Chapter 6: The Town of Shelburne

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6.1 Introduction

This chapter contains information on one drinking water system for the Town of Shelburne. Various consultants have completed the work presented, all of which was reviewed by South Georgian Bay-Lake Simcoe Source Water Protection (SGBLS) staff and members of the Technical Work Group.

Each municipal system section 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 or Intake Protection Zone), and the assignment of a 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 (MECP, 2021~~OE, 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 the responsible consultant reports and memos (found in Appendix MO and SB) for a more in-depth description of the methods used, as well as the Glossary for any unfamiliar terms.

6.2 Drinking Water Systems

The Town of Shelburne operates ~~groundwater-based~~groundwater-based water supplies in one community and does not have any surface ~~water-based~~water-based supplies. As shown in **Error! Reference source not found.**~~Table 6-1~~ and **Error! Reference source not found.**~~Figure 6-1~~ the groundwater supply is predominantly within the ~~South Georgian Bay-Lake Simcoe (SGBLS)~~

Source Protection Region (SPR), however ~~one~~ two of the wells is located in the Lake Erie Source Protection Region.

Municipal Groundwater Supply in the Town of Shelburne within the SGBLS SPR and Nottawasaga Valley Source Protection Authority, included in this report:

- Shelburne Community Water Supply

Municipal Groundwater Supplies in the Town of Shelburne within the Lake Erie SPR and Grand River SPA, but not included in this report:

- Shelburne Community Water Supply

Sections of the Shelburne WHPAs cross over both the Town of Shelburne boundaries and the SGBLS SPR border into the Townships of Melancthon and Amaranth and into the Lake Erie Source Protection Region. One of the wellheads serving Shelburne is located outside of Town limits in the Township of Melancthon.

Table 6-1: WHPAs that cross into and out of the Town of Shelburne in the SGBLS SPR

Local Municipality that WHPA extends into	Municipality where wellhead is located	Name of Water Supply	Source Protection Region & Source Protection Authority (SPA)	Location where entire Assessment can be obtained
Township of Melancthon	Town of Shelburne	Shelburne	SGBLS SPR/ Lake Simcoe Region CA & Lake Erie SPR/ Grand River CA	This Chapter
Township of Amaranth	Town of Shelburne	Shelburne	SGBLS SPR/ Lake Simcoe Region CA & Lake Erie SPR/ Grand River CA	This Chapter
Township of Melancthon	Melancthon	Shelburne	SGBLS SPR/ Lake Simcoe Region CA & Lake Erie SPR/ Grand River CA	This Chapter

6.3 Shelburne Well Supply

The Town of Shelburne is situated at the headwaters of the Boyne River in the centre of Dufferin County. It is approximately 70 km northwest of Toronto and 25 km northwest of Orangeville. The Municipal boundaries for the Town bracket an area of approximately 10 km^2.

The Shelburne Water Supply System is owned by the Town of Shelburne and operated by the Ontario Clean Water Agency (OCWA). The water system services ~~a population of approximately~~ the Town's population of approximately 8,126 residents~~5,000 people~~. The water system consists of six groundwater supply wells. ~~.~~ Four of the wells (PW1, PW3, PW5, and PW6) are located within the Nottawasaga Valley Source Protection Area of the SGBLS~~South Georgian Bay Lake Simcoe~~ Source Protection Region. The ~~fifth~~ other two ~~and sixth~~ wells (referred to as PW7 and PW8) ~~were installed in 2010 and 2014 respectively. PW7 and PW8~~ are found within the Grand River Source Protection Area, which is part of the Lake Erie Source Protection Region. It is noted that ~~A sixth well, previously referred to as~~ PW2~~,~~ was decommissioned in 2010 and has been removed from the Assessment Report as per the requirements of O.Reg. 287/07. ~~.~~

Well PW1 and the decommissioned PW2 correspond to ~~The Shelburne East Side well field consists of a single well (Well PW1) located on Dufferin Street, approximately 300 m south of Highway 89. Prior to 2010, a second well (PW2) was also located within this well field, however as mentioned above, this well has since been decommissioned and no longer forms part of the Shelburne well supply. The Town has completed all of the necessary steps (as prescribed by Ontario Regulation 287/07) to remove the decommissioned well from the Assessment Report, and exempt the well from Clean Water Act requirements. Both Well PW 1 and the now decommissioned well PW 2 were~~ the original two wells drilled for the Shelburne Municipal Supply System in the 1950s. ~~The currently active,~~ PW1 is a 300 mm diameter well, 23.5 m deep and is located on the southeast corner of Dufferin Street and Andrew Street in the pump house. The well obtains water from the upper 5 m of the bedrock aquifer which is in contact with a layer of granular material at the bottom of the overburden. ~~PW1 is permitted to pump at a maximum rate of 19 litres per second (L/s) under Permit To Take Water ## 1814-7QVK7S).~~ PW1 has been recognized as a well having groundwater under the direct influence of surface water (GUDI).

~~The West Side well field in Shelburne includes PW3, PW5, and PW6.~~ Well PW3 is located in the west half of Lot 2, Concession 3 ~~(former Township of Melancthon)~~ in a pump house on Cedar Street and~~. PW3~~ was constructed in 1977. The well has a 300 mm diameter casing and is 19.2 m deep. PW3 is equipped to pump 15.2 L/s ~~(200 lgpm)~~ and has a static water level that is approximately 2 to 3 m above grade. Although the majority of the water in PW3 is obtained from the bedrock/overburden contact aquifer, some water is obtained from deeper fractures in

the bedrock. PW3 has been recognized as a well having groundwater under the direct influence of surface water (GUDI). PW5 is located approximately 38 m east of the 4th Line Melancthon in the pump house. The well has a 300 mm diameter casing and is 23.5 m deep. PW6 was constructed in 1989 and is a 150 mm diameter well, 24.4 m deep. The well is located approximately 4 m west of PW5. ~~PW5 and PW6 are permitted to pump a maximum of 22.7 L/s combined (300 lgpm) (PTTW# 1814-7QVK7S).~~

~~In 2010 the Town of Shelburne installed pumping Well 7 (PW 7) to address a projected increase in system demand, and secure a new municipal water supply that would address the issue of naturally occurring arsenic found in the remainder of the Town's wells. This new well (~~PW 7 and PW8 are~~) is~~ located approximately 3 km west of the Town of Shelburne on 2nd Line southwest and is located Melancthon Township in the Lake Erie Source Protection Region, just outside of the South Georgian Bay Lake Simcoe Region border. ~~The~~ PW7~~well~~ was drilled to a depth of 86.6 meters below ground surface (mbgs) and is 305 mm in diameter with a steel casing that extends down to a depth of 47.2 mbgs, followed by 39.4 m of open hole to target the deeper aquifer unit. ~~In contrast to the other four wells which are constructed in the shallow bedrock contact aquifer, Well 7 extends to the deeper aquifer unit. This deeper Gasport aquifer unit is considered to be regionally extensive and confined by a series of overlying bedrock aquitards. This aquifer is also considered to have a more desirable water chemistry, particularly with regards to the levels of naturally occurring arsenic. Testing at the well has indicated that the well is capable of providing a sustained flow of approximately 18.9 L/s. This rate has been assumed as the future permitted rate for PW7 when it is brought online.~~

~~The Town of Shelburne installed an alternate backup pumping Well 8 (PW 8) adjacent to PW 7, approximately 10 m apart. The current PTTW allows for one or the other well to be pumped at a maximum rate of 18.9 L/s, or pumped simultaneously to a maximum of 18.9 L/s.~~ Well 8 was drilled to a depth of 86.56 mbgs and is 305 mm in diameter with a steel casing that extends down to a depth of 47.6 mbgs, followed by 39.01 m of open hole to target the deeper aquifer unit. In contrast to the other four wells which are constructed in the shallow bedrock contact aquifer, wells~~Well~~ 7 and 8 extends to the deeper aquifer unit. ~~Well 7 and 8 both~~and pump from the lower Goat Island and Gasport Formations~~, and are in close enough proximity that the WHPA-A delineation for both wells may be considered identical~~. This deeper Gasport aquifer unit is considered to be regionally extensive and confined by a series of overlying bedrock aquitards. This aquifer is also considered to have a more desirable water chemistry, particularly with regards to the levels of naturally occurring arsenic. Both wells have been put into service early in 2016.

The Town of Shelburne currently obtains its water supply from productions wells that operate under a combined Permit to Take Water (PTTW) #1814-7QVK7S at the following rates:

- PW1 is permitted to pump at a maximum rate of 19 litres per second (L/s) or 1,642 cubic metres per day (m^3/d).
- PW3 is permitted to pump at a rate of 15.2 L/s or 1,309 m^3/d.
- PW5 and PW6 are permitted to pump a maximum of 22.7 L/s combined.
- PW7 is permitted at a maximum rate of 19 L/s or 1,634 m3/d.
- PW8 is permitted at a maximum rate of 19 L/s or 1,634 m3/d.

~~Well records for the municipal wells are included in Burnside, 2010a and Earthfx, 2015. In 2009, the municipal supply wells were combined into one permit to take water PTTW# 1814-7QVK7S)~~
The bedrock topography is particularly significant in Shelburne where the bedrock/overburden contact aquifer provides the vast majority of water to the Town's municipal wells. As mentioned above, only Well 7 and 8 have been installed in the deeper Gasport aquifer unit. The Niagara Escarpment, located 4 km east of Shelburne, forms the eastern boundary of the fractured bedrock/overburden contact aquifer. Well PW1 is located in an area of lower bedrock elevation while wells PW3, PW5, PW6, PW7 and PW8 are located on a bedrock high on the west and north side of the town. The bedrock low in the area of Well PW1 may be an infilled valley that curves to the east and then to the north on the south side of Shelburne.

~~The water table elevation ranges from greater than 500 meters above sea level (masl) in the northwest corner of the study area to less than 460 masl in the Boyne River Valley in the northeast portion of the study area. In general, the groundwater flows from southwest to northeast towards the Boyne River.~~

Information presented ~~for the Shelburne section of~~in this Chapter is based on reports completed by the Burnside, 2010a, and Earthfx, 2015, 2022. In 2010, Burnside ~~was retained by the South Georgian Bay Lake Simcoe SPR to~~ conducted the vulnerability assessment and threats evaluation for the Town's existing well supplies. Following the installation of well 7~~,~~ and decommissioning of PW2~~well 2~~, a review of the existing WHPA delineation and vulnerability assessment was completed by Earthfx (2015) ~~required. An update to the WHPAs and vulnerability scores was required~~ to address the effects of the addition/decommissioning of Town wells on groundwater flow patterns in the area. ~~In 2015, Earthfx was retained by the Lake Erie and South Georgian Bay Lake Simcoe SPRs to conduct a vulnerability assessment of the new well and complete an update to the vulnerability analysis for the existing Town wells.~~ The 2022 Earthfx study provided an update and evaluation of the wellhead protection areas

(WHPA) incorporating PW8, assignment of vulnerability scores, and conduct a threats assessment for the Town including the delineation of the WHPA-E for PW3.

6.3.1 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 Shelburne 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 within the WHPA was assessed and consideration was included to consider the effects of man-made structures that may increase the Vulnerability. The WHPA and the Vulnerability were considered together as per the Technical Rules to determine a Vulnerability Score for the Shelburne Water Supply. Details of the methods for the original vulnerability analysis are provided in Burnside, 2010a, while the methodology for the revised vulnerability assessment is provided in Earthfx, 2022~~15~~.

6.3.1.1 Wellhead Protection Area (WHPA) Delineation

The ~~Wellhead Protection Areas (~~WHPAs~~)~~ for Shelburne wells excluding wells PW7 and 8 ~~PW1, PW2, PW3, PW5, and PW6~~were initially delineated by Burnside, 2010a using a model developed for the previous groundwater study for the Town of Orangeville and Surrounding Area (Waterloo Hydrogeologic, 2001), which was also used in the Groundwater Management Study for the Town of Shelburne (Burnside, 2002). In 2015, the Wellhead Protection Area modelling for the Town was updated to include ~~newly installed~~ well 7~~,~~ and omit decommissioned Well 2. As part of the update, Earthfx 2015 completed a significant revision to the geologic and hydrogeologic conceptualizations for the Shelburne area. Where the previous conceptual understanding combined a number of geologic formations into a single unit, the revised conceptual model represents these individual formations as separate layers. More

specifically, the Guelph, Eramosa, Goat Island, and Gasport Formations -which were previously combined into a single Guelph- Amabel dolostone unit, are now represented as separate units in the conceptual model~~. This is significant to the results of the study, as the conceptual model layers are~~ which were translated into numerical model layers when simulating groundwater flow. Further, the 2022 Earthfx study provided an update and evaluation of the WHPA including the delineation of the WHPA-E for PW3.

~~As mentioned above, to address the effects of the newly added and decommissioned wells on groundwater flow,~~ An update to the WHPA capture zone delineations was ~~required~~completed by Earthfx (2022) ~~. WHPA capture zones are delineated~~ using groundwater flow models. Both the original and updated groundwater flow models were developed using the USGS MODFLOW package. For the updated study, completed by Earthfx 2015, a newer version of the MODFLOW code (MODFLOW-NWT) was used. Visual MODFLOW, which is a pre and post processor for standard MODFLOW applications, also includes the 3d particle tracking module MODPATH. ~~MODPATH is a three-dimensional particle tracking package.~~ For the study completed by Earthfx, 2015, a newer version of the particle tracking package called MODPATH v.6.0 (Pollack, 2012) was used. The WHPAs for the Shelburne Wells are shown in

Figure 6a- 1: Wellhead Protection Areas – Town of Shelburne

~~Figure 6a-1~~.

With the completion and calibration of the groundwater model, the delineation of time-of-travel capture zones was undertaken using the MODPATH v.6.0 module ~~of the Visual MODFLOW package~~. Capture zones were delineated based on reverse particle tracking. Where two capture zones were directly adjacent to each other, professional judgment was used to determine the extent of each capture zone. The following characterizes the WHPAs:

- ~~The WHPA for PW1 is illustrated in Figure 6a- 1.~~ PW1: The WHPA is 576 ha in size and is elongated to the south-west The WHPA for PW1 is illustrated in Figure 6a- 1.
- PW3: The WHPA is 317 ha. It thinly extends north-west.

PW5/PW6: The WHPA coves 703 ha and fan out west towards PW7/8.

- PW7/8: The WHPA is 996 ha. The WHPA A-C are circular around well and the WHPA-D extends north-west.

~~From the model output, it can be seen that the zones of the WHPA extend outward from the well in a south-westerly direction. The WHPA is elongate and oval like in appearance. WHPA-B~~

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~~makes up the largest proportion of the WHPA, followed by WHPA-C, and WHPA-D, respectively. The total area of the WHPA for PW1 is approximately 206 ha.~~

~~The WHPA delineated for PW3 merges with the WHPA delineated for PW5 and PW6 to form one large combined wellhead protection area. The merged WHPA fans outward in a westerly to south westerly direction. The WHPA for wells PW5 and PW6 was delineated as a single unit based on the mode of operation of these wells. The WHPA-B, delineated around well 3, merges with the WHPA-B zone delineated for wells 5 and 6 to form the largest proportion of the combined WHPA for Wells 3,5, and 6. Outside of the WHPA-B, the WHPA-C and WHPA-D zones for PW3 and PW5/6 also merge to form the remainder of the combined WHPA. The total area enclosed by the merged WHPA is 564 ha, with the WHPA- B making up the largest proportion of the vulnerable area, followed by the WHPA-C and finally the WHPA-D.~~

~~The WHPA around PW 7 is also presented in Figure 6a- 1. WHPAs zones A through C are developed as concentric circles around the well, while the WHPA-D zone veers off in a north-westerly direction. The total area covered by the WHPA is 535 ha, with the WHPA-D making up the largest proportion.~~ The 2022 Earthfx updated model resulted in a geometry and orientation that resembles a natural evolution of the model understanding and is consistent with the 2015 outlines; however, the following WHPA changes are noted:

Field Code Changed

- The expansions of the capture zones for Shelburne wells PW1 and PW3 reflect the higher pumping rates at those wells.
- The WHPA-D delineation for Shelburne wells PW7 and PW8 has extended in all directions due to the additional pumping from Shelburne PW8.
- The changes in the shape of the zones for Shelburne PW5 and PW6, which did not increase their pumping rate, indicate that they are influenced by both the higher rates at PW1 and PW3, as well as the doubling of the taking from the PW7 and PW8 pair.

Further details on groundwater model used for the delineation of the WHPAs can be found in Earthfx, 2015.

6.3.1.2 WHPA-E ~~/ WHPA-F~~

The Technical Rules require that all wells that are identified as evidence of having the hydraulic connection between the well and the surface water bodies near the well ~~Groundwater Under the Direct Influence of surface water (GUDI) as determined in accordance with Subsection 2(2) of O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002*~~ delineate an additional vulnerable area that is representative of its surface water Vulnerability, known as WHPA-E.

Shelburne PW1 and Shelburne PW3 have been assessed as having the hydraulic connection between the well and the surface water bodies near the well, requiring the WHPA-E delineation.

Shelburne Well PW1 was initially identified as a GUDI well in a study by Burnside (2002) due to known interactions with the shallow groundwater system in the vicinity of the well. In 2000, total coliform and *E. coli* were detected in water samples from this well. Reconstruction of the well subsequent to this event has not been regarded as having enough of an impact to remove the GUDI designation as interaction with the shallow overburden sediments in the vicinity of the well is ongoing. A new WHPA-E delineation exercise was

completed by Earthfx, 2015 for PW1

During May 5, 2020 air lifting well rehabilitation exercise, bubbling and agitation was observed in the adjacent Walter's Creek bed, at which point air lifting was stopped (SBA, 2021). These observations suggested that PW3 could be flagged under the current guideline, SBA consulting (2021) recommended that municipal well PW3 be re-classified from a groundwater well to a GUDI well with adequate in-situ filtration. This assessment is supported by the historical water quality and no detected instances of E. coli or microbial infiltration. It is also supported from the water quality samples collected during the 72-hour pumping test, also showing no detectable infiltration of microbiology, Cryptosporidium oocysts or Giardia cysts.

In addition to the stream network, the potentially contributing stormwater management system was delineated by assessing the overland drainage areas to the identified infrastructure features using of the 10-m DEM. Stormwater infrastructure features were identified using the Google Streetview application and included features such as catch basins, swales, and curbs in the drainage areas. The surface water feature located next to Shelburne PW1 is the Besley Drain and is classified as a Strahler Class II stream. The stream adjacent to Shelburne PW3 is a classified as a Strahler I stream. Both are considered headwater streams. Transit time through each segment is calculated at bankfull conditions. Shelburne PW3 has been completed at 19 mbgs and is a shallower well than Shelburne PW1.

~~Shelburne Well PW1 was initially identified as a GUDI well in a study completed by Burnside in 2002. This well was classified as GUDI due to known interactions with the shallow groundwater system in the vicinity of the well. In 2000, total coliform and *E. coli* were detected in water samples from this well. Reconstruction of the well subsequent to this event has not been regarded as having enough of an impact to remove the GUDI designation as interaction with the shallow overburden sediments in the vicinity of the well is ongoing. In 2015, a new WHPA-E~~

~~delineation exercise was performed for GUDI PW 1, as part of the WHPA delineation update completed by Earthfx, 2015.~~

~~For the WHPA-E analysis, points of potential interaction between surface water and the groundwater source for PW1 were identified as surface water bodies that intersected the predicted one year time of travel between the water table and well. Two locations of interpreted surface water – groundwater interaction that have the potential to impact the raw water source for PW1 were identified. The first location of potential interaction was interpreted to be on the nearby Beasley Drain; a manmade open drainage ditch that collects water from lands southwest of PW1. The drain originates in a wetland feature to the southwest of the Town, and proceeds east toward PW1 across mainly agricultural properties before entering the Town near County Road 11. The portion of the Town's storm sewer system that empties into the Besley Drain upstream of the intake was also considered in the WHPA-E delineation analysis; a contributing storm sewershed of 36.6. ha was included in the WHPA-E delineation. As a result, the WHPA-E may extend beyond the regulation limit.~~

~~The second interpreted location of potential surface water – groundwater interaction was the nearby storm sewer retention ponds located approximately 80 m to the south west of well 1. The pond receives storm runoff from catchment basins located within the adjacent residential lands, and represents a storm sewershed of approximately 8.3 ha. The pond is approximately 0.2 ha and the design includes a vegetated forebay from which stormwater influent flows north toward the vegetated permanent pool. Water flows from the permanent pool to the pond's micropool before being discharged to the Besley Drain. The stormwater management infrastructure was used to delineate the contributing storm sewershed. A 120 m buffer was used to assign contributing areas to catchbasins which appeared to be fed by swales or grass channels.~~

A WHPA-E was delineated ~~for PW1~~ in accordance to Rule 65(1) of the Technical Rules (MECP, 2022~~2008a~~; ~~)~~ ~~(~~Figure 6a- 2). The ~~two hour~~two-hour time-of-travel in Beasly Drain for PW1 and the headwater stream adjacent to Shelburne PW3 under bankfull conditions was used to determine the upstream limit of the WHPA-E. As a first step, two typical ~~cross sectional~~cross-sectional profiles of the ~~Beasly Drain~~streams were developed using detailed elevation mapping, aerial photography, and engineering drawings provided by the Town. The two cross sectional profiles created represented the upper and lower reaches of the channel. Using the ~~cross sectional~~cross-sectional profiles, a potential range of channel velocities under bankfull conditions were estimated. Assuming the lowest estimated velocity, the time-of-travel through the entire drains were ~~was~~ calculated to be less than two hours. A travel time of less than 2 hours warranted the inclusion of the entire drainage systems upstream of PW1 and PW3 within

the WHPA-E. A 120 m buffer was assigned to each identified drainage feature. As per Technical Rule 65 (1a), upland Conservation Authority Regulated Areas were included where these features had the potential to contribute flow to Besley Drain, as such the regulation limit defines the lateral extent of the WHPA-E. The resulting WHPA-E for PW1 covers an area of 214 ha and 107 ha for PW3. ~~185.5 ha, extending from Simon Street and Main Street in the north, east to 4th Line, and Side Road 30 to the southwest. The northern limit of the WHPA-E corresponds to the south side of Main Street (Highway 89/Highway 10). The southern limit of the WHPA-E generally corresponds to Side Road 30, except near the southwestern corner of the area, where a portion of a farm field appears to drain across Side Road 30 into the marshlands at the top of the Beasley Drain~~. The methodology for the delineation of WHPA-E is provided in more detail in Earthfx, 2015 and 2022.

In the case of Shelburne PW3, the WHPA-E extends to the southwest intersecting pockets of sand surrounded by till. Around the well, including the urban area (and almost half of the WHPA-E) loose to compact material is found. The agricultural lands in the southwest overlay lower permeability materials. The WHPA-E delineation extends to the west and the topographic divide that separates the Grand River from the Nottawasaga River Valley watersheds.

~~The Technical Rules require that a WHPA-F is delineated when a WHPA-E has been delineated and a Drinking Water Issue is identified that originates outside of the areas WHPA-A through WHPA-E. At Shelburne PW1 there were no Issues identified and the delineation of WHPA-F for this source was not required.~~

6.3.1.3 Groundwater Vulnerability

The Groundwater Vulnerability within the WHPAs of the Shelburne municipal wells are shown in Figure 6a- 3.

The Groundwater Vulnerability was calculated using the surface to well advective time method (SWAT). When employing the SWAT methodology, the classification of low, medium, and high groundwater vulnerability zones is based on actual travel times from the surface to the well. Areas of high vulnerability are those areas with travel times to a well of less than 5 years, while areas of medium vulnerability have a travel time greater than or equal to 5 years but less than or equal to 25 years. Areas of low vulnerability are those where travel times greater than 25 years. The determination of surface to well advective travel times consists of two components: the vertical travel time through the unsaturated zone above the water table (UZAT), and the travel time from the water table to the well through the saturated zone (WWAT). The determination of the time of travel through the unsaturated zone is highly complex as it

requires the use of a variety of data, such as the unsaturated soil properties in the study area. Data on unsaturated soil properties were non-existent for the area and due to the uncertainties related to the estimation of unsaturated travel times, the unsaturated zone travel times were not factored into the calculation of SWAT values. Instead, SWAT calculations conservatively assumed rapid flow through the unsaturated zone, causing the travel times to slightly increase the size of the high and medium aquifer vulnerability zones.

The second component of the SWAT calculation, as mentioned above, is the determination of water table to well advective times (WWAT). Water table to well advective times were determined by releasing virtual particles from model cells in the uppermost active groundwater model layer (the layer containing the water table) within a larger area surrounding the 25 year time of travel (TOT) capture zones. Using MODPATH the particles were then forward tracked from the water table, to the municipal well or to another discharge point such as a nearby stream. The times-of-travel for particles ending up in the municipal wells were assigned back to the originating model cell. The final value for the water table to well advective time in years was based on the results of the forward tracking analysis.

More details on the SWAT approach and its limitations are available in Earthfx, 2015 and 2022.

~~The Groundwater Vulnerability is shown in Figure 6a- 3. Within the Town of Shelburne's boundaries the aquifers are classed dominantly as Medium Vulnerability with several windows of High Vulnerability. The most extensive area of high vulnerability is located towards the western edge of town in the vicinity of the WHPA-A and WHPA-B zones for PW3. Other areas of high vulnerability are located within the WHPA-A zone of PW 5/6, on the southern WHPA boundary for PW5/6.There is also a significant area of High Vulnerability located on the eastern side of the Town within the WHPA-A and B for PW1. An area of Low Vulnerability can be found on the southern tip of the WHPA-D zone for PW1, and in the northern part of WHPA-D for PW7. There is also a small area of Low Vulnerability on the western edge of the WHPA delineated for PW 5/6. Areas of High Vulnerability may be associated with the occurrence of sandy deposits in the vicinity of some of the drainage channels or with the occurrence of this overburden layer in the general vicinity of the municipality.~~ Within the Town of Shelburne's municipal boundaries the aquifers are classed dominantly as Medium Vulnerability with several windows of High Vulnerability; however, the groundwater vulnerability in the total area of the WHPAs is considered as Low vulnerability.

6.3.1.4 Transport Pathway Increase

The Technical Rules allows for an increase in vulnerability rating of an aquifer due to the presence of transport pathways that may increase the vulnerability of the aquifer by providing

a conduit for contaminants to bypass the natural protection of the aquifer. 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.

Transport pathways are developed where man-made (anthropogenic) features in the aquifer provide a path along which contaminants can migrate to the regional aquifer. ~~The following features were considered as transport pathways within the context of the Earthfx, 2015 study. It should be noted that in the analysis of SWAT times, unsaturated zone travel times (UZAT) were already set equal to zero, therefore constructed pathways that could possibly reduce unsaturated zone travel times, such as pipeline bedding and excavations, above the water table would not have resulted in an increase of the vulnerability scores already assigned. The focus instead was on identifying constructed pathways that could reduce travel times in the saturated zone.~~ The following features were considered those that could reduce travel times in the saturated zone according to the Earthfx, ~~2015~~ 2022 study~~study~~:

Domestic Water Wells

Domestic water wells are the most common man-made preferential pathway in rural areas. Improperly constructed wells can potentially introduce a cumulative impact to drinking water sources, particularly when the casing deteriorates. Similarly, if the well is no longer in use, improper abandonment also provides a preferential pathway for a contaminant to impact a drinking water source.

A review of water well records from the MOE water well database was conducted to identify wells within the WHPAs. The wells were then ranked based on their risk to the supply aquifer. This process is described by ~~in detail in~~ Earthfx, 20~~22~~15. A total of 157 private wells were identified within the delineated WHPA-A through WHPA-D areas for the Shelburne supply wells~~The survey resulted in the identification of 91 water wells within the WHPAs.~~ A total of 28 high risk wells were identified which likely do not meet the current ~~MOE~~ MECP well standards and may be in connection with the aquifer used for municipal water supply. ~~and classified 20 of the wells as high risk.~~

~~Water wells are the main Transport Pathway of concern because they present a risk to the municipal supply as they may create a conduit for contaminants to enter the aquifer. To account for the potential risk for contaminants to enter the aquifer by high risk wells, the Vulnerability around each well for a 30 m radius was increased directly to the high vulnerability category. A 30 m radius has been chosen based on the recommended setback distance from contamination sources in the Ontario Regulation 903 as amended. It should be noted that 9 of~~

~~the 20 high risk wells are located within WHPA-A zones, which are already at the highest vulnerability scoring of 10. The vulnerability zone rating for the area around these wells was therefore left unchanged. Low or medium risk wells identified within the WHPAs were increased by one vulnerability category (i.e. from low to medium, or medium to high).~~

There are a number of decommissioning records in the vulnerable area, not all of which could be reconciled with previously active wells. In addition, the medium and high risk wells are generally older and their location accuracy tends to be inconsistent. For these reasons, it was felt to be more appropriate to leave the vulnerability levels un-adjusted (Earthfx, 2022). A~~Within the Earthfx, 2015 study, an upgrade of Vulnerability based on Transport Pathways was only performed for areas that fell within the WHPAs delineated as part of the study. The locations of transport pathways and increased vulnerability are reflected in the maps of Vulnerability Scores (See Section 6.3.1.5).~~

Aggregate Operations

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Aggregate operations are defined as activities that involve the extraction of material from the surface and in the current study include both pits and quarries. Pits and quarries present a Transport Pathway as their creation serves to remove a potential layer or layers of protection from the regional aquifer. In some cases, these excavations may extend below the groundwater table, in which case the pit or quarry is a direct conduit to the aquifer that the municipal source may be a part of.

Currently there is no active aggregate operation that lie at least partially lie within the delineated WHPAs

6.3.1.5 Vulnerability Score

The WHPA zones for the Shelburne Water Supply, as shown in

Figure 6a- 1: Wellhead Protection Areas – Town of Shelburne

~~Figure 6a-1~~, the Groundwater Vulnerability, as shown in Figure 6a- 3~~., and the Transport Pathways identified in section 6.3.1.4, were used to assign a Vulnerability Score by using the matrix from Table 5.3 (Chapter 5: Methods Overview, Section 5.2.4)~~. Figure 6a- 4 and Figure 6a-5~~Figure 6a- 5~~ illustrates the Vulnerability Scores for the Shelburne Water Supply; the vulnerability scoring will be used to assess Drinking Water Threats in Section 6.3.3. ~~The Transport Pathways are illustrated as circles with a 30 m radius in the WHPAs.~~

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6.3.1.6 Vulnerability Score for WHPA-E

Under the Technical Rules (MECP, 2022), the method for assigning a vulnerability score for the WHPA-E is the same as the method used in the case of an IPZ-2. The approach relies on the application of professional judgment to determine a representative area vulnerability factor and source vulnerability factor for the WHPA-E area, with the final vulnerability score being calculated as the product of these two factors.~~The Technical Rules: Assessment Report (Clean Water Act 2006) outline that the vulnerability score for a WHPA-E is determined based on the same principles as an Intake Protection Zone-2 which is defined based on Area Vulnerability (V_a) and Source Vulnerability (V_s) factors. Within the current study area vulnerability and source vulnerability were developed using the following methodology.~~

Area Vulnerability was calculated based on the percentage of land in the WHPA-E, land cover and soil properties, and hydrological and hydrogeological conditions within the WHPA-E. Each factor was rated as either vulnerable or not vulnerable and assigned a score of 1 or 0, respectively. Scores were summed at the end of the analysis and based on total score of 1, 2, or 3, the area vulnerability was ranked as 7, 8 or 9. Overall, an area vulnerability factor of 8 was assigned to the WHPA-E for PW1 and 7 for PW3.

Source Vulnerability was calculated based on the depth of the well and the dimensions of the associated water body and the inferred potential for dilution of contaminants within that body. Wells that were less than 15 m deep were regarded as vulnerable and given a score of 1, those greater than 15 m deep were scored as 0 for less vulnerable. Since well PW1 and PW3 are ~~is~~ completed to a depth greater than 15m, ~~it~~ both were~~was~~ given a score of 0. The dimensions of each water body and the potential for dilution of contaminants were examined. A water body with a large capacity for dilution was rated as low vulnerability and scored as 0 while a water body with low potential for dilution was rated as 0.1. These numbers were summed to produce the overall source vulnerability which was assigned as a summed score of 0.1 representing a source vulnerability of 0.9 for both wells.

The overall vulnerability score for the WHPA-E at Shelburne PW1 as determined by the above methodology is 7.2 where the overall vulnerability score of PW3 is 6.3. This score has been applied to the WHPA-E in Figure 6a-5.

Table 6-2 summarizes the derivation of the final vulnerability score for the WHPA-E of Shelburne PW1 and PW3. The methodology used for the derivation of the vulnerability score is provided in Earthfx, 20221~~4~~.

Table 6-2: WHPA-E Vulnerability Score

Well	Intake Type	Area Vulnerability Factor	Source Vulnerability Factor	Final Vulnerability Score
PW1	D	8	0.9	7.2
PW3	D	7	0.9	6.3

6.3.1.7 Uncertainty Rating

The Technical Rules require that an Uncertainty Rating of either High or Low be assigned with each Vulnerable Area as outlined in Technical Rules 13-15 (Part I.4 – Uncertainty Analysis – Water Quality (MECP, 2022~~MOE, 2008a~~)). There are two components for which an Uncertainty Rating is to be provided; the first is the WHPA delineation and the second is the vulnerability assessment. It should be noted that a technical peer review consultant was retained to review the methodology, modelling, and results of the WHPA delineation and vulnerability assessment. The peer review memo is provided in Appendix SB~~—~~. It should be noted that the peer reviewers agreed with methodology, modelling, and results provided in the Earthfx 2015 report. ~~The Uncertainty Rating associated with the WHPA A-D delineation for the Shelburne wells was assessed by Earthfx using the qualitative process outlined in Earthfx, 2015.~~

The Uncertainty Rating assigned for the Shelburne WHPAs is Low. The full results of the WHPA delineation uncertainty assessment are available in Earthfx, 2022~~15~~. During the WHPA delineation analysis sources of uncertainty were introduced from both the groundwater model and the time-of –travel analysis itself. It is possible that subtle variations in flow directions near the wells caused by local variations in aquitard and aquifer hydraulic conductivity values, and/or recharge rates can lead to changes in flow paths of the particles. As a result, there is a chance that some of these subtleties may not be explained through the time-of- travel analysis. ~~More information on the uncertainty of the WHPA delineation is available in Earthfx, 2015.~~

WHPA-E are assigned a ranking of “high” or “low”. Based on the considerations discussed above, the delineation of the WHPA-E is considered to have a low uncertainty, while the assignment of the associated vulnerability score has a high uncertainty. The scoring is done by assigning a subjective numerical value and scaling it by subjective adjustment factors. ~~The WHPA-E delineation was primarily a mapping exercise, and the degree of uncertainty related to the delineation was therefore considered low. Some uncertainty was associated with the calculation of flow velocities within the Beasley Drain. Despite the uncertainty pertaining to~~

~~these calculations, the WHPA-E delineation extended to the end of the drain, and therefore included the most likely contaminant source areas.~~

The Vulnerability Uncertainty Assessment methodology used by Earthfx, 2015 and 2022 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. Using information from the Vulnerability mapping and the Transport Pathway update it is concluded that the uncertainty of the overall Vulnerability Score can be considered to be Low.

6.3.2 Drinking Water Issues Evaluation

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.

~~As part of the Issues Evaluation, Burnside 2010a originally assessed whether any contaminants would impact or have the potential to impact or interfere with any of the Shelburne wells. The evaluation was done by reviewing available water quality data. Since the last drinking water issues evaluation, the Town of Shelburne has added well 7 (PW7) to the Town's supply network. As a result, Earthfx 2015, undertook a review of available water quality data to evaluate any drinking water issues specific to well 7. The following parameters were identified as parameters of concern by Burnside 2010a, and Earthfx, 2015 for Shelburne supply wells 1, 3,5, and 6: iron, hardness, manganese, and arsenic.~~

~~High iron concentrations in the groundwater have been identified in the annual reports as an aesthetic concern. Iron is an aesthetic objective, which means that it may impair the taste, smell, or color of the water or interfere with good water quality control practices. Plotted iron concentrations indicate that concentrations in Wells 3, 5, 6, and the previously decommissioned well 2, are in exceedance of the ODWQS aesthetic guideline of 0.3 mg/L. To control the release of iron into the water, treatment including iron sequestering is applied to Shelburne's raw water before distribution. Since iron is an aesthetic objective and levels are treated to acceptable levels it is not considered a drinking water quality Issue.~~

~~Hardness concentrations ranging from 232 to 363 mg/L were reported in historical water quality data for Shelburne wells 1, 3, 5, and 6. These levels are elevated above the Operational~~

~~Guideline (OG) range of 80-100 mg/L listed in the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines, 2006. This level of hardness is typical of drinking water obtained from a bedrock source and is therefore naturally occurring. Hardness in water is also an aesthetic objective and is typically handled using household water softeners; hardness therefore should not interfere with the use of water from these sources.~~

~~Manganese is considered an aesthetic objective in the ODWQS. Elevated levels of manganese are a result of naturally occurring minerals in many bedrock aquifers. All but one data point fall below the ODWQS aesthetic objective of 0.05 mg/L. It is possible that this point represents an anomalous value that is not reflective of the overall values in the aquifer. Based on the noted level of manganese associated with the remaining values it is concluded that manganese is not considered a water quality Issue for the Shelburne water supply.~~

~~Currently the ODWQS for arsenic is 25 ug/L; however, in 2006 Health Canada reduced the CDWQG for arsenic to 10 ug/L (Health Canada, 2006). Ontario is currently reviewing the adoption of a more stringent ODWQS for arsenic (10 ug/L). Arsenic concentrations for Well 1 are well below the ODWQS. Concentrations for Well 3, 5, and 6 are below the ODWQS. Current levels are however above 10 ug/L and if the ODWQS were to change to 10 ug/L, they would be in exceedance of provincial guidelines.~~

~~The possibility of a future exceedance in acceptable arsenic concentrations for the Town's drinking water was one of the reasons that the newest supply well (PW 7) was completed in the deeper source aquifer. The drinking water issues evaluation for the new supply well (PW7) is detailed in Earthfx, 2015. Water quality data was obtained from water quality testing completed by Golder and Banks, 2013, during which the suitability of the well for use as a municipal drinking water supply was assessed. All of the analyzed parameters were found to be below their respective ODWQS criteria, with the exception of total hardness, which ranged from 234 to 325 mg/L as calcium carbonate. These levels are elevated above the Operational Guideline (OG) range of 80-100 mg/L listed in the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines, 2006. As stated above, elevated levels of total hardness are typical of groundwater sourced from bedrock aquifers. Because total hardness is considered to be an operational objective that is often treated using household water softening systems, this parameter has not been identified as an issue. As mentioned above, because the naturally occurring arsenic is assumed to originate from sources in the shallow aquifers, the new supply well (PW7) was screened in the deeper formation in hopes that the intervening low conductivity units found between the deep and shallow systems would prevent the transport of arsenic to the deeper aquifer. Water quality samples collected during testing of the new supply well were found to range from 0.4 to 3.8 ug/L. These levels are well~~

~~below the current and projected future ODWQS criteria of 25 ug/L and 10 ug/L, respectively. However, it should be noted that during a 72 hour pumping test, arsenic concentration increased from 0.9 ug/L to 3.6 ug/L. This increase may indicate that the drawdown caused by pumping in the deeper aquifer was sufficient to induce downward movement of the arsenic through the confining units. This indicates that the deeper aquifer system is not completely separated hydraulically from the shallow system, and in fact, likely receives vertical inflows from overlying aquifers. Ongoing monitoring is recommended to identify possible increasing trends. At this time, arsenic is not considered to be an issue for the quality of drinking water from supply well 7.~~

~~Based on a review of the existing literature on this occurrence, it is concluded that the arsenic in the Shelburne wells is naturally occurring and common in groundwater originating from shale bedrock in this area. In accordance with the Technical Rules, with the arsenic in the Shelburne wells being naturally occurring there is no Issue with this parameter.~~

~~**No Drinking Water Issues were identified for the Shelburne Water Supply.**~~The Town of Shelburne produces annual reports for their Drinking Water System (e.g., Town of Shelburne, 2021). The water supply is of high quality with levels of organic contaminants below detection limits. Elevated levels of fluoride and arsenic were noted but are considered to be naturally occurring.

The purpose of drilling the deeper PW7 and PW8 wells was to find a source of water with lower arsenic concentrations, as discussed further on. The construction of the deeper supply wells PW7 and PW8 was motivated by reoccurring water quality problems related to arsenic in the other Town supply wells. Because the source of arsenic is assumed to be from naturally-occurring arsenopyrite in the Guelph Formation, the new well was screened in the deeper Gasport Formation in hopes that the intervening low conductivity units would prevent the transport of arsenic to the deeper aquifer. Water quality samples collected during testing of the new supply well were found to range from 0.4 to 3.8 µg/L, which is below both the current ODWQS of 10 µg/L. It was noted that during the 72-hour pumping test, arsenic concentration increased from 0.9 µg/L to 3.6 µg/L. This increase could reflect that the enhanced vertical gradient caused by the drawdown in the deeper aquifer was sufficient to induce downward flux of arsenic through the confining units.

A number of other studies in the Shelburne area have included water quality assessments. Older studies include the Burnside (2010) review. A water quality review of well PW7 was completed by Golder and Banks (2013), during which the suitability of the well in the deeper bedrock for use as a municipal drinking water supply was assessed. Water quality samples were

collected during November and December of 2010 and tested for parameters listed in Schedule 1, 2, and 3 of the ODWQS and Table 4 of the Technical Support Document for the Ontario Drinking Water Standards, Objectives and Guidelines.

The PW7 analysis showed that all of the analyzed parameters were found to be below their respective ODWQS criteria, with the exception of total hardness, which ranged from 234 to 325 mg/L as CaCO3. These levels exceeded the Operational Guideline range of 80-100 mg/L. Elevated levels of total hardness are typical of groundwater sourced from bedrock aquifers, and have been persistent in the Town of Shelburne's drinking water supply. Because total hardness is considered to be an operational guidelines/aesthetic objective this parameter has not been identified as an issue. Drinking water issues for all of the operating wells were evaluated by reviewing the available water quality data reported in the 2016-1018 and 2020 Drinking Water System Annual Reports prepared by OCWA (OCWA, 2017, 2018, 2019, 2021). Water quality data were compared to the ODWQS to identify the parameters that were in exceedance and data were assessed to identify any increasing trends in concentration.

As noted, arsenic has been historically detected in the shallow Shelburne supply wells. Concentrations above the current ODWQS of 10 µg/L have been observed in wells PW1, PW3, PW5, and PW6 on a regular basis. The elevated arsenic concentrations are considered to be naturally occurring in the local groundwater, and are not identified as an issue.

Sodium concentrations have been observed to exceed the ODWQS, however levels are generally low and likely natural, but they may be related to road salt application or water treatment using sodium hypochlorite. Sodium declined to below reporting limits in 2020, perhaps indicating a downward trend.

The wells have also been found to exhibit naturally high iron levels; however, these levels are reduced through iron sequestration in the treatment system. Low levels of fluoride were observed in 2020, but fluoride is known to be naturally occurring in bedrock aquifers that occur beneath Shelburne.

Regarding the GUDI status of PW3, it is noted that were no occurrences of E.coli or total coliforms in the 2015-2019 monitoring data, and none observed during the 2020 testing period (Burnett, 2021). Other surface water indicators such as nitrate, nitrite, total phosphorous, DOC, and TKN, all returned values under the guideline limit.

No Drinking Water Issues were identified for the Shelburne Water Supply.

6.3.3 Drinking Water Threats Evaluation

An assessment of Drinking Water Threats for the Shelburne water supply was initially completed by Burnside, in accordance with the detailed methodology presented in Burnside 2010a. ~~In 2015, Earthfx was retained by the Lake Erie SPR to update the WHPA delineation for the Town of Shelburne to include well 7.~~ As part of the Earthfx 2015 study~~, Earth~~, and assessment was ~~fx also~~ completed ~~an assessment~~ of the drinking water threats found within the WHPA for well 7~~,~~ and an update to the WHPA delineations for the remaining Town wells; however, the study did not include a re-assessment of drinking water threats within the updated WHPAs for wells 1,3,5 and 6. The 2022 Earthfx report corresponds to a full review of the drinking water evaluation associated to all municipal wells for the Shelburne municipal drinking water system, including a ~~A~~ detailed description of the methodology employed ~~for the PW7 threats assessment is presented in Earthfx, 2015. As the Earthfx study did not address changes to threat counts outside of the well 7 WHPA, a re-assessment of the drinking water threats within the remaining WHPAs was required~~. A detailed description of the methodology employed to re-assess the status of previously identified threats in the revised WHPAs is provided in Section 6.3.3.5.1 below.

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 Shelburne water supply builds on the information from the Vulnerability Analysis and Issues Evaluation and includes the 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

6.3.3.1 List of Drinking Water Threats – Activities

The list of Prescribed Drinking Water Threats considered in the assessment for the Shelburne drinking water supply is provided in Chapter 5, section 5. 5.1.

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

6.3.3.2 List of Drinking Water Threats – Conditions

A review of available data for the properties that intersect the updated WHPAs included the National Pollutant Release Inventory (NPRI), MECP Brownfields Site Registry, and MECP Waste Disposal Sites Inventory. The previous studies completed in the area by Burnside (2002; 2010) and Golder and Banks (2013) provided additional resources for screening for past and historic activities that could pose a threat to water quality. ~~The following information sources were consulted to identify existing Conditions that could affect the Shelburne Well Supply:~~

- ~~Ecolog Environmental Risk Information Services Ltd Search. Databases used include:~~
  - ~~Federal Government Source databases~~
  - ~~Provincial Government Source Databases~~
  - ~~Private Source Databases~~
  - More details and on these sources can be found in ~~Burnside 2010a, and~~ Earthfx, 2022~~15~~.

One threat, the Shelburne Wood Preservative operation, was identified in the NPRI database. It is unknown whether off-site contamination is present at this site, but given the proximity to PW1, it is assumed to be a Hazard rating of 10.

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Brownfields:

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The MECP Brownfields database is divided into two parts, first with records between 2004 and 2011, and second with records after 2011. A search of the pre-2011 records in the Municipality of Shelburne and Melancthon identified four records (Table 9.29). No threats were identified. A search of the post 2011 records in the Municipality of Shelburne and Melancthon identified two records (Table 9.30). No threats were identified.

Waste Disposal Site Search

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Waste management in Shelburne is managed by the County of Dufferin. In addition to local pickup services, the Waste Drop-off Facility is located outside of the WHPA area at the Orangeville - Dufferin Transfer Station at 473051 Dufferin County Rd 11, Orangeville, ON. No waste sites from this database were identified in the WHPA zones.

~~**One Condition and one potential Condition has been identified for the Shelburne Water Supply.**~~

The following was previously referenced (Burnside, 2010) as conditions in Shelburne:

An historic landfill site is located at Greenwood Street within the WHPA-B of PW1 and according to the MOE 1991 Historical Waste Disposal Site Approval Inventory the site received municipal, rural, and domestic waste and was closed in 1962. Water quality monitoring on the site was conducted from 1999 to 2005 (Burnside, 2005). Monitoring was discontinued with approval of the MOE since there were no increasing trends or potential significant impacts to water quality. Water quality results taken in May 2005 exceeded the standards for potable water of Table 2 Soil, Groundwater, and Sediment for the parameters selenium and nitrate at one of the monitoring wells on site. There is no reported evidence that the site is causing off site contamination. According to the Technical Rules, the site is a Condition with a Hazard Rating of 6. The Risk Score of the Condition is 48 and therefore is a Low Drinking Water Threat.

Two spills at an industrial site (wood preservative company) in Shelburne were identified by the MOE's Occurrence Reporting Information System. One spill occurred in 1990 and was 2,500 L of wood preservative spilled on the ground. The second spill occurred in 1991 and consisted of 2 L of oil spilled onto soil in the parking lot. These spills may have resulted in soil contamination however at this time there is no data to confirm that a Condition exists and therefore is currently only a potential Condition.

One Condition and one potential Condition has been identified for the Shelburne Water Supply.

6.3.3.3 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 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 tables can be found at the Government of Ontario's Drinking Water Threats and Circumstances.

6.3.3.3.1 Pathogen Parameters

The ~~Key Table on Figure 6a- 6 can be used in conjunction with the~~ Vulnerability Scores can be used in conjunction to identify the areas where Activities associated with pathogen threats are or would be Significant, Moderate, or Low Drinking Water Threats for the Shelburne Well Supply (Figure 6a- 6). Activities that are or would be Significant Drinking Water Threats for pathogens can be observed within the areas where the Vulnerability Score is 10. Pathogens can also only be a Significant, Moderate, or Low Threat within WHPA-A, -B and -E.

6.3.3.3.2 Chemical Parameters

The ~~Key Table on Figure 6a- 7 can be used in conjunction with the~~ Vulnerability Scores can be used in conjunction to identify the areas where Activities associated with chemical threats are or would be Significant, Moderate, or Low Drinking Water Threats for the Shelburne Well Supply (Figure 6a- 7). Activities that are or would be Significant Drinking Water Threats for chemicals can be observed within areas where the Vulnerability Score is equal to or greater than 8.

6.3.3.3.3 DNAPL Chemical Parameters

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

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

Further to Section 6.3.3.2, one Condition and one potential Condition have been confirmed within the WHPA for the Shelburne Well Supply.

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 6a- 4 through Figure 6a- 5~~Figure 6a- 5~~ illustrate the Vulnerability Score map for Shelburne well supply that can be used to determine where a Condition is or would be a Significant, Moderate, or Low Threat to Drinking Water.

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6.3.3.5 Enumerating Drinking Water Threats

6.3.3.5.1 Enumerating Significant Drinking Water Threats – Methods

Identification and enumeration of Significant Drinking Water Threats related to Issues and Conditions have been described in Section 6.3.2 and 6.3.3.2, 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 Burnside, 2010a and Earthfx, 2015 and 2022. 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.

~~As mentioned above, F~~following the update of the WHPA delineation by Earthfx, 2022~~15~~, another additional desktop exercise was performed by SGBLS staff to re-evaluate the number and status of threats in the revised WHPA delineations ~~for wells 1,3,5 and 6~~. To confirm the status of the previously identified significant threats, SGBLS staff compared the location of the

threats in the old WHPAs against their location in the revised WHPAs. This exercise helped identify which, if any of the previously identified significant threats would no longer be considered significant due to their location within the updated WHPA delineation. ~~SGBLS staff also looked at the low and moderate threats previously identified in the Burnside, 2010 study to determine if any of them should be upgraded to significant threat status based on their location within the revised WHPA. It should be noted that as a result of the updated WHPA delineations and vulnerability scorin~~.g, Conversely, it is likely that some activities previously not identified as threats will need to be re-evaluated, and may result in additional significant threats within the Shelburne WHPAs. ~~Parcels not previously located within WHPA boundaries will need to be further evaluated for significant threats.~~ All new significant threats within the Town's WHPAs will be investigated by the Risk Management Official for the Town of Shelburne during the implementation of the SGBLS source protection plan policies.

~~The remainder of this section will outline the general methodology undertaken for enumerating significant threats.~~ In order to classify activities in the study area, the various databases and sources outlined in Section 6.3.3.2 were reviewed and information on site activities was compiled. The circumstances under which activities are considered threats and the classification of those threats are ~~contained in the Table of Drinking Water Threats provided by the MOE (MOE 2008b).~~ found at Government of Ontario's Drinking Water Threats and Circumstances.

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~~An automated process was developed to search the Table and provide an indication of the Hazard and Risk Score for each identified Activity. The automated process generates a project database that houses information on the threat and also includes the various component scores that are included in the final determination of risk category. The risk category in the automated process is calculated using processes described by the MOE in their document Threats EBR Lookups (MOE, 2009d) and is identical to that used by the Tables of Drinking Water Threats. As a quality control mechanism, the calculated risk categories were verified by manual searches of the MOE Tables of Drinking Water Threats to ensure that the automated calculations were correct for threats categorized as Significant. In order to ensure consistency in the approach for assumptions regarding various activities and the methodology for the evaluations of threats, a consensus was arrived at among all consultants conducting work within the SGBLS Region (SGBLS, 2010).~~

The hazard ratings and risk scores were calculated via the MOECC threats tables, which include the vulnerability scores that make an activity low, moderate or significant. The Risk Score is calculated by multiplying the Vulnerability Score as defined by the Vulnerability component of

the study (Section 6.3.1.5) with the Hazard Rating which provides a score out of 100. The Risk Score is classified as Significant when the score is greater than 80.

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', where present, 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.

Some Threats such as the Application of Agricultural Source Material to Land have Circumstances based on datasets that are on a scale larger than individual properties. These Circumstances included percent Managed Lands, Livestock Density, and Impervious Surfaces. Therefore, additional calculations were required to determine these Circumstances for each WHPA. The percent Managed Lands and Livestock Density calculations were completed for this project using a methodology developed in consultation with the SGBLS Source Protection Region and was based on the MOE Technical Bulletin for Managed Land and Livestock Density Calculations (MOE, ~~September~~ November 2009). ~~Following the update of the WHPA delineation, SGBLS staff re-evaluated the percent managed lands, livestock density, and impervious surface calculations for wells 1,3,5 and 6 using the same methodology applied by Earthfx, 2015 and Burnside, 2010.~~ Managed Lands, Livestock Density, and Impervious Surfaces are discussed in more detail below.

6.3.3.5.1.1 Managed Lands

~~Managed Land is land to which nutrients (Agriculture Source Material (ASM), commercial fertilizer, Non-Agricultural Source Material (NASM)) are applied. 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) (MECP, 2021~~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 Table of Drinking Water Threats.

Managed Lands were identified and the Managed Lands proportions were determined for the Shelburne WHPAs. ~~The managed lands specific to the well 7 WHPA were determined as outlined in Earthfx, 2015~~. The managed lands for the WHPAs corresponding to wells 1,3,5, and 6 were originally determined by Burnside, 2010a-c and well 7 by Earthfx (2015); this has been reassessed by Earthfx (2022) for all wells~~, however the WHPA delineation update completed by Earthfx, 2015, generated the requirement for a reassessment of the managed lands. This re-assessment was conducted by SGBLS staff~~ using the ~~same~~ methodology outlined in the Technical Bulletin for Managed Land and Livestock Density Calculations (MOE, ~~September~~ November 2009) ~~and Earthfx, 2015~~. The results from this analysis were used in the enumeration of Significant Drinking Water Threats ~~(Section 6.3.3.5.16.3.3.5.2)~~.

Figure 6a- 9 and Figure 6a- 10 illustrate the distribution of Managed Lands within the delineated WHPA zones for the Shelburne Supply.

6.3.3.5.1.2 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) (MECP, 2021~~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 Table of Drinking Water Threats. The Livestock Density was originally determined for the Town of Shelburne WHPAs as outlined in Burnside, 2010a-c and updated in 2015 by Earthfx to reflect the addition of PW 7,

~~. The addition of PW7 to the Town's water supply required that the Livestock Density be determined for the newly delineated well 7 WHPA. This work was conducted by Earthfx according to the methodology outlined in Earthfx, 2015.~~ An update to the WHPA delineations for the existing wells also generated the requirement for a re-assessment of the livestock density within the Shelburne WHPAs. This reassessment was conducted by ~~SGBLS staff using the same methodology outlined in the Technical Bulletin for Managed Land and Livestock Density Calculations (MOE, September 2009) and~~ Earthfx, 2022~~15~~. The results from this analysis were used in the enumeration of Significant Drinking Water Threats (Section 6.3.3.5.2). Figure

6a- 11 and Figure 6a- 12 illustrate the distribution of Livestock Density within the delineated WHPA zones for the Shelburne Supply.

6.3.3.5.1.3 Impervious Surfaces

~~Impervious surfaces are defined in the Technical Rules as areas that receive road salt application and include roads and parking lots. The areas were determined using road mapping from the National Road Network (Natural Resources Canada) and satellite air photography to identify large parking lots and paved areas. Using a 1 km x 1 km grid centered over each vulnerable area, the percentage of impermeable surfaces within each square kilometre was calculated. For further details on the methods used to assess impervious surfaces for the Town of Shelburne WHPAs see Earthfx, 2015.~~

Technical Rule 16(11) (MECP, 2021~~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 Table of Drinking Water Threats.

Figure 6a- 13 illustrates the distribution of Impervious Surface within the delineated WHPA zones for the Shelburne Supply.

6.3.3.5.2 Enumerating Significant Drinking Water Threats – Results

There are no Significant Threats associated with Drinking Water Issues. There is one Significant Threat Condition that is discussed in Section 6.3.3.2.

Table 6-3 documents the enumeration of existing and potential Activities that are considered to be Significant Drinking Water Threats within the WHPAs for the Shelburne Water Supply.

A total of ~~forty~~ 66~~–one (41~~) Activities that are considered to be Significant Drinking Water Threats were identified in association with 66~~thirty-two (32)~~ land parcels in the WHPA for the Shelburne Water Supply. The identified Activities relate to use of private individual sewage disposal systems (13~~9~~), application of agricultural source material to land (7~~2~~), application of commercial fertilizer to land (7~~3~~), handling and storage of fuel (18~~9~~), and handling and storage of DNAPLs (9~~3~~).~~ One (1) Threat activity has been assigned to address the potential presence of municipal sanitary sewers for each WHPA with a Vulnerability Score of 10. Each private connection to the municipal sewer in this area could be considered as an area of increased Threat potential~~. ~~One (1) additional Significant threat has also been included within the area~~

~~where the Vulnerability Score is 10 to represent the potential for subsurface storage of fuel for home heating purposes.~~

Table 6-3: Number of Significant Drinking Water Threats for the Shelburne Well Supply Enumeration of Significant Threats (Wellhead Protected Area)

Threat Number	Threat	Significant Threat Counts Number of Threats	Significant Threat Counts Number of Parcels
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V or the Environmental Protection Act		
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	13	13
3	The application of agricultural source material to land	7	7
4	The storage of agricultural source material to land		
5	The management of agricultural source material		
6	The application of non-agricultural source material to land	7	7
7	The handling and storage of non-agricultural source material		
8	The application of commercial fertilizer to land	7	7
9	The handling and storage of commercial fertilizer to land		
10	The application of pesticide to land	3	3
11	The handling and storage of pesticide		
12	The application of road salt		
13	The handling and storage of road salt		
14	The storage of snow		
15	The handling and storage of fuel	18	18
16	The handling and storage of dense non-aqueous phase liquid	9	9
17	The handling and storage of an organic solvent	1	1
18	The management of runoff that contains chemicals used in the de-icing of aircraft		

Threat Number	Threat	Significant Threat Counts Number of Threats	Significant Threat Counts Number of Parcels
21	The use of land as livestock grazing or pasturing land, and outdoor confinement area, or a farm-animal yard	1	1
22	The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.		
-	Total Number	66	66

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~~Threat Number~~	~~Threat~~	~~Significant Threat Counts Number of Threats~~	~~Significant Threat Counts Number of Parcels~~
~~1~~	~~The establishment, operation or maintenance of a waste disposal site within the meaning of Part V or the Environmental Protection Act~~	~~0~~	~~0~~
~~2~~	~~The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage~~	~~22~~	~~22~~
~~3~~	~~The application of agricultural source material to land~~	~~2~~	~~2~~
~~4~~	~~The storage of agricultural source material to land~~	~~0~~	~~0~~
~~5~~	~~The management of agricultural source material~~	~~0~~	~~0~~
~~6~~	~~The application of non-agricultural source material to land~~	~~0~~	~~0~~
~~7~~	~~The handling and storage of non-agricultural source material~~	~~0~~	~~0~~

Threat Number	Threat	Significant Threat Counts Number of Threats	Significant Threat Counts Number of Parcels
8	The application of commercial fertilizer to land	3	3
9	The handling and storage of commercial fertilizer to land	0	0
10	The application of pesticide to land	2	2
11	The handling and storage of pesticide	0	0
12	The application of road salt	0	0
13	The handling and storage of road salt	0	0
14	The storage of snow	0	0
15	The handling and storage of fuel	9	7
16	The handling and storage of dense non-aqueous phase liquid	3	3
17	The handling and storage of an organic solvent	0	0
18	The management of runoff that contains chemicals used in the de-icing of aircraft	0	0
21	The use of land as livestock grazing or pasturing land, and outdoor confinement area, or a farm-animal yard	0	0
22	The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.	0	0
-	Total Number	41	32

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. * All identified threats will require further investigation.

Figure 6–1: Vulnerable Areas in the Town of Shelburne

Figure 6a- 1: Wellhead Protection Areas – Town of Shelburne

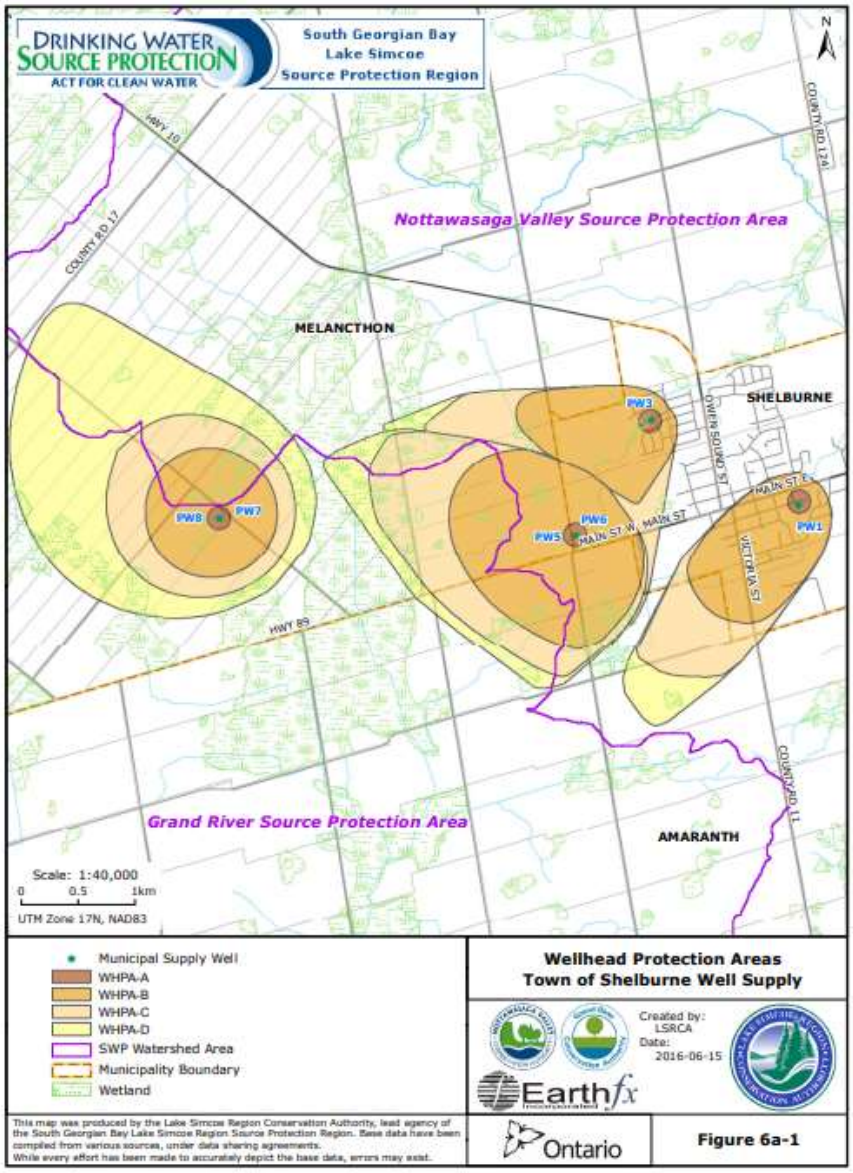

Figure 6a- 2: Wellhead Protection Areas - WHPA-E - Town of Shelburne (PW1)

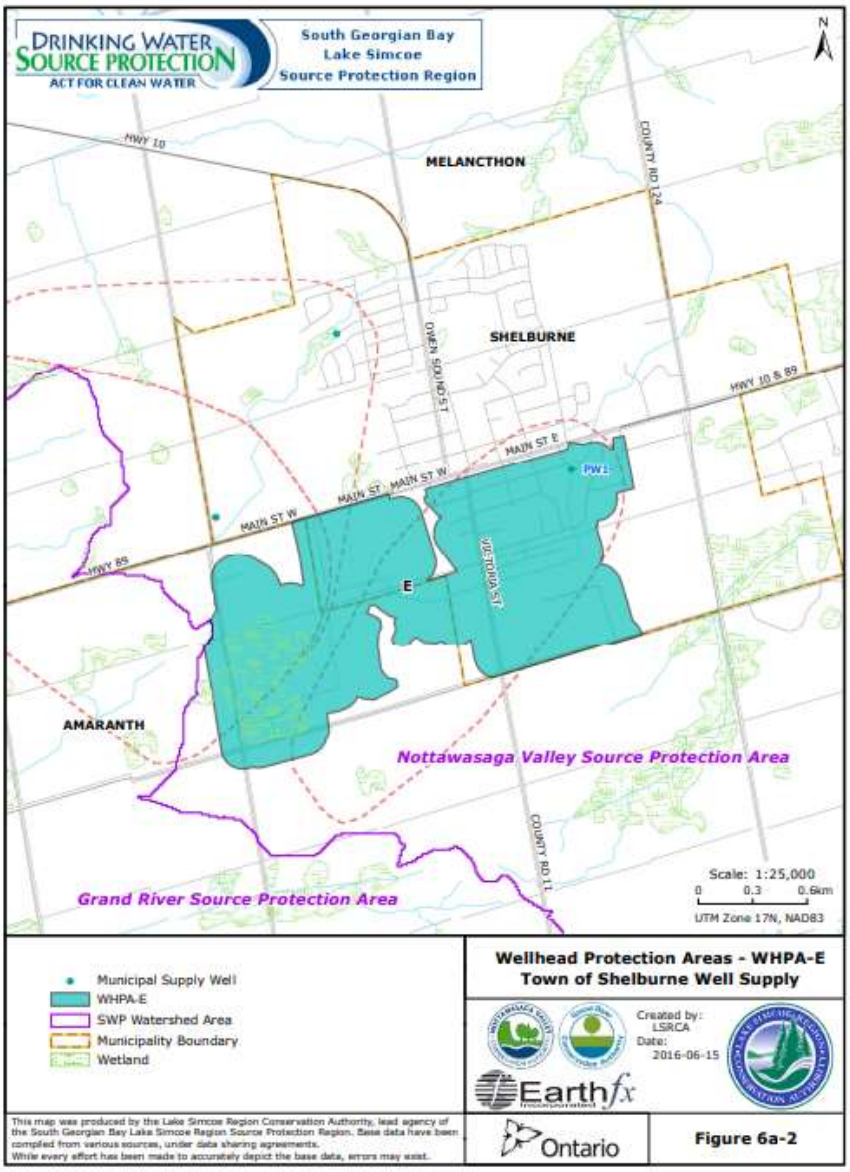

Figure 6a- 3: Groundwater Vulnerability - Town of Shelburne

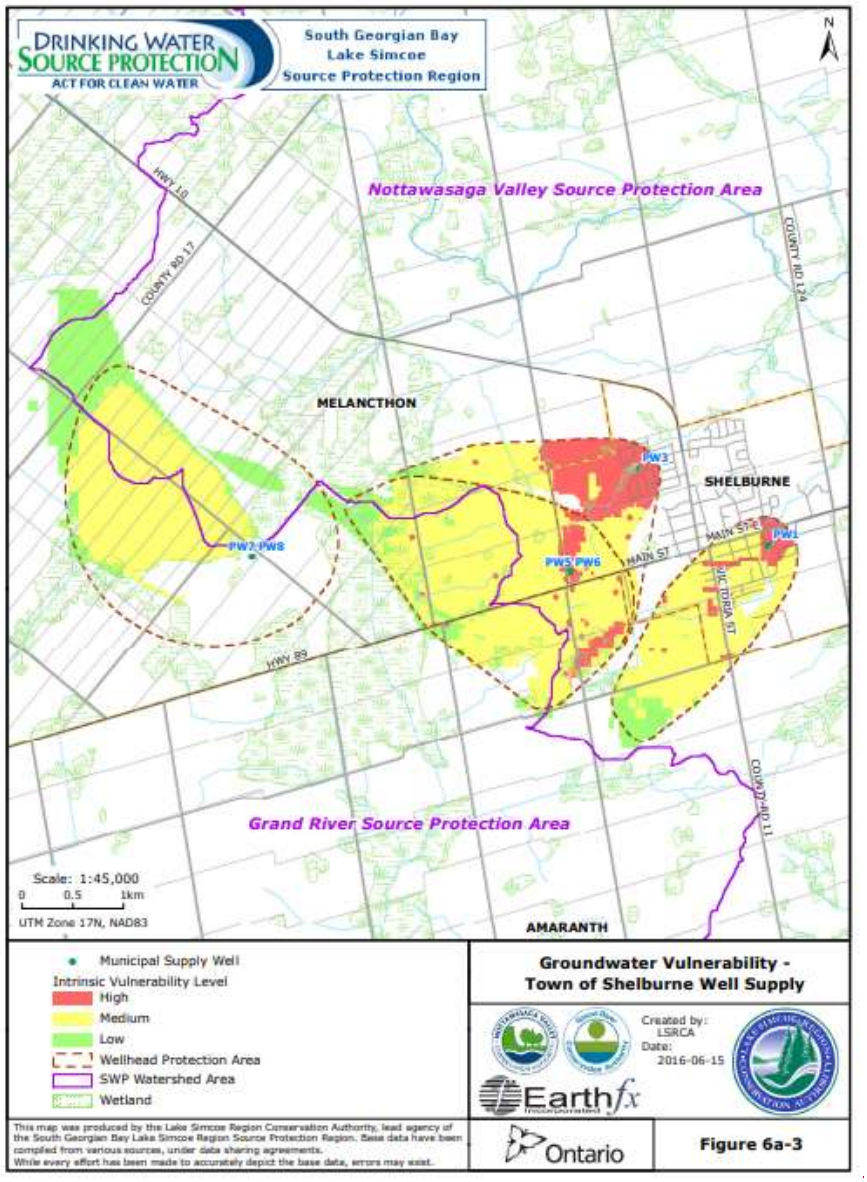

Figure 6a- 4: Vulnerability Scores – Town Of Shelburne

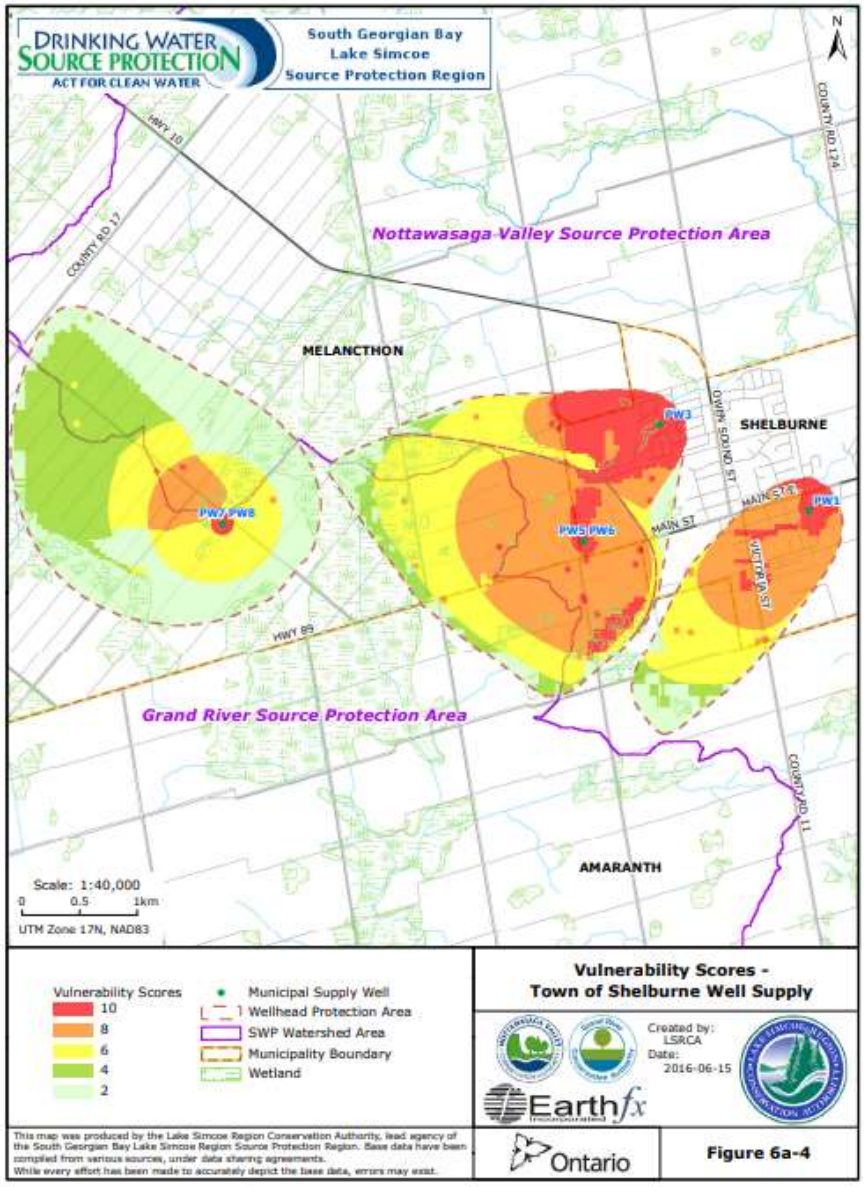

Figure 6a- 5: Vulnerability Scores - WHPA-E (PW1)

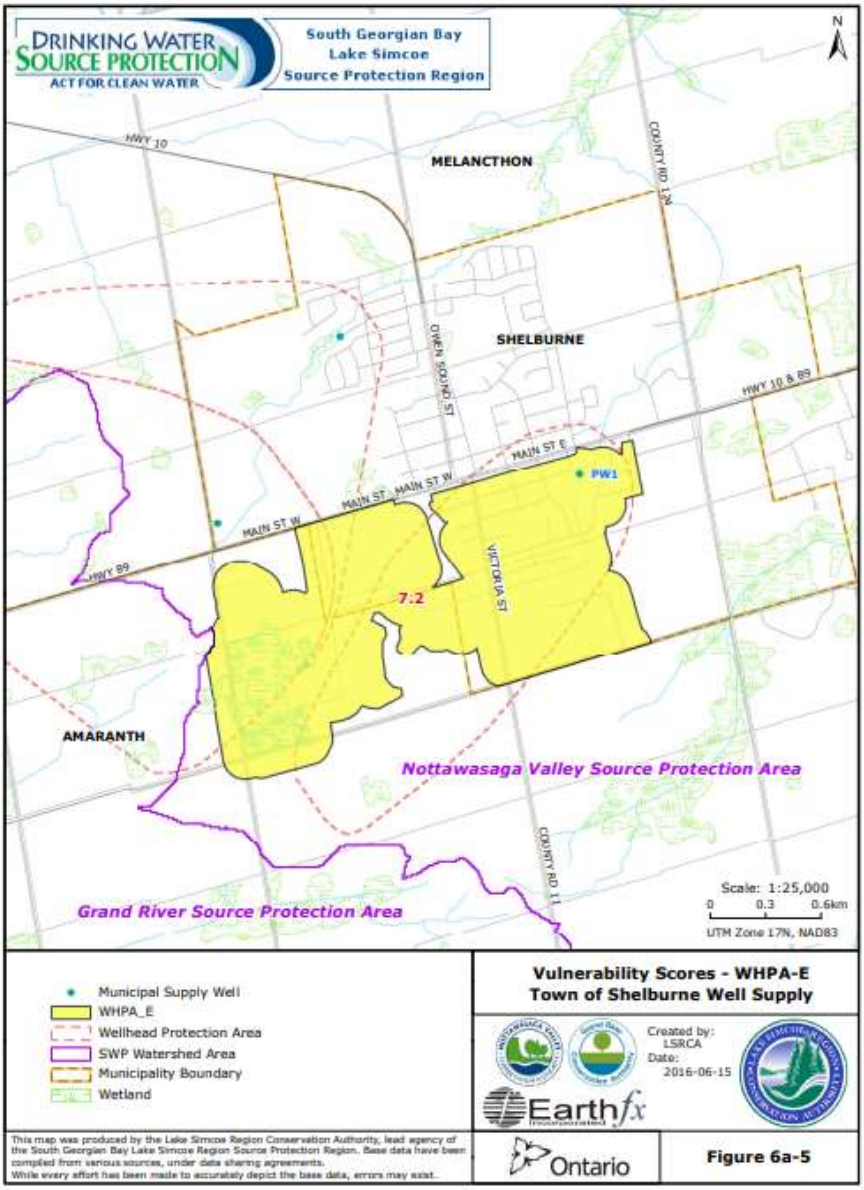

Figure 6a- 6: Areas of Significant, Moderate or Low Threats – Pathogens

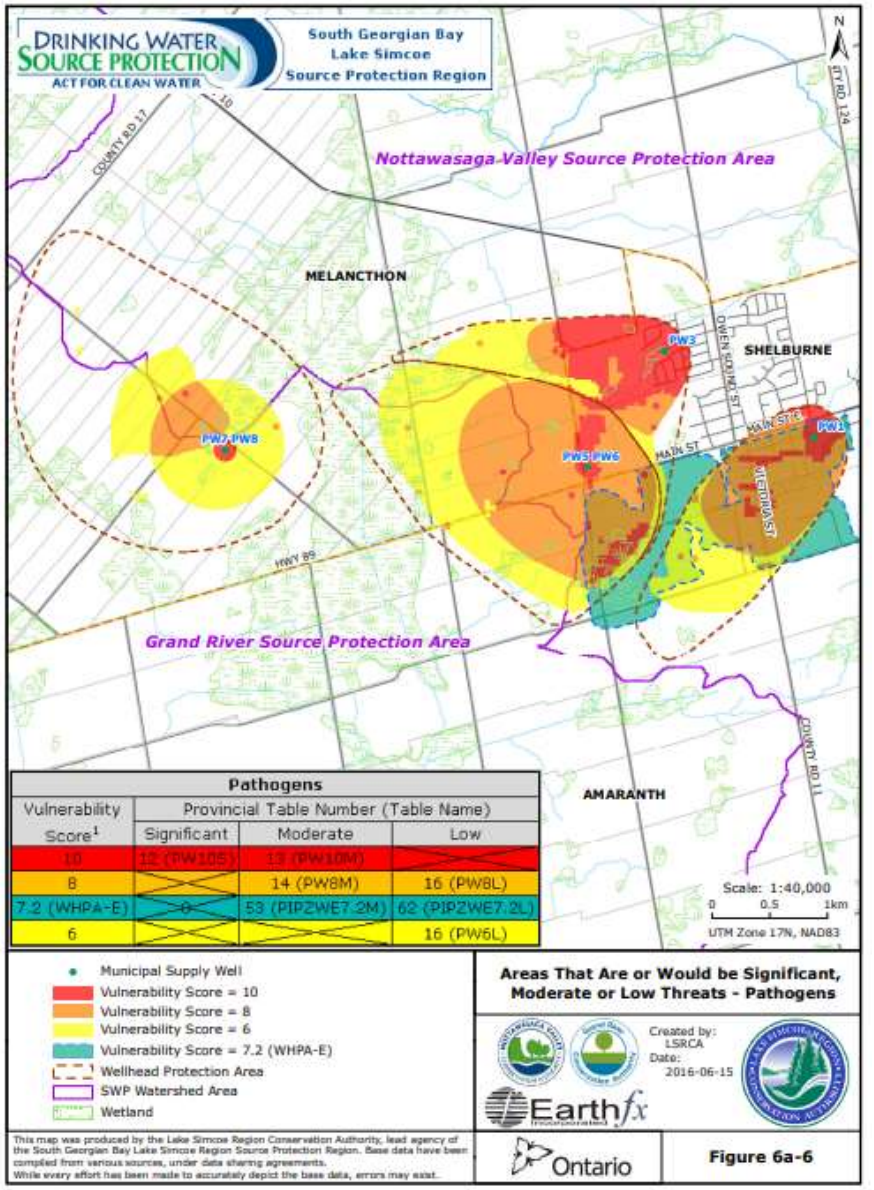

Figure 6a- 7: Areas of Significant, Moderate or Low Threats – Chemicals

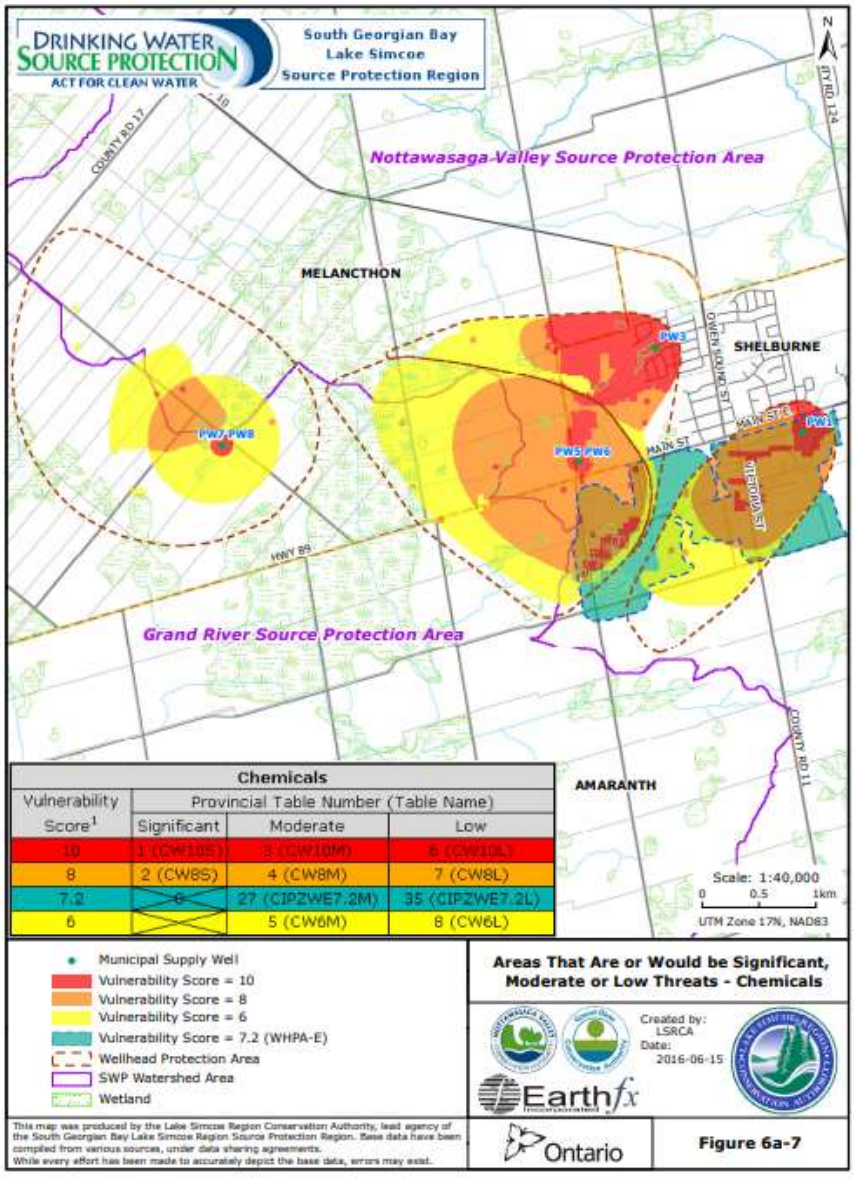

Figure 6a- 8: Areas of Significant, Moderate or Low Threats – DNAPLs

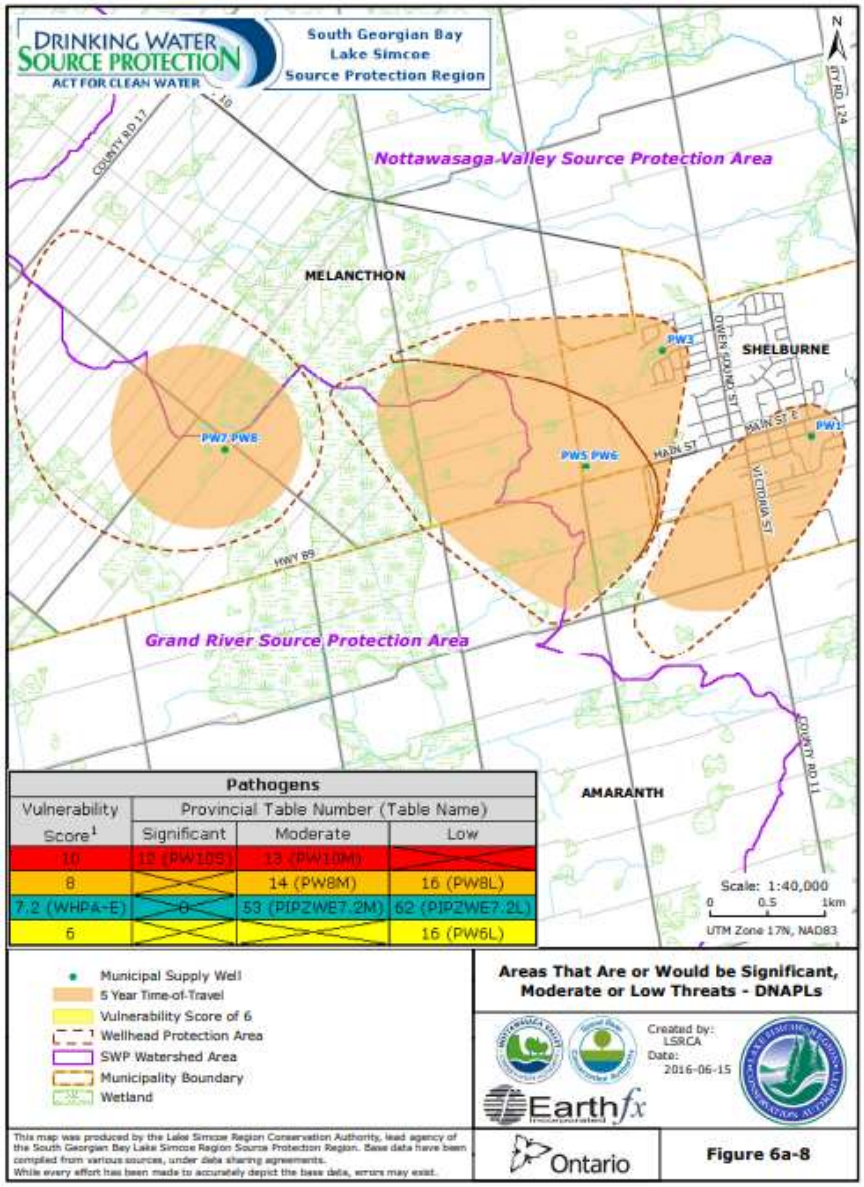

Figure 6a- 9: Managed Lands - Town of Shelburne

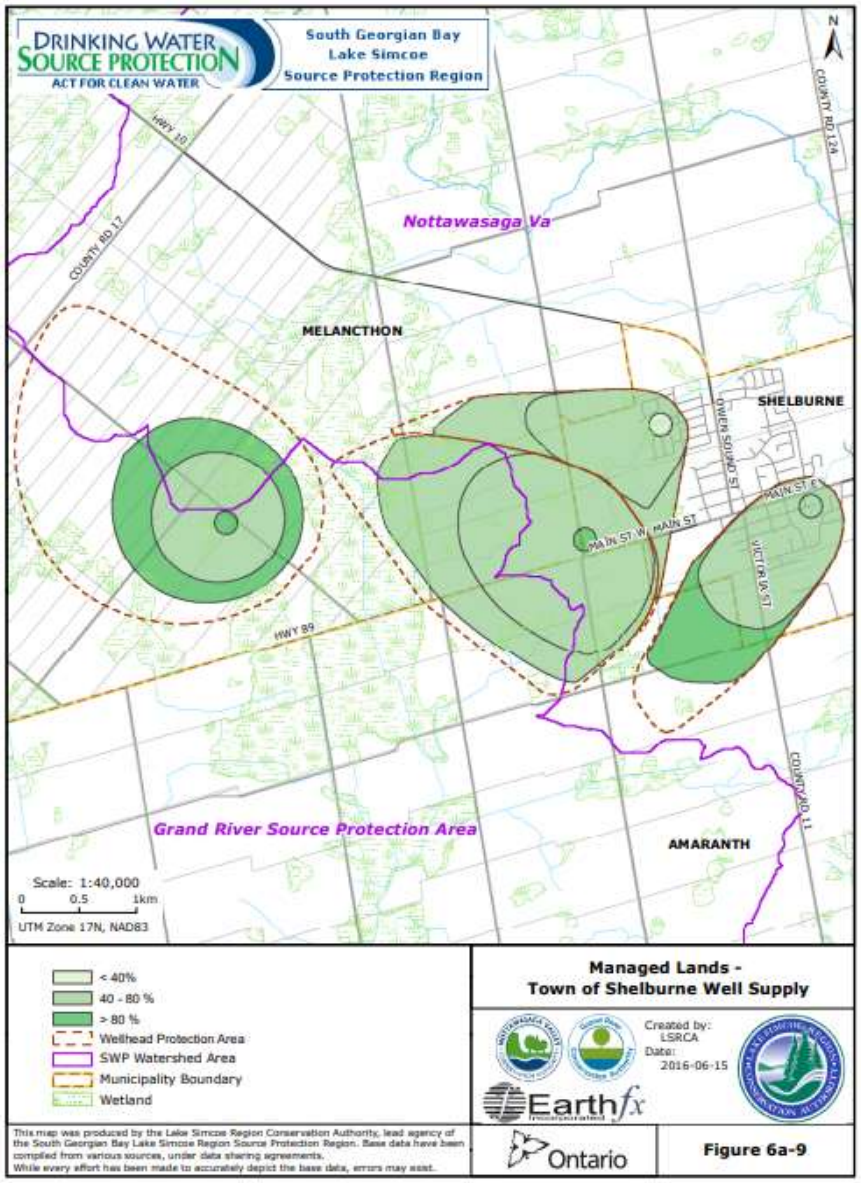

Figure 6a- 10: Managed Lands - WHPA-E (PW1)

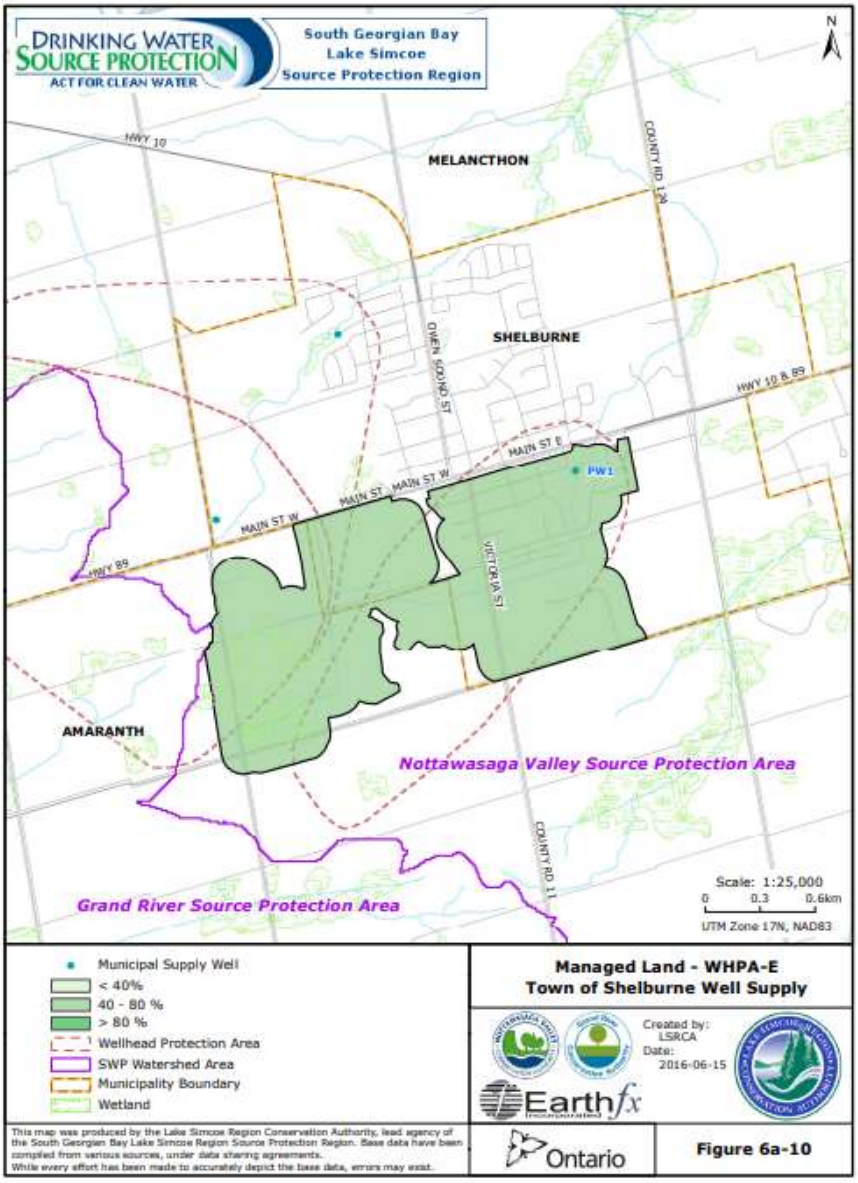

Figure 6a- 11: Livestock Density - Town of Shelburne

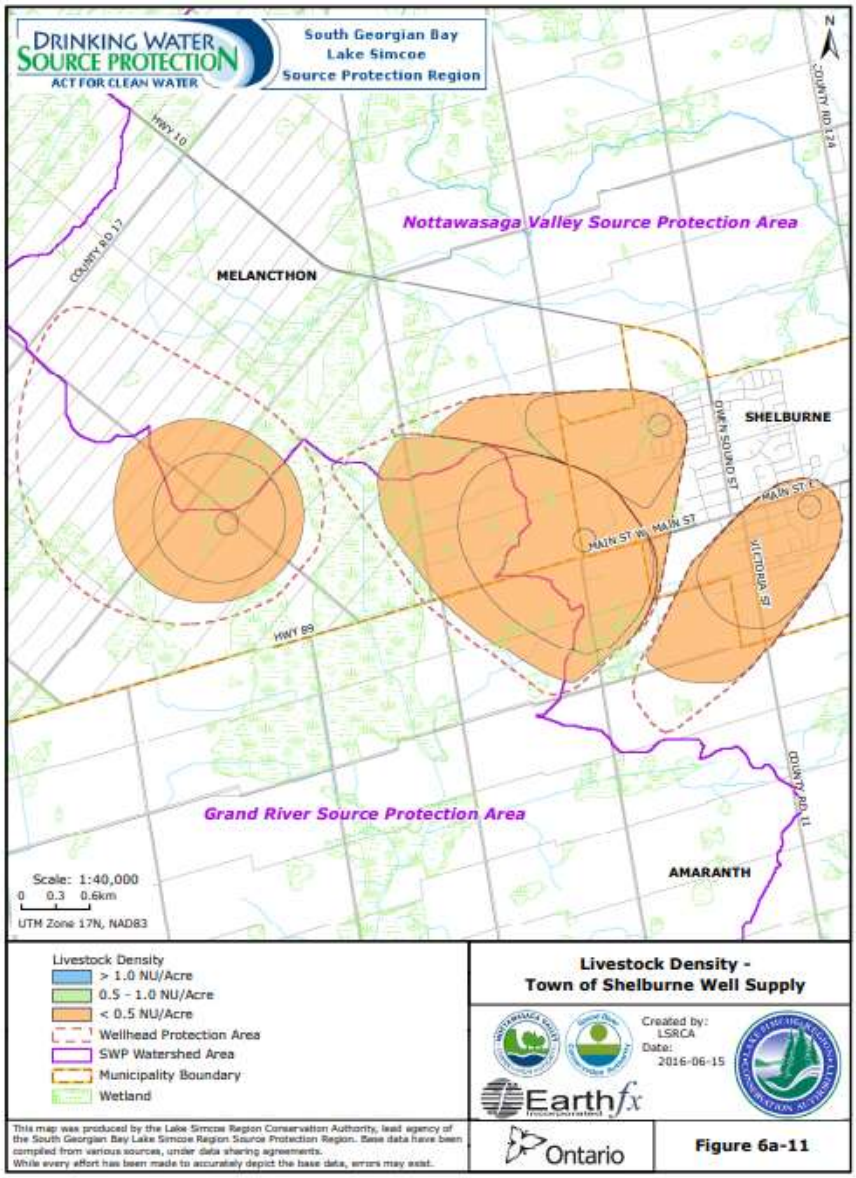

Figure 6a- 12: Livestock Density - WHPA-E (PW1)

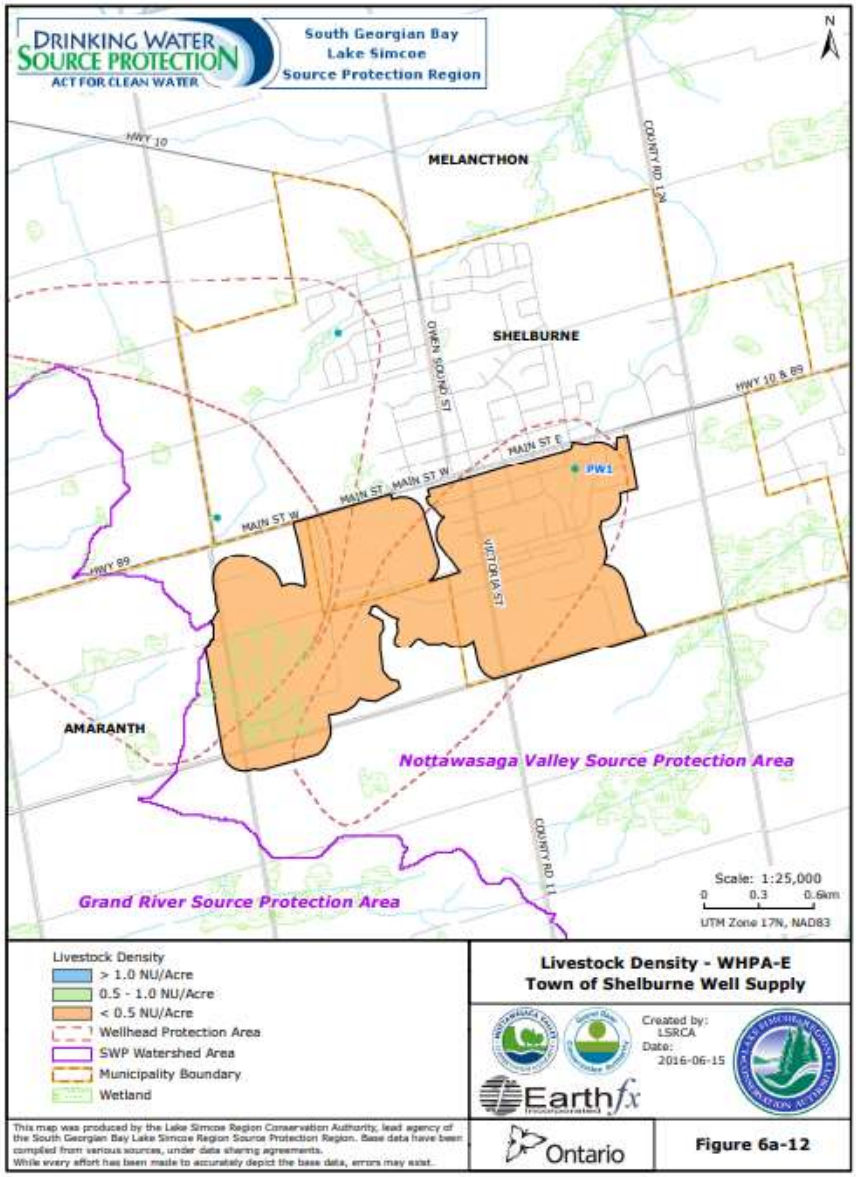

Figure 6a- 13: Impervious Surfaces - Town of Shelburne