Chapter 9: City of Barrie

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9 City of Barrie

9.1 Introduction

The City of Barrie Drinking water system, including the surface water intake, is for the most part located in the Lake Simcoe and Couchiching-Black Source Protection Region. However, as four wells are located in the Nottawasaga Valley Source Protection Region, the groundwater supply is also presented in this Assessment Report. Various consultants have 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~~Various consultants have completed the work presented, all of which was reviewed by South Georgian Bay-Lake Simcoe Source Water Protection staff, City of Barrie 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 2010f (found in Appendix MO and B) for a more in depth description of the methods used, as well as the Glossary for any unfamiliar terms.

9.2 Drinking Water Systems

The City of Barrie operates groundwater and surface water based supplies for the entire City. As shown in Figure 9-1, the groundwater and surface water supply are within the South Georgian Bay-Lake Simcoe (SGBLS) Source Protection Region (SPR). The list below indicates the Source Protection Region and corresponding lead Source Protection Authority (SPA) for the municipal water supplies.

Municipal Groundwater Supply in the City of Barrie within the Lake Simcoe and Couchiching/ Black River SPA and the Nottawasaga Valley SPA SGBLS SPR included in this report:

- Barrie Well Supply

Municipal Water Supply in the City of Barrie within the lake Simcoe and Couchiching/Black River SPA and the Nottawasaga Valley Source Protection Authority (SPA) SGBLS SPR but not included in this report:

- Barrie Water Treatment Plant

While the majority of wells are within the Lakes Simcoe and Couchiching / Black River SPA, four wells are within the Nottawasaga watershed in addition to a number of Wellhead Protection Areas (WHPA) from other Barrie wells. Information on all Barrie Well supplies and the Surface Water supply are presented in the Lakes Simcoe and Couchiching-Black River SPA Assessment Report (Chapter 9).

9.3 Barrie Well Supply

The Barrie Well WHPA delineation, supply Vulnerability and Threats Assessment was completed by Golder Associates Limited (Golder, 2004, 2010f) under contract of the City of Barrie.

The City of Barrie is located on Kempenfelt Bay of Lake Simcoe. The City currently obtains potable water from groundwater and surface water sources and has a total of fourteen municipal wells that service approximately 78,500 residents. The Barrie Groundwater Supply operates under Permit To Take Water # 2353-7SLPRF, which expires June 17, 2019. The City of Barrie Water Treatment Plant obtains surface water via an intake constructed in Kempenfelt Bay, on the southwest side of Lake Simcoe. The surface water treatment plant was brought online in the summer of 2011, and now serves the southern portion of the city; as a result, demand on the city's groundwater wells has decreased

The majority of the municipal wells are located within the central and lakeshore area of Barrie, and consist of Wells, 3A, 4, 5, 7, 11, 12, 14, 15, 17, 18, and 19. Three wells, Wells 9, 13, and 16, are located in the north part of the City. With the exceptions of Wells 9/13, 11/14, and 17/18, all wells are constructed at separate locations (Figure 9a-1). It should be noted that an additional well (Well 10), previously located in the south part of the City was decommissioned in 2013, and has been removed from the list of operational well supplies. The City of Barrie has completed all of the necessary steps, as prescribed by Ontario Regulation 287/07, to ensure that the Clean Water Act no longer applies to this decommissioned well; as a result, Well 10 has been removed from the Assessment Report. The aquifers underlying the City of Barrie are part of a regionally extensive and complex aquifer system, within which four major sand and gravel aquifer units have been identified. Locally, these are referred to as the upper (Aquifer A1), intermediate (Aquifer A2), and lower (Aquifer A3 and A4) aquifers.

Aquifer A1 is largely unconfined under all of the central and most other parts of the City and is therefore susceptible to contamination from surface activities. The portions of the upper aquifer identified in the Oro-Medonte and upland areas immediately west of the City correspond to the regional Aquifer A1, which is mapped as ice contact stratified drift. In some places, this aquifer may be confined by the silt till materials also mapped in the uplands. This aquifer is described as coarse textured lacustrine deposits, which are part of a regionally extensive plain extending west to Angus.

Aquifer A2 is regionally extensive, but does pinch out in some areas, for example to the south, in the Town of Innisfil and to the northwest. It is thickest and most extensive towards the west and under the Oro Moraine. The aquifer is complex within the central core area of Barrie,

where it consists of inter-layered sand and silt/clay materials. The aquifer is overlain by 5 to 20 or more metres of confining materials in most areas, reported to consist of clayey and silty sediments. The lower elevation of the aquifer in the vicinity of Kempenfelt Bay corresponds with the deeper channelized aquifer (see below) and suggests that it may represent infilled former river channels in this area.

The lower aquifers, A3 and A4, are extensive sand and gravel aquifers, which form the source of the majority of Barrie's groundwater supply, as well as that of the surrounding communities of Midhurst, Shanty Bay, and Stroud. These aquifers are in direct contact with one another under the central Barrie area, as well as further to the west. It is noted that Aquifer A2 is in contact with the lower aquifer in the vicinity of Well 6. Additionally, based on the base elevation of the Kempenfelt Bay and the known elevation of the upper surface of Aquifer A3, it is interpreted that the aquifer is in contact with Kempenfelt Bay in areas to the east.

Wells 3A, 5, and 12 are all constructed in the deeper Aquifer A4. Wells 7, 9, 11, 13, 14, 15, 17, and 18 are located approximately in the centre of the combined A3/A4 aquifer, whereas the remaining wells (Wells 4, and 16) are located in the upper part of Aquifer 3.

9.3.1 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 City of Barrie 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:

- confirm the WHPA for delineation for Well 19 and evaluation of the WHPA delineation for all of the Barrie wells based on the inclusion of Well 19

- assess Groundwater Vulnerability (AVI 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 the final Vulnerability Score
- determine the level of uncertainty in the Vulnerability Assessment

Detailed methods describing the Vulnerability Analysis completed by Golder (2010f) are provided in Appendix B. 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 MECP~~OE~~ detailing the reason why the alternate method could not be used is provided in Appendix B.

9.3.1.1 Wellhead Protection Area (WHPA) Delineation

The South Simcoe Groundwater Study (SSGS) included the delineation of the WHPAs for all of the municipal wells in the City of Barrie. A three-dimensional (FEFLOW) groundwater flow model was constructed to enhance the knowledge of the regional groundwater system and to delineate the capture zones for the Barrie wells. A detailed description of the groundwater flow modeling undertaken for these wells can be found in the SSGS report (Golder, 2004).

Two additional wells, Well 18 and 19, were developed by the City of Barrie subsequent to the issuance of the SSGS report. The WHPA for Well 18 was delineated as part of an earlier system permit application (Golder, 2008). The most recent update to the FEFLOW model included the addition of municipal Well 19 (Golder, 2008). As part of the 2008 work, time-of-travel capture zones were delineated for Well 19; however, the remaining Barrie municipal well capture zones were not revisited. Therefore the WHPAs previously delineated for the other City of Barrie wells have been re-assessed (See Golder, 2010f).

The WHPAs for the City of Barrie wells are complex and cover much of the city core seamlessly. There are a number of instances where similar time-of-travel zones from different wells border one another, while in other instances different time-of travel zones are side by side. These

model output WHPAs (WHPA B and C) have been modified to produce final WHPAs which represent combined capture areas as shown on Figure 9a-1.

The WHPAs in the core area of the City have been combined into two main areas: the Lakeshore Wells (Wells 11, 12, 14, and 15) and wells west of the Lakeshore Wells (Wells 3A, 4, 5, 7, 17, 18, and 19). The combined WHPAs, in place of the individual core area WHPAs, have been implemented based on the rationale found in the Golder (2010f) report.

9.3.1.2 Groundwater Vulnerability

The Groundwater Vulnerability within the WHPA of the fourteen municipal wells in Barrie is shown in Figure 9a-2.

The regional scale intrinsic susceptibility index (ISI) Vulnerability was completed for the City of Barrie in the SSGS. As the municipal aquifers in the City of Barrie 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 this lower than 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 were utilized to calculate the Vulnerability to the municipal aquifer.

The Groundwater Vulnerability has been determined from an analysis of AVI approaches as documented in Golder, 2010f. Due to the depth of the municipal aquifer and presence of confining units, all of the City of Barrie WHPAs are calculated to have a Low Intrinsic Vulnerability.

9.3.1.3 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 Barrie systems, 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 Barrie within the area of the WHPAs in 2007. Details on the methodology can be found within the report Golder (2008). 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:

- 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
- 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, 2010f. The location of Transport Pathways and the resulting increase to Vulnerability Scores are presented in Figure 9a-3.

9.3.1.4 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.~~

9.3.1.5 Vulnerability Score

The WHPA zones for the Barrie Water Supply, (Figure 9a-1), the Groundwater Vulnerability, (Figure 9a-2), and increases due to Transport Pathways (Section 9.3.1.3) were used to assign a Vulnerability Score using the matrix from Table 5.3 (Chapter 5: Methods Overview, Section 5.2.4). Figure 9a-3 illustrates the Vulnerability Scores for the Barrie Water Supply. Figure 9a-3 will be used to assess Drinking Water Threats in Section 9.3.3.

9.3.1.6 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 2010f 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 2010f.

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 Barrie WHPAs is High. The full results of the WHPA delineation Peer Review process for Barrie is available in Appendix B and discussed in Chapter 5 (Methods Overview). Based on the rationale provided for the Vulnerability Assessment (see below), Golder 2010f, 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, 2010f. 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 Barrie Water Supply is considered Low close to the municipal wells and increases at the outer reaches of the 25 year capture area. Overall the Vulnerability Uncertainty is characterized as Low.

9.3.2 Drinking Water Issues

The intent of the Issues Evaluation is to identify parameters (e.g. chemicals 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. 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 City of Barrie Drinking Water Issues Evaluation was based on previously completed groundwater studies (Golder, 2004), annual drinking water quality reports, water quality digital data provided by the City, as well as input from municipal authorities to confirm the Issues list.

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.

Based on the review of the data, Drinking Water Issues were identified for the City of Barrie.

Well 3A – Chloride

Well 3A has been identified to have a Drinking Water Issue due an increasing trend of chloride concentrations. The most recent reported concentration of chloride from this well was 73 mg/L. The projected 50 year concentration trend indicates that chloride at Well 3A (245 mg/L) would approach the ODWQS limit. However, recent data suggests a possible steepening in the chloride trend and therefore it has been included as a Drinking Water Issue. Chloride is listed in the ODWQS as an aesthetic objective, however, its origins are considered to be anthropogenic in this area. The chloride Issue for Well 3A likely results from non-point source inputs such as road salt. As delineation of an Wellhead Protection Area-Issue Contributing Area (WHPA-ICA) is difficult, it is considered that the entire WHPA should be part of the WHPA-ICA (Figure 9a-4).

Well 11, 12 and 14 – Chloride and Sodium

Wells 11, 12 and 14 have been identified to have a Drinking Water Issue due to elevated chloride concentrations. Recent reported chloride concentrations are 110 mg/L at Well 11, 85 mg/L at Well 14, and 197 mg/L at Well 12. The trend in chloride concentrations at these wells indicates that chloride concentrations would approach or exceed the ODWQS limit of 250 mg/L within a 50 year period. Recent data at Well 14 suggest a possible stabilizing trend; however,

chloride is still considered a Drinking Water Issue considering its shared capture with and proximity to Well 11.

In addition to chloride, Well 11 and Well 12 also exhibit increasing concentration trends of sodium, which are projected to exceed the ODWQS limit of 200 mg/L in 50 years. As with chloride, sodium is an aesthetic objective within the ODWQS, but the increasing concentrations are considered to be associated with anthropogenic impacts. It is noted that the concentrations of chloride and sodium exhibit a scattered pattern at Well 12, which may result in varying interpretation of trends, however, an overall upward trend is observed at this well. Chloride and sodium are considered to result from non-point source inputs; therefore the entire WHPAs for these wells are considered part of the WHPA-ICA. Given the proposed combined capture zones for the Lakeshore wells, the combined Well 11, 12, 14, and 15 WHPA would be delineated as the WHPA-ICA (Figure 9a-4).

Within the Wellhead Protection Area-Issue Contributing Area, the Technical Rules require that all Threats related to a particular issue are modified to be a Significant Drinking Water Threat, regardless of the Vulnerability. Therefore if a property is located with the Issue Contributing Area and has been identified as having a prescribed Threat related to Chloride or Sodium (according to the ~~MECP~~ Technical Rules~~OE Tables~~) then the property is flagged as a Significant Drinking Water Threat. The following lists the Threats related to chloride and sodium as defined by the ~~MECPOE database of Threats~~Technical Rules and associated chemical parameters:

- Application of Road Salt
- Handling and Storage of Road Salt
- Storage of Snow
- Sewage System or Sewage Works – Discharge of Untreated Stormwater From Stormwater Retention Pond
- Sewage System or Sewage Works – Industrial Effluent Discharges
- Sewage System or Sewage Works – Septic Systems
- Sewage System or Sewage Works – Septic System Holding Tank

The results of the Drinking Water Issues related threats are provided in Section 9.3.3.5. As discussed in Section 9.3.3.5, the Threats related to septic systems and application of road salt have been assigned as one threat for each threat type within each Issue Contributing Area (one for the combined Lakeshore wells' WHPA and the other for the combined WHPA of wells

upgradient of this) instead of assigning individual threats at each parcel where a septic system or application of road salt was identified.

Lakeshore Wells VOC Detections

Low concentrations of volatile organic compounds (VOC) have been detected on more than one occasion at Wells 11, 12, 14, and 15, located in the Lakeshore area. The presence and trends of the VOC at these wells were reviewed to determine if a Drinking Water Issue designation is warranted. Based on the evaluation of the existing data it was determined that there was insufficient evidence to support the inclusion of the VOCs as a Drinking Water Issue. This evaluation is based upon the approach noted above, as follows:

- whereas the municipal production wells have exhibited detectable concentrations of VOC including perchloroethylene (PCE), trichloroethylene (TCE), and cis-1,2-dichloroethylene (DCE), the reported concentrations are consistently below the maximum allowable concentrations outlined in the ODWQS
- in the case of Wells 12 and 15, the reported concentrations are only detected sporadically and are near the laboratory reporting limit
- current data indicate that the overall trend of the concentrations of these compounds is stable at the current pumping rates and therefore trending does not indicate exceedance of the ODWQS in 50 years (it is noted that the relationship between the observed concentrations and pumping rate requires further investigation. Should further evaluation provide additional information to support identification of VOC as a Drinking Water Issue, this should be included in future updates to the Assessment Report)
- there have been no reported concentrations which have exceeded the ODWS in any monitoring wells completed within the municipal aquifer (A3/A4)
- the presence of VOC is assessed within the Water Operations Branch Operational Plan

Barrie established a monitoring program in 2003 that includes regular sampling from a series of production wells and sentinel monitoring wells. The monitoring program is managed by the Environmental Operations Branch. VOC analysis, which includes TCE, is carried out monthly at the production wells and annually at the monitoring wells with the exception of some select monitoring well locations which are sampled quarterly or on a semi-annual basis.

9.3.3 Drinking Water Threats Evaluation

An assessment of Drinking Water Threats for the Barrie Water Supply was completed in accordance with the detailed methodology presented in Golder, 2010f (Appendix B). 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 Barrie 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

9.3.3.1 List of Drinking Water Threats – Activities

The list of Prescribed Drinking Water Threats considered in the assessment for Barrie 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) [And the updated MECP Threat Lookup Tool (2021): Source Water Protection Information Portal]
- 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)
- City of Barrie mapping and datasets including snow storage, storm water management ponds, and sewer exemption list (2009)
- Golder Field Windshield Surveys (2008/2009)

Section 9.3.3.5 describes how these datasets were used to identify and enumerate potential Significant Threat Activities for the Barrie drinking water system.

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

9.3.3.2 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 (now MECP) 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. The scoring of Condition Threats implemented by Golder uses the precautionary approach of assuming a Hazard Score of 10 since the Condition review methodology did not include detailed evaluation of all potential evidence/documentation that the contamination has not and will not move off-site. This type of information is typically not readily available for contaminated sites. The Conditions assessment was supplemented with information provided by Barrie for properties known to meet the Conditions criteria.

Six Conditions were identified for the Barrie Well Supply, based on the criteria outlined in the Technical Rules.

The Conditions identified are not linked with the Drinking Water Issues (chloride and sodium) for the Barrie wells. The majority of the Conditions identified are on lands owned by the City of Barrie, as this information was most readily available for assessment of Conditions. The six Conditions are related to:

- TCE (2)
- Petrohydrocarbons (1)
- BTEX (benzene, toluene, ethylbenzene and xylenes) and PHCs (petroleum hydrocarbons) (2)
- Vinyl Chloride (1)

Of the six Conditions, all six are considered Significant Drinking Water Threats. Additional information is provided in Golder, 2010f (Appendix B).

9.3.3.3 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 Threats~~Technical Rules threat circumstances can be used to correlate activities that are or would be Drinking Water Threats with the Vulnerability Scores. ~~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 CircumstancesGovernment of Ontario's Drinking Water Threats and Circumstances.~~

Field Code Changed

9.3.3.3.1 Pathogen Parameters

The ~~MECP table of Drinking Water Threats~~Technical Rules ~~Key Table on Figure 9a-5~~ 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 City of Barrie Water Supply (Figure 9a-5). 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.

9.3.3.3.2 Chemical Parameters

The ~~MECP table of Drinking Water Threats~~Technical Rules ~~Key Table on Figure 9a-6~~ 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 City of Barrie Water Supply (Figure 9a-6). 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 9a-6 illustrates where Activities associated with chemical threats are or would be Low Drinking Water Threats for the City of Barrie Water Supply.~~

9.3.3.3.3 DNAPL Chemical Parameters

Figure 9a-7 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 Threat for the City of Barrie Water Supply. The ~~MECP table of Drinking Water Threats~~Technical Rules ~~Key Table on Figure 9a-7~~ 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.

9.3.3.3.4 Sodium and Chloride Drinking Water Issue

Sodium and Chloride were identified as a Drinking Water Issues. As per the Technical Rules, land use activities that can release parameters that are identified as a Drinking Water Issue within the identified Wellhead Protection Areas-Issues Contributing Area (WHPA-ICA) are to be considered as Significant Drinking Water Threats. Appendix B provides a list of the land uses that can potentially release Sodium and Chloride to the environment within the identified WHPA-ICA ~~Issues Contributing Area~~ (Figure 9a-4).

Figure 9a-4 illustrates the WHPA-ICA ~~Issues Contributing Area~~ where activities and circumstances listed in Appendix B are considered to be a Significant Drinking Water Threat for the Barrie Well Supply.

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

Further to Section 9.3.3.2, six Conditions were identified within the WHPA for the City of Barrie Water Supply (Golder, 2010f).

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 9a-3 illustrates the Vulnerability Score map for Barrie well supply that can be used to determine where a Condition is or would be a Significant, Moderate, or Low Threat to Drinking Water.

9.3.3.5 Enumerating Drinking Water Threats

9.3.3.5.1 Enumerating Significant Drinking Water Threats – Methods

Identification and enumeration of Significant Drinking Water Threats related to Issues and Conditions have been described in Section 9.3.2 and 9.3.3.2, 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, 2010f. 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 2010f and summarized in section 9.3.3.1. 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, 2010f, 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 as in the City of Barrie WHPAs.

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 and IPZ. 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.

9.3.3.5.1.1 Managed Lands

Managed Land is land to which nutrients (Agriculture Source Material (ASM), commercial fertilizer, and/or 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 include 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 the ~~Part XII of the~~ Technical Rules ~~(December 2021)~~ ~~Table of Drinking Water Threats.~~

Managed Lands were identified and the Managed Lands proportions were determined for the Barrie WHPAs as outlined in Golder, 2010f. The calculation of Managed Lands was updated to reflect the methodology in the most recent technical bulletin (November, 2009).

The results from this analysis were used in the enumeration of Significant Drinking Water Threats (Section 9.3.3.5). Figure 9a-8 illustrates the location and proportion of Managed Lands within the delineated WHPA zones for the Barrie Water Supply where Vulnerability Scores were 6 or greater for WHPA-A to WHPA-D. The Managed Land within the majority of Barrie is within the lowest threshold of 0 to 40%. Managed Lands within the WHPAs of Wells 16, and 9 and 13 are calculated to be within the moderate category of 40 to 80%. Within the Well 16 WHPA-A, greater than 80% Managed Land is calculated. This is due to WHPA-A encompassing the parcel of the neighboring golf course, thus increasing the managed land area. This is a function of the methodology of including the entire parcel area into the calculation rather than including only the area within the WHPA.

9.3.3.5.1.2 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 the ~~Part XII of the~~ Technical Rules ~~(December 2021). Table of Drinking Water Threats.~~

The Livestock Density was determined for the Barrie WHPA as outlined in Golder, 2010f. The results from this analysis were used in the enumeration of Significant Drinking Water Threats (Section 9.3.3.5). Figure 9a-9 illustrates the distribution of Livestock Density within the delineated WHPA zones for the Barrie 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. As expected, the Livestock Density calculations result in <0.5 NU/acres within all of Barrie WHPAs where densities were calculated (i.e. greater than a Vulnerability of 6), with the exception of the Barrie 9/13 WHPA-B which has a livestock density of 0.5 to 1.0 NU/acre.

9.3.3.5.1.3 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 the ~~Part XII of the~~ Technical Rules ~~(December 2021)~~. ~~Table of Drinking Water Threats.~~

The proportion of Impervious Surfaces within the Barrie WHPA was determined in accordance with the methodology in Golder, 2010b. 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 9.3.3.5). The Impervious Surfaces are used in the identification of threat activities associated with the application of winter de-icing agents (salt).

Figure 9a- 10 illustrates the distribution of Impervious Surfaces within the delineated WHPA zones for the Barrie 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 City limits as the WHPAs generally cover an urban or urban/rural mix of land use types.

9.3.3.5.2 Enumerating Significant Drinking Water Threats – Results

A total of 320 activities that are considered to be Significant Drinking Water Threats were identified in association with 293 land parcels in the WHPAs for the City of Barrie groundwater supply. This represents approximately 1% of the parcels assessed within the Barrie 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. Table 9-1, Table 9-2, and Table 9-3 document the enumeration of existing activities that are considered to be Significant Drinking Water Threats within the WHPAs for the Barrie groundwater supply. The total number of Condition Threats identified in the WHPAs is six of which six are ranked as Significant.

A total of eighty-seven (87) Significant Activity Threats related to Drinking Water Issues were identified in these WHPAs. There were no Conditions identified that are related to the identified Drinking Water Issues. Of the Activity Threats related to the Drinking Water Issues, two (2) were related to application of road salt (one threat for each Issue Contributing Area), seventy-nine (79) to storm water ponds, two (2) to septic tanks (one threat for each Issue Contributing Area), one (1) to storage of snow, and three (3) to storage of road salt. The Threats related to septic systems and application of road salt are based on assigning one threat for each threat type within each of the WHPA-ICAIssue Contributing Areas (Figure 9a-4). There are potentially 536 septic system and 745 application of road salt threats identified which could be categorized as a Significant Threat. However, individually these sources are not expected to significantly contribute to the Drinking Water Issue. This is highlighted by the fact that a number of the septic system threats are located within WHPA-D, at distance from the wells and therefore their contribution to the Drinking Water Issue is questionable. Instead it was determined that these threats should be identified as one combined threat for each Issue Contributing Area. The application of road salt threat within the Issue Contributing area represents road salt application on the transportation networks within the City as well as on individual parking lot parcels.

Table 9-1: Number of Significant Drinking Water Threats in the WHPA for City of Barrie Wells 3A, 4, 5, 7, 11, 12, 14, 15, 17, 18, and 19, 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	12~~1~~
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	102
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~~1~~
10	The application of pesticide to land	0~~1~~
11	The handling and storage of pesticide	1
12	The application of road salt	57~~2~~
13	The handling and storage of road salt	57~~3~~

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Commented [MT1]: Annual reporting from 2024 shows 45 salt application threats in Barrie, not sure why the original number was ever as low as 2.

Threat Number	Threat	Significant Threat Counts Number of Threats
14	The storage of snow	46~~1~~
15	The handling and storage of fuel	3
16	The handling and storage of dense non-aqueous phase liquid	162
17	The handling and storage of an organic solvent	2
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**	~~442~~~~279~~* significant threats (on 339 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. *18 verified existing Threats and 261 potential Threats that require further investigation

Table 9-2: Number of Significant Drinking Water Threats in the WHPA for City of Barrie Wells 9 and 13, 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	1
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

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Threat Number	Threat	Significant Threat Counts Number of Threats
14	The storage of snow	0
15	The handling and storage of fuel	1
16	The handling and storage of dense non-aqueous phase liquid	5
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*** 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. *2 verified existing Threats and 5 potential Threats that require further investigation

Table 9-3: Number of Significant Drinking Water Threats in the WHPA for City of Barrie Well 16, 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	1
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	32
9	The handling and storage of commercial fertilizer to land	0
10	The application of pesticide to land	1
11	The handling and storage of pesticide	0
12	The application of road salt	0
13	The handling and storage of road salt	0

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Threat Number	Threat	Significant Threat Counts Number of Threats
14	The storage of snow	0
15	The handling and storage of fuel	0
16	The handling and storage of dense non-aqueous phase liquid	0
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**	**34*** significant threats (on **33** properties)

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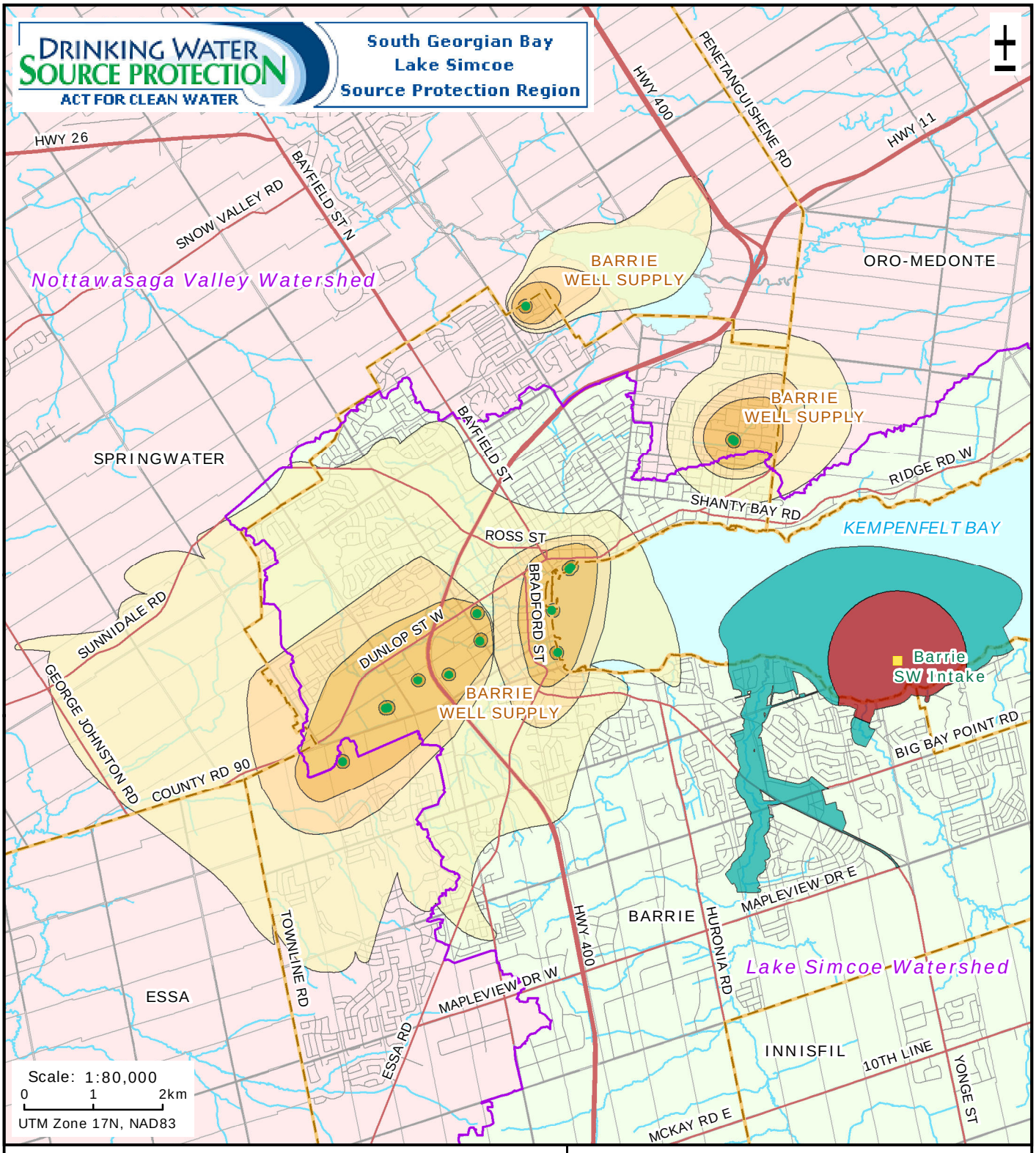
Notes for the table above:

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. *2 verified existing Threats and 32 potential Threats that require further investigation



- Municipal Surface Water Intakes
- IPZ-1 (1000m on water or 120m inland)
- IPZ-2 (2 hr time of travel)
- Municipal Supply Well in City of Barrie
- WHPA-A (100m)
- WHPA-B (2-years time of travel)
- WHPA-C (5-years time of travel)
- WHPA-D (25-years time of travel)

Drinking Water System Vulnerable Areas in City of Barrie

Created by: LSRCA
Date: 2014-04-10

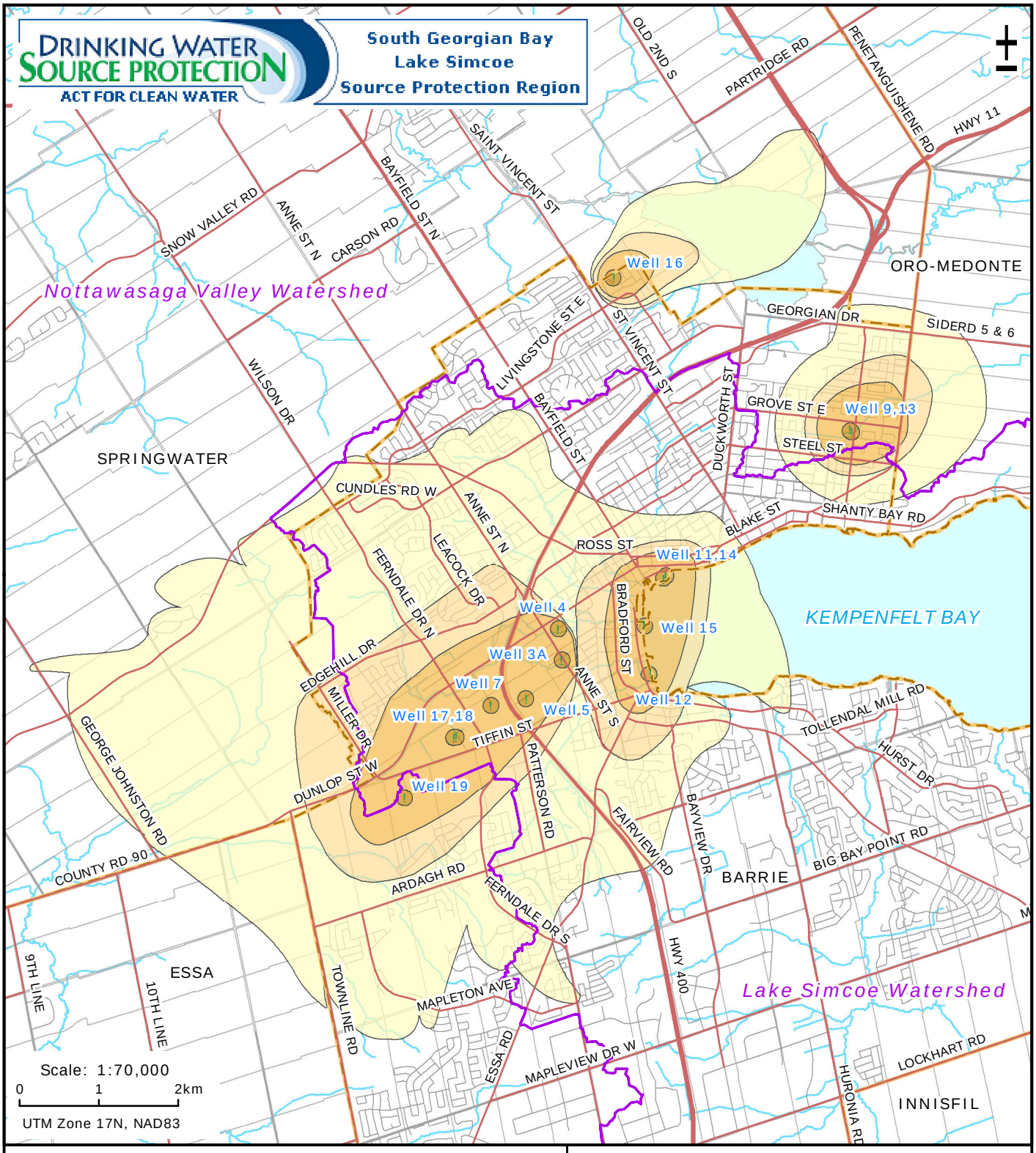
Golder Associates
Barrie, Ontario

Nottawasaga Valley Conservation Authority

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 9-1



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

City of Barrie
Wellhead Protection Areas

Created by: LSRCA
Date: 2014-04-10

Golder Associates
Barrie, Ontario

Nottawasaga Valley Conservation Authority

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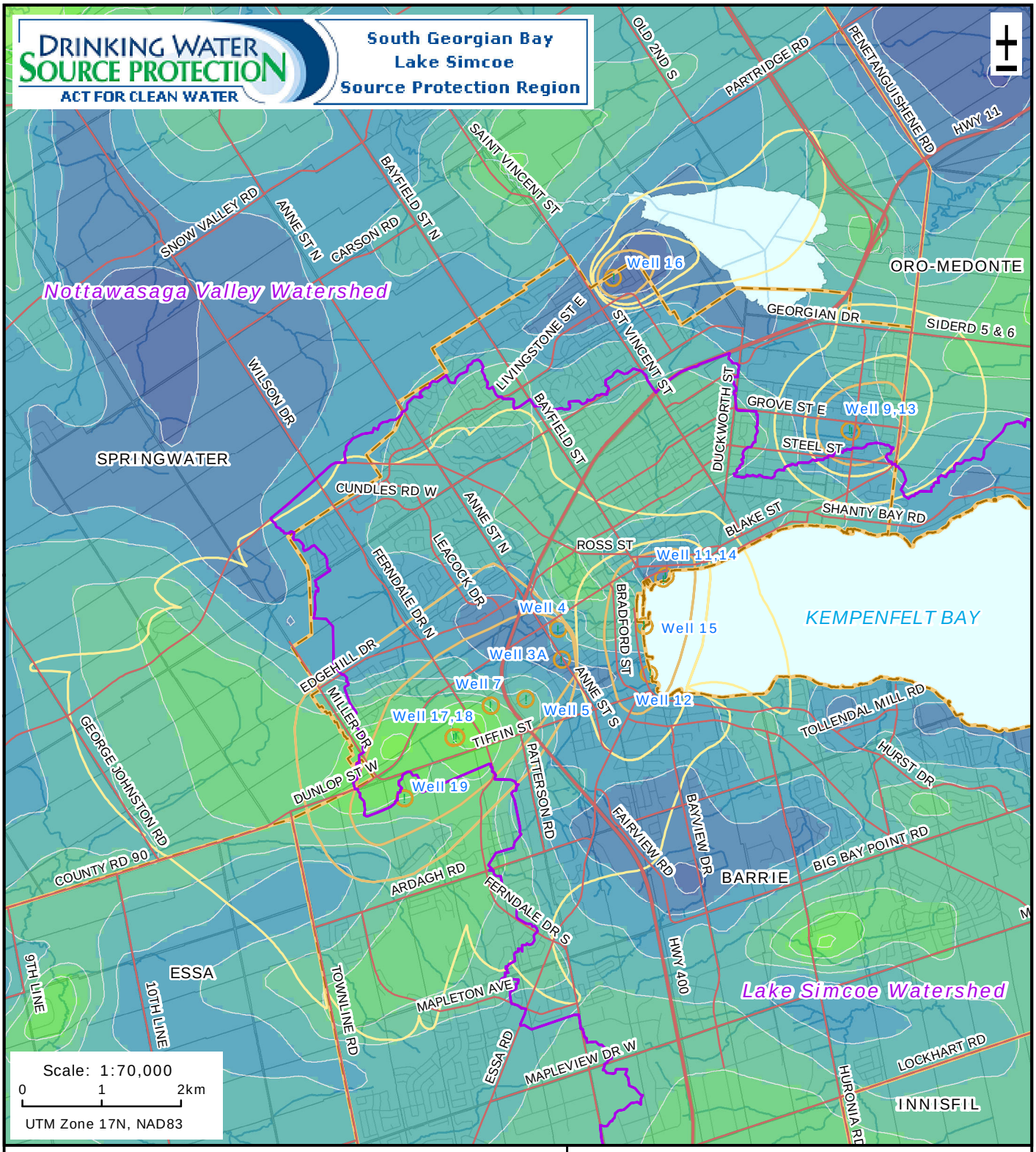
While every effort has been made to accurately depict the base data, errors may exist.

Ontario

Figure 9a-1



Calculated AVI
- < 140
- 141 - 145
- 146 - 150
- 151 - 155
- 156 - 160
- 161 - 165
- 166 - 170
- 171 - 175
- 176 - 180
- 181 - 185
- 186 - 190
- 191 - 195
- 196 - 200
- > 200

- ! Municipal Supply Well
- WHPA-A (100m)
- WHPA-B (2-yr TOT)
- WHPA-C (5-yr TOT)
- WHPA-D (25-yr TOT)
- SWP Watershed Area
- Municipality Boundary

Model Calculated AVI To Top Of Aquifer A3 with Combined Capture Zones

Created by: LSRCA
Date: 2014-04-10

Golder Associates
Barrie, Ontario

Nottawasaga Valley Conservation Authority

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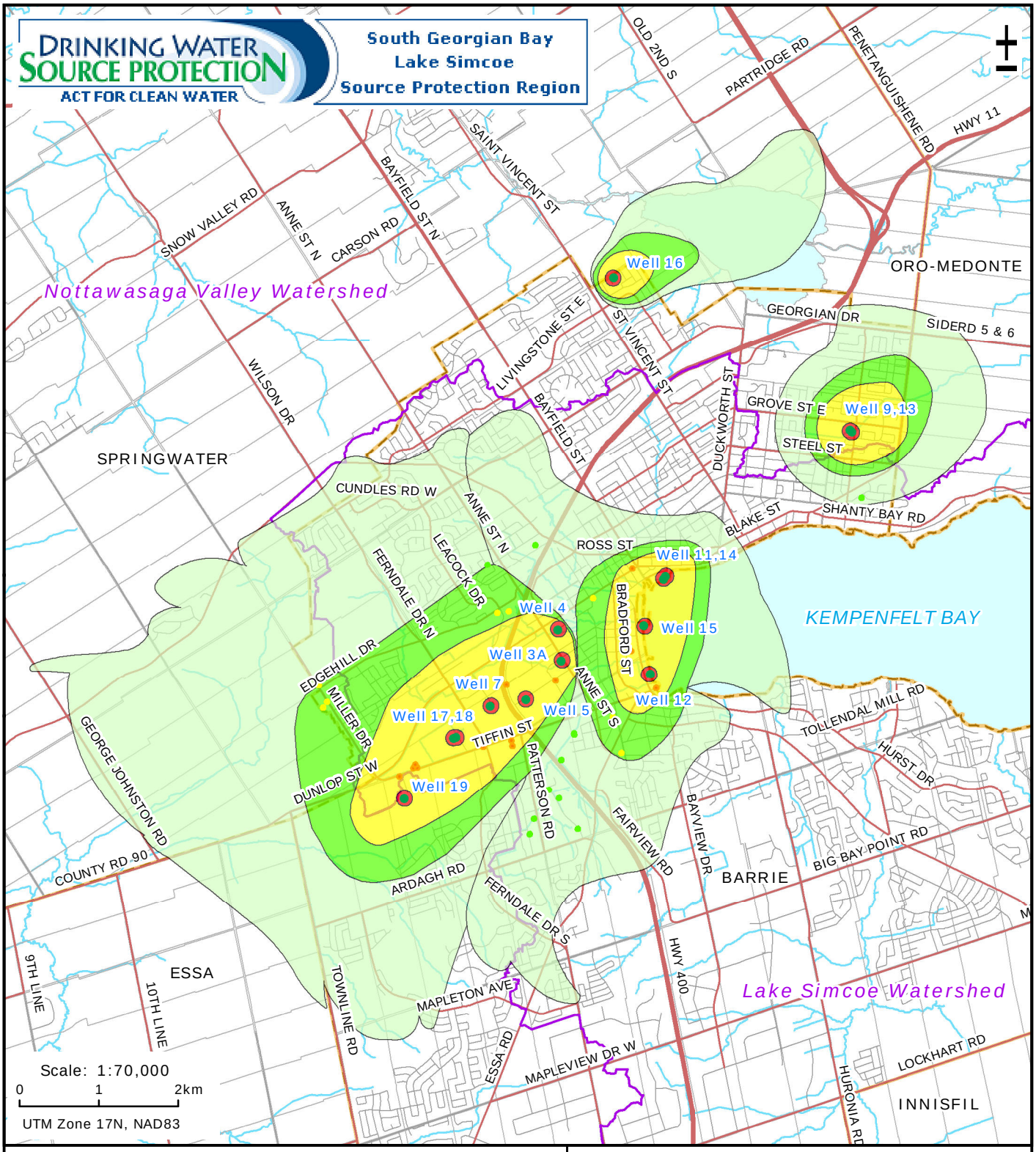
Ontario

Figure 9a-2



! Municipal Supply Well
Vulnerability Score = 10
Vulnerability Score = 8
Vulnerability Score = 6
Vulnerability Score = 4
Vulnerability Score = 2
SWP Watershed Area
Municipality Boundary

City of Barrie
Wellhead Protection Areas
Final Vulnerability Scoring

Created by: LSRCA
Date: 2014-04-10

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Barrie, Ontario

Nottawasaga Valley Conservation Authority

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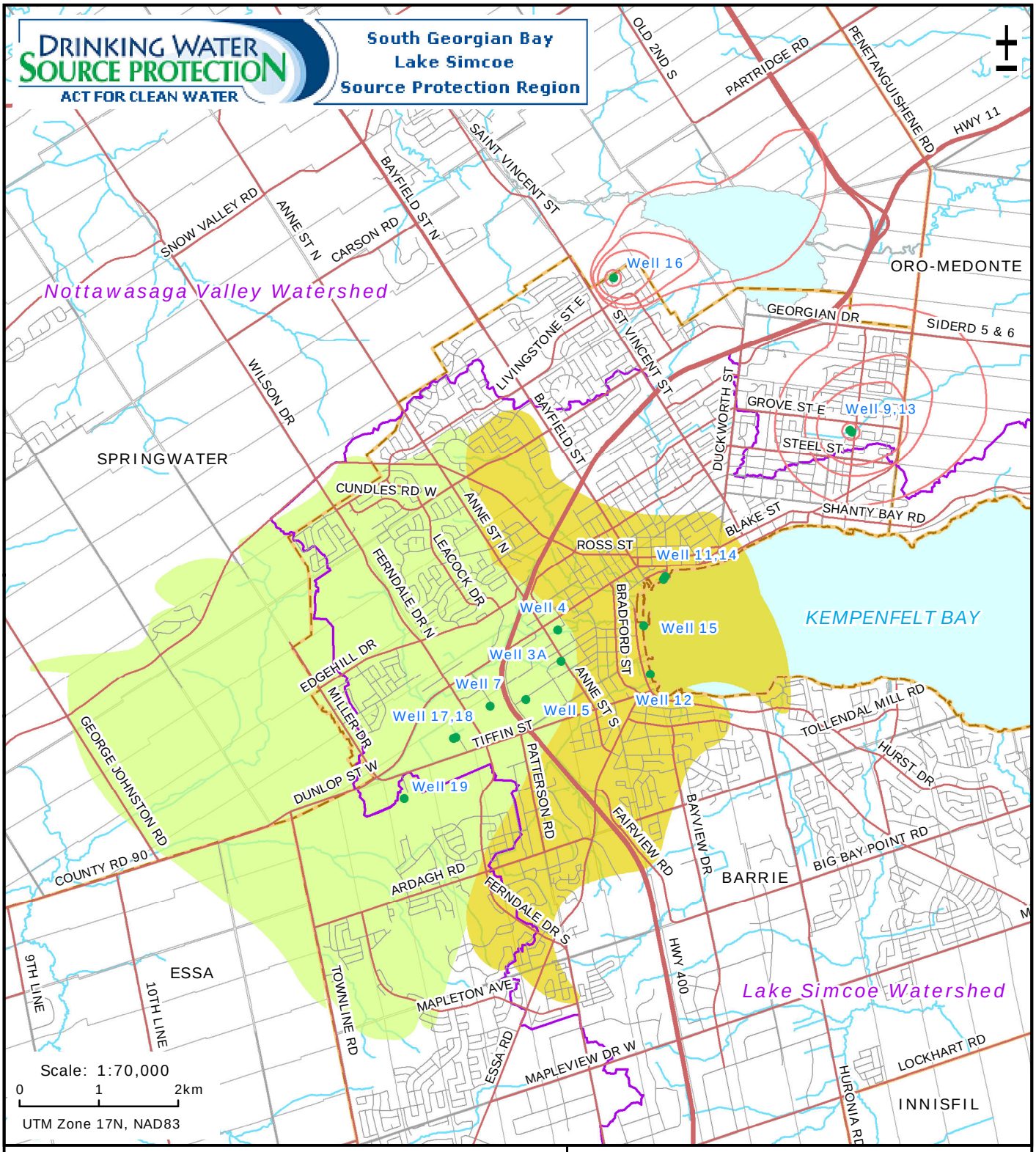
Ontario

Figure 9a-3



! Municipal Supply Well

Issue Contributing Area
- Chloride and Sodium
- Chloride

- SWP Watershed Area
- Municipality Boundary
- Adjacent Well Field WHPA

City of Barrie Drinking Water Issues Contributing Areas

Created by: LSRCA
Date: 2014-04-10

Golder Associates
Barrie, Ontario

Nottawasaga Valley Conservation Authority

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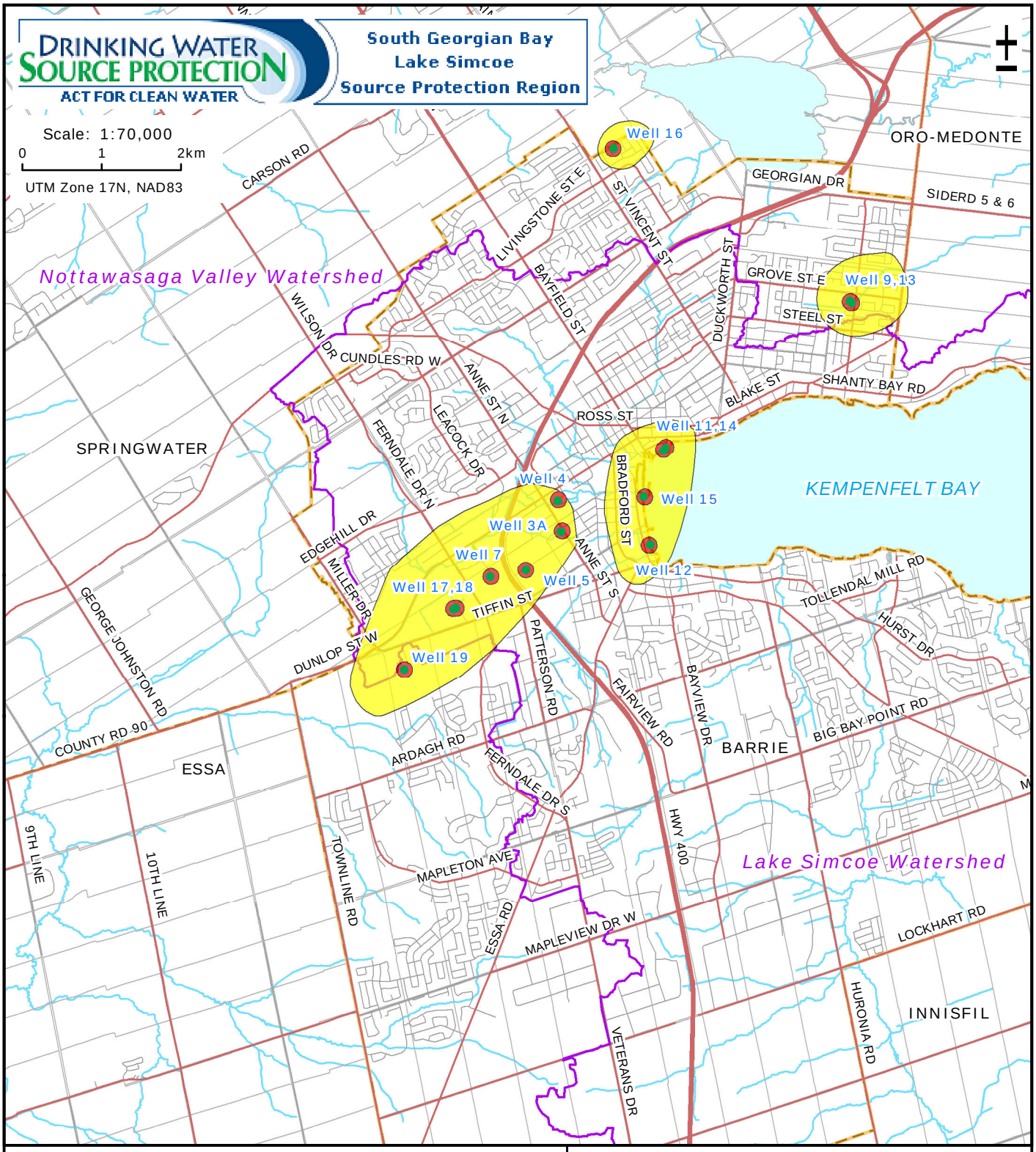
While every effort has been made to accurately depict the base data, errors may exist.

Ontario

Figure 9a-4



! Municipal Supply Well
Vulnerability Score = 10
Vulnerability Score = 8
Vulnerability Score = 6
SWP Watershed Area
Municipality Boundary

Areas That are or would be Significant, Moderate or Low Drinking Water Threats Activities Pathogen

Created by: LSRCA
Date: 2014-04-10

Golder Associates
Barrie, Ontario

Nottawasaga Valley Conservation Authority

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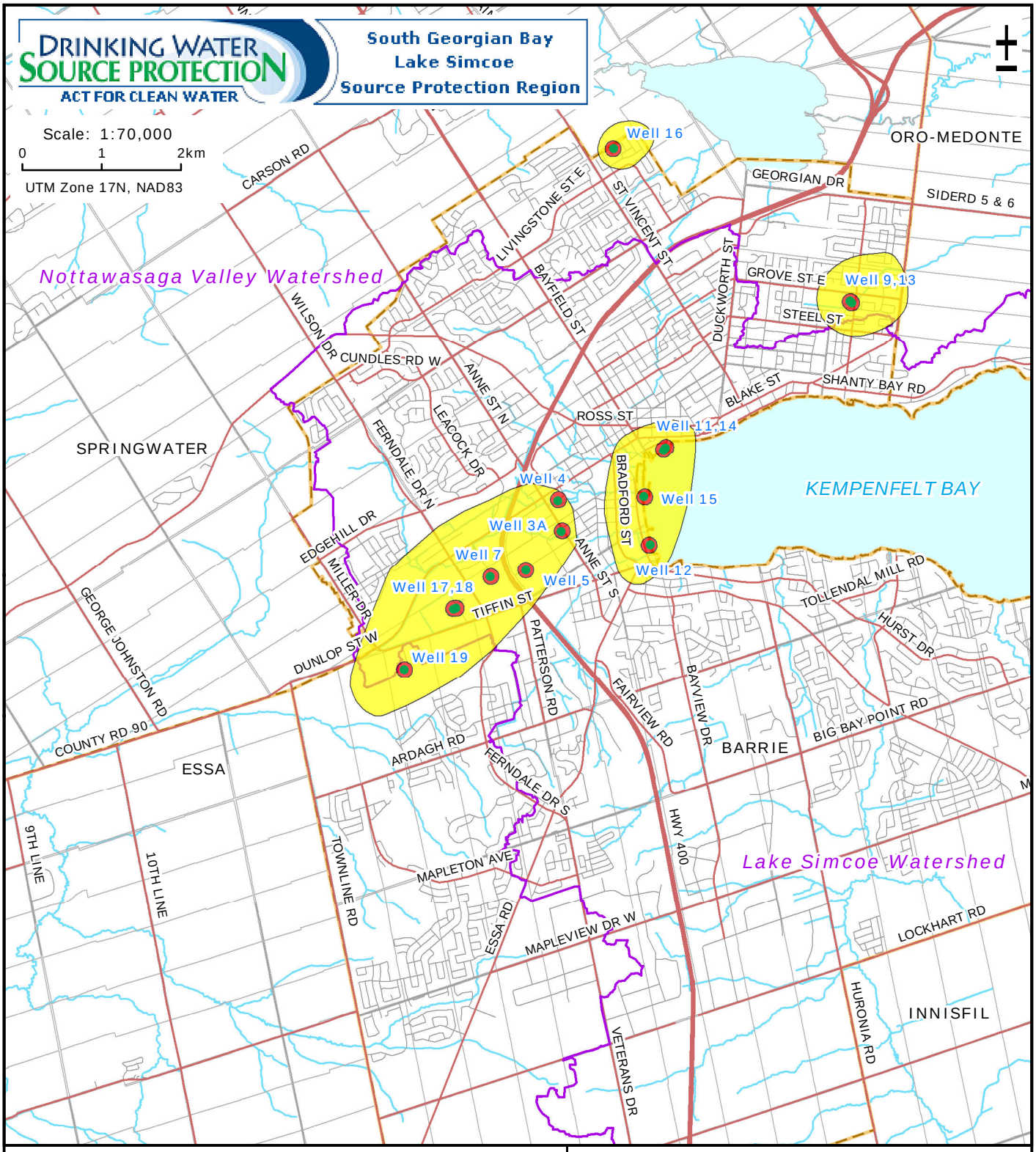
While every effort has been made to accurately depict the base data, errors may exist.

Ontario

Figure 9a-5



! Municipal Supply Well
Vulnerability Score = 10
Vulnerability Score = 8
Vulnerability Score = 6
SWP Watershed Area
Municipality Boundary

Areas That are or would be Significant, Moderate or Low Drinking Water Threats Activities Chemical

Created by: LSRCA
Date: 2014-04-10

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Barrie, Ontario

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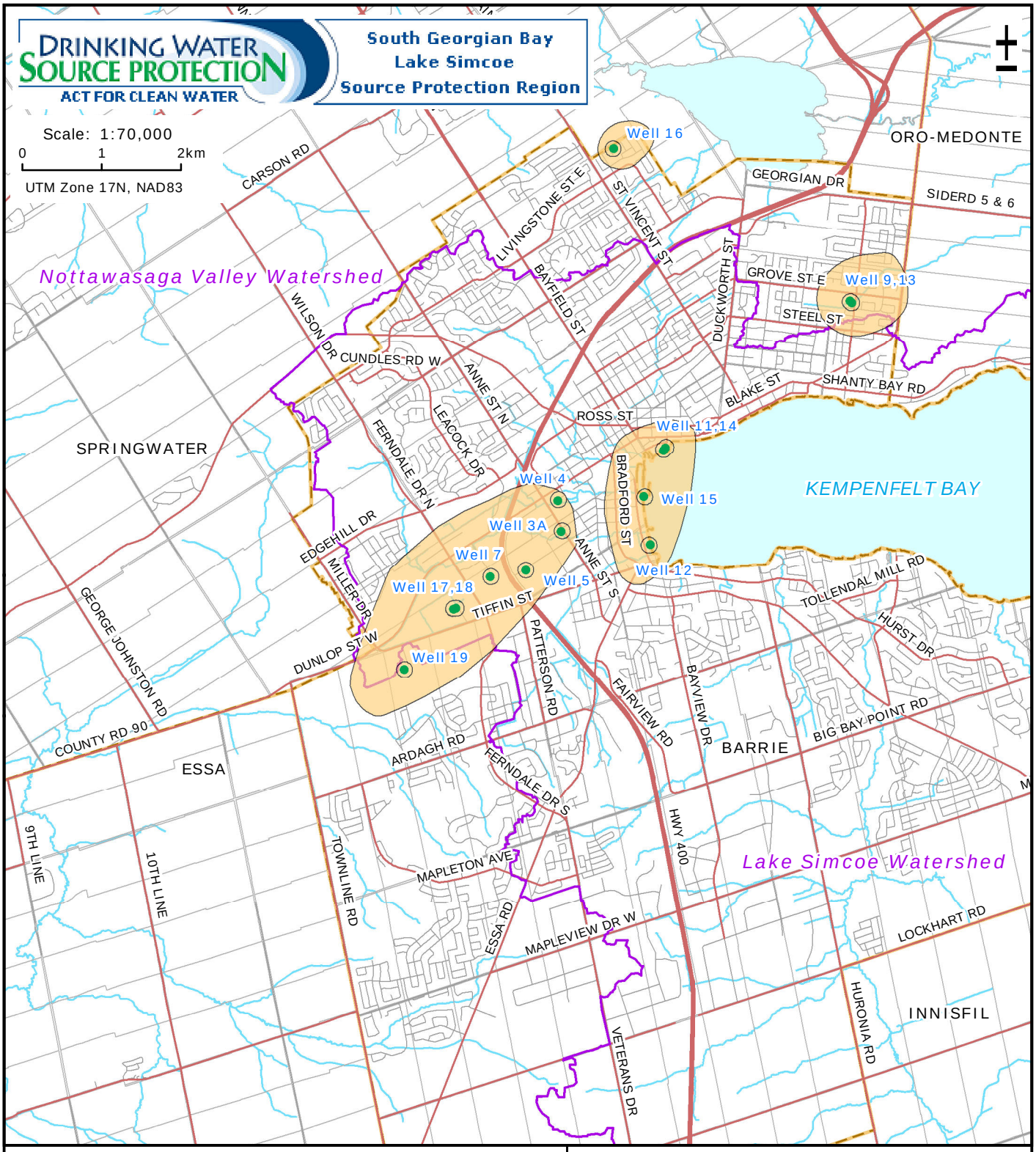
While every effort has been made to accurately depict the base data, errors may exist.

Ontario

Figure 9a-6



! Municipal Supply Well
WHPA A, B, C or C1
WHPA D with V.Score >= 6
SWP Watershed Area
Municipality Boundary

Areas That are or would be Significant, Moderate or Low Drinking Water Threats Activities DNAPLs

Created by: LSRCA
Date: 2014-04-10

Golder Associates
Barrie, Ontario

Nottawasaga Valley Conservation Authority

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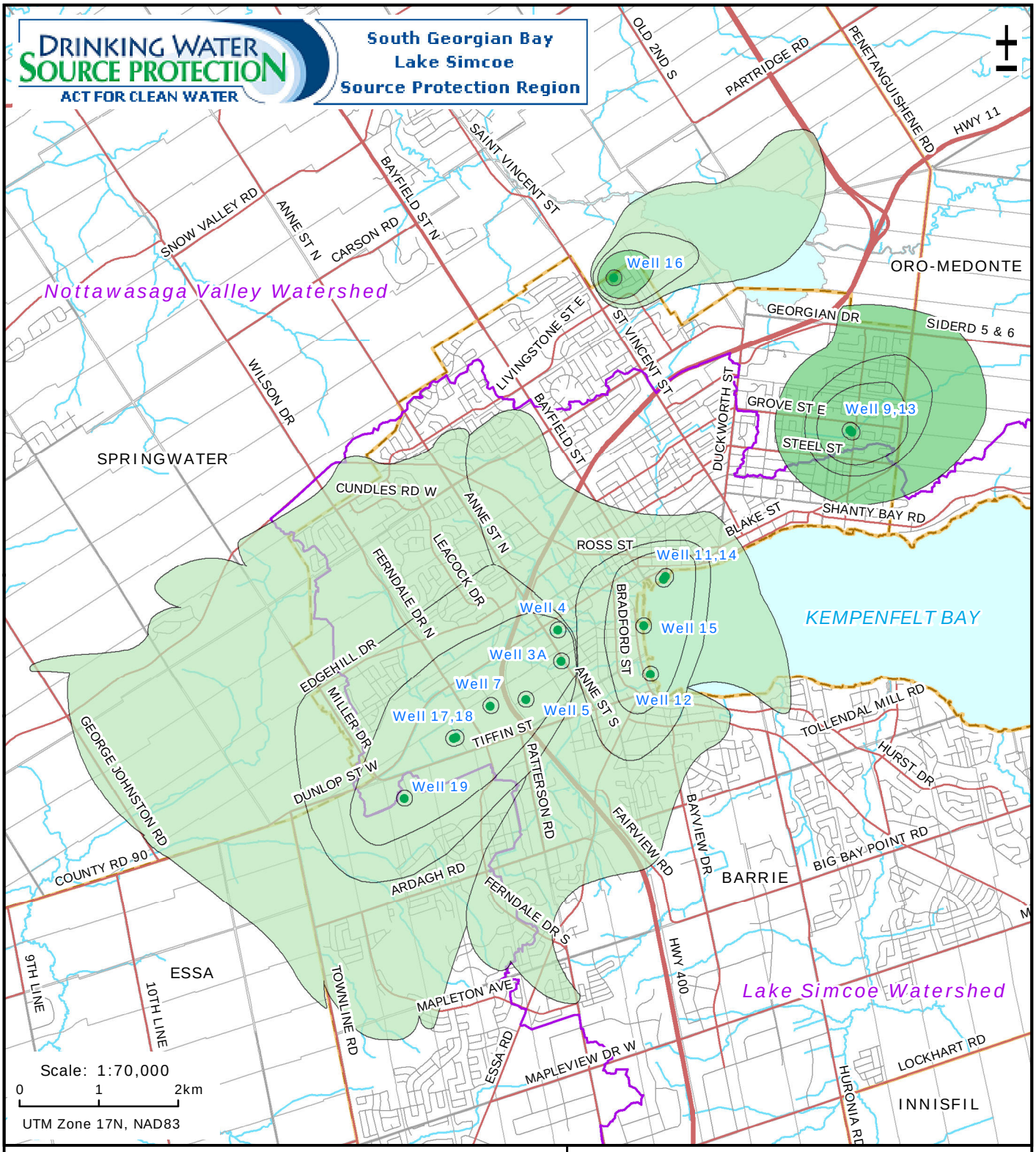
While every effort has been made to accurately depict the base data, errors may exist.

Ontario

Figure 9a-7



! Municipal Supply Well

Percent Managed Lands

- Managed Land < 40%
- Managed Land 40 - 80%
- Managed Land > 80%
- SWP Watershed Area
- Municipality Boundary

City of Barrie
Wellhead Protection Areas
Managed Land

Created by: LSRCA
Date: 2014-04-10

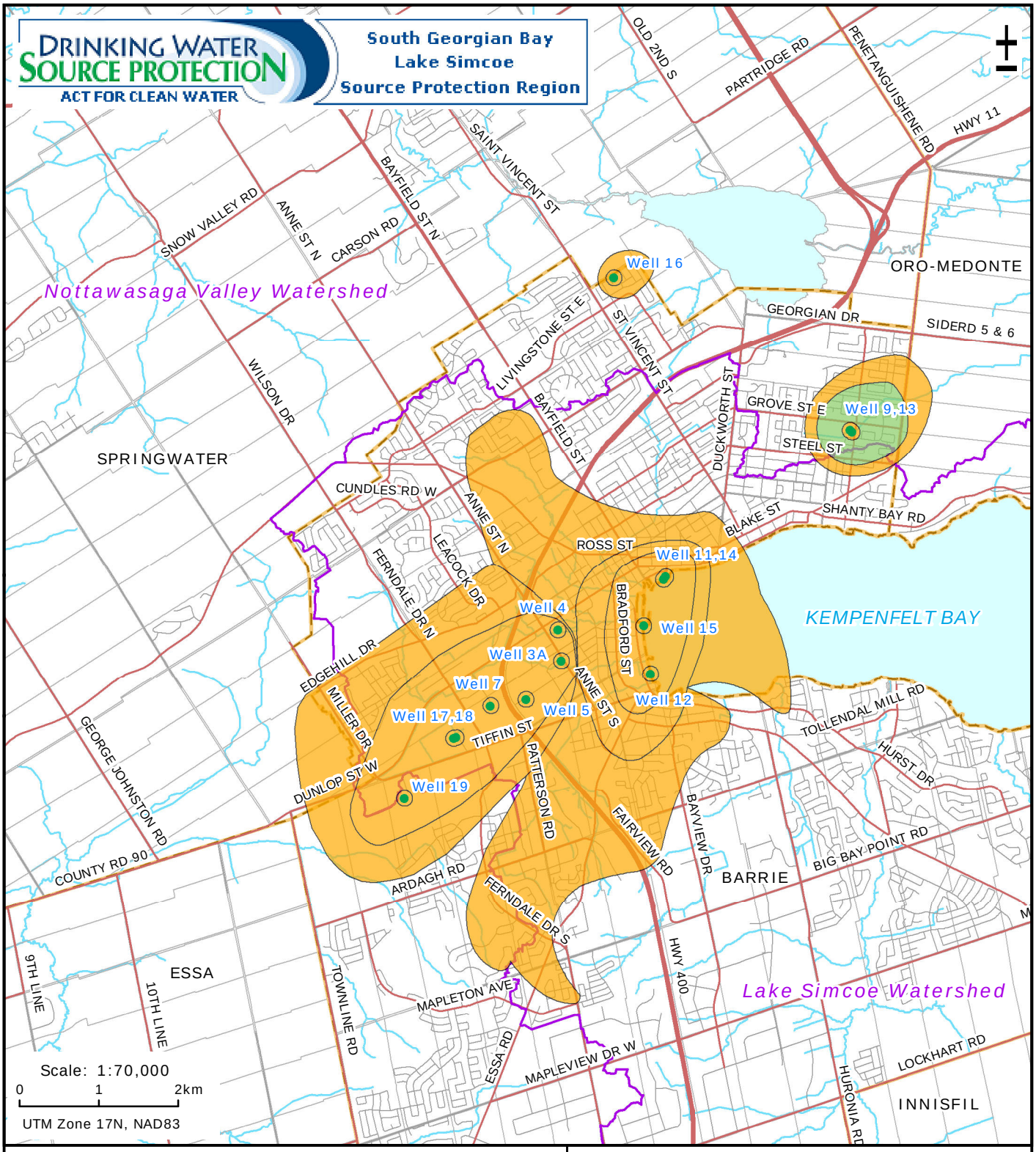
Golder Associates
Barrie, Ontario

Nottawasaga Valley Conservation Authority

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 9a-8



! Municipal Supply Well

Livestock Density

- Livestock Density <0.5 NU/Acre
- LivestockDensity 0.5-1.0 NU/Acre
- SWP Watershed Area
- Municipality Boundary

City of Barrie
Wellhead Protection Areas
Livestock Density

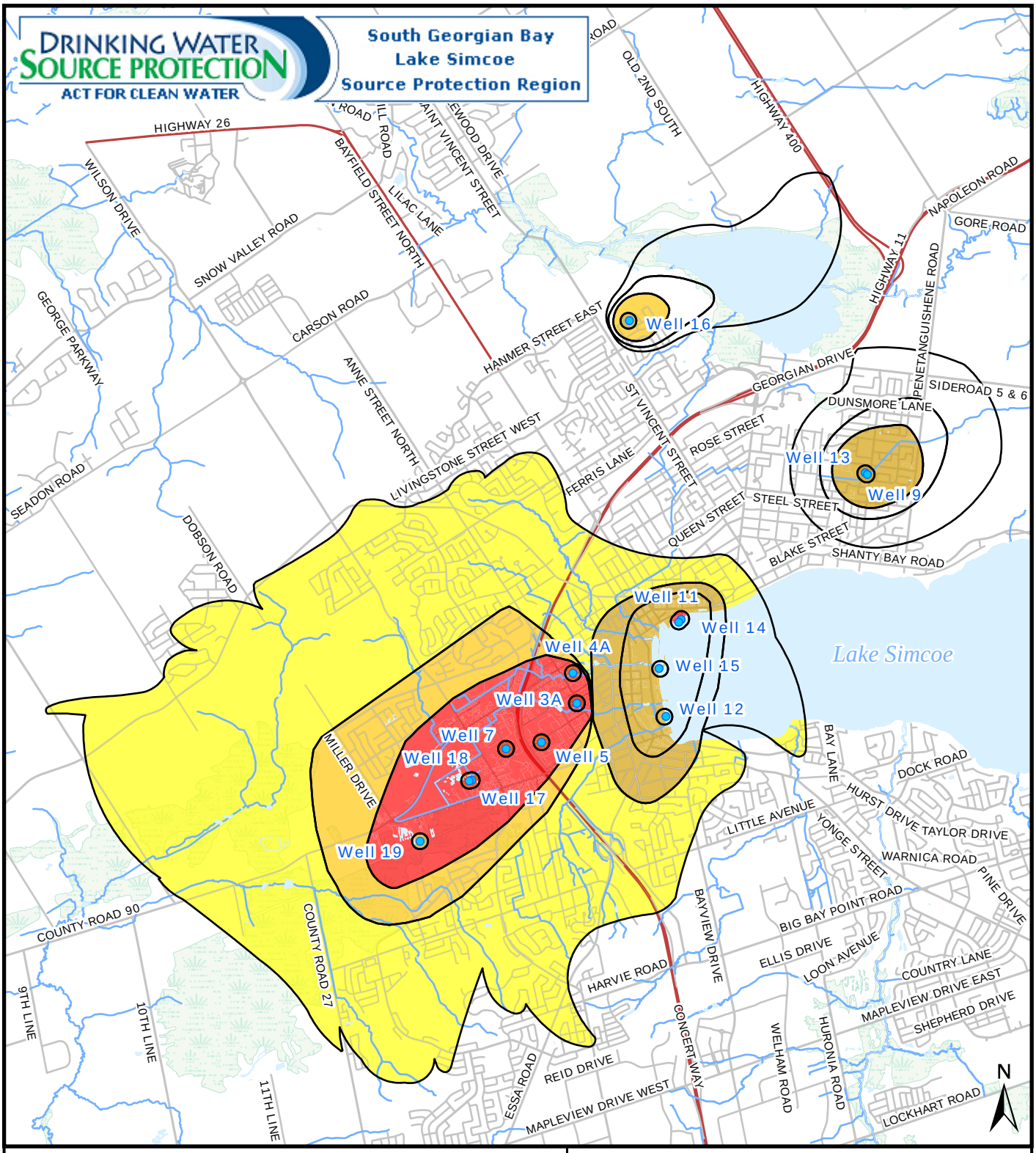
Created by: LSRCA
Date: 2014-04-10

Golder Associates
Barrie, Ontario

Nottawasaga Valley Conservation Authority

Ontario

Figure 9a-9



Well

Impervious Surfaces in WHPA

- <1%
- =1 - <6%
- =6 - <8%
- =8 - <30%
- >=30%

Impervious Surfaces - Barrie Wells
WHPA **& WHPA-ICA**

Created by: LSRCA, 2025-08-05

Scale 1:70,000

0 600 1,200 2,400 m

UTM Zone 17N, NAD83

Ontario

Figure 8a-10