Chapter 12: Township of Essa

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12.1 Introduction

This chapter contains information on two drinking water systems for Township of Essa. Golder Associates Ltd has completed the work presented, which has also been reviewed by South Georgian Bay-Lake Simcoe Source Water Protection staff and members of the Technical Work Group or the Source Protection Committee~~. Golder Associates Ltd (Golder, 2010d) has completed the work presented, all of which was reviewed by South Georgian Bay-Lake Simcoe Source Water Protection staff, Township of Essa staff, and members of the Source Protection Committee~~.

The chapter begins with an introduction of the characteristics of the drinking water system. This includes an overview of the location, number of people served, and source of the water supply. The sections following the system introductions are comprised of a Vulnerability Assessment and Issues and Threats evaluation of the system. The Vulnerability assessment includes the delineation of the Vulnerable Area(s) (Wellhead Protection Area), and the assignment of Vulnerability Score for the delineated area. An Uncertainty Rating is also provided for the Vulnerable Area delineation and the Vulnerability Assessment as per Technical Rules 13-15 (Part I.4 – Uncertainty Analysis – Water Quality (MOE, 2008a)) to express the level of confidence in the results based on the information that was available for the study.

The Issues evaluation is intended to identify chemical parameters or pathogens in the raw drinking water that will limit the ability of the water to serve as a drinking water source either now, or in the future. Any Issues identified for the systems will be listed in this section, along with a map illustrating the Issues Contributing Area if an Issue is known. The Threats evaluation identifies potential Significant Drinking Water Threats within the delineated Vulnerable Areas. This process includes creating lists for Drinking Water Threats for Activities and Conditions, generating maps showing areas that are or would be Significant, Moderate, or Low Drinking Water Threats, and a final enumeration of Significant Drinking Water Threats.

For more information, readers are encouraged to read Chapter 5: Methods Overview as well as Golder 2010d (found in Appendix MO and E) for a more in depth description of the methods used, as well as the Glossary for any unfamiliar terms.

12.2 Drinking Water Systems

The Township of Essa operates groundwater based water supplies in two (2) communities and does not have any surface water supplies. As shown in Figure 12-1 both of the groundwater

supplies are within the South Georgian Bay-Lake Simcoe (SGBLS) Source Protection Region (SPR).

Municipal Groundwater Supply in the Township of Essa within the Nottawasaga Valley Source Protection Authority (SPA) included in this report:

- Angus
- Glen Ave (Thornton)

In addition to the groundwater systems within Essa, a number of vulnerable areas from surrounding municipalities extend into the Township (Table 12-1). WHPAs from the Barrie (City of Barrie) and Cookstown (Town of Innisfil) Well supplies extend into the Township of Essa. Information on these systems can be found in this report, Chapter 9 and 13 respectively.

Also, WHPAs from the Angus and Glen Ave water supplies extend out of the Township into other municipalities and CFB Borden (Table 12-1).

Table 12-1: WHPA that cross into and out of the Township of Essa in the SGBLS SPR.

Local Municipality that WHPA extends into	Municipality where wellhead is located	Name of Water Supply	Source Protection Region and Source Protection Authority (SPA)	Location where entire Assessment can be obtained
Township of Essa	City of Barrie	Barrie	SGBLS SPR and Nottawasaga Valley SPA	This report (Chapter 9)
Township of Essa	Town of Innisfil	Cookstown	SGBLS SPR and Nottawasaga Valley SPA	This report (Chapter 13)

Local Municipality that WHPA extends into	Municipality where wellhead is located	Name of Water Supply	Source Protection Region and Source Protection Authority (SPA)	Location where entire Assessment can be obtained
Township of Springwater	Township of Essa	Angus	SGBLS SPR and Nottawasaga Valley SPA	This Chapter
CFB Borden	Township of Essa	Angus	SGBLS SPR and Nottawasaga Valley SPA	This Chapter
Town of Innisfil	Township of Essa	Glen Ave (Thornton)	SGBLS SPR and Nottawasaga Valley SPA	This Chapter

12.3 Angus Well Supply

The community of Angus obtains its water supply from ~~two~~ three well fields comprising of a total of six~~three~~ wells, referred to as the Mill Street Well 1 and Centre St. Well 1 and 2. The Brownley Wells 4, 5 and 6 are also within the Angus system but were not developed at the time of the South Simcoe Groundwater Study (SSGS) (Golder, 2004) and therefore was not covered under that report. The details on the construction of these wells can be found in reports completed by Golder (2005) and International Water Supply Ltd. (2007). The Brownley Wells were brought online in 2009.

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The aquifer system beneath Angus is part of the Barrie-Borden "tunnel valley" aquifer system. This aquifer system is dominated by an east-west trending aquifer that extends from Kempenfelt Bay to the Niagara Escarpment and contains thick sand and gravel deposits that are found deep below the ground surface. Outside of the "tunnel valley" aquifer system, a stratified multi-aquifer system extends under much of the area, consisting of layers of sand and silt/clay till material. The sand aquifer materials are relatively continuous throughout the Angus area, except in areas of bedrock highs, or thick till deposits.

The Nottawasaga River separates the groundwater flow system in the Community of Angus. This river creates a regional groundwater divide, with groundwater flowing toward it from the east and the west. As a result, the eastern portion of the Angus system is modelled with the Kempenfelt Bay model developed for the SSGS, whereas the western portion is modelled separately.

Four overburden aquifers occur within the vicinity of Angus. They are referred to in this report as the upper unconfined aquifer (A1) and the lower confined aquifers (A2, A3 and A4). Aquifer A1 is unconfined and composed of fine to medium grained sand. It occurs at elevations above approximately 190 meters above sea level (masl). The confined aquifers are of different geological origins, but may be hydraulically connected in places. The confining layer which separates Aquifer A1 and the lower aquifers is a cohesive clay and/or silt to clay and gravel unit with a thickness of 9 to 34 m.

Aquifer A2 is up to 19 m thick and, where well defined, the upper contact of A2 occurs between 25 and 35 meters below ground level (mbgl). This aquifer appears intermittent or interlayered with low permeable materials though the interpreted elevation range of this aquifer in the Brownley area. The Brownley Wells are constructed in Aquifer A2. Investigations have indicated that Aquifer A2 is hydraulically connected with Aquifers A3 and A4 within the vicinity of Angus.

The Mill Street and two Centre Street wells are constructed in the municipal water supply Aquifer A3/A4. The aquifer is overlain by 30 to 50 meters of mainly lacustrine silts and clays in the area of Angus, corresponding to similar deposits overlying the deep aquifers in the Barrie area.

12.3.1 Groundwater Vulnerability Assessment

The Wellhead Protection Area (WHPA) is the primary Vulnerable Area delineated to ensure the protection of the municipal water supply wells. The Groundwater Vulnerability has been assessed to provide an indication, within the WHPA, which current (or future) Threats at the surface present the greatest risk to contaminate the water supply. The Vulnerability Analysis considers the WHPA and the Groundwater Vulnerability, as well as the potential for the vulnerability to be increased by man-made (anthropogenic) structures, through Transport Pathways, by developing a "Vulnerability Score" within the WHPA. Conversion of Vulnerability categories (High, Medium and Low) to Vulnerability Scores (10, 8, 6, 4 and 2) results in a new map for each WHPA that expresses the relative degree to which a Threat could affect the drinking water supply. A higher value Vulnerability Score will always be assigned to the immediate vicinity of the well and to any areas that are shown to be vulnerable.

The Groundwater Vulnerability for the Angus water supply has been delineated following the process recommended in the Technical Rules. The areas that contribute groundwater to the wells were delineated as WHPA. The Groundwater Vulnerability Assessment was carried out as follows:

- delineation of the Brownley Well Field WHPA
- complete a preferential pathways private well inventory in the Brownley WHPA
- assess groundwater Vulnerability (AVI Method and ISI Method)
- assign Vulnerability Score prior to modifiers (transport pathways)
- consider modifications to Vulnerability Score based on transport pathways
- assign final Vulnerability Score
- determine level of uncertainty in Vulnerability assessment

Detailed methods describing the Vulnerability Analysis completed by Golder (2010d) are provided in Appendix E. Note that the methods used to assign vulnerability scores in the Golder report differ slightly than those within this Assessment Report. The Golder report includes a modification to vulnerability based on water quality. While Directors approval to use this alternate approach was requested under Technical Rule 15.1, approval was only given to increase vulnerability from low to medium, and not to increase vulnerability to high. As permission to only partially increase the vulnerability score was approved, it was recommended

not to increase vulnerability due to water quality. An explanation from MOE detailing the reason why the alternate method could not be used is provided in Appendix E.

12.3.1.1 Wellhead Protection Area (WHPA) Delineation

The SSGS included the delineation of the WHPAs for all of the municipal wells in the Township of Essa with the exception of the Brownley Wells that were under development and not included in the original groundwater study. A detailed description of the groundwater flow models used can be found in the SSGS report (Golder, 2004).

Industry standard groundwater modeling software packages Visual MODFLOW, FEFLOW, and USEPA's WHPA were used to develop capture zones for each of the wells/well fields in the Township. The more advanced approaches to the modeling were used in areas of critical stress within the aquifer and in the larger, more complex systems. As such, the Angus wells were modeled with numerical flow models. The Mill Street well was modeled using Visual MODFLOW and was part of the Angus-Borden numerical model, whereas the Centre Street wells were modeled using FEFLOW, as part of the Kempenfelt Bay area model.

The well fields in Angus (Mill Street and Brownley/Centre Street) are simulated in different models due to the fact that they are located on opposite sides of the Nottawasaga River, the regional groundwater divide, and as such, these well fields capture water from two distinctly different groundwater regimes.

The Brownley and Center Street WHPAs were updated since April 30, 2005 and therefore WHPA-C have been delineated and WHPA-C1 are delineated for the Mill Street well and the Thornton wells.

No updates were completed to the model domain as part of this project for the Mill Street system with details on modeling scope provided within the SSGS. The location of the Mill Street well has been updated (approximately 150 m) since the SSGS, with recent updated locations based on well survey results provided by SGBLS on August 31, 2009. The location of the well along with the entire capture area provided in the SSGS was shifted to match the updated location. Considering the variance of scale in parameter distribution (i.e. hydraulic conductivity resolution of 250 m) within the model domain, re-evaluation of the hydrogeology or remodelling the capture zone was not required. The Mills Street Well WHPA is illustrated on Figure 12a-1.

The Centre Street Wells 1 and 2 were modeled as part of the SSGS with pumping rates of 427 m_3/day. In 2007 the MOE requested an evaluation of the interference among the three municipal well fields. The numerical flow model was used as part of the evaluation with the

taking from the Centre Street wells increased to 1,300 m_3/day to more accurately reflect the estimated average taking required for Angus (Golder, 2007). The capture zones for the Centre Street well were delineated at the higher pumping rate and are shown on Figure 12a-1. The capture zones also reflect a shift in well location (approximately 30 m) to reflect updated locations provided by SGBLS. As indicated in Figure 12a-1, the capture zone for the Centre Street wells is long and slender and bends northward toward an interpreted groundwater elevation high in this direction. The capture zone presented herein is different than the one provided in the SSGS, reflecting the increased pumping rate and additional interpretation of the modelling outputs compared to the SSGS modeling.

Subsequent to the issuance of the SSGS report the Brownley Well Field (Wells 4, 5, and 6) have been developed by the Township. As such, the delineation of the Brownley WHPA was completed as part of the scope of work for this project. The Kempenfelt Bay model extends west to the Nottawasaga River and therefore encompasses the Brownley wells within its domain. The FEFLOW model was used to delineate the Brownley WHPAs. Details on the updated modelling are provided in the Township of Essa, Angus Water Supply Brownley Capture Zone Modelling (Golder, 2008) and Golder, 2010d.

The scope of the work involved delineating the 2, 5, 10 and 25 year WHPAs of Brownley Wells No. 4, 5 and 6 using the existing Barrie FEFLOW model. For modeling purposes, the three wells, which are situated close to each other, were combined as one well. The Brownley wells were modeled at 1,750 m_3/day based on water demand estimates provided by the Township Engineer. The rate reflects an average day demand which was estimated at approximately half of the maximum yield of Well 4 and 6 (Well 5 used for short term peaking). The Brownley well capture zones are shown on Figure 12a-1. Notably, the downgradient extent of capture does not reach the Nottawasaga River, further reinforcing previous studies indicating these wells are not under the influence of surface water.

12.3.1.2 Groundwater Vulnerability

The Groundwater Vulnerability within the WHPA of the six municipal wells in Angus is shown in Figure 12a-2.

The regional scale intrinsic susceptibility index (ISI) Vulnerability was completed for the Township of Essa in the SSGS. As the municipal aquifers in the Township, are located below the first aquifer defined in this method, the resulting ISI Vulnerability does not accurately reflect the Vulnerability of the municipal supply aquifer, which in most cases is overlain by low permeability materials.

To account for the added protection that the confining units may provide and thus lower the calculated Vulnerability of the aquifer, the Vulnerability was calculated to the municipal aquifer for each well. The Vulnerability of the municipal aquifers was calculated using the Aquifer Vulnerability Index (AVI) method rather than the ISI approach. As many of the wells in the area do not reach the depth of the municipal aquifer, it was not possible to use the geologic logs of the individual well records to calculate the Vulnerability. Therefore the layers from the calibrated numerical model developed as part of the SSGS was utilized to calculate the Vulnerability to the municipal aquifer.

The Mill Street and Centre Street WHPAs fall within Low Vulnerability areas with greater than 100 AVI score throughout the WHPAs (Figure 12a-2 and Figure 12a-3). The Brownley WHPAs (Figure 12a-4) score as Medium Vulnerability within a portion of the WHPA to the west and Low Vulnerability for the remaining portion of the WHPA.

12.3.1.3 Transport Pathway Increase

The Technical Rules allow for increasing the aquifer vulnerability based on Transport Pathways that are anthropogenic in origin (i.e. man-made structures). The presence of the Transport Pathways should be accounted for in the Vulnerability assessment and include:

- private water wells, unused water wells and abandoned water wells
- construction of underground services
- subsurface excavations
- pits and quarries

There were no adjustments made to the Vulnerability Scoring for the Angus system, with the exception of private wells.

Constructed Transport Pathways to an aquifer, for example water wells, can have a locally significant impact on the Vulnerability of an aquifer. To assess this impact, a transport pathway private well inventory was undertaken for the Township of Essa within the area of the WHPAs in 2006 and 2008 (Brownley). Details on the methodology can be found within the report Golder (2006, 2009). The inventories were aimed at identifying and locating wells within the WHPAs and included a categorization of those wells which pose the highest risk to the aquifer. The wells were classified based on:

1. the physical condition of the well (i.e., Class A, B or C), based on height of the casing above grade and likely condition of the well cap; and
2. increasing risk (category 1, 2, and 3) based on the aquifer they were completed in

Wells with a risk rating of 3C were included as transport pathways as they are considered to have the highest risk as this comprises the wells completed to the municipal aquifer which have below standard well casing height. The high risk rating does not imply that these wells necessarily represent a Transport Pathway that is or could cause impact to the municipal aquifer. It implies that, based on the physical condition and depth of the well, there is an increased risk associated with these locations. These are the only wells (3C) that have been used to modify the Vulnerability Scoring, based on the rationale provided in Golder, 2010d. Two 3C wells were identified as Transport Pathways in the Angus Water Supply system. The location of these Transport Pathways and the resulting increase to Vulnerability Scores are presented in Figure 12a-5.

12.3.1.4 WHPA-E

None of the wells in this study have been identified as Groundwater Under the Influence of surface water (GUDI), therefore delineation of a WHPA-E was not required~~. Since a WHPA-E was not required for any of the wells, the delineation of a WHPA-F was also not required~~.

12.3.1.5 Vulnerability Score

The WHPA zones for the Angus Water Supply, as shown in Figure 12a-1, the Groundwater Vulnerability, as shown in Figure 12a-2 to Figure 12a-4, and increases due to Transport Pathways (Section 12.3.1.3) were used to assign a Vulnerability Score using the matrix from Table 5.3 (Chapter 5: Methods Overview, Section 5.2.4). Figure 12a-5 illustrates the Vulnerability Scores for the Angus Water Supply. Figure 12a-5 will be used to assess Drinking Water Threats in Section 12.3.3.

12.3.1.6 Uncertainty Rating

The Technical Rules require that an Uncertainty Rating, characterized as High or Low, be assigned for completed Vulnerability and WHPA assessments. Uncertainty assessment for WHPA delineation was undertaken by both Golder 2010d and independent peer review. In situations where different uncertainty estimates are provided (i.e. Low and High), the most conservative (High uncertainty) has been applied. Uncertainty of the Vulnerability Assessment was only undertaken by Golder 2010d.

The independent peer review of WHPA delineation was undertaken by Dillon Consulting using a standard scoring matrix (Table 1, Appendix MO). The Uncertainty Rating assigned for the Angus WHPAs is High. The full results of the WHPA delineation Peer Review process, for Angus is available in Appendix E and discussed in Chapter 5 (Methods Overview). Based on the rationale

provided for the Vulnerability Assessment (see below), Golder 2010d, characterized uncertainty of the WHPA delineation as Low. As this differs from that provided by the peer review, the most conservative, 'High' Uncertainty ranking will currently apply.

The uncertainty associated with the Vulnerability Assessment was evaluated using a qualitative process outlined in Golder, 2010d. The Uncertainty Assessment methodology considers the type, quantity and quality of available data, the methods used to determine the Vulnerability Assessment components, and the nature of the groundwater flow system.

Considering all of the available data, the uncertainty of the Vulnerability for the Angus Water Supply is considered Low close to the municipal wells and increases at the outer reaches of the 25 year capture area, but overall the Vulnerability uncertainty is characterized as Low.

12.3.2 Drinking Water Issues

The intent of the Issues Evaluation is to identify parameters (e.g. chemicals or pathogen) in the raw drinking water that will limit the ability of the water to serve as a drinking water source either now, or in the future. To be considered a Drinking Water Issue, a parameter needs to be at a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water or if there is a trend of increasing concentrations of the parameter and a continuation of that trend that would result in the deterioration of the quality of the water as a source of drinking water (Technical Rule 114.(1)(a-b)). However, a parameter may not be considered an Issue in cases where it is naturally occurring or effective treatment is in place.

The Township Drinking Water Issues evaluation was based on a review of water quality data from the SSGS and annual drinking water quality reports provided by the Ontario Clean Water Agency for 2003 to 2008.

Water quality data from municipal supply wells and sentinel wells for the municipal supply wells was assessed to identify parameters (including pathogens) for which there were indications of elevated concentrations. These parameters were further reviewed to determine if:

- current or projected concentrations exceed the Ontario Drinking Water Quality Standards (ODWQS)
- the parameter was considered to be anthropogenic or natural in origin
- the parameter should be made a Drinking Water Issue

The projected concentrations were based on linear regression analysis for the available dataset. Where projected trends at 50 years indicated concentrations which were close to but not exceeding the ODWQS, the most recent data was evaluated to determine if there was

indication of an increase in the trend or stabilization in the concentrations. If recent data indicated concentrations above the projected trend line, the parameter was included as a Drinking Water Issue.

Historically, raw water quality samples were taken from individual well supplies, however, recent changes in regulated sampling requirements have resulted in sampling of raw or treated samples which are a combination of wells from a given well field. This is the case for the Centre Street wells in Angus. Since 2003, sampling results are from combined sources. This provides complications where low concentration (of a given parameter) water is mixed with high concentration water. Since only a combined result is available, accurate tracking of individual source concentrations are not possible. It is recommended that the raw general water quality sampling be conducted for the individual municipal wells in the Township on a yearly basis to track water quality trending parameters.

With these limitations in mind, the inventory for the water quality issues for each system has been provided. The parameters that were considered and justification of Issues identification are provided in Golder, 2010d.

No drinking water Issues were identified for the Angus well supply.

The Brownley wells have a limited dataset of water quality to determine Drinking Water Issues. Quality results are limited to those obtained during aquifer testing of the wells. During testing of Well 6 nitrate levels declined from 11.1 mg/L to 8.28 mg/L after 72 hour of pumping, whereas the adjacent Well No. 4 nitrate levels ranged from 2.41 to 2.53 mg/L. The variability of the nitrate levels over the site requires further investigation to determine possible sources. The nitrate was not considered a Drinking Water Issue at this time based on the available data set. Should further evaluation provide additional information to support nitrate as a Drinking Water Issue, it should be included in future updates to the Assessment Report.

12.3.3 Drinking Water Threats Evaluation

An assessment of Drinking Water Threats for the Angus Water Supply was completed in accordance with the detailed methodology presented in Golder, 2010d (Appendix E). A Drinking Water Threat is defined as “an Activity, or Condition that adversely affects or has the potential to adversely affect, the quality and quantity of any water that is or may be used as a source of drinking water, and includes any activity or condition that is prescribed by the regulations as a drinking water threat.” An Activity is one or a series of related processes, natural or anthropogenic that occurs within a geographical area and may be related to a particular land use, whereas a Condition refers to the presence of a contaminant in the soil, sediment, or

groundwater resulting from past activities. Therefore, it is not only presently existing Threats that must be regulated, but future ones as well.

The Drinking Water Threats Assessment for the Angus Water Supply includes preparation of:

- a list of Drinking Water Threats for Activities
- a list of Drinking Water Threats for Conditions
- maps showing areas that are or would be Significant, Moderate, or Low Drinking Water Threats for Activities
- maps showing areas that are or would be Significant, Moderate, or Low Drinking Water Threats for Conditions
- an enumeration of Drinking Water Threats

12.3.3.1 List of Drinking Water Threats – Activities

The list of Prescribed Drinking Water Threats considered in the assessment for the Angus Drinking Water Supply is provided in Chapter 5 section 5.5.1.

The key data sources used to identify Threats on properties included:

- MOE Look Up Tables (LUT) Database (2009)
- Municipal Property Assessment Corporation (MPAC) (2007) assessment information
- South Simcoe Groundwater Study (SSGS) Contaminant Source Inventories
- Hazardous Waste Information Network (HWIN) (2009)
- MOE Records Database (2009)
- MOE Biosolids Database (2004- 2008)
- NVCA Mapping including land use, snow storage, and storm water management ponds (2009)
- Golder Field Windshield Surveys (2008/2009)
- Township of Essa Sanitary Service Mapping

Section 12.3.3.5 describes how these datasets were used to identify and enumerate potential Significant Threat Activities for the Angus drinking water system.

No additional local Drinking Water Threats were identified for consideration. No local circumstances for prescribed Threats were identified.

12.3.3.2 List of Drinking Water Threats – Conditions

The initial compilation of Conditions was based on the MOE Records Database and the MOE Brownfields Database (2009) and supplemented by information provided by the City. The MOE Records database (2009) included a compilation of files from the MOE District office for properties within approximately 500 m of a municipal well. The database included a number of records relating to Certificates of Approval, Records of Site Condition, miscellaneous reports, waste generator registration information, permits, applications and correspondence. The files in this list of potential Conditions were reviewed in greater detail to determine if there was sufficient evidence to confirm a Condition based on the Technical Rules criteria.

No confirmed Conditions have been identified for the Angus water supply. No potential Conditions have been identified for consideration at this time.

12.3.3.3 Identifying Areas of Significant/Moderate/Low Threats – Activities

The areas where Activities are or would be Drinking Water Threats are illustrated on a series of maps based on the Vulnerability Scores and Vulnerable Area delineations. The maps combined with the ~~table of drinking water~~Technical Rules threat circumstances can be used to correlate activities that are or would be Drinking Water Threats. ~~include references to a series of tables prepared by MOE to correlate activities that are or would be Drinking Water Threats with the Vulnerability Scores.~~ The circumstances~~tables~~ can be found at ~~the~~https://threats.swpip.ca/ ~~https://swpip.ca/~~. ~~Government of Ontario's Drinking Water Threats and Circumstances.~~

12.3.3.3.1 Pathogen Parameters

The ~~MECP table of Drinking Water Threats~~Technical Rules can be used in conjunction with the Vulnerability Scores ~~Key Table on Figure 12a-6 can be used in conjunction with the Vulnerability Scores~~ to identify the areas where Activities associated with pathogen Threats are or would be Significant, Moderate, or Low Drinking Water Threats for the Angus Water Supply Areas within the WHPA-A and WHPA-B with a Vulnerability Score of less than six are not illustrated as they do not contain Circumstances (high enough Hazard Score) for an Activity Threat to be considered Significant, Moderate or Low (Figure 12a-6).

12.3.3.3.2 Chemical Parameters

The ~~MECP table of Drinking Water Threats~~Technical Rules ~~Key Table on Figure 12a-7~~ can be used in conjunction with the Vulnerability Scores to identify the areas where activities associated with chemical threats are or would be Significant, Moderate, or Low Drinking Water

Threats for the Angus Water Supply (Figure 12a-7). Areas within the WHPA that have a Vulnerability Score of less than six are not illustrated as they do not contain Circumstances (high enough Hazard Score) for an Activity Threat to be considered Significant, Moderate or Low. The Key Table on Figure 12a-7 illustrates where activities associated with chemical threats are or would be Low Drinking Water Threats for the Angus Water Supply.

12.3.3.3.3 DNAPL Chemical Parameters

Figure 12a-8 illustrates the area of the 5-year time-of-travel zone (WHPA-C) and areas with a Vulnerability Score of 6, where activities associated with DNAPL parameters are considered to be a Significant Drinking Water Threats for the Angus Water Supply. The MECP table of Drinking Water ThreatsTechnical Rules Key Table on Figure 12a-8 can be used to can be used to identify the circumstances in which these Activities would be Significant, or Moderate, or Low Drinking Water Threats.

12.3.3.4 Identifying Areas of Significant/Moderate/Low Threats – Conditions

Further to Section 12.3.3.2, no Conditions have been confirmed within the WHPA for the Angus Water Supply (Golder, 2010d).

A Condition or potential Condition that has not been identified would potentially be a Significant, Moderate, or Low Threat to Drinking Water based on the combination of Hazard Rating and Vulnerability Rating as described in Section 5.5.5 (Chapter 5: Methods Overview) and Technical Memorandum A5 (Appendix MO). The Hazard Rating is dependent on whether there is evidence the Condition is causing off-site contamination, and whether the Condition is located on the same property as the supply well.

A Condition would be a threat to municipal drinking water in the following situations:

- **Significant**: where the Vulnerability Score is ≥ 8 and there is evidence that the Condition is causing off-site contamination, and/or that the Condition is located on the same property as the supply well
- **Moderate**:
    1. where the Vulnerability Score ≥ 6 and < 8, and there is evidence that the Condition is causing off-site contamination, and/or that the Condition is located on the same property as the supply well; or
    2. where the Vulnerability Score is 10, and there is no evidence of off-site contamination

- **Low**: where the Vulnerability Score ≥ 8 and < 10 and there is no evidence of off-site contamination

Figure 12a-5 illustrates the Vulnerability Score map for Angus well supply that can be used to determine where a Condition is or would be a Significant, Moderate or Low Threat to Drinking Water.

12.3.3.5 Enumerating Drinking Water Threats

~~12.3.3.5~~

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12.3.3.5.1 Enumerating Significant Drinking Water Threats – Methods

Identification and enumeration of Significant Drinking Water Threats related to Issues and Conditions have been described in Section 12.3.2 and 12.3.3.2, respectively. This section describes the identification and enumeration of Significant Drinking Water Threat Activities. Identification of Activities requires determining where they are located in terms of vulnerable areas and their associated Risk Score based on the type of Activity. Detailed methodology can be found in Golder, 2010d. Additional refinement of the Significant Drinking Water Threats enumeration was completed using the methodology outlined in Chapter 5 (Section 5.5.6.4) of this Assessment Report.

A number of data sources were utilized as part of the Activity Threat Assessment. The data sources used to obtain Threat information for the GIS based algorithm developed for the project are described in Golder 2010d and summarized in section 12.3.3.1. In most cases, the detailed information required to document the MOE Circumstances was not readily available. The approach was designed to represent typical Activities occurring at different property types. The approach is considered conservative and, in many cases, likely results in a higher Threat ranking than may otherwise actually be present in many cases. The assumed Circumstances and MOE Hazard Scores are described in Golder, 2010d, and were based on MPAC property codes (and MOE LUT Activities). It is noted that the assessment has not involved field verification or site visits to validate information.

The Threat ranking algorithm was designed to perform the Threat rankings in an automated manner for properties within the WHPAs. The Threat ranking algorithm process begins with a yes/no question for each Prescribed Threat (e.g., Application of Agricultural Source Material (ASM) to Land, Application of Road Salt) to assess if the Activity is occurring on the property. If the answer was no, then no Threat was identified, and the algorithm did not calculate a Risk Score for that Threat. If the answer was yes, the algorithm proceeded to the Hazard Score related to the assumed Circumstance using the MOE LUT database.

The input data lead the algorithm to relevant reference IDs in the MOE Drinking Water Threats Tables that reflect the Circumstances identified on the property. A lookup table is used to link the selected Circumstance to an MOE Hazard Score which, when multiplied by the Vulnerability Score, provides the resultant Risk Score for the Threat in question. When multiple chemical parameter Circumstances are present for a given Threat, Risk Scores are calculated for each parameter and the highest score is tabulated for the Threat. It is noted that the Vulnerability Score used to rank a property is based on the maximum Vulnerability Score intersected by the parcel for the WHPA being evaluated. Finally, if the calculated Risk Score for a Threat is greater than or equal to 80, the Threat is ranked as Significant.

Two unique 'polygon' Threats were assigned to each WHPA with a Vulnerability Score of 10 in accordance with the common methodology developed by SGBLS (SGBLS, 2010). For the Threat 'sewage system or sewage works – sanitary sewers and related pipes', one Threat was assigned to each WHPA to account for the potential Threat that could exist related to the sanitary network. One Threat was assigned to represent the entire network since detailed information regarding distribution and conveyance capacities was not readily available within some study areas. The second polygon Threat assigned was related to domestic fuel storage (i.e. Fuel Storage) which may be on a property as a primary source of heating fuel. One fuel storage Threat was assigned to each WHPA where there was a high probability that natural gas was not available in the area. Generally in urban areas, where natural gas was probable, the polygon Fuel Threat was not assigned.

Some Threats such as the Application of Agricultural Source Material to Land have Circumstances based on datasets that are on a scale larger than individual properties. These Circumstances included percent Managed Lands, Livestock Density and Impervious Surfaces. Therefore, additional calculations were required to determine these Circumstances for each WHPA. The percent Managed Lands and Livestock Density calculations were completed for this project using a methodology developed in consultation with the South Georgian Bay Lake Simcoe Source Protection Region and was based on the MOE Technical Bulletin for Managed Land and Livestock Density Calculations (MOE, November ~~September~~ 2009). The percent Managed Land and the Livestock Density of an area is used as an estimation to represent the quantity of nutrients present as a result of nutrient generation, storage and land application within a WHPA. Managed Lands, Livestock Density and Impervious Surfaces are discussed in more detail below.

12.3.3.5.1.1 Managed Lands

Managed Land is land to which nutrients (Agriculture Source Material (ASM), commercial fertilizer, Non-Agricultural Source Material (NASM)) are applied. It includes crop land, fallow land, pasture land, golf courses, sports fields and residential lawns. Managed Lands is broken into two subsets; agricultural managed lands and non-agricultural managed lands. Agricultural managed lands include areas of crop land, fallow and pasture land that may receive nutrients. Non-agricultural managed lands includes golf courses, sports fields and residential lawns and other built up grassed areas that may receive nutrients (primarily commercial fertilizers).

Technical Rule 16(9) ~~(August 2009)~~ requires the Assessment Report to include maps showing the location of Managed Lands and the percentage of Managed Lands within a Vulnerable Area, including WHPA-A, -B, -C, -D, and –E . This mapping is not required where the Vulnerability Scores for the area are less than the Vulnerability Score necessary for the Activity to be considered a threat in ~~Part XII of~~ the Technical Rules ~~(December 2021)~~. ~~the Table of Drinking Water Threats.~~

Managed Lands were identified and the Managed Lands proportions were determined for the Angus WHPA as outlined in Golder, 2010d.

The results from this analysis were used in the enumeration of Significant Drinking Water Threats (Section 12.3.3.5.2). Figure 12a-9 illustrates the location and proportion of Managed Lands within the delineated WHPA zones for the Angus Water Supply where Vulnerability Scores were 6 or greater for WHPA-A to WHPA-D.

Managed Lands within the Mill Street WHPA is calculated to be within the lowest category of 0 to 40%. Within the Brownley WHPAs, 40 to 80% is calculated. Finally the Centre Street WHPAs have a calculated range of 40 to 80% from WHPA-A to C and 0 to 40% in WHPA-D.

12.3.3.5.1.2 Livestock Density

Livestock Density is calculated to provide a measure of the potential for generating, storing and land applying ASM as a source of nutrients within a defined area. The livestock density is expressed as Nutrient Units per Acre. It is determined by dividing the Nutrient Units generated in each area by the number of acres of agricultural managed land in the area where agricultural source material is applied.

Technical Rule 16(10) ~~(August 2009)~~ requires the Assessment Report to include maps showing the Livestock Density within WHPA-A, -B, -C, -D, and –E. This mapping is not required where the Vulnerability Scores for the area are less than the Vulnerability Score necessary for the Activity

to be considered a Threat in ~~Part XII of~~ the Technical Rules ~~(December 2021).~~ ~~the Table of Drinking Water Threats.~~

The Livestock Density was determined for the Angus WHPA as outlined in Golder, 2010d. The results from this analysis were used in the enumeration of Significant Drinking Water Threats (Section 12.3.3.5.2). Figure 12a-10 illustrates the distribution of Livestock Density within the delineated WHPA zones for the Angus Water Supply where Vulnerability Scores were greater than 6 for WHPA-A to WHPA-D. The Livestock Density figure reflects the distribution of Agricultural Managed Lands. The majority of the Angus WHPAs fall into the livestock density calculations of <0.5 NU/acres, with a small section in the Centre Street WHPA having 0.5-1.0 NU/acre where densities were calculated (i.e. greater than a Vulnerability of 6).

12.3.3.5.1.3 Impervious Surfaces

Technical Rule 16(11) ~~(August 2009)~~ requires the Assessment Report to include maps showing the percentage of surface area where road salt could be applied to Impervious Surfaces within WHPA-A, -B, -C, -D, and –E . This mapping is not required where the Vulnerability Scores for the area are less than the Vulnerability Score necessary for the Activity to be considered a Threat in ~~Part XII of~~ the Technical Rules ~~(December 2021).~~ ~~the Table of Drinking Water Threats.~~

The proportion of Impervious Surfaces within the Angus WHPA was determined in accordance with the methodology in Golder, 2010d. Methodology in Technical Memorandum A5.1 (Appendix MO) was used in 2023 to update the proportion of Impervious Surfaces within the delineated WHPA zones using the 2021 Technical Rules. The results from this analysis were used in the enumeration of Significant Drinking Water Threats (Section 12.3.3.5.2). The Impervious Surfaces are used in the identification of threat activities associated with the application of winter de-icing agents (salt).

Figure 12a-11 illustrates the distribution of Impervious Surfaces within the delineated WHPA zones for the Angus Water Supply where Vulnerability Scores were greater than 6 for WHPA-A to WHPA-D. ~~It is noted that an impervious area of 8 to 80% has been assigned within all lands contained within the Angus WHPAs, with the exception of the Centre Street WHPAs which have 1 to 8%.~~

12.3.3.5.2 Enumerating Significant Drinking Water Threats – Results

As noted previously, there were no Threats related to Conditions or Drinking Water Issues identified in the Angus WHPAs.

Table 12-2, Table 12-3, and Table 12-4 document the enumeration of existing and potential activities that are considered Significant Drinking Water Threats within the Mill St., Brownley, and Centre St. WHPAs, respectively.

A total of twenty-three (23) Activities that are considered to be potential Significant Drinking Water Threats have been identified in association with (11) land parcels within the WHPAs for the Angus Water Supply. This represents approximately 4% of the parcels assessed with the Angus WHPAs. The total number of Significant Threats is higher than the total number of properties with Significant Threats because there are properties that have multiple Threats identified.

The identified Significant Threats relate to systems that collect, store, transmit, treat, or dispose of sewage (5), application of agricultural source material to land (2), storage of agricultural source material (2), handling and storage of commercial fertilizer (2), application of pesticide to land (1), handling and storage of pesticide (1), handling and storage of fuel (8), handling and storage of DNAPLs (1), and handling and storage of organic solvents (1).

Table 12-2: Number of Parcels with Significant Threat Activities for the Angus (Mill Street) Water Supply, Enumeration of Significant Threats (Wellhead Protected Area)

Threat Number	Threat	Significant Threat Counts Number of Threats
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V or the Environmental Protection Act	0
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	3
3	The application of agricultural source material to land	1
4	The storage of agricultural source material to land	1
5	The management of agricultural source material	0
6	The application of non-agricultural source material to land	0
7	The handling and storage of non-agricultural source material	0
8	The application of commercial fertilizer to land	0
9	The handling and storage of commercial fertilizer to land	0
10	The application of pesticide to land	0
11	The handling and storage of pesticide	0
12	The application of road salt	0
13	The handling and storage of road salt	0

Threat Number	Threat	Significant Threat Counts Number of Threats
14	The storage of snow	0
15	The handling and storage of fuel	4
16	The handling and storage of dense non-aqueous phase liquid	1
17	The handling and storage of an organic solvent	1
18	The management of runoff that contains chemicals used in the de-icing of aircraft	0
21	The use of land as livestock grazing or pasturing land, and outdoor confinement area, or a farm-animal yard	0
22	The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.	0
-	**Total Number**	**11*** significant threats (on 6 properties)

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Notes for the table above:

1. The number of parcels identified will typically be less than the number of significant threats as multiple threats can be observed per parcel
2. *1 verified existing Threats and 10 potential Threats that require further investigation

Table 12-3: Number of Parcels with Significant Threat Activities for the Angus (Brownley) Water Supply, Enumeration of Significant Threats (Wellhead Protected Area)

Threat Number	Threat	Significant Threat Counts Number of Threats
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V or the Environmental Protection Act	0
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	2
3	The application of agricultural source material to land	1
4	The storage of agricultural source material to land	1
5	The management of agricultural source material	0
6	The application of non-agricultural source material to land	0
7	The handling and storage of non-agricultural source material	0
8	The application of commercial fertilizer to land	0
9	The handling and storage of commercial fertilizer to land	1
10	The application of pesticide to land	1
11	The handling and storage of pesticide	1
12	The application of road salt	0
13	The handling and storage of road salt	0
14	The storage of snow	0
15	The handling and storage of fuel	2
16	The handling and storage of dense non-aqueous phase liquid	0

Threat Number	Threat	Significant Threat Counts Number of Threats
17	The handling and storage of an organic solvent	0
18	The management of runoff that contains chemicals used in the de-icing of aircraft	0
21	The use of land as livestock grazing or pasturing land, and outdoor confinement area, or a farm-animal yard	0
22	The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.	0
-	**Total Number**	**9*** significant threats (on **3** properties)

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Notes for the table above:

1. The number of parcels identified will typically be less than the number of significant threats as multiple threats can be observed per parcel
2. *9 potential Threats that require further investigation

Table 12-4: Number of Parcels with Significant Threat Activities for the Angus (Centre Street) Water Supply, Enumeration of Significant Threats (Wellhead Protected Area)

Threat Number	Threat	Significant Threat Counts Number of Threats
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V or the Environmental Protection Act	0
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	0
3	The application of agricultural source material to land	0
4	The storage of agricultural source material to land	0
5	The management of agricultural source material	0
6	The application of non-agricultural source material to land	0
7	The handling and storage of non-agricultural source material	0
8	The application of commercial fertilizer to land	0
9	The handling and storage of commercial fertilizer to land	1
10	The application of pesticide to land	0
11	The handling and storage of pesticide	0
12	The application of road salt	0
13	The handling and storage of road salt	0
14	The storage of snow	0
15	The handling and storage of fuel	2
16	The handling and storage of dense non-aqueous phase liquid	0

Threat Number	Threat	Significant Threat Counts Number of Threats
17	The handling and storage of an organic solvent	0
18	The management of runoff that contains chemicals used in the de-icing of aircraft	0
21	The use of land as livestock grazing or pasturing land, and outdoor confinement area, or a farm-animal yard	0
22	The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.	0
-	**Total Number**	**3*** significant threats (on **2** properties)

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Notes for the table above:

1. The number of parcels identified will typically be less than the number of significant threats as multiple threats can be observed per parcel
2. *3 potential Threats that require further investigation

12.4 Glen Ave (Thornton) Well Supply

Thornton currently obtains its water supply from two well fields consisting of four wells, referred to as the Glen Avenue well field (Wells 1 and 2) and the Thornton Estates well field (Wells 3 and 4). The wells are located in a deep confined aquifer found locally in the elevation range of approximately 215 to 260 masl. This aquifer, which is locally extensive, corresponds to the elevation of the regional A2 Aquifer. The aquifer is under confined artesian conditions and is overlain by a shallow semi-confined sand aquifer.

The static water levels of the Glen Ave system wells range from near surface (1 to 2 meters) at the Thornton Estates wells, to approximately 11 mbgl at the Glen Avenue wells. Water levels are highest to the northeast, which is a localized recharge area and decline to the west, toward the Nottawasaga River.

The confining material overlying the municipal aquifer ranges from approximately 20 m at the Thornton Estates wells to 30 m at the Glen Avenue wells. These materials appear to be till as well as lacustrine silts and clays. The semi-confined aquifer noted above may be connected with unconfined to semi-confined shallow aquifers to the northwest. Elevated nitrate concentrations identified in the Thornton Estates wells suggest that recharge within the past few decades has influenced the quality of both the shallow and municipal aquifers.

The groundwater flow system in the Thornton area is complicated. Groundwater flow directions in the vicinity of the Glen Ave wells is influenced by two recharge areas to the northwest and immediate southeast and by the discharge to the Nottawasaga River to the west. It is noted that all of the Glen Ave wells are in the same aquifer, however, the Thornton Estates wells exhibit elevated nitrate, whereas the Glen Avenue wells do not, suggesting different recharge areas for the systems.

12.4.1 Ground Water Vulnerability

The Wellhead Protection Area (WHPA) is the primary Vulnerable Area delineated to ensure the protection of the municipal water supply wells. The Groundwater Vulnerability has been assessed to provide an indication, within the WHPA, which current (or future) Threats at the surface present the greatest risk to contaminate the water supply. The Vulnerability Analysis considers the WHPA and the Groundwater Vulnerability, as well as the potential for the vulnerability to be increased by man-made (anthropogenic) structures, through Transport Pathways, by developing a “Vulnerability Score” within the WHPA. Conversion of Vulnerability categories (High, Medium and Low) to Vulnerability Scores (10, 8, 6, 4 and 2) results in a new map for each WHPA that expresses the relative degree to which a Threat could affect the

drinking water supply. A higher value Vulnerability Score will always be assigned to the immediate vicinity of the well and to any areas that are shown to be vulnerable.

The Groundwater Vulnerability for the Glen Ave water supply has been delineated following the process recommended in the Technical Rules. The areas that contribute groundwater to the wells were delineated as WHPA. The Groundwater Vulnerability Assessment was carried out as follows:

- assess groundwater Vulnerability (AVI Method and ISI Method)
- assign Vulnerability Score prior to modifiers (water quality and transport pathways)
- consider modifications to Vulnerability Score based on water quality data and transport pathways
- assign final Vulnerability Score
- determine level of uncertainty in Vulnerability assessment

Details of the methods for the Vulnerability Analysis and details of the work performed to assess the Groundwater Vulnerability in Essa are provided are provided in Golder, 2010d.

12.4.1.1 Wellhead Protection Area (WHPA) Delineation

The SSGS included the delineation of the WHPAs for all of the municipal wells in the Township of Essa with the exception of the Brownley Wells that were under development and not included in the original groundwater study. A detailed description of the groundwater flow models used can be found in the SSGS report (Golder, 2004).

Industry standard groundwater modeling software packages Visual MODFLOW, FEFLOW, and USEPA's WHPA were used to develop capture zones for each of the wells/well fields in the Township. The more advanced approaches to the modeling were used in areas of critical stress within the aquifer and in the larger, more complex systems. As such, an analytical WHPA model was developed for the Thornton wells.

The WHPAs for the Thornton wells were simulated using an analytical modelling approach, with the United States Environmental Protection Agency's WHPA code. Details on the model properties, design and approach are provided in the SSGS report. No updates were made to the modelling completed as part of this project, with the exception of updating well locations based on well survey results provided by SGBLS. The location of the Thornton Estates and Glen Avenue wells and associated capture zones were shifted to reflect the updated locations (approximately 40 m and 30 m respectively). The WHPAs for the Thornton wells are illustrated on Figure 12b-1.

In viewing the WHPAs for all of the Township wells, it is important to consider that the Technical Rules require the 'lines on a map' to delineate the WHPAs and vulnerability. This provides areas where 'slivers' of land exist, which would suggest that, for example, one parcel of land is within the 25 year capture zone while an adjacent parcel is not. The conceptual hydrostratigraphic model, numerical flow models, or analytical flow models used to develop the WHPAs are based on regional scale information. In addition, it is noted that the MOE water well records, a key data source, utilized for the original SSGS, has been relied on to develop an understanding of the hydrogeological conditions on a regional scale. The information provided by these records may be insufficient to interpret local scale effects for a number of reasons such as:

- natural variability of geologic conditions, even over short distances
- uncertainty regarding the location of the well on a local scale
- uncertainty in the correlation of the geologic materials (thickness and material type), as recorded by various well drillers, between adjacent or nearby wells

This uncertainty does not detract from using these and other information sources to assess aquifer characteristics on a regional scale. Water well records, coupled with other sources of information such as Quaternary geological mapping, are used to guide a wide variety of earth science projects including groundwater supply development, landfill site selection and highway routing. However, prudence is needed when judging 'lines on a map' and the certainty in the datasets they portray.

12.4.1.2 Groundwater Vulnerability

The Groundwater Vulnerability within the WHPA of the four municipal wells in the Glen Ave Water Supply is shown in Figure 12b-2.

The regional scale intrinsic susceptibility index (ISI) Vulnerability was completed for the Township of Essa in the SSGS. As the municipal aquifers in the Township, are located below the first aquifer defined in this method, the resulting ISI Vulnerability does not accurately reflect the Vulnerability of the municipal supply aquifer, which in most cases is overlain by low permeability materials.

The AVI method was not implemented for the Thornton wells as no numerical flow model exists and the original ISI Vulnerability scoring was used. The ISI method used within the SSGS was considered appropriate for the assessment of Vulnerability in Thornton. The WHPAs for the Thornton wells fall within a medium Vulnerability zone (Figure 12b-2) which is consistent with

the hydrogeologic setting and water quality results of the Thornton wells (i.e. elevated nitrate levels in the Thornton Estates wells)

12.4.1.3 Transport Pathway Increase

The Technical Rules allow for increasing the aquifer vulnerability based on Transport Pathways that are anthropogenic in origin (i.e. man-made structures). The presence of the Transport Pathways should be accounted for in the Vulnerability assessment and include:

- private water wells, unused water wells and abandoned water wells
- construction of underground services
- subsurface excavations
- pits and quarries

There were no adjustments made to the Vulnerability Scoring for the Thornton system, with the exception of private wells.

Constructed Transport Pathways to an aquifer, for example water wells, can have a locally significant impact on the Vulnerability of an aquifer. To assess this impact, a transport pathway private well inventory was undertaken for the Township of Essa within the area of the WHPAs in 2006. Details on the methodology can be found within the report Golder (2006, 2009). The inventories were aimed at identifying and locating wells within the WHPAs and included a categorization of those wells which pose the highest risk to the aquifer. The wells were classified based on:

1. the physical condition of the well (i.e., Class A, B or C), based on height of the casing above grade and likely condition of the well cap; and
2. increasing risk (category 1, 2, and 3) based on the aquifer they were completed in

Wells with a risk rating of 3C were included as transport pathways as they are considered to have the highest risk as this comprises the wells completed to the municipal aquifer which have below standard well casing height. The high risk rating does not imply that these wells necessarily represent a Transport Pathway that is or could cause impact to the municipal aquifer. It implies that, based on the physical condition and depth of the well, there is an increased risk associated with these locations. These are the only wells (3C) that have been used to modify the Vulnerability Scoring, based on the rationale provided in Golder, 2010d. No 3C wells were identified as Transport Pathways in the Glen Ave Water Supply system.

12.4.1.4 WHPA-E

None of the wells in this study have been identified as Groundwater Under the Influence of surface water (GUDI), therefore delineation of a WHPA-E was not required. ~~Since a WHPA-E was not required for any of the wells, the delineation of a WHPA-F was also not required.~~

12.4.1.5 Vulnerability Score

The WHPA zones for the Glen Ave Water Supply, as shown in Figure 12b-1, and the Groundwater Vulnerability, as shown in Figure 12b-2, were used to assign a Vulnerability Score using the matrix from Table 5.3 (Chapter 5: Methods Overview, Section 5.2.4). Figure 12b-3 illustrates the Vulnerability Scores for the Glen Ave Water Supply. Figure 12b-3 will be used to assess Drinking Water Threats in Section 12.4.3.5.2.

12.4.1.6 Uncertainty Rating

The Technical Rules require that an Uncertainty Rating, characterized as High or Low, be assigned for completed Vulnerability and WHPA assessments. Uncertainty assessment for WHPA delineation was undertaken by both Golder 2010d and independent peer review. In situations where different uncertainty estimates are provided (i.e. Low and High), the most conservative (High uncertainty) has been applied. Uncertainty of the Vulnerability Assessment was only undertaken by Golder 2010d.

The independent peer review of WHPA delineation was undertaken by Dillon Consulting using a standard scoring matrix (Table 1, Appendix MO). The Uncertainty Rating assigned for the Glen Ave WHPAs is High. The full results of the WHPA delineation Peer Review process, for Glen Ave is available in Appendix E and discussed in Chapter 5 (Methods Overview). Based on the rationale provided for the Vulnerability Assessment (see below), Golder 2010d, characterized uncertainty of the WHPA delineation as Low. As this differs from that provided by the peer review, the most conservative, 'High' Uncertainty ranking will currently apply.

The uncertainty associated with the Vulnerability Assessment was evaluated using a qualitative process outlined in Golder, 2010d. The Uncertainty Assessment methodology considers the type, quantity and quality of available data, the methods used to determine the Vulnerability Assessment components, and the nature of the groundwater flow system.

Considering all of the available data, the uncertainty of the Vulnerability for the Glen Ave Water Supply is considered Low close to the municipal wells and increases at the outer reaches of the 25 year capture area, but overall the Vulnerability uncertainty is characterized as Low.

12.4.2 Drinking Water Issues

The intent of the Issues Evaluation is to identify parameters (e.g. chemicals or pathogen) in the raw drinking water that will limit the ability of the water to serve as a drinking water source either now, or in the future. To be considered a Drinking Water Issue, a parameter needs to be at a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water or if there is a trend of increasing concentrations of the parameter and a continuation of that trend that would result in the deterioration of the quality of the water as a source of drinking water (Technical Rule 114.(1)(a-b)). However, a parameter may not be considered an Issue in cases where it is naturally occurring or effective treatment is in place.

The Township Drinking Water Issues evaluation was based on a review of water quality data from the SSGS and annual drinking water quality reports provided by the Ontario Clean Water Agency for 2003 to 2008.

Water quality data from municipal supply wells and sentinel wells for the municipal supply wells was assessed to identify parameters (including pathogens) for which there were indications of elevated concentrations. These parameters were further reviewed to determine if:

- current or projected concentrations exceed the Ontario Drinking Water Quality Standards (ODWQS)
- the parameter was considered to be anthropogenic or natural in origin~~,~~
- the parameter should be made a Drinking Water Issue~~.~~

The projected concentrations were based on linear regression analysis for the available dataset. Where projected trends at 50 years indicated concentrations which were close to but not exceeding the ODWQS, the most recent data was evaluated to determine if there was indication of an increase in the trend or stabilization in the concentrations. If recent data indicated concentrations above the projected trend line, the parameter was included as a Drinking Water Issue.

Historically, raw water quality samples were taken from individual well supplies, however, recent changes in regulated sampling requirements have resulted in sampling of raw or treated samples which are a combination of wells from a given well field. This is the case for the Glen Ave system. Since 2003, sampling results are from combined sources. This provides complications where low concentration (of a given parameter) water is mixed with high concentration water. Since only a combined result is available, accurate tracking of individual source concentrations are not possible. For example the Thornton Estates wells historically showed elevated sodium, chloride and nitrate levels, however, recent sampling is from a

combination of all of the Glen Ave wells (Glen Avenue and Thornton Estates) and therefore when mixed with lower nitrate level water from Glen Avenue, the resulting concentration provides a result of mixed water and a decreased nitrate level. It is recommended that the raw general water quality sampling be conducted for the individual municipal wells in the Township on a yearly basis to track water quality trending parameters.

No drinking water Issues were identified for the Glen Ave Water Supply.

12.4.3 Drinking Water Threats Evaluation

An assessment of Drinking Water Threats for the Glen Ave Water Supply was completed in accordance with the detailed methodology presented in Golder, 2010d (Appendix E). A Drinking Water Threat is defined as "an Activity, or Condition that adversely affects or has the potential to adversely affect, the quality and quantity of any water that is or may be used as a source of drinking water, and includes any activity or condition that is prescribed by the regulations as a drinking water threat." An Activity is one or a series of related processes, natural or anthropogenic that occurs within a geographical area and may be related to a particular land use, whereas a Condition refers to the presence of a contaminant in the soil, sediment, or groundwater resulting from past activities. Therefore, it is not only presently existing Threats that must be regulated, but future ones as well.

The Drinking Water Threats Assessment for the Glen Ave Water Supply includes preparation of:

- a list of Drinking Water Threats for Activities
- a list of Drinking Water Threats for Conditions
- maps showing areas that are or would be Significant, Moderate, or Low Drinking Water Threats for Activities
- maps showing areas that are or would be Significant, Moderate, or Low Drinking Water Threats for Conditions
- an enumeration of Drinking Water Threats

12.4.3.1 List of Drinking Water Threats – Activities

The list of Prescribed Drinking Water Threats considered in the assessment for Glen Ave Drinking Water Supply is provided in Chapter 5 section 5.5.1.

The key data sources used to identify Threats on properties included:

- MOE Look Up Tables (LUT) Database (2009)~~;~~

- Municipal Property Assessment Corporation (MPAC) (2007) assessment information~~;~~
- South Simcoe Groundwater Study (SSGS) Contaminant Source Inventories~~;~~
- Hazardous Waste Information Network (HWIN) (2009)~~;~~
- MOE Records Database (2009)~~;~~
- MOE Biosolids Database (2004- 2008)~~;~~
- NVCA Mapping including land use, snow storage, and storm water management ponds (2009)~~;~~
- Golder Field Windshield Surveys (2008/2009)~~.~~
- Township of Essa Sanitary Service Mapping

Section 12.4.3.5 describes how these datasets were used to identify and enumerate potential Significant Threat Activities for the Angus drinking water system.

No additional local Drinking Water Threats were identified for consideration. No local circumstances for prescribed Threats were identified.

12.4.3.2 List of Drinking Water Threats – Conditions

The initial compilation of Conditions was based on the MOE Records Database and the MOE Brownfields Database (2009) and supplemented by information provided by the City. The MOE Records database (2009) included a compilation of files from the MOE District office for properties within approximately 500 m of a municipal well. The database included a number of records relating to Certificates of Approval, Records of Site Condition, miscellaneous reports, waste generator registration information, permits, applications and correspondence. The files in this list of potential Conditions were reviewed in greater detail to determine if there was sufficient evidence to confirm a Condition based on the Technical Rules criteria.

No confirmed Conditions have been identified for the Glen Ave water supply. No potential Conditions have been identified for consideration at this time.

12.4.3.3 Identifying Areas of Significant/Moderate/Low Threats – Activities

The areas where Activities are or would be Drinking Water Threats are illustrated on a series of maps based on the Vulnerability Scores and Vulnerable Area delineations. The maps combined with the ~~table of drinking water~~Technical Rules threat circumstances can be used to correlate activities that are or would be Drinking Water Threats. ~~include references to a series of tables~~

~~prepared by MOE to correlate activities that are or would be Drinking Water Threats with the Vulnerability Scores.~~ The circumstances ~~tables~~ can be found at ~~the~~https://threats.swpip.ca/ ~~https://swpip.ca/~~. ~~Government of Ontario's Drinking Water Threats and Circumstances.~~

12.4.3.3.1 Pathogen Parameters

The ~~MECP table of Drinking Water Threats~~Technical Rules can be used in conjunction with the Vulnerability Scores ~~Key Table on Figure 12b-4 can be used in conjunction with the Vulnerability Scores~~ to identify the areas where Activities associated with pathogen Threats are or would be Significant, Moderate, or Low Drinking Water Threats for the Glen Ave Water Supply Areas within the WHPA-A and WHPA-B with a Vulnerability Score of less than six are not illustrated as they do not contain Circumstances (high enough Hazard Score) for an Activity Threat to be considered Significant, Moderate or Low (Figure 12b-4).

12.4.3.3.2 Chemical Parameters

The ~~MECP table of Drinking Water Threats~~Technical Rules ~~Key Table on Figure 12b-5~~ can be used in conjunction with the Vulnerability Scores to identify the areas where activities associated with chemical threats are or would be Significant, Moderate, or Low Drinking Water Threats for the Glen Ave Water Supply (Figure 12b-5). ~~,~~ Areas within the WHPA that have a Vulnerability Score of less than six are not illustrated as they do not contain Circumstances (high enough Hazard Score) for an Activity Threat to be considered Significant, Moderate or Low. ~~The Key Table on Figure 12b-5 illustrates where activities associated with chemical threats are or would be Low Drinking Water Threats for the Glen Ave Water Supply.~~

12.4.3.3.3 DNAPL Chemical Parameters

Figure 12b-6 illustrates the area of the 5-year time-of-travel zone (WHPA-C) where activities associated with DNAPL parameters are considered to be a Significant Drinking Water Threats for the Glen Ave Water Supply. The ~~MECP table of Drinking Water Threats~~~~Key~~Technical Rules ~~Table on Figure 12b-6~~ can be used to can be used to identify the circumstances in which these Activities would be Significant, or Moderate, or Low Drinking Water Threats.

12.4.3.4 Identifying Areas of Significant/Moderate/Low Threats – Conditions

Further to Section 12.4.3.2, no Conditions have been confirmed within the WHPA for the Glen Ave Water Supply (Golder, 2010d).

A Condition or potential Condition that has not been identified would potentially be a Significant, Moderate, or Low Threat to Drinking Water based on the combination of Hazard

Rating and Vulnerability Rating as described in Section 5.5.5 (Chapter 5: Methods Overview) and Technical Memorandum A5 (Appendix MO). The Hazard Rating is dependent on whether there is evidence the Condition is causing off-site contamination, and whether the Condition is located on the same property as the supply well.

A Condition would be a threat to municipal drinking water in the following situations:

- **Significant**: where the Vulnerability Score is ≥ 8 and there is evidence that the Condition is causing off-site contamination, and/or that the Condition is located on the same property as the supply well
- **Moderate**:
  1. where the Vulnerability Score ≥ 6 and < 8, and there is evidence that the Condition is causing off-site contamination, and/or that the Condition is located on the same property as the supply well; or
  2. where the Vulnerability Score is 10, and there is no evidence of off-site contamination
- **Low**: where the Vulnerability Score ≥ 8 and < 10 and there is no evidence of off-site contamination

Figure 12b-3 illustrates the Vulnerability Score map for Glen Ave well supply that can be used to determine where a Condition is or would be a Significant, Moderate or Low Threat to Drinking Water.

12.4.3.5 Enumerating Drinking Water Threats

~~12.4.3.5~~

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12.4.3.5.1 Enumerating Significant Drinking Water Threats – Methods

Identification and enumeration of Significant Drinking Water Threats related to Issues and Conditions have been described in Section 12.4.2 and 12.4.3.2, respectively. This section describes the identification and enumeration of Significant Drinking Water Threat Activities. Identification of Activities requires determining where they are located in terms of vulnerable areas and their associated Risk Score based on the type of Activity. For a general summary on the methods, see Section 12.3.3.5.1. Detailed methodology can be found in Golder, 2010d. Additional refinement of the Significant Drinking Water Threats enumeration was completed using the methodology outlined in Chapter 5 (Section 5.5.6.4) of this Assessment Report.

12.4.3.5.1.1 Managed Lands

Managed Land is land to which nutrients (Agriculture Source Material (ASM), commercial fertilizer, Non-Agricultural Source Material (NASM)) are applied. It includes crop land, fallow land, pasture land, golf courses, sports fields and residential lawns. Managed Lands is broken into two subsets; agricultural managed lands and non-agricultural managed lands. Agricultural managed lands include areas of crop land, fallow and pasture land that may receive nutrients. Non-agricultural managed lands includes golf courses, sports fields and residential lawns and other built up grassed areas that may receive nutrients (primarily commercial fertilizers).

Technical Rule 16(9) ~~(August 2009)~~ requires the Assessment Report to include maps showing the location of Managed Lands and the percentage of Managed Lands within a Vulnerable Area, including WHPA-A, -B, -C, -D, and –E . This mapping is not required where the Vulnerability Scores for the area are less than the Vulnerability Score necessary for the Activity to be considered a threat in ~~Part XII of the~~ Technical Rules ~~(December 2021).~~ ~~the Table of Drinking Water Threats.~~

Managed Lands were identified and the Managed Lands proportions were determined for the Angus WHPA as outlined in Golder, 2010d.

The results from this analysis were used in the enumeration of Significant Drinking Water Threats (Section 12.4.3.5.2). Figure 12b-7 illustrates the location and proportion of Managed Lands within the delineated WHPA zones for the Glen Ave Water Supply where Vulnerability Scores were 6 or greater for WHPA-A to WHPA-D.

Managed Lands within the Glen Ave WHPAs is calculated to be within low to medium range with some portions having 0-40% and others 40-80%.

12.4.3.5.1.2 Livestock Density

Livestock Density is calculated to provide a measure of the potential for generating, storing and land applying ASM as a source of nutrients within a defined area. The Livestock Density is expressed as Nutrient Units per Acre. It is determined by dividing the Nutrient Units generated in each area by the number of acres of agricultural managed land in the area where agricultural source material is applied.

Technical Rule 16(10) ~~(August 2009)~~ requires the Assessment Report to include maps showing the Livestock Density within WHPA-A, -B, -C, -D, and –E. This mapping is not required where the Vulnerability Scores for the area are less than the Vulnerability Score necessary for the Activity to be considered a Threat in ~~Part XII of the~~ Technical Rules ~~(December 2021).~~ ~~the Table of Drinking Water Threats.~~

The Livestock Density was determined for the Glen Ave WHPA as outlined in Golder, 2010d. The results from this analysis were used in the enumeration of Significant Drinking Water Threats (Section 12.4.3.5.2). Figure 12b-8 illustrates the distribution of Livestock Density within the delineated WHPA zones for the Glen Ave Water Supply where Vulnerability Scores were greater than 6 for WHPA-A to WHPA-D. The Livestock Density figure reflects the distribution of Agricultural Managed Lands. All of the Glen Ave WHPAs fall into the livestock density calculations of <0.5 NU/acres, where densities were calculated (i.e. greater than a Vulnerability of 6).

12.4.3.5.1.3 Impervious Surfaces

Technical Rule 16(11) ~~(August 2009)~~ requires the Assessment Report to include maps showing the percentage of surface area where road salt could be applied to Impervious Surfaces within WHPA-A, -B, -C, -D, and –E . This mapping is not required where the Vulnerability Scores for the area are less than the Vulnerability Score necessary for the Activity to be considered a Threat in ~~Part XII of the~~ Technical Rules ~~(December 2021).~~ ~~the Table of Drinking Water Threats.~~

The proportion of Impervious Surfaces within the Glen Ave WHPA was determined in accordance with the methodology in Golder, 2010d. Methodology in Technical Memorandum A5.1 (Appendix MO) was used in 2023 to update the proportion of Impervious Surfaces within the delineated WHPA zones using the 2021 Technical Rules. The results from this analysis were used in the enumeration of Significant Drinking Water Threats (Section 12.3.3.5.2). The Impervious Surfaces are used in the identification of threat activities associated with the application of winter de-icing agents (salt).

Figure 12b-9 illustrates the distribution of Impervious Surfaces within the delineated WHPA zones for the Glen Ave Water Supply where Vulnerability Scores were greater than 6 for WHPA-A to WHPA-D. ~~It is noted that an impervious area of 8 to 80% has been assigned within all lands contained within the Glen Ave WHPAs.~~

12.4.3.5.2 Enumerating Significant Drinking Water Threats – Results

As noted previously there were no Threats related to Conditions or Drinking Water Issues identified in the Glen Ave. WHPAs.

Table 12-5 and Table 12-6 document the enumeration of existing and potential activities that are considered to be Significant Drinking Water Threats within the Glen Avenue and Thornton Estates WHPAs, respectively.

A total of twenty-one (21) Activities that are considered to be potential Significant Drinking Water Threats have been identified in association with nineteen (19) land parcels within the WHPAs for the Glen Ave. Water Supply. This represents approximately 20% of the parcels assessed within the Glen Ave. WHPAs. The total number of Significant Threats is higher than the total number of parcels with Significant Threats because there are parcels which have multiple Threats identified.

The identified Significant Threats relate to systems that collect, store, transmit, treat or dispose of sewage (16), handling and storage of fuel (3), and handling and storage of DNAPLs (2).

Table 12-5: Number of Significant Drinking Water Threats for the Glen Avenue Drinking Water Supply, Enumeration of Significant Threats (Wellhead Protected Area)

Threat Number	Threat	Significant Threat Counts Number of Threats
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V or the Environmental Protection Act	1~~0~~
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	12
3	The application of agricultural source material to land	0
4	The storage of agricultural source material to land	0
5	The management of agricultural source material	0
6	The application of non-agricultural source material to land	0
7	The handling and storage of non-agricultural source material	0
8	The application of commercial fertilizer to land	0
9	The handling and storage of commercial fertilizer to land	0
10	The application of pesticide to land	0
11	The handling and storage of pesticide	0
12	The application of road salt	0
13	The handling and storage of road salt	0

Threat Number	Threat	Significant Threat Counts Number of Threats
14	The storage of snow	0
15	The handling and storage of fuel	2
16	The handling and storage of dense non-aqueous phase liquid	1
17	The handling and storage of an organic solvent	0
18	The management of runoff that contains chemicals used in the de-icing of aircraft	0
21	The use of land as livestock grazing or pasturing land, and outdoor confinement area, or a farm-animal yard	0
22	The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.	0
-	**Total Number**	**1~~65~~*** significant threats (on **14** properties)

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Notes for the table above:

1. The number of parcels identified will typically be less than the number of significant threats as multiple threats can be observed per parcel
2. *12 verified existing Threats and 3 potential Threats that require further investigation

Table 12-6: Number of Significant Drinking Water Threats for the Glen Avenue (Thornton Estates) Drinking Water Supply, Enumeration of Significant Threats (Wellhead Protected Area)

Threat Number	Threat	Significant Threat Counts Number of Threats
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V or the Environmental Protection Act	0
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	4
3	The application of agricultural source material to land	0
4	The storage of agricultural source material to land	0
5	The management of agricultural source material	0
6	The application of non-agricultural source material to land	0
7	The handling and storage of non-agricultural source material	0
8	The application of commercial fertilizer to land	0
9	The handling and storage of commercial fertilizer to land	0
10	The application of pesticide to land	1~~0~~
11	The handling and storage of pesticide	0
12	The application of road salt	0
13	The handling and storage of road salt	0
14	The storage of snow	0
15	The handling and storage of fuel	1

Threat Number	Threat	Significant Threat Counts Number of Threats
16	The handling and storage of dense non-aqueous phase liquid	1
17	The handling and storage of an organic solvent	0
18	The management of runoff that contains chemicals used in the de-icing of aircraft	0
21	The use of land as livestock grazing or pasturing land, and outdoor confinement area, or a farm-animal yard	0
22	The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.	0
-	**Total Number**	~~7~~6* significant threats (on **7** properties)

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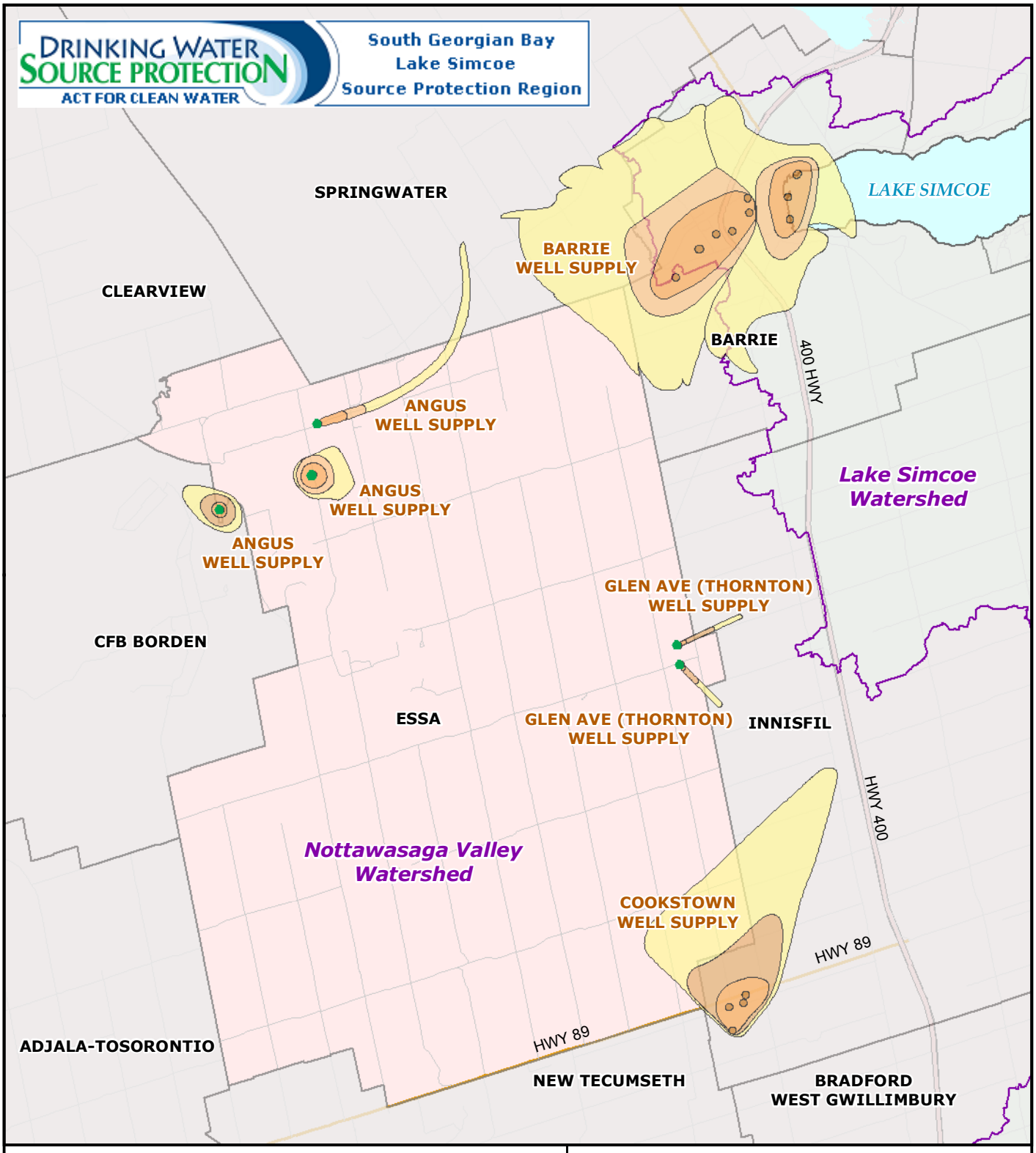
Notes for the table above:

1. The number of parcels identified will typically be less than the number of significant threats as multiple threats can be observed per parcel
2. *4 verified existing Threats and 2 potential Threats that require further investigation



- Municipal Supply Well in Township of Essa
- WHPA-A (100m)
- WHPA-B (2 years time of travel)
- WHPA-C (5 years time of travel)
- WHPA-C1 (10 years time of travel)
- WHPA-D (25 years time of travel)
- SWP Watershed Area
- Municipality Boundary

Drinking Water System Vulnerable Areas in Township of Essa

Created by: LSRCA
Date: 2011-04-01

Scale: 1:150,000
0 2 4km
UTM Zone 17N, NAD83

This map was produced by the Lake Simcoe Region Conservation Authority, lead agency of the South Georgian Bay Lake Simcoe Region Source Protection Region. Base data have been compiled from various sources, under data sharing agreements.
While every effort has been made to accurately depict the base data, errors may exist.

Ontario

Figure 12-1

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Angus Wellhead Protection Areas

CLEARVIEW
SPRINGWATER
ADJALA TOSORONTIO
ESSA
Brownley

GEORGE-JOHNSTON RD
SUNNIDALE RD
COUNTY RD 90
COUNTY RD 56
COUNTY RD 10
MILL ST
BRENTWOOD RD

Centre Street
Well #1
Well #2

Mill Street
Well #1

Well #4
Well #6
Well #5

- Municipal Well
- Secondary Highway
- Other Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Municipal Boundary

WHPA TOT

- WHPA-A (100 m radius)
- WHPA-B (2 yr TOT)
- WHPA-C (5 yr TOT)
- WHPA-C1 (10 yr TOT)
- WHPA-D (25 yr TOT)

Scale: 1:40,000
0 1,000Meters
UTM Zone 17N, NAD83

Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number: EssaCaptureZonesAngus.mxd
Date: 2009-11-02

Ontario

12a-1

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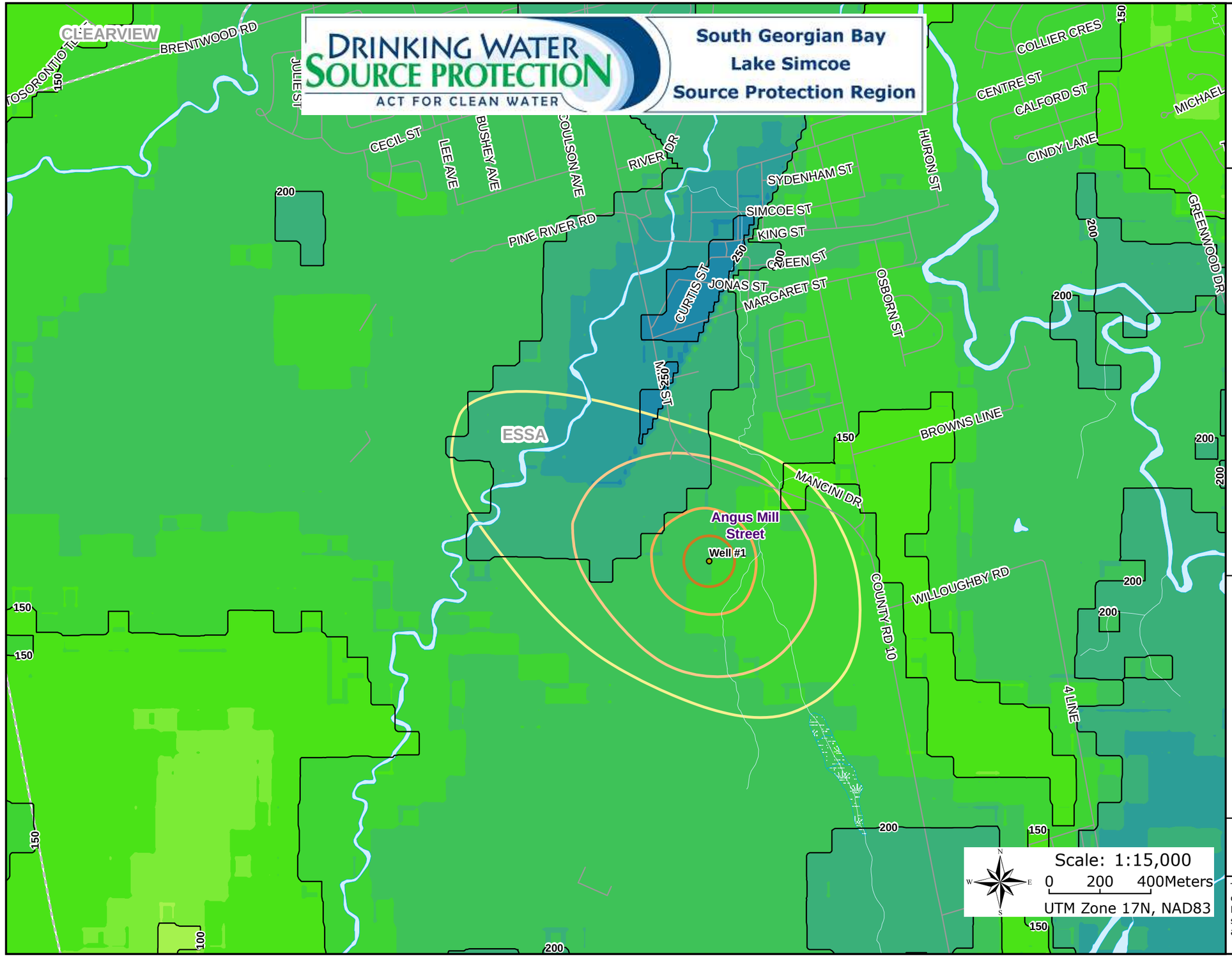
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Angus Mill Street Model Calculated AVI To Top Of Aquifer A3



- Municipal Well
- Contour (50 AVI)

Model Calculated Aquifer Vulnerability Index (AVI)

- 0-30
- 31 - 80
- 81 - 100
- 101 - 125
- 126 - 150
- 151 - 175
- 176 - 200
- 201 - 225
- 226 - 250
- 251 - 275
- 276 - 300
- 301 - 325
- 326 - 350
- 351 - 375

WHPA TOT

- WHPA-A (100 m radius)
- WHPA-B (2 yr TOT)
- WHPA-C1 (10 yr TOT)
- WHPA-D (25 yr TOT)
- Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Municipal Boundary

Notes:
Low Vulnerability (AVI > 80)
Medium Vulnerability (AVI 30 to 80)
High Vulnerability (AVI < 30)

Scale: 1:15,000
0 200 400 Meters
UTM Zone 17N, NAD83

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Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number: EssaMill_AVI.mxd
Date: 2009-11-02

Ontario

12a-2

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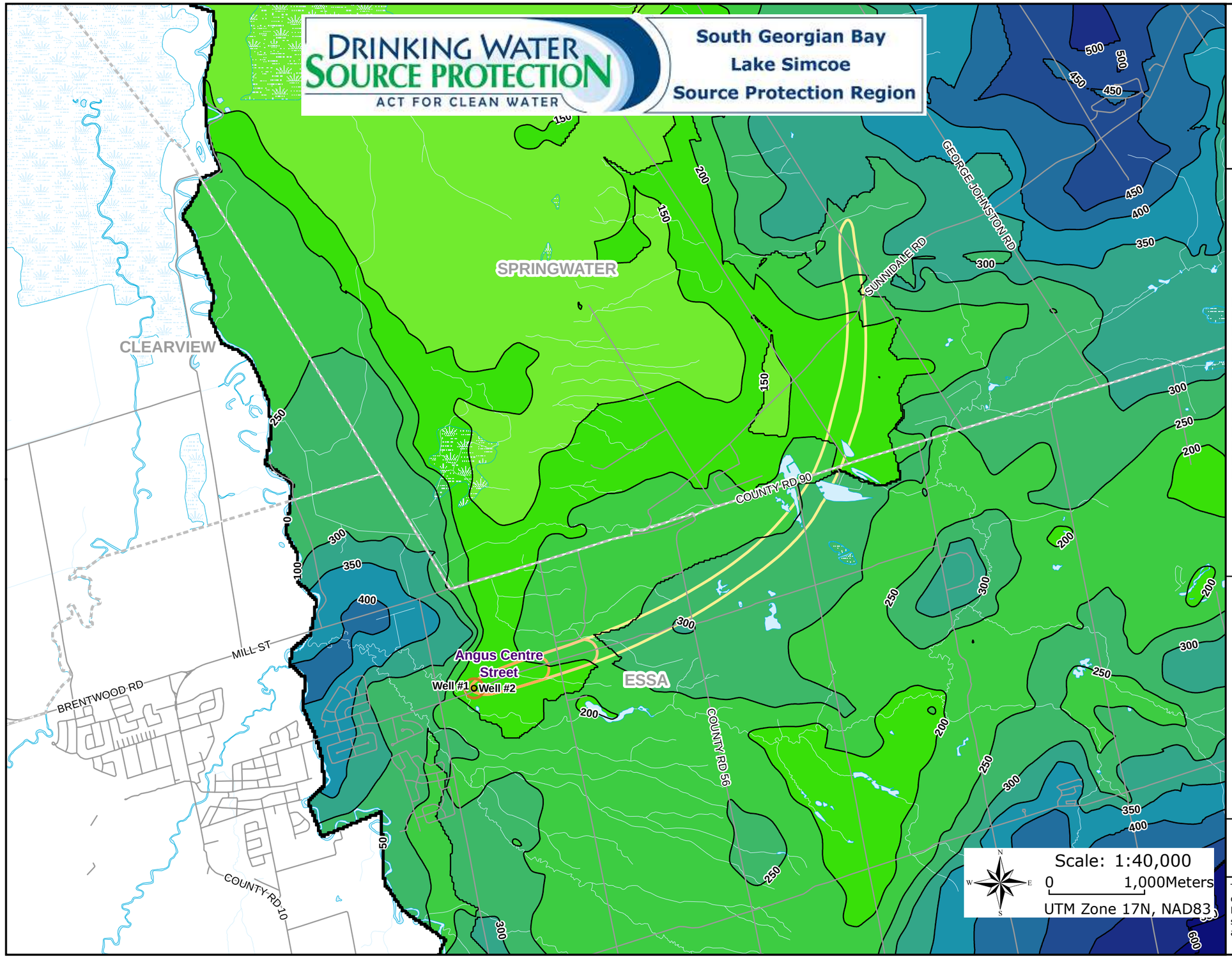
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Angus Centre Street Model Calculated AVI To Top Of Aquifer A3



Municipal Well
Contour (50 AVI)

Model Calculated Aquifer Vulnerability Index (AVI)

- 0-30
- 31 - 80
- 81 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600

WHPA TOT

- WHPA-A (100 m radius)
- WHPA-B (2 yr TOT)
- WHPA-C (5 yr TOT)
- WHPA-D (25 yr TOT)

- Secondary Highway
- Other Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Municipal Boundary

Notes:
Low Vulnerability (AVI > 80)
Medium Vulnerability (AVI 30 to 80)
High Vulnerability (AVI < 30)

Scale: 1:40,000
0 1,000Meters
UTM Zone 17N, NAD83

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Barrie, Ontario

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Project #: 07-1170-0014
File Number: EssaCentre_AVI.mxd
Date: 2009-11-02

Ontario

12a-3

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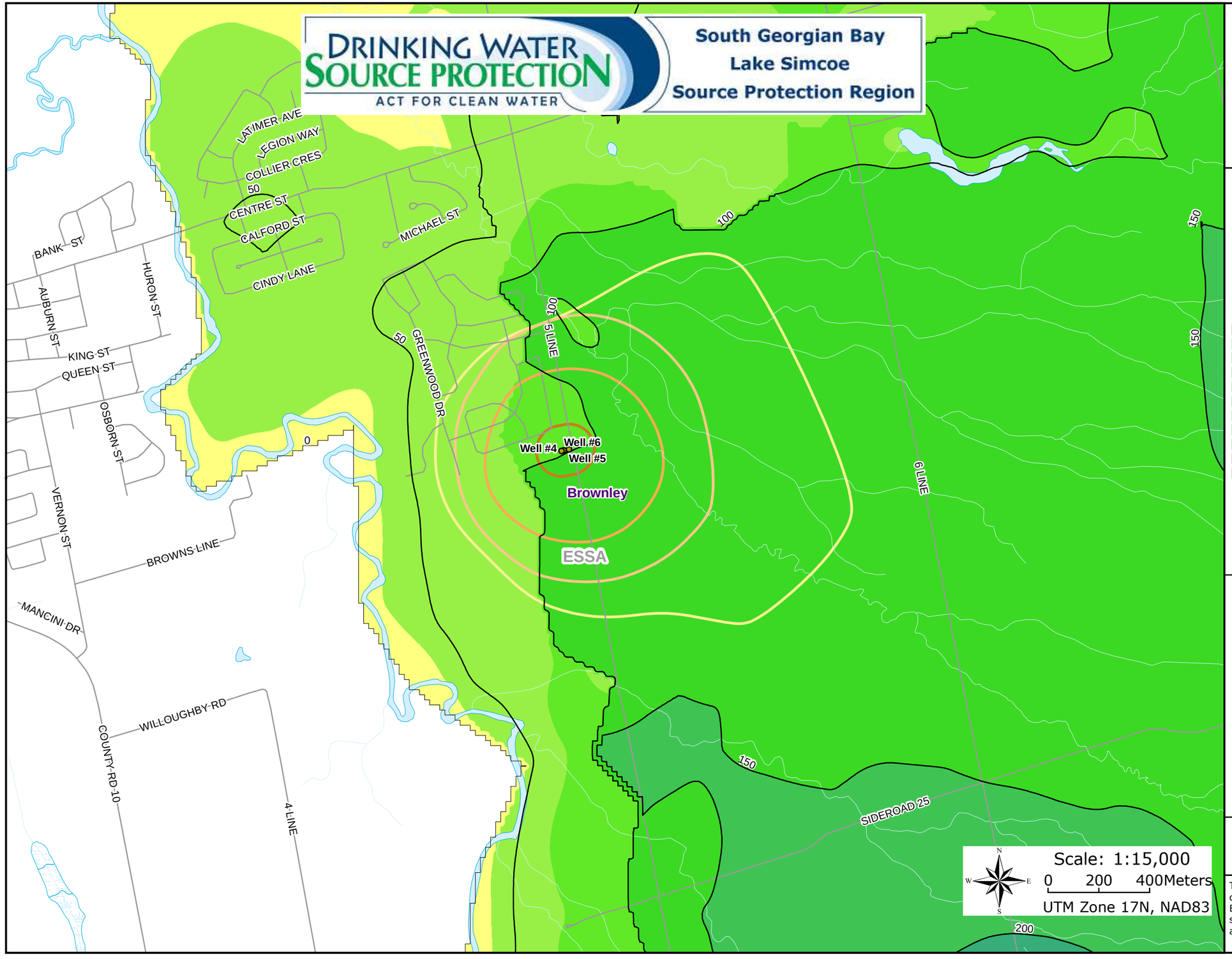
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Angus Brownley Model Calculated AVI To Top Of Aquifer A2



- Municipal Well
- Contour (50 AVI)

Model Calculated Aquifer Vulnerability Index (AVI)

- 0 - 30
- 31 - 80
- 81 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500

WHPA TOT

- WHPA-A (100 m radius)
- WHPA-B (2 yr TOT)
- WHPA-C (5 yr TOT)
- WHPA-D (25 yr TOT)
- Road
- Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Municipal Boundary

Notes:
Low Vulnerability (AVI > 80)
Medium Vulnerability (AVI 30 to 80)
High Vulnerability (AVI < 30)

Scale: 1:15,000
0 200 400 Meters
UTM Zone 17N, NAD83

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Project #: 07-1170-0014
File Number: EssaBrownley_AVI.mxd
Date: 2009-11-02

Ontario

12a-4

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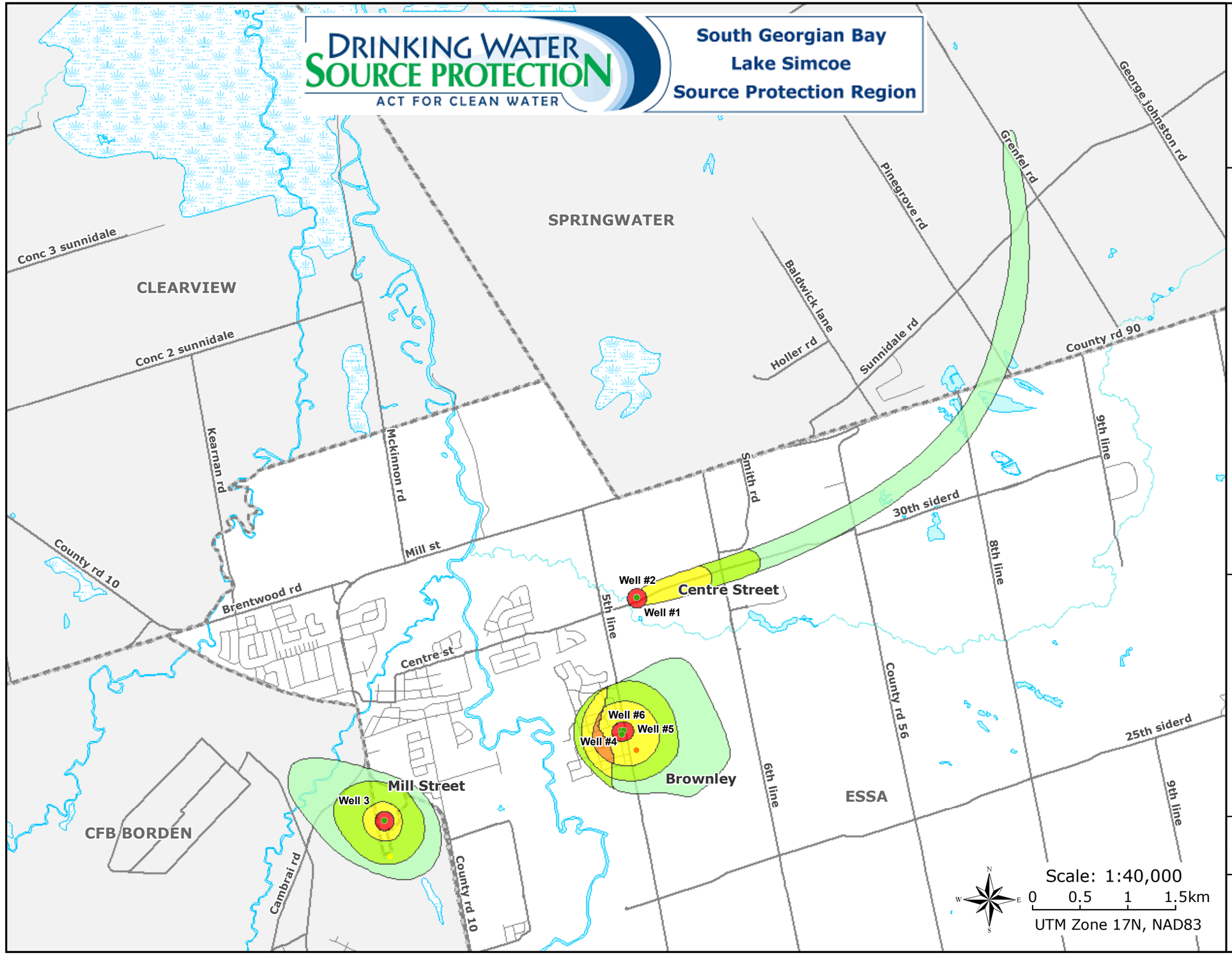
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Angus Wellhead Protection Areas Final Vulnerability Scoring



- Municipal Well
- 3C Well Pathways

Vulnerability Score

- 10
- 8
- 6
- 4
- 2
- Municipal Boundary
- Collector
- Other Road
- Water Area, Permanent
- Wetland, Permanent
- Watercourse

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Barrie, Ontario

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Project #: 07-1170-0014
File Number: EssaIV_Final_ScoringMap_withPathways
Date: 2011-08-09

Ontario

12a-5

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DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Angus
Areas That Are or Would Be Significant, Moderate or Low Drinking Water Threats: Activities Chemical

Conc 3 sunnidale
Conc 2 sunnidale
CLEARVIEW
Kearnan rd
Mckinnon rd
Mill st
County rd 10
Brentwood rd
Centre st
SPRINGWATER
Baldwick lane
Holler rd
Sunnidale rd
Smith rd
30th siderd
8th line
5th line
Centre Street
Well #2
Well #1
Well #6
Well #5
Well #4
Brownley
6th line
County rd 56
ESSA
Mill Street
Well 3
Cambrai rd
County rd 10
CFB BORDEN

Municipal Well
Vulnerability Score
10
8
6
Municipal Boundary
Collector
Other Road
Water Area, Permanent
Wetland, Permanent
Watercourse

Scale: 1:40,000
0 0.5 1 1.5km
UTM Zone 17N, NAD83

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Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number:
Essa_Chemical_Threat.mxd
Date: 2011-07-28

Ontario

12a-6

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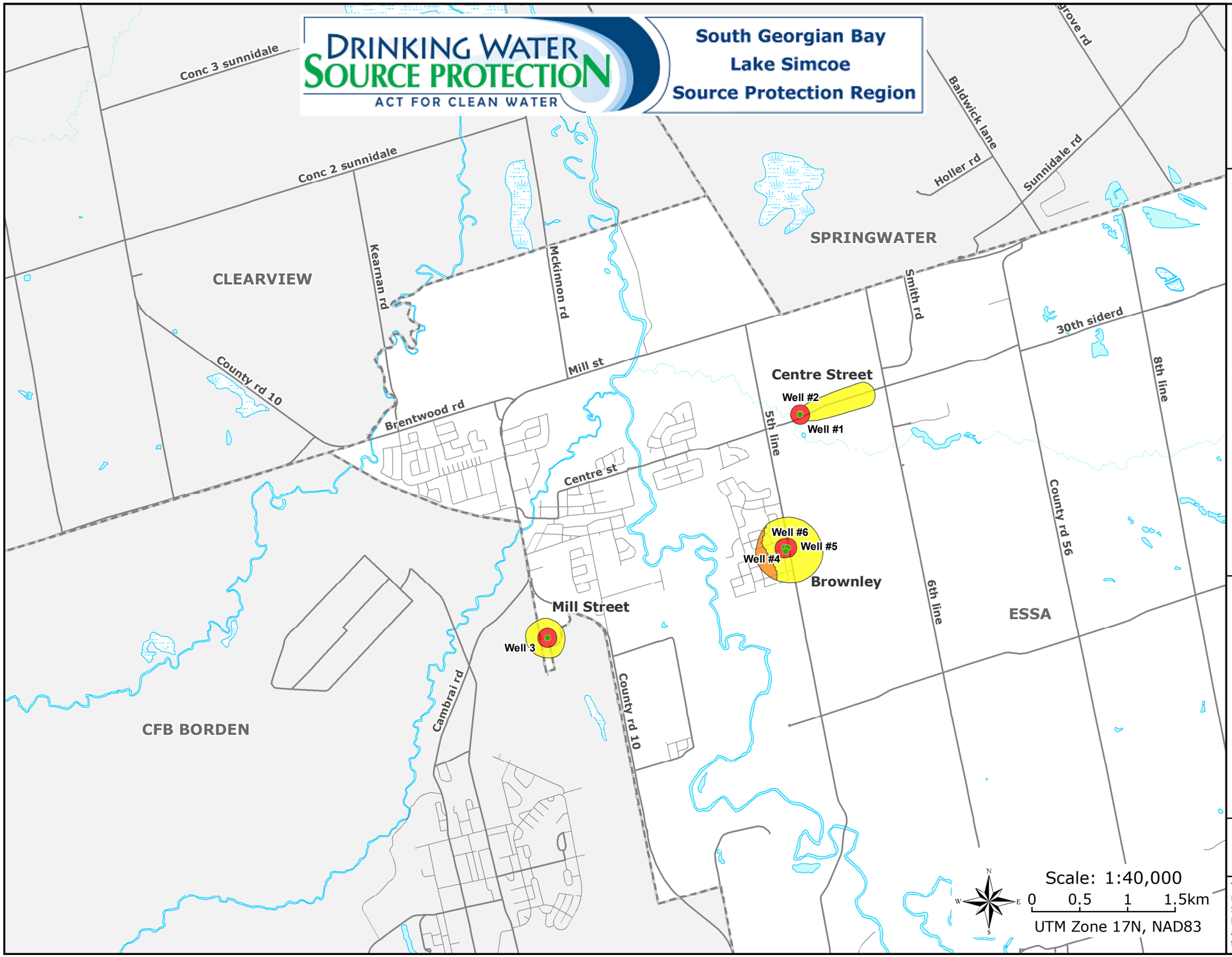
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Angus Areas That Are or Would Be Significant, Moderate or Low Drinking Water Threats: Activities Pathogen



- Municipal Well

Vulnerability Score
- 10
- 8
- 6
- Municipal Boundary
- Collector
- Other Road
- Water Area, Permanent
- Wetland, Permanent
- Watercourse

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Project #: 07-1170-0014
File Number:
Essa_Pathogen_Threat.mxd
Date: 2011-07-12

Ontario

12a-7

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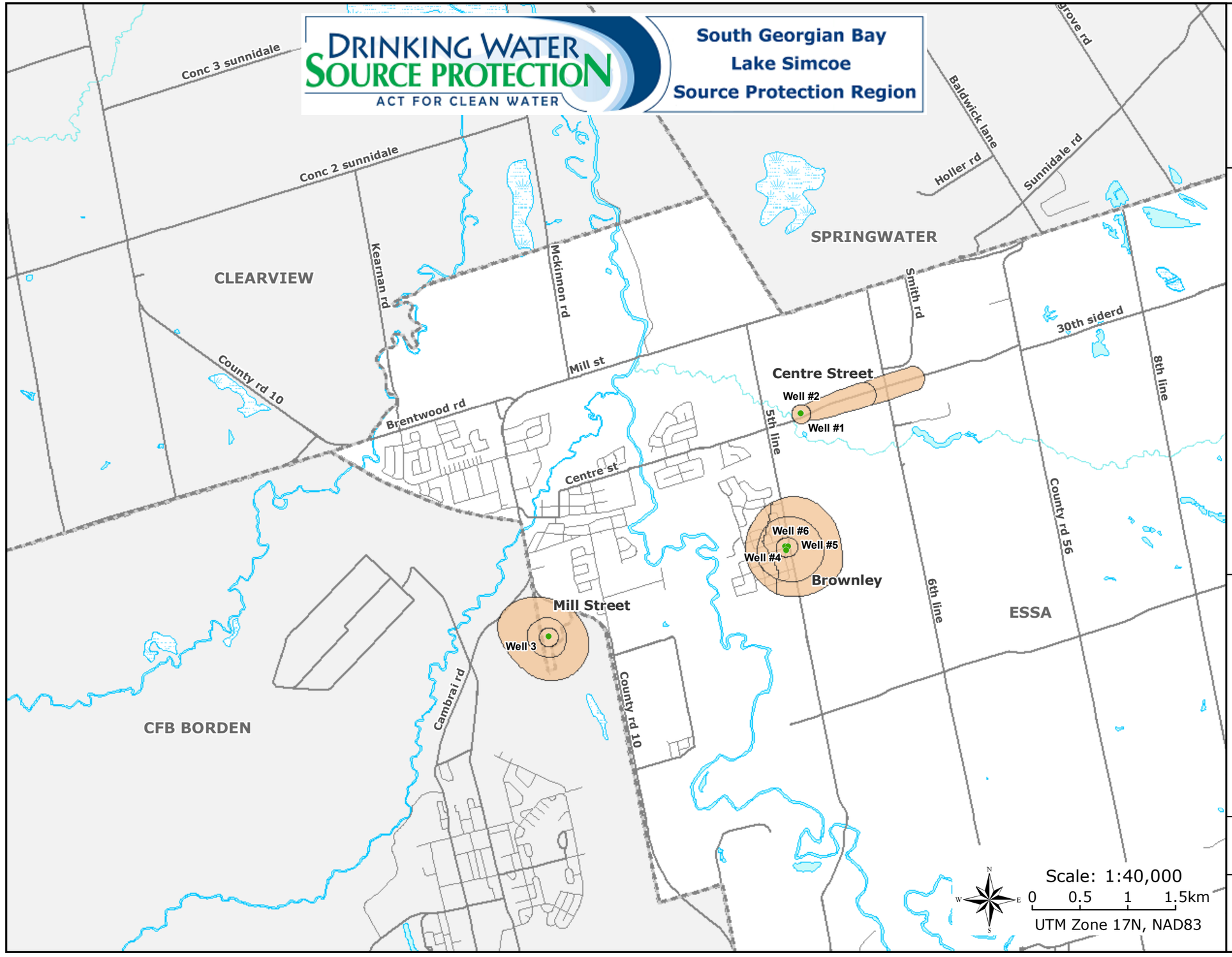
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Angus Areas That Are or Would Be Significant, Moderate or Low Drinking Water Threats: Activities DNAPLs



Municipal Well
WHPA A, B, C or C1
WHPA D with V.Score >= 6
Municipal Boundary
Collector
Other Road
Water Area, Permanent
Wetland, Permanent
Watercourse

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Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number:
Essa_DNAPL_Threat.mxd
Date: 2011-08-09

Ontario

12a-8

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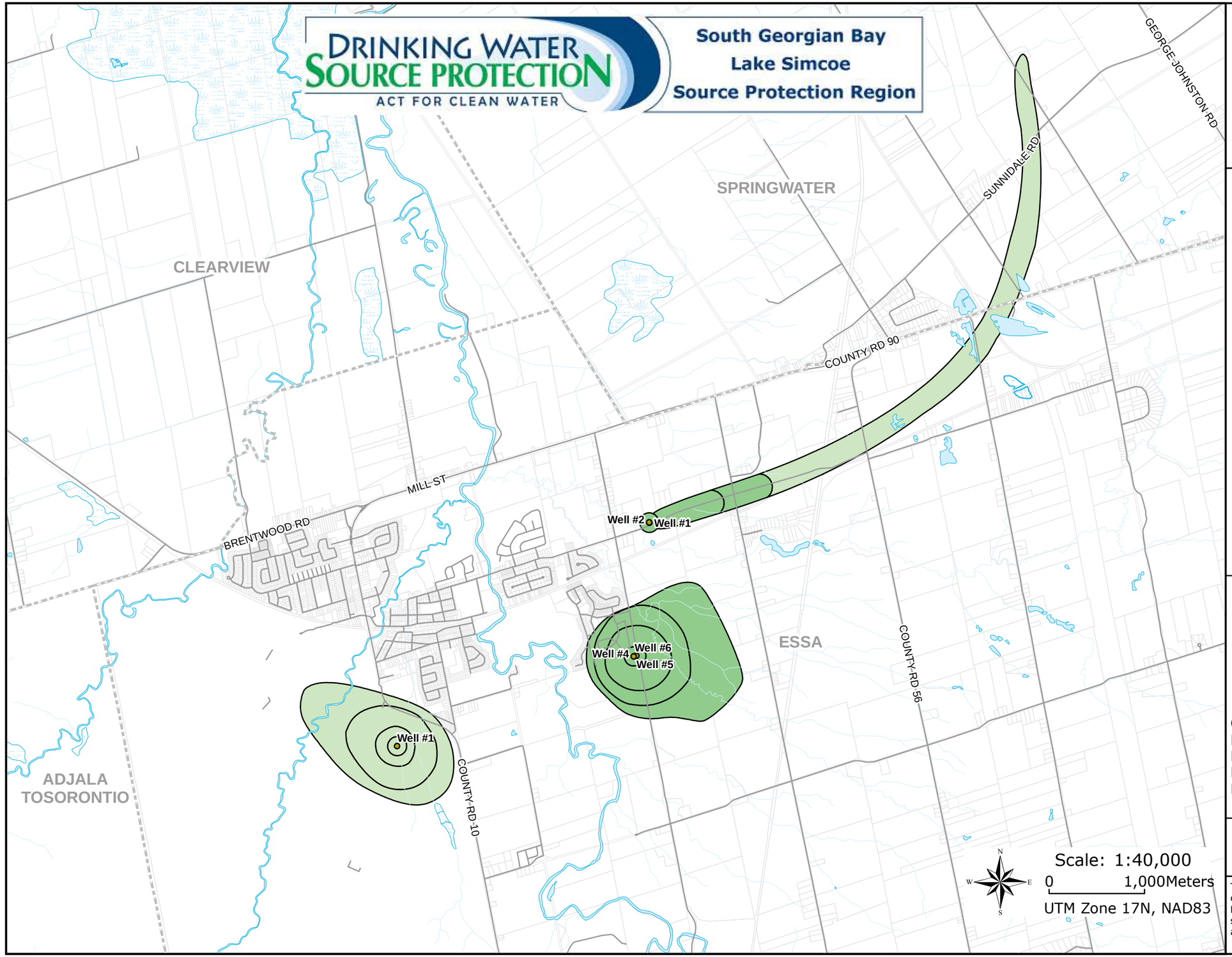
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Angus Wellhead Protection Areas Managed Lands



- Municipal Well

Percent of Managed Lands

- 0% - 40%
- 40% - 80%
- Secondary Highway
- Other Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Parcel Fabric
- Municipal Boundary

Scale: 1:40,000
0 1,000 Meters
UTM Zone 17N, NAD83

Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number:
Essa_Managed_Land.mxd
Date: 2010-02-02

Ontario

12a-9

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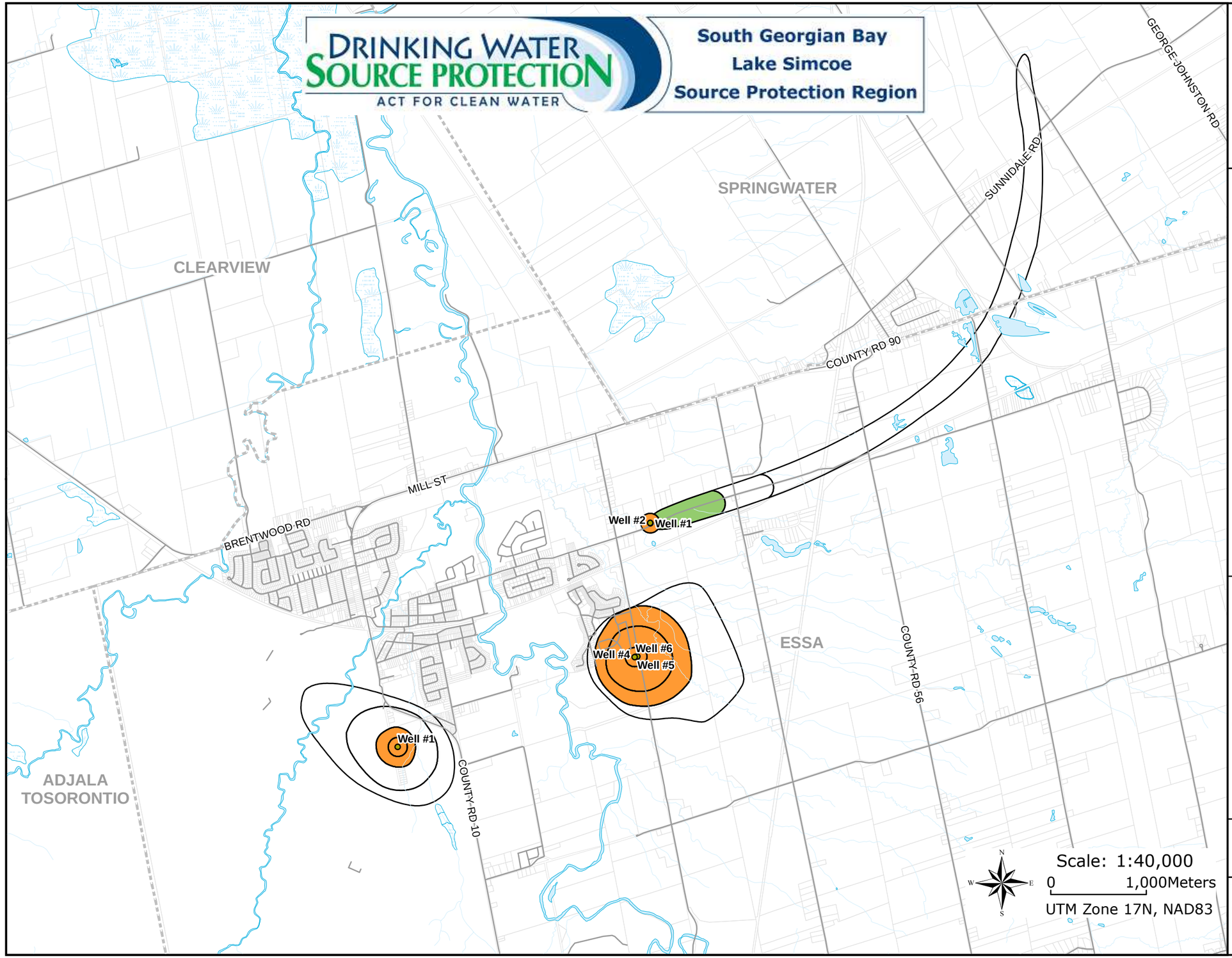
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Angus Wellhead Protection Areas Livestock Density



- Municipal Well

Livestock Density

- < 0.5 NU/Acre
- 0.5 - 1.0 NU/Acre
- Secondary Highway
- Other Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Parcel Fabric
- Municipal Boundary

Scale: 1:40,000
0 1,000 Meters
UTM Zone 17N, NAD83

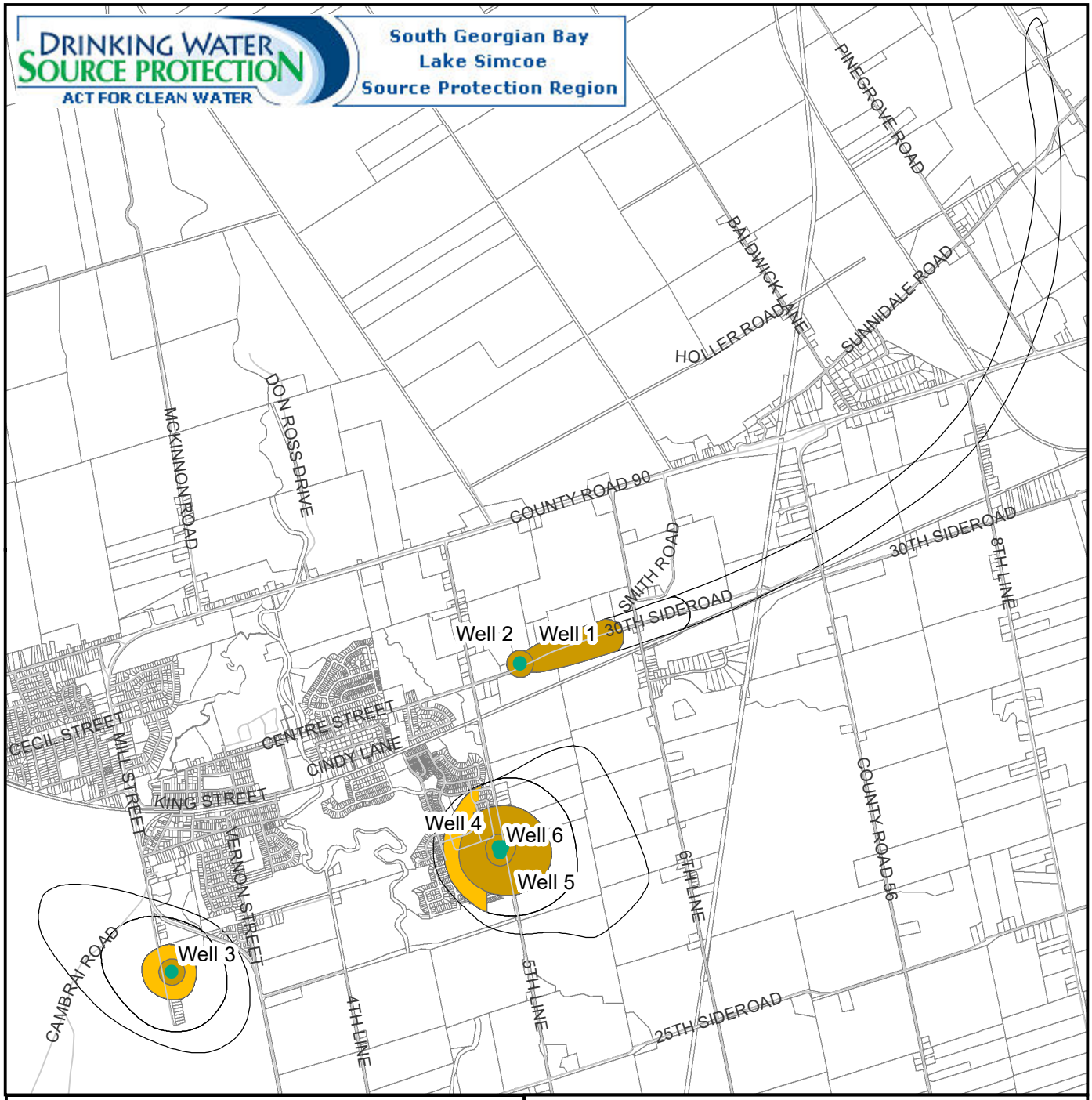
Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number:
Essa_Livestock_Density.mxd
Date: 2010-02-02

Ontario

12a-10

This map was produced for the Township of Essa, for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.



Legend

- Municipal Well Location
- <1%
- =1 - <6%
- =6 - <8%
- =8 - <30%
- =>30%

N
W E
S

450 225 0 450 Meters

The Impervious Surfaces proportion is illustrated where the vulnerability score is greater than 6.

This map was produced for the South Georgian Bay Lake Simcoe Protection Region for the purpose of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.

IMPERVIOUS SURFACES - ANGUS

ASSESSMENT OF DRINKING WATER THREATS
SELECTED MUNICIPAL GROUNDWATER SUPPLIES
South Georgian Bay Lake Simcoe
Source Protection Region

Created by: NVCA
Date: 2025-09

Scale: 1:45,000

UTM Zone 17N, NAD83

Nottawasaga Valley Conservation Authority

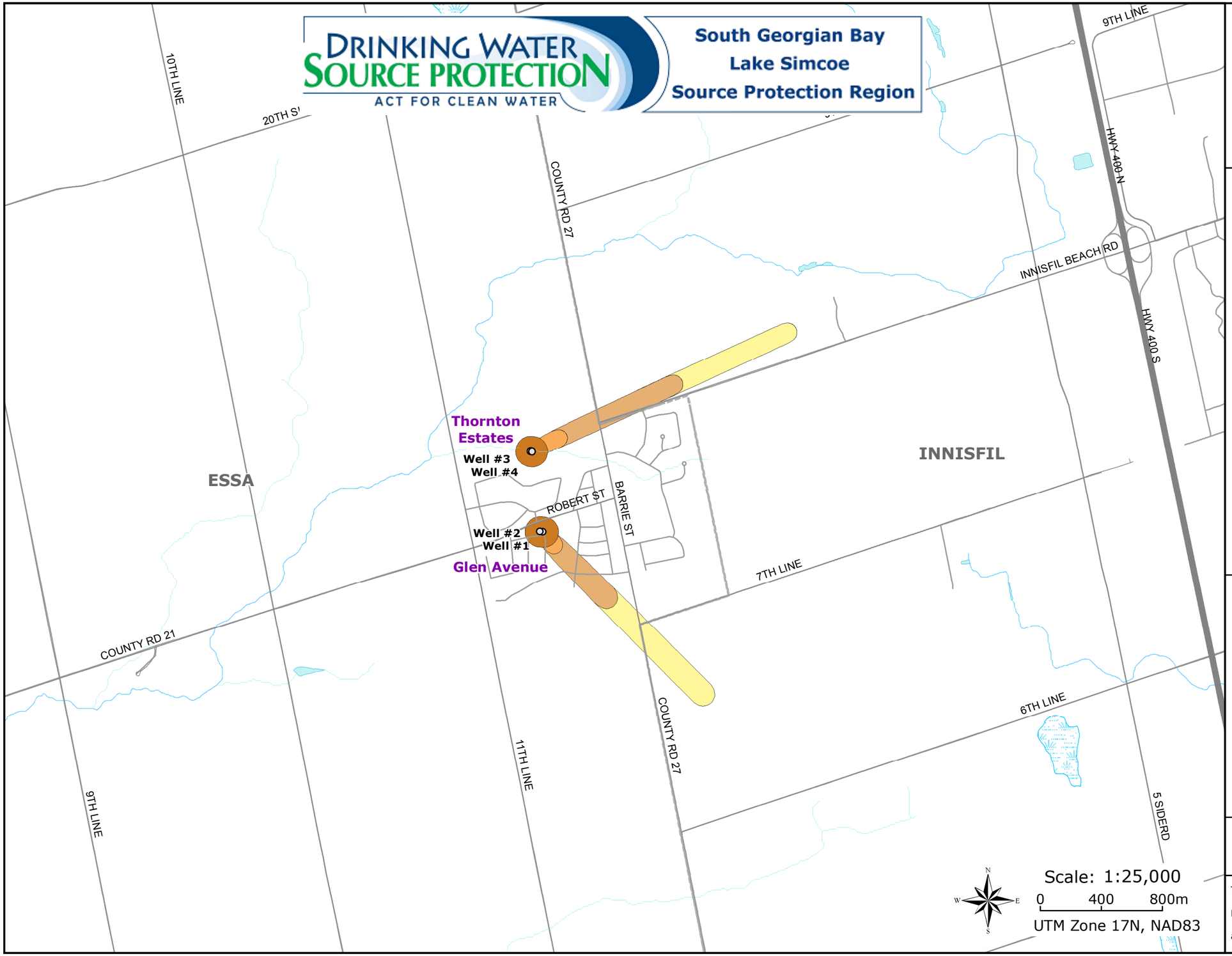
Ontario

Figure 12a-11

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Thornton Wellhead Protection Areas



- Municipal Well
- Highway
- Seconary Highway
- Other Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Municipality Boundary

WHPA TOT

- WHPA-A (100m Radius)
- WHPA-B (2 yr TOT)
- WHPA-C1 (10 yr TOT)
- WHPA-D (25 yr TOT)

Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number: EssaCaptureZones_Thornton.mxd
Date: 2009-09-01

Ontario

12b-1

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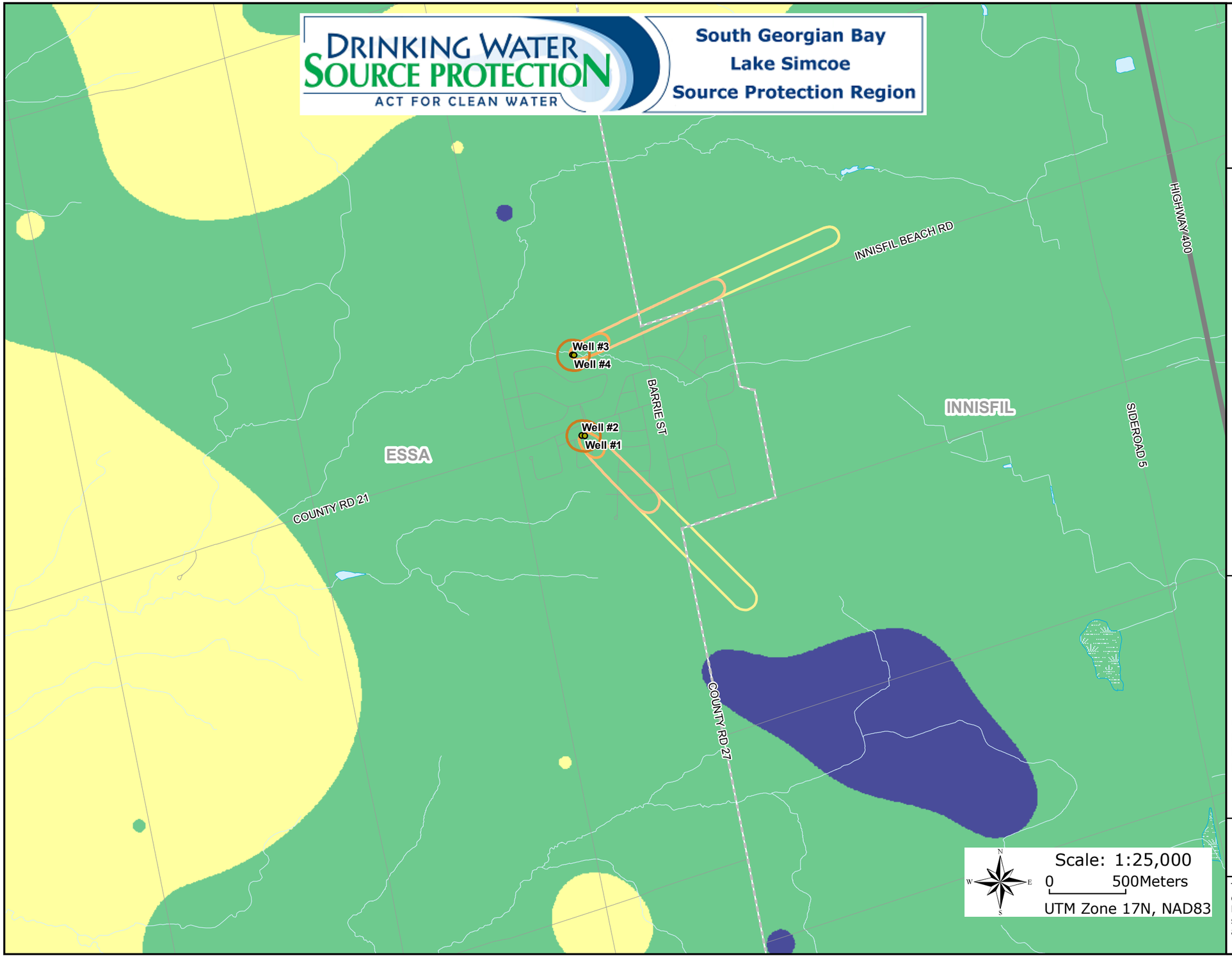
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Thornton Intrinsic Susceptibility Index (ISI)



- Municipal Well
- Highway
- Secondary Highway
- Other Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Municipal Boundary

WHPA TOT

- WHPA-A (100 m radius)
- WHPA-B (2 yr TOT)
- WHPA-C1 (10 yr TOT)
- WHPA-D (25 yr TOT)

ISI

- Low Vulnerability (ISI <30)
- Medium Vulnerability (ISI 30 - 80)
- High Vulnerability (ISI >80)

Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number: EssaCaptureZones_Thornton_ISI.mxd
Date: 2009-11-02

Ontario

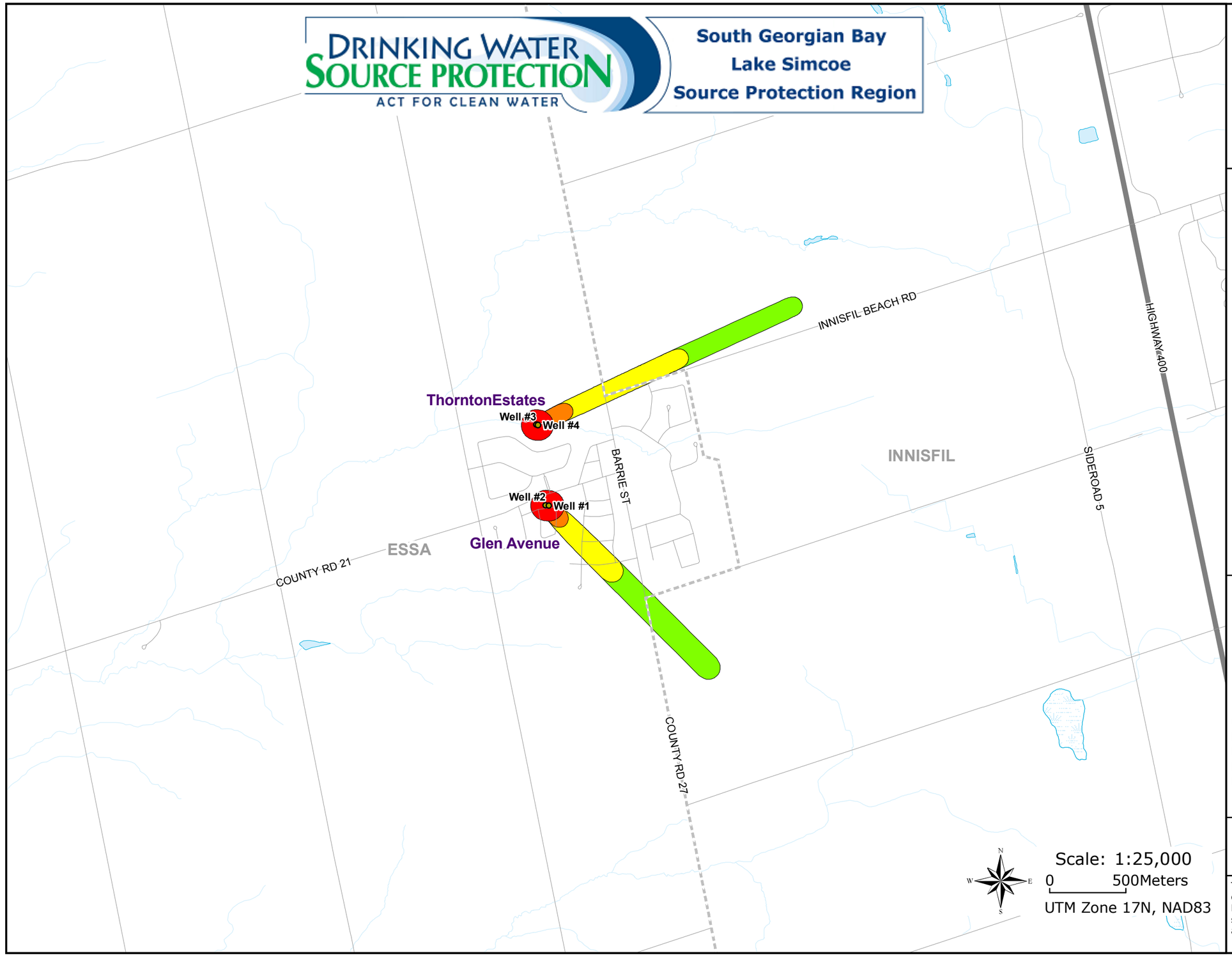
12b-2

This map was produced for the Township of Essa, for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Thornton Final Vulnerability Scoring



Municipal Well

Vulnerability Score

- 10
- 8
- 6
- 4
- 2

Highway
Secondary Highway
Other Road
Watercourse
Water Area, Permanent
Wetland, Permanent
Municipal Boundary

N
W
E
S

Scale: 1:25,000
0 500Meters
UTM Zone 17N, NAD83

Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number:
EssaCaptureZonesThornton_withPathways.mxd
Date: 2009-11-02

Ontario

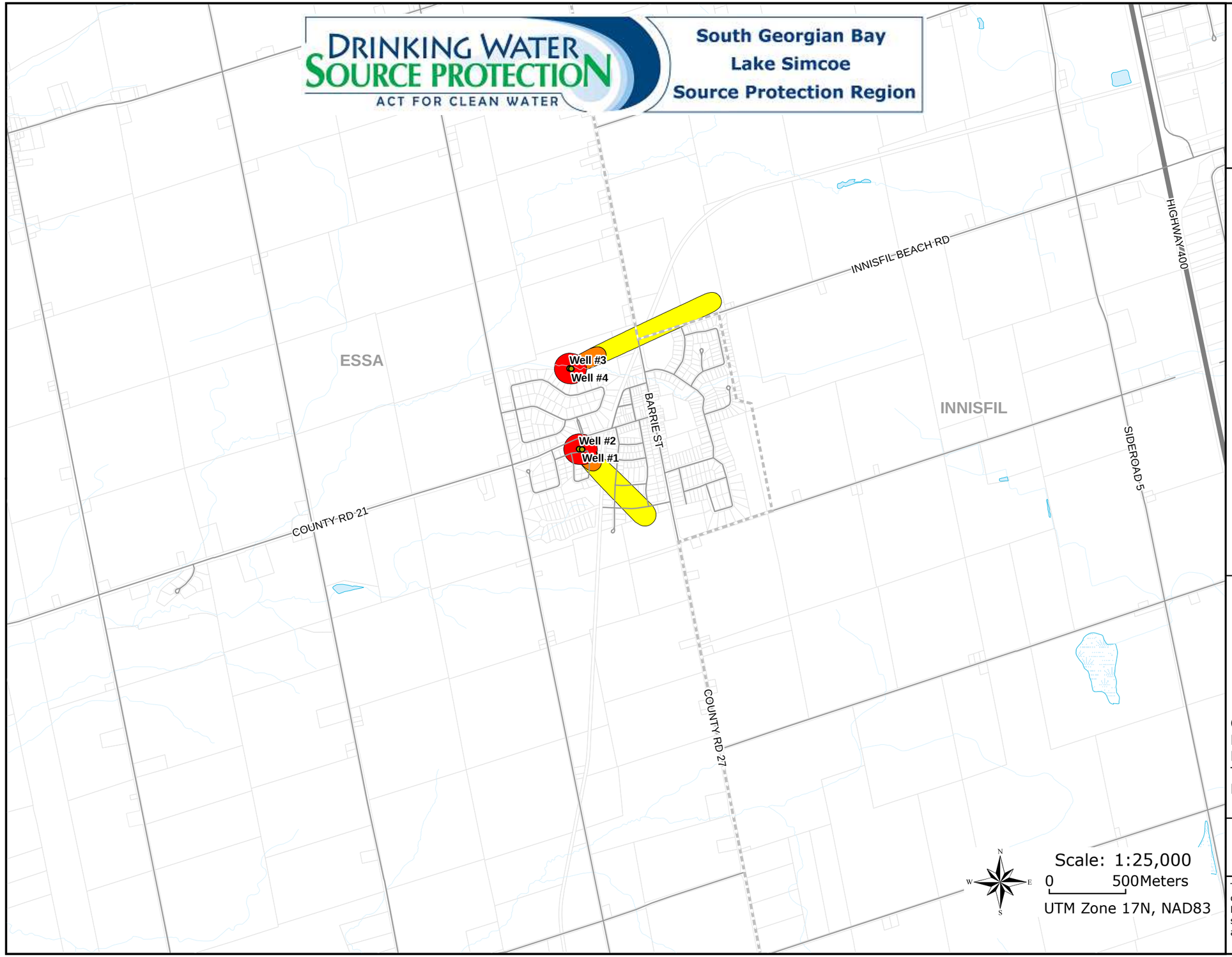
12b-3

This map was produced for the Township of Essa, for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Thornton Areas That Are or Would Be Significant, Moderate or Low Drinking Water Threats: Activities Chemical



Municipal Well

Vulnerability Score

- 10
- 8
- 6

Principal Highway
Secondary Highway
Other Road
Watercourse
Water Area, Permanent
Wetland, Permanent
Parcel Fabric
Municipal Boundary

Scale: 1:25,000
0 500Meters
UTM Zone 17N, NAD83

Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number: Thornton_Chemical_Threat.mxd
Date: 2010-02-02

Ontario

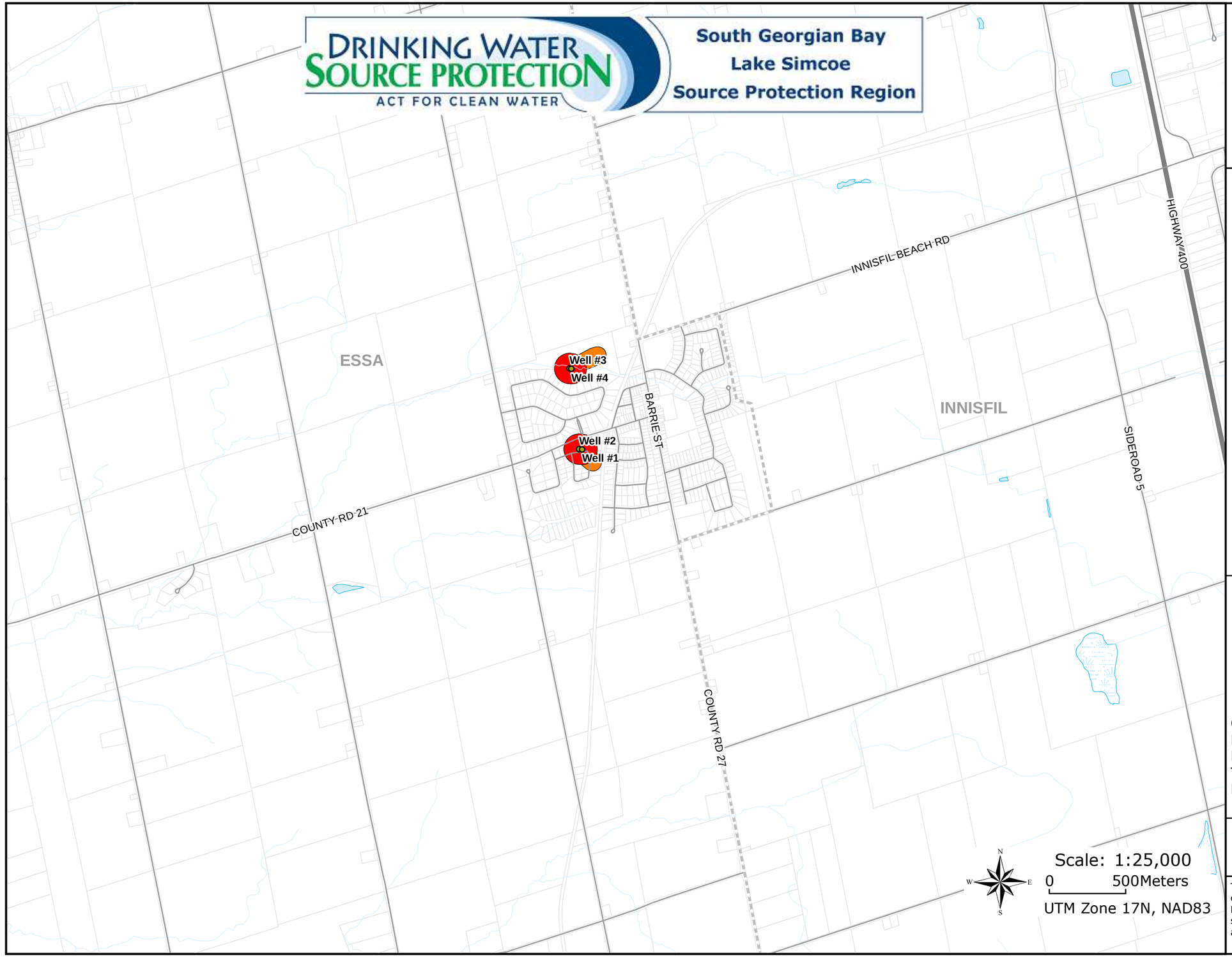
12b-4

This map was produced for the Township of Essa, for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Thornton Areas That Are or Would Be Significant, Moderate or Low Drinking Water Threats: Activities Pathogen



- Municipal Well

Vulnerability Score

- 10
- 8
- 6
- Principal Highway
- Secondary Highway
- Other Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Parcel Fabric
- Municipal Boundary

Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number: Thornton_Pathogen_Threat.mxd
Date: 2010-02-02

Ontario

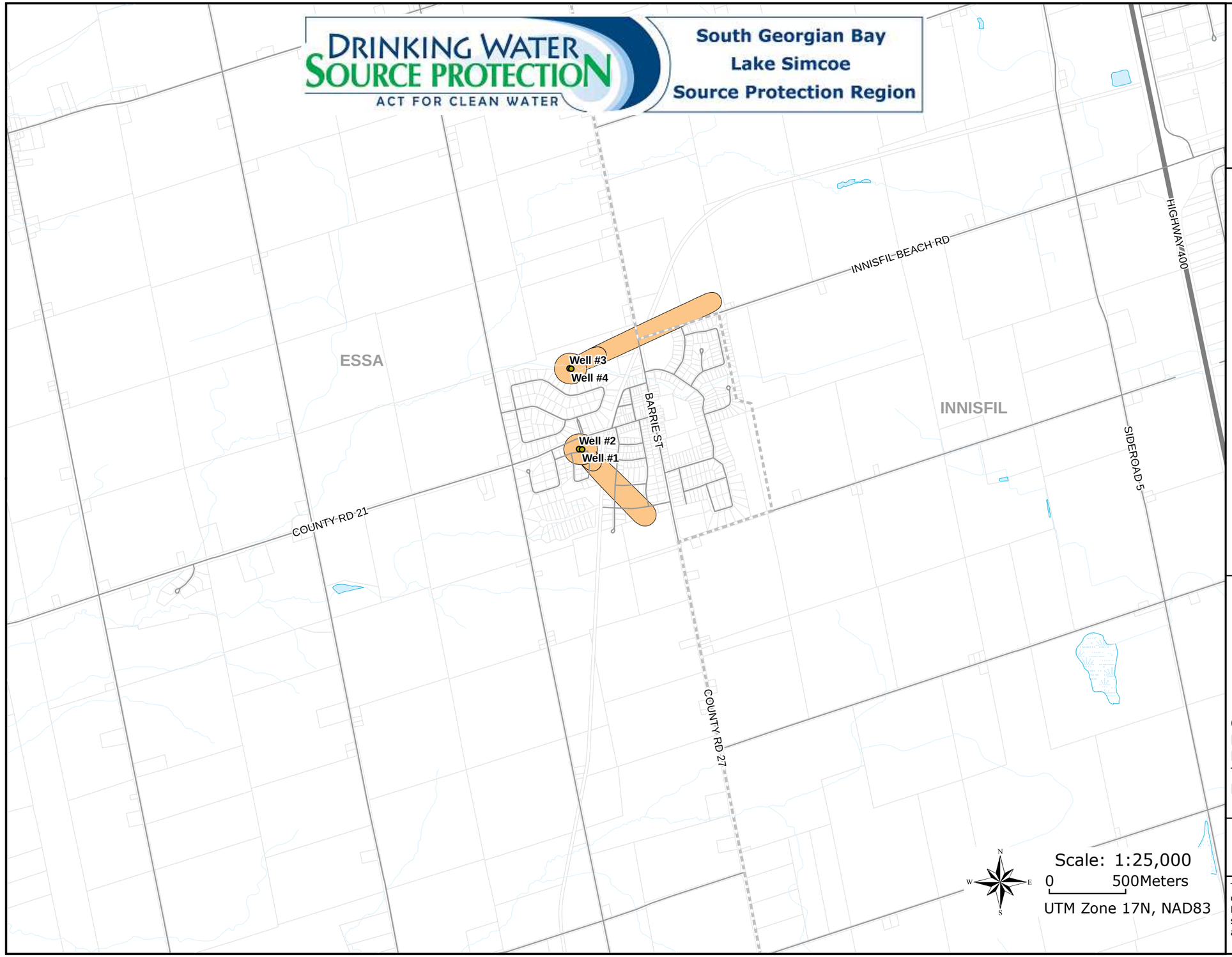
12b-5

This map was produced for the Township of Essa, for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Thornton Areas That Are or Would Be Significant, Moderate or Low Drinking Water Threats: Activities DNAPLs



- Municipal Well
- WHPA A, B, C, C1
- WHPA D with Vulnerability ≥ 6
- Primary Highway
- Secondary Highway
- Other Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Parcel Fabric
- Municipal Boundary

Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number:
Thornton_DNAPL_Threat.mxd
Date: 2010-02-02

Ontario

12b-6

This map was produced for the Township of Essa, for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Thornton Wellhead Protection Areas Managed Lands

- Municipal Well

Percent of Managed Lands

- 0% - 40%
- 40% - 80%
- Principal Highway
- Secondary Highway
- Other Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Parcel Fabric
- Municipal Boundary

Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number:
Thornton_Managed_Land.mxd
Date: 2010-02-02

Ontario

12b-7

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DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

South Georgian Bay
Lake Simcoe
Source Protection Region

Township of Essa: Thornton Wellhead Protection Areas Livestock Density

- Municipal Well

Livestock Density

- < 0.5 NU/Acre
- Principal Highway
- Secondary Highway
- Other Road
- Watercourse
- Water Area, Permanent
- Wetland, Permanent
- Parcel Fabric
- Municipal Boundary

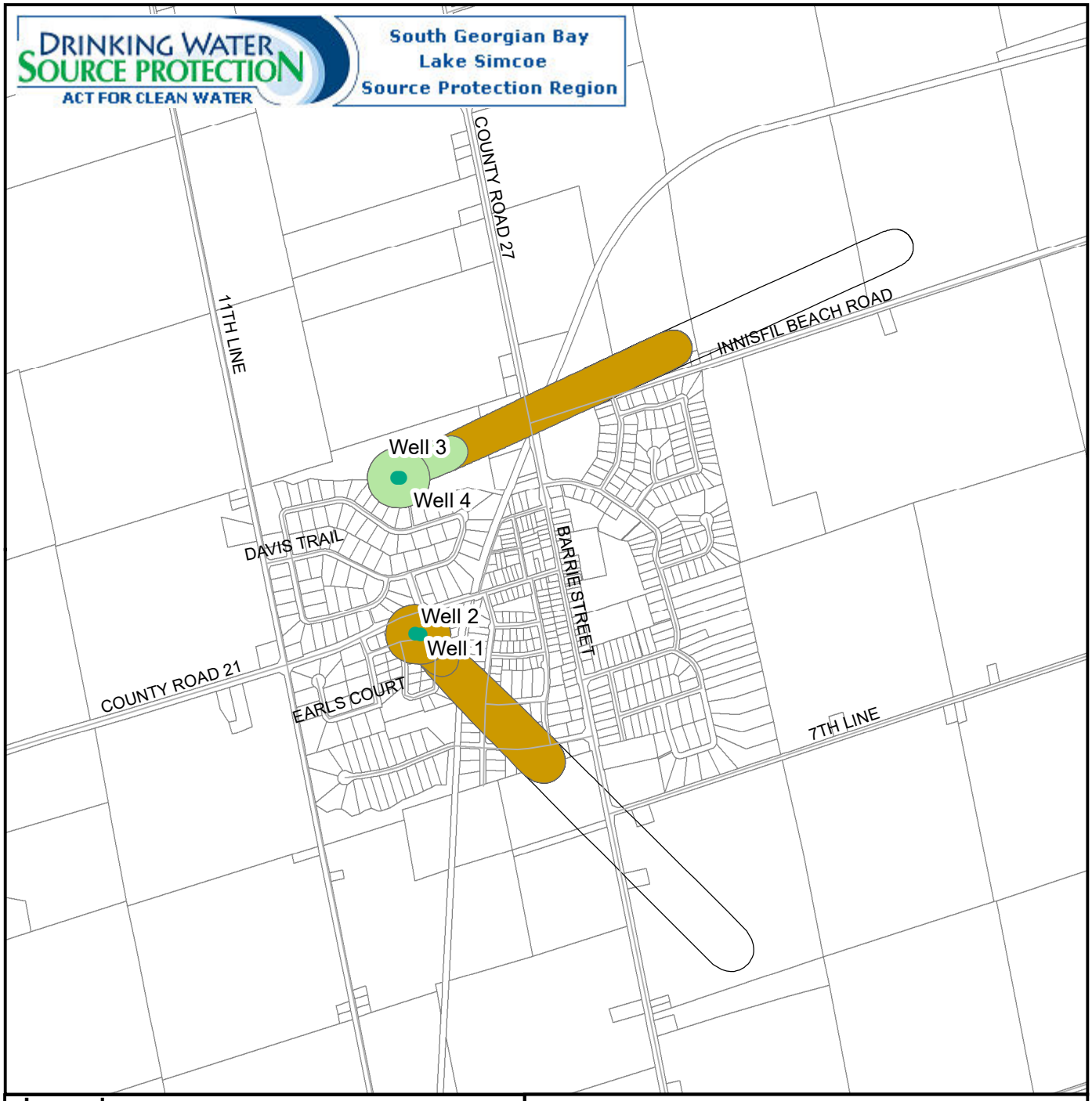
Golder Associates
Barrie, Ontario

Created by: Golder Associates Ltd.
Project #: 07-1170-0014
File Number:
Thornton_Livestock_Density.mxd
Date: 2010-02-02

Ontario

12b-8

This map was produced for the Township of Essa, for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.



Legend

- Municipal Well Location
- <1%
- =1 - <6%
- =6 - <8%
- =8 - <30%
- =>30%

N W E S

200 100 0 200 Meters

The Impervious Surfaces proportion is illustrated where the vulnerability score is greater than 6.

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IMPERVIOUS SURFACES - THORNTON

ASSESSMENT OF DRINKING WATER THREATS
SELECTED MUNICIPAL GROUNDWATER SUPPLIES
South Georgian Bay Lake Simcoe
Source Protection Region

Created by: NVCA
Date: 2025-09

Scale: 1:20,000

UTM Zone 17N, NAD83

Ontario

Figure 12b-9