Approved

Chapter 4

WATER QUALITY

APPROVED ASSESSMENT REPORT
for the
Saugeen Valley Source Protection Area

Approval Date: October 15, 2015
Effective Date: July 1, 2016
Amended: ~~February~~ June 15, 2026

Approved

This page intentionally left blank.

Approved

APPROVED ASSESSMENT REPORT
for the
Saugeen Valley Source Protection Area

Table of Contents

CHAPTER 4.0 WATER QUALITY

Approved

List of Figures

Figure 4.1.1 Pollutograph for Lio

Figure 4.1.2 Percent Fuel Lost Th

Figure 4.1.3 Assumed Drainage a

Figure 4.1.4 Events-based Policy

List of Tables

Approved

Approved

Approved

Approved

Approved

List of Maps

Approved

Approved

Map 4.4.M2	Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA)
Map 4.4.M3	HVA Vulnerability
Map 4.4.M5	HVA and SGRA – Impervious Surfaces
Map 4.4.M6	HVA – Managed Lands
Map 4.4.M7	HVA – Nutrient Units

Markdale:

Map 4.4.G1.1	Wellhead Protection Area (WHPA) Delineation
Map 4.4.G1.2	WHPA – Aerial Photo
Map 4.4.G1.3	WHPA – Vulnerability
Map 4.4.G1.4	WHPA – Impervious Surfaces
Map 4.4.G1.5	WHPA – Managed Lands
Map 4.4.G1.6	WHPA – Nutrient Units
Map 4.4.E1.1	Wellhead Protection Area E (WHPA-E) Components
Map 4.4.E1.2	WHPA-E – Delineation
Map 4.4.E1.3	WHPA-E – Aerial Photo
Map 4.4.E1.4	WHPA-E – Vulnerability
Map 4.4.E1.5	WHPA-E – Impervious Surfaces
Map 4.4.E1.6	WHPA-E – Managed Lands
Map 4.4.E1.7	WHPA-E – Nutrient Units

TOWN OF HANOVER:

Map 4.5.M1	Intrinsic Susceptibility Index
Map 4.5.M2	Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA)
Map 4.5.M3	HVA Vulnerability
Map 4.5.M5	HVA and SGRA – Impervious Surfaces
Map 4.5.M6	HVA – Managed Lands
Map 4.5.M7	HVA – Nutrient Units

Hanover:

Map 4.5.G1.1	Wellhead Protection Area (WHPA) Delineation
Map 4.5.G1.2	WHPA – Aerial Photo
Map 4.5.G1.3	WHPA – Vulnerability
Map 4.5.G1.4	WHPA – Impervious Surfaces
Map 4.5.G1.5	WHPA – Managed Lands

Approved

Map 4.5.G1.6 WHPA – Nutrient Units
Map 4.5.E1.1 Wellhead Protection Area E (WHPA-E) Components
Map 4.5.E1.2 WHPA-E – Delineation
Map 4.5.E1.3 WHPA-E – Aerial Photo
Map 4.5.E1.4 WHPA-E – Vulnerability
Map 4.5.E1.5 WHPA-E – Impervious Surfaces
Map 4.5.E1.6 WHPA-E – Managed Lands
Map 4.5.E1.7 WHPA-E – Nutrient Units

Ruhl Lake:

Map 4.5.S1.1 Intake Protection Zone (IPZ) Components
Map 4.5.S1.2 IPZ – Delineation
Map 4.5.S1.3 IPZ – Aerial Photo
Map 4.5.S1.4 IPZ – Vulnerability
Map 4.5.S1.5 IPZ – Impervious Surfaces
Map 4.5.S1.6 IPZ – Managed Lands
Map 4.5.S1.7 IPZ – Nutrient Units

TOWNSHIP OF HURON-KINLOSS:

Map 4.6.M1 Intrinsic Susceptibility Index
Map 4.6.M2 Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA)
Map 4.6.M3 HVA Vulnerability
Map 4.6.M5 HVA and SGRA – Impervious Surfaces
Map 4.6.M6 HVA – Managed Lands
Map 4.6.M7 HVA – Nutrient Units

Ripley:

Map 4.6.G1.1 Wellhead Protection Area (WHPA) Delineation
Map 4.6.G1.2 WHPA – Aerial Photo
Map 4.6.G1.3 WHPA – Vulnerability
Map 4.6.G1.4 WHPA – Impervious Surfaces
Map 4.6.G1.5 WHPA – Managed Lands
Map 4.6.G1.6 WHPA – Nutrient Units

Blairs Grove:

Map 4.6.G2.1 Wellhead Protection Area (WHPA) Delineation
Map 4.6.G2.2 WHPA – Aerial Photo

Approved

Map 4.6.G2.3 WHPA – Vulnerability
Map 4.6.G2.4 WHPA – Impervious Surfaces
Map 4.6.G2.5 WHPA – Managed Lands
Map 4.6.G2.6 WHPA – Nutrient Units

Huronville:

Map 4.6.G3.1 Wellhead Protection Area (WHPA) Delineation
Map 4.6.G3.2 WHPA – Aerial Photo
Map 4.6.G3.3 WHPA – Vulnerability
Map 4.6.G3.4 WHPA – Impervious Surfaces
Map 4.6.G3.5 WHPA – Managed Lands
Map 4.6.G3.6 WHPA – Nutrient Units

Murdock Glen:

Map 4.6.G4.1 Wellhead Protection Area (WHPA) Delineation
Map 4.6.G4.2 WHPA – Aerial Photo
Map 4.6.G4.3 WHPA – Vulnerability
Map 4.6.G4.4 WHPA – Impervious Surfaces
Map 4.6.G4.5 WHPA – Managed Lands
Map 4.6.G4.6 WHPA – Nutrient Units

Point Clark:

Map 4.6.G5.1 Wellhead Protection Area (WHPA) Delineation
Map 4.6.G5.2 WHPA – Aerial Photo
Map 4.6.G5.3 WHPA – Vulnerability
Map 4.6.G5.4 WHPA – Impervious Surfaces
Map 4.6.G5.5 WHPA – Managed Lands
Map 4.6.G5.6 WHPA – Nutrient Units

MUNICIPALITY OF KINCARDINE:

Map 4.7.M1 Intrinsic Susceptibility Index
Map 4.7.M2 Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA)
Map 4.7.M3 HVA Vulnerability
Map 4.7.M5 HVA and SGRA – Impervious Surfaces
Map 4.7.M6 HVA – Managed Lands
Map 4.7.M7 HVA – Nutrient Units

Scott Point:

Approved

Map 4.7.G1.1 Wellhead Protection Area (WHPA) Delineation
Map 4.7.G1.2 WHPA – Aerial Photo
Map 4.7.G1.3 WHPA – Vulnerability
Map 4.7.G1.4 WHPA – Impervious Surfaces
Map 4.7.G1.5 WHPA – Managed Lands
Map 4.7.G1.6 WHPA – Nutrient Units

Underwood:

Map 4.7.G2.1 Wellhead Protection Area (WHPA) Delineation
Map 4.7.G2.2 WHPA – Aerial Photo
Map 4.7.G2.3 WHPA – Vulnerability
Map 4.7.G2.4 WHPA – Impervious Surfaces
Map 4.7.G2.5 WHPA – Managed Lands
Map 4.7.G2.6 WHPA – Nutrient Units

Tiverton:

Map 4.7.G3.1 Wellhead Protection Area (WHPA) Delineation
Map 4.7.G3.2 WHPA – Aerial Photo
Map 4.7.G3.3 WHPA – Vulnerability
Map 4.7.G3.4 WHPA – Impervious Surfaces
Map 4.7.G3.5 WHPA – Managed Lands
Map 4.7.G3.6 WHPA – Nutrient Units

Armow:

Map 4.7.G4.1 Wellhead Protection Area (WHPA) Delineation
Map 4.7.G4.2 WHPA – Aerial Photo
Map 4.7.G4.3 WHPA – Vulnerability
Map 4.7.G4.4 WHPA – Impervious Surfaces
Map 4.7.G4.5 WHPA – Managed Lands
Map 4.7.G4.6 WHPA – Nutrient Units

Kincardine:

Map 4.7.S1.1 Intake Protection Zone (IPZ) Components
Map 4.7.S1.2 IPZ – Delineation
Map 4.7.S1.3 IPZ – Aerial Photo
Map 4.7.S1.4 IPZ – Vulnerability
Map 4.7.S1.5 IPZ – Impervious Surfaces
Map 4.7.S1.6 IPZ – Managed Lands
Map 4.7.S1.7 IPZ – Nutrient Units

Map 4.7.S1.8 IPZ – Events-based Area
Map 4.7.S1.9 IPZ – Events-based Area Policy Components

TOWN OF MINTO:

Map 4.8.M1 Intrinsic Susceptibility Index
Map 4.8.M2 Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA)
Map 4.8.M3 HVA Vulnerability
Map 4.8.M5 HVA and SGRA – Impervious Surfaces
Map 4.8.M6 HVA – Managed Lands
Map 4.8.M7 HVA – Nutrient Units

Clifford:

Map 4.8.G1.1 Wellhead Protection Area (WHPA) Delineation
Map 4.8.G1.2 WHPA – Aerial Photo
Map 4.8.G1.3 WHPA – Vulnerability
Map 4.8.G1.4 WHPA – Impervious Surfaces
Map 4.8.G1.5 WHPA – Managed Lands
Map 4.8.G1.6 WHPA – Nutrient Units

Minto Pines:

Map 4.8.G2.1 Wellhead Protection Area (WHPA) Delineation
Map 4.8.G2.2 WHPA – Aerial Photo
Map 4.8.G2.3 WHPA – Vulnerability
Map 4.8.G2.4 WHPA – Impervious Surfaces
Map 4.8.G2.5 WHPA – Managed Lands
Map 4.8.G2.6 WHPA – Nutrient Units

TOWN OF SAUGEEN SHORES:

Map 4.9.M1 Intrinsic Susceptibility Index
Map 4.9.M2 Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA)
Map 4.9.M3 HVA Vulnerability
Map 4.9.M5 HVA and SGRA – Impervious Surfaces
Map 4.9.M6 HVA – Managed Lands
Map 4.9.M7 HVA – Nutrient Units

Southampton:

Map 4.9.S1.1 Intake Protection Zone (IPZ) Components

Approved

Map 4.9.S1.2 IPZ – Delineation
Map 4.9.S1.3 IPZ – Aerial Photo
Map 4.9.S1.4 IPZ – Vulnerability
Map 4.9.S1.5 IPZ – Impervious Surfaces
Map 4.9.S1.6 IPZ – Managed Lands
Map 4.7.S1.7 IPZ – Nutrient Units
Map 4.7.S1.8 IPZ – Events-based Area
Map 4.7.S1.9 IPZ – Events-based Area Policy Components

MUNICIPALITY OF SOUTH BRUCE:

Map 4.10.M1 Intrinsic Susceptibility Index
Map 4.10.M2 Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA)
Map 4.10.M3 HVA Vulnerability
Map 4.10.M5 HVA and SGRA – Impervious Surfaces
Map 4.10.M6 HVA – Managed Lands
Map 4.10.M7 HVA – Nutrient Units

Mildmay:

Map 4.10.G1.1 Wellhead Protection Area (WHPA) Delineation
Map 4.10.G1.2 WHPA – Aerial Photo
Map 4.10.G1.3 WHPA – Vulnerability
Map 4.10.G1.4 WHPA – Impervious Surfaces
Map 4.10.G1.5 WHPA – Managed Lands
Map 4.10.G1.6 WHPA – Nutrient Units

Teeswater:

Map 4.10.G2.1 Wellhead Protection Area (WHPA) Delineation
Map 4.10.G2.2 WHPA – Aerial Photo
Map 4.10.G2.3 WHPA – Vulnerability
Map 4.10.G2.4 WHPA – Impervious Surfaces
Map 4.10.G2.5 WHPA – Managed Lands
Map 4.10.G2.6 WHPA – Nutrient Units

TOWNSHIP OF SOUTHGATE:

Map 4.11.M1 Intrinsic Susceptibility Index
Map 4.11.M2 Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA)

Map 4.11.M3 HVA Vulnerability
Map 4.11.M5 HVA and SGRA – Impervious Surfaces
Map 4.11.M6 HVA – Managed Lands
Map 4.11.M7 HVA – Nutrient Units

TOWNSHIP OF WELLINGTON NORTH:

Map 4.12.M1 Intrinsic Susceptibility Index
Map 4.12.M2 Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA)
Map 4.12.M3 HVA Vulnerability
Map 4.12.M5 HVA and SGRA – Impervious Surfaces
Map 4.12.M6 HVA – Managed Lands
Map 4.12.M7 HVA – Nutrient Units

Mount Forest:

Map 4.12.G1.1 Wellhead Protection Area (WHPA) Delineation
Map 4.12.G1.2 WHPA – Aerial Photo
Map 4.12.G1.3 WHPA – Vulnerability
Map 4.12.G1.4 WHPA – Impervious Surfaces
Map 4.12.G1.5 WHPA – Managed Lands
Map 4.12.G1.6 WHPA – Nutrient Units

MUNICIPALITY OF WEST GREY:

Map 4.13.M1 Intrinsic Susceptibility Index
Map 4.13.M2 Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA)
Map 4.13.M3 HVA Vulnerability
Map 4.13.M5 HVA and SGRA – Impervious Surfaces
Map 4.13.M6 HVA – Managed Lands
Map 4.13.M7 HVA – Nutrient Units

Durham:

Map 4.13.G1.1 Wellhead Protection Area (WHPA) Delineation
Map 4.13.G1.2 WHPA – Aerial Photo
Map 4.13.G1.3 WHPA – Vulnerability
Map 4.13.G1.4 WHPA – Impervious Surfaces
Map 4.13.G1.5 WHPA – Managed Lands
Map 4.13.G1.6 WHPA – Nutrient Units

Approved

Map 4.13.E1.1 Wellhead Protection Area E (WHPA-E) Components
Map 4.13.E1.2 WHPA-E – Delineation
Map 4.13.E1.3 WHPA-E – Aerial Photo
Map 4.13.E1.4 WHPA-E – Vulnerability
Map 4.13.E1.5 WHPA-E – Impervious Surfaces
Map 4.13.E1.6 WHPA-E – Managed Lands
Map 4.13.E1.7 WHPA-E – Nutrient Units

Neustadt:

Map 4.13.G2.1 Wellhead Protection Area (WHPA) Delineation
Map 4.13.G2.2 WHPA – Aerial Photo
Map 4.13.G2.3 WHPA – Vulnerability
Map 4.13.G2.4 WHPA – Impervious Surfaces
Map 4.13.G2.5 WHPA – Managed Lands
Map 4.13.G2.6 WHPA – Nutrient Units
Map 4.13.E2.1 Wellhead Protection Area E (WHPA-E) Components
Map 4.13.E2.2 WHPA-E – Delineation
Map 4.13.E2.3 WHPA-E – Aerial Photo
Map 4.13.E2.4 WHPA-E – Vulnerability
Map 4.13.E2.5 WHPA-E – Impervious Surfaces
Map 4.13.E2.6 WHPA-E – Managed Lands
Map 4.13.E2.7 WHPA-E – Nutrient Units

Approved

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 13 municipalities, 16 groundwater systems and three surface water systems with four intakes, there are 312 maps, 182 tables and one figure for this SPA.

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 4.7.M3 is in chapter 4, for municipality 7 (Kincardine) 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,

Approved

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 4.6.G2.3 is a map in chapter 4 for municipality 6 (the Township of Huron-Kinloss). It is the second groundwater (G2) drinking water system in the municipality 6 (Ripley) and the content is the "Vulnerability Score of Wellhead Protection Area and Transport Pathways". This system is described in section 4.2.6.2.2.

Table 4.5.S1.2b is a table in chapter 4 for municipality 5 (Town of Hanover). It is the first surface water (S) drinking water system in the municipality (Ruhl Lake) and the content is the "Source Vulnerability Score". This system is described in section 4.2.5.3.1.

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		
3	IPZ with Aerial Photo		

Approved

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

4.1 Background and Methodology

4.1.1 Overview on the Regulatory Context

This chapter portrays how the legislation and rules apply to the Northern Bruce Peninsula 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 Source Protection Programs Branch of the MOECC. 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

Approved

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 2013 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.

Approved

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 MOECC, 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 2013 Tables of Drinking Water Threats and Tables of Drinking Water Threats 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.

Approved

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 MOECC 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 MOECC 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 (ISI) 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 3.14, 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 per cent 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 3.14.

4.1.2.4 Delineating Intake Protection Zones (IPZs)

There are nine surface water systems within the planning region, three of which are in the Saugeen Valley Source Protection Area. The source of raw water for two intakes is Lake Huron, while Ruhl Lake, a small inland waterbody, supplies the Town of Hanover. Intakes for Kincardine and Southampton exploit Lake Huron.

Intake protection zones (IPZs) define areas of vulnerability for each intake. 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 the water bodies that form part of the 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 MOECC after consulting with operators and is set at a minimum of 2 hours.

Approved

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

Approved

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 MOECC 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 sewer sheds (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.

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 (MNR) 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.

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.

Approved

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.

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 (MOE) Technical Bulletin: Delineation of Intake Protection Zone 3 Using the Event Based Approach. The steps completed were as follows:

Approved

- 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

Approved

	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.

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 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).

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.

Approved

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

Approved

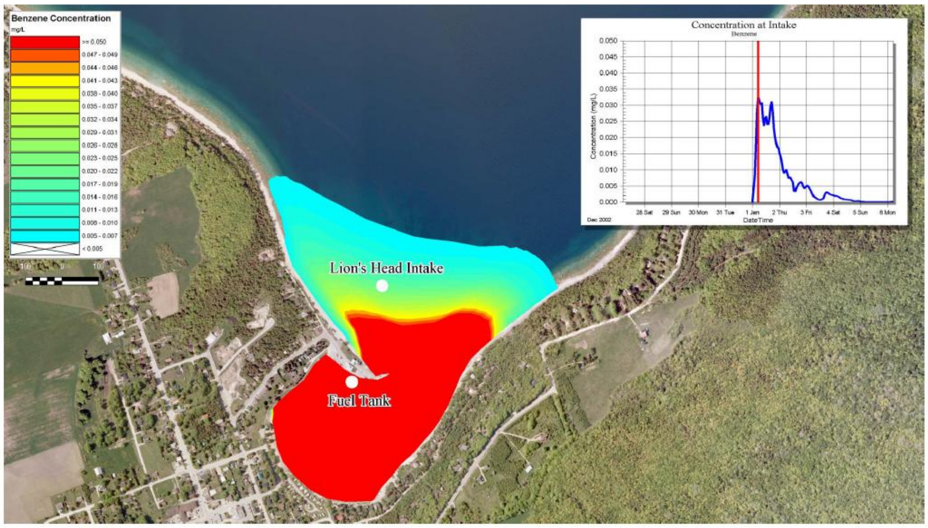

Figure 4.1.1 – Pollutograph for Lion's Head Marina Spill (Baird, 2013)

For limitations on spill modelling, see section 3.6 of *IPZ-3 Modelling for Identification 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).

Approved

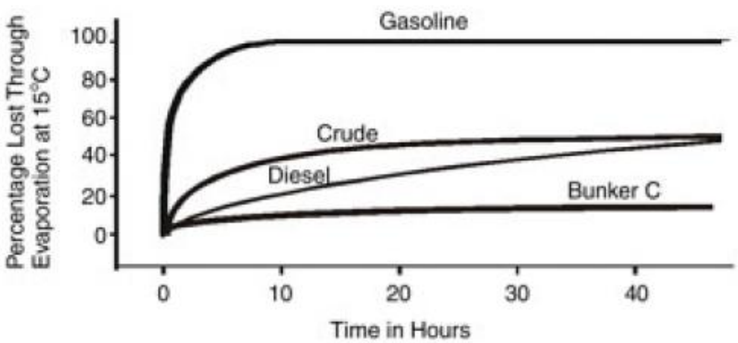

Figure 4.1.2 – Percent Fuel Lost Through Evaporation over Time (Committee on Oil in the Sea 2003)

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).

Approved

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).

Approved

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					714	**0.019 mg/L**
	East Linton		Gasoline	50,000 L	1.5%Benzene	3,342	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**

Approved

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 MOECC, 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.

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

Approved

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

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

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

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:

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

Approved

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).

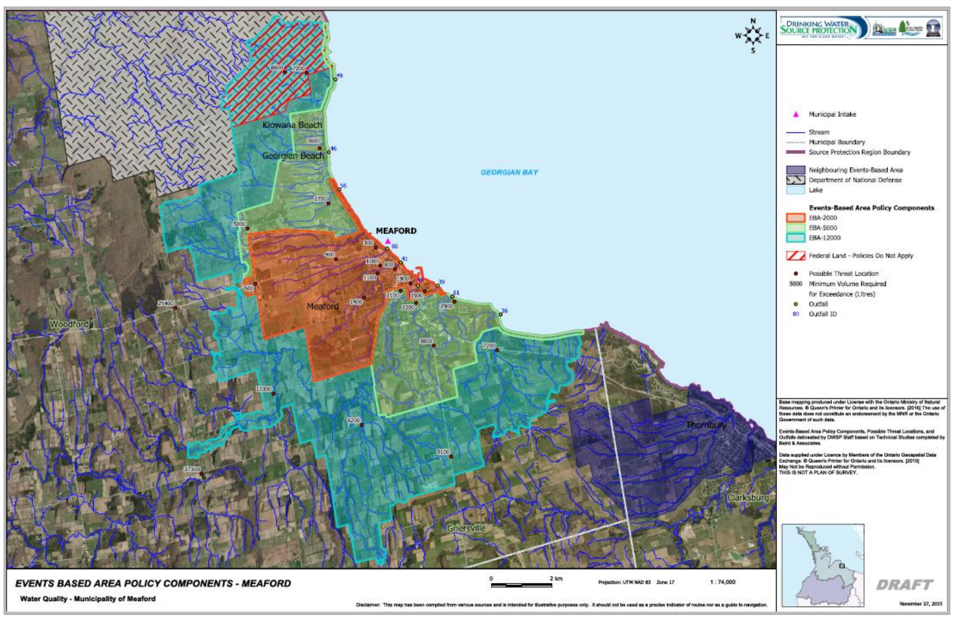

Figure 4.1.4 – Events-based Policy Area for Meaford Intake

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.

Approved

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.

Approved

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 2-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:

Approved

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 MOECC 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 vulnerability (coincident with highly vulnerable aquifers) were given a score of six. Significant groundwater recharge areas that have moderate and low intrinsic vulnerability 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 (WHPAs)

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

Approved

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

Approved

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

Approved

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.

Approved

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.

Approved

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 (2009b).

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)

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 MOECC 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 4.1.11 – Barn/Nutrient Unit Relationship

Livestock Type	***Nutrient Units per Barn Area [m^2/NU]***	***Nutrient Units per Barn Area [ft^2/NU]***
Dairy	11	120
Beef	9	100
Swine	7	70
Horse	26	275

Approved

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.

Approved

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 (MNR Frequently Asked Questions)	Ontario Ministry of Natural Resources (MNR)	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.

Scale for WHPAs	Scale for IPZs
=>30%	=>8%
=8 - <30%	=6 - <8%
=1 - <8%	=1 - <6%
< 1%	< 1%

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 2013 Tables 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 <u>is or would be</u> 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 <u>is</u> 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 <u>activity</u> that <u>is</u> a significant drinking water threat is being engaged in, and
> f) the number of locations at which a <u>condition</u> resulting from a past activity <u>is</u> a significant drinking water threat." (Technical Rules)

Direction provided by the MOECC 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 2013 Tables 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 2013 Tables 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 MOECC for approval.

Based on such a request, MOECC 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

Approved

ID	Legal Name	Short Name*
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
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~~Agricultural Source Material (ASM) Generation~~,~~ ~~an o~~Outdoor ~~confinement~~ Confinement ~~area~~ Area (OCA) or a ~~farm~~Farm ~~-animal~~ Animal ~~yard~~Yard.	Outdoor Confinement Area~~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 4.1.4 – List of Local Drinking Water Threats as requested by the Source Protection Committee and approved by MOECC

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 2013 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 Tables of Drinking Water Threats (2017/2018) 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 , Conservation and Parks'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.

Approved

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 MOECC's 2013 Tables 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.

Approved

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

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.

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.

Approved

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, 2006* 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 Saugeen Valley 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 Saugeen Valley 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 Tables of Drinking Water Threats (2017/2018) and online Threats Tool 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 Tables 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 Provincial 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 Level Possible		
Threat	*Zone*	*Vulnerability Score*	*Significant*	*Moderate*	*Low*
Chemical and DNAPL	**HVA**	6		(yellow)	(green)
		<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.

Approved

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 Technical 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 related to data limitations of the Intrinsic Susceptibility 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 (Waterloo Hydrogeologic Inc., 2003) and the Wellington County Groundwater Study (Golder, 2006). 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 from the Grey-Bruce Study 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, was developed for Armow and Minto Pines Wells by Waterloo Numeric Modelling Corp on behalf of B.M. Ross and Associates (2010), which did not have WHPAs delineated previously. Additionally, the Walkerton WHPA, originally developed by Golder (2003), was updated by Waterloo Numeric Modelling Corp (2010).

The groundwater model was 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 well and showed a reasonable fit to the observed groundwater conditions recorded in the tests. Stream flow data were also used for calibration. The calibration process found that the hydraulic conductivities of the geological units, simulated flow pattern within the bedrock aquifer, and modelled 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) and Golder (2006). 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) and the Wellington County Groundwater Study (2006).

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 Saugeen Valley Source Protection Area.

TABLE 4.1.18 - Uncertainty Assessment for Groundwater Systems – Saugeen Valley 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 Saugeen Valley Source Protection Area is 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.

The in-water modelling of the Lake Huron Coast (Kincardine and Southampton) used in-situ acoustic Doppler current profiler (ADCP) data and backwards particle tracking in the near-shore and offshore regions of Port Elgin and Southampton to calibrate and validate the numerical model. For the Kincardine model, a low level of confidence has been established for the relevance of this data, while for the Southampton model the relevance is high.

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

Overview

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.

Particle Tracking and Area Delineation
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.

<u>Conclusion on Modelling Uncertainty</u>
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.

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***

Approved

					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 the Ruhl Lake Surface Water System

The Ruhl Lake system is different from the Great Lakes system because the water body is fully contained within IPZ-1 therefore no further modelling is necessary to delineate the in-water section of IPZ-2. Also, tributary analysis is not necessary because the contributing watershed is very small. Uncertainty of data on drainage (tile drains, transport pathways) is high.

The uncertainty sub factors results are displayed in Table 4.1.20 for the Ruhl Lake intake. For IPZ-1, uncertainty in the area delineation rating is always low, because it is fully prescribed by the Technical Rules. The delineation of IPZ-2 is high, because all uncertainty is embedded within the stream layer and the tile drainage assumptions. Systemic uncertainty in numerical modelling and calibration data does not apply, but the confidence on data availability regarding transport pathways is low.

The overall uncertainty related to the vulnerability of the IPZ-1 is low and for the IPZ-2 is high.

TABLE 4.1.20 – Uncertainty Rating for the Ruhl Lake Intake (Type D)

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

	Accuracy of the vulnerability factors	*Low*	*Low*
	Overall	**Low**	**High**

n/a – (not applicable) modelling is not required for the delineation of the IPZ-1 and for the Ruhl Lake intake, because IPZ-2 only includes onland areas.

4.1.8.4 Uncertainty in the Assessment of WHPA-Es Associated with GUDI Wells

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

Data

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 4.1.21 summarizes input data, method to obtain these, and data uncertainty:

TABLE 4.1.21 – 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 thus 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 ToT 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.

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.

Approved

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

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				
	Point of inter-action	*Hydraulic Analysis*			**Over all**	*Area Vulnerability*		*Source Vulnerability*		**Over all**
Consideration Factor		*Data*	*Mod elling*	*Calibration*		*Data*	*Metho d*	*Data*	*Method*	
Chepstow	*High*	*High*	*High*	*High*	**High**	*High*	*Low*	*High*	*High*	**High**
Durham 1b & 1c	*High*	*Low*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**
Durham 2 & 2a	*High*	*High*	*High*	*High*	**High**	*High*	*Low*	*High*	*High*	**High**
Hanover	*High*	*High*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**
Lake Rosalind	*High*	*High*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**
Markdale	*High*	*High*	*High*	*High*	**High**	*High*	*Low*	*High*	*High*	**High**
Neustadt 1	*High*	*Low*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**
Neustadt 2 & 3	*High*	*High*	*Low*	*Low*	**High**	*High*	*Low*	*High*	*High*	**High**

Approved

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 located in two Source Protection Areas: Grey Sauble SPA and Saugeen Valley SPA. In 2016, the population was 6803, which was an increase of 0.8% from 2006 (Statistics Canada, 2016b). Arran-Elderslie is in the heart of Bruce County and close to many major tourist destinations. The three main towns are Chesley (population 1880), Tara (population 905) and Paisley (population 1033). Smaller villages include Dobbinton, Invermay, Arkwright, and Burgoyne.

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

In Arran-Elderslie, 355 farms cover a total land area of 42,885 ha (average farm size 121 ha), of which 53.9% are cropped according to the Agricultural Census (Statistics Canada, 2006a). Of 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%. 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. Additionally, there are no pigs, 2,805 sheep, 510 horses, and 747 goats reported in this municipality.

The Quaternary, or overburden, geology in the Municipality of Arran-Elderslie consists of a drumlinized till plain with a clay plain in the south and till moraines throughout (Chapman and Putnam, 1984). The main physiographic regions in the Municipality were reported to be the Arran Drumlin Field, the Saugeen Clay Plain and the Horseshoe Moraines.

The susceptibility of groundwater aquifers for this municipality is mapped in 4.1.M1.

4.2.1.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.1.M2 shows the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. The south part of the Municipality, which lies in the Saugeen Valley Source Protection Area, is characterized by thick overburdens with low conductivity so that groundwater aquifers are mostly shielded against contamination and recharge. The overburden in the north-western tip of the Municipality is 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 consisting of the same glaciolacustrine origin (including parts of the Chesley WHPA) and partly consisting of ice-contact stratified drift. The north-easterly part of the Municipality, between Dobbinton and

Approved

Tara, has low overburden thickness, which is typical of large parts of the Sauble watershed and the 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 HVA and SGRA.

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 SVSPA, the total area of SGRAs is 37.7 km^2 and the total area of HVAs is 7.4 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 4.2.1.1).

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	37.7 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	7.4 km^2
	Managed Land and Livestock Density	ML% >80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

Note: Total areas relate to the full source protection region

Approved

4.2.1.2 Groundwater Municipal Systems

4.2.1.2.1 Arran-Elderslie Drinking Water System

The community of Chesley is served by three drilled wells that are identified as Community Park Wells 1, 2 and 3 (CPW 1, 2 and 3). The wells are situated on a single municipally owned property located in the eastern portion of Chesley, south of the North Saugeen River. CPW 1 and 2 are located approximately 17 metres apart and CPW 3 is located approximately 270 metres southeast of CPW 1 and 2 (GENIVAR, 2010). CPW 3 is located approximately 1200 metres west of the boundary between Bruce and Grey Counties (Grey-Bruce Line). CPW 4 was drilled in 2024 to a depth of 42.7 metres and is located approximately 56 metres East of CPW 3. The associated water supply system is classified as a large municipal residential system (GENIVAR, 2010).

Community Park Well 1 was installed in 1948 and was constructed with a 340 millimetre (13 3/8 inch) diameter inner casing inside a 450 millimetre diameter outer casing. The well was screened in a sand and gravel horizon, over 4.6 metres in length, from a depth of 15.5 to 20.1 metres. Soil conditions at the well location reportedly consisted of clay to a depth of 11.3 metres, followed by clay and gravel to 12.2 metres, coarse gravel to 14.9 metres, gravel and boulders to 16.2 metres, and sand and gravel to 20.1 metres (GENIVAR, 2010).

Community Park Well 2 was installed in 2001 and was constructed with a 300 millimetre diameter casing and screened in a sand and gravel horizon from a depth of 13.7 to 18.3 metres. Soil conditions at the well location reportedly consisted of silty clay to a depth of 1.8 metres, followed by clay to a depth of 3.6 metres, sand and gravel with silty clay lenses to a depth 18.9 metres, and sand, silt and clay to a depth of 24.4 metres. This description of soils varied from the description of soil conditions at CPW 1, located approximately 17 metres to the south, and indicated the potential presence of higher permeability soils overlying the water supply aquifer than was indicated at CPW 1 (GENIVAR, 2010).

Community Park Well 3 was installed in 2002 and was constructed with a 250 millimetre diameter casing and screened in a sand and gravel horizon just above the bedrock from a depth of 33.2 to 36.3 metres. Soil conditions at the well location reportedly consisted of sand and silty sand from ground surface to a depth of 6.1 metres, followed by predominantly silty clay and clay to 29.6 metres, sand and silt to 33.5 metres, coarse sand to 34.3 metres, gravel to 37.8 metres, soft sediment (possibly shale) to 38.1 metres, and limestone bedrock to 38.4 metres (GENIVAR, 2010).

Aquifer testing carried out in 2003 (Henderson and Paddon, 2003) indicated that there was no interference drawdown in CPW 1 and CPW 2 as a result of pumping from CPW 3, which indicated that the strata in which the wells were screened were not hydraulically connected (GENIVAR, 2010).

The Annual Compliance report, dated March 2004 or March 24, 2004, indicates that currently the distribution system services 850 homes, 7 industries and 18 institutional facilities with an approximate population size of 1,850 residents (MOECC, 2006b). The pump house is equipped with a sodium hypochlorite disinfection system comprised of a 130 litre capacity solution tank and two chemical metering pumps (one duty and one standby). The injection pumps are rated between 1.74 and 2.88 litres per hour (MOECC, 2006b).

Pumping rates and modelled pumping rates are listed in Table 4.1.G1.1. Using the available data since 2006, the annual daily average of the combined pumping rate varies between 1,000 m^3/day in 2008 and 1,400 m^3/day in 2006. The total combined pumping rate of 2,228 m^3/day used in the groundwater modelling was approximately 80% higher than the average combined pumping rate of 1,230 m^3/day recorded for the years 2006, 2007 and 2008. This was considered to be reasonably conservative given the inclusion of the Paisley distribution system, which is not accounted for in the 2006-2008 pumping data. In 2022 the maximum day pumping rate was 1,687 m3/d and the average day rate was 954 m3/day. This water use continues to be significantly less than the modelled pumping rates.

Formatted: x_msonormal, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Pattern: Clear (White)

Formatted: Font: Times New Roman, 12 pt

Based on the pump test results for CPW 4, it was noted that water quality results indicate that the contact aquifer is a secure source of groundwater, and not a GUDI water source. It was also determined that the groundwater source is essentially the same as Well #3, as Well #4 is located at a similar depth and only 56 metres East of Well #3.

A wellhead protection area (WHPA) for the Arran-Elderslie DWS was first developed as part of the Grey Bruce Groundwater Study (WHI, 2003). This initial WHPA was developed for the Victoria Park well, which has since been taken offline and used solely for monitoring purposes, as well as CPW 1. Since completion of the initial WHPA, CPW 2 and CPW 3 have been drilled and pumping rates changed in order to account for increased usage as the community of Paisley has since been connected to the Chesley system via pipeline. 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 these wells as part of the Municipality of Arran-Elderslie Groundwater Vulnerability Study (GENIVAR, 2009).

Once Well #4 comes online, the municipality plans to decommission Well #1. Well #2 will be operated with Well #3 or Well #4 to handle higher summer demands. Notwithstanding Table 4.1.G1.1, the combined rate and volume of water taking from CPW3 and CPW4 shall not exceed 4,078 m^3/day for a maximum PTTW of 6,206 m^3/day for the system.

Formatted: Font: Times New Roman

Formatted: Font: Times New Roman

This modelled rate was compared to the current average pumping rates, which have only increased slightly over the past 20 years. As the original rate was quite conservative, it was felt that the original modelled rate is still valid.

Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers

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

Well Name	CPW1	CPW2	CPW 3	CPW 4
Drinking Water System ID	220002725			
Drinking Water System Classification	Large Municipal Residential System			
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA			
Northing/Easting	4904900.2 / 492870.4	4904921.5 / 492862.3	4904793 / 493121.9	4904794 / 493177

Formatted Table

Formatted Table

Approved

Year Constructed	1948	2001	2002	2024
Well Depth	20.1 m	~~24.4~~18.3 m	36.3 m	42.7 m
Uncased Interval	15.5 - 20.1 m	13.7-18.3 m	33.2 - 36.3 m	35.9-42.7 m
Aquifer	Saline/Guelph Formation bedrock	Saline/Guelph Formation bedrock	Guelph Formation bedrock	Guelph Formation bedrock
GUDI	No	No	No	No
Number of Users Served	1850 persons			
Design Capacity (CoA)	~~not known~~65 L/s ~~not known~~ ~~not known~~			
Permitted Rate (PTTW)	1,800 m³/day	2,128 m³/day	2,946 m³/day	2,946 m³/day
Average Annual Usage [*]	378 m³/day	379 m³/day	322 m³/day	
Modelled Pumping Rate	460 m³/day	590 m³/day	1,178 m³/day	
Treatment	Hypochlorite disinfection system			

Formatted: Font: (Default) +Body (Calibri), 11 pt
Formatted: Font: (Default) +Body (Calibri), 11 pt
Formatted: Right
Formatted: Right
Formatted: Centered
Formatted Table

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. 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	CHESLEY
	Total Area [hectare]	422.58
Impervious Surfaces Area [ha]	<1%	89.46
	1% – <8%	325.65
	8% – < 30%	7.46
	Larger or equal than 30%	-

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	**CHESLEY**				
Well Name	No.1&2	No.1,2&3	No.1,2&3	No.1,2&3	No.3
Zone	A	B	C	D	A
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	N/A	<0.5
% Managed Lands (<40%, 40-80%, >80%)	>80%	>80%	>80%	N/A	40-80%

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

Approved

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5. The model built on the one created for the 2003 Grey Bruce Groundwater Study (WHI, 2003). WHI conceptualized Grey and Bruce Counties as a three-layered hydrogeology system consisting of a variable overburden layer underlain by a thin weathered bedrock aquifer that was, in turn, underlain by a thick un-weathered bedrock aquifer. In the area of the Chesley model, groundwater flow in the bedrock was inferred to be from east to west (Map 4.1.G1.1).

Given the location of the new Well #4, the current WHPA provides suitable protection for the new water supply, with a slight extension to the WHPA-A around Well #4 at the South end of the area. The addition of a new WHPA-A for Well #4 affects the same properties and does not result in the addition of any new properties or threats.

The resulting WHPA encompasses a total area of 8.41 km^2. The capture zones extend predominantly to the east to a distance of approximately 7.5 kilometres from the municipal wells. Approximately 1,200 metres east of CPW ~~3~~4, the WHPA encounters the boundary between Bruce and Grey Counties (Grey-Bruce Line) and then extends into the Township of Chatsworth. In the southern half of the Municipality in the vicinity of Chesley, the Saugeen Clay Plain region, which is located in the drainage basin of the Saugeen River, consists of deep stratified clay deposited by glacial Lake Warren. The clay plain in this area was mapped as glaciolacustrine clay and silt. The Horseshoe Moraines region exists on the east side of the Chesley model area, beyond the community boundary, and consists of a till moraine and spillway overlying a till plain. The till plain reportedly consists of a stony-boulder till with a sandy silt matrix, which is likely Elma Till. The spillway, located south of the Gibraltar Moraine, reportedly follows the course of the North Saugeen River and consists mainly of glaciofluvial outwash sand and gravel. The Ontario Geological Survey Quaternary geology mapping was used to estimate the hydraulic conductivity zones for the groundwater model developed by WHI for the vicinity of the WHPA (Grey Bruce Groundwater Study WHI, 2003, in GENIVAR 2010).

Map 4.1.G1.2 shows the borders of all zones of WHPA overlaying 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 4.1.2.5), unless the vulnerability is already rated high.

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

Vulnerability
After overlaying the intrinsic susceptibility index (Map 4.2.M1) on the delineation of wellhead capture zones, vulnerability scores were determined and elevated according to transport pathways. The vulnerability is shown on Map 4.1.G1.3.

Approved

The low aquifer vulnerability scores (based on ISI) are primarily a function of the depth of the overlying overburden in the area. The presence of a significant clay and silt layer between the ground surface and the aquifer also provide some protection of the aquifer, although the lateral continuity of this aquitard are not well established.

Only 2% of the capture zone has the maximum vulnerability score of ten, 10% of the capture area has a score of eight, 35% of the capture area has a moderate vulnerability score of six, and the remaining area has a low vulnerability score of four or less.

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 2 significant drinking water threats in the Chesley wellhead protection area A-D. These threats include two activities related to contamination with hazardous chemicals. (see detailed Table 4.1.G1.3 and summary Table 4.1.G1.4).
<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 4.1.G1.3 – Chesley: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: CHESLEY** *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										
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
	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										
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

TABLE 4.1.G1.4 – Chesley 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**			
CHESLEY	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	2	0	0	2	0	0	0	0

Quality of Raw Water at the Well

The 2000 Engineer's Report for the Chesley Water Works (Henderson and Paddon) included an assessment of bacteriological data of the raw water at the Community Park Well (CPW 1) from January 1997 to October 2000. Samples were taken almost every week and the results did not detect any total coliform or *E. coli*. The report stated that the groundwater supply from CPW 1 had been of high quality. The report also stated that there was significant clay overburden at the location of CPW 1, which appeared to provide protection from surface water influence. A review of available chemical water quality data for CPW 1 extends back to 1990. The well water met the Ontario Drinking Water Standards with the exception of alkalinity and hardness, which were not health-related standards. The report also noted that manganese and iron concentrations were slightly high on occasion in samples from both CPW 1 and the Victoria Park Well (GENIVAR, 2010).

Approved

Other reports confirmed that all parameter concentrations were less than the ODWQS with the exception of hardness, which was measured at 295 mg/L for CPW 2 and up to 393 mg/L for CPW 3 (GENIVAR, 2010).

Available water quality data for the current Arran-Elderslie DWS wells did not identify a potential drinking water issue as defined in the Technical Rules.

Drinking Water Issues and Conditions
Table 4.2.G1.5 indicates that no well issues were identified that met the threshold identified by the Source Protection Committee. 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 – Chesley: 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.

Approved

4.2.2 Municipality of Brockton

The Municipality of Brockton is located in Bruce County and is contained entirely within the Saugeen Valley Source Protection Area. The eastern portion of the municipality consists of a series of small recreational lakes and excellent farm land, which comprise the Saugeen Clay Plains in the north and the Horseshoe Moraines around Walkerton. The western portion of the municipality includes the Greenock Swamp, the largest protected Class 1 wetland in Southern Ontario and recognized in Canada for its uniqueness. In 2016, the population of the Municipality was 9,461, which was a decrease of 2% from 2001 (Census, 2016b). The main town is Walkerton with a population of 4,851. Smaller villages include Cargill, Chepstow, Elmwood, Glammis, and Pinkerton.

The Municipality of Brockton currently operates three municipal water supply systems: Chepstow Drinking Water System, Lake Rosalind Drinking Water System (Well No. 1 and Well No. 3) and Walkerton Drinking Water System (Well No. 7 and Well No. 9). No new drinking water systems are planned.

In Brockton, 436 farms cover a total land area of 45,031 ha (average farm size 103 ha), of which 68.7% are cropped according to the Agricultural Census (Statistics Canada, 2006a). From this cropped area, alfalfa and other fodder crops take up 7.2% of the land, soybeans take up 19.7% and other crops (corn, wheat, etc.) take up 24.5%. The total livestock density is 0.17 nutrient units per acre. According to the same census, there are 137,000 chickens on 54 farms (Statistics Canada, 2006a). The total number of cattle is 34,646 (13% dairy, remainder beef) on 276 farms. Further, there are 37,898 pigs, 4,541 sheep, 563 horses, and 1,228 goats reported in this municipality.

The susceptibility of groundwater to contamination 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 shows the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. The Municipality is characterized by variable bedrock geology, the Greenock Swamp, the thick overburden located around Dunkeld and between Hanover and Elmwood, and the thin overburden along the Saugeen River from the Eden Grove Wetland to Walkerton and Otter's Creek in the Municipality of South Bruce. This thin area is designated HVA. The areas east of the Greenock Swamp are also vulnerable along Greenock Creek, the Teeswater River and Allens Creek. The latter also joins the Walkerton DWS.

Significant recharge areas to the north and west of the Greenock Swamp cover a large area and include the Chepstow Well. This area varies from two to seven km in width and follows the Saugeen River between Ellengowan and Walkerton before continuing upstream to Hanover where it encompasses the IPZ of Ruhl Lake and the wellhead protection areas of the Hanover wells (located in the Municipality of Brockton) and Lake Rosalind.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.2.M3).

Approved

In this municipality, the total area of SGRAs is 176.7 km^2 and the total area of HVAs is 116.2 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 4.2.2.1).

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 Municipality of Brockton

SGRA	Total Area of SGRA	176.7 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	116.2 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

Note: Total areas relate to the full source protection region

Approved

4.2.2.2 Groundwater Municipal Systems

4.2.2.2.1 Walkerton Drinking Water System

The Walkerton Drinking Water System uses two production wells: Walkerton Well Nos. 7 and 9. The wells are 100 m from each other and are located west of Walkerton at the corner of Bruce Road 2 and Bruce Road 3. Walkerton Well No. 7 is cased to a depth of 13.7 metres with a total depth of about 76 metres. Walkerton Well No. 9 is cased to a depth of 47 metres with a total depth of about 79 metres. The combined pumping requirement for these wells is approximately 6,000 m^3/day (Golder, 2003).

The geology of the shared WHPA for Walkerton Well Nos. 7 and 9 is variable. Geologic cross-sections of the area indicate a continuously changing series of overburden layers within the WHPA. Sand and gravel layers dominate and relatively thin layers of silt, clay and till are imbedded between. MOECC well records for Walkerton No. 7 indicate a total overburden thickness of 6.7 m, which is composed of alternating clay and gravel layers. The overburden at Walkerton No. 9 consists of 3 m of sandy silt.

The original WHPA for the Walkerton system was developed by Golder and Associates as part of the Town of Walkerton Groundwater Protection Study (2001), and was subsequently updated in 2003 to account for the removal of Well No. 6, which has been taken offline and converted to a monitoring well.

TABLE 4.2.G1.1 – Description of the Drinking Water System and Wells

Well Name	Walkerton 7	Walkerton 9
Drinking Water System ID	220002690	
Drinking Water System Classification	Large Municipal Residential System	
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA	
Northing/Easting	4886345.7 / 483715.1	4886245.9 / 483737.9
Year Constructed	1986	2001
Well Depth	76.2 m	79.2 m
Uncased Interval	13.7 - 76.2 m	46.9 - 79.2 m
Aquifer	Transition zone between the Dunkeld and Elma Tills (OGS, 2007)	
GUDI	No	No
Number of Users Served	4500 persons	
Design Capacity (CoA)	4,910 m^3/day	4,910 m^3/day
Permitted Rate (PTTW)	7,139.52 m^3/day	7,139.52 m^3/day
Average Annual Usage	not known	not known
Modelled Pumping Rate	6,000	combined
Treatment	Chlorination, Ultrafiltration	

Approved

Several investigations have been undertaken by the Municipality in order to assess the viability of these and other wells in the area, and as a result a completely new WHPA was developed as part of the Municipal Technical studies (Waterloo Numeric Modelling Corp, 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 4.2.G1.2a and shown on Map 4.2.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. The results are listed in Table 4.2.G1.2b and shown on Maps 4.2.G1.5 and 4.2.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.2.G1.2a – Impervious Surfaces

General	Code for WHPA	WALKERTON
	Total Area [hectare]	1265.34
Impervious Surfaces Area [ha]	<1%	246.77
	1% – <8%	1018.02
	8% – < 30%	0.55
	Larger or equal than 30%	0.0

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

TABLE 4.2.G1.2b – Managed Land and Livestock Density

WHPA_NAME	**WALKERTON**			
Well Name	No.7&9	No.7&9	No.7&9	No.7&9
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%	>80%	>80%	>80%

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

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

The Walkerton wellhead protection area (WHPA) is the largest WHPA investigated in this study (Map 4.2.G1.1). The area has considerable measurement data available based on pumping tests with tracers. This data indicated groundwater flow speeds far above those expected in the overburden, which are associated with the karstic nature of its limestone bedrock.

The resulting WHPA encompasses a total area of 12.65 km^2 and extends south 7.7 km from the well location. Greenock Creek flows through the WHPA. The land use types that are within this zone consist of industrial, commercial, residential, and agricultural.

Approved

The intrinsic vulnerability of the aquifer to contamination from surface activities within the Walkerton WHPA ranges from moderate to high. Corrections were made for potential contaminant conduits to impact the aquifer including constructed transport pathways throughout the WHPA and the presence of overburden material with a higher permeability above the aquifer (CRA 2009).

Map 4.2.G1.2 shows the borders of all zones of the WHPA overlaying 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 4.1.2.5), unless the vulnerability is already rated high.

Aquifer vulnerability was adjusted one level to account for transport pathways within the Walkerton 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 4.2.G1.3.

Vulnerability
The Walkerton wells are located in a rural area three km west of the town of Walkerton. After overlaying the intrinsic susceptibility index (Map 4.2.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.2.G1.3.

This area has high aquifer vulnerability scores (based on ISI) predominantly due to the high water table and relatively thin, permeable overburden in the WHPA. In the southern portion of the WHPA, the presence of less permeable overburden deposits have lower aquifer vulnerability sores associated with them.

Approximately 40% of the capture zone has the maximum vulnerability score of ten, 31% of the capture zone has a score of eight and the remaining area has a moderate vulnerability score of six. A tributary of the Saugeen River and its wetland are within 40 metres of the wells (CRA, 2009).

Approved

TABLE 4.2.G1.3a – Walkerton: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: WALKERTON** *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	4	2		1		1		3		**11**
3	Agricultural source material - Application to land	9									**9**
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	9									**9**
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land	4									**4**
11	Pesticide - Handling and storage										
12	Road Salt – Application		5								**5**
13	Road Salt – Handling and Storage		5								**5**
14	Snow - Storage										
15	Fuel - Handling and storage	2									**4**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards	2									**2**
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage		6								**6**
	PATHOGENS										
1	~~Untreated Septage – Application to land~~disposal of hauled sewage to land										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal	4	2		1		1		3		**11**
3	Agricultural source material - Application to land	9									**9**
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~~ Outdoor Confinement Area or other farm-animal yards	2									**2**

Approved

TABLE 4.2.G1.4 – Walkerton 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**			
WALKERTON	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	63	6	28	97	25	3	3	31

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 97 significant drinking water threats in the Walkerton (Well Nos. 7 and 9) wellhead protection area A-D. These threats include 28 activities related to the potential for pathogen contamination, 63 activities related to contamination with hazardous chemicals and 6 activities related to DNAPLs. The total number of properties with threats is 36 (see detailed Table 4.2.G1.3a and summary Table 4.2.G1.4.).

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
As part of the Drinking Water Surveillance Program, raw groundwater samples were collected between 2001 and 2005. The number of samples ranged from five to 12 samples per year.

As a result of natural groundwater factors (aquifer characteristics), the measured hardness in the raw water exceeded the operational guideline (80-100 mg $CaCO_3$/L) for drinking water. Values for the five year sampling period were near 500 mg $CaCO_3$/L, which is the level that water is considered unsuitable for drinking. This high carbonate content also reaffirms the abundance of limestone bedrock and is in line with other indications of karst.

Another naturally occurring element is selenium, which infrequently exceeded guidelines in ODWQS Schedule 2 in both Well Nos. 7 and 9.

Approved

Drinking Water Issues and Conditions

Walkerton Nitrate Issue
A drinking water source protection issue was declared for nitrates for the Walkerton system by the SPC, based on water quality thresholds identified by the SPC. Preliminary analysis of raw water quality data indicated that the wells Nos. 7 and 9 had elevated nitrate levels which were approaching thresholds established by the SPC for identifying potential issues.

Upon further study, it was determined that the levels of nitrates in local monitoring wells were declining and that it was unlikely any mixing between aquifers was occurring. As a result, the SPC, with approval of the MOECC, directed staff to remove the Walkerton nitrate issue from the SVSPA Assessment Report and its associated policies from the Source Protection Plan.

Conditions from Historic Land Use
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.G1.5 – Walkerton: Issues and Conditions

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

Approved

4.2.2.2.2 Chepstow Drinking Water System

The Chepstow Drinking Water System is located in the community of Chepstow in the Municipality of Brockton. This well supply consists of one bedrock well that was constructed in 1978 to a depth of 57 m. The well is located in the Powers Subdivision, 100 metres north of the main road (Concession 6) that runs east to west through the town. The Teeswater River runs 220 metres to the north of the well. The residential lots are serviced by private septic systems with the closest septic system being 30 to 60 metres south of the well.

The well serving the Village of Chepstow has been considered a GUDI source by the consultant, lan D. Wilson Associates (2002a). The consultant noted the potential for surface water to enter the well under certain conditions. The Teeswater River is located 220 m to the north of this well. The consultant has suggested that if the well were to be pumped for a period of 600 minutes, the drawdown cone would likely extend to the river, and thus reverse the gradient such that river water could be induced to flow towards the well (MOECC, 2004). However, the GUDI study concluded that the well is situated under fine-grained overburden approximately 15 metres thick. Ian D. Wilson recommended that this layer serves as confining layer that inhibits the vertical infiltration of surface contaminates in the close vicinity of the well (MOECC, 2004).

A wellhead protection area (WHPA) for the Chepstow Drinking 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, to account for projected development in the area, as part of the Round 1 Technical Study for the Saugeen Grey Sauble Northern Bruce Peninsula Source Protection Region (CRA, 2007).

TABLE 4.2.G2.1 – Description of the Drinking Water System and Wells

Well Name	Chepstow
Drinking Water System ID	220008765
Drinking Water System Classification	Small Municipal Residential System
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA
Northing/Easting	4889047.7 / 477442.1
Year Constructed	1978
Well Depth	57 m
Uncased Interval	17.1 - 57 m
Aquifer	Detroit River group limestone bedrock
GUDI	Yes
Number of Users Served	14 homes (planned up to 41)
Design Capacity (CoA)	not known
Permitted Rate (PTTW)	216 m^3/day
Average Annual Usage	13 m^3/day **
Modelled Pumping Rate	16.8 m^3/day
Treatment	Chlorination (sodium hypochlorite)

*** CRA Phase I, Round 1 Report 2007, Table 3.1 (years 2000-2006)*

Approved

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.G2.2a and shown on Map 4.2.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. The results are listed in Table 4.2.G2.2b and shown on Maps 4.2.G2.5 and 4.2.G2.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.2.G2.2a – Impervious Surfaces

General	Code for WHPA	CHEPSTOW
	Total Area [hectare]	56.36
Impervious Surfaces Area [ha]	<1%	2.38
	1% – <8%	53.98
	8% – < 30%	0.0
	Larger or equal than 30%	-

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

TABLE 4.2.G2.2b – Managed Land and Livestock Density

WHPA_NAME	**CHEPSTOW**			
Well Name	CHEPSTOW	CHEPSTOW	CHEPSTOW	CHEPSTOW
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%

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

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

The WHPA extends south east from the well with a long and relatively narrow funnel shape (Map 4.2.G2.1). WHPAs A and B extend 600 metres south from the well and have institutional, residential and agricultural land use. WHPAs C and D extend three km southeast from the well and consist of all agricultural properties. The total area of WHPAs A-D is 56.3 ha.

WHPA-E was delineated in the surface water body that influences this GUDI well. The closest surface water is Teeswater River, which drains the Greenock Swamp to the west and the Chepstow Swamp to the south. To identify the point of interaction, Technical Rule 47(5a) was applied and the point closest to the well was identified within the Teeswater River. The WHPA-E extends upstream direction of the river and includes all tributaries within the 2-hour ToT. The greater of a 120 meter setback or the conservation authority regulation limit, and areas with agricultural tile drainage were added (for details, see Section 4.1.2.7).
Transport Pathways

Approved

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 4.1.2.5), unless the vulnerability is already rated high.

No transport pathway adjustments were made in the Chepstow WHPA as existing properties are either on municipal services, or have wells that are in compliance with existing standards.

Vulnerability

After overlaying the intrinsic susceptibility index (Map 4.2.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.2.G2.3.

On a regional scale, the intrinsic susceptibility index of the area surrounding the Chepstow well is designated as medium to high susceptibility (Map 4.2.M1), which is likely due to the exposed bedrock surfaces along the Teeswater River, and the lack of a significant aquitard in the area. Further south, the intrinsic vulnerability is reduced to low or medium, which likely reflects the presence of lower permeable materials (e.g., clay and hardpan) in the overburden. Within the Chepstow WHPA, intrinsic vulnerability is reduced with distance from the supply well. The Teeswater River is located 200 to 300 metres north of the well on a down-gradient outside of the WHPA (CRA, 2009). The vulnerability is shown on Map 4.2.G2.3.

The total vulnerability of the WHPA-E associated with the Chepstow well is relatively low (7.2). This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.2.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) for the WHPA-E area with the source vulnerability score 0.9 (moderate) due to medium overburden protection.

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.4 for details).

Approved

TABLE 4.2.G2.2c – Vulnerability of WHPA-E Associated with the Chepstow DWS

Name of WHPA	CHEPSTOW	
DWIS_ID	220008765	
Area (Total), hectares	747.31	
Vulnerability (Total)	**7.2**	
Source Vulnerability	**0.9**	
SV - Distance to surfacing Karst [m]	> 500 m	0.8
SV - Overburden Protection	16.49 m	0.9
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	Moderately fine loam	8
Soil permeability *	Highly permeable	7
Slope [%]	6.6%	9
AV Transport Pathways	**7.7**	
Tile Drainage [% of land area]	82.6%	9
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.*

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 28 significant drinking water threats in the Chepstow wellhead protection area A-D. These threats include 13 activities related to the potential for pathogen contamination, and 15 activities related to contamination with hazardous chemicals. The total number of properties with threats is 12 (see detailed Table 4.2.G2.3 and summary Table 4.2.G2.4).

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

Approved

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 4.2.G2.3 – Chepstow: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: CHEPSTOW** *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							11		**12**
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	1									**1**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal	1							11		**12**
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										

Approved

21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										

TABLE 4.2.G2.4 – Chepstow 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**			
CHEPSTOW	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	15	0	13	28	1	11	0	12
WHPA E				0				0

Quality of Raw Water at the Well

Regular inspections of the raw water have shown that iron levels commonly exceed the ODWQS aesthetic standards. Iron often occurs naturally in groundwater aquifers. Concentrations of iron in groundwater are often higher than in surface water but the taste and smell of iron at concentrations above the drinking water guidelines may be noted by some water users. Fluoride levels, which also naturally occur in groundwater, were sometimes elevated above the recommended standards of ODWQS Schedule 2 (Wilson, 2002).

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.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 4.2.G2.5 – Chepstow: Issues and Conditions

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

Approved

4.2.2.2.3 Lake Rosalind Drinking Water System

Lake Rosalind Drinking Water System is located on the west side of Lake Rosalind in the Municipality of Brockton, northwest of the Town of Hanover. The Lake Rosalind Drinking Water System currently consists of two wells. Well No. 1 is a shallow dug well, less than four metres deep, located on the west side of Lake Rosalind. The date of installation is unknown but the well was recently upgraded in 2005. Well No. 3 is an overburden well that was constructed in 1987 to a depth of 22.9 metres.

Both wells Nos. 1 and 3 operate in conjunction to service approximately 68 residential lots (approximately 170 people) with private septic systems. Lake Rosalind Well No. 3 is located 120 metres west of Lake Rosalind with agricultural land to the west according to the record for Lake Rosalind Well No. 3, there is only 1.5 metres of clay overlying the overburden sand aquifer, which is located at a depth of 13.4 metres. Due to the limited thickness of clay in the overburden, natural protection of the aquifer from surface activities is limited, therefore both wells are confirmed GUDI. Microbiological water quality from Well No. 1 is poor with frequent testing results showing high concentrations of total coliform with the occasional test result detecting *E. coli.* In comparison, microbiological water quality from Well No. 3 is significantly better than Well No.1, but it is still considered poor. The well is clearly impacted by drought, with shown effects of reduced well yield and low water levels during a lack of precipitation over an extended period of time (MOECC, 2011b).

A wellhead protection area (WHPA) for the Lake Rosalind 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 and future development 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 4.2.G3.2a and shown on Map 4.2.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. The results are listed in Table 4.2.G3.2b and shown on Maps 4.2.G3.5 and 4.2.G3.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

Approved

TABLE 4.2.G3.1 – Description of the Drinking Water System and Wells

Well Name	Lake Rosalind 1	Lake Rosalind 3
Drinking Water System ID	220007800	
Drinking Water System Classification	Small Municipal Residential System	
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA	
Northing/Easting	4890922.58 / 495670.39	4890848.66 / 495723.63
Year Constructed	not known	not known
Well Depth	4 m	22.9 m
Uncased Interval	Unknown	Unknown
Aquifer	Overburden	Overburden
GUDI	Yes	Yes
Number of Users Served	200 persons	
Design Capacity (CoA)	30.24 m^3/day	110.88 m^3/day
Permitted Rate (PTTW)	30.24 m^3/day	110.592 m^3/day
Average Annual Usage *	31 m^3/day	
Modelled Pumping Rate	10.5 m^3/day	31.08 m^3/day
Treatment	Sodium hypochlorite disinfection, cartridge filtration system, secondary chlorination	

** MOECC, 2003c*

TABLE 4.2.G3.2a – Impervious Surfaces

General	Code for WHPA	LAKE_ROSALIND
	Total Area [hectare]	11.30
Impervious Surfaces Area [ha]	<1%	0.0
	1% – <8%	0.0
	8% – < 30%	11.30
	Larger or equal than 30%	-

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

TABLE 4.2.G3.2b – Managed Land and Livestock Density

WHPA_NAME	LAKE ROSALIND			
Well Name	No. 1&3	No. 1&3	No. 1&3	No. 1&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%	>80%	40-80%

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

Approved

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

The Lake Rosalind wells are located 120 metres west of Lake Rosalind and form a single WHPA. It is one of the smallest WHPAs investigated under this study as it only encompasses a total area of 0.11 km^2 (11 ha). It extends north-west of the well 700 metres (Map 4.2.G3.1). The wells supply water to a residential area with private septic systems and some private wells along the shores of Lake Rosalind. Agricultural lands lie to the west of the well. WHPAs A and B have a portion of Lake Rosalind within the capture zone and the land use consists of residential and agricultural. WHPAs C and D have residential and agricultural land uses.

A WHPA-E was delineated in the surface water body that influences this GUDI well. The surface water closest to the well is Lake Rosalind, which covers part of the WHPA-A. This manmade lake has a surface area of 0.43 km^2 and a maximum depth of 6-7 metres. Summer temperatures are high, suggesting full mixing. To identify the points of interaction, Technical Rule 47(5a) was applied and the points closest to the wells were identified, located in the lake at less than 100 metres of distance. The WHPA-E includes the full lake and 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).

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 4.1.2.5), unless the vulnerability is already rated high.

Aquifer vulnerability was adjusted one level to account for transport pathways in the urban area within the Lake Rosalind 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 4.2.G3.3.

Vulnerability
After overlaying the intrinsic susceptibility index (Map 4.2.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.2.G3.3.

<u>WHPA A-D</u>
On a regional scale, the intrinsic susceptibility index in the area surrounding the wells has a medium to low susceptibility (Map 4.2.M1). The variability of the ISI values are largely a function of the lateral discontinuity of the overburden layers. A relatively large percentage of the Lake Rosalind WHPA is rated with a high vulnerability to surface contamination due to the relatively large size of the WHPA-A (i.e., represents 45% of the total area of the capture zone) where the intrinsic vulnerability score is solely based on proximity to the supply well (CRA, 2009).

<u>WHPA-E</u>

Approved

The total vulnerability of the WHPA-E associated with the Lake Rosalind wells is comparatively high (8.0) for both wells Nos. 1 and 3. This score was determined by multiplying the area vulnerability score with the source vulnerability scores (see Table 4.2.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 the WHPA-E areas, with the source vulnerability score of 1.0 (high) due to a minimum of overburden protection above the two wells.

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

TABLE 4.2.G3.2c – Vulnerability of WHPA-E Associated with the Lake Rosalind DWS

Name of WHPA	**LAKE_ROSALIND**	
DWIS_ID	220007800	
Area (Total), hectares	196.43	
Vulnerability (Total)	**8.0**	
Source Vulnerability	**1.0**	
SV - Distance to surfacing Karst [m]	> 500 m	0.8
SV - Overburden Protection	4 m	1.0
Area Vulnerability	**8 (8.1)**	
AV - Percent Land: Score	**9**	
AV - Percentage of Land	> 70%	9
AV - Land Characteristics	**7.7**	
Land Cover *	50% Agricultural, 10% Developed, 40% Natural	7.7
Soil type	22.8% gravel, 5.3% organic deposits, 70.3% sand,	7.1
Soil permeability *	100% A,	7.0
Slope [%]	7.0%	9.0
AV Transport Pathways	**7.7**	
Tile Drainage [% of land area]	17.7%	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.

Approved

WHPA A-D
There are 38 significant drinking water threats in the Lake Rosalind (Well Nos. 1 and 3) wellhead protection area A-D. These threats include 19 activities related to the potential for pathogen contamination and 19 activities related to contamination with hazardous chemicals. The total number of properties with threats is 19 (see detailed Table 4.2.G3.3 and summary Table 4.2.G3.4).

WHPA-A and most of WHPA-B are highly vulnerable. The significant drinking water threats in WHPA-A are related to septic systems for private households. The vulnerability for WHPAs C and D is low; therefore, there are no significant threats in these capture zones.

WHPA-E
With surface water influencing both wells Nos. 1 and 3, the 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. Some activities that discharge sewage would be considered pathogen threats, but none were identified in this area. Agricultural activities that have the potential to contaminate surface water with pathogens were identified, associated with the handling, storage and application of agricultural source material and non-agricultural source material, also with the livestock. A total of 10 activities were identified in this area as significant threats to drinking water sources (Table 4.2.G3.3b).

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
High levels of total coliform bacteria have been detected in raw water samples from both of the Lake Rosalind wells.

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.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 4.2.G3.3a – Lake Rosalind: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

	Land Use Category

Approved

Prescribed Threat WHPA: LAKE_ROSALIND *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								19		**19**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								19		**19**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

Approved

TABLE 4.2.G3.3b – Lake Rosalind: 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*		**LAKE ROSALIND**
	PATHOGENS		
1	disposal of hauled sewage to land~~Untreated Septage - Application to land~~		
3	Agricultural source material - Application to land		4
4	Agricultural source material - Storage		2
6	Non-agricultural source material - Application to land		
7	Non-agricultural source material - Handling and storage		
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing	Grazing and pasturing	4
21		Yards and confinement	
	Grand Total		**10**

TABLE 4.2.G3.4 – Lake Rosalind WHPA: Summary of Significant Drinking Water Threats

LAKE ROSALIND	**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	19	0	19	38	0	19	0	19
WHPA-E			10	10	4			4

TABLE 4.2.G3.5 – Lake Rosalind: Issues and Conditions

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

4.2.2.3 Surface Water Municipal Systems

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

Approved

4.2.3 Township of Chatsworth

The Township of Chatsworth is located in the heart of Grey County in the center of the Source Protection Region. It is partially within the Grey Sauble Source Protection Area and partially within the Saugeen Valley Source Protection Area. In 2016, the population was 6630, which was an increase of 3.6% from 2006. Essentially a rural community, the Township gets its 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 Walters Falls (population 150). Smaller villages include Massie, Holland Centre, Berkeley, and Mooresburg.

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 (corn, wheat, etc.) take up 7.7%. The total livestock density 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.

Two municipal groundwater systems are located in this municipality. One residential municipal groundwater system serves the village of Chatsworth and another serves the village of Walters Falls. These two systems are located in the neighbouring Grey Sauble Source Protection Area, so please refer to the Assessment Report for that SPA. No new drinking water systems are planned.

The susceptibility of groundwater aquifers for this municipality is mapped in 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 also an HVA because of the thin and permeable overburden with the exception of the southeast. The southeast contains a ridge that starts southwest of the village 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 with lower vulnerability 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).

Approved

For the portion of this municipality that lies within the SVSPA, the total area of SGRAs is 131.5 km^2 and the total area of HVAs is 150 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	131.5 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1–8 %
HVA	Total Area of HVA	150 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces average)	1–8 %

Note: Total areas relate to the full source protection region

4.2.3.2 Groundwater Municipal Systems

The two municipal groundwater systems (Chatsworth and Walters Falls) are located in the neighbouring Grey Sauble Source Protection Area, please refer to the Assessment Report for that SPA. In this municipality, no municipal drinking water systems that use groundwater exist within this source protection area.

4.2.3.3 Surface Water Municipal Systems

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

Approved

4.2.4 Municipality of Grey Highlands

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

The Municipality is located within three source protection areas and two source protection regions: portions are in the Grey Sauble SPA and the Saugeen Valley SPA, which are in the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region; a portion also belongs to 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 include 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 (Saugeen Valley SPA) and the Kimberley-Amik-Talisman Well Supply (see Assessment Report of Grey Sauble SPA). The Feversham Water system, which serviced the Beaver Heights Subdivision, has been decommissioned. No new drinking water systems are planned.

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, 4,086 sheep, 1,133 horses and 272 goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is mapped in 4.4.M1.

4.2.4.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.4.M2 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. The landscape is dominated by the Niagara Escarpment's karstic bedrock and the Beaver Valley's silty till. Karst bedrock features are expressed on the ground surface only in a few areas and these areas are considered SGRAs. 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 4.4.M3). The portion of this municipality that lies within this SPA has a total area of SGRAs of 76.6 km^2 and a total area of HVAs of 156.6 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 Municipality of Grey Highlands in this Source Protection Region

SGRA	Total Area of SGRA	76.6 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1–8 %
HVA	Total Area of HVA	156.6 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1–8 %

Note: Total areas relate to the full source protection region

Approved

4.2.4.2 Groundwater Municipal Systems

4.2.4.2.1 Markdale Well Supply

The Markdale Well Supply consists of three bedrock wells. The Isla Street Well, also known as Well No. 1, was constructed in 1976 and the Eliza St. Wells, also known as Well Nos. 3 and 4, were constructed in 2002.

Well No. 1 is located in the southwest corner of Markdale in a commercial section of town. The well is 750 metres southwest of Highway 10 on Isla Street near the intersection of Glasgow Street.

Wells No. 3 and No. 4 are located at the end of Eliza Street behind the Markdale water tower and are 150 metres south of Highway 10.

Currently, the village of Markdale only utilizes Well Nos. 1, 3 and 4. The Isla Street well has its own pump house and treatment system and has been designated as non-GUDI.

Well No. 3 and 4 share a pump house and treatment system and have been designated as GUDI wells. An adverse water quality incident in 2005 prompted the review of water quality results for the Markdale Well Supply. The presence of microbiological contaminants in the raw water source for Well Nos. 3 and 4 was not reflective of a true ground water source. Thus, Well Nos. 3 and No. 4 are now assumed to be GUDI (MOECC, 2008). A GUDI study was completed by Henderson Paddon and reviewed by the Ministry of Environment in the year 2001, prior to placing Wells 3 and 4 into production. At that time, it was established that Well Nos. 1, 3 and 4 were non-GUDl wells although the Ministry required additional monitoring to confirm the status of Well Nos. 3 and 4.

Well No. 1 is 73.2 metres deep and the casing extends through the overburden to a depth of approximately 20 metres, near the overburden bedrock contact. Well No. 3 has a depth of 97.5 metres and is cased to a depth of 45 metres. Well No. 4 has a depth of 119 metres and is cased to a depth of 50 metres.

The surrounding area land use is low-density residential, industrial and institutional, which are mostly on full municipal services.

A wellhead protection area (WHPA) for the Markdale 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 and future development as part of the Round 1 Technical Study for the Saugeen Grey Sauble Northern Bruce Peninsula Source Protection Region (CRA, 2007).

Approved

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

Well Name	Markdale 1 (Isla)	Markdale 3	Markdale 4
Drinking Water System ID	220001744		
Drinking Water System Classification	Large Municipal Residential System		
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA		
Northing/Easting	4906819.4 / 527512.3	4906932.6 / 528288.8	4906945.7 / 528300
Year Constructed	1973	2002	2002
Well Depth	73.2 m	97.5 m	118.9 m
Uncased Interval	20.6 – 73.2 m	13.7 – 97.5 m	15.2 – 118.9 m
Aquifer	Guelph/Amabel, limestone	Guelph/Amabel, limestone	Guelph/Amabel, limestone
GUDI	No	Yes	Yes
Number of Users Served	1,300 persons		
Design Capacity (CoA)	2,618 m^3/day	3,862 m^3/day	
Permitted Rate (PTTW)	2,620.8 m^3/day	2,782.08 m^3/day	1,080 m^3/day
Average Annual Usage *	941 m^3/day	548 m^3/day	250 m^3/day
Modelled Pumping Rate	2,520 m^3/day	757 m^3/day	757 m^3/day
Treatment	UV disinfection and prim. Chlorination, sec. chlorination		

* *CRA Phase I, Round 1 Report 2007, Table 3.1 (2002-2006 for Isla, 2005-6 for the other wells)*

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. 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	MARKDALE
	Total Area [hectare]	953.83
Impervious Surfaces Area [ha]	<1%	251.01
	1% – <8%	379.57
	8% – < 30%	284.30
	Larger or equal than 30%	-

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

Approved

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

WHPA_NAME	MARKDALE					
Well Name	No. 3&4	No. 3&4	ISLA	ISLA	No. 3&4-ISLA	No. 3&4-ISLA
Zone	A	B	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
% Managed Lands (<40%, 40-80%, >80%)	40-80%	40-80%	40-80%	40-80%	40-80%	>80%

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

Wellhead Protection Area

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

The WHPAs within the Municipality of Grey Highlands are variable with respect to their intrinsic vulnerability to contamination. The Markdale WHPA is one of the largest WHPAs investigated under this study and encompasses most of the community of Markdale. The 2-year capture zones of Markdale Well Nos. 3 and 4 merge together. The 5-year and 25-year capture zones (WHPAs C and D) are shared by all three wells (Map 4.4.G1.1).

WHPAs A-D (the 25-year ToT zone) have a total land area of 9.54 km^2, which is partly due to the large pumping rates for the Markdale system. The full WHPA contains the majority of the urban area of Markdale and extends into rural areas to the north, east and southeast. The WHPA consists of residential, commercial, municipal, institutional, former railroad, landfill, industrial, forested, and agricultural lands. Tributaries and small wetland complexes associated with the Rocky Saugeen River traverse the WHPA throughout, controlling the shape of the WHPA boundary.

A WHPA-E was delineated in the surface water body that influences this GUDI well. The closest surface water to the Markdale wells is a small tributary that flows into the Saugeen River, and wetlands to the south and northeast of Markdale. To identify the points of interaction, Technical Rule 47(5a) was applied and the points closest to the wells were identified. Markdale Well Nos. 3 and 4 have their point of interaction within the WHPA. The point of interaction for Markdale Well No. 3 is 400 metres south-west of the well, into a creek that flows into the Saugeen River. The point of interaction for Markdale Well 4 is 420 metres south-east of the well, into a creek that flows into the Saugeen River. The WHPA-E extends 2.5 km in upstream direction of the river and includes the tributary 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 4.4.G1.2 shows the borders of all zones of WHPA overlaying aerial photography.

Approved

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 4.1.2.5), unless the vulnerability is already rated high.

No Transport pathway adjustments were made in the Markdale WHPA as existing properties are either on municipal services, or have wells that are in compliance with existing standards.

Vulnerability
<u>WHPA A-D</u>
The Rocky Saugeen River and associated tributaries and wetland areas transect the Markdale WHPA in close proximity to the wells. After overlaying the intrinsic susceptibility index (Map 4.4.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.4.G1.3.

Due to the overburden permeability (Map 4.4.M1) and thickness, aquifer vulnerability values (based on ISI) are mostly high and moderate. The resultant WHPA vulnerability results in the largest portion (74%) of the Markdale WHPA rated moderately vulnerable (scores range between five and seven). The remaining portions have a high vulnerability (20%) and a low vulnerability (3%) (CRA, 2009).

<u>WHPA-E</u>
The total vulnerability of the WHPA-E associated with the Markdale wells (Nos. 1 and 2) is moderate (7.2). This score was determined by multiplying the area vulnerability score with the source vulnerability scores (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) for the WHPA-E areas, with the source vulnerability score of 0.9 (moderate) due to a shallow overburden protection above the two wells.

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.4 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.

<u>WHPA A-D</u>
There are 27 significant drinking water threats in the Markdale (Well Nos. 1, 2 and 3) wellhead protection area A-D. These threats include 25 activities related to contamination with hazardous chemicals and 2 activities related to DNAPLs. The total number of properties with threats is 6

Approved

(see detailed Table 4.4.G1.3 and summary Table 4.4.G1.4). Some of these properties are located in the Municipality of West Grey.

TABLE 4.4.G1.2c – Vulnerability of WHPA-E Associated with the Markdale Well Supply

Name of WHPA	**MARKDALE**	
DWIS_ID	220001744	
Area (Total), hectares	153.41	
Vulnerability (Total)	**7.2**	
Source Vulnerability	**0.9**	
SV - Distance to surfacing Karst [m]	> 500 m	0.8
SV - Overburden Protection	13.7 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 *	80% Agricultural, 20% Natural	7.8
Soil type	67.7% diamicton, 2.6% gravel, 20.4% organic deposits, 9.4% sand,	7.5
Soil permeability *	100% B,	7.7
Slope [%]	5.9%	9.0
AV Transport Pathways	**7.7**	
Tile Drainage [% of land area]	0.0%	7
Storm Catchment	None	7

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

In the vicinity of Well No. 1 (Isla), residential and commercial properties are served by a municipal sewage system, and the lines of this system are significant chemical and pathogen threats. Other significant threats are waste disposal (mostly commercial and industrial) as well as the storage of fuels (both commercial and private) and organic solvents (commercial). There is an aggregate operation and agricultural land use within the WHPA-B.

The majority of activities associated with potentially significant threats within WHPAs A and B of the Eliza wells, located in the center of a densely inhabited town, are residential with some institutional, such as schools and churches. Dominant threats are the lines of the municipal sewage system and fuel storage. Institutional land, commercial land and utilities within the WHPA-B pose DNAPL threats.

Within the WHPA-C that is shared by both wells, DNAPL handling is likely in areas with commercial and institutional land use and poses significant threats.

Approved

TABLE 4.4.G1.3 – Markdale: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: MARKDALE** *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										
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		10								**10**
13	Road Salt – Handling and Storage		10								**10**
14	Snow - Storage										
15	Fuel - Handling and storage		3			1			1		**5**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage			2							**2**
	PATHOGENS										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										

Approved

Approved

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 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
All three Markdale wells show occurrences of *E. coli* bacteria. This is usual for wells that are connected to surface water (GUDI).

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.G1.4 – Markdale 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			
MARKDALE	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	25	2	0	27	0	1	5	6
WHPA E				0				0

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

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

4.2.4.3 Surface Water Municipal Systems

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

Approved

4.2.5 Town of Hanover

The Town of Hanover is located in Grey County and is entirely in the Saugeen Valley Source Protection Area. The Town serves as the retail and recreational hub for the Saugeen area. In 2016, the population was 7, 688, which was an increase of 7% from 2006.

The area contains a large number of creeks, lakes and ponds. The Saugeen River runs through Hanover and is known for its recreational opportunities, such as canoeing and fishing.
The Town of Hanover currently operates three municipal water supply sources. The municipal supply system receives water from a small surface water source, Ruhl Lake, and two groundwater wells, Hanover No. 1 and Hanover No. 2. The Town operates a single water treatment plant. Raw water from the surface intake is treated separately from the raw groundwater, but the water is combined prior to distribution. One-third of the water supply comes from the lake and one-third from each of the wells, together supplying water to a population of approximately 6,600 in the Town of Hanover.

The Town of Hanover is unique because the wells are located in the Municipality of Brockton but serve the Town of Hanover. No new drinking water systems are planned.

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 shows the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. In the northwest, one square kilometre is SGRA due to sandy and gravelly soils. Another SGRA is located in the southern end of town along the Beatty Saugeen River. The two HVAs are to the west (2.8 km^2) and the southeast (0.6 km^2).

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

In this municipality, the total area of SGRAs is 2.4 km^2 and the total area of HVAs is 3.4 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 4.2.5.1).

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.

Approved

TABLE 4.2.5.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Town of Hanover

SGRA	Total Area of SGRA	2.4 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1–8 %
HVA	Total Area of HVA	3.4 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1–8 %

Note: Total areas relate to the full source protection region

Approved

4.2.5.2 Groundwater Municipal Systems

4.2.5.2.1 Hanover Water Treatment Plant (Wells No. 1 and No. 2)

Hanover's groundwater-based drinking water supply uses two overburden wells known as Hanover Well No. 1 and Hanover Well No. 2. Both are located to the west of the Town of Hanover in the Municipality of Brockton.

Hanover Well No. 1 is located northwest of Hanover, on the west side of Marl Lake, in close proximity to the Saugeen Municipal Airport. It was constructed in 1961 and has a depth of 33.6 metres. It is screened from 24.4 to 33.6 m and draws water from the overburden aquifer. Hanover Well No. 2 is located southeast of Marl Lake. It was constructed in 1986 and has a depth of 55.5 metres. It is screened from 43.9 to 55.5 m and draws water from the overburden aquifer.

Both wells draw groundwater from a sand and gravel aquifer located above the bedrock. A hydrogeological assessment was completed for Well No. 1 by Harden Environmental in March 2002. The hydrogeological report indicates that the aquifer is providing effective in-situ filtration. The well is located within 100 metres of a small lake and wetland. According to that study, using the fixed radius method, it was determined that the lake is within a 50 day capture zone for the well. Hanover No. 2 is deeper and not designated a GUDI well, however much of the WHPA underlies Marl Lake.

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

Well Name	Hanover 1	Hanover 2
Drinking Water System ID	210000167	
Drinking Water System Classification	Large Municipal Residential System	
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA	
Northing/Easting	4889953.1 / 495357.2	4889944 / 496027.8
Year Constructed	1961	1986
Well Depth	33.6 m	55.5 m
Uncased Interval	24.4 – 33.6 m	43.9 – 55.5 m
Aquifer	Overburden	Overburden
GUDI	Yes	No
Number of Users Served	7,000 persons	conjunctive with Well 1
Design Capacity (CoA)	3,888 m^3/day	3,888 m^3/day
Permitted Rate (PTTW)	4,546 m^3/day	4,582.368 m^3/day
Average Annual Usage*	1,350 m^3/day	1,454 m^3/day
Modelled Pumping Rate	1,442 m^3/day	1,553 m^3/day
Treatment	Pre and post gas chlorination system, and two packaged mixed media filter/clarifier water treatment	

** CRA Phase I, Round 1 Report 2007, Table 3.1 (2002-2006 both wells)*

Approved

A wellhead protection area (WHPA) for the Hanover 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 reflect planned development for the system, as part of the Round 1 Technical Study for the Saugeen Grey Sauble Northern Bruce Peninsula Source Protection Region (CRA, 2007). Lake Rosalind Drinking Water System, operated by the Municipality of Brockton, is in close proximity to the Hanover water supply system and is included in the numerical groundwater model for this well 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. 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.G1.2a – Impervious Surfaces

General	Code for WHPA	HANOVER_1	HANOVER_2
	Total Area [hectare]	38.13	44.20
Impervious Surfaces Area [ha]	<1%	0.13	8.19
	1% – <8%	15.84	8.01
	8% – < 30%	22.16	28.00
	Larger or equal than 30%	-	-

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	**HANOVER**							
Well Name	No. 1				No. 2			
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	0.5-1.0	0.5-1.0	0.5-1.0	0.5-1.0
% Managed Lands (<40%, 40-80%, >80%)	<40%	<40%	<40%	40-80%	40-80%	<40%	40-80%	<40%

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

Approved

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

Hanover Well No. 1 is located adjacent to the Saugeen Municipal Airport property. Its WHPA extends 650 metres northwest of the well and 200 metres south (Map 4.5.G1.1). WHPAs A and B include a portion of Marl Lake as well as residential properties. WHPAs C and D encompass the airport, including hangars, runways and the terminal, as well as agricultural land. The full WHPA for Hanover Well No. 1 encompasses a total land area of approximately 0.38 km^2. Its land cover is residential, municipal, commercial, industrial, flood hazard, and agricultural lands. Portions of the 100 metre WHPA-A extend under Marl Lake. A portion of WHPA-D extends below Lake Rosalind.

Hanover Well No. 2 is located southeast of Marl Lake and its pump rate is projected as slightly greater than Hanover Well No. 1, which results in a proportionally larger total capture zone. The capture zone extends north 650 metres from the well. WHPAs A and B extend into Marl Lake and include both residential and agricultural lands. WHPAs C and D elongate north to the south end of Lake Rosalind. Marl Lake as well as land uses such as residential and agricultural are located within the WHPAs. A portion of the 100 metre buffer, WHPA-A, and all other zones stretch out under Marl Lake. WHPAs A-D for Hanover Well No. 2 encompass a total land area of approximately 0.44 km^2. Land uses within WHPA-D are residential, forested, flood hazard, and agricultural.

A WHPA-E was delineated in the surface water body that influences this GUDI well. The surface water systems that have an interaction on Hanover Well No. 1 is Marl Lake and a creek flowing into Marl Lake. To identify the point of interaction, Technical Rule 47(5a) was applied and the point closest to the well was identified. It is located in the WHPA-A just east of the well in a small creek that discharges into Marl Lakes. Taking into account of the result of the hydrogeological assessment (Harden Environmental, 2002) which identifies the influence of Marl Lake to the well, a second point of influence was added located within this lake.

The WHPA-E includes both Marl Lake and Lake Rosalind. It extends 3.8 km in upstream direction north includes all tributaries that discharge into these lakes within a 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 4.5.G1.2 shows the borders of all WHPA zones overlain 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 4.1.2.5), unless the vulnerability is already rated high.

Aquifer vulnerability was adjusted one level to account for transport pathways in the urban area within the Hanover WHPA. This adjustment was based on the documented existence of wells which are out of compliance with existing standards. Areas where aquifer vulnerability was adjusted are shown in Map 4.5.G1.3.

Approved

Vulnerability

WHPA A-D

After overlaying the intrinsic susceptibility index (Map 4.5.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.5.G1.3.

The intrinsic vulnerability of groundwater aquifers within the Town of Hanover is mostly moderate (Map 4.5.M1). Hanover Well No. 1 is relatively more vulnerable to sources of contamination than Hanover Well No. 2. According to WHI (2003), there are 8.2 metres of clay in Hanover Well No. 1 and 32 metres of clay in Hanover Well No. 2. However, there are areas with medium to high intrinsic susceptibility caused by the presence of areas with permeable overburden materials. These are potential conduits for contaminants that may impact the aquifer (CRA, 2009).

Approximately 21% of the total area of the capture zone for Hanover Well No. 1 has a vulnerability score that is high (greater than eight). The rest of the WHPA has a moderate score of six.

In the WHPA for Hanover Well No. 2, only 12% of the total area has a high vulnerability score. The remaining area scores moderate with values of four and six.

WHPA-E

The total vulnerability of the WHPA-E associated with the Hanover wells is 7.2 (moderate). 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 the WHPA-E area with the source vulnerability score 0.9 (moderate) due to medium overburden protection.

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.4 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.

Approved

TABLE 4.5.G1.2c – Vulnerability of WHPA-E Associated with the Hanover WTP

Name of WHPA	HANOVER	
DWIS_ID	210000167	
Area (Total), hectares	258.4791068	
Vulnerability (Total)		**7.2**
Source Vulnerability		**0.9**
SV - Distance to surfacing Karst [m]	> 500 m	0.8
SV - Overburden Protection	24.4 m	0.9
Area Vulnerability		**8 (8.1)**
AV - Percent Land: Score		**9**
AV - Percentage of Land	> 70%	9
AV - Land Characteristics		**7.7**
Land Cover *	30% Agricultural, 20% Developed, 50% Natural	7.8
Soil type	22.5% gravel, 5.6% organic deposits, 69.5% sand,	7.1
Soil permeability *	100% A,	7.0
Slope [%]	6.3%	9.0
AV Transport Pathways		**7.7**
Tile Drainage [% of land area]	13.4%	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.*

<u>WHPA A-D</u>
There are no significant drinking water threats in the Hanover (Well No. 1) wellhead protection area A-D. (see detailed Table 4.5.G1.3 and summary Table 4.5.G1.4).

There are 18 significant drinking water threats in the Hanover (Well No. 2) wellhead protection area A-D. These threats include 8 activities related to the potential for pathogen contamination and 10 activities related to contamination with hazardous chemicals. The total number of properties with threats is eight (see detailed Table 4.5.G1.3 and summary Table 4.5.G1.4).

The main land use in this WHPA is residential since the properties within WHPAs A and B surrounding Marl Lakes and Lake Rosalind are homes or cottages. Marl Lake is part of the WHPA-A of Hanover Well No. 1 with residential properties along its shore. The majority of the significant threats are associated with these properties. The threats pertain to septic systems, and the application of fertilizers to lands. There is a municipal airport within the WHPA. The main facilities of the airport are in WHPA-D, which is located further away from the well so the threats have a moderate score.

<u>WHPA-E</u>

Approved

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 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
As part of the Drinking Water Surveillance Program, four to 12 raw groundwater samples were collected per year between 2000 and 2005.

As a result of natural groundwater factors, or aquifer characteristics, raw water occasionally exceeded some drinking water standards, such as iron and hardness levels. Iron levels were approximately three times the aesthetic quantity of 300 ug/l from 2000 to 2002 and then significantly dropped well below that level in 2003. Arsenic levels are well below the maximum acceptable concentration of 25 ug/l and a drop occurred from a maximum concentration of approximately 4 ug/l in 2002 to below 0.5 ug/l in 2003. The average hardness levels are well above the operational guideline of 80-100 mg/l (measured in $CaCO_3$ mg/l) for the six years that were sampled. In 2004 and 2005, maximum hardness levels are close to 500 mg/l, which is the limit that deems water intolerable for drinking. Sulphur content in the Hanover wells is generally high.

Turbidity levels in both wells are occasionally reported, as is usual in wells under direct influence of surface water (GUDI).

Approved

TABLE 4.5.G1.3a – Hanover Well No. 1: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat WHPA: HANOVER_1 *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										
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
22	Liquid Hydrocarbon Pipelines										
	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										
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										

Approved

TABLE 4.5.G1.3b – Hanover Well No. 2: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: HANOVER_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								7		**7**
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	1									**1**
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land	1									**1**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
1	disposal of hauled sewage to land~~Untreated Septage - Application to land~~										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								7		**7**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

Approved

TABLE 4.5.G1.4 – Hanover 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			
HANOVER 1	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				0
HANOVER 2								
WHPA A-D	10	0	8	18	1	7	0	8

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.G1.5 – Hanover: Issues and Conditions

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

Approved

4.2.5.3 Surface Water Municipal Systems

4.2.5.3.1 Hanover Water Treatment Plant (Ruhl Lake Intake)

The Hanover Water Treatment Plant receives water from the two Hanover wells and from a small surface lake, Ruhl Lake. This drinking water system services 7000 users in the Town of Hanover, which makes it a large municipal residential system under Ontario Regulation 170/03. The intake of Ruhl Lake, which has a total surface area of 2.63 ha, is classified as a Type D intake (other sources) under the *Clean Water Act, 2006*. Ruhl Lake proper is roughly circular in shape, approximately 10 m maximum depth, with a total water volume of roughly 100,000 m^3. Under normal conditions, Ruhl Lake has only one major surface water tributary, a small, spring-fed creek (Spring Creek) that enters the northern portion of the lake. A former tributary to the lake, Burrell Creek, was diverted during development of the water system in the 1920's, and now parallels the west perimeter of the Lake. With the distance of only 30 metres to the west of the lake, it frequently discharges into Ruhl Lake, especially after precipitation events. Also, it is likely that Burrell Creek has a connection via groundwater flow into the lake. Burrell Creek is thus treated as a tributary to Ruhl Lake. Groundwater seepage and discharge are also thought to be major inputs to the lake, as indicated by water replenishment of the lake during dry periods.

The sole surface water outlet from the lake is located at the south limits and immediately joins Burrell Creek, forming Ruhl Creek, which flows southerly, eventually outleting into the Saugeen River near Hanover.

The lake supplies the water treatment plant (WTP) using a pumping station next to the lake. The water pumped from Ruhl Lake into the plant is pre-disinfected via gas chlorination. In the WTP, a chemical feed system adds a coagulant aid, aluminum sulphate, to the water before it is directed through the two packaged mixed media filter/clarifier. Finally, post-gas chlorination maintains the chlorine level required by law. The water treatment system has a capacity of 7630 m^3/day.

TABLE 4.5.S1.1 – Description of the Drinking Water System

Intake Name	Ruhl Lake Intake
Drinking Water System ID	210000167
Drinking Water System Classification	Large Municipal Residential System
SPA of Intake and Vulnerable Area (IPZ)	Saugeen Valley SPA
Intake Type	D (other)
Northing/Easting of Intake	494648.67 / 4890770.38
Intake Pipe Length	55 m
Depth of Intake Crib *	6 m
Number of Users Served (Hanover WTP)	7,000 persons
Intake Capacity	not known
Average Annual Usage	3,548 m^3/day
Maximum Usage	6,008 m^3/day

** Estimated from water level (Stantec, 2008). Resulting from the small size of this lake, water levels can change quickly over the year.*

Approved

TABLE 4.5.S1.1b – Managed Land, Livestock Density and Impervious Surfaces

General	IPZ ID	RUHL_LAKE
	Area Total [hectare]	395.13
	Area Offshore [hectare]	2.97
	Area Onshore [hectare]	392.16
IPZ 1 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	12.45
	Livestock Density [NU/Acre]	0.86
	Managed Land Area [hectare]	4.37
	% Managed Lands	35.09
	Category	**ML% <40%, NU/acre 0.5-1.0**
IPZ 2 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	120.66
	Livestock Density [NU/Acre]	0.39
	Managed Land Area [hectare]	79.36
	% Managed Lands	65.99
	Category	**ML% >80%, NU/acre 0.5-1.0**
Impervious Surface: Area per Category [hectare]	<1%	129.88
	1% – <8%	246.13
	8% – < 30%	19.12
	Larger or equal than 30%	0.0

Note: All areas relate to the full IPZ, including areas located in other municipalities (in this case Brockton).

There is a 350 mm diameter intake pipe that extends 58 metres from the low-lift pumping station into Ruhl Lake. The opening is located approximately 1.5 metres above the lakebed and roughly six metres below the surface.

Managed Land, Livestock Density and Impervious Surfaces

Shortly after development of the Lake as a water supply for the Town, a significant portion of the surrounding land (~90 acres) was purchased by the Town and re-forested, including the entire waterfront area of the Lake. Remaining land use in the contributing drainage area is predominantly agricultural, with a mixture of cash crop and pasture agricultural systems. 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. Results are listed in Table 4.5.S1.1b and on Maps 4.5.S1.4, 5 and 6.

The Ruhl Lake IPZ-1 is classified as an area where the percentage of managed land of the vulnerable area is less than 80% and the livestock density is between 0.5 and 1.0 NU/acre. The IPZ-2 is classified as an area where the percentage of managed land of the vulnerable area is between 40% and 80% and the livestock density is less than 0.5. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

Approved

The Hydrology of Ruhl Lake
Ruhl Lake is a small inland lake with a roughly circular in shape, a radius of approximately 98 metres and a surface area of 2.63 ha (approximately four soccer fields). The maximum depth is approximately 10 m, with a total water volume of roughly 100,000 m^3. The physical characteristics of the Lake and raw water intake structure are assumed to be generally equivalent to the engineering drawings provided by the Town, as designed by the F.W. Thorold Co. Ltd. Consulting Engineers, in 1923 (Stantec, 2008).

The hydrology of Ruhl Lake is complex because both groundwater and surface water enter the lake. Ruhl Lake has only one major surface water tributary, a small, spring-fed creek (Spring Creek) that enters the northern portion of the lake. Groundwater seepage and discharge are also thought to be major inputs to the lake. The sole surface water outlet to the lake is located in the south.

A second creek, Burrell creek, formally discharged into Ruhl Lake, confluences with the outlet only 20 metres downstream the lake. After water quality problems, Burrell Creek was separated from the lake by an artificially maintained dike that is 15 metres wide and now flows to the west of Ruhl Lake; however, operators report that Burrell Creek drains into the lake when rainfalls are heavy because of the wetland characteristic of the area surrounding the lake. Several other non-permanent drains are visible on aerial photography, but these are not formally defined as surface water bodies.

Much of the surface material directly surrounding the lake consists of muck and peat, stressing the swampy characteristic of these areas that are frequently flooded. Indeed, operators report that during precipitation events, agricultural fields between shoreline of Ruhl Lake and a nearby road that passes 500 m south of the lake frequently flood and form a connected water body up to a culvert.

Ruhl Lake is fed by groundwater springs. Especially in summer, these groundwater springs keep the water temperature cool and contribute a significant share of the inflow. These springs may originate from contact with the deep overburden aquifer.

For the delineation of IPZ-2, the Ruhl Lake system has unique characteristics. While the lake hydrological system is complex, complete mixing of the top six meters of water column must be assumed under 10-year wind conditions from any directions, a mixing time of only 30 minutes is assumed, as turbulence at the slopes can facilitate mixing and due to its small size (2.63 hectares).

This water system collects the overland runoff from all surrounding fields. Some of these have artificial drains, and other fields show the formation of erosive, non-permanent drains in SWOOP aerial photography.

The full watershed that contributes surface water to the lake was delineated through topographic analysis with the MNRF Digital Elevation Model. The resulting watershed stretches north of the lake for 2.9 km and west for 2.6 km and has an area of 645.2 hectares.

Approved

Intake Protection Zone
The offshore component of IPZ-1 includes the entire surface water body. The full IPZ-1 is the full lake surface plus a 120 metre setback along the shoreline. Including this onshore component, the total area of IPZ-1 is 15.4 ha.

IPZ-2 is completely on-land, because the full in-water area of the lake is already contained in IPZ-1. The IPZ-2 contains the 2-hour time-of-travel of all creeks that feed into Ruhl Lake, namely, Burrell Creek, Spring Creek and an unnamed watercourse. A 120 m setback was added from all watercourses. Under flood conditions when the lake level raises, the Burrel Creek canal to the south and west of Ruhl Lake can be flooded so that the 120-metre setback of Burrel Creek was added until it joins with Ruhl Creek downstream the lake.

The resulting area of the IPZ-2 covers 380 hectares that is all onshore. The IPZ-1 has 15.4 hectares, of which only the area of the lake, 2.63 ha, is water surface.

IPZ-1 and IPZ-2 are shown on Map 4.5.S1.2 and on Map 4.5.S1.3 with underlying aerial photography.

The delineation approach was peer reviewed and because IPZ-2 already covers the full stream network of all creeks feeding into Ruhl Lake.

Storm Sewer Systems and Transport Pathways
Land use in the intake protection zone is forest or agriculture, and there is no storm sewer system within the time-of-travel chosen for delineating the IPZ-2, the watersheds of Ruhl and Burrell Creek.

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 extend. Agricultural fields within the Ruhl Lake watershed were assumed to have tile drainage, and so these areas were added to the delineation.

Vulnerability
The area vulnerability factor for IPZ-1 is ten (10), as prescribed by the Technical Rules.

Area Vulnerability Factor
The area vulnerability factor for IPZ-1 is ten, as prescribed by the Technical Rules. For IPZ-2, it is determined by averaging the percentage of land, land characteristics and transport pathways sub factors. These three factors are discussed separately and rating is summarized in Table 4.5.S1.2a.

The resulting area factor rating for the Ruhl Lake IPZ-2 is eight (8).

Approved

Percentage of Land
The percentage of land sub factor has been divided equally between the three ranges outlined in the Technical Rules (< 33% = 7, 33% to 66% = 8, > 66% = 9). For Ruhl Lake IPZ-2, 100% of land is onshore and the vulnerability sub score is thus nine (9).

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 of the IPZ-2 (all upland) is primarily forested, with some agricultural land use. Therefore, a low vulnerability rating for the land cover component was used for the Ruhl Lake intake and the vulnerability sub score is seven (7).

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 Soil Survey of Bruce County (Hoffman and Richards, 1954) and the mapping updates (Agriculture and Agri-Food Canada, 1983) specify minor gravel for most of the Ruhl Creek and Burrell Creek watersheds, with some muck and peat, some gravelly silt and some silt. Quaternary geology is dominated by glaciofluvial outwash sand. As previously described, the lake not only receives water from surface runoff, but is also connected to a groundwater spring. The resulting soil type vulnerability is thus medium or eight (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). Due to the dominance of minor gravel, the permeability is high (9).

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 IPZ-2 has an average of approximately 3%. This was determined with the MNRF Digital Elevation Model. The slope component rating is eight (8).

Land Characteristics (Summary) The resulting land characteristics sub factor, calculated using an averaged equal representation of each component listed above is eight (8)

Transport Pathways
The transport pathway sub factor has the components; storm catchment areas, storm outfalls, watercourses and drains, and tile drained areas. All land uses within the IPZ-2 are agricultural, and there are neither storm sewers nor other storm outfalls that drain into the IPZ-2. The rating with respect to the number of outfalls, watercourses and drains per 1000 ha of land was set for 0-3/1000 ha in the zone (7), 4 to 7/1000 ha in the zone (8) and > 7/1000 ha in the zone (9). With the two larger creeks and one smaller one for an area of 630 hectares, the rating is eight (8).

Approved

There are no tile drains marked in the Tile Drainage Areas GIS dataset, even though surface drains and erosive natural drains are visible. The rating for tile drainage is thus low and has a sub score of seven (7).

However, the low average of these scores is misleading and can be attributed mainly to the shape of Burrell Creek. It is believed that surface transport strongly contributes to water quality concerns in Ruhl Lake, especially if surrounding lands are flooded and it becomes one connected water body. For this reason, the vulnerability sub score for transport pathways is elevated to a score of eight (8.0).

<u>Source Vulnerability</u>
The source vulnerability factor for Ruhl Lake combines intake characteristics, such as depth and length of pipe, and past water quality concerns. As prescribed in the Technical Rules for a Type D intake, source vulnerability is rated between 0.8 (low) and 1.0 (high).

The intake crib depth is six metres and approximately 55 metres from the shoreline. Past water testing has shown that levels of *E. coli* and sulphur are commonly exceeded.

Due to the close vicinity of the intake to the shore and the rapid mixing of the water column, the overall source vulnerability factor is 1.0. The relatively shallow depth of the intake is not sufficient to protect it from run-off influence and full mixing (Table 4.5.S1.2b).

<u>Resulting Vulnerability</u>
The vulnerability for IPZ-1 is ten and for IPZ-2 is eight (Table 4.5.S1.2c).

TABLE 4.5.S1.2a – Area Vulnerability Scores for the Ruhl Lake Intake: IPZ-2

Area Vulnerability Factor Rating for IPZ-2	**8**
Percentage of land	9.0
Land Characteristics	8.0
▪ *Land cover*	*7*
▪ *Soil Type*	*8*
▪ *Permeability*	*9*
▪ *Setback slope*	*8*
Transport Pathways	8.0*
▪ *Storm Catchment Areas*	*7*
▪ *Storm Outfalls, Watercourses, Drains*	*8**
▪ *Tile Drained Area*	*7*

** The wetland characteristic and the physical form of Burrell creek leads to an adjustment of transport pathways to a vulnerability sub score for transport pathways that is eight (8)*

Approved

TABLE 4.5.S1.2b – Source Vulnerability Scores for the Ruhl Lake Intake

Sub Factor	Score
Intake Depth	0.8
Length of Pipe (offshore)	1.0*
Recorded Water Quality	1.0*
Source Vulnerability Factor	1.0

** The vicinity of the intake to the shore and the rapid mixing of the water body lead to an overall vulnerability score of 1.0.*

TABLE 4.5.S1.2c – Vulnerability Scores for the Ruhl Lake Intake Protection Zone (IPZ)

Intake Type	Area Vulnerability Factor		Source Vulnerability Factor	Vulnerability Score	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
D	10	8	1.0	10	8

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.

Under the threat-based approach, 27 activities were identified as significant drinking water threats in the Ruhl Lake intake protection zone. These threats include 19 related to the potential for pathogen contamination and 8 related to contamination with hazardous chemicals. The total number of properties with threats is 15, all of which are agricultural.

Moderate and Low Threats
There are other properties located within the intake protection zone that, under the threat-based approach, have a drinking water risk level of moderate. 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 4.5.S1.3 – Ruhl Lake IPZ (both IPZ-1 and IPZ-2): Significant Drinking Water Threats by Activity and Land Use (Chemical, Pathogen and DNAPL)

Prescribed Threat **IPZ: RUHL LAKE** *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**
Chemical threats											
1	Waste disposal site										
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										
8	Commercial fertilizer - Application to land	1									**1**
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land	1									**1**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards	2									**2**
22	Liquid Hydrocarbon Pipelines										
DNAPL threats											
16	Dense non-aqueous phase liquid - Handling and storage										
Pathogen threats											
1	disposal of hauled sewage to land~~Untreated septage – Application to land~~										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
3	Agricultural source material - Application to land	13									**13**
4	Agricultural source material - Storage	4									**4**
6	Non-agricultural source material - Application to land										

7	Non-agricultural source material - Handling and storage										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards	2									**2**

TABLE 4.5.S1.4 – Ruhl Lake IPZ: Summary of Significant Drinking Water Threats

	Number of "are or would be significant" threats				**Number of *properties* with "are or would be significant" threats**			
RUHL LAKE	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
	8	0	19	27	15	0		15

Quality of Raw Water at the Intake

Microbiological

Under DWIS, raw water is analyzed for microbiological parameters, but there is no Maximum Allowable Concentration (MAC) in the ODWQS for raw water; *E. coli* as the standard applies to treated water only. It is a reportable parameter in WPP annual reports so that trends in source water quality can be observed. A summary of results observed at the subject intake includes:

- Coliforms are considered to be always present in the raw lake water with observed levels up to 1,100 and 14,100 cfu, cited in the O. Reg. 170/03 annual reports for 2005 and 2006, respectively.
- *E. coli* is also typically present with ranges of 0-210 cfu and 0-340 cfu reported for 2005 and 2006, respectively.

Chemical

In reviewing the various data sources obtained, the Drinking Water Surveillance Program appears to be the most comprehensive database in terms of the number of parameters sampled for evaluation of the raw water quality in terms of non-microbiological parameters such as metals, pesticides and volatile organics. The Drinking Water Surveillance Program dataset contains most of the parameters listed in the Ontario Drinking Water Standards, Guidelines and Objectives and unlike many of the monitoring programs; its samples are representative of the actual intakes. The data reviewed within the current work spans three years, from 2004 to 2006. Observed results include the following:

- No exceedances of ODWQS health related standards were observed at the Ruhl Lake intake, with most parameters at least an order magnitude less than the required health standard. Parameters reviewed included Nitrate (NO_3), Nitrite (NO_2), Aluminum, Turbidity, Total Kjeldahl Nitrogen (TKN), Total Phosphorous (TP), and Dissolved Organic Carbon (DOC)
- Occasional exceedances of non-health related standards were observed, in particular colour, alkalinity, and hardness
- No exceedances of ODWQS were observed for pesticides reviewed, though it should be noted that the method detection limit often exceeds the PWQO for a given parameter. In this regard, it cannot be stated with certainty that the PWQO are being achieved. The

concentration at which aquatic life may be compromised by these pesticides is far less than those that are considered acceptable from a public health perspective.

Three years of quarterly data from the Drinking Water Surveillance Program database were reviewed to determine the existence and/or magnitude of seasonal trends, with the following observations:

- Seasonal trends were identified for temperature, conductivity, alkalinity, hardness, DOC, turbidity, and colour.
- Conductivity, alkalinity, and hardness all increased in the late winter/early spring and decreased in the summer
- Temperature, DOC, colour, and turbidity all increased in the summer and decreased in the winter.
- No seasonal trends were observed for pH, iron, aluminum, total phosphorus, nitrates, or nitrites.

Nitrates and Other Operator Concerns

Historical data for the Ruhl Lake water supply and discussions with operators have revealed a number of drinking water quality concerns. The highest concern to operations staff is a slightly elevated level of nitrates (N-NO_3). In an effort to pinpoint the source of this excess nitrates levels, operation staff established a monitoring program in the spring of 2006, with sampling being completed at a number of locations around and in the Lake.

Given its characteristic as the sole surface water contributor to Ruhl Lake, Spring Creek should inherently be considered of primary concern for most contaminants; it certainly represents the transport pathway for the system. The headwaters of Spring Creek system exhibit relatively low nitrate concentrations, ranging from 3.2 – 5.5 mg/L. A minor secondary tributary to the Creek lying west of the “main” branch upstream of the access road crossing exhibited the highest of all measurements, with readings ranging from 8.1 - 10.5 mg/L. As expected, the measurements in the Creek downstream of the confluence with the west tributary were typically an average of the upstream readings. The elevated readings within the creek system were further mitigated prior to the intake, with levels observed at the pumphouse routinely in the 4.1 - 6.4 mg/L range, with one incidence of 7.3 mg/L. Nitrate concentrations in the west tributary to Spring Creek were consistently 3.5 - 5 mg/L greater than the concentrations at the intake, indicating the presence of a mitigating (dilution) factor between these two points, thought to be groundwater discharge.

There are no noticeable seasonal patterns in the nitrate data, implying that the origin of the contaminant is a consistent source such as groundwater.

Approved

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.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 4.5.S1.5 – Ruhl Lake: Issues and Conditions

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

Approved

4.2.6 Township of Huron-Kinloss

The Township of Huron-Kinloss lies in the south-west corner of Bruce County. Lake Huron borders its entire west coast. The Township of Huron-Kinloss lies within two Source Protection Areas, the Saugeen Valley Source Protection Area and the Maitland Valley Source Protection Area. These two SPAs also belong to different source protection regions and fall under the jurisdiction of two separate source protection authorities.

In 2016, the population was 7069, which was an increase of 7.8% from 2006. The main towns are Ripley (population 600) and Lucknow (population 1,100). Smaller communities include Point Clark, Amberley, Holyrood, Pine River, and Kinloss.

The Township's four municipal water supply systems are the Village of Ripley Well Supply, Lakeshore Drinking Water System, Lucknow, and Whitechurch. The Lucknow and Whitechurch systems are a part of the Maitland Valley Source Protection Area. No new drinking water systems are planned.

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 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. The overburden has low permeability and provides good protection for the aquifers. However, a band of gravelly sand exists from Clover Valley north, which is an SGRA. Around Lucknow there are some patches of permeable overburden that are designated as HVA.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.6.M3).

The portion of this municipality that lies within this SPR has a total area of SGRAs of 24.1 km^2 and a total area of HVAs of 3.7 km^2. The percentage of managed lands located within the SGRAs and HVAs is less than 40%. The livestock density is between 0.5 and 1.0 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 Township of Huron-Kinloss in this Source Protection Region

SGRA	Total Area of SGRA	24.1 km^2
	Managed Land and Livestock Density	ML% <40%, NU/acre 0.5-1.0
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	3.7 km^2
	Managed Land and Livestock Density	ML% <40%, NU/acre <0.5

	Impervious Surfaces (average)	1-8 %

Note: Total areas relate to the full source protection region

4.2.6.2 Groundwater Municipal Systems

4.2.6.2.1 Village of Ripley Well Supply

The Village of Ripley Well Supply is centrally located near the intersection of Huron Street and Jessie Street in the Village of Ripley and services a population of approximately 680 persons. The Ripley system consists of production Well Nos. 1, 2 and 3. A fourth well has been drilled as a backup and for monitoring purposes. Wells 1 and 2 are located in the centre of Ripley at the fire station. Well No. 1 was drilled in 1947 and has a depth of 84.4 m. The metal casing reaches a depth of 36.6 m terminating at the overburden bedrock. Well No. 2 was drilled in 1994 and has a depth of 85.3 m, which is similar to Well No. 1. The metal casing reaches a depth of 34.0 m terminating at the overburden bedrock. Well Nos. 3 and 4 are located on the Township of Huron-Kinloss Municipal Office property. Well No. 3 was drilled in 2011 and has a depth of 85m. Well No. 4 was drilled in 2012 and has a depth of 85 m.

All wells are non-GUDI according to the Drinking Water Information System (DWIS) database.

A WHPA for the Ripley 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). The WHPA for Well Nos. 3 and 4 was developed after the Township decided to increase capacity by drilling new wells. The groundwater study and delineations were completed by Matrix Solutions Inc. in 2016.

TABLE 4.6.G1.1 – Description of the Drinking Water System and Wells

Well Name	Ripley 1	Ripley 2	Ripley 3	Ripley 4
Drinking Water System ID	220002636			
Drinking Water System Classification	Large Municipal Residential System			
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA			
Northing/Easting	4879793.3 / 453641.8	4879790.3 / 453667	453605 / 4880224	453598 / 4880234
Year Constructed	1947	1994	2011	2012
Well Depth	84.4 m	85.3 m	85 m	85 m
Uncased Interval	36.6-4.4m	34-85.3 m	not known	not known
Aquifer	Limestone bedrock			
GUDI	No			
Number of Users Served	680 persons			
Design Capacity (CoA)	864 m^3/day		not known	

Approved

Permitted Rate (PTTW)	864 m^3/day	not known
Average Annual Usage *	not known	
Modelled Pumping Rate	181 m^3/day	2,016 m^3/day
Treatment	Sodium hypochlorite chlorination	

* *CRA Phase I, Round 1 Report 2007, Table 3.1*

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 4.6.G1.2a and shown on Map 4.6.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. The results are listed in Table 4.6.G1.2b and shown on Maps 4.6.G1.5 and 4.6.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.6.G1.2a – Impervious Surfaces

General	Code for WHPA	RIPLEY
	Total Area [hectare]	3040.23
Impervious Surfaces Area [ha]	<1%	1525.64
	1% – <8%	1485.61
	8% – < 30%	28.98
	Larger or equal than 30%	-

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

TABLE 4.6.G1.2b – Managed Land and Livestock Density

WHPA_NAME	**RIPLEY**			
Wells	No. 1 and 2			
Zone	A	B	C	D
Livestock Density Category [<0.5, 0.5-1.0, >1.0]	<0.5	N/A	N/A	N/A
% Managed Lands (<40%, 40-80%, >80%)	<40%	N/A	N/A	N/A
Wells	No. 3 and 4			
Zone	A	B	C	D
Livestock Density Category [<0.5, 0.5-1.0, >1.0]	<0.5	N/A	N/A	N/A
% Managed Lands (<40%, 40-80%, >80%)	40-80%	N/A	N/A	N/A

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

Approved

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

WHPAs A-D for the Ripley system encompasses a total land area of approximately 3040.23 ha and spans out south-east of the well 18.5 km (Map 4.6.G1.1). WHPAs A and B encircle downtown Ripley and have commercial, residential and agricultural properties within. WHPAs C and D are largely characterized by agricultural land use activities with some residential areas.

Map 4.6.G1.2 shows the borders of all zones of WHPA overlaying 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 4.1.2.5), unless the vulnerability is already rated high.

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

Vulnerability
After overlaying the intrinsic susceptibility index (Map 4.6.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.6.G1.3.

The intrinsic susceptibility index for the Ripley WHPA is low to moderate due to the approximately 30 metres of low permeability overburden overlying the bedrock aquifer, which provides natural protection to the aquifer (Map 4.6.M1). Review of the water well records confirms the presence of approximately 30 m of low permeable overburden (e.g., clay, hardpan) throughout the area. Land use around the Ripley wells is residential, commercial and institutional. The area is serviced by municipal sanitary sewers.

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 69 significant drinking water threats in the Ripley (Well Nos. 1, 2, 3 and 4) wellhead protection area A-D. These threats include 6 activities related to contamination with hazardous chemicals, 1 activity related to pathogen threats and 2 activities related to DNAPLs. The total

number of properties with threats is 5 (see detailed Table 4.6.G1.3 and summary Table 4.6.G1.4).

<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.G1.3 – Ripley: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: RIPLEY** *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										
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								4		**4**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	<u>Outdoor Confinement Area</u>~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage		2								**2**
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal										
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~~Outdoor Confinement Area or other farm-animal yards - Livestock grazing	1									**1**

TABLE 4.6.G1.4 – Ripley 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			
RIPLEY	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	6	2	1	9	1	4	2	6

Quality of Raw Water at the Well
Levels of ODWQS chemical standards (Schedule 2) were exceeded in the raw water for fluoride, which is attributed to natural occurrence in the aquifer (DWIS; BM Ross, 2001a).

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 4.6.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 4.6.G1.5 – Ripley: Issues and Conditions

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

Approved

4.2.6.2.2 Lakeshore Drinking Water System

The Lakeshore Drinking Water System is located along the shoreline of Lake Huron and extends from the Municipality of Kincardine in the north to Point Clark in the south. This system services a population of approximately 3,500. It includes six drilled bedrock wells (one not in service), four pumping stations, a ground level reservoir, and an elevated storage facility.

There are three main pressure zones, one to the south and two to the north. The south zone includes Blairs Grove and Point Clark Development and the north zone includes Murdock Glen and Huronville South.

The southern system is comprised of the Point Clark Development and the Blairs Grove pump houses and associated production wells. The Point Clark Development Well Nos. 2 and 3 are located at Part Lot 6, Concession Lake Range and have a depth of approximately 75 metres to bedrock. Point Clark Well No. 1 has been decommissioned in September 2014 due to reported casing failures. Well No. 3 was drilled in 1992 to replace Well No. 1. Blairs Grove Well Nos. 2 and 3 are located near the intersection of Cathcart Street and Moore Drive and have a depth of approximately 74 metres into the bedrock. Blairs Grove Well No. 2 was taken off line in August 2020 due to a casing failing. Blair Grove Well No. 3 has been established as a replacement Well for the community.

The northern systems are comprised of the Murdock Glen and Huronville South pump houses and their respective production wells. Murdock Glen Well No. 2 is located in Part Lot 33 in Lot 51, Concession A. Murdock Glen Well No. 2 has a depth of 80.5 metres into the bedrock. Huronville South Well No. 2 is located in Part of Blocks A and Block B, Plan 3M-101 (address taken from MOECC, 2005b). Huronville South Well No. 2 has a depth of 93.3 metres into the bedrock and is cased to a depth of 52.1 metres. Murdock Glen Well No. 1 and Huronville South Well No. 1 have been decommissioned.

The Lakeshore wells are not considered to be GUDI according to the DWIS database. This is primarily due to the thick layer of fine-grained overburden (St. Joseph's Till) that protects the Bedrock aquifer in this area.

WHPAs for the Lakeshore Drinking Water System's wells were first developed as part of the Grey Bruce Groundwater Study (WHI, 2003). The initial WHPAs were 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).

Pumping tests for Well 2 & 3 were conducted on September 24-25, 2020 by Wilson Associates Consulting Hydrogeologist. In the report titled 'Confirmatory Well Re-Evaluation Blairs Grove Well Supply' that was prepared for the Township of Huron-Kinloss (dated October 16, 2020), analysis of the pump test demonstrated that Well 2 and Well 3 are in the same aquifer, with similar depths (69.5m and 74.1m), located 23 metres apart, and the long-term interference risk from Well 3 is anticipated to be effectively identical to Well 2.

Approved

Given the findings of this report and pump test results it was determined that minor adjustments could be completed to the Blairs Grove WHPA to address the new location for Well 3 using the existing groundwater model and technical work completed for Well 2.

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 4.6.G2.2a and shown on Maps 4.6.G2.4, 4.6.G3.4, 4.6.G4.4 and 4.6.G5.4. 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. The results are listed in Table 4.6.G2.2b. The percentage of managed land is shown on Maps 4.6.G2.5, 4.6.G3.5, 4.6.G4.5 and 4.6.G5.5. The livestock density is shown on Maps 4.6.G2.6, 4.6.G3.6, 4.6.G4.6 and 4.6.G5.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.6.G2.1 – Description of the Drinking Water System and Wells

Well Name	Blairs Grove 3	Huronville 2	Murdock Glen 2	Point Clark 2 and 3
Drinking Water System ID	220000425			
Drinking Water System Classification	Large Municipal Residential			
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA			
Northing/Easting	4882536 / 441202	4889428.55 / 447490.56	4887061.13 / 445493.97	4879455.09 / 440202.4 440205.2 / 4879471.68
Year Constructed	1992	Not known	Not known	Not known
Well Depth	74 m	93.3 m	80.5 m	75/82.3 m
Uncased Interval	Not known	Not known	Not known	Not known
Aquifer	Detroit River Group bedrock			
GUDI	No	No	No	No
Number of Users Served	Lakeshore DWS, 3,000 persons			
Design Capacity (CoA)	2,617.9 m^3/day	3,931.2 m^3/day	not known	3,274.6 m^3/day
Permitted Rate (PTTW)	2,621 m^3/day	3,927.7 m^3/day	1,814.4 m^3/day	3,273.1 m^3/day
Average Annual Usage	not known	not known	not known	not known
Modelled Pumping Rate*	171.0 m^3/day	290.0 m^3/day	216.0 m^3/day	324 m^3/day
Treatment	Sodium hypochlorite disinfection, iron treatment			

** CRA Phase I, Round 1 Report 2007, Table 3.1*

Wellhead Protection Area

The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5. The Blairs Grove, Huronville South, Murdock Glen, and Point Clark wells are all part of the Lakeshore Drinking Water System (Maps 4.6.G2.1, 4.6.G3.1, 4.6.G4.1 and 4.6.G5.1).

TABLE 4.6.G2.2a – Impervious Surfaces

General	Code for WHPA	BLAIRS_GROVE	HURONVILLE	MURDOCK_GLEN	POINT_CLARK
	Total Area [hectare]	186.54	90.15	228.14	337.61
Impervious Surfaces Area [ha]	<1%	104.38	5.48	174.87	245.49
	1% – <8%	58.86	70.20	53.26	71.35
	8% – < 30%	23.30	14.47	0.0	20.77
	Larger or equal than 30%	-	-	-	-

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

TABLE 4.6.G2.2b – Managed Land and Livestock Density

WHPA_NAME	**LAKESHORE**							
Well Name	POINT CLARK				BLAIRS GROVE			
Zone	A	B	C	D	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	N/A	N/A	N/A	<0.5	<0.5	<0.5	<0.5
% Managed Lands (<40%, 40-80%, >80%)	<40%	N/A	N/A	N/A	<40%	<40%	40-80%	<40%
WHPA_NAME	**LAKESHORE**							
Well Name	HURONVILLE				MURDOCK GLEN			
Zone	A	B	C	D	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	>1.0	0.5-1.0	N/A	<0.5	<0.5	N/A	N/A
% Managed Lands (<40%, 40-80%, >80%)	40-80%	<40%	<40%	N/A	<40%	40-80%	N/A	N/A

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

<u>Blairs Grove:</u>
WHPAs A-D for the Blairs Grove WHPA encompasses a total land area of approximately 1.87 km^2. The WHPA extends five km east off the well. The land use in WHPAs A and B is all residential. Land use is primarily residential along the shoreline of Lake Huron in WHPAs A, B and C, and is agricultural in WHPA-D. A permanently-flowing tributary of the Pine River intersects the WHPA. This causes a pressure gradient that slightly modifies the shape of the WHPA.

Approved

Map 4.6.G2.2 shows the borders of all zones of the WHPA overlaying aerial photography.

Huronville:
WHPAs A-D for the Huronville WHPA encompasses a total land area of approximately 0.91 km^2. The WHPA begins near the Lake Huron shoreline and extends eastward into the Municipality of Kincardine to a distance of 7 km from the well. WHPAs A and B are characterized by residential and municipal land uses along the Lake Huron shoreline. These zones contain woodlands and sewage lagoons. The land uses of WHPAs C and D are primarily rural and agricultural. Several aggregate operations, both historic and active, were noted within WHPA-B and areas immediately surrounding the Huronville WHPA.

Map 4.6.G3.2 shows the borders of all zones of the WHPA overlaying aerial photography.

Murdock Glen:
A new production well, Murdock Glen Well No. 2, was installed in Murdock Glen. The Murdock Glen WHPA encompasses a total land area of approximately 2.28 km^2. The WHPA extends five km southeast of the well. Land use is primarily rural and agricultural with residential areas located along the Lake Huron shoreline in WHPA-A and a small portion of WHPA-B. A permanently-flowing tributary of Royal Oak Creek flows across WHPA-D.

Map 4.6.G4.2 shows the borders of all zones of the WHPA overlaying aerial photography.

Point Clark:
The Point Clark WHPA encompasses a total land area of approximately 3.38 km^2. The wells are located in the village of Point Clark 700 m inland from Lake Huron and 3.3 km west of Highway 21. The WHPA extends six km southeast from the well. WHPA-A is characterized by residential land use along the Lake Huron shoreline. The land uses of WHPAs B, C and D are primarily rural and agricultural. Similar to Murdock Glen, the right-angled fan shape of the Point Clark WHPA to the northeast and southeast is caused by the direction of regional groundwater flow.

Map 4.6.G5.2 shows the borders of all zones of the WHPA overlaying aerial photography.

Vulnerability and 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 4.1.2.5), unless the vulnerability is already rated high. Areas where vulnerability was adjusted are shown in Maps 4.6.G2.3, 4.6.G3.3, 4.6.G4.3 and 4.6.G5.3.

After overlaying the intrinsic susceptibility index (Map 4.6.M1) on the delineation of wellhead capture zones, vulnerability scores were determined considering the transport pathways (see Section 4.3.1 for detail). The vulnerability is shown on Maps 4.6.G2.3, 4.6.G3.3, 4.6.G4.3 and 4.6.G5.3.

The WHPAs within the Township of Huron-Kinloss vary significantly in their vulnerability to contamination. A large percentage of the total area within the Blairs Grove, Murdock Glen, Point Clark, and Ripley WHPAs has a low intrinsic vulnerability to contamination. Blairs Grove and

Point Clark has a low vulnerability in over 94% of their area. Huronville South has a slightly higher vulnerability to contamination and a larger portion of moderate vulnerability.

Blairs Grove:
The intrinsic susceptibility index mapping of Blairs Grove shows a medium to high susceptibility within the vicinity of the supply wells along the lakeshore. The mapping also shows a low susceptibility further uphill from the shoreline that, according to WHI (2003), is likely due to the low permeability overburden that is overlying the bedrock aquifer and providing natural protection to the aquifer.

Aquifer Vulnerability was adjusted one level to account for transport pathways in the Blairs Grove WHPA. This adjustment was based on the existence of wells that are suspected to be out of compliance with existing standards.

Huronville:
The intrinsic susceptibility index mapping of Huronville shows low to medium susceptibility throughout the WHPA because overburden with low or moderate permeability overlays the bedrock aquifer and provides natural protection. The Huronville wells are both located in a municipal park, and the adjacent land use is residential and serviced by individual septic systems.

Within the WHPA for the Huronville well is located a landfill (formerly a gravel pit) as well as a decommissioned gravel pit. A significant aquitard consisting of up to 60 m of clay associated with the St. Joseph's Till overlies the bedrock aquifer in this area. Accordingly, vulnerability was not adjusted in this area as these uses are located within shallow sand deposits, which are known to be hydraulically separate from the underlying bedrock aquifer that is being exploited by the municipal well.

Murdock Glen:
The intrinsic susceptibility index mapping of Murdock Glen shows low susceptibility throughout the WHPA because overburden with low or moderate permeability overlays the bedrock aquifer and provides natural protection. No transport pathway adjustments were made in the Murdoch Glen WHPA. Existing properties are either on municipal services, or have wells that are in compliance with existing standards.

Point Clark:
The intrinsic susceptibility index mapping of Point Clark shows medium to high susceptibility within the vicinity of the supply wells along the lakeshore. The intrinsic susceptibility index mapping in Point Clark also shows low susceptibility east of the shoreline due to the lower permeability and increased thickness of the overburden.

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

Threats and Risks

Approved

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
Activities that pose drinking water threats are listed in Table 4.6.G2.3a-d and summarized in Table 4.6.G2.4. 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.

Blairs Grove:
There are 60 significant drinking water threats in the Blairs Grove (Well No. 3) wellhead protection area A-D. These threats include 28 activities related to the potential for pathogen contamination and 32 activities related to contamination with hazardous chemicals. The total number of properties with threats is 28, all of which are residential.

In the less vulnerable zones C and D, there are both residential and agricultural land uses. These are considered moderate, not significant, threats.

Huronville:
There are 8 significant drinking water threats in the Huronville (Well No. 2) wellhead protection area A-D. These threats include two activities related to the potential for pathogen contamination and 4 activities related to contamination with hazardous chemicals. The total number of properties with threats is 8. Of the above threats one activity related to the potential for pathogen contamination and one activity related to contamination with hazardous chemicals are found on one property designated other land uses within the Municipality of Kincardine.

The WHPA-A and a section of WHPA-B are residential areas. The threats associated with private households are the handling and storage of fuel, the application of fertilizer to the land, waste disposal, and sanitary sewers or related pipes. There are water and sewage treatment facilities located in WHPA-B.

Murdock Glen:
There are 12 significant drinking water threats in the Murdock Glen (Well No. 2) wellhead protection area A-D. These threats include 10 activities related to the potential for pathogen contamination, and 2 activities related to contamination with hazardous chemicals. The total number of properties with threats is 10.

Point Clark:
There are 33 significant drinking water threats in the Point Clark (Well Nos. 2 and 3) wellhead protection area A-D. These threats include 15 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 15.

Quality of Raw Water at the Well
Data collected as part of the Drinking Water Surveillance Program was obtained for the year 2000 only. Fluoride, hardness, iron, and sodium concentrations were above established values for drinking water; however, all four parameters are attributed to naturally occurring aquifer conditions. All five samples had fluoride and hardness levels above 1.5 mg/l and 80-100 mg $CaCO_3$/l respectively. At least one sample exceeded the aesthetic level of 300 ug/l for iron. Although sodium concentrations did not exceed the aesthetic level of 200 mg/l, samples were over 20 mg/l, which would require reporting to a public health officer.

In Blairs Grove and Point Clark Well, raw aquifer water exceeds the standards for fluoride, iron and total dissolved solids, which are all attributed to natural occurrences in the aquifer (BM Ross, 2001b). Blairs Grove also had elevated sulphate levels. Levels of fluoride were reportedly exceeded in Huronville, Murdock Glen.

TABLE 4.6.G2.3a – Lakeshore Blairs Grove: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: BLAIRS_GROVE** *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								28		**28**
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								4		**4**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										

Approved

16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								28		**28**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

TABLE 4.6.G2.3b – Lakeshore Huronville: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: HURONVILLE** *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*				**2**
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								4		**4**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal						2*				**2**
3	Agricultural source material - Application to land										

Approved

4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

** One threat of each stated threat count is found in the Municipality of Kincardine.*

TABLE 4.6.G2.3c – Lakeshore Murdock Glen: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: MURDOCK_GLEN** *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								10		**10**
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								2		**2**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								10		**10**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

TABLE 4.6.G2.3d – Lakeshore Point Clark: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: POINT_CLARK** *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						14		**15**
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								3		**3**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal		1						14		**15**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

Approved

TABLE 4.6.G2.4 – Lakeshore 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
BLAIRS GROVE	32	0	28	60	0	28	0	28
HURONVILLE	6*	0	2*	8	0	6	2**	8
MURDOCK GLEN	12	0	10	22	0	10	0	10
POINT CLARK	18	0	15	33	0	14	1	15

** One threat of the stated threat count is found in the Municipality of Kincardine.*
*** One property of the stated property count is found in the Municipality of Kincardine.*

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.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 4.6.G2.5 – Lakeshore: Issues and Conditions

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

4.2.6.3 Surface Water Municipal Systems

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

4.2.7 Municipality of Kincardine

The Municipality of Kincardine is located in Bruce County in the Saugeen Valley Source Protection Area. The western portion of the Municipality is bordered by Lake Huron. In 2016, the population was 11,389, which was an increase of 1.9% from 2006. Seasonal residents add to the population during peak periods. The main towns are Kincardine (population 6,113) and Tiverton (population 743). Smaller villages include Inverhuron, Millarton, Underwood, Armow, and Bervie.

There are five municipal drinking water systems in the Municipality of Kincardine, four are groundwater wells and one is a surface water intake. The groundwater well systems are: the Armow Drinking Water System, Scott Point Drinking Water System, Tiverton Drinking Water System (the Dent well and two wells at Briar Hill), and the Underwood Drinking Water System. None of the five wells are GUDI wells. The Great Lake intake supplies the town of Kincardine. No new drinking water systems are planned.

Approved

The Kincardine Drinking Water System obtains its water from Lake Huron. The Kincardine water distribution system has recently been expanded to provide water to the four former groundwater supply systems of Kinhuron, Craig-Eskrick, Lake Huron Highlands, and Port Head Estates.

Two groundwater computer models were established within the original groundwater study for the delineation of the wellhead protection areas (Kincardine North and Kincardine South, WHI 2003). The municipal well systems in the northern part of the Municipality of Kincardine, Scott Point and Underwood, were combined into one model called the Kincardine North Model. Established WHPAs were based on raw water flow rates averaged over the 5-year period from 1997 to 2001, plus a 20-year projected rate (2021). The municipal well systems in the southern part of the Municipality of Kincardine were combined into one model called the Kincardine South Model (WHI, 2003).

Agricultural land use in Kincardine consists of 332 farms managing a total land area of 32,014 ha (average farm size 96 ha), of which 67.7% are cropped according to the Agricultural Census (Statistics Canada, 2006a). From this cropped area, alfalfa and other fodder crops take up 0.2% of the land, soybeans take up 20.2% and other crops (corn, wheat, etc.) take up 29.1%. The total livestock density is 0.11 nutrient units per acre. According to the same census, there are 149,000 chickens on 49 farms (Statistics Canada, 2006a). The total number of cattle is 17,720 (12% dairy, remainder beef) on 202 farms. Further, there are 29,777 pigs, 5,570 sheep, 465 horses, and 482 goats reported in this municipality.

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. In general, overburden with low permeability provides good protection to the aquifers. However, a narrow band of gravel-like sand, the width usually not exceeding 400 m, stretches from Clover Valley in the Township of Huron-Kinloss north, passing Armow on the west by 1.2 km. This band is an SGRA. The sandy areas along the shore are HVAs.

TABLE 4.2.7.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Municipality of Kincardine

SGRA	Total Area of SGRA	30.9 km^2
	Managed Land and Livestock Density	ML% <40%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	24.6 km^2
	Managed Land and Livestock Density	ML% <40%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

Note: Total areas relate to the full source protection region

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.7.M3).

Approved

In this municipality, the total area of SGRAs is 30.9 km^2 and the total area of HVAs is 24.6 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.

4.2.7.2 Groundwater Municipal Systems

4.2.7.2.1 Scott Point Drinking Water System

Scott Point water distribution system serves a population of approximately 100 people living in a small residential area of approximately 40 residences with no commercial or industrial water users.

The Scott Point Drinking Water System is comprised of one bedrock well (Well #1), located approximately 4 kms north of the Bruce Nuclear Power Development, 100 m inland from Lake Huron. It was constructed in 1970 and has a depth of 35.7 m cased to a depth of 30.9 m. Well #1 was abandoned in 2023 and replaced by a new Well #2 that was constructed in 2022 at a depth of 73.2 m. The new Well #2 is located approximately 200 metres East of the original Well #1. The well record indicates a 25 m total thickness of clay and shale above the water-bearing layer. These low permeability materials protect the raw water from surface activities. It is open hole from 32 to 73.32 m and draws water from a bedrock aquifer.

The Scott Point Well is designated non-GUDI. Digital data on water distribution lines as well as sewer lines is not available to DWSP.

TABLE 4.7.G1.1 – Description of the Drinking Water System and Wells

Well Name	Scott Point 2
Drinking Water System ID	220007043
Drinking Water System Classification	Small Municipal Residential System
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA
Northing/Easting	4911572/ 456421
Year Constructed	2022
Well Depth	73.2 m
Uncased Interval	32 to 73.2 m
Aquifer	Bedrock
GUDI	No
Number of Users Served	95 persons

Approved

Design Capacity (CoA)	not known
Permitted Rate (PTTW)	77.8 m^3/day
Average Annual Usage *	19.8 m^3/day
Modelled Pumping Rate	31 m^3/day
Treatment	Dual media filters (sand and anthracite), 12% sodium hypochlorite, iron removal

* *Matrix 2023 WHPA Study Table 3 (2018-2022)*

A WHPA for the original Scott Point Well #1 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).

The original groundwater model was inspected for appropriateness and applied in the Municipality of Kincardine as a part of a WHPA delineation for the new Scott Point Well #2. The model is regional in extent, such that the model boundaries do not impact the WHPA delineation results. The new well location is located within the existing refined model grid. The only modification to the model was adding the new Scott Point Well #2, associated particle locations for delineating the WHPAs, and the additional records from the Water Well Information System (WWIS) drilled since 2000 for evaluating the model calibration.

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 4.7.G1.2a and shown on Map 4.7.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. The results are listed in Table 4.7.G1.2b and shown on Maps 4.7.G1.5 and 4.7.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.7.G1.2a – Impervious Surfaces

General	Code for WHPA	SCOTT_POINT
	Total Area [hectare]	28.89
Impervious surfaces Area [ha]	<1%	6.74
	1% – <8%	22.15
	8% – < 30%	0.0
	Larger or equal than 30%	-

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

TABLE 4.7.G1.2b – Managed Land and Livestock Density

WHPA_NAME	**SCOTT POINT**			
Well name	No.1			
Zone	A	B	C	D

Approved

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%

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

Wellhead Protection Area

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

Scott Point WHPA intersects the Lake Huron shoreline and encompasses a total land area of approximately 0.30 km^2. The WHPA extends 2.6 km southeast of the well (Map 4.7.G2.1). It is long and narrow, typical of other WHPAs located along the Lake Huron shoreline. Land use is primarily residential in WHPAs A and B and agricultural in WHPAs C and D. WHPA-D intersects a large portion of the Lake Fringe wetland complex with bush and woodland.

Map 4.7.G2.2 shows the borders of all zones of WHPA overlaying 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 4.1.2.5), unless the vulnerability is already rated high.

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

Vulnerability

After overlaying the intrinsic susceptibility index (Map 4.7.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.7.G1.3.

Due to the higher intrinsic susceptibility of the underlying aquifer (Map 4.7.M1), Scott Point has a large portion of the total capture area designated as moderate vulnerability, which means that the vulnerability scores range between five and seven. On a regional scale, the intrinsic susceptibility index mapping shows that the areas surrounding the WHPA boundaries have a medium to high susceptibility and the area immediately surrounding the well has a low susceptibility. However, according to WHI (2003), the medium to high susceptibility index is based on the uppermost significant aquifer being present in the overburden materials with little or no natural protection. The Scott Point well is located in the deeper bedrock aquifer, which has some natural protection. Consequently, the intrinsic susceptibility index may be over-estimating the vulnerability for this WHPA (CRA, 2009). Given the Scott Point Well #2 is approximately twice as deep as Scott Point Well #1, vulnerability scoring will be even more overestimated than in the previous study.

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 30 significant drinking water threats in the Scott Point (Well No. 2) wellhead protection area A-D. These threats include 15 activities related to the potential for pathogen threats related to sewage systems and 15 chemical threats from sewage systems. The total number of properties with threats is 15. (see detailed Table 4.7.G1.3 and summary Table 4.7.G1.4).

<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.G1.3 – Scott Point: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: SCOTT_POINT** *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		14		**15**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal						1		14		**15**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

TABLE 4.7.G1.4 – Scott Point WHPA: Summary of Significant Drinking Water Threats

SCOTT POINT	**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	15	0	15	30	0	14	1	15

Quality of Raw Water at the Well

The raw water contains elevated levels of fluoride and sodium, both naturally occurring. Aesthetic parameters that are elevated include iron, hardness, total dissolved solids, and sulphates. The raw water pH ranges from 7.2 to 7.6. These chemicals occur naturally in the aquifer and are dealt with during treatment.

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.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 4.7.G1.5 – Scott Point: Issues and Conditions

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

Approved

4.2.7.2.2 Underwood Drinking Water System

The Underwood Drinking Water System utilizes one bedrock well, which is located near the centre of Underwood at the municipal building, 50 m west of Highway 21. The well was constructed in 1972 and has a depth of 121.9 m cased to a depth of 44.7 m. The Underwood Well is designated non-GUDI. The distribution system serves approximately 32 residences and ten commercial/institutional connections.

The WHPA for the Underwood 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 as part of the Round 1 Technical Study for the Saugeen Grey Sauble Northern Bruce Peninsula Source Protection Region (CRA, 2007).

TABLE 4.7.G2.1 – Description of the Drinking Water System and Wells

Well Name	Underwood 1
Drinking Water System ID	220007052
Drinking Water System Classification	Small Municipal Residential System
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA
Northing/Easting	4906118.2 / 461364.1
Year Constructed	1972
Well Depth	121.9 m
Uncased Interval	44.5 - 121.9 m
Aquifer	Detroit River group limestone bedrock
GUDI	No
Number of Users Served	75 persons
Design Capacity (CoA)	196 m^3/day
Permitted Rate (PTTW)	90.8 m^3/day
Average Annual Usage*	21 m^3/day
Modelled Pumping Rate	30 m^3/day
Treatment	Sodium hypochlorite disinfection

* *CRA Phase I, Round 1 Report 2007, Table 3.1*

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 4.7.G2.2a and shown on Map 4.7.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. The results are listed in Table 4.7.G2.2b and shown on Maps 4.7.G2.5 and 4.7.G2.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

Approved

TABLE 4.7.G2.2a – Impervious Surfaces

General	Code for WHPA	UNDERWOOD
	Total Area [hectare]	16.43
Impervious Surfaces Area [ha]	<1%	0.0
	1% – <8%	16.43
	8% – < 30%	0.0
	Larger or equal than 30%	-

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

TABLE 4.7.G2.2b – Managed Land and Livestock Density

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

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

Wellhead Protection Area

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

The Underwood WHPA is relatively small, encompassing a total land area of approximately 0.16 km^2 (Map 4.7.G2.1). The WHPA extends southeast 875 m away from the well and is long and narrow, which is typical of other WHPAs located along the Lake Huron shoreline. WHPAs A and B encircle most of the village of Underwood. The WHPA is characterized by residential, municipal and commercial land uses in zones A and B. WHPAs C and D extend southeast and contain residential and agricultural land uses.

Map 4.7.G2.2 shows the borders of all zones of WHPA overlaying 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 4.1.2.5), unless the vulnerability is already rated high.

Aquifer vulnerability was adjusted one level to account for transport pathways in the urban area within the Underwood 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 4.7.G2.3.

Vulnerability

Approved

After overlaying the intrinsic susceptibility index (Map 4.7.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.7.G2.3.

The WHPAs within the Municipality of Kincardine have a relatively low vulnerability to surface (or near-surface) contamination as indicated by the low susceptibility scores (Map 4.7.M1). On the regional scale, the areas surrounding the WHPA have a low intrinsic susceptibility index due to the presence of 30-60 metres of low permeability overburden material overlying the bedrock, which provides natural protection to the bedrock aquifer. As such, a high percent of the Underwood system is characterized by low intrinsic vulnerability. The geologic log of the Underwood Well indicates the presence of 27 m of clay and 17 m of hardpan.

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 Underwood Well wellhead protection area A-D. These threats include 11 activities related to the potential for pathogen contamination, and 15 activities related to contamination with hazardous chemicals. The total number of properties with threats is 12, of which nine are residential and three are other land uses (see detailed Table 4.7.G2.3 and summary Table 4.7.G2.4).

The Underwood WHPA-A encompasses downtown Underwood and Highway 21. The land use within the WHPA-A includes residential, commercial, institutional, and industrial.

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 4.7.G2.3 – Underwood: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: UNDERWOOD** *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				1		8		**11**
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								2		**2**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal		2				1		8		**11**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

Approved

TABLE 4.7.G2.4 – Underwood 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			
UNDERWOOD	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	15	0	11	26	0	12		12

Quality of Raw Water at the Well
The raw water in Underwood has high fluoride content. This chemical occurs naturally in the aquifer and is dealt with during treatment.

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.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 4.7.G2.5 – Underwood: Issues and Conditions

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

4.2.7.2.3 Tiverton Drinking Water System

The Tiverton Drinking Water System serves about 800 people and has approximately 320 service connections serving residential and associated commercial and industrial establishments. The Municipality of Kincardine drilled a new bedrock well, Briar Hill Well No. 2, in August of 2006 in the village of Tiverton to address water demand and supply issues associated with the Tiverton DWS. The new well is located in the north part of Tiverton, 650m north of the main intersection and Highway 21, adjacent (~30 m) to the original Briar Hill well (Briar Hill Well No. 1). It operates in conjunction with Briar Hill Well No. 1, alternating duty.

The Tiverton Well supply is comprised of three bedrock wells, which are all non-GUDI. The Dent Well (Dent Well No. 2) was constructed in 2003 to a depth of 87.2 m and cased to a depth of 39.6 m. Briar Hill Well No. 1 was constructed in 1971 to a depth of 93.0 m and cased to a depth of 47.6 m, and Briar Hill Well No. 2 was constructed in 2006 to a depth of 93.0 m and cased to a depth of 52.1 m.

TABLE 4.7.G3.1 – Description of the Drinking Water System and Wells

Well Name	**Tiverton Dent**	**Tiverton Briar Hill 1**	**Tiverton Briar Hill 2**
Drinking Water System ID	220002609		

Approved

Drinking Water System Classification	Large Municipal Residential System		
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA		
Northing/Easting	4901755 / 456361.2	4902419.4 / 456792.3	4902419.4 / 456792.3
Year Constructed	2003	1971	2006
Well Depth	87.2 m	93 m	93 m
Uncased Interval	39.6 - 87.2 m	47.6 - 93 m	52.1 - 93 m
Aquifer	Detroit River group limestone bedrock	Detroit River group limestone bedrock	Detroit River group limestone bedrock
GUDI	No	No	No
Number of Users Served	760 persons, conjunctive		
Design Capacity (CoA)	397.44 m^3/day	527.04 m^3/day	720 m^3/day
Permitted Rate (PTTW)	250.5 m^3/day	524.16 m^3/day	720 m^3/day
Average Annual Usage*	Combined 365 m^3/day		Not known (new)
Modelled Pumping Rate	128 m^3/day	271 m^3/day	
Treatment	Sodium hypochlorite disinfection, iron and manganese sequestering system		

* *CRA Phase I, Round 1 Report 2007, Table 3.1*

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 4.7.G3.2a and shown on Map 4.7.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. The results are listed in Table 4.7.G3.2b and shown on Maps 4.7.G3.5 and 4.7.G3.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.7.G3.2a – Impervious Surfaces

General	Code for WHPA	TIVERTON_BRIARHILL	TIVERTON_DENT
	Total Area [hectare]	31.26	25.44
Impervious Surfaces Area [ha]	<1%	0.0	0.0
	1% – <8%	31.26	16.46
	8% – < 30%	0.0	8.97
	Larger or equal than 30%	-	-

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

TABLE 4.7.G3.2b – Managed Land and Livestock Density

WHPA_NAME	TIVERTON			
Well Name	DENT	DENT	DENT	DENT
Zone	A	B	C	D

Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	N/A
% Managed Lands (<40%, 40-80%, >80%)	<40%	<40%	<40%	N/A

WHPA_NAME	**TIVERTON**			
Well Name	BRIAR HILL 1&2	BRIAR HILL 1&2	BRIAR HILL 1&2	BRIAR HILL 1&2
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%	<40%	N/A	N/A

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

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

The Tiverton Briar Hill WHPA encompasses a total land area of approximately 0.31 km^2 and extends 1.8 km southeast of the well. To the south, the Tiverton Dent WHPA encompasses a slightly smaller land area of 0.25 km^2; however it extends southeast 2.3 km from the well (Map 4.7.G3.1).

The Tiverton Dent WHPA is primarily located within the residential and commercial areas of the village of Tiverton. WHPAs C and D also extend through the downtown area of Tiverton and encompass Highway 21. WHPA-D is characterized by agricultural land use activities. The Tiverton Briar Hill WHPA is located in a less densely populated area of the town and is characterized by residential, municipal and agricultural land uses. WHPAs C and D extend east and consist of agricultural and woodland properties. An extensive reach of a permanently flowing tributary of the Little Sauble River intersects WHPA-D. The unique shape of zone D for the Tiverton Dent and Briar Hill WHPAs is controlled by the presence of river boundary conditions, which alters the regional flow lines computed by the model and shape of the WHPA boundary.

Map 4.7.G3.2 shows the borders of all zones of WHPA overlaying 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 4.1.2.5), unless the vulnerability is already rated high.

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

Approved

There are a number of shallow, dug wells in the urban areas of Tiverton; however, a significant aquitard consisting of up to 60 m of clay associated with the St. Joseph's Till overlies the bedrock aquifer in this area. Accordingly, vulnerability was not adjusted in this area as these wells are located within shallow sand deposits, which are known to be hydraulically separate from the underlying bedrock aquifer that is being exploited by the municipal well.

Vulnerability
After overlaying the intrinsic susceptibility index (Map 4.7.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.7.G3.3.

The aquifer surrounding the Tiverton Dent and Tiverton Briar Hill supply wells are overlain by approximately 50 metres of coarser-textured, higher-permeability, overburden materials providing less protection to the underlying aquifer (as reflected by the medium ISI index, Map 4.7.M1), which results in a higher vulnerability score. However, MOECC water well records indicated unconsolidated glacial deposits overlying the bedrock have a 50 m thickness and are predominately made up of clay and stones. A 2004 Well Evaluation for the Dent Well and a 2006 Well Evaluation for the Briar Hill Well by Ian D. Wilson Associates also confirms "the bedrock aquifer is consistent with a low risk of surface water influence" (CRA, 2007).

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 in the Tiverton (Briar Hill) wellhead protection area A-D. The total number of properties with threats is zero (see detailed Table 4.7.G3.3 and summary Table 4.7.G3.4).

There are no significant drinking water threats in the Tiverton (Dent) wellhead protection area A-D.

All of these threats are within zone A of the WHPA. The land use within WHPA-A consists of residential and agricultural. The threats that pertain to the residential properties include septic systems and also sewer lines, fuel storage and waste disposal. The significant threats that pertain to the agricultural properties include application of agricultural source material to land, application of non-agricultural source material to land and application of pesticide to land.

Moderate and Low Threats

Approved

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
The raw water in all Tiverton wells has high fluoride and iron levels. Both chemicals occur naturally in the aquifer and are dealt with during treatment.

TABLE 4.7.G3.3 – Tiverton Briar Hill: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: TIVERTON_BRIARHILL** *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										
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
	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										
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										

21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

TABLE 4.7.G3.3 – Tiverton Dent: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: TIVERTON_DENT** *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										
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										
22	Liquid Hydrocarbon Pipelines										
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										
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing										

Approved

TABLE 4.7.G3.4 – Tiverton WHPA: Summary of Significant Drinking Water Threats

WHPA A-D	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
TIVERTON BRIAR HILL	0	0	0	0	0	0	0	0
TIVERTON DENT	0	0	0	0	0	0	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 4.7.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 4.7.G3.5 – Tiverton: Issues and Conditions

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

4.2.7.2.4 Armow Drinking Water System

The Armow Drinking Water System is non-GUDI and consists of a single well located on Part Lot 16, Concession 7, Bruce Township (459008 E, 4893364 N). The well was drilled in September 2005 to a depth of 62.5 m. The well is equipped with a submersible pump rated at 0.95 L/sec.

The treatment equipment is located inside the Public Works shed, and the well is located outside to the west of the Public Works shed. The land use in the vicinity of the well is residential and commercial. There are no municipal sanitary sewers. There are known wells in the area (MOECC, 2009d).

The overburden layer in the vicinity of Armow is typically about 60 m thick consisting mainly of fine-grained formations. The depth and character of the overburden serves as a secure confining unit. Travel times from the surface to the bedrock can be anywhere from many tens to many hundreds of years.

Treatment consists of ultraviolet light for primary disinfection and sodium hypochlorite for secondary disinfection. Treated water is discharged to the distribution system via a 50 mm diameter PVC pipe. The distribution system was installed in 2008 to service nine connections and consists of approximately 830 m of two inch PVC water main and five valves. The Armow distribution system was installed new in the fall of 2008.

Approved

AWHPA for the Armow well was first developed by WHI (2009) using the existing groundwater model for the area.

TABLE 4.7.G4.1 – Description of the Drinking Water System and Wells

Well Name	ARMOW
Drinking Water System ID	220008792
Drinking Water System Classification	Small Municipal Residential
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA
Northing/Easting	4893370 / 459003.7
Year Constructed	2005
Well Depth	62.5 m
Uncased Interval	Not known
Aquifer	Bedrock
GUDI	No
Number of Users Served	10 persons
Design capacity (CoA)	82 m^3/day
Permitted Rate (PTTW)	82 m^3/day
Average Annual Usage	15 m^3/day
Modelled Pumping Rate*	15 m^3/day
Treatment	UV and Sodium hypochlorite disinfection

** Schlumberger 2009, 2009 Grey-Bruce Model Update. Internal Memo*

TABLE 4.7.G4.2a – Impervious Surfaces

General	Code for WHPA	ARMOW
	Total Area [hectare]	5.22
Impervious Surfaces Area [ha]	<1%	0.0
	1% – <8%	5.22
	8% – < 30%	0.0
	Larger or equal than 30%	-

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

TABLE 4.7.G4.2b – Managed Land and Livestock Density

WHPA_NAME	**ARMOW**			
Well Name	ARMOW	ARMOW	ARMOW	ARMOW
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%	N/A	N/A

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

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 4.7.G4.2a and shown on Map 4.7.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. The results are listed in Table 4.7.G4.2b and shown on Maps 4.7.G4.5 and 4.7.G4.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

The WHPA of Armow extends east from the well. With a length of only 500 metres, it is the shortest WHPA in the source protection area resulting from the small pumping rate. The WHPA-A has a radius of 100 metre in every direction from the well, and WHPA-B is narrow and extends 330 metres from the well. However, land use within the WHPA-A cover a wide range of residential, agricultural, industrial, municipal and commercial properties.

Map 4.7.G4.2 shows the borders of all zones of WHPA overlaying 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 4.1.2.5), unless the vulnerability is already rated high.

Aquifer Vulnerability was adjusted one level to account for transport pathways in the urban area within the Armow 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 4.7.G4.3.

Vulnerability
After overlaying the intrinsic susceptibility index (Map 4.7.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.7.G4.3.

The susceptibility of the groundwater aquifer below the WHPA to surface or near surface, contamination is low in the whole WHPA (Map 4.7.M1). The vulnerability of WHPA zone A is ten. After transport pathway adjustment, WHPA zone B scores six and eight and six, the vulnerability score in WHPAs C and D is four and two respectively.

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.

Approved

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 22 significant drinking water threats in the Armow Well wellhead protection area A-D. These threats include 8 activities related to the potential for pathogen contamination, and 14 activities related to contamination with hazardous chemicals. The total number of properties with threats is 10 (see detailed Table 4.7.G4.3 and summary Table 4.7.G4.4).

<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.G4.3 – Armow: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

	Prescribed Threat **WHPA: ARMOW** *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		6		**7**
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	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**
13	Salt - Storage						1				**1**
14	Snow - Storage										
15	Fuel - Handling and storage								2		**2**
17	Organic solvent - Handling and storage										

18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
22	Liquid Hydrocarbon Pipelines										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
1	disposal of hauled sewage to land~~Untreated Septage - Application to land~~										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal						1		6		**7**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										

Approved

TABLE 4.7.G4.4 – Armow WHPA: Summary of Significant Drinking Water Threats

ARMOW	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	14		8	22	1	6	3	10

Quality of Raw Water at the Well
The quality of the raw water is acceptable in regards to the main quality parameters. Hardness, fluoride, sodium, and arsenic are all elevated but naturally occurring. The raw water pH is slightly alkaline at approximately 8.2.

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 4.7.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 4.7.G4.5 – Armow: Issues and Conditions

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

4.2.7.3 Surface Water Municipal Systems

4.2.7.3.1 Kincardine Drinking Water System (Intake and Water Treatment Plant)

The Kincardine WTP is located at 155 Durham Street, Kincardine. The Kincardine Drinking Water System is categorized as a large municipal residential system under Ontario Regulation 170/03 and it is classified as a Great Lakes (Type A) intake within the *Clean Water Act, 2006*. The design population for the Kincardine DWS is 9,250 (Stantec 2008, Phase 1 Report).

The Kincardine water treatment plant and supply facilities have undergone numerous changes since they were first constructed. The current plant configuration was completed in 2007. The water treatment plant provides filtration, a chlorination system and an underground reservoir. The chlorination system consists of three gas chlorinators; two of the chlorinators are dedicated to pre- and post-chlorination and the third acts as a standby. Pre-chlorination occurs at the raw water intake, during periods when zebra mussel control measures are in place, and upstream of the flocculation tanks. Low lift pumping facilities consist of a separate low lift pumping station building, a concrete pump well having a total volume of 101 m^3 at low lake level and three vertical turbine low lift pumps (Stantec 2008, Phase 1 Report).

The distribution system serves the town of Kincardine, residents north of the town via a pipeline and the Huronville subdivision, with a total of approximately 3300 connections. Recently, the

Approved

Kincardine water distribution system was expanded to provide water to four former groundwater supply systems as follows: Kinhuron, Craig-Eskrick, Lake Huron Highlands, and Port Head Estates.

The Kincardine WTP obtains it water from Lake Huron. One surface water intake structure is located in Lake Huron at a depth of 6.8 m. The intake pipe has a diameter of 50.8 cm and a length of 765 m. The approved intake capacity is 18,750 m^3 per day. In the annual WTP report for 2006 (MOECC), operators reported June to be the highest demand month with a maximum raw water daily flow of 7,227 m^3/day and an average daily raw water flow of 4,889 m^3/day.

The majority of marine activity in Kincardine and nearby is related to the marina, which is operated by the Municipality. The marina has capacity for 154 recreational vessels and 20 transient vessels. Two piers extend from the shore out into the lake and line the entrance channel to the harbour. The north pier extends 196 m out into the lake and the south pier extends 153 m. Two berths are maintained at the Kincardine marina for Southampton tugboats in the event that a safe harbour is required. Occasionally, commercial fishing boats operate from the Kincardine Harbour. Bruce Power, a nuclear power plant, is located more than 10 km to the north at Douglas Point. It has a major shoreline infrastructure relating to the various water-cooling intakes and discharges and shoreline development (Stantec 2008, Phase 1 Report)

Digital data on water distribution lines as well as sewer lines was provided to DWSP by the operator.

TABLE 4.7.S1.1 – Description of the Drinking Water System

Intake Name	Kincardine WTP
Drinking Water System ID	220002716
Drinking Water System Classification	Large Municipal Residential System
Intake Type	A (Great Lakes)
SPA of Intake and Vulnerable Area (IPZ)	Saugeen Valley SPA
Northing/Easting of Intake	448199.1 / 4892402.77
Intake Pipe Length	765 m
Lake Depth at Intake*	6.8 m
Top of Crib*	4.8m
Number of Users Served	6,000 persons
Intake Capacity	18,750
Average Annual Usage	4,889 m^3/day
Maximum Usage	7,227 m^3/day

** Elevations measured from plan & profile drawings 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.*

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.S1.5, 6 and 7.

The Kincardine 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).

Intake Protection Zone
The Kincardine raw water intake is located in eastern Lake Huron and 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 4.1.5, 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 1.4 km long. For IPZ-1, the onshore area is 0.2 km^2 and the offshore area of 2.8 km^2.

The IPZ-2 offshore delineation was completed using revised hydrodynamic modelling. The IPZ-2 stretches out 4.5 km north of the intake, 6.2 km south of the intake and 1.3 km 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 larger than the area of the Regulation Limit. For IPZ-2, the resulting onshore area is 6.7 km^2 and the offshore area is 11.6 km^2.

TABLE 4.7.S1.1b – Managed Land, Livestock Density and Impervious Surfaces

General	IPZ ID	KINCARDINE
	Area Total [hectare]	3,393.24
	Area Offshore [hectare]	2,013.51
	Area Onshore [hectare]	1,470.62
IPZ 1 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	15.80
	Livestock Density [NU/Acre]	0.00
	Managed Land Area [hectare]	2.59
	% Managed Lands	16.44
	Category	**ML% <40%, NU/acre <0.5**
IPZ 2 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	1,473.89
	Livestock Density [NU/Acre]	0.11
	Managed Land Area [hectare]	763.74
	% Managed Lands	52.50
	Category	**ML% 40% - 80%, NU/acre <0.5**
Impervious Surface: Area per category [hectare]	<1%	124.55
	1% – <6%	618.50
	6% – < 8%	728.51

	Larger or equal than 8%	0.0

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

The full IPZ is shown on Map 4.7.S1.2 and on 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 Kincardine and around the IPZ-2. Volumes ranged from 1,400 L to 22,500 L and were split into three EBA categories (see map 4.7.S1.1.9);

- 3,000 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).

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, storm sewer networks, and tile drainage. Also included in the onshore IPZ-2 are the appropriate bank setbacks for watercourses and/or municipal drains. The IPZ-2 extends across Highway 21 within the town of Kincardine and along the lakeshore. Storm sewers extend over most parts of the town of Kincardine and Huron Ridge. In the IPZ-2, 305 ha of tile drainage area was located at the headwaters of tributaries of some unnamed creeks, Andrews Creek and the midsection of Tiverton Creek, and a small number of tributaries branching from the Penetangore River. The resulting area is 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 extend.

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 4.7.S1.2a).

<u>Percentage of Land</u>

Approved

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 delineation of the Kincardine IPZ-2 has approximately 43% land area, determined by the WPS dataset. 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 mixed vegetative and developed areas. Based on the available SOLRIS GIS dataset, the land cover type is 56% agricultural fields, parks, vegetation and natural landscapes (e.g. cliffs, prairies, etc). Therefore, a land cover component rating of 8 was prescribed for the Kincardine DWS.

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). Although the Soil Survey of Bruce County (Hoffman and Richards, 1954) and the mapping updates (Agriculture and Agri-Food Canada, 1983) do not have specific data for the developed area of Kincardine, extrapolations were made from the soil map based upon soils illustrated in the surrounding areas of Kincardine. Soils within the upland IPZ-2 area consist of areas of sandy loams with good drainage, as well as areas of clay, silt, and silty clay loams 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 Kincardine DWS is 1,296 ha of land with 377 ha of impervious cover. The impervious land cover was determined using SOLRIS (2009) information. Approximately 71% of the upland area is pervious, and 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 0.5% to 3.0%, with an average slope of approximately 2%. This was determined using Ontario Base Mapping (OBM) contours. As a conservative approach, the greatest slope range (3.0%) was used to assign the component rating due to the steep Lake Huron bluff and Penetangore River ravines on site. These area features moderately increase runoff directly to the source water. 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.

Approved

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 area is 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 equally divided into; < 33% area (7), 33% to 66% area (8) and > 66% area (9). Storm catchment areas were unavailable for the Kincardine WTP study area but were assumed based on the provided storm sewer networks and the area of the developed land. The area of the developed land was based on 2006 aerial photography and was determined to be 43% (560 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 Kincardine WTP IPZ-2 using the WFV Dataset, as well as storm sewer networks and outfall locations provided by the municipality. The rating range has been set for 0-3/1,000 ha in the zone (7), 4 to 7/1,000 ha in the zone (8) and > 7/1,000 ha in the zone (9). Six watercourses and 42 outfalls (34 listed by Public Works and 8 inferred by Stantec) discharge into Lake Huron within the IPZ-2 giving a calculated 37 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 the area vulnerability factor assessment is for the IPZ-2 only.

Tile Drained Area Tile drained area is based on the percent land artificially drained as indicated by the Tile Drainage Areas GIS dataset. 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 Kincardine upland IPZ-2 is 305 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 8.

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

Source Vulnerability Factor

Approved

The source vulnerability factor for the Kincardine Drinking Water System combines intake characteristics, such as depth and length of pipe, and past water quality concerns. The intake crib depth is 4.8 m and its vulnerability sub score is 0.6. The Kincardine intake is located approximately 765 m (B.M. Ross, 1976) from the shoreline; however, it is located within the wave-breaking zone and is susceptible to water column mixing. With consideration given to the local hydrodynamic conditions within the wave-breaking zone the sub factor is 0.6. Process data for turbidity, pH and temperature were analyzed to characterize the raw water. The data was compared to the Ontario Drinking Water Quality Standards (ODWQS) (MOECC, 2002) and no parameter was found to consistently measure above the standard. Annual reports for 2004 and 2005 for the Kincardine WTP were reviewed and the ODWQS for in-organics or organics were not exceeded (Stantec 2008, Phase 1 Report). Information supporting human health concerns for the Kincardine WTP source water was not identified.

The source vulnerability factor is determined by averaging the above listed sub factors. The source factor rating for the Kincardine IPZ is 0.6 (Table 4.7.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 4.7.S1.2c).

TABLE 4.7.S1.2a – Area Vulnerability Scores for the Kincardine Intake: IPZ-2

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	**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)*	
Tile Drained Area *(less than 33 %)*	7

TABLE 4.7.S1.2b – Source Vulnerability Factor for the Kincardine Intake

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

Approved

** located within the wave-breaking zone and susceptible to water column mixing*

TABLE 4.7.S1.2c – Vulnerability Scores for the Kincardine 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	0.6	6	4.8

Uncertainty Rating
The uncertainty rating for the area delineation of IPZ-1 is low, as it is a fixed radius of 1 km as 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 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 4.7.S1.4 indicates that no activities for this surface water intake are rated at a "significant" level of risk 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). Twelve 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 – Kincardine IPZ: Significant Drinking Water Threats for Events-based Area

Prescribed Threat **IPZ: KINCARDINE** *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		12								**12**

Approved

TABLE 4.7.S1.4 – Kincardine IPZ: Summary of Significant Drinking Water Threats

IPZ Name	Number of "are or would be significant" threats			
	Pathogen	Chemical	DNAPL	Total
Kincardine	0	12	0	12

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 Intake

Water quality at the Kincardine intake is considered excellent, with no reported exceedances of any ODWQS.

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 – Kincardine: Issues and Conditions

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

Approved

4.2.8 Town of Minto

The Town of Minto is located along the north-western boundary of Wellington County. The northern portion of the Municipality lies within the Saugeen Valley Source Protection Area while the remainder is part of the Maitland Valley Source Protection Area. In 2016, the population was 8,671, which was an increase of 1.9% from 2006. The main towns are Palmerston (population 2,518) and Harriston (population 2,034). Smaller villages include Clifford, Greenbush and Drew.

There are two municipal drinking water systems in the Town of Minto that are within the Saugeen Valley Source Protection Area: the Minto Pines Subdivision Drinking Water System and the Clifford Well Supply. No new drinking water systems are planned.

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. The parts of Minto that are within this Source Protection Area are characterized by hummocky topography and are SGRA. Surrounding these areas are the ice-contact stratified drifts and with their high content of sand and gravel they are also SGRA. Only a few areas with thin overburden, mostly along Meux Creek, are HVAs. All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.8M3).

The portion of this municipality that lies within this SPR has a total area of SGRAs of 59.7 km^2 and a total area of HVAs of 9.1 km^2. The percentage of managed lands located within the SGRAs and HVAs is more than 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 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 Minto in this Source Protection Region

SGRA	Total Area of SGRA	59.7 km^2
	Managed Land and Livestock Density	ML% >80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	9.1 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

Note: Total areas relate to the full source protection region

Approved

4.2.8.2 Groundwater Municipal Systems

4.2.8.2.2 Clifford Well Supply

The Clifford Well Supply is owned and operated by the Town of Minto. Clifford represents one of the smaller urban settlements in Minto, with an estimated population of 790. The community is largely a residential and commercial centre that services the surrounding agricultural community. Some highway commercial development is evident along Highway 9. Clifford is located along Highway 9, near the north-western border of the Town of Minto and the County of Wellington.

Clifford is currently serviced by a municipal waterworks that consists of three drilled wells, two well houses, an elevated 1,275 m^3 storage tank, and a distribution network of water-mains. The water-mains range in diameter from 100 mm to 150 mm. The municipal water system is also used for fire protection and has approximately 46 fire hydrants throughout the distribution system. In the event of a prolonged power outage, a portable generator, which can be moved to well house No. 1 to supply back-up power, is available at the public works shed (MOECC, 2009e).

All used wells are non-GUDI. Well No. 2 was under the direct influence of surface water (GUDI), and was plugged and abandoned on Dec. 13, 2005 by Well Initiatives Ltd. as part of the upgrades to the system as required by the Certificate of Approval.

The WHPA for the Clifford wells was first developed as part of the Town of Minto Groundwater Study (R.J. Burnside, 2001a). Subsequently, these results were integrated into a county wide study, which included re-delineating the WHPA based on new pumping rates as part of the Wellington County Groundwater Protection Study (Golder, 2006). 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 Ausable Bayfield Maitland Source Protection Region (Waterloo Numeric Modelling Corp., 2009).

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. 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).

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

The 25-year capture zones (WHPA-D) for the Clifford wells merge together and extend approximately 3 km to the south in the direction (upgradient) of regional groundwater flow. A portion of the 25-year capture zone extends to the west of the County of Wellington limits, across the Howick-Minto Townline Road. The land use overlying the Clifford WHPA is primarily rural agricultural, although the 2-year capture zones for the wells are overlain by the urban footprint of Clifford (Golder 2006).

Well Nos. 1, 3 and 4 are located within build-up areas with residential land uses and eventually commercial and other land uses dominating WHPAs A and B. WHPAs C and D also include agricultural land use.

Map 4.8.G1.2 shows the borders of all zones of WHPA overlaying aerial photography.

TABLE 4.8.G1.1 – Description of the Drinking Water System and Wells

Well Name	Clifford Well 1	Clifford Well 3	Clifford Well 4
Drinking Water System ID	220000031		
Drinking Water System Classification	Large Municipal Residential System		
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA		
Northing/Easting	4868554 / 501696	4868046.7 / 501737.9	4868044.6 / 501741.9
Year Constructed	not known	not known	not known
Well Depth	52.4 m	35.7 m	43.3 m
Uncased Interval	not known	32.3 - 35.7 m	41 - 43.3 m
Aquifer	Bedrock	Bedrock	Bedrock
GUDI	No	No	No
Number of Users Served	711 persons		
Design Capacity (CoA)	1,308.96 m^3/day	1,313.28 m^3/day	1,313.28 m^3/day
Permitted Rate (PTTW)	131 m^3/day	655 m^3/day	1,309.248 m^3/day
Average Annual Usage	300 m^3/day	416 m^3/day	(backup)
Modelled Pumping Rate	300 m^3/day	416 m^3/day	0 m^3/day
Treatment	Filtering (sodium silicate for iron sequestering), 12 percent sodium hypochlorite disinfection		

TABLE 4.8.G1.2a – Impervious Surfaces

General	Code for WHPA	CLIFFORD
	Total Area [hectare]	456.06
Impervious Surfaces Area [ha]	<1%	41.16
	1% – <8%	252.02
	8% – < 30%	162.87
	Larger or equal than 30%	0.0

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

Approved

TABLE 4.8.G1.2b – Managed Land and Livestock Density

WHPA_NAME	**CLIFFORD**				
Well Name	CLIFFORD 2	CLIFFORD 3&4	CLIFFORD 2,3&4	CLIFFORD 2,3&4	CLIFFORD 2,3&4
Zone	A	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	0.5-1.0	<0.5	>1.0
% Managed Lands (<40%, 40-80%, >80%)	<40%	<40%	40-80%	>80%	40-80%

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

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 4.1.2.5), unless the vulnerability is already rated high.

Aquifer Vulnerability was adjusted one level to account for transport pathways within the Clifford 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.G1.3.

Vulnerability

After overlaying the intrinsic susceptibility index (Map 4.8.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.8.G1.3.

The susceptibility of the groundwater aquifer below the WHPA to surface, or near surface, contamination is moderate or low (Map 4.8.M1). This is due to the presence of a significant layer of fine-grained overburden throughout the study area. A higher percentage of the capture zone has adjusted vulnerability scores ranging between eight and ten in WHPAs A-B, six dominating WHPA-C and four dominating WHPA-D.

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.

Approved

WHPA A-D
There are 23 significant drinking water threats in the Clifford (Well Nos. 1, 3 and 4) wellhead protection area A-D. These threats include 8 activities related to the potential for pathogen contamination, 14 activities related to contamination with hazardous chemicals and 1 activity related to DNAPLs. The total number of properties with threats is 14 (see detailed Table 4.8.G1.3 and summary Table 4.8.G1.4). Some of these properties are in the Maitland Valley SPA.

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
All three wells show high levels of hardness. Well Nos. 1 and 4 exceed or nearly exceed Ontario Drinking Water Standards for iron and manganese, which naturally occur in the aquifer.
To enhance the water quality, due to the accumulation of iron and mineral build up in the distribution pipes, a sequestering agent is used in Clifford. The iron sequestering agent, sodium silicate, provides a protective coating around the raw water iron molecule prior to the introduction of the corrosive disinfection agent, sodium hypochlorite. This protection helps prevent iron build up in the distribution system.

Approved

TABLE 4.8.G1.3 – Clifford: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: CLIFFORD** *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						6		**7**
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		4				2				**6**
13	Road Salt – Handling and Storage		4				2				**6**
14	Snow - Storage										
15	Fuel - Handling and storage								1		**1**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage		1								**1**
	PATHOGENS										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal		1						6		**7**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
22	Liquid Hydrocarbon Pipelines										

Approved

TABLE 4.8.G1.4 – Clifford WHPA: Summary of Significant Drinking Water Threats

CLIFFORD	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	14	1	9	23	0	7	2	9

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.G1.5 – Clifford: Issues and Conditions

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

4.2.8.2.1 Minto Pines Subdivision Drinking Water System

Ownership of the Minto Pines Drinking Water System was transferred to the Town of Minto in December 2003. Minto Pines is a 35 lot residential subdivision located in parts of Lots 8 and 9 on Concession 14 just south of Hwy. 89 approximately 10 km west of Mount Forest. Approximately 25 of the 35 lots are currently developed. The Minto Pines Subdivision DWS is equipped to service all 35 lots when the remaining lots are developed.

The Minto Pines Well #1 was drilled in 1982to a depth of 41.5 m. It was screened in the interval 23.9 - 41.5 m. Well #1 was inspected in 2017 with a reported condition of "fair to poor" and recommended for replacement. The replacement Well 1A was constructed in 2023 to a depth of 38.1 m, with a stainless steel casing installed to a depth of 26.5 m. Well 1A was completed in the same aquifer as Well 1 at a distance of 6 metres north. Well 1A was commissioned and started providing water to the system on May 10, 2024. The pump house is located at 13 Minto Pines Road in the Minto Pines Subdivision. The well is located 6 metres north of pump house and is the primary production well that services the subdivision.

The Minto Pines well house is located on the northwest corner of Lot 8, Concession 14. The bedrock well is 200 mm in diameter and equipped with a submersible pump.
Treatment consists of disinfection with l2% sodium hypochlorite (chlorine) solution. The point of injection for chlorine is located after the flow meter but just before the pressure tanks. The recently treated water is discharged into an underground chlorine contact pipe, which is located immediately north of the existing well house. The chlorine contact pipe is looped, 49 m in length and 300 mm in diameter.

Approved

Treated water is directed to a 100 mm diameter iron header that connects to the distribution system. The flow is monitored by a Krohne magnetic flow meter. Two continuous online analyzers are included in the treatment process: the chlorine analyzer measures the levels of free chlorine residual and the turbidity analyzer measures turbidity. The chlorine analyzer is equipped with an alarm.

The distribution system consists of 100 mm diameter PVC piping that is not installed in a looped format; therefore, there are dead ends in the system. There are no reservoirs or standpipes in this distribution system, nor is it equipped for fire-fighting.

A WHPA for the Minto Pines well was first developed by Waterloo Numeric Modelling Corp (2010) using the existing groundwater model for the area. In 2023 R.J. Burnside & Associates Limited (Burnside) was retained by the Town to obtain a new Permit to Take Water and review possible source water protection implications. Based on their review, Burnside recommended that the existing WHPA B, C and D areas for Well 1 be retained, with an amended WHPA A re-drawn to account for the shift of Well 1A 6 metres to the north.

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

Well Name	Minto Pines Well 1A
Drinking Water System ID	260007088
Drinking Water System Classification	Small Municipal Residential
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA
Northing/Easting	4868514 / 515079
Year Constructed	2023
Well Depth	38.1 m
Uncased Interval	26.5 m to 38.1 m
Aquifer	Bedrock
GUDI	No
Number of Users Served	133 persons
Design Capacity (CoA)	328.32 m^3/day
Permitted Rate (PTTW)	326.80 m^3/day
Average Annual Usage	20 m^3/day
Modelled Pumping Rate	25 m^3/day
Treatment	12% Sodium Hypochlorite (disinfectant)

TABLE 4.8.G2.2a – Impervious Surfaces

Approved

General	Code for WHPA	MINTO_PINES
	Total Area [hectare]	3.12
Impervious Surfaces Area [ha]	<1%	0.0
	1% – <8%	2.96
	8% – < 30%	0.16
	Larger or equal than 30%	0.0

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	**MINTO PINES Well 1A**			
Well Name	MINTO PINES	MINTO PINES	MINTO PINES	MINTO PINES
Zone	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	<0.5	<0.5	N/A
% Managed Lands (<40%, 40-80%, >80%)	<40%	<40%	<40%	N/A

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

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

The WHPA of Minto Pines extends south-east from the well, with a length of 2,300 metres for the full WHPA. The WHPA-A has a radius of 100 metres in every direction from the well, and WHPA-B is narrow and extends 250 metres from the well. The border of Pike Lake has a distance of only 230 metres from the well and takes course in parallel to it, however without ever crossing the WHPA boundary. Land use within WHPAs A, B and C is residential and agricultural.

Map 4.8.G2.2 shows the borders of all zones of WHPA overlaying 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 4.1.2.5), unless the vulnerability is already rated high.

No Transport pathway adjustments were made in the Minto Pines WHPA as existing properties are either on municipal services, or have wells that are in compliance with existing standards.

Vulnerability
After overlaying the intrinsic susceptibility index (Map 4.8.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.8.G2.3.

The susceptibility of the groundwater aquifer below the WHPA to surface or near surface, contamination is moderate in the whole WHPA (Map 4.8.M1). This is due to the presence of a layer of fine-grained overburden throughout the study area. However, all areas in WHPAs A and B were increased for preferential transport pathways. The vulnerability score is consequently always ten in WHPAs A and B, eight and six in WHPA C and four dominating WHPA-D.

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 12 significant drinking water threats in the Minto Pines wellhead protection area A-D. These threats include 6 activities related to the potential for pathogen contamination and 6 activities related to chemical contaminants. The total number of properties with threats is 6 (see detailed Table 4.8.G2.3 and summary Table 4.8.G2.4). The eight agricultural threats located on one property are within the Municipality of West Grey.
TABLE 4.8.G2.3 – Minto Pines: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: MINTO_PINES** *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								5		**5**
3	Agricultural source material - Application to land										
4	Agricultural source material - Storage	1									**1**
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										

Approved

14	Snow - Storage										
15	Fuel - Handling and storage										
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
22	Liquid Hydrocarbon Pipelines										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage										
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								5		**5**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										

** All of the agricultural threats are located in the Municipality of West Grey.*

Approved

TABLE 4.8.G2.4 – Minto Pines WHPA: Summary of Significant Drinking Water Threats

MINTO PINES	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	6	0	6	12	1	5	0	6

<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 Well
There are no known exceedances of Ontario Drinking Water Quality Standards.

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 – Minto Pines: Issues and Conditions

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

4.2.8.3 Surface Water Municipal Systems

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

Approved

4.2.9 Town of Saugeen Shores

Located in Bruce County in the Saugeen Valley Source Protection Area, Saugeen Shores has a mix of urban and rural characteristics. The Town is located on the easterly shores of Lake Huron. In 2006, the population was 13,715, which was an increase of 14.6% from 2006. Seasonal residents add to the population during peak seasons. The main towns are Port Elgin (population 7,445) and Southampton (population 4,075). Smaller villages include Burgoyne, Dunblane, and North Bruce.

There is one municipal drinking water system in Southampton. No new drinking water systems are planned.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.9.M1.

4.2.9.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.9.M2 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. The massive sand layers that prevail in this area originate from the shallow water deposits and shorelines of glacial lakes. These sand layers are good water conductors; therefore, the areas are designated significant recharge areas (SGRAs). Only a few aquifers are identified as highly vulnerable (HVA) such as the Lake Huron shore with its dunes, some surfacing karst areas and an area around Stoney Creek to the south. All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.9.M3).

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.

In this municipality, the total area of SGRAs is 58 km^2 and the total area of HVAs is 25.1 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 4.2.9.1).

TABLE 4.2.9.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Town of Saugeen Shores

SGRA	Total Area of SGRA	58 km^2
	Managed Land and Livestock Density	ML% <40%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	25.1 km^2
	Managed Land and Livestock Density	ML% <40%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

Note: Total areas relate to the full source protection region

4.2.9.2 Groundwater Municipal Systems

Approved

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

4.2.9.3 Surface Water Municipal Systems

4.2.9.3.1 Southampton Water Treatment Plant (Southampton and Port Elgin)

Since 2008, the Town of Saugeen Shores has operated a single municipal water system that supplies water to the residents of Southampton and Port Elgin. Saugeen Shores now operates two intakes: a new main intake that was activated in 2008, and the old intake that is maintained as backup and for emergencies. Both intakes and the water treatment plant are located in Southampton. They take water from Lake Huron, which makes this a Great Lakes (Type A) system. It serves approximately 5,270 users and is classified as a large municipal residential system under Ontario Regulation 170/03.

The Southampton Water Treatment Plant (WTP) was upgraded in 2007 to meet average (6,889 m^3/day) and maximum (14,250 m^3/day) water demands (Saugeen Shores 2009a). The former Port Elgin WTP was decommissioned in October 2008. The Southampton WTP is located at 140 Island Street approximately 50 m inland. The pumping station is located east of the beach at the end of Bay Street in Southampton. The current WTP was constructed in 1990, with upgrades in 1992, 1993 and 2006 (Stantec 2009, Phase 1 Technical Addendum).

The Southampton WTP is a Class 3 WTP with a Class 2 distribution system. The pumping station consists of a raw water well and a heated structure that houses pumping, treatment and control facilities, including three vertical turbine pumps, two self-cleaning strainers with a 1.5 m^3 strainer backwash wastewater storage tank, two metering pumps each rated at 20 L/hr, a chlorine solution feed line for zebra mussel control, and a 230 kW diesel engine standby power generator and associated equipment.

The membrane filtration system is comprised of four individual submerged membrane trains, five permeate pumps, two back pulse pumps, two clean-in-place membrane wash pumps, two vacuum pumps, two oil free compressors, two air blowers, and feed systems for sodium hypochlorite, citric acid, sodium bisulphate, and sodium hydroxide.

The treatment system is comprised of a flocculator/clarifier, two equalization tanks, alum feed system, a neutralization tank, two decant chambers, and a sodium bisulphate feed system. There are two clear wells with a total storage volume of 3,720 m^3, two sets of three high lift pumps, a sodium hypochlorite disinfection system, and a 750 kW diesel standby power generator (Stantec 2008, Phase 1 Report).

During upgrades at the Southampton WTP, a new intake structure was constructed. This intake is located approximately 895 m in length with a depth of the intake crib of 7.5 m and a lake depth of 10.1 m (Stantec 2009, Phase 1 Technical Addendum).The backup intake is maintained and ready to supply treated water in an emergency. It also draws water for the Southampton WTP is a 600 mm diameter concrete pipe approximately 355 m in length, and has a depth of 3.4 m (MOECC, 2005a). The intake crib is wooden with a flat sealed top at the end of the pipe for protection. A 38 mm diameter high-density polyethylene chlorine solution feed line is located inside the intake pipe and provides chlorination for zebra mussel control (MOECC, 2006c). A total residual analyzer located within the low lift pumping station monitors chlorination levels for zebra mussel control (MOECC, 2005a). Regular Water testing continues (Saugeen Shores, 2009b).

Digital data on the location of the drinking water supply was provided by the operator.

TABLE 4.9.S1.1 – Description of the Drinking Water System

Intake Name	Main Intake	Backup Intake
Drinking Water System ID	210000078	
Drinking Water System Classification	Large Municipal Residential System	
Intake Type	A (Great Lakes)	
SPA of Intake and Vulnerable Area (IPZ)	Saugeen Valley SPA	
Northing/Easting of Intake	468099.18 / 4924741.58	468948.48 / 4925883.81
Intake Pipe Length	895 m	355 m
Lake Depth at Intake*	10.1 m	3.2 m
Top of Intake Crib*	7.5 m	1.5 m
Number of Users Served	5,270 persons	
Intake Capacity	not known	not known
Average Annual Usage**	2,009 m^3/day	Emergency only
Maximum Usage**	4,772 m^3/day	Emergency only

** Elevations measured from plan & profile drawings (AV Anderson, Jan 2006) (main) and (Philips & Roberts, Feb 1966) (backup intake) and converted to International Great Lakes Datum 1985 (IGLD 85) by comparing recorded water levels with historical information from US Army Corps of Engineers (2009). In: Stantec 2009, Phase 1 Technical Addendum*
*** Flow data from Saugeen Shores Water Treatment, Schedule 22. Summary Report for the Period of June 30, 2007 to December 31, 2007. Ontario Clean Water Agency, 2008*

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 4.9.S1.1b, c and in Maps 4.9.S1.4, 5 and 6.

The Southampton 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).

Intake Protection Zone
Both raw water intake of the Southampton WTP are located in eastern Lake Huron and are classified as a Great Lakes Type A intake.

Approved

Main 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 4.1.5, 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).

Where the main 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. Where this 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 hazard lands, whichever was greater (Stantec 2009, Phase 1 Technical Addendum). A small island located within the IPZ-2, Chantry Island, is fully included into the vulnerable area, because no point of this island is more than 120 m away from the shore.

TABLE 4.9.S1.1b – Managed Land, Livestock Density and Impervious Surfaces

General	IPZ ID	Main Intake
	Area Total [hectare]	1,788.83
	Area Offshore [hectare]	1,107.67
	Area Onshore [hectare]	681.16
IPZ 1 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	8.75
	Livestock Density [NU/Acre]	0.00
	Managed Land Area [hectare]	1.22
	% Managed Lands	13.39
	Category	**ML% <40%, NU/acre <0.5**
IPZ 2 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	0
	Livestock Density [NU/Acre]	0
	Managed Land Area [hectare]	0
	% Managed Lands	0
	Category	**ML% <40%, NU/acre <0.5**
Impervious Surface: Area per category [hectare]	<1%	32.66
	1% – <6%	178.59
	6% – < 8%	416.75
	Larger or equal than 8%	52.48

Note: All areas relate to the full IPZ including other municipalities. Impervious Surface numbers apply to both intakes.

Backup Intake

Hydrodynamic modelling was completed for the Southampton backup intake to provide an independent in-water IPZ-2 (Baird for Stantec 2009, Phase 1 Technical Addendum). The ToT contours were used to complete the tributary analysis for the Southampton backup intake (Stantec 2009, Phase 1 Technical Addendum). The distance up-tributary calculated for each watercourse was determined to be greater than the length of the watercourse; therefore, all delineations were terminated at the headwaters of each watercourse with a circular cap radius of 120 m. A 120 m setback off each bank was applied however, where the DEM or subwatershed boundaries indicated overland flow traveling away from the watercourse, the 120 m setback was truncated (Stantec 2009, Phase 1 Technical Addendum). The small island located within the IPZ-2, Chantry Island, is fully included into the vulnerable area, because no point of this island is more than 120 m away from the shore.

TABLE 4.9.S1.1c – Managed Land, Livestock Density and Impervious Surfaces

General	IPZ ID	Backup Intake
	Area Total [hectare]	1,543.84
	Area Offshore [hectare]	926.84
	Area Onshore [hectare]	617.00
IPZ 1 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	24.20
	Livestock Density [NU/Acre]	0.00
	Managed Land Area [hectare]	3.12
	% Managed Lands	12.89
	Category	**ML% <40%, NU/acre <0.5**
IPZ 2 Managed Land and Livestock Density	Vulnerable Land Area [hectare]	584.24
	Livestock Density [NU/Acre]	0.11
	Managed Land Area [hectare]	289.87
	% Managed Lands	49.61
	Category	**ML% 40%-80%, NU/acre <0.5**

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

Up-Tributary Analysis

For each river and drain that outlets into the intake protection zone, the up-tributary extend of the 2-hour ToT distance was computed for Underwood Creek, Little Sauble River and four unnamed creeks. The estimated up-tributary extent is longer than the actual length of these water courses for both the main and the backup ToT zones; therefore, the delineation was terminated at the headwaters of each watercourse with a circular cap radius of 120 m. A 120 m setback off each bank was applied however, where the DEM or subwatershed boundaries indicated overland flow traveling away from the watercourse, the 120 m setback was truncated.

The up-tributary extent of the Saugeen River is within the 2-hour ToT contour of the main intake and is not included in this tributary analysis. The full up-tributary extent for Mill Creek is already included in the 120 m setback from the Saugeen River and therefore not further regarded (Stantec 2009, Phase 1 Technical Addendum).

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 Southampton, Port

Elgin and around the IPZ-2. Volumes ranged from 6,300 L to 49,300 L and were split into two EBA categories (see map 4.1.S1.1.9);

- 13,000 L and greater
- 22,500 L and greater

For the purposes of the IPZ-3 and EBA work, the backup intake was not considered. As the backup intake is close to shore and in shallow water, it is considered to be relatively vulnerable. As such, it would take a catastrophic failure of the municipal intake for the backup intake to be put back into production. The municipality assured Source Protection staff that the intake is unusable in its current condition and would take considerable effort and expense to become functional. The municipality has also assured the Source Protection staff that municipal staff would inform the SPC if the backup intake were to be used as a municipal drinking water source again. The MOECC provided guidance and comments on the removal of this intake from consideration.

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 a storm sewer network and a tile drain network. Catchment areas of the storm sewer networks were estimated and included all areas of developed land for the main and the backup intakes (see Stantec 2009, Phase 1 Technical Addendum, Section 5.3.3/4). Those areas that are located within the 2 hour time-of-travel area were added to the intake protection zone according to the Technical Rules (see Section 4.1.2.6 – Onshore Components). The only tile drainage area included in both intakes onshore components is located east of Carlisle Street in Southampton (Stantec 2009, Phase 1 Technical Addendum). The resulting area is shown on Map 4.9.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, it is determined by averaging the percentage of land, land characteristics and transport pathways sub factors. These three factors are discussed separately and rating is summarized in Table 4.9.S1.2a.

Approved

Percentage of Land

The percentage of land sub factor has been divided equally between the three ranges outlined in the Technical Rules (< 33% = 7, 33% to 66% = 8, > 66% = 9). The Southampton main intake IPZ-2 is 1,448 ha in size with approximately 46% (666 ha) land area determined by the WPS. Therefore, the % land component of 8 was assigned to the main intake IPZ-2.

The Southampton backup intake IPZ-2 is 1,270 ha in size with approximately 47% (597 ha) land area and therefore the % land sub factor has a score of 8.

Land Characteristics

Land Cover The land characteristics 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. 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, residential, and commercial areas. Based on the available SOLRIS GIS dataset, the land cover type is 67% natural green areas for the main intake IPZ-2 and 73% natural green areas for the backup intake IPZ-2. Therefore, land cover component ratings of 7 were prescribed for both IPZ-2s.

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). Soils within the upland IPZ-2 area consist of sandy loams with imperfect drainage on overburden that does not significantly contribute to the generation of high runoff volumes, however internal drainage may be slowed in some areas due to the presence of impermeable clay or rock layers (Hoffman and Richards, 1954). The soil type component rating is 8 and was assigned to both IPZ-2s.

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 Saugeen Shores main IPZ-2 is 666 ha of land with 449 ha (67%) of pervious cover. The Saugeen Shores backup IPZ-2 is 597 ha of land with 435 ha (73%) of pervious cover. The impervious land cover was determined using SOLRIS (2009) information. Therefore, the permeability component rating prescribed to the main and backup IPZ-2 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 Southampton upland IPZ-2 was described as having flat topography with gentle sloping towards the shoreline. Using OBM contours, the slope of the study area ranges from 0.9% to 2.0%. A slope component rating of 7 was assigned to both IPZ-2s.

Approved

Land Characteristics (Summary) The resulting land characteristics component of 7.3 was calculated using an averaged equal representation of each component listed above for the main and backup vulnerable areas (Table 4.9.S1.2a).

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 outfall locations were unavailable for the Saugeen Shores study area. Storm sewer catchments were assumed based on the area of the developed land. The area of the developed land was based 2006 SWOOP data. The main intake upland area was determined to be 34% (229 ha) storm sewer drained. The backup intake upland area was determined to be 29% (174 ha) storm sewer drained. This resulted in a component rating of 8 and 7 for the main and backup intake upland areas respectively.

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 1000 ha of land was calculated for the Saugeen Shores IPZ-2 using the WVF dataset. The rating range has been set for 0-3/1,000 ha in the zone (7), 4 to 7/1,000 ha in the zone (8) and > 7/1,000 ha in the zone (9). Seven watercourses and 27 outfalls discharge into the alongshore extent of the main IPZ-2 (assumed using aerial storm network data) giving a calculated 51 outfalls *per* 1,000 ha of land. This resulted in a sub factor of 9 for the main intake IPZ-2. Three watercourses and 21 outfalls discharge into the alongshore extent of the backup IPZ-2 giving a calculated 40 outfalls *per* 1,000 ha of land. This resulted in a sub factor of 9 for the backup intake IPZ-2. 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 the area vulnerability factor applies to the IPZ-2 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). Tile drained areas represent 2% of the main and backup IPZ-2s, therefore a sub factor of 7 has been assigned to both.

Transport Pathways (Summary) Calculated using an averaged equal representation of the components listed above, component ratings of 8 were determined for the main IPZ-2 and 7.7 for the backup IPZ-2 (Table 4.9.S1.2a).

Approved

The resulting area factor rating for the Southampton WTP IPZ-2 is eight, equally for the backup intake and the main intake.

Source Vulnerability Factor

The source vulnerability factor for the Southampton WTP combines intake characteristics, such as depth and length of pipe, and past water quality concerns. The intake crib of the main intake is located at a depth of 7.5 m and its vulnerability sub score is low at 0.5. The backup intake crib depth is 1.5 m and its vulnerability sub score is high at 0.7.

The Southampton WTP's main intake is located approximately 895 m from the shoreline; however, through hydrodynamic modelling it has been identified as being within the wave-breaking zone. Therefore, the intake is susceptible to water column mixing. Despite the intake being approximately 895 m from the shoreline, the location within the wave-breaking zone means that it cannot be assigned a low score, thus a medium score of 0.6 was selected (Stantec 2009, Phase 1 Technical Addendum). The backup intake is located approximately 355 m from the shoreline and is also located within the wave-breaking zone. An elevated score of 0.7 has been qualitatively selected.

TABLE 4.9.S1.2a – Area Vulnerability Scores for the Southampton Intake

	Main Intake	***Backup Intake***
Area Vulnerability Factor Rating *(Rounded average of percentage of land, land characteristics and transport pathways)*	**8**	**8**
Percentage of Land	**8**	**8**
Land Characteristics	**7.3**	**7.3**
Land Cover	7	7
Soil Type	8	8
Permeability	7	7
Setback Slope	7	7
Transport Pathways	**8**	**7.7**
Storm Catchment Areas *(more than 33% but less than 66 % for the main intake, lesser than 33 percent for backup intake)*	8	7
Storm Outfalls, Watercourses, Drains *(The number of storm outfalls, watercourses and drains per 1,000 ha is larger than 7 for both intakes)*	9	9
Tile Drained Area *(less than 33 % for both intakes)*	7	7

Approved

TABLE 4.9.S1.2b – Source Vulnerability Factor for the Southampton Intake

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

TABLE 4.9.S1.2c – Vulnerability Scores of the Southampton Intake Protection Zone (IPZ)

Intake Type	Area Vulnerability Factor		Source Vulnerability Factor	Vulnerability Score	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
Main (A)	10	8	0.5	5	4
Backup (A)	10	8	0.6	6	4.8

Based upon a review of available data (Drinking Water Surveillance Program, DWIS), there appears to be no drinking water issues for the main and backup intakes. This results in a sub factor of 0.5 for both intakes.

The source vulnerability factor is determined by averaging the above-listed sub factors. The source factor rating for the Saugeen Shores IPZ is 0.5 for the main intake and 0.6 for the backup intake (Table 4.9.S1.2b).

Resulting Vulnerability of the Intake Protection Zone

The resulting vulnerability of the main intake is five for IPZ-1 and four for IPZ-2. For the backup intake, the vulnerability for IPZ-1 is six and IPZ-2 is 4.8 (Table 4.9.S1.2c).

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 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

Approved

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 4.9.S1.4 indicates that no activities for this surface water intake are rated at a "significant" level of risk 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). Five existing significant drinking water threats were identified through events-based modelling (see detailed Table 4.9.S1.3 and summary Table 4.9.S1.4).

TABLE 4.9.S1.3 – Southampton IPZ: Significant Drinking Water Threats for Events-based Area

Prescribed Threat **IPZ: SOUTHAMPTON** *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		4				1				**5**

TABLE 4.9.S1.4 – Southampton IPZ: Summary of Significant Drinking Water Threats

IPZ Name	**Number of "are or would be significant" threats**			
	Pathogen	Chemical	DNAPL	Total
Southampton	0	5	0	5

<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
The Southampton Water Treatment Plant gets its water from an intake in Lake Huron and an additional intake has been constructed. Samples were collected from 1992 to 2005 and the number of samples collected each year ranged from one to nine. No Drinking Water Surveillance Program data is available for metal (copper, lead, and zinc) concentrations at the intake but sediments were analyzed by the Environment Canada-Ontario Water Quality Monitoring and Surveillance Office, which routinely monitors offshore in Lake Huron. The closest station is LH 02-29, which is near Douglas Point. Sediment quality samples showed that provincial lowest effect levels for copper, manganese and nickel were exceeded. No Drinking Water Surveillance Program values were recorded for total phosphorus. There were two years when samples exceeded acceptable lead concentrations. Turbidity levels were near or above recommended levels each year.

Approved

Other samples were collected in nearby Port Elgin from 1990 to 2005 before the plant at that location was decommissioned. The number of samples ranged from one to nine per year. Recommended levels for lead were near or exceeded once during the sample period. The levels for total phosphorus were near or exceeded five times during the sample period and levels for turbidity were near or exceeded 14 times during the sample period.

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 4.9.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 4.9.S1.5 – Southampton: Issues and Conditions

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

Approved

4.2.10 Municipality of South Bruce

The Municipality of South Bruce is located in the southern portion of Bruce County in the Saugeen Valley Source Protection Area. The Municipality of South Bruce has a strong agricultural sector due to its fertile soil. Livestock husbandry and crop production are the main farming activities within the municipality. South Bruce has a thriving aggregate industry with quality gravel deposits throughout the municipality. In 2016, the population was 5,639, which was a decrease of 5.3% from 2006. The main towns are Mildmay (population 1,150) and Teeswater (population 1,109). Smaller villages include Formosa, Carlsruhe and Deemerton. The Municipality of South Bruce has two municipal water supply systems, one servicing the former Village of Teeswater and a second servicing the former Village of Mildmay and adjacent development. These municipal water supply systems utilize groundwater wells drilled into the bedrock aquifer. No new drinking water systems are planned.

Agricultural land use in South Bruce includes 476 farms that manage a total land area of 40,830 ha (average farm size 86 ha), of which 71.5% are cropped according to the Agricultural Census (Statistics Canada, 2006a). From this cropped area, alfalfa and other fodder crops take up 18.2% of the land, soybeans take up 17.9%, barley takes up 8.2%, and other crops (corn, wheat, etc.) take up 26.5%. The total livestock density is 0.21 nutrient units per acre. According to the same census, there are 522,000 chickens on 61 farms (Statistics Canada, 2006a). The total number of cattle is 27,066 (26% dairy, remainder beef) on 332 farms. Further, there are 39,586 pigs, 4,089 sheep, 481 horses, and 1,892 goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.10.M1.

4.2.10.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.10.M2 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. The rolling landscape of South Bruce originated from the drifts of glaciers with alternating areas of till, ice-contact stratified drift and glaciofluvial outwash. The sandy and gravelly drifts and outwashes are highly permeable and are areas of significant groundwater recharge (SGRA). Due to erosion in the rolling topography, some areas have a thin and permeable overburden and are also designated HVAs.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.10.M3).

The portion of this municipality that lies within this SPR has a total area of SGRAs of 251.4 km^2 and a total area of HVAs of 194.3 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 4.2.10.1).

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 4.2.10.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Municipality of South Bruce in this Source Protection Region

Approved

SGRA	Total Area of SGRA	251.4 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	194.3 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

Note: Total areas relate to the full source protection region

4.2.10.2 Groundwater Municipal Systems

4.2.10.2.1 Mildmay Well Supply

The Mildmay Well Supply is comprised of two bedrock wells. Well No. 1 was constructed in 1968 and Well No. 2 was constructed in 1989. Mildmay Well No. 2 is a standby well.

The Mildmay Well Supply is located on Absalom Street West, near the centre of the village, and services a population of approximately 1,200. The system includes two wells that are only 6 metres apart, and a pump house located 20 m west of Otter Creek situated beyond the floodplain according to Conservation Authority mapping. Mildmay production Well No. 1 is currently the duty well and Well No. 2 is strictly on standby. Both wells are artesian and naturally produce an unrestricted flow of water drawn from the Bois-Blanc limestone bedrock aquifer. The Mildmay wells are considered non-GUDI according to the DWIS database.

Well No. 1 has a depth of 34.9 metres. It is constructed of a 250 mm diameter metal casing to a depth of 34 m. Well No. 2 has a depth of 34.4 m. The well is constructed of a 250 mm diameter metal casing to a depth of 32.9 m.

A wellhead protection area (WHPA) for the Mildmay 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 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 4.10.G1.2a and shown on Map 4.10.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. The results are listed in Table 4.10.G1.2b and shown on Maps 4.10.G1.5 and 4.10.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

Approved

The Mildmay WHPAs are large and they encompass a combined area of 6.04 km^2. The WHPA extends south 6.5 kilometres from the well (Map 4.10.G1.1). Otter Creek flows through WHPAs A and B and the land uses are institutional, industrial, residential, and agricultural.
Land use within WHPAs A-D consists of residential, flood hazard, commercial, institutional, landfill, mining (aggregate), a former railroad, and agricultural lands. Several tributaries and small wetland complexes are located within the WHPA. Small ponds are spread out in WHPAs C and D.

Map 4.10.G1.2 shows the borders of all zones of WHPA overlaying aerial photography.

TABLE 4.10.G1.1 – Description of the Drinking Water System and Wells

Well Name	Mildmay 1	Mildmay 2
Drinking Water System ID	220002654	
Drinking Water System Classification	Large Municipal Residential System	
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA	
Northing/Easting	4876290.8 / 490221.6	4876287.4 / 490216.9
Year Constructed	1968	1989
Well Depth	34.9 m	34.4 m
Uncased Interval	33.9 - 34.9 m	32.9 - 34.4 m
Aquifer	Bois-Blanc limestone bedrock	
GUDI	No	No
Number of Users Served	1,200 persons	
Design Capacity (CoA)	1,637 m^3/day	
Permitted Rate (PTTW)	1,637.28 m^3/day	1,637.28 m^3/day
Average Annual Usage*	657 m^3/day	
Modelled Pumping Rate	361 m^3/day	361 m^3/day
Treatment	12% Sodium Hypochlorite (disinfectant)	12% Sodium Hypochlorite (disinfectant)

* *CRA Phase I, Round 1 Report 2007, Table 3.1*

TABLE 4.10.G1.2a – Impervious Surfaces

General	Code for WHPA	MILDMAY
	Total Area [hectare]	603.66
Impervious Surfaces Area [ha]	<1%	103.12
	1% – <8%	486.10
	8% – < 30%	14.44
	Larger or equal than 30%	-

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

TABLE 4.10.G1.2b – Managed Land and Livestock Density

Approved

WHPA_NAME	MILDMAY			
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)	>1.0	<0.5	<0.5	<0.5
% Managed Lands (<40%, 40-80%, >80%)	<40%	<40%	>80%	>80%

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

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 4.1.2.5), unless the vulnerability is already rated high.

Aquifer vulnerability was adjusted one level to account for a number of former and active aggregate pits within the WHPA-C for the Mildmay WHPA (See Map 4.10.G1.3). No transport pathway adjustments were made in the urban area (within WHPA-A and WHPA-B) as existing properties are either on municipal services, or have wells that are in compliance with existing standards.

Vulnerability
After overlaying the intrinsic susceptibility index (Map 4.10.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.10.G1.3.

The WHPA is moderately susceptible to surface, or near surface, contamination (Map 4.10.M1). This is primarily due to the presence of an approximately 13 metre thick layer of clay and silt between the ground surface and the aquifer. A high percentage of the capture zone has adjusted vulnerability scores ranging between five and seven. Otter Creek is located 20 m downhill (northeast) from the Mildmay wells.

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 Mildmay (Well Nos. 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 2 (see detailed Table 4.10.G1.3 and summary Table 4.10.G1.4).

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 4.10.G1.3 – Mildmay: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: MILDMAY** *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	1									**1**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
22	Liquid Hydrocarbon Pipelines										
	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										

Approved

6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Outdoor Confinement AreaPastures or other farm-animal yards										

TABLE 4.10.G1.4 – Mildmay WHPA: Summary of Significant Drinking Water Threats

MILDMAY	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	0	2

Quality of Raw Water at the Well
There are no reports of any standards being exceeded.

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 4.10.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 4.10.G1.5 – Mildmay: Issues and Conditions

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

Approved

4.2.10.2.2 Teeswater Well Supply

The Teeswater Well Supply is comprised of an artesian bedrock well, Well No. 3, located in close proximity to the Teeswater River. It serves the village and some adjacent developments with a total population of approximately 1,000.

The Teeswater system is centrally located near the intersection of Clinton Street North (Bruce Road 4) and Hillcrest Street East (Bruce Road 6) in Teeswater. The well is located 20 - 30 m south of the Teeswater River. It is located beyond the 1:100-year floodplain of the River but within the regional storm flood line according to Conservation Authority mapping.

The Teeswater well was drilled in 1996 and has a depth of 85.3 m with the casing extending 25.9 m. The well is artesian and naturally produces an unrestricted flow of approximately 76 L/s under a pressure of approximately 11 pounds per square inch (psi) and a head of approximately eight metres. The wellhead is located in close proximity of the pump house and extends approximately 0.5 m above ground level. A hydrogeological assessment is provided (Engineer's Report, R. J. Burnside & Associates Limited, May 28, 2001). The well is considered non-GUDI based on artesian conditions and water quality analysis.

A wellhead protection area (WHPA) for the Teeswater 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 as part of the Round 1 Technical Study for the Saugeen Grey Sauble Northern Bruce Peninsula Source Protection Region (CRA, 2007).

TABLE 4.10.G2.1 – Description of the Drinking Water System and Wells

Well Name	Teeswater 3
Drinking Water System ID	220002618
Drinking Water System Classification	Large Municipal Residential System
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA
Northing/Easting	4872031.15 / 476982.55
Year Constructed	1996
Well Depth	85.3m
Uncased interval	Not known
Aquifer	Detroit River Group limestone
GUDI	No
Number of Users Served	1,000 persons
Design Capacity	1,600 m^3/day
Permitted Rate	1,600 m^3/day
Average Annual Usage*	455.0 m^3/day
Modelled Pumping Rate*	488.0 m^3/day
Treatment	Sodium hypochlorite disinfection

** CRA Phase I, Round 1 Report 2007, Table 3.1 (years 2001-2005)*

Approved

TABLE 4.10.G2.2a – Impervious Surfaces

General	Code for WHPA	TEESWATER
	Total Area [hectare]	885.37
Impervious Surfaces Area [ha]	<1%	337.67
	1% – <8%	511.12
	8% – < 30%	36.58
	Larger or equal than 30%	-

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

TABLE 4.10.G2.2b – Managed Land and Livestock Density

WHPA_NAME	**TEESWATER**			
Well Name	No.3	No.3	No.3	No.3
Zone	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	<0.5	0.5-1.0	<0.5	>1.0
% Managed Lands (<40%, 40-80%, >80%)	<40%	40-80%	>80%	>80%

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

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 4.10.G2.2a and shown on Map 4.10.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. The results are listed in Table 4.10.G2.2b and shown on Maps 4.10.G2.5 and 4.10.G2.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

Wellhead Protection Area
The wellhead protection area (WHPA) was estimated using numerical modelling, following the methodology described in Section 4.1.2.5.

The WHPA for this system extends 7.2 km southeast of the well. WHPAs A and B extend two km southeast with Muskrat Creek flowing through the zones (Map 4.10.G2.1). The land use within these zones consists of industrial, commercial, municipal, residential, and agricultural. WHPAs C and D consist of residential, agricultural and agricultural properties.

Map 4.10.G2.2 shows the borders of all zones of WHPA overlaying aerial photography.

Approved

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 4.1.2.5), unless the vulnerability is already rated high.

No Transport pathway adjustments were made in the Teeswater WHPA as existing properties are either on municipal services, or have wells that are in compliance with existing standards.

Vulnerability
After overlaying the intrinsic susceptibility index (Map 4.10.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.10.G2.3.

The Teeswater WHPA encompasses an area of 8.9 km^2. The WHPA is moderately susceptible to surface, or near surface, contamination (Map 4.10.M1) with a higher percentage of the capture zone having adjusted vulnerability scores ranging between five and seven. The Teeswater River is located 30 m downhill and to the north of the well. Sensitivity to contamination is reduced with distance from the supply well.

On a regional-scale, the intrinsic susceptibility index mapping shows that the area surrounding the Teeswater WHPA boundary is designated as high in zones A, B and a portion of D The remaining sensitivity zones are rated medium to low. According to WHI (2003), the higher susceptibility is likely a result of the limited thickness of low permeability overburden materials that overlay the bedrock aquifer. However, the Teeswater well is a flowing artesian well of more than 50 L/s; therefore, the aquifer is confined, which indicates a confining layer exists that likely protects the aquifer from surface activities. A hydro-geological assessment (R.J. Burnside, 2003) indicates that the overburden in the Teeswater area is relatively thin particularly in the vicinity of the Teeswater River. A more significant confining layer may exist in the areas surrounding Teeswater as is indicated by the low susceptibility index values (CRA 2007, CRA 2009).

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.

Approved

WHPA A-D
There are 28 significant drinking water threats in the Teeswater (Well No. 3) wellhead protection area A-D. These threats include 9 activities related to the potential for pathogen contamination, and19 activities related to contamination with hazardous chemicals. The total number of properties with threats is 8 (see detailed Table 4.10.G2.3 and summary Table 4.10.G2.4).

In WHPA-A, there are a few residential homes with septic systems and fuel handling threats. Due to high vulnerability, these threats also extend into WHPA-B. Industrial threats also exist with the potential for activities such as DNAPL storage and handling, and fuel storage and handling. Commercial land use may have activities including DNAPL handling/storage, septic systems and storage of fuel.

In WHPA-B, there are also some agricultural properties with threats that are significant. The threats include the application of agricultural source material to land, application of non-agricultural source material to land and application of pesticide to land.

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
There are no reports of any standards being exceeded.

Approved

TABLE 4.10.G2.3 – Teeswater: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: TEESWATER** *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						6		**8**
3	Agricultural source material - Application to land										
4	Agricultural source material - Storage						1				**1**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
8	Commercial fertilizer - Application to land	1									**1**
9	Commercial fertilizer - Handling and storage										
10	Pesticide - Application to land	3									**3**
11	Pesticide - Handling and storage										
12	Road Salt – Application		2								**2**
13	Road Salt – Handling and Storage		2								**2**
14	Snow - Storage										
15	Fuel - Handling and storage								2		**2**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal	1	1						6		**8**
3	Agricultural source material - Application to land										
4	Agricultural source material - Storage						1				**1**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										

TABLE 4.10.G2.4 – Teeswater 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			
TEESWATER	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	19	0	9	28	1	6	1	8

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 4.10.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 4.10.G2.5 – Teeswater: Issues and Conditions

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

4.2.10.3 Surface Water Municipal Systems

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

Approved

4.2.11 Township of Southgate

The Township of Southgate is located at the southern-most part of Grey County in the Saugeen Source Protection Area. The township is made up of rural agricultural land and swamp land. In 2006, the population was 7,167, which was an increase of 3.8% from 2001. The main town is Dundalk (population 1,972). Smaller villages include Holstein, Cedarville, Hopesville, and Varney. The municipal drinking water systems in this municipality are not located within the Saugeen Source Protection Authority; therefore, they are not included in this report. No new drinking water systems are planned. The vulnerable areas (HVAs/SGRAs) within this municipality are included in this report. In 2016, a new well referred to as D5 was constructed on the east side of Dundalk between the two existing municipal wells. A small portion of the WHPA D zone for Dundalk Well D5 protection area falls within the Saugeen Source Protection Area.

Agricultural land use in Southgate consists of 454 farms covering a total land area of 40,381 ha (average farm size 89 ha), of which 60.3% are cropped according to the Agricultural Census (Statistics Canada, 2006a). From this cropped area, alfalfa and other fodder crops take up 12.5% of the land, barley takes up 10.1% and other crops (corn, wheat, etc.) take up 20.7%. The total livestock density is 0.13 nutrient units per acre. According to the same census, there are 204,000 chickens on 98 farms (Statistics Canada, 2006a). The total number of cattle is 33,440 (14% dairy, remainder beef) on 316 farms. Further, there are 13,699 pigs, 17,680 sheep, 1,009 horses, and 2,168 goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.13.M1.

4.2.11.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.11.M2 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. In the western portion, groundwater recharge is significant. With topsoil that originated from glaciofluvial outwash and ice-contact stratified drift from the Late Wisconsinan deposits, the material is mostly gravely or undifferentiated mixes of sand, gravel and silt. Its topography is often hummocky and creates a great number of small pockets that allow strong infiltration. A second, smaller area of recharge is the Pleistocenic ice-contact stratified drift west of Kingscote, which extends northwards as a narrow stretch.

Overburden thickness varies considerably across this municipality, with thin areas around Maple Lane, Keldon and south of Ventry that are highly vulnerable to contamination from the surface (HVA).

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.11.M3).

The portion of this municipality that lies within this SPA has a total area of SGRAs of 179.9 km^2 and a total area of HVAs of 111.2 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 4.2.11.1).

Approved

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 4.2.11.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Municipality of Southgate in this Source Protection Region

SGRA	Total Area of SGRA	174.6 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	111.2 km^2
	Managed Land and Livestock Density	ML% 40-80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

Note: Total areas relate to the full source protection region

The WHPAs for the Dundalk Wells extend north-northeast from the village in the direction (upgradient) of local groundwater flow through the bedrock. The majority of the WHPAs are within the Grand River Source Protection Authority, however a small portion of the WHPA-D extends into Saugeen Valley Source Protection Authority with a vulnerability score of 2. Addition information on the Dundalk WHPAs can be found in the Updated Assessment Report for the Grand River Source Protection Area.

Approved

4.2.12 Township of Wellington North

The Township of Wellington North is located at the northern part of Wellington County. The northern third of the municipality lies within the Saugeen Valley Source Protection Area while the remainder is partly within the Maitland Valley SPA and partly within the Grand River SPA. The Township contains an agricultural setting with some of the best farmland the county has to offer as well as a substantial industrial base and a wealth of conservation land. In 2016, the population was 11,914, which was an increase of 6.2% from 2006. The main towns are Mount Forest (population 4,584) and Arthur (population 2,284). Smaller villages include Conn, Damascus, Kenilworth, and Riverstown.

The Township of Wellington North has two municipal water supply systems, one servicing the community of Mount Forest and a second servicing the community of Arthur. The Mount Forest Drinking Water System falls under the jurisdiction of the Saugeen Valley Source Protection Authority, because it is located in the Saugeen watershed. The Arthur well supply is located in the Grand River source protection area and falls under the jurisdiction of the Grand River Source Protection Authority. No new drinking water systems are planned.

Agricultural land use in Wellington North consists of 465 farms that cover a total land area of 38,056 ha (average farm size 82 ha), of which 80.2% are cropped according to the Agricultural Census (Statistics Canada, 2006a). From this cropped area, alfalfa and other fodder crops take up 0.2% of the land, soybeans take up 18.3% and other crops (corn, wheat, etc.) take up 27.6%. The total livestock density is 0.18 nutrient units per acre. According to the same census, there are 905,000 chickens on 89 farms (Statistics Canada, 2006a). The total number of cattle is 24,902 (29% dairy, remainder beef) on 278 farms. Further, there are 38,959 pigs, 2,729 sheep, 833 horses, and 1,035 goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.12.M1.

4.2.12.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.12.M2 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. Only the northern part of this municipality is described in this Assessment Report. Bands of sandy and gravelly soils function as significant recharge areas. Along the Clare Creek Complex, vulnerable aquifers stretch out beyond the wetland areas.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.12.M3).

The portion of this municipality that lies within this SPR has a total area of SGRAs of 48.5 km^2 and a total area of HVAs of 23.4 km^2. The percentage of managed lands located within the SGRAs and HVAs is more than 80%. The livestock density is between 0.5 and 1.0 NU/acre. Only 1-8% of all surfaces in SGRAs and HVAs are classified as impervious (Table 4.2.12.1).

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 4.2.12.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Township of Wellington North in this Source Protection Region

SGRA	Total Area of SGRA	48.5 km^2
	Managed Land and Livestock Density	ML% >80%, NU/acre 0.5-1.0
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	12.9 km^2
	Managed Land and Livestock Density	ML% >80%, NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

Note: Total areas relate to the full source protection region

Approved

4.2.12.2 Groundwater Municipal Systems

4.2.12.2.1 Mount Forest Drinking Water System

The Town of Mount Forest is currently serviced by four municipal wells: production Wells Nos. 3, 4, 5, and 6. Well No. 3 is located in the Village of Mount Forest and the remaining wells are located on the northern outskirts of the village. There are two monitoring wells, Nos. 1 and 2. Each of the four drilled wells separately feeds into a common distribution system. Each well is equipped with one well pump, a discharge line and a sodium hypochlorite disinfection system. Water storage is in the form of a standpipe that has a total volume of 2,083 m^3. A booster pumping station, located at the base of the standpipe, and a diesel generator were added in 2007. The storage supply is also used for fire protection and emergencies.

The raw water is disinfected with 12% sodium hypochlorite. The solution is injected into the process streams using solenoid-driven metering pumps with manual stroke length and speed control. The chlorine residual entering the clear well is monitored by an analyzer to ensure the chlorination system is working properly. Chlorine is added when well pumps start up and stops when water flow stops. A second chlorine residual analyzer monitors the free chlorine residual entering the distribution system. Both chlorine residual analyzers will alarm if their low or high set points are reached and the on-call operator will respond (MOECC, 2005c).
The Mount Forest production wells are drilled into the bedrock to depths up to approximately 120 m and typically have yields up to about 22 L/s. Well No. 5 has a depth of 122 m; however, the well casing does not extend deep into the bedrock and the well obtains most of its supply from the deep overburden and upper 10 m of fractured bedrock of the Salina Formation. Well Nos. 3, 4 and 6 are constructed so that the well casings extend into the deeper bedrock and obtain groundwater from a fracture system ranging in depth from approximately 105 - 160 m in the Guelph Formation.

A wellhead protection area (WHPA) for the Mount Forest wells was first developed as part of the Wellington County Groundwater Protection Study (Golder, 2006). The initial WHPA was updated using the existing groundwater model for the area, in order to account for revised pumping rates as part of Wellington County's updated groundwater protection study (Golder, 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 4.12.G1.2a and shown on Map 4.12.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. The results are listed in Table 4.12.G1.2b and shown on Maps 4.12.G1.5 and 4.12.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

Approved

TABLE 4.12.G1.1 – Description of the Drinking Water System and Wells

Well Name	MF Well 3	MF Well 4	MF Well 5	MF Well 6
Drinking Water System ID	220000068			
Drinking Water System Classification	Large Municipal Residential System			
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA			
Northing/ Easting	4869532.00 / 521699.00	4869547.00 / 520645.00	4870430.88 / 520743.98	4869650.0 / 520221.00
Year Constructed	2005 (plugged)	1962	1965	1975
Well Depth	73.8 (orig. 123.4) m	122.2 m	121.9 m	121.9 m
Uncased Interval	Not known	Not known	Not known	Not known
Aquifer	Bedrock	Bedrock	Bedrock	Bedrock
GUDI	No	No	No	No
Number of Users Served	4500 persons			
Design Capacity (CoA)	1,964.16 m^3/day	conjunctive	3,928.32 m^3/day	Conjunctive
Permitted Rate	1,964 m^3/day	1,964 m^3/day	392.9 m^3/day	3,930 m^3/day
Average Annual Usage	724 m^3/day	724 m^3/day	535 m^3/day	724 m^3/day
Modelled Pumping Rate*	724 m^3/day	724 m^3/day	535 m^3/day	724 m^3/day
Treatment	Sodium hypochlorite disinfection			

** CRA Phase I, Round 1 Report 2007, Table 3.1. WHPA delineation completed by Golder.*

TABLE 4.12.G1.2a – Impervious Surfaces

General	Code for WHPA	MOUNT_FOREST
	Total Area [hectare]	913.40
Impervious Surfaces Area [ha]	<1%	108.98
	1% – <8%	309.92
	8% – < 30%	494.49
	Larger or equal than 30%	0.0

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

Wellhead Protection Area

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

WHPAs A-D encompass all four well systems and combined they have a total land area of approximately 9.13 km^2 (Map 4.12.G1.1). The full WHPA contains the majority of the urban area and extends into rural areas to the east and south. Land uses in the urban area are residential, commercial, institutional, and industrial. The rural area consists of residential, forested and agricultural lands.

Map 4.12.G1.2 shows the borders of all zones of WHPA overlaying aerial photography.

Approved

TABLE 4.12.G1.2b – Managed Land and Livestock Density

WHPA_NAME	MOUNT FOREST								
Well Name	No.3	No.3	No.4	No.5	No.5	No.6	No. 4&6	No.3,4, 5&6	No.3,4, 5&6
Zone	A	B	A	A	B	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%	<40%	<40%	<40%	<40%	<40%

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

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 4.1.2.5), unless the vulnerability is already rated high.

Aquifer vulnerability was adjusted one level to account for transport pathways in the urban area within the Mount Forest 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 4.12.G1.3.

Vulnerability
After overlaying the intrinsic susceptibility index (Map 4.12.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.12.G1.3.

The WHPAs within the Township of Wellington North are large and have a relatively low susceptibility to surface, or near-surface, contamination (Map 4.12.M1). The WHPAs have a large portion of their total areas designated with a low vulnerability (between two and four). A very small percentage of the WHPAs is designated as highly vulnerable due to the proximity to the supply wells (e.g., WHPA-A protection zone). On a regional scale, the aquifer vulnerability index mapping shows that the area surrounding the WHPAs is designated as low. Although not explicitly addressed in the County of Wellington Groundwater Protection Study (Golder, 2006), the low vulnerability is likely due to the presence of low permeability material present above the respective groundwater aquifer.

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 116 significant drinking water threats in the Mount Forest (Well Nos. 3, 4, 5, and 6) wellhead protection area A-D. These threats contain 8 activities related to the potential for pathogen contamination, 50 activities related to contamination with hazardous chemicals and 58 activities related to DNAPLs. The total number of properties with threats is 57 (see detailed Table 4.12.G1.3 and summary Table 4.12.G1.4).

The land use surrounding Well No. 6 includes commercial, industrial, and residential. The significant threats for commercial properties located within WHPAs A and B of Well No. 6 are related to handling and storage of fuel. The industrial property threats are related to DNAPLs and storage of fuel. Threats associated with residential properties are related to DNAPLs and storage of fuel.

WHPAs A and B of Well No. 4 are mostly residential land with the same associated threats listed above. Well No. 3 is surrounded with commercial, recreational, institutional, and residential land. The significant threats for the commercial properties are storage and handling of DNAPLs and fuels, and storage of organic solvents. The significant threats for the recreational lands are related to DNAPLs. The significant threats for the institutional properties include DNAPLs and storage of fuel.

The land use within WHPAs A and B of Well No. 5 are commercial, institutional, residential, and agricultural. The significant threats for these land uses are the same as the other Mount Forest Wells. There are no significant threats for the agricultural lands within the Mount Forest WHPAs.

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

The chemistry of the water makes it suitable for drinking water because all parameters are below the Ontario Drinking Water Quality Standards. The raw water and treated water consistently tests negative for Total Coliform and *E. coli* bacteria, which confirms that the water is not under the influence of surface water.
However, for Mount Forest Wells 4 and 6, the level of iron was infrequently exceeded due to natural occurrence. Levels of fluoride were also infrequently exceeded in Well No. 6 (B.M. Ross, 2000).

Approved

TABLE 4.12.G1.3 – Mount Forest: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: MOUNT_FOREST** *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								8		**8**
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										
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		12			2	6				**20**
13	Road Salt – Handling and Storage		12			2	6				**20**
14	Snow - Storage										
15	Fuel - Handling and storage								2		**2**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
22	Liquid Hydrocarbon Pipelines										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage		20	10	6	10	0	2	10		**58**
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								8		**8**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										

TABLE 4.12.G1.4 – Mount Forest WHPA: Summary of Significant Drinking Water Threats

MOUNT FOREST	**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	50	58	8	116	0	20	48	37

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 4.12.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 4.12.G1.5 – Mount Forest: Issues and Conditions

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

4.2.12.3 Surface Water Municipal Systems

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

Approved

4.2.13 Municipality of West Grey

The Municipality of West Grey is located in Grey County in the Saugeen Valley Source Protection Area. Three branches of the Saugeen River pass through the municipality en-route to Lake Huron. In ~~2016~~2021, the population was ~~12,518~~13,131, which was an increase of ~~2.6~~4.9% from ~~2006~~2016. The main towns are Durham (population ~~2,647~~2,755) and Neustadt (population 562). Smaller villages include Ayton, Elmwood, Crawford, and Allan Park.

The Municipality of West Grey has seven groundwater municipal residential drinking water supply wells: Four servicing Durham (Durham Well 1B, 1C and Durham Well 2 and 2A) and three servicing Neustadt (Neustadt Well 1 and Neustadt Wells 2/3).

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Agricultural land use in West Grey consists of 604 farms covering a total land area of 44,992 ha (average farm size 74 ha), of which 57.1% are cropped according to the Agricultural Census (Statistics Canada, 2006a). From this cropped area, alfalfa and other fodder crops take up 11.3% of the land, soybeans take up 7.4% and other crops (corn, wheat, etc.) take up 17%. The total livestock density is 0.13 nutrient units per acre. According to the same census, there are 907,000 chickens on 102 farms (Statistics Canada, 2006a). The total number of cattle is 29,171 (14% dairy, remainder beef) on 381 farms. Further, there are 17,890 pigs, 6,226 sheep, 1,311 horses, and 2,388 goats reported in this municipality.

The susceptibility of groundwater aquifers for this municipality is shown on Map 4.13.M1.

4.2.13.1 Highly Vulnerable Aquifers & Significant Groundwater Recharge Areas

Map 4.13.M2 portrays the locations of highly vulnerable aquifers (HVAs) and significant groundwater recharge areas (SGRAs) in this municipality. A large portion of the soil in this municipality is glaciolacustrine sediment and ice-contact stratified drift with high contents of sand and gravel. Due to the high permeability of these overburdens, many areas are identified as recharge areas (SGRA). With varying overburden thickness in this sloping terrain, those areas with less overburden are also highly vulnerable (HVA). These areas do not show a specific pattern.

All HVAs outside of WHPAs/IPZs have a groundwater vulnerability score of six (Map 4.13.M3).

In this municipality, the total area of SGRAs is 448.7 km^2 and the total area of HVAs is 382.5 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 4.2.13.1).

Approved

TABLE 4.2.13.1 – Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Municipality of West Grey

SGRA	Total Area of SGRA	448.7 km^2
	Managed Land and Livestock Density	ML% 40-80%,- NU/acre <0.5
	Impervious Surfaces (average)	1-8 %
HVA	Total Area of HVA	382.5 km^2
	Managed Land and Livestock Density	ML% 40-80%, - NU/acre <0.5
	Impervious Surfaces (average)	1-8 %

Note: Total areas relate to the full source protection region

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.

4.2.13.2 Groundwater Municipal Systems

4.2.13.2.1 Durham Well Supply

The Durham Well Supply presently uses four wells, namely Durham Well 1B, ~~1C~~ 1C and Durham Well 2 and 2A. Durham's water supply system was originally constructed in 1939 with an artesian well. Water from the artesian well was piped to an underground reservoir on the corner of Albert and South Streets and from there it was pumped to a standpipe located at the north end of Durham. In 1949, Durham Well 1 was drilled at the site of the underground reservoir to improve a deteriorating water supply. In 1966, Durham Well 2 was drilled in the eastern portion of Durham, 100 m north of Grey Road 4 and 200 m south of McGowan's Falls. ~~Well 2A was drilled~~ This supply system remained in place until 1987 when Durham Wells 1A and 1B were drilled (Cobean, 2001). Well 1A was immediately abandoned after drilling, because part of the borehole collapsed, but was reserved for use as an observation well (Cobean, 2001; Henderson and Paddon, 2002a). Durham Well 1B was drilled in the southern part of Durham, 60 m east of Highway 6, in 1987 and was put into production in 1989. This well is located 9.8 m northwest of Well 1A.

Well 1B has a depth of 77.7 m with cement grouting along the entire well casing, which extends to 20.6 m. Durham Well 1C was drilled in 2024 to a depth of ~~X~~70.7 m, located approximately 400 metres east and upgradient of well 1B.

Well records indicate that Well 2 was drilled in 1966 to a depth of 74.7 m with a 12.8 m casing. The depth of the grouting is not known or indicated in well records; however, cement grout is evident at this well (Henderson and Paddon, 2002a). Well 2 is considered an excellent production well. In the year 2000, water levels in the casing were nearly overflowing between pump cycles, suggesting a strong artesian condition (Cobean, 2001).

Currently Durham Wells 1B, 1C, 2 and 2A provide all of Durham's drinking water. Well 1B and 2 pump houses were upgraded in 2005 and 2006 to include filtration and ultra-violet (UV)

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

treatment. ~~Maps of the water distribution system were provided in pdf format.~~Reported municipal pumping for the years 2018 to 2021 indicates an average current demand of 1086 m3/d (12.5 L/s), which remains lower than the rates used to delineate the existing wellhead protection areas in WHI (2003).

A wellhead protection area (WHPA) for the Durham 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 and projected operations as part of the Round 1 Technical Study for the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region (CRA, 2007). Aqua Insight Inc. completed an extensive source protection study in 2026 to support an amended WHPA and vulnerability assessment for the Durham wells. As part of this study the groundwater model was updated with conceptual refinements, resulting in significant changes in the size, shape, and orientation of the WHPAs. WHPAs were delineated using the average daily pumping rates representative of the estimated future (i.e., 2052) daily demand for the town of Durham. Future daily demand for the town of Durham was forecasted to be 2594 m3/d. The total demand was allocated between wells 1B, 1C, 2, and 2A in accordance with aquifer transmissivity estimates and with anticipated municipal operations. As such the highest pumping rates were applied in areas of the highest transmissivity. For Well 1B and 1C a rate of 950 m3/d was applied, and for Wells 2 and 2A a rate of 347 m3/d was applied (Aqua Insight, 2026).

Formatted: Normal

Well 2A was drilled in August 2013 and put on line on April 16, 2017. It is located on George Street East site approximately 20 metres south of the pumphouse and consists of a 250 mm diameter drilled well to an approximate depth of 68 meters. The amended Permit to Take Water (PTTW) for Well's 2 and 2A identifies a total individual or combined taking of 1,634,400 L/day for Well's 2 and 2A and Schedule C of the Municipal Drinking Water ~~Licence~~ License lists the rated capacity of 1636 cubic meters per day for the combined Well #2 & 2A.

Given the close proximity to Well 2, similar depth, and same allocated pumping rates that were permitted for Well 2 as well as the combined rates for Well 2 and 2A, it was determined that an adjustment to the Durham Well 2A WHPA would be based on the existing groundwater model that was completed for the area.

GUDI Status

Durham Well 2 is a confirmed GUDI well (Henderson and Paddon, 2002a) for precautionary reasons due to the low topographic setting of the wellhead, the potential for ice dam flooding during the spring thawing condition, especially in the McGowan Dam area adjacent to Well 2. The shallow overburden offers little aquifer protection (Henderson and Paddon, 2002a).

Durham Well 1B was originally considered groundwater under the direct influence of surface water as noted by the Hydrogeological Report prepared by Henderson Paddon and Associates dated October, 2002 due to the proximity of contamination sources (Durham Water Works MOECC Inspection #228.03, May 20, 2003). The well is located near an industrial gravel pit to the south, which is causing the deterioration of the protective overburden layer. The gravel pit extends through most of its WHPA A-D. Historical land uses in this area were mostly industrial. The 2002 Henderson Paddon and Associates report already identified numerous above and below ground storage tanks and dispensing facilities within 100 metres of the well sites. Storage tanks contain fuels and other unknown substances that pose a potential risk to the aquifer and the town of Durham's water supply (MOECC, 2003b).

In 2026 Aqua Insight's review of Well 1B, forward particle tracking within the base case model indicated induced recharge from the Saugeen River with associated travel times ranging from 11 to 21 years. The travel times estimated through modelling suggest pathogens would be deprived of oxygen for a sufficient period of time during their subsurface transport to render them inert. Furthermore, surface water reaching the well would be diluted with groundwater reaching the well that is sourced from recharge. Analysis using numerical modelling results indicates that the water from the Saugeen River reaching Well 1B comprised less than 1% of the total water reaching the well. This indicates that water from the Saugeen River reaching the well would be diluted by a factor of 100 or more.

The results of the microbiological analyses for Well 1C indicated no E. coli or total coliforms were detected and that the bacteriological background count was also zero. Based on this analysis, Wells 1B and 1C are not considered GUDI sources.

TABLE 4.13.G1.1 – Description of the Drinking Water System and Wells

Well Name	Durham 1B	Durham 1C	Durham 2	Durham 2A
Drinking Water System ID	220001771			
Drinking Water System Classification	Large Municipal Residential System			
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA			
Northing/Easting	4890971.8 / 514683.9	4891047/ 515086	4891689 / 515100	4891673 / 515117
Year Constructed	1987	2024	1966	2013
Well Depth	77.7 m	70.7 m	74.7 m	68 m
Uncased Interval	20.6 - 77.7 m	17.1 – 70.7 m	12.8 - 74.7 m	
Aquifer	n/a	n/a	n/a	n/a
GUDI	~~Yes~~No	No	Yes	Yes
Number of Users Served	2,500 persons	conjunctive	conjunctive	conjunctive
Design Capacity (CoA)	1,375 m^3/day		1,636 m^3/day	1,636 m^3/day
Permitted Rate (PTTW)	1,363.8 m^3/day		1,634.4 m^3/day	1,634.4 m^3/day
Average Annual Usage *	925 m^3/day		648 m^3/day	648 m^3/day
Modelled Pumping Rate**	~~870~~ 950 m^3/day	950 m^3/day	~~672~~ 347 m^3/day	~~672~~ 347 m^3/day
Treatment	Filtration and ultra-violet (UV) treatment			

* *CRA Phase I, Round 1 Report 2007, Table 3.1*

*** A total modelled pumping rate of 2,594 m^3/day was used for the system*

Impervious Surfaces, Managed Land and Livestock Density

Approved

The percentage of impervious surfaces in the wellhead protection area has been computed. The results are listed in Table 4.13.G1.2a and shown on Map 4.13.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. The results are listed in Table 4.13.G1.2b and shown on Maps 4.13.G1.5 and 4.13.G1.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.13.G1.2a – Impervious Surfaces

General	Code for WHPA	DURHAM ~~1B~~
	Total Area [hectare]	~~85.19~~1031.8
Impervious Surfaces Area [ha]	<1%	~~0.0~~35
	1% – <8%	~~13.92~~552
	8% – < 30%	~~66.45~~372.6
	Larger or equal than 30%	~~4.81~~72.2

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

Formatted Table

TABLE 4.13.G1.2b – Managed Land and Livestock Density

WHPA_NAME	**DURHAM**			
Well Name	DURHAM ~~1B~~	DURHAM ~~1B~~	DURHAM ~~1B~~	DURHAM ~~1B~~
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%~~<40%~~	40-80%

~~**WHPA_NAME**~~	~~**DURHAM**~~			
~~**Well Name**~~	~~DURHAM 2 & 2A~~	~~DURHAM 2 & 2A~~	~~DURHAM 2 & 2A~~	~~DURHAM 2 & 2A~~
~~**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%~~

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

Wellhead Protection Area
WHPA A-D

The wellhead protection area (WHPA) was originally estimated using numerical modelling, following the methodology described in Section 4.1.2.5. In the surrounding area of Durham, groundwater flows from east to west, which causes the capture zones to extend east, uphill from the well in the direction of groundwater flow ~~(Map 4.13.G1.1)~~.

Approved

A recent study conducted by Brunton and Brintnell, 2020), identified Durham as being located within an ancient Barrier Reef Complex. Such karst features have the potential to result in high porosity zones within the aquifer. Furthermore, reef mounds are expected to follow a north-south orientation, which may explain some of the observed water level responses during pumping of Well 1C.

The updated model was calibrated under a steady-state condition to static, observed water levels at time of drilling from water well records, and transiently to the 2024, 3-day pumping test at Well 1-C (Aqua Insight, 2026). Another factor that affected the change in WHPA were the pump tests for Well 1C which identified moderate hydraulic connections between wells 2A and B (located to the north), versus a low hydraulic connection to Well 1B, which is approximately 400m to the west.

Effective porosity values of 20% and 3% were utilized in overburden and bedrock units, respectively, consistent with those applied during the transient calibration and other WHPA delineation studies within southwestern Ontario. Based on the results of the tracer tests, a value of 3% was assigned as the effective porosity for the bedrock units in the Study Area (Aqua Insight, 2026).

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

In comparison to the previous model developed by WHI (2003), several key differences were identified in the Aqua Insight study, resulting in significant WHPA changes (Map 4.13.G1.1):

- The refined conceptualization of the regional bedrock layer structure results in wider WHPAs in the north-south direction.
- Given the proximity of Wells 2 and 2A to the Saugeen River, the northern component of the current WHPAs indicates that these wells capture a portion of their source water from north of Saugeen River, which was not simulated in the previous modelling effort.
- The current model extends further east to include the furthest conceptual recharge source waters from the Singhampton Moraine and groundwater inflow rate within the previous model was un-calibrated.
- The inclusion of pumping from Well 1C, which was not constructed at the time of the previous assessment, captures groundwater that would otherwise be captured by Well 1B (located approximately 400 m west and downgradient of Well 1C). This further broadens the WPHA south of Well 1C.
- Finally, the currently applied pumping rates, based on a greater future average daily water demand in accordance with future (2052) population projection, were greater than those applied for the previous WHPA delineation (WHI, 2003). This greater total pumping rate results in larger WHPAs, both in breadth and length.

Formatted: Bulleted + Level: 1 + Aligned at: 0.63 cm + Indent at: 1.27 cm

The Durham ~~Well 1B~~ WHPA ~~-D~~ is approximately ~~0.35~~2.8 km in width and ~~2.5~~ 3.7 km in length, which captures a total area of approximately ~~85~~ 1000 ha. The ~~differences in~~ overall WHPA size and shape is due to the presence of the Saugeen River, which essentially flows along the length of the ~~Durham 2~~ WHPA~~, and a larger pumping rate at Well 1B, which draws more water into the well and generates a slightly larger and wider capture zone~~.

Approved

For Durham ~~Well 1B~~, the 2-year time-of-travel, WHPAs A and B, extends ~~300~~ 1,500m from the well. Land uses in that area are commercial, industrial and residential, including warehousing and aggregate operations with large gravel quarries. WHPAs C and D have industrial/quarry, agricultural and residential properties within.

WHPA A-D Uncertainty Cases

The 2026 Aqua Insight vulnerability assessment was undertaken using the composite capture zones, which were developed using base case calibrated groundwater flow model as well as 3 uncertainty cases. The fastest travel time under each case (i.e., base and 3 uncertainty cases) was carried forward to the calculation of the total advective travel times (Aqua Insight, 2026). The resulting uncertainties associated with the WHPA delineation, groundwater vulnerability, and transport pathways assessment were considered low for all the resultant vulnerability score polygons for the WHPAs in the Durham Area.

The changes in hydraulic conductivities implemented through the uncertainty scenarios were primarily chosen to explore alternative hypotheses that we considered plausible. Compensating parameter changes (i.e., lower hydraulic conductivity with lower groundwater recharge) were implemented to maintain a similar degree of model calibration. A scenario is considered suitable for making capture zone or other predictions only if it is calibrated to an equivalent degree.

For the first uncertainty case the conductivity of the Upper Guelph Formation was lowered to be consistent with earlier interpretations by Genivar (2013), which stemmed from a pumping test at Well #2. Additionally, inferred stratification of hydraulic conductivity were removed within the bedrock layers because, although the stratification is conceptually expected, little local data is available to confirm this stratification.

For the second uncertainty case built upon the first by changing the bedding plane features to karst-like features with broader hydraulic conductivity zones. This change was designed to evaluate the impact of changing the type of high hydraulic conductivity features near the production wells.

The third uncertainty case was primarily intended to evaluate lower groundwater recharge and the potential impact on hydraulic conductivity and capture zone extent. In addition, the higher hydraulic conductivity zone within the bedrock (Goat Island Formation layer) was extended to evaluate the effect of a broader zone of enhanced hydraulic conductivity on the shape and extent of the capture zones.

The groundwater recharge estimates applied in this study were based on the GASWER hydrologic modelling (AquaResource, 2008b), which was calibrated to stream flow monitoring data. That hydrologic modelling is subject to uncertainty in water budget assumptions. The most impactful assumption relates to the rate of actual evapotranspiration because it is the dominant component in the water balance; consequently, the estimated recharge is subject to uncertainty in the evapotranspiration losses. In considering this uncertainty, the relatively high number of water bodies in the area were considered to evaporate water at the potential evaporation rate, which could reduce the estimated groundwater recharge by 20%. Consequently,

Formatted: Not Highlight
Formatted: Underline
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: Times New Roman
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: Times New Roman
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: Times New Roman
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: Times New Roman
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt

the Study concluded that it was prudent to lower the recharge by 20% as part of the uncertainty analysis.

Formatted: Font: (Default) Times New Roman, 12 pt

Map 4.13.G1.2 shows the borders of all zones of WHPA overlaying aerial photography.

WHPA-E
WHPA-Es were delineated in the surface water body that influences both GUDI wells.

The closest surface water body to Durham Well 2 is the Saugeen River. Two dams are located immediately north of this well, Middle Durham Dam and the upper dam at McGowan Falls. Both dams create reservoirs of 6.4 ha and 2 ha respectively. Technical Rule 47(5a) was applied and the point closest to the well was identified. Durham well No. 2's point of interaction is located 150 metres north of the well, on the Saugeen River, outside the WHPA. Using modelling, the WHPA-E was delineated for the Durham Well 2, with the Saugeen River as influencing surface water. The WHPA-E extends 8.4 km in upstream direction of the river and includes all tributaries within the 2-hour ToT.

Durham Well 1B is located north-east of Lower Durham Dam. The closest surface water body is Durham Creek that drains into Saugeen River at South Street West. However, several ponds are located within the Durham 1B WHPA that are likely to contribute water to the aquifer. Technical Rule 47(5a) was applied and the point closest to the well was identified. The point of interaction for the Durham 1B well is a small tributary to the west of the well, approximately 230 metres upstream its mouth into the Saugeen River. For Durham Well 1B, numerical modelling or analysis was not necessary because the length of the influencing surface water body is less than 1 km. Thus, the complete water body was considered WHPA-E.

For ~~both~~ WHPA-Es, a 120 metre setback, and the regulation limit whichever is greater, and areas with agricultural tile drainage were added (for details, see Section 4.1.2.7).

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 4.1.2.5), unless the vulnerability is already rated high.

The Durham Well ~~1B~~ WHPA is covered extensively by active gravel pits with above water table extraction activities. Extraction activities remove the protective overburden material above aquifers, which increases vulnerability. Developed and ~~built up~~built-up areas within WHPAs A and B of ~~each~~ Durham WHPA are serviced by municipal sanitary sewers.

To account for these features, the Technical Rules (MECP, 2021) note that the vulnerability rating can be increased from moderate to high, or low to moderate (or high) in areas where preferential pathways are present. Professional judgement is then used to determine whether to increase the vulnerability category rating in an area based on the hydrogeological conditions, the depth and nature of the pathway and potential for cumulative impacts.

Approved

Preferential pathways were assessed by Aqua Insight in 2026 and reviewed to determine where updates to the vulnerability category rating should be conducted. The preferential pathways assembled included the following categories:

- Linear infrastructure including underground storm and sanitary sewers
- Vertical features, including:
    - Current and historic landfills
    - Stormwater detention ponds
    - Aggregate extraction areas
    - Boreholes clustered in groups of 6 or more within 100 m of one another that were drilled prior to 1990 ~~Aquifer Vulnerability was adjusted one level to account for an out of compliance well within the WHPA-D for the Durham WHPA (See Map 4.13.G1.3). No transport pathway adjustments were made in the urban area (within WHPA A and WHPA B), or for the former and active aggregate pits located in WHPA C and WHPA D as these areas were already designated as highly vulnerable.~~

A couple aggregate extraction operations were located in the southwestern portion of the WHPA. SWAT vulnerability ratings for these properties resulted in a mix of low, moderate and high vulnerability. The potential for fuel storage on-site as well as the assumption that these operations will continue to extract aggregate into the future, thereby reducing overburden thickness, is interpreted to increase the vulnerability of the underlying bedrock production aquifer. As such the vulnerability rating was increased from low or moderate to high over the entire property footprint (i.e., land parcel) of both operations.

Vulnerability

After overlaying the intrinsic susceptibility index (Map 4.13.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.13.G1.3. As part of the 2026 Aqua Insight vulnerability assessment, groundwater vulnerability was evaluated within the newly delineated WHPAs using the surface to well advective travel time (SWAT) methodology, versus the Intrinsic Susceptibility Index (ISI) that was used in the original assessment. SWAT calculations provide a physically based estimate of aquifer vulnerability based on estimates the total travel time from ground surface to a pumping well. This approach uses the calibrated groundwater flow model and the values applied are expressed in units of time, rather than subjective index values. The SWAT approach was selected to evaluate the aquifer vulnerability as it utilizes the three-dimensional hydrogeologic characterization and groundwater flows and calculations are more consistent with the particle tracking techniques employed to delineate WHPAs.

WHPA A-D

~~Both t~~The revised Durham WHPA~~s~~ are categorized by high intrinsic groundwater susceptibility (Map 4.13.M1) as a result of the abundance of course-grained gravel deposits or thin overburden deposits, which provide limited protection to the underlying groundwater aquifers.

Because groundwater vulnerability is categorized as high, the vulnerability scores for all WHPAs show that groundwater vulnerability decreases with distance from the supply well. WHPA-A is the most sensitive area and closest to the supply well. A vulnerability score of ten is assigned in this zone to reflect the high vulnerability that groundwater will be contaminated by surface

Formatted: List Paragraph, Bulleted + Level: 1 + Aligned at: 0.63 cm + Indent at: 1.27 cm

Formatted: List Paragraph, Bulleted + Level: 2 + Aligned at: 1.9 cm + Indent at: 2.54 cm

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: Not Italic

Formatted: Justified

conditions or activities in close proximity to the wellhead. The remaining sensitive areas have a relatively high vulnerability ranging from six to ten, which are the maximum scores that can be assigned within each zone, as a result of the high intrinsic vulnerability of groundwater across the WHPA (CRA, 2009).

WHPA E

The vulnerability of the WHPA-Es associated with the Durham wells is relatively high; Well ~~1B (9.0), Well~~ 2 (8.0). This score was determined by multiplying the area vulnerability score with the source vulnerability score (see Table 4.13.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 9 (high) for the Durham 1B WHPA-E area and~~ 8 (moderate) for the Durham 2 WHPA-E area with the source vulnerability score 1.0 (high) for both areas due to little overburden protection.

Uncertainty for WHPA-E delineation is high (see Section 4.1.7.4 for details).

TABLE 4.13.G1.2c – Vulnerability of WHPA-E Associated with the Durham Well Supply

Name of WHPA	**DURHAM_2**	
DWIS_ID	220001771	
Area (Total), hectares	731.48	
Vulnerability (Total)	**8.0**	
Source Vulnerability	**1.0**	
SV - Distance to surfacing Karst [m]	> 500 m	0.8
SV - Overburden Protection	7.28 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	Moderately fine loam	8
Soil permeability *	Highly permeable	7
Setback Slope [%]	12.6%	9
AV Transport Pathways	**7.33**	
Tile Drainage [% of land area]	< 33%	7
Storm Catchment	< 33%	7
Number of Watercourses/1,000 ha	4-6	8

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

Formatted Table

Approved

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.

The vulnerability scoring was completed to include documented potential preferential transport pathways within the WHPAs that warranted an increase in the vulnerability. Staff used the updated WHPA and vulnerability mapping to complete a threats assessment and identified 69 additional potential threats that may need to be addressed within the updated WHPA for Durham (T~~ABLE~~able 4.13.G1.3a).

WHPA A-D
There are ~~5~~ 69 significant drinking water threats in the Durham ~~(Well 1B)~~ wellhead protection area A-D~~-~~. These threats include ~~one~~ 20 ~~activity~~ activities related to the potential for pathogen contamination, and 49 activities related to contamination with hazardous chemicals. The total number of properties with threats is ~~3~~ 50 (see detailed Table 4.13.G1.3 and ~~summary~~ Summary Table 4.13.G1.4).

WHPAs A and B scored a high vulnerability, creating a large area where activities are rated as significant drinking water threats to drinking water sources. Commercial, residential and industrial/aggregate are dominating land uses of WHPAs A and B. The significant threats within the residential areas of WHPAs A and B include storage of fuel. The significant threats within the commercial areas include DNAPL~~,~~ and storage of fuel. MOECC data indicates fuel spills in the direct vicinity of Well 1B and historic conditions related to automobile repair within 100 m of the well.

~~There are no significant drinking water threats in the Durham (Well 2 and 2A) wellhead protection area A-D (see detailed Table 4.13.G1.3 and summary Table 4.13.G1.4).~~

The threats within WHPA-A consist of residential lands having threats of septic systems, fuel storage and waste disposal. There is a threat in WHPA-B linked to conservation lands, which is a threat of sanitary sewers and related pipes. WHPAs C and D are classified as low vulnerability and consist of residential and agricultural properties.

WHPA-E
With surface water influencing ~~the Well 1B and~~ Well 2, WHPA-E~~s~~ ~~were~~ was delineated. The vulnerability score of the WHPA-E ~~for Well 1B is 9.0 and~~ for Well 2 is 8.0; chemical and pathogen threats can be significant (see Section 4.1.5.7). For chemical threats, there is one activity related to the application of road for the Durham ~~Well 1B~~ WHPA-E. Some activities that discharge sewage would be considered pathogen threats, but none were identified in this area. Agricultural activities that have the potential to contaminate surface water with pathogens were

identified totalling 10 for the Durham Well 2 and 2A WHPA-E. A total of 11 activities were identified in this area as significant threats to drinking water sources (Table 4.13.G1.3c).

<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 4.13.G1.3a – Durham~~ Well 1B~~: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: DURHAM_1B** *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~~18		**~~1~~18**
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	Salt – Application to land		~~2~~8								**~~2~~8**
13	Road Salt – Handling and Storage		2								**2**
14	Snow – Storage										
15	Fuel - Handling and storage		10								**10**
17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards										
22	Liquid Hydrocarbon Pipelines										
DNAPLs											
16	Dense non-aqueous phase liquid - Handling and storage		11								**11**
PATHOGENS											
2	Sewage systems - Collection, storage, transmittance, treatment or disposal								~~1~~18		**~~1~~18**
3	Agricultural source material - Application to land	1									**1**
4	Agricultural source material - Storage										
6	Non-agricultural source material - Application to land										

Approved

7	Non-agricultural source material - Handling and storage										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards	1									1

~~TABLE 4.13.G1.3b – Durham Well 2 and 2A: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)~~

Quality of Raw Water at the Well
There are no reports of any standards being exceeded.

TABLE 4.13.G1.~~3c~~ 3b – Durham~~ Well 1B and 2~~: Significant Drinking Water Threats Associated with the WHPA-E

	Prescribed Threat Name *For full legal name of prescribed threat, see Table 4.1.5*		**DURHAM 2**
	CHEMICALS		
12	Salt - Application to land		1
	PATHOGENS		
1	disposal of hauled sewage to land~~Untreated septage - Application to land~~		2
3	Agricultural source material - Application to land		2
4	Agricultural source material - Storage		
6	Non-agricultural source material - Application to land		
7	Non-agricultural source material - Handling and storage		1
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing	Grazing and pasturing	4
21		Yards and confinement	1
	Grand Total		~~10~~11

Formatted Table

TABLE 4.13.G1.4 – Durham WHPA: Summary of Significant Drinking Water Threats

DURHAM ~~1B~~	**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	~~1~~38	~~0~~11	~~1~~20		~~2~~69		~~0~~1	~~0~~18	~~1~~50		~~1~~69
WHPA E	1		~~0~~10		~~0~~11		~~0~~6		1		~~1~~7
~~**DURHAM 2**~~											
~~WHPA A-D~~	~~0~~	~~0~~	~~0~~	-	~~0~~	-	~~0~~	~~0~~	~~0~~	-	~~0~~
~~WHPA E~~	~~0~~		~~10~~		~~10~~		~~6~~				~~6~~

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

4.13.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 4.13.G1.5 – Durham: Issues and Conditions

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

Approved

4.2.13.2.2 Neustadt Well Supply

The water supply system for Neustadt is comprised of three bedrock supply wells (Neustadt Wells 1, 2 and 3) servicing approximately 540 people. The wells are located in an agricultural setting south of Neustadt. Until the installation of these wells, Neustadt relied on private shallow dug wells for water service (Henderson and Paddon, 2002b). Wells 1 and 3 are considered the main pumping wells, and Well 2 acts as a standby. Water from all three wells is treated at a single treatment facility.

Well records indicate that Well 1 has a depth of 38.1 m and was drilled in 1990. A steel casing was installed to a depth of 20.7 m, with an additional 1.4 m capped and bolted section extending above ground. Well 2 has a depth of 29.6 m and was drilled in 1992. A steel casing was installed to a depth of 12.5 m, with cement grouting along the entire casing length and an additional 1.3 m capped, bolted and padlocked section extending above ground (Montgomery, 2001).

GUDI status was confirmed by studies from Henderson, Paddon & Associates Ltd. in 2002(b). For Well 1, there is a potential influence due to a relatively thin and permeable overburden in the area of this well.

TABLE 4.13.G2.1 – Description of the Drinking Water System and Wells

Well Name	Neustadt 1	Neustadt 2	Neustadt 3
Drinking Water System ID	210002147		
Drinking Water System Classification	Large Municipal Residential System		
SPA of Well and Vulnerable Area (WHPA)	Saugeen Valley SPA		
Northing/Easting	4878593.5 / 500146.3	4878694.4 / 500743.2	4878694.7 / 500726.3
Year Constructed	1990	1992	1993
Well Depth	38.1 m	29.6 m	30.8 m
Uncased Interval	20.7 - 38.1 m	12.5 - 29.6 m	12.2 - 30.8 m
Aquifer	Bedrock	Bedrock	Bedrock
GUDI	Yes	Yes	Yes
Number of Users Served	460 persons		
Design Capacity (CoA)	915.84 m^3/day		
Permitted Rate (PTTW)	276 m^3/day	916 m^3/day	527 m^3/day
Average Annual Usage*	43 m^3/day	28 m^3/day	64 m^3/day
Modelled Pumping Rate	62 m^3/day	29 m^3/day	58 m^3/day
Treatment	Primary chlorination disinfection, UV disinfection system for seasonal use		

** CRA Phase I, Round 1 Report 2007, Table 3.1*

Approved

Well 3 has a depth of 30.8 m and was drilled in 1993. A steel casing was installed to a depth of 12.2 m, with cement grouting along the entire casing length. This well is located in a low-lying area and has a history of surface water pooling around the wellhead (Montgomery, 2001); however, there has been no history of flooding in the area. GUDI status was confirmed by a separate study (Henderson and Paddon, 2002b).

Maps of the water distribution system were obtained.

A wellhead protection area (WHPA) for the Neustadt 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 planned operation of the wells 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 4.13.G2.2a and shown on Map 4.13.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. The results are listed in Table 4.13.G2.2b and shown on Maps 4.13.G2.5 and 4.13.G2.6. This classification impacts the risk rating of some activities (see Section 4.1.4.4).

TABLE 4.13.G2.2a – Impervious Surfaces

General	Code for WHPA	NEUSTADT_1	NEUSTADT_2_3
	Total Area [hectare]	55.14	36.26
Impervious Surfaces Area [ha]	<1%	21.39	14.60
	1% – <8%	33.75	21.66
	8% – < 30%	0.0	0.0
	Larger or equal than 30%	-	-

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

Wellhead Protection Area

<u>WHPA A-D</u>

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

The Neustadt capture zones are longer and thinner than the Durham capture zones with groundwater flowing north, which causes the capture zones to extend south, uphill along the groundwater flow path (Map 4.13.G2.1).

The Neustadt Well 1 capture zone has a narrow width of approximately 100 m but widens to approximately 500 m at the terminus, which is within the vicinity of Meux Creek. Its total length is approximately 3 km. The land use in WHPAs A and B consists of residential and agricultural properties. WHPAs C and D consist of agricultural and wooded land. Meux Creek flows through WHPA-D.

Approved

Neustadt Wells 2 and 3 share a capture zone that is slightly wider than Neustadt 1 but thins out at the terminus.

The total capture area for the Neustadt wells is 55 ha for Well 1 and 36 ha for Wells 2 and 3. This WHPA extends south of the well 3.6 kilometres. The land use in WHPAs A and B consists of residential and agricultural properties. WHPAs C and D consist of agricultural and wooded land.

Map 4.13.G2.2 shows the borders of all WHPA zones overlaying aerial photography.

TABLE 4.13.G2.2b – Managed Land and Livestock Density

WHPA_NAME	**NEUSTADT**			
Well Name	NEUSTADT 1	NEUSTADT 1	NEUSTADT 1	NEUSTADT 1
Zone	A	B	C	D
Livestock Density Category (<0.5, 0.5-1.0, >1.0)	0.5-1.0	0.5-1.0	0.5-1.0	<0.5
% Managed Lands (<40%, 40-80%, >80%)	40-80%	>80%	>80%	>80%

WHPA_NAME	**NEUSTADT**			
Well Name	NEUSTADT 2&3	NEUSTADT 2&3	NEUSTADT 2&3	NEUSTADT 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%)	40-80%	>80%	>80%	>80%

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

WHPA-E

A WHPA-E was delineated for Well 1, and a separate one for Wells 2 and 3. A point of interaction is not known for the Neustadt wells. Thus, Technical Rule 47(5a) was applied and the point closest to the well was identified.

Wells 2 and 3, which are only 17 metres apart, have an identical point of interaction in an unnamed, small tributary of the Meux Creek. Both wells have their point of interaction outside of their WHPAs, at a distance of approximately 300 metres. The upland section of all surface water bodies was very small, so that no modelling needed to be performed. Along these water bodies, the 120 m setback was used to delineate the upland area. Agricultural tile drainage was added accordingly. No Conservation Authority regulation limits exist in the vicinity of the WHPA-E.

No surface water can be associated with Well 1 and the point of interaction is the well itself, and the WHPA-E is the 120 m setback to this point, a circle.

Approved

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 4.1.2.5), unless the vulnerability is already rated high.

The eastern edge of the Neustadt Wells 2 and 3 WHPA-D borders a zone of moderate intrinsic vulnerability. This fringe of moderate intrinsic vulnerability area intersecting WHPA-D is more a reflection of the coarse grid resolution as opposed to the actual conditions. Previous ISI mapping at a smaller grid cell size places the Neustadt WHPAs entirely in a high ISI index zone (WHI, 2003).

Aquifer vulnerability was adjusted one level to account for transport pathways within the Neustadt 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 4.13.G2.3.

Vulnerability
<u>WHPA A-D</u>
After overlaying the intrinsic susceptibility index (Map 4.13.M1) on the delineation of wellhead capture zones, vulnerability scores were determined (see Section 4.3.1 for detail). The vulnerability is shown on Map 4.13.G2.3.

The Neustadt WHPAs are categorized with a high intrinsic groundwater susceptibility (Map 4.13.M1), namely as a result of the abundance of course-grained gravel deposits or thin overburden deposits, which provide limited protection to the underlying groundwater aquifers.

Because groundwater vulnerability is categorized as high, the vulnerability scores for all WHPAs show that groundwater vulnerability decreases with distance from the supply well. WHPA-A is the most sensitive area, due to its proximity to the supply well, and has a vulnerability score of ten. The remaining sensitive areas have a relatively high vulnerability ranging from six to ten, which are the maximum scores that can be assigned within each zone, as a result of the high intrinsic vulnerability of the groundwater across the WHPA (CRA, 2009).

<u>WHPA-E</u>
The total vulnerability of both WHPA-Es associated with the Neustadt wells is moderate (7.2). These scores were determined by multiplying the area vulnerability score (8, moderate) with the source vulnerability score (0.9, moderate, for all wells).

Approved

TABLE 4.13.G2.2c – Vulnerability of WHPA-E Associated with the Neustadt Well Supply

Name of WHPA	Neustadt_1		Neustadt_2_3
DWIS_ID	210000167		210000167
Area (Total), hectares	258.4791068		
Vulnerability (Total)		**7.2**	
Source Vulnerability		**0.9**	
SV - Distance to surfacing Karst [m]	> 500 m	0.8	
SV - Overburden Protection	24.4 m	0.9	
Area Vulnerability		**8 (8.1)**	
AV - Percent Land: Score		**9**	
AV - Percentage of Land	> 70%	9	
AV - Land Characteristics		**7.7**	
Land Cover *	30% Agricultural, 20% Developed, 50% Natural	7.8	
Soil type	22.5% gravel, 5.6% organic deposits, 69.5% sand,	7.1	
Soil permeability *	100% A,	7.0	
Slope [%]	6.3%	9.0	
AV Transport Pathways		**7.7**	
Tile Drainage [% of land area]	13.4%	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 19 significant drinking water threats in the Neustadt (Well 1) wellhead protection area A-D. These threats include 8 activities related to the potential for pathogen contamination, and 11 activities related to contamination with hazardous chemicals. The total number of properties with threats is five (see detailed Table 4.13.G2.3 and summary Table 4.13.G2.4).

Approved

There are 13 significant drinking water threats in the Neustadt (Well 2 and 3) wellhead protection area A-D. These threats include 6 activities related to the potential for pathogen contamination, and 7 activities related to contamination with hazardous chemicals. The total number of properties with threats is three (see detailed Table 4.13.G2.3 and summary Table 4.13.G2.4).

The wells are located outside of Neustadt and the land use surrounding the wells is agricultural, including farm houses. Activities associated with potentially significant threats include the application of pesticides to land, the storage of commercial fertilizers, pesticide and fuel. Pathogens may enter the drinking water through the application of agricultural and non-agricultural source material and Outdoor Confinement Area~~pastures~~.

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

Neustadt Well 1 shows that levels of coliform bacteria were infrequently exceeded (DWIS). This is usual for wells that are under the influence of surface water (GUDI).

TABLE 4.13.G2.3a – Neustadt Well 1: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: NEUSTADT_1** *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							3		**4**
3	Agricultural source material - Application to land	2									**2**
4	Agricultural source material - Storage	1									**1**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
8	Commercial fertilizer - Application to land	2									**2**
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	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing	1									**1**
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
1	disposal of hauled sewage to land~~Untreated Septage – Application to land~~										
2	Sewage systems - Collection, storage, transmittance, treatment or disposal	1							3		**4**
3	Agricultural source material - Application to land	2									**2**
4	Agricultural source material - Storage	1									**1**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards - Livestock grazing	1									**1**

TABLE 4.13.G2.3b – Neustadt Wells 2 and 3: Significant Drinking Water Threats by Activity and Land Use in WHPA A-D (Chemical, Pathogen and DNAPL)

Prescribed Threat **WHPA: NEUSTADT_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	1									**1**
3	Agricultural source material - Application to land	1									**1**
4	Agricultural source material - Storage	1									**1**
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	1									**1**
10	Pesticide - Application to land										
11	Pesticide - Handling and storage										
14	Snow - Storage										
15	Fuel - Handling and storage										

Approved

17	Organic solvent - Handling and storage										
18	De-icing chemicals - Runoff from airports										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards	3									**3**
22	Liquid Hydrocarbon Pipelines										
	DNAPLs										
16	Dense non-aqueous phase liquid - Handling and storage										
	PATHOGENS										
1	disposal of hauled sewage to land~~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	1									**1**
6	Non-agricultural source material - Application to land										
7	Non-agricultural source material - Handling and storage										
21	Outdoor Confinement Area~~Pastures~~ or other farm-animal yards	3									**3**

Approved

TABLE 4.13.G2.4 – Neustadt 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			
NEUSTADT_1	Chemical	DNAPL	Pathogen	Total	Agri-cultural	Resid-ential	Others	Total
WHPA A-D	11	0	8	19	2	3	0	5
WHPA E				0				0
NEUSTADT_2_3								
WHPA A-D	7	0	6	13	3	0	0	3
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 4.13.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 4.13.G2.5 – Neustadt: Issues and Conditions

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

4.2.13.3 Surface Water Municipal Systems

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

Approved

REFERENCES

Agriculture and Agri-Food Canada, 1983. Updates to Soils Mapping from the Soil Survey of Bruce County, Report No.16 of the Ontario Soil Survey, Hoffman and Richards, 1954.

Aqua Insight Inc., 2026. Source Protection Study for the Community of Durham for the Municipality of West Grey, Waterloo, ON. February, 2026.

Baird, 2012. Numerical Modelling in Support of IPZ-3 Delineation, Saugeen, Grey Sauble, Northern Bruce Peninsula. W.F. Baird & Associates Coastal Engineers Ltd. Oakville, ON. February, 2012.

Baird, 2013. IPZ-3 Modelling for Identification of Significant Threats, Saugeen, Grey Sauble, Northern Bruce Peninsula. W.F. Baird & Associates Coastal Engineers Ltd. Oakville, ON. September, 2014.

Burniston *et al.,* 2006. Sediment Quality in Canadian Lake Huron Tributaries: A Screening – Level Survey. Environment Canada.

Burnside, R.J., 2001a. Town of Minto Groundwater Study. R. J. Burnside & Associates Limited.

Burnside, R.J., 2001b. Engineer's Report. Teeswater Well Supply. R. J. Burnside & Associates Limited, May 28, 2001.

Burnside, R.J., 2023. PTTW Amendment. Minto Pines Subdivision Well. Burnside & Associates Limited, June 20, 2023.

Chapman, L.J. and D.F. Putnam, 1984. *The Physiography of Southern Ontario*. Ontario Geological Survey.

CRA, 2007. 2005-2006 Groundwater Technical Study, Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region. Conestoga-Rovers & Associates. Owen Sound, ON. November 2007.

CRA, 2008. Round 2 Groundwater Technical Study Groundwater Vulnerability Assessment for the Municipalities of West Grey and Northern Bruce Peninsula. Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region. Conestoga-Rovers & Associates. Owen Sound, ON. September 2008.

CRA, 2008b. Preliminary Analysis For Municipal Well Head Protection Areas Grey Sauble Conservation Authority Owen Sound, Ontario. Reference No. 047059 (2). February 2008.

CRA, 2009. Phase II: Groundwater Technical Study: Groundwater Vulnerability Assessment Drinking Water Quality Threats. Commissioned by Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region. Conestoga-Rovers & Associates. Owen Sound, ON. August 2009.

Approved

Cobean, S.J., 2001. First Engineer's Report for the Durham Municipal Water Works, Corporation of the Township of West Grey, County of Grey. D.J. Peach & Associates Ltd. Professional Engineers, Durham ON. January 2001.

Colozza, F.C., 2001. The Corporation of the Municipality of West Grey Wellhead Inspection Report for the Neustadt Groundwater Supply System. AMEC Earth and Environmental Limited. London, ON. May 2001.

Environment Canada, 1999. *Canadian Environmental Protection Act, 1999.* Government of Canada.

GENIVAR, 2009. Municipality of Arran-Elderslie Groundwater Vulnerability Study. GENIVAR Consultants LP.

GENIVAR, 2010. Source Water Protection Round 2 Groundwater Technical Study Communities of Tara and Chesley Municipality of Arran-Elderslie. GENIVAR Consultants LP.

Golder, 2001. Town of Walkerton Groundwater Protection Study. Golder and Associates.

Golder, 2003. Determination of Capture Zones for Walkerton Wells 7 and 9 Municipality of Brockton County of Bruce, ON. Golder and Associates. February 28, 2003.

Golder, 2006. County of Wellington Groundwater Protection Study. Golder and Associates.

Golder, 2010. Update to County of Wellington Groundwater Protection Study. Golder and Associates.

Harden Environmental, 2002. Hanover Well No. 1 Hydrogeological Assessment. March 2002.

Henderson and Paddon, 2000. Engineer's Report for the Chesley Water Works.

Henderson and Paddon, 2002a. Hydrogeologic Study to Examine Groundwater Sources Potentially Under the Direct Influence of Surface Water (Town of Durham Supply Wells #1B & #2), (Former Town of Durham), Municipality of West Grey. Henderson, Paddon & Associates Limited, Civil Engineering Consultants and Planners. Owen Sound, ON. October 2002.

Henderson and Paddon, 2002b. Hydrogeologic Study to Examine Groundwater Sources Potentially Under the Direct Influence of Surface Water (Neustadt Water Supply Wells 1, 2, and 3) Former Village of Neustadt, Municipality of West Grey. Henderson, Paddon & Associates Limited Civil Engineering Consultants and Planners. Owen Sound, ON. September 2002.

Henderson and Paddon, 2003: "Municipality of Arran-Elderslie (Chesley), Well Assessment and Groundwater Study, Community Park Well 3", Henderson Paddon & Associates Limited, Project No. 101075, October 2003.

Approved

Hoffman and Richards, 1954. Hoffman, D.W. and N.R. Richards, Soil Survey of Bruce County, Report No.16 of the Ontario Soil Survey, 1954.

Matrix, 2016. Town of Ripley, Township of Huron Kinloss Wellhead Protection Area Delineation Ripley Wells 3 And 4. Matrix Solutions Inc. Breslau, ON. January, 2016.

Matrix, 2023. Preliminary Wellhead Protection Area Delineation and Vulnerability Scoring, Scott Point Well, Table 3 (2018-2022), Matrix Solutions Inc. Breslau, ON. March, 2023.

MNRF, Water Poly Segment (WPS). GIS Dataset. Ontario Ministry of Natural Resources. Queen's Printer for Ontario.

MNRF, 1999. Water Virtual Flow (WVF). GIS Dataset. Created 1998, updated 1999. Ontario Ministry of Natural Resources. Queen's Printer for Ontario.

MNRF, 2006a. Southwestern Ontario Orthophotography Project (SWOOP). Images taken in 2006 at 30 cm resolution by First Base Solutions, Inc., 2006. Ontario Ministry of Natural Resources. Queen's Printer for Ontario.

MNRF, 2006b. Digital Elevation Model Version 2.0.0. GIS Dataset. Created 2005, updated 2006. Ontario Ministry of Natural Resources. Queen's Printer for Ontario.

MNRF, 2009. Southern Ontario Land Resource Information System (SOLRIS) Version 2.0. GIS Dataset. Created 2000, updated 2009. Ontario Ministry of Natural Resources. Queen's Printer for Ontario.

MNRF, 2009. Ontario Base Mapping (OBM). Contour. GIS Dataset. Created 1977, updated 2009. Ontario Ministry of Natural Resources. Queen's Printer for Ontario.

MNRF, 2010. Southwestern Ontario Orthophotography Project (SWOOP) 2010. Data supplied under License by Members of the Ontario Geospatial Data Exchange. Ontario Ministry of Natural Resources. Queen's Printer for Ontario.

MOECC, 2001. Groundwater Studies 2001/2002 Technical Terms of Reference. Ontario Ministry of the Environment. Queen's Printer for Ontario, 2001.

MOECC, 2002. *Safe Drinking Water Act, 2002*. Ontario Ministry of the Environment. Queen's Printer for Ontario, 2002.

MOECC, 2003a. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. Ontario Ministry of the Environment. Queen's Printer for Ontario, 2006.

MOECC, 2003b. Drinking Water Inspection Report. Durham Water Works Inspection #228.03, May 20, 2003. Ontario Ministry of the Environment.

Approved

MOECC, 2003c. Drinking Water Inspection Report. Lake Rosalind Water Works. Inspection February 6, 2003. Ontario Ministry of the Environment, Safe Drinking Water Branch. Report compiled February 20, 2003.

MOECC, 2004. Drinking Water Inspection Report. Chepstow Well Supply. Powers Subdivision Well Supply Inspection #1-PHHN, September 28, 2004. Ontario Ministry of the Environment, Safe Drinking Water Branch. Report compiled December 15, 2004.

MOECC, 2005a. Ontario Ministry of the Environment. Drinking Water Systems Regulation O.Reg. 170/03 Southampton Water Treatment Plant, Annual Report-Part III Form 2, 2005.

MOECC, 2005b. Drinking Water System Inspection Report. Lakeshore Well Supply. Inspection #1-49RZ8, May 10, 2005. Ontario Ministry of the Environment, Safe Drinking Water Branch. Report compiled August 5, 2005.

MOECC, 2005c. Drinking Water System Inspection Report. Mount Forest Well Supply. Inspection #1-TYK5, February 15, 2005. Ontario Ministry of the Environment, Safe Drinking Water Branch. Report compiled April 18, 2005.

MOECC, 2006a. *Clean Water Act, 2006.* Ontario Ministry of the Environment. Queen's Printer for Ontario, 2006.

MOECC, 2006b. Drinking Water System Inspection Report. Arran-Elderslie Well Supply. Inspection #1-5CF2R, June 7, 2006. Ontario Ministry of the Environment, Safe Drinking Water Branch. Report compiled July 31, 2006.

MOECC, 2006c. Ministry of the Environment Amended Certificate of Approval Municipal Drinking Water Systems Southampton WTP #0482-6U2PG4, November 2006.

MOECC, 2006d. Drinking Water System Inspection Report. Kincardine Water Treatment Plant. Inspection 2006. Ontario Ministry of the Environment, Safe Drinking Water Branch.

MOECC, 2008. Drinking Water System Inspection Report. Markdale Well Supply. Inspection #1-6ONY7, May 6, 2008. Ontario Ministry of the Environment, Safe Drinking Water Branch. Report compiled July 18, 2008.

MOECC, 2009a. Technical Rules: Assessment Report to the *Clean Water Act*, *2006*. Section 107. Ontario Ministry of the Environment. Queen's Printer for Ontario, 2009.

MOECC, 2009b. Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source of Material, Non-Agricultural Source of Material and Commercial Fertilizers. Ontario Ministry of the Environment. Queen's Printer for Ontario, September 2009.

MOECC, 2009c. "Brownfield Registry." Ontario Ministry of the Environment. Queen's Printer for Ontario, 2007. Web. http://www.ene.gov.on.ca/en/land/brownfields. Accessed Oct. 23, 2009.

Approved

MOECC, 2009d. Drinking Water System Inspection Report. Armow Well Supply. Inspection #1-7HFRM, November 10, 2009. Ontario Ministry of the Environment, Safe Drinking Water Branch. Report compiled December 22, 2009.

MOECC, 2009e. Drinking Water System Inspection Report. Clifford Well Supply. Inspection #1-7I8XZ, November 17, 2009. Ontario Ministry of the Environment, Safe Drinking Water Branch. Report compiled January 11, 2010.

MOECC, 2011a. 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. Ontario Ministry of the Environment, January 26, 2011.

MOECC, 2011b. Drinking Water System Inspection Report. Lake Rosalind Drinking Water System. Ontario Ministry of the Environment, Safe Drinking Water Branch.

MECP, 2021. Tables of Drinking Water Threats. Ministry of the Environment, Conservation and Parks. Queen's Printer for Ontario, 2021. Web. https://www.ontario.ca/page/tables-drinking-water-threats#section-0.

Montgomery, T.H., 2001. Engineers' Reports for the Groundwater Supply System in the Municipality of West Grey: Neustadt Groundwater Supply System. KMK Consultants Limited. Kitchener, ON. May 2001.

OMAFRA, 2000. Publication 19: Pasture Production. Manual created February 1, 2000; reviewed February 25, 2015. Ontario Ministry of Agriculture, Food and Rural Affairs. Queen's Printer for Ontario, 2015.

OMAFRA. Constructed Drains GIS dataset. Ontario Ministry of Agriculture, Food and Rural Affairs. Queen's Printer for Ontario.

OMAFRA, 2009. Tile Drainage Areas GIS dataset. Ontario Ministry of Agriculture, Food and Rural Affairs. Queen's Printer for Ontario, 2009.

Ontario Clean Water Agency, 2008. Saugeen Shores Water Treatment, Schedule 22. Summary Report for the Period of June 30, 2007 to December 31, 2007.

Ross, B.M., 2001a. Township of Huron-Kinloss Village of Ripley Engineer's Report. B.M. Ross and Associates Limited, Consulting Engineers. Goderich, ON. January 2001.

Ross, B.M., 2001b. Township of Huron-Kinloss Lakeshore Area Engineer's Report. B.M. Ross and Associates Limited, Consulting Engineers. Goderich, ON. January 2001.

SGSNBP SPC, 2009. Technical Report 7c, Development of Water Quality Standards for Issues Evaluation. Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Committee, January 23, 2009.

Approved

SGSNBP SPR, 2008. Watershed Characterization Report. Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Region. Drinking Water Source Protection Project Report, 2008.

Saugeen Shores, 2009. Water and Sanitary Sewer Servicing Master Plan. Town of Saugeen Shores. OS-08-054-11-OS. Prepared by Genivar Consultants LP, June 2009.

Saugeen Shores, 2009b. O.Reg. 170/03 Annual Water Report. Port Elgin. Town of Saugeen Shores, Feb. 2009.

Schlumberger, 2009. 2009 Grey-Bruce Model Update. Internal Memo from Lucas Carson to Don Smith, DWSP Project Manager. April 28th, 2009.

Stantec, 2008 (Phase 1 Report). Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Planning Technical Study: Phase 1 Report “Surface Water Source Protection Technical Studies”. Commissioned by the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Authority. Stantec Consulting Ltd., February 2008.

Stantec, 2009 (Phase 1 Technical Addendum). Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Planning Technical Study: Phase 1 Technical Addendum: Riverine and Pathway, Vulnerability, and Uncertainty Level Analyzes for the Kincardine, Southampton, Lion’s Head, Wiarton, Presqu’ile, East Linton, R.H. Neath, Meaford, and Thornbury, Water Treatment Plants. Commissioned by the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Authority. Stantec Consulting Ltd., DRAFT, November 2009.

Stantec, 2009 (Phase 2). Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Planning Technical Study: Phase 2 – Potential Threats Analysis Technical Memorandum. Commissioned by the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Protection Authority. Stantec Consulting Ltd., DRAFT, December 2009.

Statistics Canada, 2006a. 2006 Census of Agriculture, Farm Data and Farm Operator Data. Catalogue no. 95-629-XWE.

Statistics Canada, 2016b. 2006 Community Profiles. 2016 Census. Catalogue no. 92-591-XWE. Ottawa. Released March 13, 2017. Accessed April 10, 2020.

TBCS, 2009. The Federal Contaminated Inventory. Treasury Board of Canada Secretariat. Government of Canada. Web. http://www.tbs-sct.gc.ca/fcsi-rscf/home-accueil-eng.aspx.

Waterloo Numeric Modelling Corporation, 2009. Round 1 Technical Study for the Ausable Bayfield Maitland Source Protection Region.

Wilson, 2002a. Hydrogeological Study Powers Subdivision Well Community of Chepstow Municipality of Brockton. Ian D. Wilson Associates Limited Consulting Hydrogeologists. Clinton, ON. August 2002.

WHI, 2003. Grey and Bruce Counties Groundwater Study, Final Report. Waterloo Hydrogeologic Inc. Waterloo, ON. July 2003.

Approved

This page intentionally left blank.