

Chapter 4: Assessing Regional Groundwater Vulnerability

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4 Assessing Regional Groundwater Vulnerability

Within the Nottawasaga Valley Source Protection Area, approximately 9% of the population relies on municipal drinking water from surface water intakes in Georgian Bay. A larger portion of the population 67% relies on municipal drinking water that uses groundwater as the source, while the remaining population relies on private wells (groundwater) as their source of drinking water. The *Clean Water Act, 2006* requires that all sources of drinking water must be assessed for vulnerability. The vulnerability of municipal drinking water is assessed through development of surface water intake protection zones (IPZs) and Wellhead Protection Areas (WHPAs); these are discussed in detail within Chapter 5 and each municipal chapter (Chapter 6 to 19). The vulnerability of private wells (groundwater) is discussed within this Chapter. The vulnerability is determined through a regional groundwater vulnerability assessment which identifies “Highly Vulnerable Aquifers (HVAs)” and “Significant Groundwater Recharge Areas (SGRAs)”.

Surface water and groundwater can be naturally or anthropogenically vulnerable to a decrease in water quantity or decrease in water quality (contamination). The vulnerability of a groundwater system is an expression of the relative ease through which the aquifer could become contaminated by threat activities occurring on or beneath the ground surface. An aquifer that can easily become contaminated is considered to be vulnerable.

The groundwater vulnerability analysis has been undertaken to identify areas that contribute water to regional aquifers and to evaluate the relative vulnerability of these areas to contamination by the types of threat activities that may exist in that area, either now, in the past, or in the future. The groundwater vulnerability is assessed to provide an indication, within the regional landscape, where activities at surface present the greatest risk to contaminate the aquifer(s). The vulnerability analysis considers the groundwater vulnerability as well as the potential for the vulnerability to be increased by man’s activities, through transport pathways, in developing a “vulnerability rating” and assigning a “vulnerability score”. The resulting vulnerability rating can then be used to delineate the “Highly Vulnerable Aquifers (HVAs)” and “Significant Groundwater Recharge Areas (SGRAs)” within the South Georgian Bay-Lake Simcoe Source Protection Region (SGBLS SPR).

It should be noted that this Chapter only documents the methods used to delineate Groundwater Vulnerability for HVAs and SGRAs. Groundwater Vulnerability within each WHPA for individual municipal drinking water systems was determined using a different methodology and each municipal chapter should be referred to for that information.

The following is a summary of the steps taken to delineate the HVA and SGRA vulnerable areas within the Nottawasaga Source Protection Area:

Step 1: Delineating Groundwater Vulnerability

The first step in determining both HVAs and SGRAs is to delineate the groundwater vulnerability using a methodology that will categorize vulnerability as “High”, “Medium” or “Low” as prescribed by Technical Rules 37 and 38 (MOE, 2008a), and discussed in Section 4.1.1.

Step 2: Vulnerability Scoring for Highly Vulnerable Aquifers (HVAs)

The second step is to classify the areas categorized as “High” in step one above as Highly Vulnerable Aquifers (HVAs).

Step 3: Delineating Significant Groundwater Recharge Areas (SGRAs)

Recharge rates across the study area are determined using a surface water model (PRMS), which is discussed in great detail within Chapter 3 and Appendix WB-4. SGRAs were determined by using Technical Rule 44 (1) (MOE, 2008a), which specifies SGRAs are the areas where the recharge is 15% greater than the average recharge across the study area.

Step 4: Vulnerability Scoring SGRAs

Using the categorized groundwater vulnerability delineated in step one, the vulnerability within the SGRAs are categorized as “High”, “Medium” or “Low”.

4.1 Groundwater Vulnerability

This Section discusses the methodology used to delineate the groundwater vulnerability for the Nottawasaga Valley Source Protection Area study area.

Various considerations must be given when identifying vulnerable areas and assigning a vulnerability score. Not all vulnerable areas are equally vulnerable, so numeric scores are attached to denote the Intrinsic Vulnerability in each case. Generally, the faster water is able to flow through the ground to an aquifer, the more vulnerable the area is to contamination. The vulnerability scores are determined by factors such as:

- how deep/thick the aquifer and overlying aquitard is
- what type(s) of soils are present
- how quickly water can travel through the ground
- what type of man-made transport pathways are present

Man-made transport pathways can create a direct route for water at the ground surface to travel to an aquifer that is a drinking water source. Potential Transport Pathways includes (but not limited to) pits, quarries, mines, pipelines, and poorly constructed or abandoned wells. If these pathways exist in a vulnerable area the score can be increased from Medium to High, Low to Medium, or Low to High in accordance with the potential for artificial transport pathways to increase the observed vulnerability.

The Technical Rules (MOE, 2008a) require that an Uncertainty Rating be assigned with each vulnerable area. The uncertainty assessment 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. A high uncertainty rating does not necessarily reflect a low degree of confidence in the vulnerability assessment, but instead reflects the irregular distribution and high variability in the quality and consistency of the data available to use for the assessment.

Following the delineation of vulnerability scores, the next step is to use the scores to identify the drinking water threats related to water quantity and/or quality that would be rated Significant, Moderate or Low.

The Regional Groundwater Vulnerability within the South Georgian Bay-Lake Simcoe Source Protection Region was delineated by Genivar (2010d), and was delineated in accordance with the Technical Rules (13-15, 37-43) (MOE, 2008a). The following Sections (4.1.1 to 4.2.1) were taken directly from the report.

4.1.1 Methodology

Technical Rules 37 and 38 (MOE, 2008a) provide guidance on categorizing the groundwater vulnerability as either “High”, “Medium” or “Low” using one of the following assessment methods:

1. Intrinsic Susceptibility Index (ISI)
2. Aquifer Vulnerability Index (AVI)
3. Surface to Aquifer Advection Time (SAAT), where advection time refers to the estimated time for groundwater to move through the subsurface
4. Surface to Well Advection Time (SWAT)

The ISI and AVI methods use a scoring system that reflects the thickness and the type of overburden material. Aquifers of High Vulnerability have an ISI or AVI score less than 30, meaning the overlying material is thin and/or permeable. While aquifers of a Low Vulnerability have an ISI or AVI score greater than 80, meaning the overlying material is thicker and/or less permeable. Aquifers with a Medium Vulnerability will have a score that falls between 30 and 80. Table 4.1-1 outlines the Intrinsic Vulnerability based on an ISI or AVI score. This is explained in greater detail below.

Table 4.1- 1: Vulnerability based on ISI/AVI Scores

ISI/AVI Score	Intrinsic Vulnerability
<3_0	High
30 to 80	Medium
80	Low

The SAAT and SWAT methods (#3 and 4 listed above) for determining aquifer vulnerability are determined through use of the calibrated numerical groundwater flow models. Highly Vulnerable Aquifers are determined by a travel time to the aquifer (or well) of less than 5 years, while aquifers of Low Vulnerability are determined by a travel time to the aquifer (or well) of greater than 10 years. A single calibrated numerical groundwater flow model is not available for the SGBLS SPR and it was felt that it would be more appropriate to use a single methodology throughout the entire Source Protection Region.

The approach followed to determine the Regional Groundwater Vulnerability (HVAs and SGRAs) in the SGBLS SPR was the AVI method and is described in detail in Technical Memorandum A1 (Genivar, 2010d) found within Appendix RGV. The approach calculated an AVI for each delineated aquifer to produce a map of regional groundwater vulnerability across the landscape expressed as either “High”, “Medium”, or “Low”. The Technical Memorandum only documents the approach used to determine groundwater vulnerability for the purposes of HVAs and SGRAs. Chapter 5 – Methods and each municipal chapter should be referred to for more information on the methods used to delineate groundwater vulnerability for each municipal system.

The output of this step is a regional map showing the distribution of vulnerability categories as “High”, “Medium”, or “Low”. This will be used in subsequent steps.

Previous Work

The data used to delineate the Highly Vulnerable Aquifers within the South Georgian Bay-Lake Simcoe Source Protection Region were compiled from a variety of sources including:

1. North Simcoe Groundwater Study (Golder, 2005)
2. South Simcoe Groundwater Study (Golder, 2004)
3. NVCA Geological/Hydrostratigraphic Model Development (AquaResource & Golder, 2009)
4. CAMC/YPDT and LSRCA borehole database

5. CAMC/YPDT regional Version 4 ground surface layer

These studies were reviewed to assess the applicability of information provided for use in the delineation of groundwater vulnerability and Highly Vulnerable Aquifer maps. The studies were also used as a quality control check to provide confidence in the results of the work completed as part of this study (Genivar, 2010d).

Stratigraphy

The vulnerability within the Nottawasaga Valley Source Protection Areas was determined using an interpreted hydrostratigraphic model created by AquaResources and Golder Associates Limited on a 100 m x 100 m grid. A draft version of the model was made available in 2009.

The work included previously completed studies and well record information and created a model containing 17 individual layers. The layers are identified in Table 4.1- 2. The layers are listed in the order they occur in the model in reverse order of deposition from most recent to oldest.

All of the layers are continued across the model extent and thin to a thickness of 0.1m in areas where they are interpreted to not exist. This minimal thickness is required for functionality in the numerical modeling, but does not restrict using these layers for the assessment of groundwater vulnerability and the subsequent delineation of the Highly Vulnerable Aquifers.

Table 4.1- 2: Nottawasaga Valley Model Layers (AquaResource & Golder, 2009)

Layer Order	Layer Identifier	Layer Correlation
1	01SC1	Ground Surface; Aquitard
2	02SA1	Aquifer
3	03SC2	Aquitard
4	04SA2	Aquifer
5	05SC3	Aquitard
6	06SA3	Aquifer
7	07SC4	Aquitard
8	08SA4	Aquifer

Layer Order	Layer Identifier	Layer Correlation
9	09C1GA	Aquitard; Interpreted Top of Guelph Amabel; Interpreted Top of Bedrock above the Niagara Escarpment
10	10A2	Aquifer
11	11C2CC	Aquitard; Interpreted Top of Clinton Cataract above the Niagara Escarpment
12	12A3	Aquifer
13	13C3Q	Aquitard; Interpreted Top of Queenston Shale above the Niagara Escarpment
14	14A4	Aquifer
15	15C4	Aquitard
16	16GB	Aquifer; Interpreted Top of Georgian Bay Formation
17	17SG	Impermeable Boundary; Interpreted Top of Simcoe Group and Precambrian Bedrock

Assessing Vulnerability

The vulnerability was assessed using the AVI method outlined above. The groundwater vulnerability was assessed and included consideration for the effects of man-made structures that may increase the vulnerability. The resulting vulnerability was considered as per the Technical Rules to determine the Highly Vulnerable Aquifers and to assign these a vulnerability score for the Nottawasaga Valley Source Protection Area portion of the SGBLS SPR.

More detail on the methodology is available in Technical Memorandum B1 (Genivar, 2010d).

The resulting groundwater vulnerability within the Nottawasaga Valley Source Protection Area is shown in Figure 4.1-1. This figure shows the range of vulnerability ratings, including Low and Medium, as well as High.

Areas West of the Niagara Escarpment

The areas within the Nottawasaga Valley SPA located on the Niagara Escarpment were examined separately from the rest of the Nottawasaga Valley SPA due to differences in

stratigraphy generated by the significant change in elevation. The overburden above the escarpment is generally thinner and contains fewer of the layers present below the escarpment. In the areas below the escarpment, the top of the bedrock is generally interpreted as Layer 16GB (Table 4.1- 2), while above the escarpment, bedrock is interpreted as the top of Layer 09C1GA (Table 4.1- 2).

As bedrock aquifers receive recharge from overburden aquifers located directly above them, and as the bedrock is the dominant aquifer present in this area above the escarpment, the vulnerability analysis was completed to the top of the aquifer layer directly overtop of the bedrock, in this case, to the top of Layer 08SA4 (Table 4.1- 2). The escarpment line was drawn at the eastern-most edge of the official Niagara Escarpment boundary and included the entire area west of that line. This analysis is reflected in the area west of the escarpment shown on Figure 4.1-1.

Data Verification

Technical Memorandum A1 (Genivar, 2010d) outlines the methods employed to check and increase confidence in the work presented in this report. These methods included variations of parameters used in the AVI analysis, including the minimum aquifer thickness required for classification as a significant aquifer, changing the K-factors, utilizing model-generated hydraulic conductivities on model layers (after converting them to K-factors), and previously existing vulnerability mapping. Technical Memorandum A1 (Genivar, 2010d) includes figures showing the results of applying these parameter variations.

Minimum Aquifer Thickness

To avoid designating aquifers as highly vulnerable where they are not interpreted to be present, an aquifer thickness filter was applied to select only areas where the aquifers were considered to be present.

Minimum aquifer thicknesses of 1.0 m and 1.5 m were considered. Applying these thicknesses was intended to select aquifers that may be of sufficient thickness to function as a local water supply. Additional filtering for a minimum aquifer thickness of 1.5 m was considered to follow similar methodologies applied in neighbouring Source Protection Regions.

Very little variation was observed between the resulting maps so the minimum aquifer thickness of 1.5 m was selected in consultation with technical staff of the SGBLS SPR in order to be reasonably consistent with methods used in neighbouring SPRs.

Selection of K-Factors

A K-factor (Table A1-2 in Technical Memorandum A1 (Genivar, 2010d)) is a number assigned to represent or simplify the hydraulic conductivity (k) of a material, which is the rate of movement

of water through a porous medium such as a soil or aquifer. The lower the K-factor, the higher the permeability of the material is. For example, gravel has a lower K-factor than clay.

The selection of K-factors of 1 for aquifers and 4 for aquitards is considered to be conservative but is also considered to be reasonable in view of other uncertainties and simplifications employed in the regional methodology. At the request of the technical staff of the SGBLS SPR, different K-factors were applied to determine whether the choice of 1 and 4 may be overly conservative. The K-factor of 1 applies to gravel or fractured bedrock while 4 applies to silt (Table A1-2 in Technical Memorandum A1 (Genivar, 2010d)). As the layers are interpreted hydrostratigraphic units, the geology is likely to be highly variable and heterogeneous. As a result, K-factors of 2 (sand) and 5 (till) were applied to the aquifers and aquitards respectively.

For the Nottawasaga Valley SPA and Severn Sound SPA, hydraulic conductivity values generated from the numerical groundwater flow model created by AquaResource and Golder (2010) were also available for each interpreted layer. These values were converted into K-factors (the rough correlation between hydraulic conductivity and K-factor values is presented in Table 3.2 of the Draft Appendix 3 for Assessment Report Guidance Module 3—Groundwater Vulnerability Analysis (MOE, October 2006). These hydraulic conductivities tended to convert to K-factors of 3 for the aquifers and either 4 or 5 for the aquitards.

Very little variation was observed between the resulting maps. The more conservative K-factor selections of 1 and 4 were concluded to be suitable for delineating the groundwater vulnerability using the hydrostratigraphic layers with a minimum aquifer thickness of 1.5 m.

Saturated Aquifer Conditions

In review of the draft, preliminary groundwater vulnerability maps, the study team noticed that the layers identified as high groundwater vulnerable aquifer layers could be above the mapped water table. An additional filter was applied to only select saturated or partially saturated aquifer units by requiring that the water table was interpreted to be present above the bottom of the identified aquifer hydrostratigraphic layer (the water table can either be within or above the interpreted aquifer entirely). If the water table did not meet either of these requirements, the hydrostratigraphic unit was considered to be dry and was not considered as a Highly Vulnerable Aquifer.

This filter was not applied to the base layer in each interpreted hydrostratigraphic interpretation as these layers were assumed to be saturated bedrock layers.

Other Data Sources

Following the generation of the preliminary map of Highly Vulnerable Aquifer(s) which incorporated the above filters, the mapping was compared against the other data sources and mapping products within each Source Protection Area. These data sources include:

1. Intrinsic Susceptibility Index (ISI) mapping generated as part of the North and South Simcoe Groundwater Studies (Golder Associates Ltd., Ainley Group, and Waterloo Hydrogeologic Inc., 2004)
2. Intrinsic Susceptibility Index (ISI) mapping presented in “Groundwater Modelling of the Oak Ridges Moraine Area” (CAMC/YPDT, 2006)
3. Ontario Geological Survey (OGS) surficial sand and gravel deposit mapping

Coverage from item 1. extends across parts of the Nottawasaga Valley SPA, Severn Sound SPA, and the Black-Severn River watershed. Item 2. provides coverage only in portions of the Lake Simcoe watershed. The OGS mapping is continuous across all four watersheds within the SGBLS SPR. The other data sources generally provided a good correlation with the vulnerability mapping produced as part of this study.

Consider Vulnerability Increase for Transport Pathways

The groundwater vulnerability as delineated in accordance with Technical Rules 37 or 38 (Part IV) take into account the best available understanding of the natural geological layers in relation to delineated aquifers. Technical Rules 39-41 (Part IV) provide an opportunity to consider situations where man-made or anthropogenic influences can increase the natural vulnerability by decreasing the time required for contaminants to move down to the water supply aquifer.

Examples of features that may provide a Transport Pathway that could result in an increased vulnerability to a water supply source include:

- existing wells or boreholes (all types)
- unused or abandoned wells
- pits and quarries
- mines
- construction activities (such as deep building basements/parking garages)
- storm water infiltration
- septic systems
- storm sewer, sanitary sewer and water distribution system infrastructure

The methodology followed to determine where to consider a vulnerability increase due to Transport Pathways is described in more detail in Technical Memorandum A1 (Genivar, 2010d). Many of these features are typically found in more urbanized environments and would not apply on a regional scale. Within the SGBLS SPR, the most likely activity or feature to be found

that might influence the natural vulnerability is extraction from pits and/or quarries. The output of this analysis is a map illustrating the extent to where the vulnerability increase is to be considered.

Technical Memorandum A1 (Genivar, 2010d) outlines the process followed in determining and incorporating the Transport Pathway Increase for the Nottawasaga Valley Source Protection Area as per the Technical Rules. The Vulnerability Rating can be increased from Medium to High, Low to Medium, or from Low to High in accordance with the potential for artificial transport pathways to increase the observed vulnerability. Under the Technical Rules, Vulnerability Ratings cannot be increased beyond High.

The land uses that were considered in the vulnerability increase from Transport Pathways included active or formerly active pits or quarries. These land uses may strip protective cover that overlies the aquifers in areas that may otherwise warrant vulnerability ratings of Medium or Low.

Figure 4.1-2 shows the areas proposed for a vulnerability increase due to the presence of Transport Pathways within the Nottawasaga Valley SPA.

Assign Vulnerability Ranking

A vulnerability score was determined for the SGBLS SPR in accordance with Technical Rule 38. According to this rule, an area with an AVI score of less than 30 is identified as having a High Vulnerability, while aquifers of a Low Vulnerability have an AVI score greater than 80. Aquifers with a Medium Vulnerability will have a score that falls between 30 and 80. Table 4.1-1 outlines the Vulnerability based on an AVI score.

The Groundwater Vulnerability map (Figure 4.1-1) expresses the relative degree to which a land use or activity could affect the local aquifers which may serve as drinking water supply aquifers elsewhere in the Source Protection Region. The Vulnerability Scores that pertain to the delineated Wellhead Protection Areas surrounding municipal supply wells as per Part VII.3 of the Technical Rules are presented within the municipal chapters.

4.1.2 Evaluate Uncertainty

As part of the Vulnerability Analysis an Uncertainty Rating is required, as outlined in Technical Rules 13 - 15 (Part I.4 – Uncertainty Analysis – Water Quality (MOE, November 2008a)).

Rule 13. An analysis of the uncertainty, characterized by “high” or “low” shall be made in respect of the following:

- (1) the assessment of the vulnerability of groundwater throughout the area undertaken in accordance with Part IV

- (2) the delineation of highly vulnerable aquifers, significant groundwater recharge areas and wellhead protection areas undertaken in accordance with Part V
- (3) the delineation of surface water intake protection zones undertaken in accordance with Part VI
- (4) the assessment of the vulnerability of significant groundwater recharge areas, highly vulnerable aquifers and wellhead protection areas undertaken in accordance with Part VII

Rule 14. The following factors shall be considered in an analysis conducted for the purpose of rule 13:

- (1) the distribution, variability, quality and relevance of data used in the preparation of the assessment report
- (2) the ability of the methods and models used to accurately reflect the flow processes in the hydrological system
- (3) the quality assurance and quality control procedures applied
- (4) the extent and level of calibration and validation achieved for models used or calculations of general assessments completed
- (5) for the purpose of subrule 13(1), the accuracy to which the groundwater vulnerability categories effectively assess the relative vulnerability of the underlying hydrogeological features
- (6) for the purpose of subrule 13(4), the accuracy to which the area vulnerability factor and the source vulnerability factor effectively assess the relative vulnerability of the hydrological features

Rule 15. An uncertainty factor of “high” or “low” shall be assigned to each vulnerable area delineated based on the results of the analysis conducted under rule 13.

The Technical Rules only allow Uncertainty Ratings to be either “High” or “Low”. This Uncertainty Rating must take into account the quantity and quality of data available and the technical methods used to determine the Vulnerability Scores and the efforts taken to maintain a quality outcome.

In most cases, the Uncertainty Rating will be governed by the quantity, quality, and distribution of information available on which the understanding of the groundwater flow system is based. In other cases, the natural system itself may justify a High Uncertainty Rating. As data distribution is often highly variable, some areas may be more accurately reflected than others.

In the technical guidance provided by the MOE ([now MECP](#)) prior to the Technical Rules as amended December 2009, the Uncertainty Rating was described as having a specific role in making decisions regarding the selection of management activities to address the identified threats to groundwater or surface water. Although this role is not clearly described in the

Technical Rules, it is apparent that the High or Low Uncertainty Rating will play a similar role in the Source Protection Planning process.

The Technical Rules require that an Uncertainty Rating be assigned with each vulnerable area as outlined above. The uncertainty assessment 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.

The Uncertainty Rating assigned for the Nottawasaga Valley SPA is High. A High uncertainty rating does not necessarily reflect a low degree of confidence in the vulnerability assessment, but instead reflects the irregular distribution and high variability in quality and consistency in the data available to use for the assessment.

The High uncertainty rating also reflects the potential variability in the vulnerability interpolated across as 100m x 100m gridded area. As the data is extrapolated to generate a surface, some averaging of individual data points occurs and while the variation may not show much variation on a regional scale, on a local scale, the results may not fully reflect local conditions which may influence the susceptibility of the aquifers to contamination from activities at surface. Collection of data in areas demonstrating low data availability may serve to lower the Uncertainty Rating.

4.2 Highly Vulnerable Aquifer Mapping (HVAs)

An understanding of what it means when an area is designated as a Highly Vulnerable Aquifer or Significant Groundwater Recharge Area under the *Clean Water Act, (2006)* is crucial for protecting the groundwater resources, found within the SGBLS SPR. *Ontario Regulation 287/07* defines a Highly Vulnerable Aquifer (HVA) as an aquifer on which external sources have or are likely to have a significant adverse effect, and includes the land above the aquifer.

In general, a Highly Vulnerable Aquifer will consist of source granular aquifer materials or fractured rock that have a high permeability and are exposed near the ground surface with a relatively shallow water table. The vulnerability of the aquifer will typically be lower where a greater thickness of fine-grained lower permeability soils is observed to cover the aquifer (Genivar, 2010d).

4.2.1 Vulnerability Scoring for HVAs

A vulnerability score was determined for the SGBLS SPR in accordance with Technical Rule 79. According to this rule, an area identified as a Highly Vulnerable Aquifer is assigned a “vulnerability score” of 6.

The map of Highly Vulnerable Aquifer Scores expresses the relative degree to which a land use or activity could affect the local aquifers which may serve as drinking water supply aquifers

elsewhere in the region. The vulnerability scores that pertain to the delineated Wellhead Protection Areas surrounding municipal supply wells as per Part VII.3 of the Technical Rules are presented in other studies.

In areas where an HVA area overlaps a delineated wellhead protection area, the shallower aquifer will be delineated as an HVA.

4.2.2 Composite Highly Vulnerable Aquifer Map

Following the delineation of the Highly Vulnerable Aquifer within each of the four watersheds, these maps were combined to create a continuous and consistent Highly Vulnerable Aquifer map that provided coverage across the entire SGBLS SPR. The below section discusses edge matching challenges and decisions made in order to combine the four Highly Vulnerable Aquifer maps. All of the checks employed returned similar results, providing confidence that the product presented in this report is defensible and adequately representative of the study area, based on the data available at this time.

Following the data verification and edge matching discussed below, the Highly Vulnerable Aquifer map generated for each SPA (Figure 4.2-1) was combined to provide a composite Highly Vulnerable Aquifer map covering the entire SGBLS SPR. This map is presented in Figure 4.2-2.

Edge Matching

The individual watershed Highly Vulnerable Aquifer maps (discussed in their respective Assessment Reports) produced overlaps at their relative boundaries. As a result, each of these overlaps required examination and a decision as to how to address the overlaps. Each of the overlaps encountered are discussed below.

Nottawasaga Valley Source Protection Area to Lake Simcoe Watershed

The hydrostratigraphic models produced by Golder and AquaResource (Nottawasaga Valley SPA/Severn Sound SPA) and CAMC/YPDT (Lake Simcoe watershed) produce an overlap that extends across the Townships of Bradford-West Gwillimbury, Innisfil, and the City of Barrie. Both Highly Vulnerable Aquifer maps show slightly different results and relative proportions of High, Medium, and Low Vulnerability Ratings. The results from each model are shown side-by-side on Figure 4.2-3 for the overlap area. While both models incorporated high quality data and professional judgment, the SGBWLS model was chosen for this area. The SGBWLS model was commissioned as part of this study and was produced using recent data that was not available when the CAMC/YPDT model was originally prepared. This decision results in a consistent product within the municipalities in Simcoe County.

Severn Sound Source Protection Area to Black-Severn River Watershed

The hydrostratigraphic model produced by Golder and AquaResource for the Nottawasaga Valley and Severn Sound watersheds and the overburden thickness map combined with surficial sand and gravel deposits produce an overlap that extends across parts of the Townships of Severn, Oro-Medonte and Tay. Both resulting maps show similar results and relative proportions of High, Medium, and Low vulnerability ratings. The results from each model are shown side-by-side on Figure 4.2-4 for the overlap area. The overburden thickness map was used only within the boundaries of the Black-Severn River watershed and was extended beyond these boundaries to reduce edge kriging errors when generating the original layer. The model covering the Severn Sound watershed was commissioned as part of this study and was produced using more current high quality data than was available in the water well database available for the Black-Severn River watershed and was chosen for coverage across the extent of the Severn Sound watershed.

4.3 Significant Groundwater Recharge Areas

An area where rain or snow seeps into the ground and flows to an aquifer is called a recharge area. Recharge areas tend to be areas that are characterized by permeable soils, such as sand or gravel which allow the water to seep easily into the ground. A recharge area is considered significant when it helps maintain the water level in an aquifer that supplies a community with drinking water, or supplies groundwater recharge to a cold water ecosystem that is dependent on this recharge to maintain its ecological function (MOE, 2007).

The Technical Rules indicate that Significant Groundwater Recharge Areas (SGRAs) need to be delineated for each Source Protection Area within the Source Protection Region. The Significant Groundwater Recharge Areas were delineated using the recharge results from the water budget described in Chapter 3 within this document. The Nottawasaga Valley and Severn Sound recharge estimates were completed by the Nottawasaga Valley Conservation Authority (2010) as part of South Georgian Bay West Lake Simcoe (SGBWLS) Tier Two Water Budget and Water Quantity Stress Assessment completed by AquaResource and Golder (2010). The aforementioned report is the guiding document for this section of the Assessment Report, and can be referred to for more detail.

The SGRAs within the Nottawasaga Valley Source Protection Area have been delineated in accordance to Technical Rules 44 – 46, 80-81 (MOE, 2008a).

4.3.1 Delineating Significant Groundwater Recharge Areas

The delineation of the Significant Groundwater Recharge Areas within the Nottawasaga Valley watershed were completed using the recharge results from the HSP-F surface water model (See Chapter 3: Water Budget and Stress Assessment and, Appendix WB-4 for more details). The

model considers variations in surficial soil, land cover and climate, when estimating average annual groundwater recharge.

The Technical Rules for delineating Significant Groundwater Recharge Areas are as follows:

Rule 44. Subject to rule 45, an area is a Significant Groundwater Recharge Area if,

- (1) The area annually recharges water to the underlying aquifer at a rate that is greater than the rate of recharge across the whole of the related groundwater recharge area by a factor of 1.15 or more; or
- (2) The area annually recharges a volume of water to the underlying aquifer that is 55% or more of the volume determined by subtracting the annual evapotranspiration for the whole of the related groundwater recharge area from the annual precipitation for the whole of the related groundwater recharge area

Rule 45. Despite rule 44, an area shall not be delineated as a Significant Groundwater Recharge Area unless the area has a hydrological connection to a surface water body or aquifer that is a source of drinking water for a drinking water system.

Rule 46. The areas described in Rule 44 shall be delineated using the models developed for the purposes of Part III of these rules and with consideration of the topography, surficial geology, and how land cover affects groundwater and surface water.

The SGRAs thresholds for the Nottawasaga Valley Source Protection Area have been delineated in accordance with Technical Rule 44(1) with consideration for Technical Rules 45 and 46. The “related groundwater recharge area” identified in Rule 44(1) was taken as the entire study area covered by the calibrated HSP-F model. This region includes the Nottawasaga Valley and Severn Sound watersheds, with the exception of a small portion of the northern Severn River, where no land use data was available. For this area, average annual groundwater recharge rates were extrapolated from neighbouring areas with similar surficial geology, assuming a forested land cover (AquaResource and Golder, 2010). The average annual recharge for the combined Nottawasaga Valley and Severn Sound Source Protection Areas is 202 mm/year; therefore, all recharge areas exceeding 232 mm/year were deemed significant (Figure 4.3-1).

Table 4.3- 1 shows the Significant Groundwater Recharge Area threshold calculated for this assessment. The threshold is calculated based on the spatially averaged annual recharge rate for the combined Nottawasaga and Severn Sound watersheds, multiplied by 115%. Figure 4.3-1 illustrates all areas in the Nottawasaga and Severn Sound watersheds where the estimated average annual groundwater recharge rates are greater than the threshold rate (232 mm/yr). As shown in this figure, SGRAs are identified predominantly within the sand and gravel regions of the watersheds.

Table 4.3- 1: Significant Groundwater Recharge Area Threshold (AquaResource and Golder, 2010)

Related Groundwater Recharge Area	Average Annual Recharge Rate (mm/yr)	Threshold Recharge Rate (115%) (mm/yr)
Nottawasaga and Severn Sound Watersheds	202	232

According to Technical Rule 45, the areas identified as Significant Groundwater Recharge Areas must be hydrologically connected to a surface water body or to an aquifer that is a source of drinking water. All recharge occurring within the Nottawasaga Valley Source Protection Area is considered to be hydrologically connected to drinking water supplies (as per Technical Rule 45). To show that all delineated SGRAs are hydrologically connected to groundwater sources used for drinking water purposes (Technical Rule 45), public, domestic and municipal well locations are shown on Figure 4.3- 4. Due to the high density of water wells within the Study Area, it is assumed that all identified SGRAs are hydraulically connected to a water supply.

As described in the HSP-F modelling report (NVCA, 2009), the unit response functions are delineated across the two watersheds with a very high level of precision as a reflection of detailed geological and land cover mapping. Consequently, the map of estimated groundwater recharge is very detailed, showing relatively small parcels of land that are above the SGRA threshold. The high level of precision in the output may not reflect the certainty of the modelling results or certainty in the initial surficial geology and land cover mapping, as much of the mapping is not field verified. As well, for the purposes of the Clean Water Act, it will likely be difficult to develop workable policy for these small parcels. As such, after estimating SGRAs a modification of the SGRA map that removes all isolated polygons with an area less than or equal to 0.1 km² (10 ha) based on the scale of the features reflected in the mapping was done. The modification focuses the delineated SGRAs to larger geologic and physiographic features that are considered more representative of mapped surficial geology features. This modification is considered more practical and workable for planning purposes.

4.3.2 – Vulnerability Scoring for SGRAs

Once each SGRA is delineated, vulnerability scores are determined by overlaying the Groundwater Vulnerability Scoring (Section 4.1 & Figure 4.1-1) with the SGRAs (Section 4.3 & Figure 4.3-1), as required in the Technical Rules 80 and 81 (MOE, Nov. 2009). The SGRAs with the vulnerability scores are shown in Figure 4.3-2. Areas with no colour are not significant groundwater recharge areas.

Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas are scored differently for vulnerability. The HVAs show only the high classification of the vulnerability analysis (with a score of 6), but SGRAs show all vulnerability classifications (see Table 4.3-2).

Table 4.3-2: Vulnerability Scores Translated into Vulnerability Categories for SGRAs

Vulnerability Score	Category
6	High
4	Medium
2	Low

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4.3.34.3.2 Evaluate Uncertainty

As per Technical Rule 13(2) (Nov. 2009), an analysis of the uncertainty with respect to the delineation of significant groundwater recharge areas was performed in accordance with the “factors” of Technical Rule 36.

Technical Rule 46 provides for the ability to evaluate the reasonableness of this threshold recharge value. Figure 4.3-3 illustrates the distribution of recharge rates as well as the volume and area exceeding each recharge rate for the Nottawasaga and Severn Sound watersheds. The cumulative exceedance curves are calculated as follows:

- **% Volume Exceeding Recharge Rate:** this curve is calculated as the sum of the total recharge flux for all unit response functions with a recharge rate equal to or above the value on the horizontal axis, divided by the total recharge flux
- **% Area Exceeding Recharge Rate:** this curve is calculated as the sum of area associated with all hydrologic response units having a recharge rate equal to or above the value on the horizontal axis, divided by the total area

Using these calculations, this figure illustrates how much volume or area would be identified as exceeding a given recharge rate. Inflections in these curves may illustrate natural divisions within the distribution and reflect the variation in surficial geologic and land use within the watersheds.

As shown in Figure 4.3-3 the distribution of recharge illustrates the different physiographic regions and geologic materials within the watersheds. Clusters around the 50 mm/yr, 125-175 mm/y and 275-425 mm/y recharge rates reflect the clays, tills, and sand/gravels, respectively. The figure illustrates that the computed threshold value (232 mm/yr) lies within an approximate “plateau” of the % volume curve (red line) and % area curve (blue line). This recharge threshold results in identifying approximately 42% of the area of the Nottawasaga and Severn Sound watersheds and 73% of the recharge volume as significant. This threshold value is deemed reasonable and practical for defining SGRAs as it encompasses the majority of the area

with underlying sand and gravels. Furthermore, the figure also suggests that at this recharge threshold, the resulting land area and recharge volume are relatively insensitive to the recharge rate. For example, if the recharge threshold were increased to 275 mm/year, the land area affected would be 39% of the watersheds as opposed to 42%, and the affected recharge volume would be 69% as opposed to 73%. This means that the delineation of SGRAs for the Nottawasaga and Severn Sound watersheds is not sensitive to the recharge threshold (AquaResource and Golder, 2010).

When relying on the SGRA map to support water quantity or water quality protection activities there is a need to consider some of the assumptions and limitations associated with the delineated SGRAs. They are as follows:

1. Significant rates and volumes of groundwater recharge occur in areas that are not classified as SGRAs. Estimated groundwater recharge rates in some areas might be high, but just below the SGRA threshold; and,
2. The HSP-F continuous streamflow generation and FEFLOW steady-state groundwater flow models are calibrated to achieve the best overall fit to measured streamflow and baseflow estimates. Within a specific watershed, there is a wide range of estimated groundwater recharge rates depending on local soil type and land cover. While the calibration process addresses the confidence of the hydrologic and hydrogeological simulation within a subwatershed, the water budget parameters for a specific land cover/geology combination are not individually calibrated and the results should only be considered as a relative measure of hydrologic processes.

The Province's objectives for incorporating SGRAs into the Water Quality Threats Assessment process are clearly defined within the Technical Rules (MOE, 2009). SGRAs are used in coordination with intrinsic susceptibility mapping to determine a vulnerability score outside of wellhead protection areas. SGRAs are one of the three types of vulnerable areas identified by the Province.

Conversely, the role of protecting SGRAs from a water quantity perspective is not prescribed in the Technical Rules (MOE, 2009). There is a good opportunity to address the need to protect groundwater quantity within the Source Protection Planning Process, but this opportunity needs to address both the value of total groundwater recharge across a subwatershed as well as those areas having higher than average values. Furthermore, the process needs to address the uncertainty in terms of the magnitude and distribution of recharge rates.

4.4 Drinking Water Threats Evaluation

Part II of the Technical Rules (16(9) to 16(11)), requires maps showing the percentage of Managed Lands, Livestock Density, and percentage of Impervious Surfaces for all Vulnerable Areas in the SGBLS SPR. In this section we discuss these maps for ~~the two~~ regional scale ~~Vulnerable Areas – HVAs and SGRAs~~ Highly Vulnerable Aquifers (HVAs). Similar maps have been prepared for the WHPAs and IPZs, and these can be found within the municipal vulnerability and threats chapters (Chapter 6-19). Here we present a short summary of how the maps were prepared, with full details presented in Technical Memorandum A5 (Appendix MO) and Genivar 2010d.

4.4.1 Managed Lands

Managed Land means land to which agricultural source material, commercial fertilizer, or non-agricultural source material is applied (Part 1.1 Technical Rules; Definitions).

The Managed Lands are used in the identification of Threat activities associated with the application of agricultural source material, non-agricultural source material and commercial fertilizer.

The following land uses were included in the Managed Land areas and were identified from the MPAC property codes:

- residential (assumed that 50% of the property area would be Managed Land)
- golf courses
- parks/recreational facilities/sporting fields
- institutional lands
- agricultural managed lands (see below)

Managed Land Areas were estimated using the total area of properties that intersect individual vulnerable areas as provided in “Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source Material and Commercial Fertilizers” (MOE, ~~September-December~~ 2009).

Figure 4.4-1 ~~and Figure 4.4-2~~ illustrates the proportion of Managed Lands within HVAs ~~and SGRAs respectively~~. For the majority of the Source Protection Area, the percent Managed Lands is estimated to > 40% and < 80%.

4.4.2 Livestock Density

The Livestock Density was determined for the HVA ~~and SGRA~~ based on the methodology described in Technical Memorandum A5 (Appendix MO). However, the methods were revised

slightly for the regional vulnerable areas in that the Livestock Density estimates were based on Census 2006 data for each subwatershed, rather than interpretation of aerial photographs. The following steps were taken to calculate Livestock Density in the regional vulnerable areas:

1. Calculate the number of different types of livestock using Canada Census Data (2006) for the subwatershed that the vulnerable areas are located within
2. Determine the nutrient units for the numbers of livestock located within the subwatershed using the conversion factors provided within Table 2 of the Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source Material, Non-Agricultural Source Material and Commercial Fertilizers (MOE, September 2009)
3. Determine the number of acres of agricultural managed lands within the subwatershed (i.e. the area nutrients could potentially be applied to)
4. Calculate the Livestock Density for the subwatershed by dividing the nutrient units by the number of acres of land where application of nutrients may be occurring

The Livestock Density within each subwatershed was then assigned to the mapped HVAs and SGRAs. The Livestock Density is used in the identification of Threat activities associated with the storage of agricultural source material and the grazing and/or confinement of livestock.

As this method differs to that recommended in the MOE ([now MECP](#)) Technical Bulletin, Directors Approval was requested in accordance with Technical Rule 15.1. At the time this report was in preparation, Directors permission had not yet been received. This approach was used for Regional Scale Vulnerable areas as it:

1. Significantly reduces the time and resources needed for completion, especially considering the potential number of farms that would require aerial interpretation if the recommended approach was used; and
2. There are a number of inherent uncertainties and assumptions that the aerial interpretation method requires, that would not occur using the census data

For example, the assumption used to determine what buildings are housing animals and what type of farm animal are being housed. Overall, this departure is considered equivalent or better to that within the Technical Rules as it relies on data provided by Census Canada, but in all other steps follows the general methods outlined in the MOE ([now MECP](#)) Technical Bulletin.

Figure 4.4-3 and Figure 4.4-4 illustrates the Livestock Density within the delineated SGRA and HVA, respectively. Both Figure 4.4-3 and Figure 4.4-4 illustrates the livestock density is mapped as < 0.5 nutrient unit/acre through the subwatersheds of the Nottawasaga Valley Source Protection Area. The livestock density is used in the identification of threat activities associated

with the storage of agricultural source material and the grazing and/or confinement of livestock.

4.4.3 Impervious Surfaces

The Impervious Surface was determined for the HVAs ~~and SGRAs~~ using the methodology described in Technical Memorandum A5 (Appendix MO). The proportion of Impervious Surfaces reflects the relative density of roads and streets within ~~1 km grid squares relative to the centre of the SGBLS SPR~~ the wellhead protection area or intake protection zone.

The percentages of the Impervious Surfaces were determined for the HVAs ~~and SGRAs~~ are shown in Figure 4.4-5 ~~and Figure 4.4-6, respectively~~. For the majority of the study area the proportion of Impervious Surfaces ~~varies between <1% and 1-8%. For a small portion of the study area the density of Impervious Surfaces area between 8 and 80%, which are typically within settlement areas.~~ is low and does not trigger any policies. There is more impervious surface cover in some more urban areas and these are the area where policies may apply. The Impervious Surfaces are used in the identification of Threat activities associated with the application of winter de-icing agents (salt).

The percentages of the Impervious Surfaces were determined for the HVAs ~~and SGRAs~~ are shown in Figure 4.4-5 ~~and Figure 4.4-6, respectively~~.

4.4.4 Identifying Areas of Significant/Moderate/Low Threats - Activities

~~The areas where Activities are or would be Drinking Water Threats within the SGRA for the Nottawasaga Valley Source Protection Area are based on the assigned distribution of Vulnerability Scores within the SGRAs.~~

~~Review of the Technical Rules able of Drinking Water Threats indicates that Activities involving pathogen parameters would not be designated as a Drinking Water Threat within a SGRA.~~

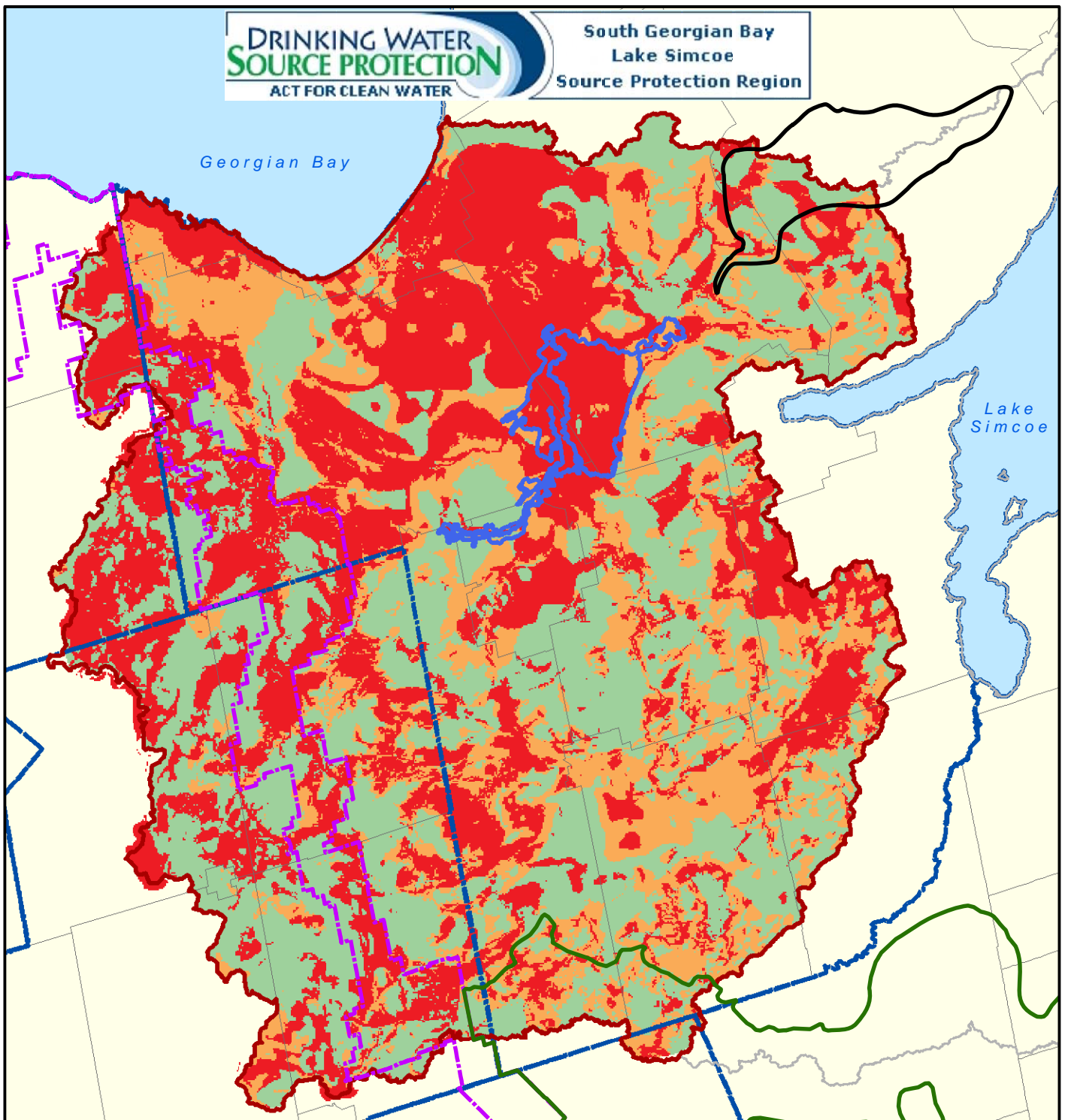
~~The key table on Figure 4.4-7-4 and Figure 4.4-8 can be used in conjunction with the Vulnerability Scores-Technical Rules to identify areas where Activities associated with chemical Threats are or would be Moderate or Low Drinking Water Threats to the drinking water sources within the identified HVAs and SGRA. Activities can be a Threat where the Vulnerability Score within the SGRA is 6. Activities cannot be a Significant Drinking Water Threat within the HVA.~~

4.4.5 Identifying Areas of Significant/Moderate/Low Threats - Conditions

~~The areas where Conditions are or would be Drinking Water Threats within the SGRA for the Nottawasaga Valley Source Protection Area are based on the assigned distribution of Vulnerability Scores within the SGRA.~~

A Condition or potential Condition that has not been identified could 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. ~~As the SGRAs and HVAs~~ have a maximum Vulnerability Score of 6, only areas with a Moderate Threat can occur. There are no areas with Low or High potential Threats for Conditions.

Figure 4.2-1 ~~and Figure 4.3-2~~ illustrates the Vulnerability Score map ~~HVAs and SGRAs respectively~~. These maps can be used to determine where a Condition is or would be a Moderate Threat to Drinking Water.



Legend

- High Vulnerability
- Medium Vulnerability
- Low Vulnerability
- Nottawasaga Valley Source Protection Area
- Oak Ridges Moraine Boundary
- Oro Moraine Boundary
- Niagara Escarpment Boundary
- Minesing Swamp Complex

Note: Groundwater Vulnerability presented in this figure does not include a Vulnerability Increase for Transport Pathways.



5 2.5 0 5 Kilometres

**NOTTAWASAGA VALLEY SPA
GROUNDWATER VULNERABILITY**

DELINEATION OF HIGHLY
VULNERABLE AQUIFERS (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:410,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F3-2

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region 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.



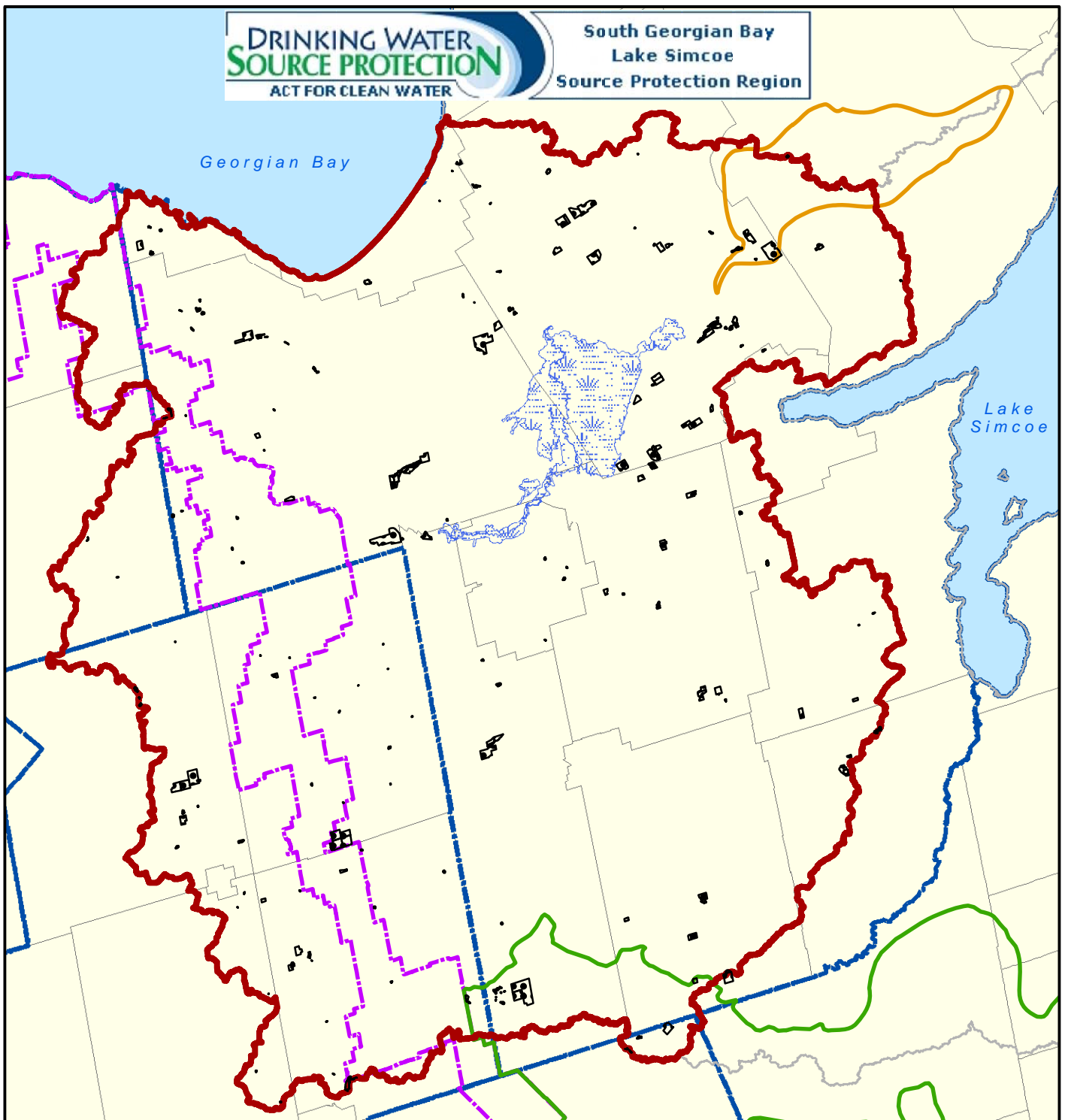
GENIVAR




Ontario

FIGURE

4.1-1



Legend

-  Proposed Transport Pathways
-  Nottawasaga Valley Source Protection Area
-  Oak Ridges Moraine Boundary
-  Oro Moraine Boundary
-  Niagara Escarpment Boundary
-  Minesing Swamp Complex



5 2.5 0 5 Kilometres

**NOTTAWASAGA VALLEY SPA
PROPOSED AREAS FOR VULNERABILITY
INCREASE FROM TRANSPORT PATHWAYS**

DELINEATION OF HIGHLY
VULNERABLE AQUIFERS (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:410,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F3-3

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region 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.



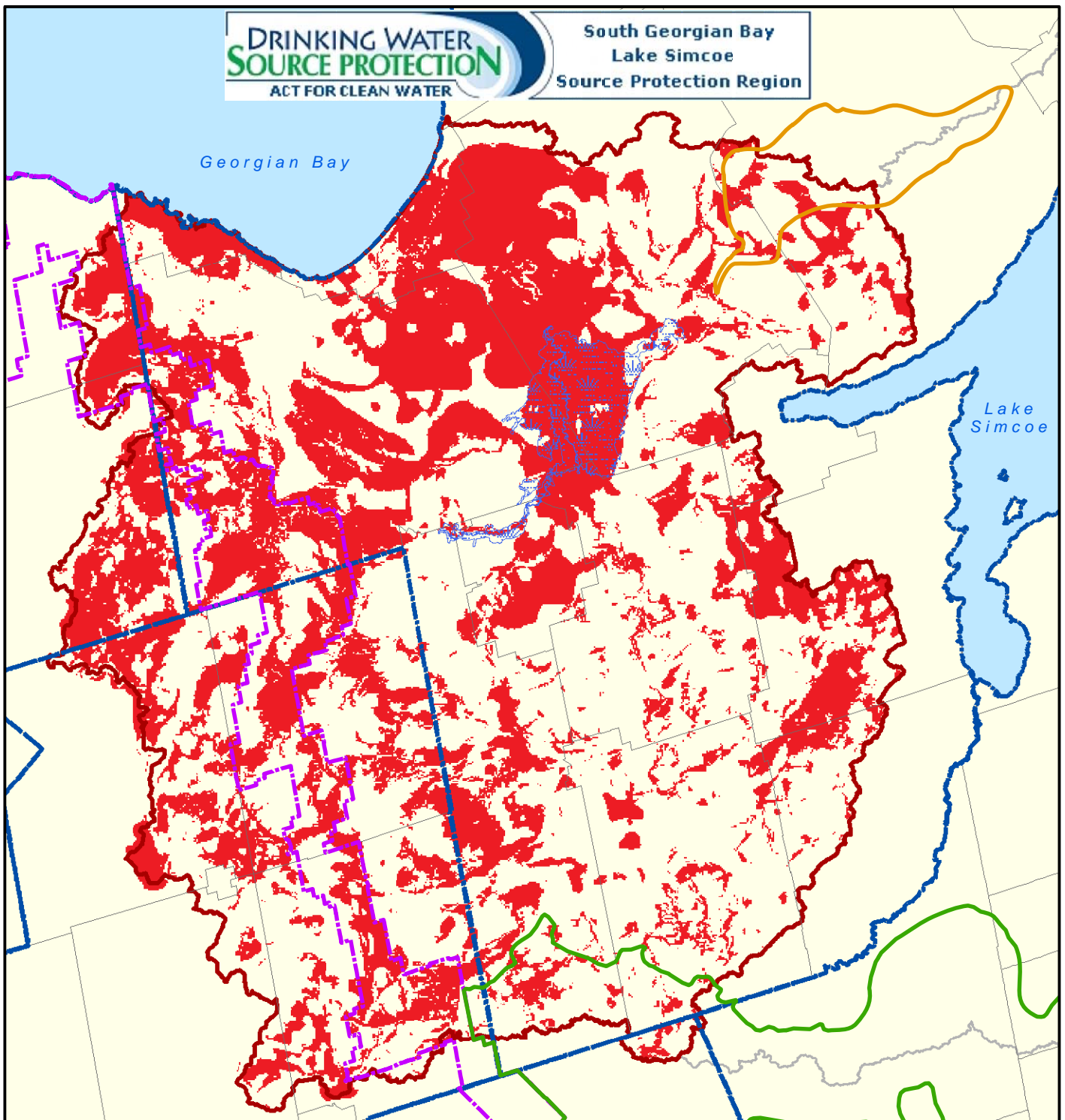
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Ontario

FIGURE

4.1-2



Legend

- High Vulnerability (Vulnerability Score = 6)
- Nottawasaga Valley Source Protection Area
- Oak Ridges Moraine Boundary
- Oro Moraine Boundary
- Niagara Escarpment Boundary
- Minessing Swamp Complex



5 2.5 0 5 Kilometres

Note: Highly Vulnerable Aquifers consider a Vulnerability Increase for Transport Pathways.

**NOTTAWASAGA VALLEY SPA
HIGHLY VULNERABLE AQUIFER**

DELINEATION OF HIGHLY
VULNERABLE AQUIFERS (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:410,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F3-4

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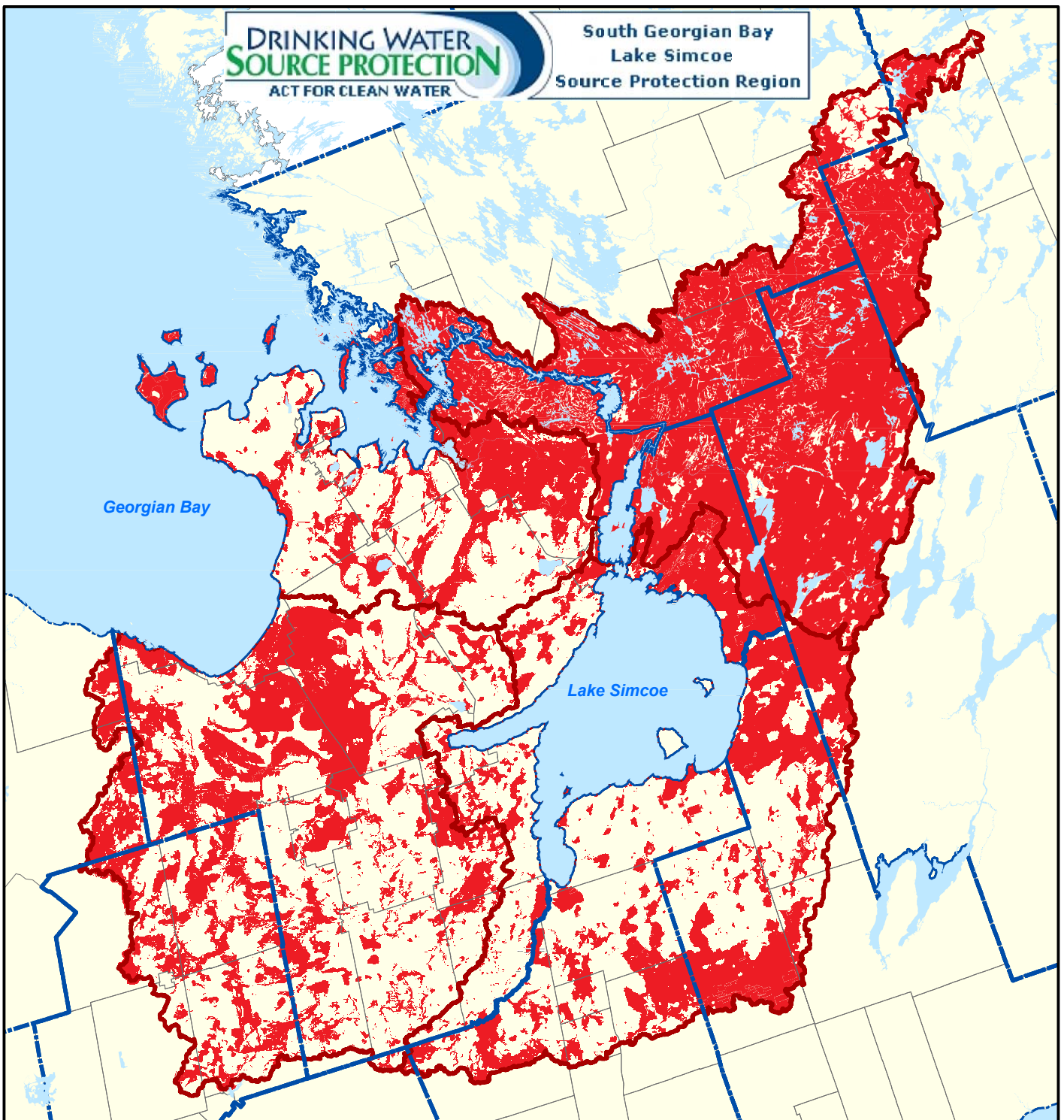
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Ontario

FIGURE

4.2-1



Legend

 High Vulnerability (Vulnerability Score = 6)



10 5 0 10 Kilometres

**SOUTH GEORGIAN BAY LAKE SIMCOE
SPR HIGHLY VULNERABLE AQUIFER**

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:810,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4-3

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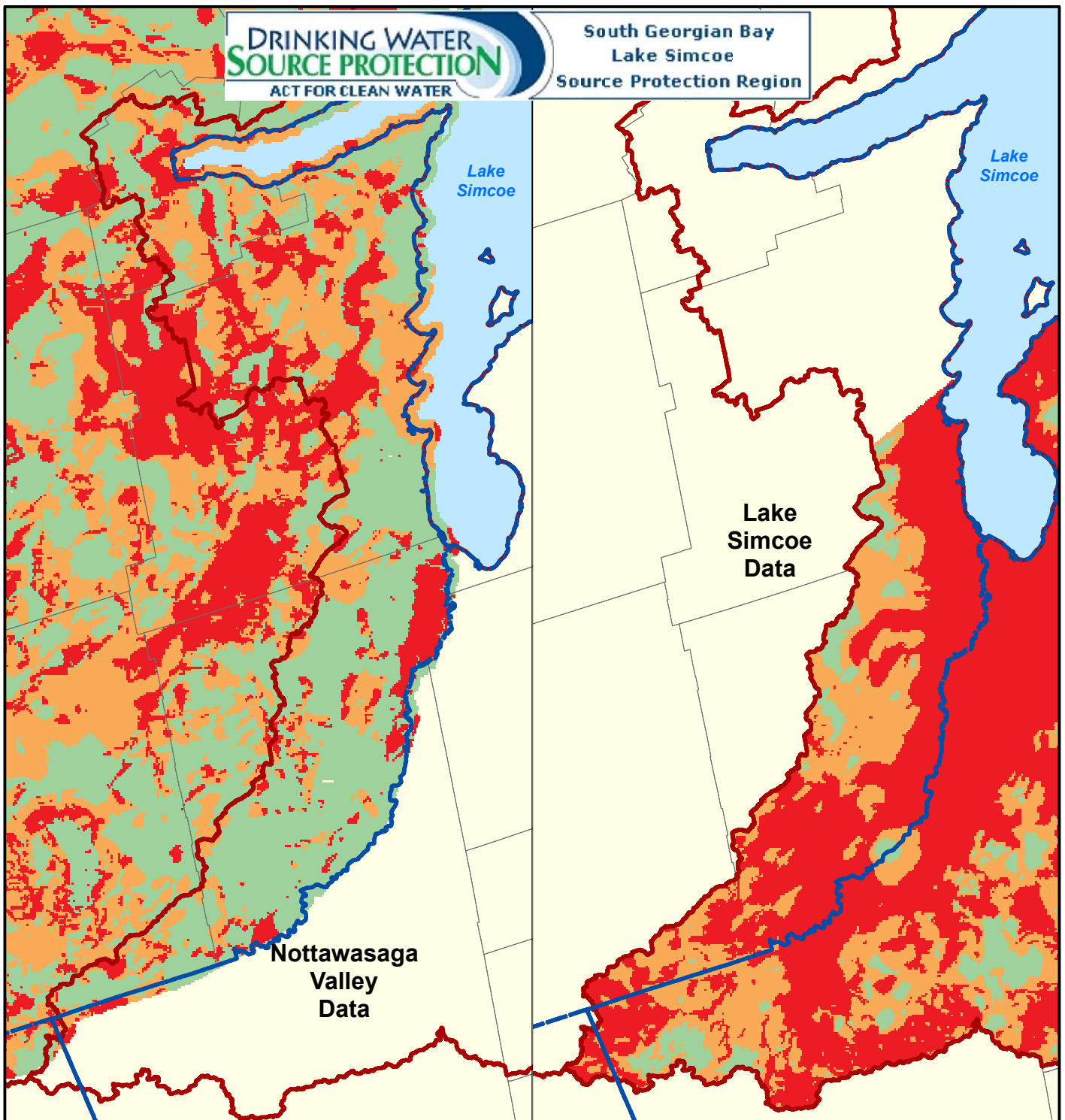
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FIGURE

4.2-2



Legend

- High Vulnerability
- Medium Vulnerability
- Low Vulnerability



2 1 0 2 Kilometres

EDGE MATCHING BETWEEN NOTTAWASAGA VALLEY SPA AND LAKE SIMCOE WATERSHED

DELINEATION OF HIGHLY VULNERABLE AQUIFER (HVA) - South Georgian Bay Lake Simcoe Source Protection Region

DATE: JULY 2010

SCALE: 1:290,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4-1

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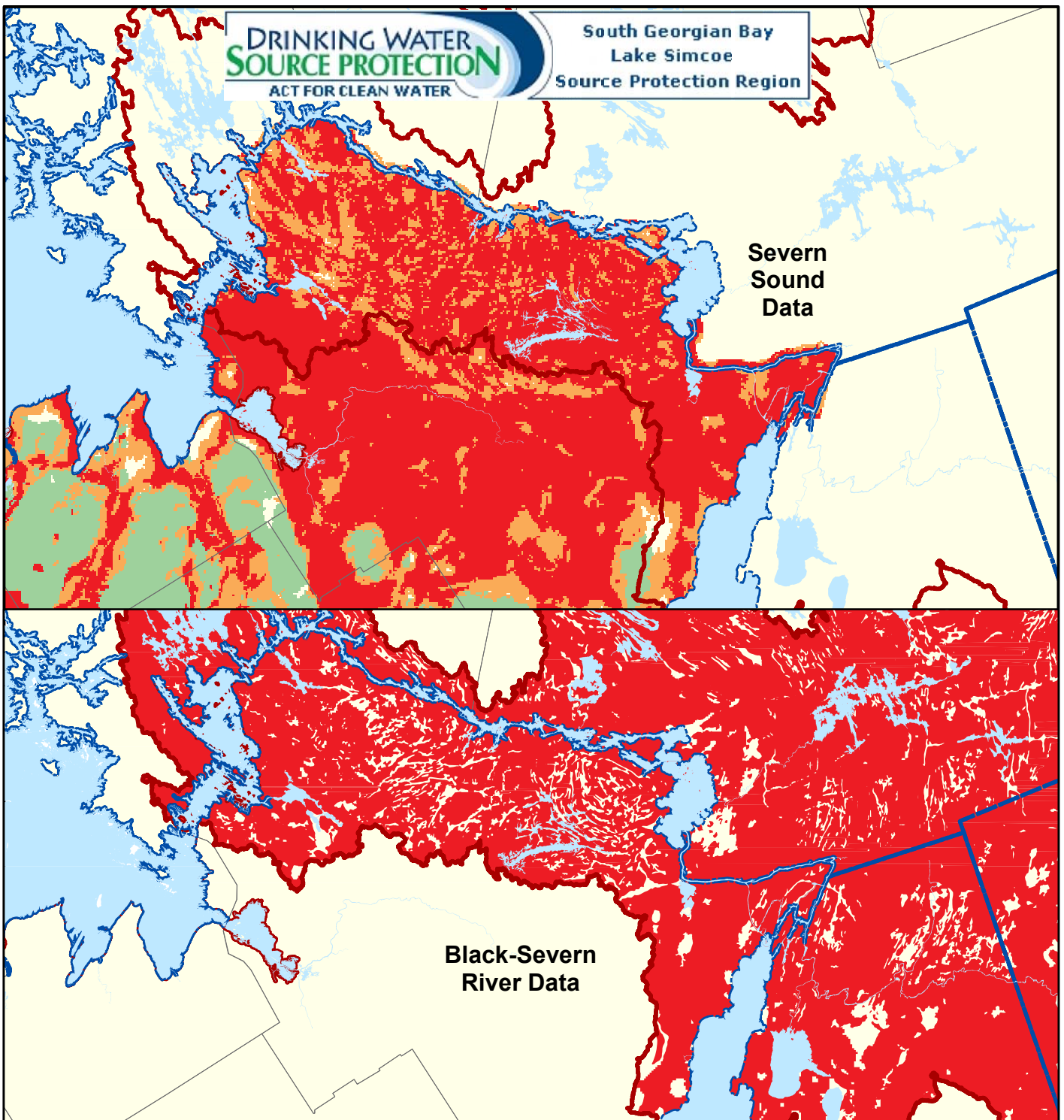
GENIVAR



Ontario

FIGURE

4.2-3



Legend

- High Vulnerability
- Medium Vulnerability
- Low Vulnerability



EDGE MATCHING BETWEEN SEVERN SOUND SPA AND BLACK-SEVERN RIVER WATERSHED

DELINEATION OF HIGHLY VULNERABLE AQUIFER (HVA) - South Georgian Bay Lake Simcoe Source Protection Region

DATE: JULY 2010

SCALE: 1:300,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4-2

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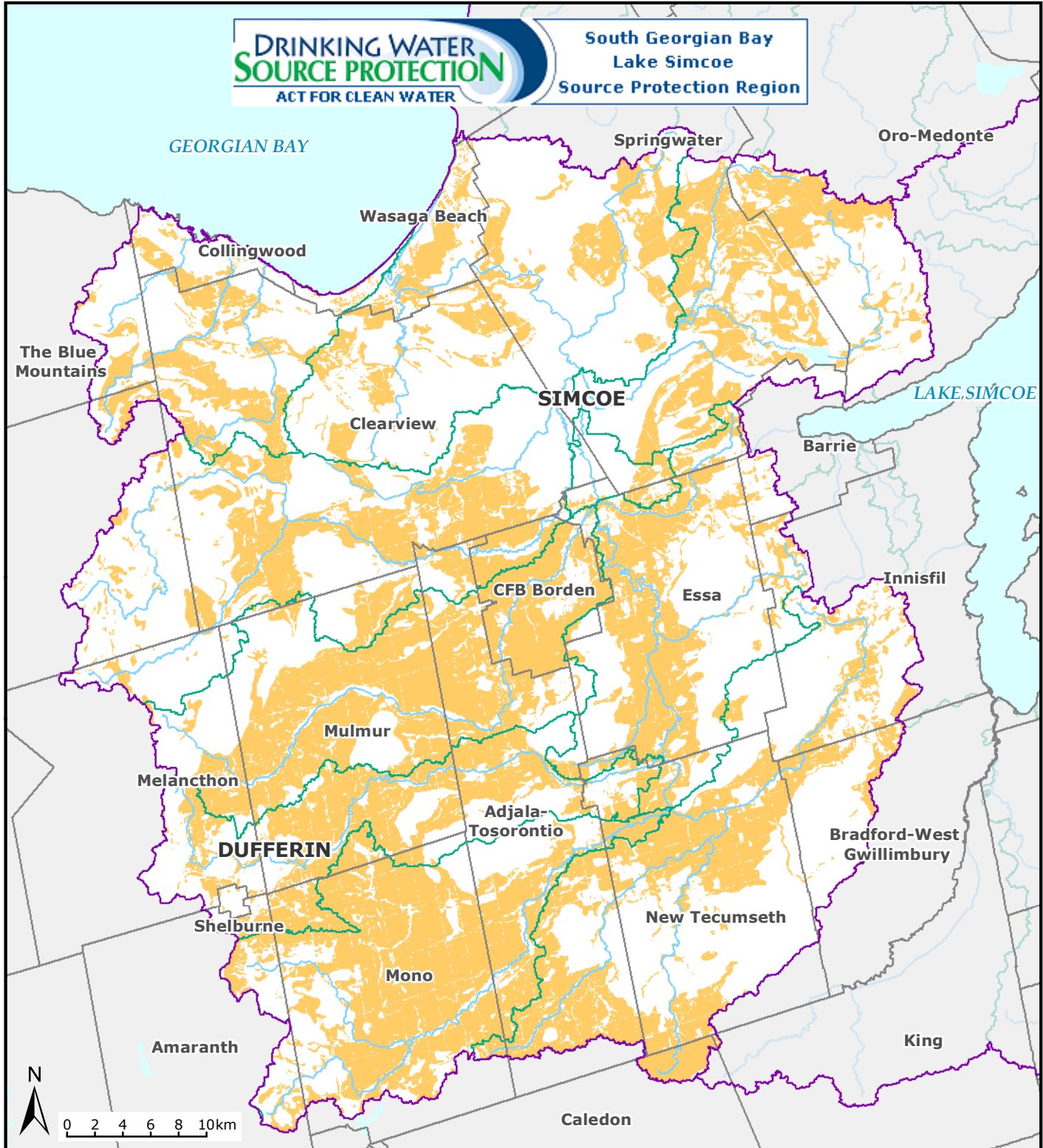
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Ontario

FIGURE

4.2-4



-  Significant Groundwater Recharge Area
-  SWP Watershed Area
-  Subwatershed Boundary
-  Municipality Boundary
-  Water Body
-  Main Water Course

Significant Groundwater Recharge Area (SGRA)

Created by: LSRCA
Date: 2010-08-25

Scale: 1:400,000
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.



Figure 4.3-1

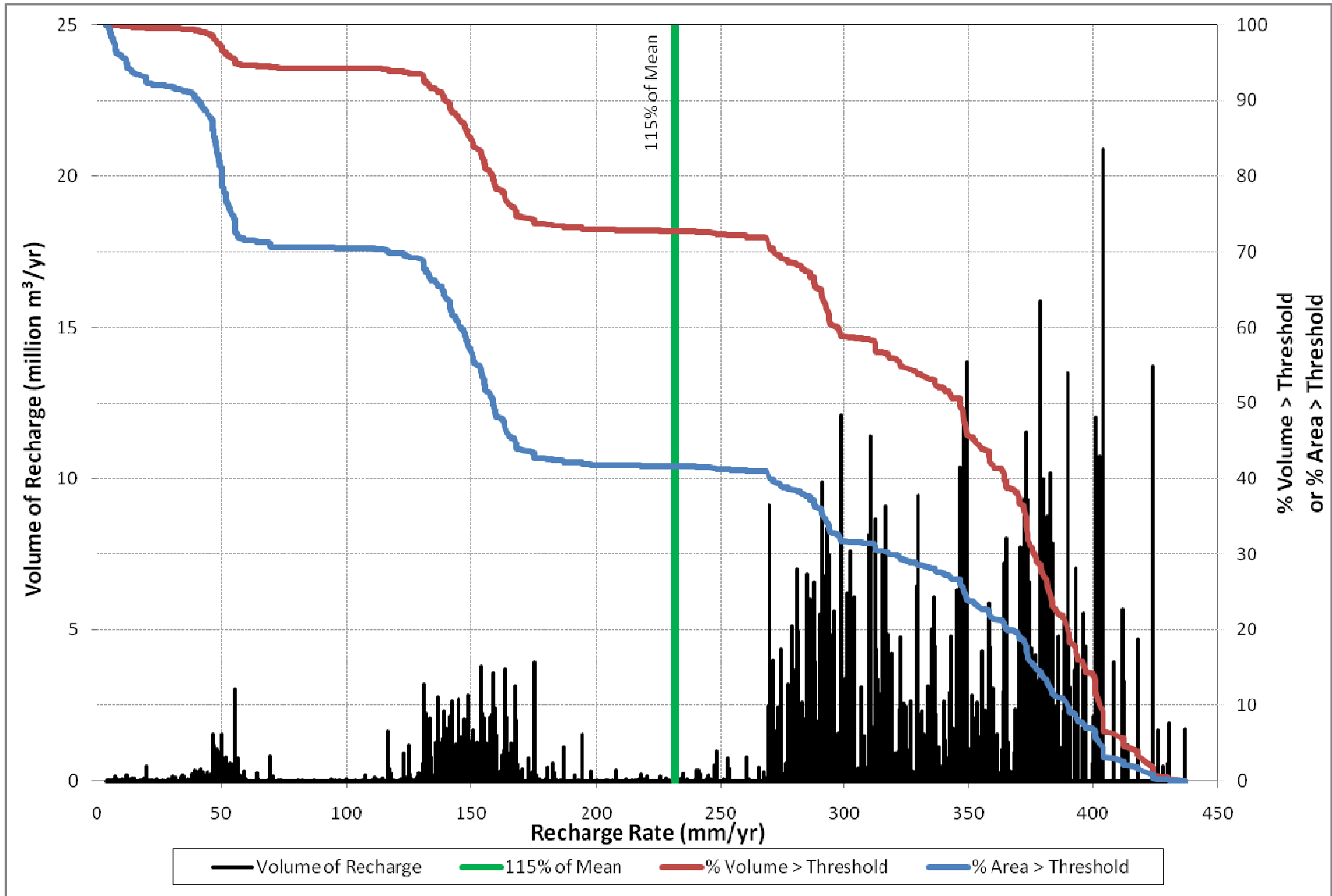
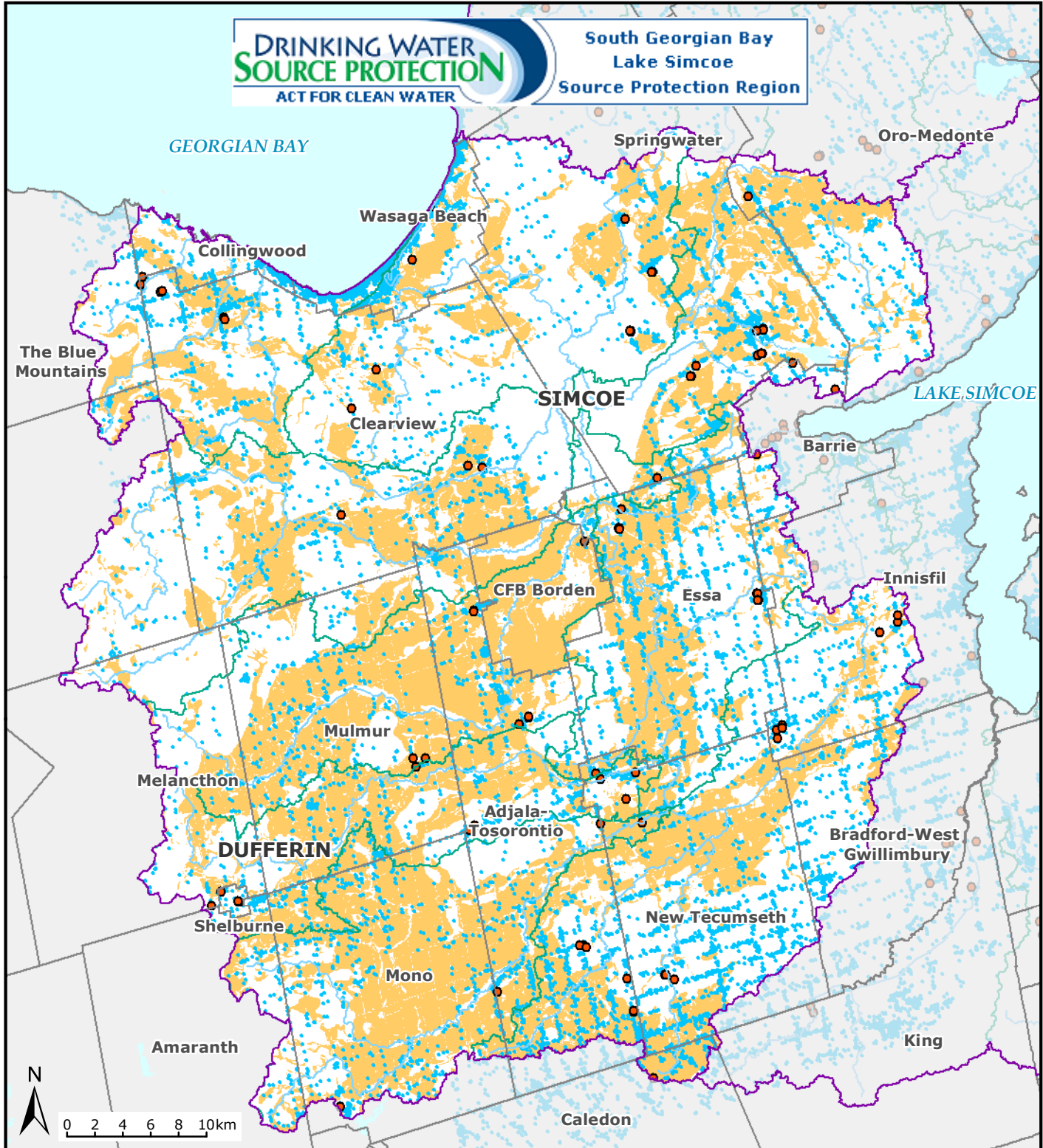


Figure 4.3-2: HSP-F Recharge DDistribution for NNottawasaga and Severn Sound Watersheds (AquaResource and Golder, 2010).



- Municipal Supply Wells
- Other Wells
- Significant Groundwater Recharge Area
- SWP Watershed Area
- Subwatershed Boundary
- Municipality Boundary
- Water Body
- Main Water Course

Significant Groundwater Recharge Area With Water Wells

Created by: LSRCA
Date: 2010-08-25

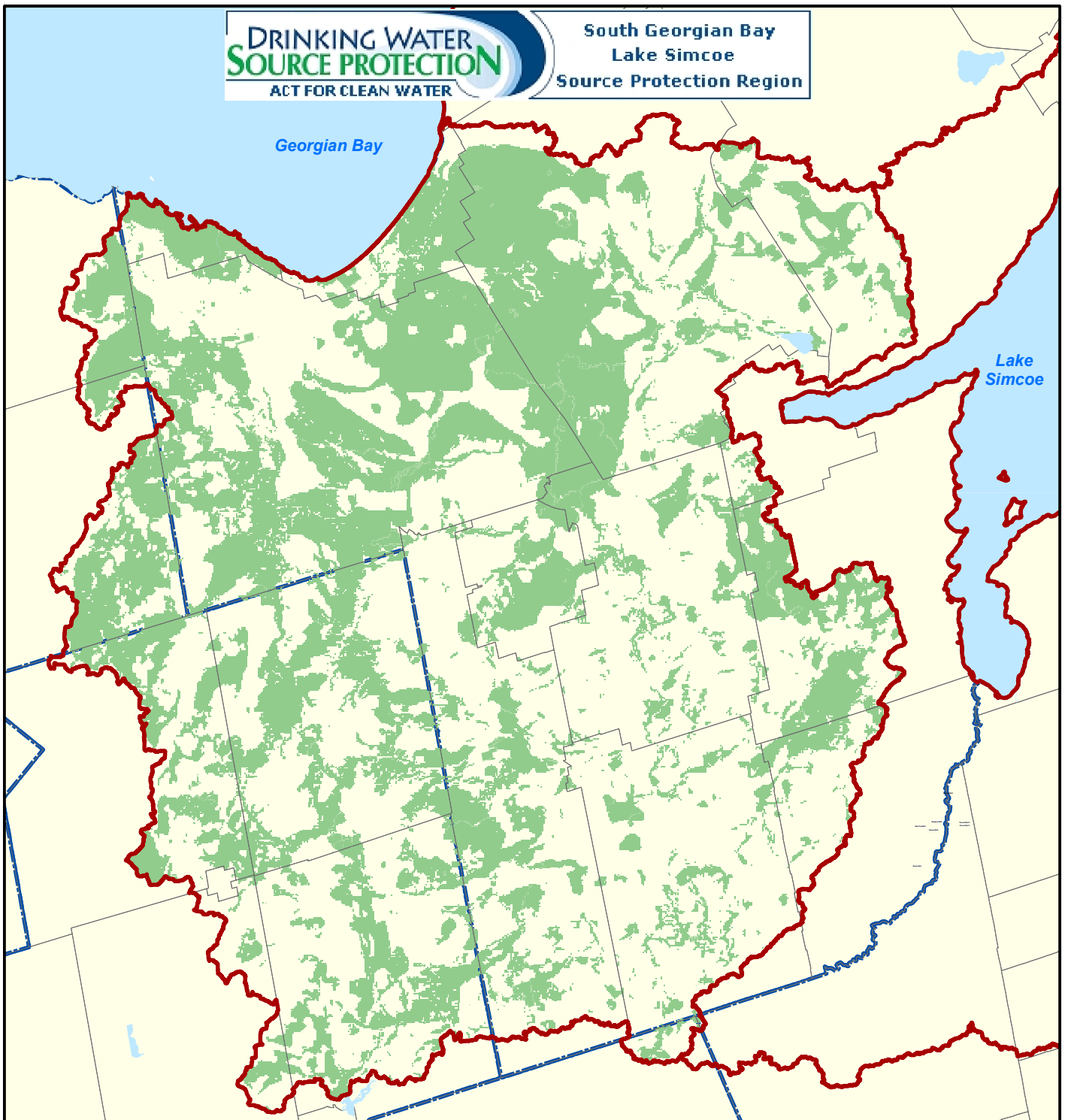
Scale: 1:400,000
UTM Zone 17N, NAD83



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Figure 4.3-3



Legend

- MANAGED LANDS (<40%)
- MANAGED LANDS (40-80%)
- MANAGED LANDS (>80%)



5 2.5 0 5 Kilometres

**HVA AND MANAGED LANDS -
NOTTAWASAGA VALLEY SPA**

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:410,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4.4-1

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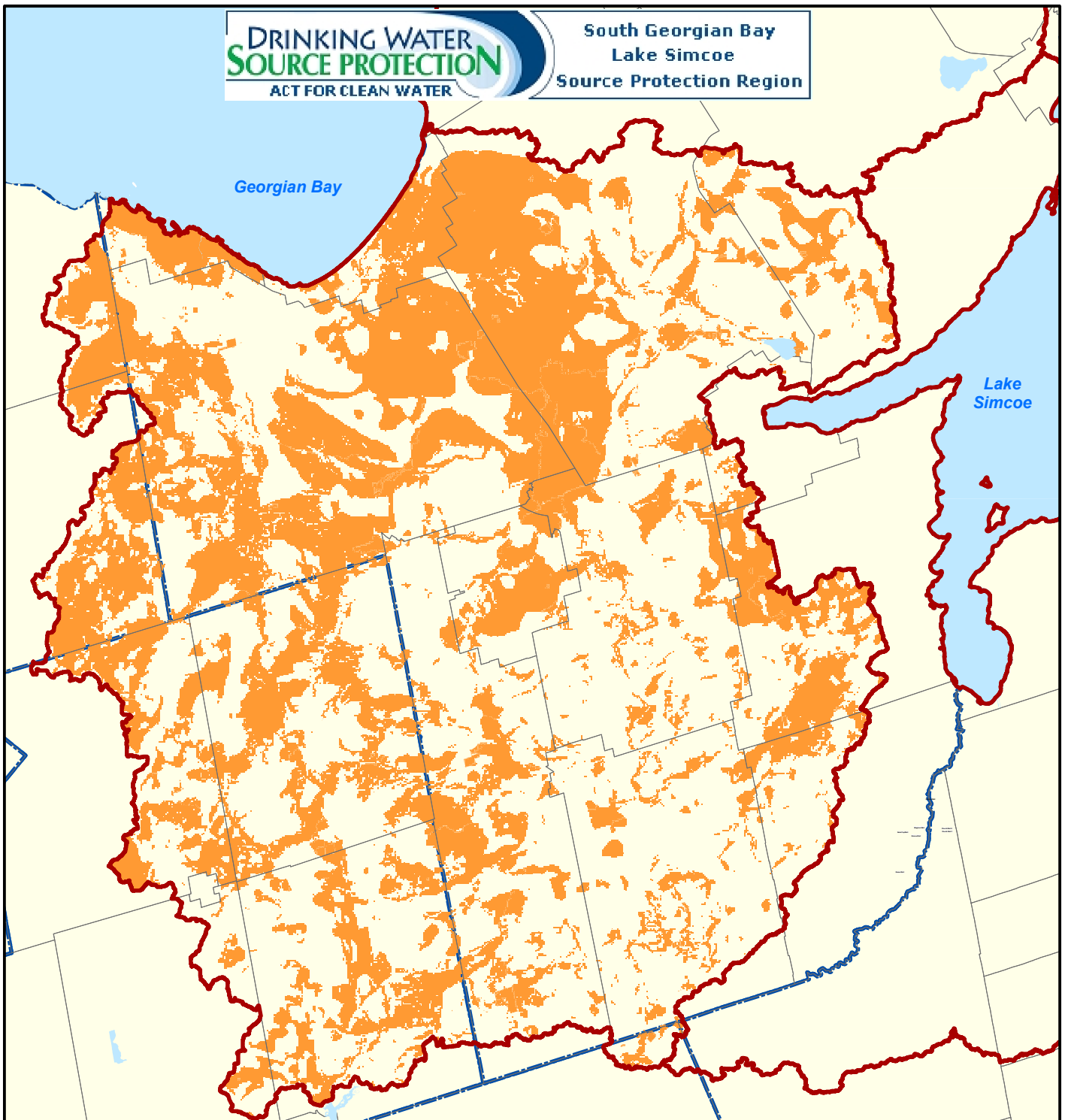
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Ontario

FIGURE

4.4-1



Legend

-  LIVESTOCK DENSITY (<0.5 NUTRIENT UNITS/ACRE)
-  LIVESTOCK DENSITY (0.5-1.0 NUTRIENT UNITS/ACRE)
-  LIVESTOCK DENSITY (>1.0 NUTRIENT UNITS/ACRE)



**HVA AND LIVESTOCK DENSITY -
NOTTAWASAGA VALLEY SPA**

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:410,000

PROJECT: 0-071948.14

FILE. NO.: 0-071948.14F4.4-3

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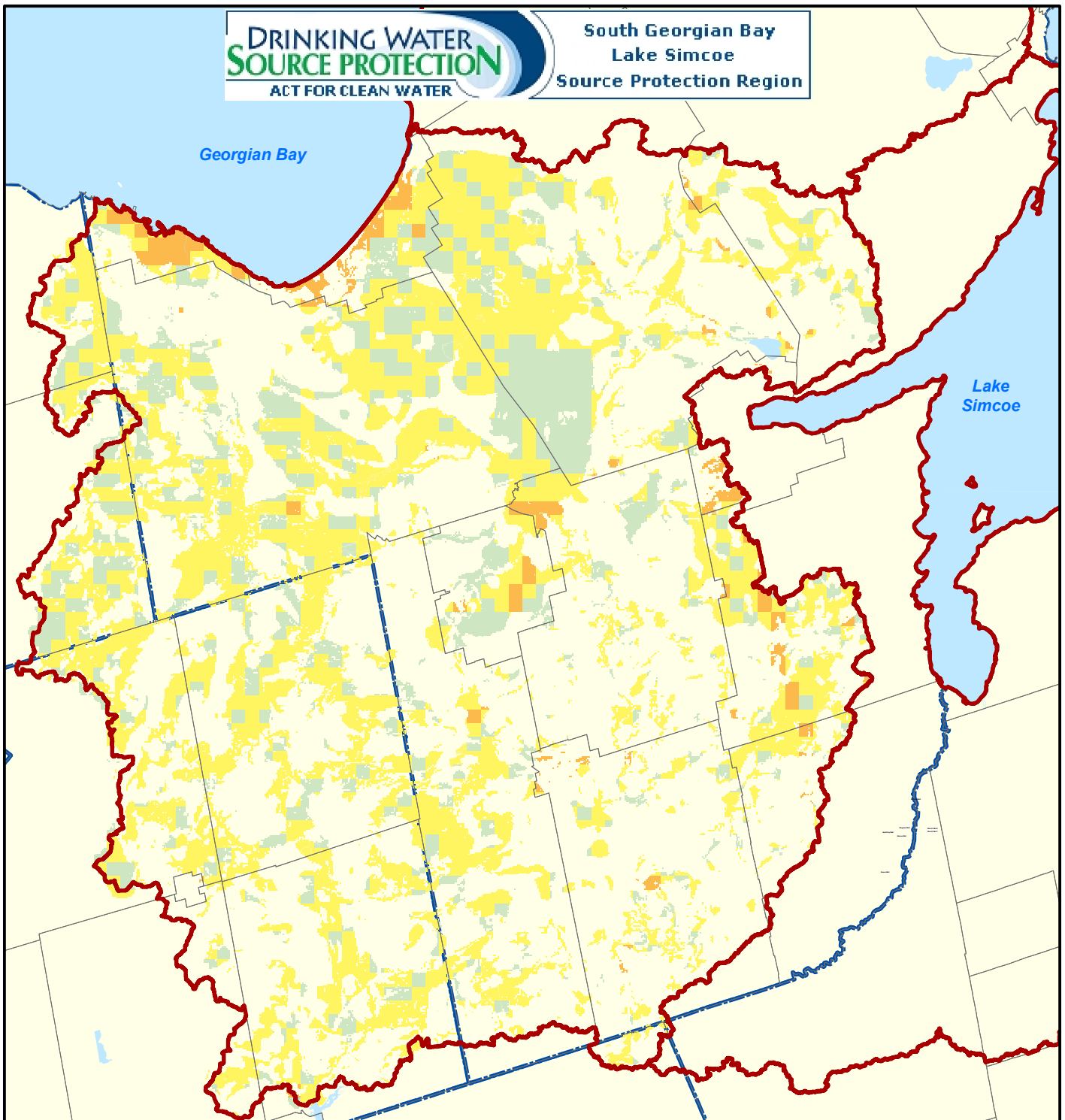
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Ontario

FIGURE

4.4-3



Legend

IMPERVIOUS SURFACE

- <1%
- >1% and <8%
- >8% and <80%



5 2.5 0 5 Kilometres

**HVA AND IMPERVIOUS SURFACES -
NOTTAWASAGA VALLEY SPA**

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:410,000

PROJECT: 0-071948.14

FILE. NO.: 0-071948.14F4.4-5

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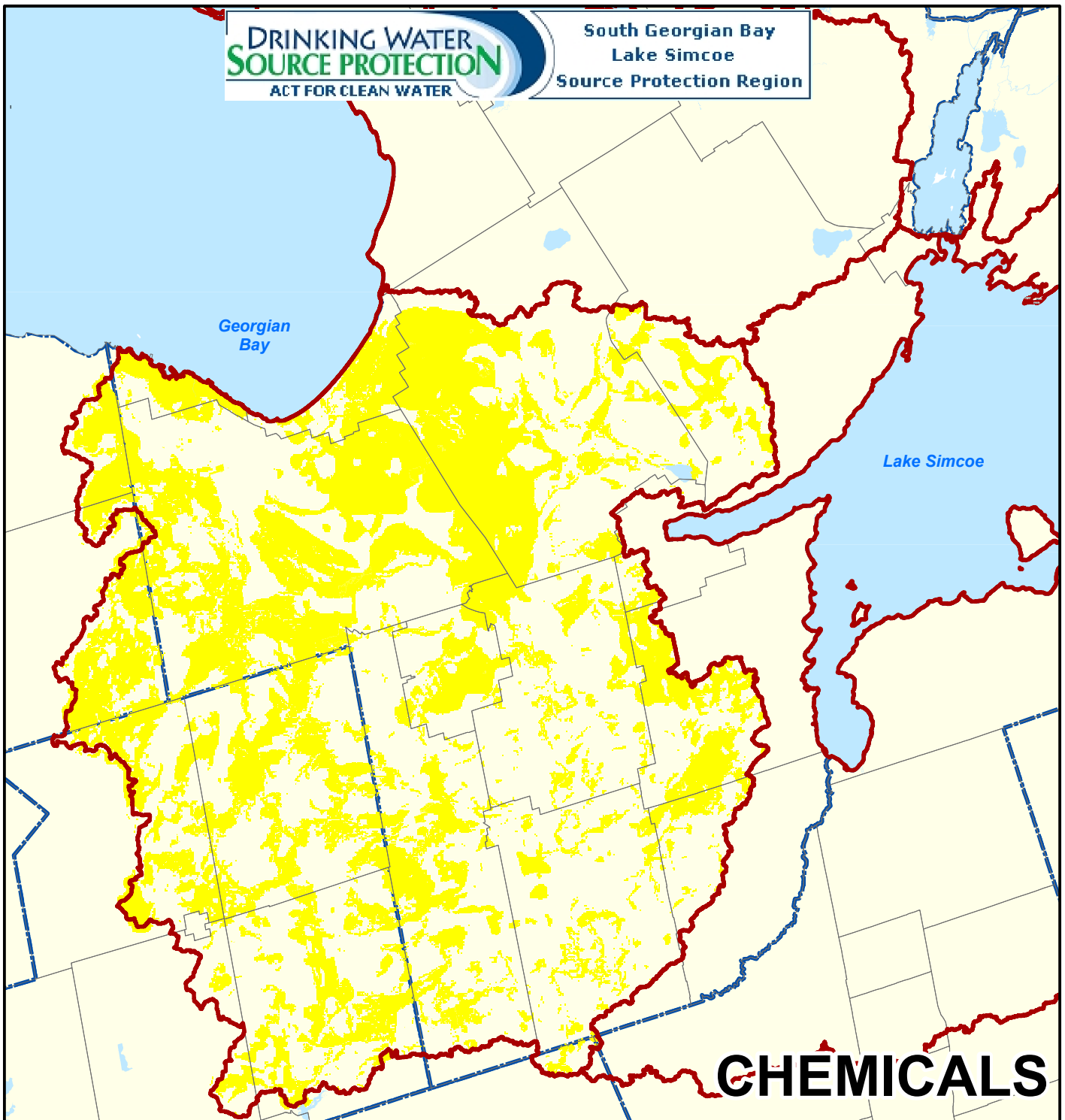
GENIVAR




Ontario

FIGURE

4.4-5



Legend

 High Vulnerability (Vulnerability Score = 6)



5 2.5 0 5 Kilometres

This figure is to be used to identify the areas where a landuse activity is or would be a drinking water threat based on the Technical Rules. The key table is intended to correlate the vulnerability score with circumstances that are significant, moderate, or low threats in the Table of Drinking Water Threats. The table shows the number of circumstances and references the table designation in the Provincial Tables of Circumstances for each threat category.

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region 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.

**HVA AND CHEMICAL THREATS -
NOTTAWASAGA VALLEY SPA**

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:490,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4.4-7



GENIVAR



Ontario

FIGURE

4.4-4