
AV Transport Pathways	**7.67**		**7**	
Tile Drainage [% of land area]	42%	8	14%	7
Storm Catchment	None	7	None	7
Number of Watercourses/1,000 ha	3-6	8	0-3	7

** Area disregarded if classified "Not categorized", thus not always adding up to 100%*
*** The Area Vulnerability Score is rounded to full number.*

Threats and Risks

Land uses and activities within the wellhead protection area were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions on how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

WHPA A-D

There are 94 significant drinking water threats in the Amabel-Sauble School (wells PW1 and PW2) wellhead protection area A-D. These threats include 46 activities related to the potential for pathogen contamination, and 48 activities related to contamination with hazardous chemicals. The total number of properties with threats is 46 (see detailed Table 4.8.G2.3 and summary Table 4.8.G2.4).

The well is located on institutional property surrounded by residential properties. All of the significant threats are located in WHPAs A and B. The land use for WHPAs C and D include residential, swamp and agricultural, none of which pose any potential significant threats.

There are 74 significant drinking water threats in the Winburk wellhead protection area A-D. These threats include 36 activities related to the potential for pathogen contamination and 38 activities related to contamination with hazardous chemicals. The total number of properties with threats is 36 (see detailed Table 4.8.G2.3 and summary Table 4.8.G2.4).

The well is located in a highly vulnerable residential area and the significant threats are located in WHPAs A and B on residential and recreational land. There are no significant threats in WHPAs C and D.

WHPA-E

With surface water influencing the Amabel-Sauble wells (PW1, PW2) and the Winburk well, WHPA-Es were delineated. The vulnerability scores of these WHPA-Es are 8.0, and chemical and pathogen threats can be significant (see Section 4.1.5.7). For chemical threats, no activity in this area meets the quantity circumstances defined in Provincial Table 22: CIPZWE8S. Some activities that discharge sewage (as defined in Provincial Table 48: PIPZWE8S) would be considered pathogen threats, but none were identified in this area. Agricultural activities that have the potential to contaminate surface water with pathogens (as defined in Provincial Table 48: PIPZWE8S) were identified, associated with the handling, storage and application of agricultural source material and non-agricultural source material, as well as with livestock. A total of 5 activities were identified in this area as significant threats to drinking water sources within the Amabel-Sauble School WHPA-E (Table 4.8.G2.3c). No significant threats were given to the Winburk WHPA-E to avoid duplicates as all instances where significant threats could occur are within the area where the WHPA-Es overlap and have already been enumerated for the Amabel-Sauble School WHPA-E.

Moderate and Low Threats

Moderate and low threats are not counted individually. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

TABLE 4.8.G2.3a – Amabel-Sauble PW1 and PW2: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL threats)

	Land Use Category

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Prescribed Threat **WHPA: AMABEL_SCHOOL** *For full legal name of prescribed threat, see Table 4.1.5*		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal					1	1		44		**46**
3	Agricultural source material - Application to land										
6	Non-agricultural source material - Application to land										
8	Commercial fertilizer - Application to land										
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
12	Road Salt – Application					1					**1**
13	Road Salt – Handling and Storage					1					**1**
14	Snow - Storage										
15	Fuel - Handling and storage										
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal					1	1		44		**46**
3	Agricultural source material - Application to land										
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards										

TABLE 4.8.G2.3b – Amabel-Sauble Winburk: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL threats)

Prescribed Threat **WHPA: WINBURK** *For full legal name of prescribed threat, see Table 4.1.5*		**Land Use Category**									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal		1						35		**36**
3	Agricultural source material - Application to land										
6	Non-agricultural source material - Application to land										
8	Commercial fertilizer - Application to land										
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
12	Road Salt – Application		1								**1**
13	Road Salt – Handling and Storage		1								**1**
14	Snow - Storage										
15	Fuel - Handling and storage		0						0		**0**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal		1						35		**36**
3	Agricultural source material - Application to land										
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards										

TABLE 4.8.G2.3c – Amabel-Sauble: Significant Drinking Water Threats Associated with the WHPA-E (all land use activities identified are agricultural)

Prescribed Threat Name *For full legal name of prescribed threat, see Table 4.1.5*			**AMABEL_SCHOOL**	**WINBURK***
	PATHOGENS			
1	Untreated septage – Application to land		0	0
3	Agricultural source material - Application to land		2	0
4	Agricultural source material - Storage		2	0
6	Non-agricultural source material - Application to land		0	0
7	Non-agricultural source material - Handling and storage		0	0
21	Pastures or other farm-animal yards - Livestock	Grazing and pasturing	1	0
21	Pastures or other farm-animal yards - Livestock	Yards or confinement	0	0
	Grand Total		**5**	**0**

TABLE 4.8.G2.4 – Amabel-Sauble WHPA: Significant Drinking Water Threats (Chemical, Pathogen and DNAPL threats)

	Number of “are or would be significant” threats				**Number of properties with “are or would be significant” threats**			
WHPA A-D	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
AMABEL SCHOOL	48	0	46	94	0	44	2	46
WINBURK	38	0	36	74	0	34	2	36
WHPA E								
AMABEL SCHOOL			5	5	5			5
WINBURK			0	0	0			0

Quality of Raw Water at the Well

Data is not available for this 2009 drinking water system.

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.8.G2.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.8.G2.5 – Amabel-Sauble: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.8.2.3 Huron Woods Water Supply Works

The Huron Woods Water Supply Works is located on the south end of Sauble Beach on Birch Street. It is comprised of three bedrock Wells No. 1, 2 and 3 and one overburden Well No. 6. Well No. 3 is currently maintained as a backup for Well No. 6 (MOECC, 2009j). All wells are located in the southern portion of Sauble Beach, less than one kilometre east of Lake Huron.

The overburden Well No. 6 was constructed in 1990 and is 16.4 m deep. Well No. 6 is the main supply well. The three backup wells draw water from the bedrock. Wells No. 1, 2 and 3 were constructed in 1969, 1973 and 1974 respectively. These three wells are 123.5, 45.1 and 109.7 m deep respectively. Two additional wells, Wells No. 4 and No. 5 constructed in 1976 and 1980 respectively, were never developed for use and remain as test wells.

All of the Huron Woods wells are considered GUDI, and were declared GUDI without study by the Municipality. The Huron Woods wells are surrounded by different surface water bodies. These include two inland lakes to the north (Silver Lake and Carson Lake) and Bannister Swamp, which is a large wetland complex that stretches from Maryville Lake Road in the south to Spring Creek Road in the north.

Digital data on the area serviced with drinking water and sewer exist with consultants but are not available to DWSP at this moment.

A wellhead protection area (WHPA) for the Huron Woods Water Supply Works was first developed as part of the Grey Bruce Groundwater Study (WHI 2003). The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates as part of the Round 1 Technical Study for the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region (CRA, 2007).

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.8.G3.2a and shown on Map 4.8.G3.4. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. For the purposes of calculating managed lands and livestock density, only the portion of the WHPA with a vulnerability score of 6 or more was used in the calculations. The results are listed in Table 4.8.G3.2b and shown on Maps 4.8.G3.5 and 4.8.G3.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

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TABLE 4.8.G3.1 – Description of the Drinking Water System and Wells

Well Name	Huron Woods 1	Huron Woods 2	Huron Woods 3	Huron Woods 6
Drinking Water System ID	220007775			
Drinking Water System Classification	Small Municipal Residential System			
SPA of Well and Vulnerable Area (WHPA)	Grey Sauble SPA			
Northing/Easting	4939301.4 / 478714.1	4939300.8 / 478822.4	4939012.7 / 478931.2	4939237.8 / 479279.9
Use	currently maintained as backup wells			production well
Year Constructed	1969	1973	1974	1990
Well Depth**	123.4 m	45.1 m	109.7 m***	16.4 m
Uncased Interval**	30.5 - 123.4 m	30.5 - 45.1 m	75.6 - 109.7 m ***	7.00 - 14.60 m
Aquifer	Guelph/Amabel limestone bedrock			Unconfined overburden aquifer
GUDI	Yes	Yes	Yes	Yes
Number of Users Served***	83 connections served in 2009, 122 approved			
Design Capacity (CoA)	457 m^3/day	conjunctive	conjunctive	743 m^3/day
Permitted Rate (PTTW)	104.6 m^3/day	52.3 m^3/day	131 m^3/day	457.632 m^3/day
Average Annual Usage *	not known	not known	70 m^3/day	64 m^3/day
Modelled Pumping Rate	105 m^3/day	52.3 m^3/day	131 m^3/day	457.6 m^3/day
Treatment	Ferrosand filter system, cartridge filter system, ultraviolet (UV) disinfection system, chlorination system			

** CRA Phase I, Round 1 Report 2007*
*** Henderson and Paddon, 2001*
**** MOECC, 2009j*

TABLE 4.8.G3.2a – Impervious Surfaces

General	Code for WHPA	HURON_WOODS_1_2	HURON_WOODS_3_6
	Total Area [hectare]	198.87	36.13
Impervious Surfaces Area [ha]	0 % – <1%	15.93	12.33
	1% – <8%	174.82	22.18
	8% – < 80%	8.13	1.62
	Larger or equal than 80%	-	-

Note: Total areas relate to the full WHPA, even if located in other municipalities

TABLE 4.8.G3.2b – Managed Land and Livestock Density

WHPA_NAME	HURON_WOODS						
Well Name	NO. 1_2			NO. 1_2_6	NO.6		
Zone	A	B	C	D	A	B	C
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
% Managed Lands (<40%, 40-80%, >80%)	<40%	<40%	40-80%	40-80%	<40%	<40%	40-80%

WHPA_NAME	HURON_WOODS			
Well name	NO. 3			
Zone	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	<0.5
% Managed Lands (<40%, 40-80%, >80%)	<40%	40-80%	<40%	40-80%

Wellhead Protection Area

The wellhead protection area (WHPA) was estimated following the methodology described in Section 4.1.2.5. It is defined by two separate WHPAs (Map 4.8.G3.1). The updated WHPA for Huron Woods Wells No. 1, 2 and 6 encompasses a total land area of approximately 1.99 km^2. The total land area encompassed by the WHPA for Well No. 3 is 0.36 km^2.

The wellheads are located in the Lake Huron fringe wetland complex. The WHPA for Huron Woods Wells No. 1 and 2 extends southeast 5.5 kilometres and shares WHPA-D with Huron Woods Well No. 6. Land use within the WHPA of Huron Woods Wells No. 1, 2 and 6 consists of residential and commercial land use activities within WHPAs A and B and agricultural, mining (aggregate) and forested/wetlands in WHPAs C and D.

The WHPA for Huron Woods Well No. 3 runs nearly parallel and just south of the WHPA of the other three wells. It extends four kilometres southeast from the well. Land use in the Huron Woods Well No. 3 WHPA consists primarily of agricultural and forested/wetland complexes, with residential land use in the WHPA-A.

The Bannister Swamp complex continues within the southeast portion of WHPA- B of Well Nos. 3 and 6. Silver Lake is located north of the wellhead and Maryville Lake intersects WHPA-D.

WHPA-Es were delineated in the surface water bodies that influence these GUDI wells. Surface water bodies in the vicinity of the wells are wetlands surrounding the wells, two inland lakes to the north (Silver Lake and Carson Lake) and the Bannister Swamp that stretches from Maryville Lake Road to the south to Spring Creek Road to the north. The specific point of interaction is not known for any of the three Huron Woods wells. Thus, Technical Rule 47(5a) was applied and the point closest to the well was identified. For all four wells, the points of interaction are located within a wetland associated with small tributaries that drain into Silver Lake.

The points of interaction for Wells No. 1 and 2 are located near the end of a small tributary south of Silver Lake, the resulting WHPA-E covers an area of 0.1 km^2 (10 hectare) in the surrounding of the well. The points of interaction for Wells No. 3 and 6 is part of the Banister Swamp where Conservation Authority regulation limits apply. Those areas that discharge through the surface water bodies that influence the well were added within the 2-hour ToT. A 120 metre setback was added (for details, see Section 4.1.2.7).

Map 4.8.G3.2 shows the borders of all zones of WHPA overlaid on aerial photography.

Vulnerability

<u>WHPA A-D</u>
The Huron Woods WHPAs A, B and C are primarily located in an area with moderate intrinsic susceptibility index (Map 4.8.M1) likely due to the depth of the aquifer (33.5 to 35.3 m below ground surface) and the presence of 6.4 m (Well No. 6) to 33.5 m (Well No. 1) of low permeability overburden material (e.g., clay) overlying the aquifer.

After overlaying the intrinsic susceptibility index (Map 4.8.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.1.3 for detail). The vulnerability is shown on Map 4.8.G3.3.

<u>WHPA-E</u>
The total vulnerability of the WHPA-E associated with the Huron Woods Well Nos. 1, 2 and 3 is moderate (7.2). The total vulnerability of the WHPA-E associated with the Huron Woods Well No. 6 is comparatively high (8.0). This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.8.G3.2c). The area vulnerability describes the propensity of the on-land area to contribute runoff (percentage of land, land characteristics and transport pathways), which is 8, moderate for all wells. The source vulnerability score describes the likelihood that the surface water transports contaminants to the well and is 0.9 (moderate) for Well Nos. 1, 2 and 3 and 1.0 (high) for Well No. 6. Uncertainty for the WHPA-E delineation is high (see Section 4.1.7.3 for details).

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TABLE 4.8.G3.2c – Vulnerability of WHPA-E Associated with the Huron Woods Water Supply Works

Name of WHPA	HURON WOODS 1 and 2		HURON WOODS 3***		HURON WOODS 6***	
DWIS_ID	220007775					
Area (Total), hectares		10.79				432.66
Vulnerability (Total)		**7.2**		**7.2**		**8.0**
Source Vulnerability		**0.9**		**0.9**		**1.0**
SV - Distance to surfacing karst [m]	>500m	0.8	>500m	0.8	>500m	0.8
SV - Overburden Protection	21.25 m	0.9	21.25 m	0.9	7 m	1.0
Area Vulnerability		**8 (8.2)**				**8 (8.1)**
AV - Percent Land: Score		**9**				**9**
AV - Percentage of Land	> 70%	9			> 70%	9
AV - Land Characteristics		**7.9**				**7.5**
Land Cover*	36% Developed, 64% Natural	7.7			1% Agricultural, 2% Developed, 97% Natural	7.0
Soil Type	100% sand	7.0			96.3% diamicton, 3.7% sand	7.5
Soil Permeability *	100% A	7.0			55% A, 45% B,	7.3
Slope [%]	7.0%	9.0			2.9%	8.0
AV Transport Pathways		**7.7**				**7.7**
Tile Drainage [% of land area]	0.0%	7			0.0%	7
Storm Catchment	None	7			None	7
Number of Watercourses/1,000 ha		9.0				9.0

** Area "Not categorized" was disregarded*
*** The Area Vulnerability Score is rounded to full number. In brackets, value rounded to 1 digit.*
**** Wells 3 and 6 influenced by the same large, interconnected wetland. WHPA-E for both wells identical; source vulnerability varies due to different depth of casing/overburden cover.*

Transport Pathways

The vulnerability of the WHPA must be increased if pathways exist that transport contaminants from the surface into the aquifer that is a source for drinking water (see Section 4.1.2.6), unless the vulnerability is already rated "high".

Aquifer vulnerability was adjusted one level to account for transport pathways in the urban area within the Huron Woods WHPA. This adjustment was based on the documented existence of wells that are out of compliance with existing standards. Areas where aquifer vulnerability was adjusted are shown in Map 4.8.G3.3. No transport pathway adjustments were made outside the urban area as properties have wells that are in compliance with existing standards.

Threats and Risks

Land uses and activities within the wellhead protection area were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

WHPA A-D

There are 50 significant drinking water threats in the Huron Woods (Wells No. 1, 2 and 6) wellhead protection area A-D. These threats include 25 activities related to the potential for pathogen contamination and 25 activities related to contamination with hazardous chemicals. The total number of properties with threats is 25 (see detailed Table 4.8.G3.3 and summary Table 4.8.G3.4).

There are 26 significant drinking water threats in the Huron Woods (Well No. 3) wellhead protection area A-D. These threats include 13 activities related to the potential for pathogen contamination and 13 activities related to contamination with hazardous. The total number of properties with threats is 13 (see detailed Tables 4.8.G3.3a,b and summary Table 4.8.G3.4).

WHPA-E

With surface water influencing the Huron Woods wells, WHPA-Es were delineated. The vulnerability score of the WHPA-E for Well No. 6 is 8.0, and chemical and pathogen threats can be significant (see Section 4.1.5.7). For chemical threats, no activity in this area meets the quantity circumstances defined in Provincial Table 22: CIPZWE8S. Some activities that discharge sewage (as defined in Provincial Table 48: PIPZWE8S) would be considered pathogen threats, but none were identified in this area. Agricultural activities have the potential to contaminate surface water with pathogens (as defined in Provincial Table 48: PIPZWE8S), if they engage in activities such as the handling, storage and application of agricultural source material and non-agricultural source material, as well as with livestock. No pathogen threats were identified in the WHPA-E of Well No. 6, and the total number of significant threats associated with the WHPA-E is zero.

The vulnerability of the WHPA-E for Huron Woods Well Nos. 1 and 2 and 3 is 7.2, so the risk level of any activity cannot exceed “moderate”.

Moderate and Low Threats

Moderate and low threats are not counted individually even if identified. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

TABLE 4.8.G3.3a – Huron Woods Well Nos. 1, 2 and 6: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL threats).

Prescribed Threat **WHPA: HURON_WOODS_1_2_6** *For full legal name of prescribed threat, see Table 4.1.5*		**Land use Category**									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal						2		23		**25**
3	Agricultural source material - Application to land										
6	Non-agricultural source material - Application to land										
8	Commercial fertilizer - Application to land										
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
14	Snow - Storage										
15	Fuel - Handling and storage								0		**0**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards - Livestock grazing										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal						2		23		**25**
3	Agricultural source material - Application to land										
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards - Livestock grazing										

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TABLE 4.8.G3.3b – Huron Woods Well No. 3: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL threats)

Prescribed Threat **WHPA: HURON_WOODS_3** *For full legal name of prescribed threat, see Table 4.1.5*		**Land Use Category**									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
	CHEMICALS										
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								13		**13**
3	Agricultural source material - Application to land										
6	Non-agricultural source material - Application to land										
8	Commercial fertilizer - Application to land										
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
14	Snow - Storage										
15	Fuel - Handling and storage								0		**0**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards - Livestock grazing										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								13		**13**
3	Agricultural source material - Application to land										
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards - Livestock grazing										

TABLE 4.8.G3.4 – Huron Woods WHPA: Summary of Significant Drinking Water Threats

	Number of "are or would be significant" threats				Number of *properties* with "are or would be significant" threats			
WHPA A-D	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
HURON_WOODS 1_2_6	25		25	50	0	23	2	25
HURON_WOODS 3	13	0	13	26	0	13	0	13
WHPA-E								
HURON_WOODS 1_2				0				0
HURON_WOODS 3				0				0
HURON_WOODS 6				0				0

Quality of Raw Water at the Well

In all Huron Woods wells, iron is elevated due to its natural occurrence in the groundwater aquifer. No other concerns are known.

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.8.G3.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.8.G3.5 – Huron Woods: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.8.2.4 Foreman Water Works

The Foreman Water Works is located southeast of Sauble Beach on Foreman Drive, which is located on the northeast side of Chesley Lake and three km north of Hwy 21. The Foreman Water Works is comprised of one bedrock well, which was constructed in 1997 and is 73.1 m deep and cased to a depth of 71.6 m.

The Foreman well is considered GUDI and was declared GUDI by the Municipality without study. Data on the area serviced with drinking water and sewer exist in paper form, but digital data is not available to DWSP.

A wellhead protection area (WHPA) for the Foreman Water Works was first developed as part of the Grey Bruce Groundwater Study (WHI, 2003). The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates as part of the Round 1 Technical Study for the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region (CRA, 2007).

TABLE 4.8.G4.1 – Description of the Drinking Water System and Wells

Well Name	Foreman
Drinking Water System ID	220007711
SPA of Well and Vulnerable Area (WHPA)	Grey Sauble SPA
Northing/Easting	4934453.9 / 482353.4
Year Constructed	1997
Well Depth	73.1 m
Uncased Interval	71.6 - 73.1 m
Aquifer	Guelph/Amabel limestone bedrock
GUDI	Yes
Number of Users Served	42 people
Design Capacity (CoA)	165 m^3/day
Permitted Rate (PTTW)	163.44 m^3/day
Average Usage	6.42 m^3/day
Modelled Pumping Rate	164 m^3/day
Treatment	Iron/Manganese removal, cartridge filters, UV disinfection and chlorination

** CRA Phase I, Round 1 Report 2007*

Impervious Surfaces, Managed Land and Livestock Density

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.8.G4.2a and shown on Map 4.8.G4.4. Following the methodology outlined in Section 4.1.4, the percentage of managed land and the livestock density (nutrient units per acre) were computed for each zone within the wellhead protection area. For the purposes of calculating managed lands and livestock density, only the portion of the WHPA with a vulnerability score of 6 or more was used in the calculations. The results are listed in Table

4.8.G4.2b and shown on Maps 4.8.G4.5 and 4.8.G4.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.8.G4.2a – Impervious Surfaces

General	Code for WHPA	FOREMAN
	Total Area [hectare]	5.74
Impervious Surfaces Area [ha]	0 % – <1%	0.00
	1% – <8%	0.00
	8% – < 80%	5.74
	Larger or equal than 80%	-

Note: Total areas relate to the full WHPA, even if located in other municipalities

TABLE 4.8.G4.2b – Managed Land and Livestock Density

WHPA_NAME	**FOREMAN**			
Well Name	Foreman	Foreman	Foreman	Foreman
Zone	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	N/A	N/A
% Managed Lands (<40%, 40-80%, >80%)	40-80%	>80%	N/A	N/A

Wellhead Protection Area

The wellhead protection area (WHPA) was estimated following the methodology described in Section 4.1.2.5. The Foreman Water Works WHPA is relatively small and is largely influenced by its proximity to Chesley Lake (Map 4.8.G4.1). The total land area of the WHPA is only 0.06 km^2 and stretches 340 metres north to south. WHPA-A, located north of the built up area along the shores of Chesley Lake, almost entirely encircles the delineated WHPAs B and C. WHPA D is entirely within the residential land area and extends into the lake.

A WHPA-E was delineated in the surface water body that influences this GUDI well. The specific point of interaction is not known for the Foreman well. Thus, Technical Rule 47(5a) was applied and the point closest to the well was identified 200 metres south of the well, in Chesley Lake as the influencing surface water system. Chesley Lake has a total surface area of 207 hectares (2 km^2), being 2.3 km long and 1.2 km wide. The full lake was included in the WHPA-E without numerical modelling. A small creek was added that passes directly behind the well at a distance of 120 metres and discharges 290 metres from the point of interaction. Furthermore, evaluated wetlands along the south of the lake within regulation limits, agricultural tile drainage and a setback of 120 metres along the shore were added to the WHPA-E area (for details, see Section 4.1.2.7).

Map 4.8.G4.2 shows the borders of all zones of WHPA overlaid on aerial photography.

Transport Pathways

The vulnerability of the WHPA must be increased if pathways exist that transport contaminants from the surface into the aquifer that is a source for drinking water (see Section 4.1.2.6), unless the vulnerability is already rated “high”.
No transport pathway adjustments were made to aquifer vulnerability in the Foreman WHPA. Existing properties are on municipal services, and no additional wells were noted in site visits.

Vulnerability

WHPA A-D
The low susceptibility index in the area is due to the presence of a lower permeability layer (e.g., hardpan/clay) within the overburden, which provides some protection to the limestone aquifer from which the well draws its water.

After overlaying the intrinsic susceptibility index (Map 4.8.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.1.3 for detail). The vulnerability is shown on Map 4.8.G4.3.

The Foreman WHPA, which is the smallest WHPA investigated under this study, is dominated by WHPA-A where the vulnerability is solely based on proximity to the supply well. Although at the regional scale the intrinsic susceptibility index mapping shows a low susceptibility to surface activities (Map 4.8.M1), the proportionally large aerial extent of WHPA-A results in a proportionally higher vulnerability.

WHPA-E
The total vulnerability of the WHPA-E associated with the Foreman well is moderate (6.4). This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.8.G4.2c). The area vulnerability describes the propensity of the on-land area to contribute runoff (percentage of land, land characteristics and transport pathways), which is 8 (moderate). The source vulnerability score describes the likelihood that the surface water transports contaminants to the well and is 0.8.

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.3 for details).

Threats and Risks

Land uses and activities within the wellhead protection area were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

TABLE 4.8.G4.2c – Vulnerability of WHPA-E Associated with the Foreman DWS

Name of WHPA		**FOREMAN**
DWIS_ID		220007711
Area (Total), hectares		399.17
Vulnerability (Total)		**6.4**
Source Vulnerability		**0.8**
SV - Distance to surfacing karst [m]	> 500 m	0.8
SV - Overburden Protection	65.67 m	0.8
Area Vulnerability		**8 (7.9)**
AV - Percent Land: Score		**8**
AV - Percentage of Land	30% - 70%	8
AV - Land Characteristics		**8.0**
Land Cover*	10% Agricultural, 10% Developed, 80% Natural	7.3
Soil Type	81.4% diamicton, 18.5% organic deposits, 0% sand,	7.6
Soil Permeability *	6.4% A, 69.4% B, 24.2% D	7.9
Slope [%]	9.6%	9.0
AV Transport Pathways		**7.7**
Tile Drainage [% of land area]	4.0%	7
Storm Catchment	None	7
Number of Watercourses/1,000 ha		9.0

** Area disregarded if classified "Not categorized"*
*** The Area Vulnerability Score is rounded to full number. In brackets, value rounded to 1 digit is shown.*

WHPA A-D

There are 2 significant drinking water threats in the Foreman wellhead protection area A-D. These threats include 1 activity related to the potential for pathogen contamination and 1 activity related to contamination with hazardous chemicals. The total number of properties with threats is one (see detailed Table 4.8.G4.3 and summary Table 4.8.G4.4).

WHPA-E

The vulnerability of this WHPA-E is 6.4, so the risk level of any activity cannot exceed "moderate".

Moderate and Low Threats

Moderate and low threats are not counted individually even if identified. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

Approved

TABLE 4.8.G4.3 – Foreman: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen threats. No DNAPL threats)

Prescribed Threat **WHPA: FOREMAN** *For full legal name of prescribed threat, see Table 4.1.5*		**Land use Category**									
		Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
CHEMICALS											
1	Waste disposal site										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land	1									**1**
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
8	Commercial fertilizer - Application to land										
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
14	Snow - Storage										
15	Fuel - Handling and storage										
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Pastures or other farm-animal yards										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land	1									**1**
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Pastures or other farm-animal yards										

TABLE 4.8.G4.4 – Foreman WHPA: Summary of Significant Drinking Water Threats

	Number of "are or would be significant" threats				Number of *properties* with "are or would be significant" threats			
FOREMAN	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	1	0	1	2	1			1
WHPA-E				0				0

Quality of Raw Water at the Well

In the Foreman well, parameters that are typically elevated in GUDI wells were higher and include fluoride, iron, water color, and turbidity.

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.8.G4.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.8.G4.5 – Foreman: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

4.2.8.3 Surface Water Municipal Systems

4.2.8.3.1 Wiarton Water Treatment Plant

The Town of Wiarton is located at the base of Colpoys Bay, an inlet off of Georgian Bay. The community of Wiarton is a major service centre for the Bruce Peninsula. Wiarton is situated in the Town of South Bruce Peninsula. Some of the city's facilities belong to the Township of Georgian Bluffs, such as the Wiarton Airport, Municipal Work Yard and three sewage treatment lagoons serving Wiarton.

In 2000, the population of Wiarton was 2,300 (Stantec 2008, Phase 1 Report). It is expected that the South Bruce Peninsula population will increase to 9,800 by the year 2021. The largest growth is expected in the primary urban centres of Wiarton and Sauble Beach (Stantec 2008, Phase 1 Report).

The water treatment plant for Wiarton is located on Colpoys Bay to the northeast of the center of Wiarton. The system takes water from the bay and is a Great Lakes (Type A) intake. The Wiarton WTP and associated distribution system are owned by the town and operated by the Ontario Clean Water Agency. The system services 2,800 residential and commercial users. The WTP is classified as a Large Municipal Residential Drinking Water System and operates under a water treatment Class 3 certificate. The plant has a maximum rated treatment capacity of 5,400 m^3/d (Stantec 2008, Phase 1 Report).

The Wiarton WTP has two raw water intakes in Colpoys Bay off the north shore at the WTP. The main intake uses a polyethylene pipe 450 mm in diameter and 180 m in length. The intake crib is constructed of cement-filled jute bags and steel gabions and located at 7.2 m lake depth, with its top at a depth of 7.0 m (Stantec 2008, Phase 1 Report). The backup intake is approximately 45 m long and of similar construction. Both intakes have zebra mussel control that utilizes sodium hypochlorite injected at the crib end (Stantec 2008, Phase 1 Report).

The treatment process consists of two flocculation tanks; two direct-filtration, dual-media gravity filters equipped with a 156 L/s filter backwash pump, an agitator and an under drain system; a sodium hypochlorite disinfection system (primary and secondary disinfection); taste and odour control via an activated carbon feed system (as of 2005 this had not ever been used); a coagulant feed system; a sodium bisulphate feed system; and a polymer feed system. Two ultraviolet (UV) disinfection reactors are used to provide primary disinfection at the plant (MOECC, 2005).
The shoreline north of Colpoys Bay is generally free from development except for some inlets and other protected areas that serve as ports and harbours. The major anthropogenic coastal structures that exist in the study area are harbour-related.

TABLE 4.8.S1.1 – Description of the Drinking Water System

Intake Name	Wiarton WTP	
Drinking Water System ID	220002681	
Drinking Water System Classification	Large Municipal Residential System	
Intake Type	A (Great Lakes)	
SPA of Intake and Vulnerable Area (IPZ)	Grey Sauble	
Northing/Easting of Intake	489496.97 / 4955887.56	489352.4 / 4955897.8
Intake pipe length	180 m	45 m
Lake Depth at Intake *	7.2 m	3.96
Depth of Top of Intake Crib *	7 m	2.96
Number of users served	2800 persons	
Intake Capacity	not known	backup
Average Annual Usage**	1638 m^3/day	0 m^3/day (backup only)
Maximum Usage**	3516 m^3/day	0 m^3/day (backup only)

**Elevations measured from plan & profile drawings (Henderson Paddon, April 1991) and converted to International Great Lakes Datum 1985 (IGLD 85) by comparing recorded water levels with historical information from US Army Corps of Engineers (in Stantec 2009, Phase 1 Technical Addendum)*

Intake Protection Zone

The Wiarton Drinking Water System uses raw water from Georgian Bay and is classified as a Great Lakes (Type A) intake. The plant comprises a 180 m long and 450 mm diam. main intake pipe and a 45 m long 450 mm diameter backup intake pipe located in Colpoys Bay. The distance between both intakes is 147 metres.

For the in-water portion of the IPZ-1 of a Type A intake, the Technical Rules prescribe to delineate the IPZ as a circle with a radius of 1,000 metres from the entry point where raw water enters the drinking water system (see Section 4.1.2.4, Offshore component). Where the IPZ-1 abutted land and was not impacted by a riverine or transport pathway, it was extended 120 m inland as it was greater than the area of the regulation limit (Stantec 2009, Phase 1 Technical Addendum). For the main intake, the shoreline length of IPZ-1 is approximately 1,930 m long. The onshore area of IPZ-1 is 0.3 km^2 and the offshore area is 2.0 km^2.

The same IPZ-2 was used for both intakes, due to the short distance between both wells and a relatively coarse model resolution of 75 x 90 m around the intakes. The in-water IPZ-2 occupies the most southern point of Colpoys Bay and extends to meet both the east and west shorelines. The western point reaches the shoreline 2,810 m north of the intake and the eastern point reaches the shoreline 1,463 m east of the intake. Where the IPZ-2 abutted land and was not impacted by a riverine or transport pathway, it extends inland 120 m as this was generally greater than the area of the regulation limit (Stantec 2009, Phase 1 Technical Addendum). The shoreline of IPZ-2 is approximately 6,800 m long.

The onshore component of the IPZ-1 includes the abutted shoreline setbacks whereas the onshore component of the IPZ-2 incorporates features that may contribute water to the intake, such as watercourses, municipal drains and storm sewer networks (Stantec 2009, Phase 1

Technical Addendum). Further, it includes the appropriate bank setbacks for watercourses and/or municipal drains.

Colpoys Creek and five unnamed water courses drain into IPZ-2, with residual times to the intake estimated between two minutes and one hour. The distance of the IPZ-2 within tributaries varies between 175 m and 3100 m onto the land (Stantec 2009, Phase 1 Technical Addendum). The resulting onshore area for IPZ-2 is 3.8 km^2 and the offshore area is 4.8 km^2.

The full IPZ is shown on Map 4.8.S1.2 and on Map 4.8.S1.3 with underlying aerial photography.

An IPZ-3 and an EBA were delineated for based on modelled spill scenarios and desktop assessment. Using the methodology described in section 4.1.2.4, minimum volumes that would result in exceedances were determined for locations distributed throughout Wiarton and around the IPZ-2. Volumes ranged from 1,200 L to 8,800 L and were split into two EBA categories (see map 4.1.S1.1.9);

- 5,000 L and greater
- 8,000 L and greater

Storm Sewer Systems and Transport Pathways

The onshore component of the intake protection zone includes properties that drain into storm sewersheds within a 2-hour ToT, and other transport pathways (Section 4.1.2.6).

Along the lakeshore and watercourses, on-land setbacks and transport pathway analysis were identified. There are storm sewers that drain into the offshore part of the IPZ-2 (Stantec 2009, Phase 1 Technical Addendum). Those areas that are located less than 2-hour time-of-travel were added to the intake protection zone according to the Technical Rules (see Section 4.1.2.6 – Onshore Components). Transport pathways are shown on Map 4.8.S1.1.

Inliers are small areas that are fully enclosed within IPZ onshore components. Following the method outlined in Section 4.1.2.4, inliers with areas less than 10 ha were added to the IPZ without further study, while the existence of preferential pathways (ditches, storm sewers) were confirmed in inliers with larger spatial extent.

Managed Land, Livestock Density and Impervious Surfaces

Following the methodology outlined in Section 4.1.4, the percentage of managed land, the livestock density (nutrient units per acre) and the percentage of impervious surfaces were computed for each intake protection zone. Computation results are listed in Table 4.8.S1.1b and in Maps 4.8.S1.4, 5 and 6.

The Wiarton WTP intake protection zone is classified as an area where the percentage of managed land of the vulnerable area are at least 40%, but not more than 80% and the livestock density is less than 0.5 NU/acre. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.8.S1.1b – Managed Land, Livestock Density and Impervious Surfaces

General	IPZ ID	WIARTON
	Area Total [hectare]	850.37
	Area Offshore [hectare]	480.39
	Area Onshore [hectare]	369.98
IPZ 1 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	32.14
	Livestock Density [NU/Acre]	0.00
	Managed Land Area [hectare]	3.41
	% Managed Lands	10.61
	Category	**ML% <40%, NU/acre <0.5**
IPZ 2 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	333.34
	Livestock Density [NU/Acre]	0.03
	Managed Land Area [hectare]	165.07
	% Managed Lands	49.52
	Category	**ML% 40%-80%, NU/acre <0.5**
Impervious Surface: Area per category [hectare]	0 % – <1%	32.75
	1% – <8%	131.95
	8% – < 80%	202.15
	Larger or equal than 80%	0.00

Note: All areas relate to the full IPZ including other municipalities.

TABLE 4.8.S1.1c – Managed Land, Livestock Density and Impervious Surfaces for Wiarton Backup

General	IPZ ID	WIARTON BACKUP
	Area Total [hectare]	850.37
	Area offshore [hectare]	480.39
	Area onshore [hectare]	398.32
IPZ 1 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	33.48
	Livestock Density [NU/Acre]	0.00
	Managed Land Area [hectare]	3.41
	% Managed Lands	10.19
	Category	**ML% <40%, NU/acre <0.5**
IPZ 2 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	333.34
	Livestock Density [NU/Acre]	0.03
	Managed Land Area [hectare]	165.07
	% Managed Lands	49.52
	Category	**ML% 40%-80%, NU/acre <0.5**

Vulnerability

Vulnerability of the protection zone of the surface water intake was delineated following the methodology described in Section 4.1.3.5. Two factors measuring the vulnerability of the area and of the raw water source are computed separately and then multiplied with each other.

<u>Area Vulnerability Factor</u>
The area vulnerability factor for IPZ-1 is ten, as prescribed by the Technical Rules. For IPZ -2, the area vulnerability factor is 8, which was determined by averaging the percentage of land, land characteristics and transport pathways sub-factors (Table 4.8.S1.2a).

<u>Percentage of Land</u>
The % land sub factor has been divided equally between the three ranges outlined in the Technical Rules (< 33% = 7, 33% – 66% = 8, > 66% = 9). The Wiarton WTP has approximately 53% land area and therefore the % land sub factor has a score of 8.

<u>Land Characteristics</u>
The land characteristic sub factor has the components; land cover, soil type, permeability, and setback slope. The land characteristics sub factor can be derived from the average of the ratings for the four components.

Land Cover The land cover rating ranges from seven to nine and has been divided into; mainly vegetated (7), mixed vegetated and developed (8) and mainly developed (9). Land in the upland portion of the IPZ-2 is primarily comprised of mixed vegetative and developed areas. Based on the available SOLRIS GIS dataset, the land cover type is 38% agricultural fields, parks, vegetation and natural landscapes (e.g. cliffs, prairies, etc) Therefore, a land cover component rating of 8 was prescribed for the Wiarton WTP.

Soil Type The soil type rating ranges from seven to nine and has been divided into; sandy soils (7), silty sand soils (8), and clay soils (9). Although the Soil Survey of Bruce County (Hoffman and Richards, 1954) and the mapping updates (Agriculture and Agri-Food Canada, 1983a) do not have specific data for the developed area of Wiarton, extrapolations were made from the soil map based upon soils illustrated in the surrounding areas of Wiarton. Soils along the shoreline of Wiarton within the upland IPZ-2 area consist of the Breypen series, rock outcrop with small pockets of soil of variable materials, drainage, and texture (Hoffman and Richards, 1954), and the Harkaway loam (Agriculture and Agri-Food Canada, 1983a), porous materials classified as having good drainage (Hoffman and Richards, 1954). Soils within the community of Wiarton consist of a sandy loam with good drainage and silty clay loam with imperfect and poor drainage. The soil type component rating is 8.

Permeability The permeability rating ranges from seven to nine and has been divided into; highly permeable (> 66% = 7), moderately permeable (33% to 66% = 8), and largely impervious (< 33% = 9). The upland area of the Wiarton WTP is 327 ha of land with 137 ha (41%) of impervious cover (59% permeable). The impervious land cover was determined using SOLRIS (2009) information. Therefore, the permeability component rating is 8.

Setback Slope The setback slope rating ranges from seven to nine and has been divided equally into; < 2% slope (7), 2% to 5% (8), and > 5% (9). The slope of the study area ranged from 0.3% to 4%, with an average of < 2%; however, a steep bluff is located on the west side of Colpoys Bay and maintains a slope of 100% (45°). This was determined using OBM contours. As a conservative approach, the greatest slope range (4%) was used to assign the component rating. The slope component rating is 8.

Land Characteristics (Summary) The resulting land characteristics sub factor, calculated using an averaged equal representation of each component listed above is 8.

<u>Transport Pathways</u>
The transport pathway sub factor has the components; storm catchment areas, storm outfalls, watercourses and drains, and tile drained areas.

Storm Catchment Areas The storm catchment areas are rated based on the percent of land area that is drained by a storm sewer system. The rating ranges from seven to nine and has been divided equally into; < 33% area (7), 33% to 66% area (8) and > 66% area (9). Storm sewer catchment areas and networks were unavailable for the Wiarton WTP study area. Storm sewer catchments were assumed based on the area of the developed land. The area of the developed land inferred based on 2006 aerial photography. The upland area was determined to be 42% (136 ha) storm sewer drained. This resulted in a component rating of 8.

Storm Outfalls, Watercourses and Drains For the purpose of rating the number of storm outfalls, watercourses and drains, a standardized method was applied to the data. The number of outfalls, watercourses and drains per 1,000 ha of land was calculated for the Wiarton WTP IPZ-2 using the WVF Provincial Dataset. The rating range has been set for 0-3/1,000 ha in the zone at 7, 4 to 7/1,000 ha in the zone at 8 and > 7/1,000 ha in the zone at 9. Six watercourses and seven outfalls provided by the Town of Wiarton discharge into Colpoys Bay within the IPZ-2 giving a calculated 37 outfalls *per* 1,000 ha of land. This resulted in a sub factor of 9.

Tile Drained Area Tile drained area is based on the percent land artificially drained as indicated by the Tile Drainage Areas GIS dataset (OMAFRA, 2009). The rating ranges from seven to nine and has been divided into; < 33% area (7), 33% to 66% area (8), and > 66% area (9). Current OMAFRA data does not indicate tile drainage areas within the Wiarton WTP upland IPZ-2 and therefore a component rating of 7 has been assigned.

Transport Pathways (Summary)	The resulting transport pathways sub factor, calculated using an averaged equal representation of the components listed above is 8.

The area vulnerability factor is determined by averaging an equal representation of the % land, land characteristics, and transport pathways sub factors. The resulting area factor rating for the Wiarton IPZ-2 is 8.

TABLE 4.8.S1.2a – Area Vulnerability Factor for the Wiarton Intake

Intake	Main	Backup
Area Vulnerability Factor Rating *(Rounded average of percentage of land, land characteristics and Transport Pathways)*	8	8
Percentage of Land	8	8
Land Characteristics	8	8
Land Cover	8	8
Soil Type	8	8
Permeability	8	8
Setback Slope	8	8
Transport Pathways	8	8
Storm Catchment Areas (more than 33% but less than 66 %)	8	8
Storm Outfalls, Watercourses, Drains (The number of storm outfalls, watercourses and drains per 1,000 ha is larger than 7)	9	9
Tile Drained Area (less than 33 %)	7	7

<u>Source Vulnerability Factor</u>
The source vulnerability factor for the Wiarton intake is a combined rating of intake characteristics (depth, length of pipe) and past water quality concerns. The intake crib depth is 7.0 m and its vulnerability sub score is 0.5. The main Wiarton intake is located approximately 150 m from the shoreline and the sub factor is 0.7. No water quality concerns relating the ODWQS listed chemical parameters and their respective MACs or IMACs; however, minor fluctuations of a slight rise in pH values and an increase in turbidity during lake turnover events were recorded. Further, microbiological tests gave relatively low concentrations of ubiquitous bacteria, so the resulting sub factor for recorded water quality concerns is 0.5 (Stantec 2009, Phase 1 Technical Addendum). The source vulnerability factor is determined by averaging the above listed sub factors. The source factor rating for the Wiarton IPZ is 0.6 (Table 4.8.S1.2b).

The backup intake is located only 45 m from the shore, the sub factor is 0.7 (high). The lake depth at the crib is 3.96 m, and the crib extends to a depth of 2.96 m, so the sub factor is 0.7 (high). Water quality for the backup intake would only be monitored if it was used, so that this category was not taken into account when computing source vulnerability. The source vulnerability score of the backup intake is 0.7 (high).

<u>Resulting Vulnerability of the Intake Protection Zone</u>
For the main intake, the resulting vulnerability for IPZ-1 is six and for IPZ-2 is 4.8.
For the backup intake, the resulting vulnerability for IPZ-1 is seven and for IPZ-2 is 5.6 (Table 4.8.S1.2c).

TABLE 4.8.S1.2b – Source Vulnerability Factor for the Wiarton Intake

Sub Factor	Score Main	Score Backup
Intake Depth	0.5	0.7
Length of Pipe (offshore)	0.7	0.7
Recorded Water Quality	0.5	(-)
Source Vulnerability Factor	0.6	0.7

TABLE 4.8.S1.2c – Vulnerability Score of the Wiarton Intake Protection Zone (IPZ)

Intake	Intake Type	Area Vulnerability Factor		Source Vulnerability Factor	Vulnerability Score	
		IPZ-1	IPZ-2		IPZ-1	IPZ-2
Main intake	A (Great Lakes)	10	8	0.6	6	4.8
Backup intake	A (Great Lakes)	10	8	0.7	7	5.6

Uncertainty Rating

The uncertainty rating for the area delineation of IPZ-1 is low, because rules are prescribed by the Technical Rules.

Numerical modelling and the delineation of on-land areas was peer reviewed. However, the uncertainty rating for the delineation of IPZ-2 is high, partly because of uncertainties embedded within the numerical modelling itself, and partly because the data required for validating these models has high uncertainty (for details, see Section 4.1.7.2).

Threats and Risks

Land uses and activities within the intake protection zone were rated under the threat-based approach to identify those activities that pose a significant or moderate risk for drinking water quality. The methodology was described in Section 4.1.5.

The vulnerability mapping can be used in conjunction with the Tables of Drinking Water Threats to determine which activities pose a significant, moderate, or low threat to drinking water, and under which circumstances. Section 4.1.5.7 gives directions how to consider the type of vulnerable area, the contaminant, and the vulnerability score at any location.

Table 4.8.S1.4 indicates that there are 7 surface water threats are rated at a “significant” level for chemical, but no DNAPLs or pathogen threats. The vulnerability score for Great Lakes intakes (both IPZ-1 and IPZ-2) is always smaller than eight. However, moderate threats were identified in the vulnerable area (Stantec 2009, Phase 2 Report). Two existing significant drinking water

threats were identified through events-based modelling (see detailed Table 4.8.S1.3 and summary Table 4.8.S1.4).

TABLE 4.8.S1.3 – Wiarton IPZ: Significant Drinking Water Threats for Events-based Area

Prescribed Threat **IPZ: WIARTON** *For full legal name of prescribed threat, see Table 4.1.5*		Land use Category: Agricultural	Commercial	Industrial	Infrastructure	Institutional	Municipal/Utilities/ Federal	Recreational	Residential	Others	Grand Total
	CHEMICALS										
15	Fuel - Handling and storage		6				1				**7**

TABLE 4.8.S1.4 – Wiarton IPZ: Significant Drinking Water Threats for Chemical, Pathogen and DNAPLs

IPZ Name	**Number of "are or would be significant" threats** Pathogen	Chemical	DNAPL	Total
Wiarton	0	7	0	7

<u>Moderate and Low Threats</u>

Moderate and low threats are not counted individually even if identified. Section 4.1.5.7 helps to identify the circumstances that would pose a moderate, low or significant drinking water threat for each vulnerable area and vulnerability score.

Quality of Raw Water at the Intake

See section "Source Vulnerability Factor".

Drinking Water Issues and Conditions

Based on available data and knowledge on raw water quality, no drinking water quality issues were identified for this water system that would result from ongoing or past activities (Table 4.8.S1.5). Also, no conditions resulting from past activities were identified within the WHPA that meet the conditions of Technical Rule 126 (see Section 4.1.5.6).

TABLE 4.8.S1.5 – Wiarton: Issues and Conditions

Drinking Water Issue	**Parameter**
None	None
Drinking Water Condition	**Threat**
None	None

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