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7.0 ELGIN COUNTY WATER QUALITY RISK ASSESSMENT

One municipal drinking water system within Elgin County is located in the Long Point Region Source Protection Area, as summarized in **Table 7-1**. The village of Richmond drinking water system is located in the Municipality of Bayham. This is a new municipal drinking water system established in 2014. The total annual takings in 2014 were 12,466 cubic meters. The communities of Port Burwell and Vienna have municipal drinking water distribution systems and source their water from Lake Erie via the Elgin Area Primary Water Supply System located in the Kettle Creek Source Protection Area.

Table 7-1: Municipality of Bayham Municipal Residential Drinking Water Systems in the Long Point Region

DWS Number	DWS Name	Operating Authority	GW or SW	System Classification[1]	Number of Users served
260074854	Richmond Community Drinking Water Supply System	Municipality of Bayham	GW	Small municipal residential	51

1 as defined by O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002.*

7.1 Municipality of Bayham Richmond Water Supply System

The Municipality of Bayham owns and operates the water supply and distribution system which provides water to residents of the Village of Richmond. The system, which is groundwater-based, consists of three wells: one bedrock well (TW1-10), and two overburden wells (TW2-12 and TW3-12). The system supplies water to approximately 51 private residences in the Village of Richmond. **Map 7-1** shows the location of the well site and serviced area.

TW1-10 is an 81.4 m deep drilled well with an outside diameter (OD) of 168mm. The well is completed as an open hole into bedrock starting at 72.5 m below grade. TW1-10 is not actively pumped as part of the Richmond water supply system because of poor ambient water quality within the deep bedrock aquifer.

TW2-12 and TW3-12 are constructed within the shallow overburden sediments to depths of 17.4 m and 18.0 m below ground surface respectively and screened within an unconfined aquifer.

7.1.1 Vulnerability Assessment

Delineation of Wellhead Protection Areas

The Long Point Tier 3 FEFLOW groundwater flow model (Matrix, 2013) was used to generate the Wellhead Protection Areas (WHPAs) for the Richmond water supply system. The groundwater model was developed to support the development of the Long Point Region water budget and local area risk assessments. Development of the Tier 3 groundwater flow model and calibration is discussed in Matrix Solutions (2013). To delineate WHPAs for the Richmond municipal wells, the Tier 3 model was recalibrated in the Richmond area to better represent local conditions (Burnside, 2015).

A continuous pumping rate of 1.0 L/s for the municipal wells was used to generate the Richmond WHPAs. This rate also accommodates the possibility for future increases in demand. The final WHPAs are presented in **Map 7-2**.

Delineation of WHPA-E and WHPA-F

Delineation of additional WHPAs may be required for each well or wellfield that has been identified as groundwater under the direct influence of surface water under subsection 2(2) of O. Reg. 170/03 (referred to as GUDI wells). A WHPA-E is required for GUDI wells where the interaction between surface water and groundwater has the effect of decreasing the travel time of water to the well.

The overburden wells in the Village of Richmond were recommended to be considered GUDI without effective in-situ filtration. The closest surface water source to these wells is Big Otter Creek. An evaluation of the site geology and topography indicated that Big Otter Creek is located a significant distance below the well intake and is separated from the aquifer in which the wells are constructed by a layer of clay. As a result, a WHPA-E for the Village of Richmond wells was not delineated. Since a WHPA- E was not generated for these wells, a WHPA-F was also not delineated.

Vulnerability Scoring in Wellhead Protection Areas

The completion of aquifer vulnerability scoring is outlined under Part VII of the Technical Rules (MOE, 2009a). Mapping for this study was completed in three stages: i) development of aquifer vulnerability mapping ii) updated aquifer vulnerability to reflect the presence of potential transport pathways and iii) assignment of vulnerability scores.

Aquifer vulnerability mapping was completed within the Lake Erie Region Source Protection Area using the Surface to Aquifer Advection Time (SAAT) method (EarthFX, 2008). The SAAT method estimates the average time required for a water particle to travel from a point at the ground surface to the aquifer of interest. The SAAT is approximated by calculating the vertical component of the advective velocity integrated over the vertical distance and the average porosity.

The SAAT travel times were grouped based on guidance provided by the MOE to create ratings which were then used to construct an aquifer vulnerability map of the study area. Time-of-travel values less than 5 years were rated as highly vulnerable. Values between 5 and 25 years were classified as medium vulnerability, and values greater than 25 years were classified as having a low vulnerability. The vulnerability ratings based on the travel times are shown in **Table 7-2.** The unadjusted intrinsic vulnerability (SAAT aquifer vulnerability) for the Richmond area is shown on **Map 7-3.**

Table 7-2: SAAT Vulnerability Ratings

Time of Travel (years)	Vulnerability Rating
<5	High
5 to 25	Medium
>25	Low

Transport Pathways in the Richmond Wellhead Protection Area

Rules 39 to 41 of the Technical Rules (MOE, 2009b) allow for an increase in the 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 mapping as presented in **Map 7-3** accounts for potential transport pathways within the Richmond WHPAs. Further analysis of possible transport pathways within the Richmond WHPA indicated that no further updates to the vulnerability mapping were required. **Map 7-4** shows the final vulnerability scoring for the Richmond Wellhead Protection Areas.

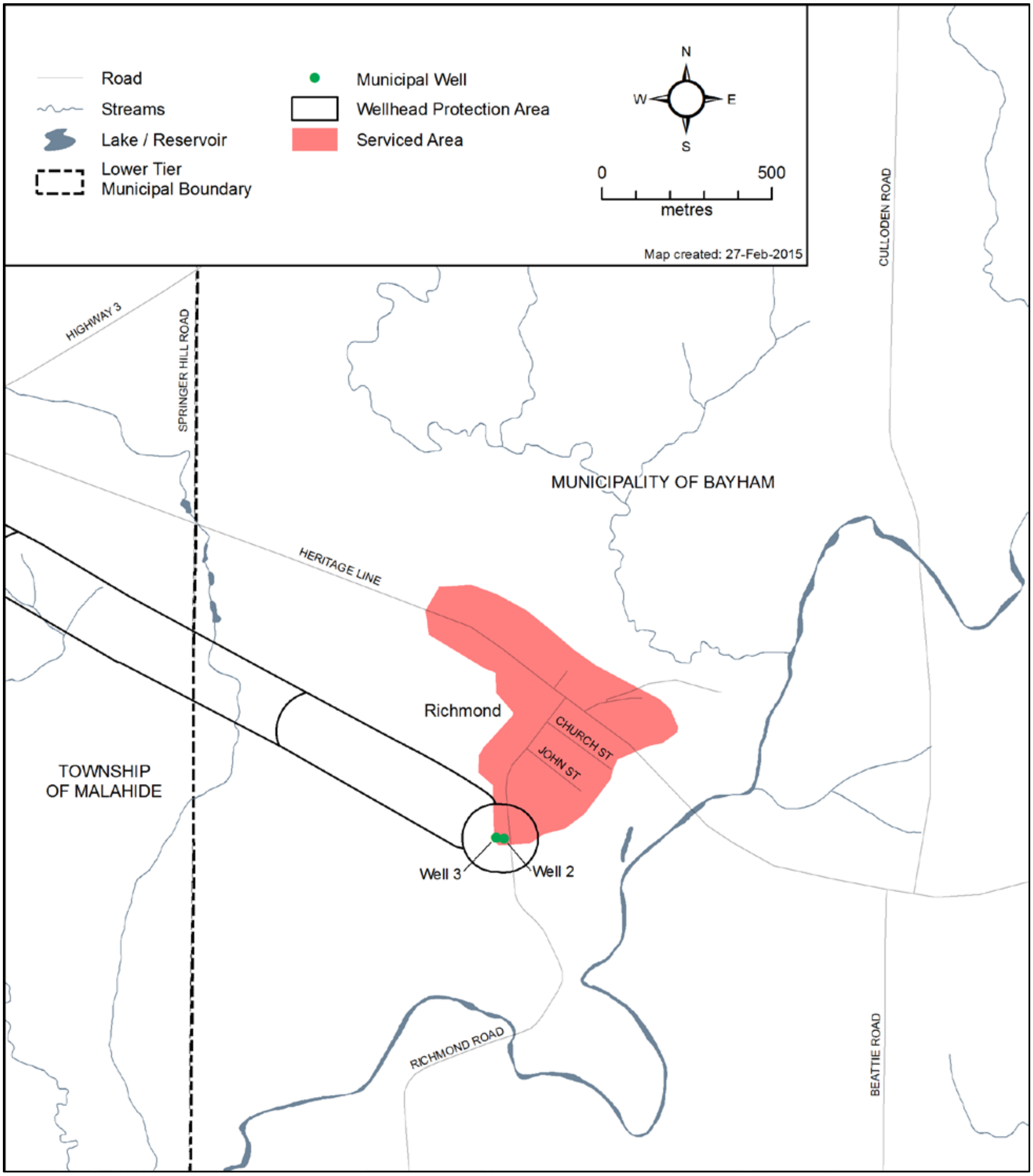
Uncertainty in the Wellhead Protection Area Delineation and Vulnerability Scoring for the Richmond Well Supply

The time-related capture zones that have been delineated in the overburden and bedrock are relatively long and narrow. These results are consistent with a setting in which wells pump at relatively low rates in permeable formations. In light of the fact that the capture zones are so narrow, there is significant uncertainty in their likely lateral extents. In addition to the high uncertainty assigned to the wellhead protection areas, there is also high uncertainty assigned to the vulnerability scores as vulnerability mapping for the Richmond wellfield was completed based on a regional scale SAAT map.

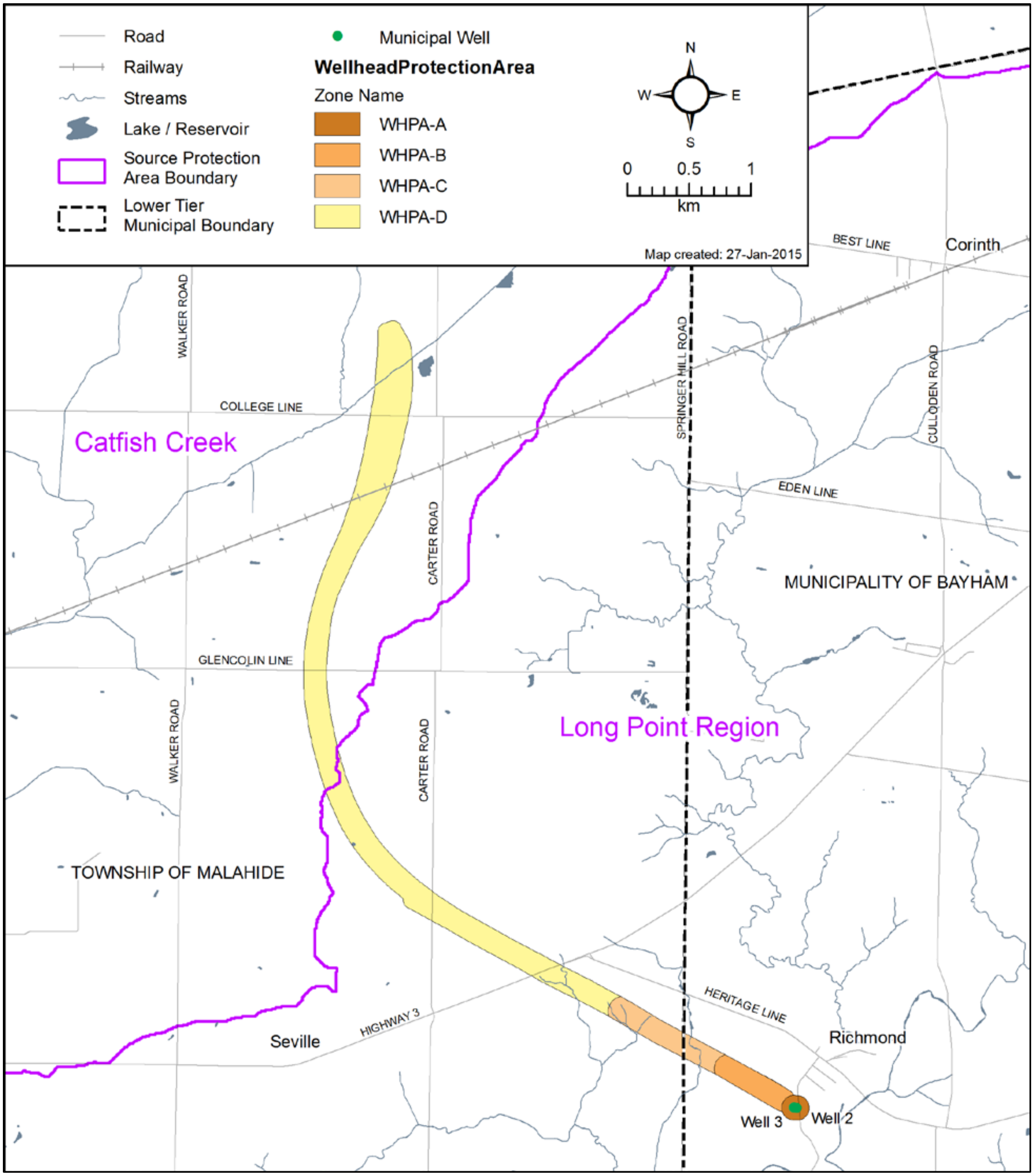
In addition, the uncertainties embedded in the Long Point Tier 3 model are carried through the Richmond analysis. Sources of uncertainty identified in the Tier 3 model include gaps in the characterization of the surface and groundwater systems; limitations in the climate and stream flow data; uncertainties associated with water use and in the representation of snow and urban systems; and limitations in the modeling approaches (Matrix Solutions, 2013). Additional sources of uncertainty have been identified in the re-calibrated Tier 3 model; these include uncertainty in the effective porosity of the overburden, gaps in the characterization of subsurface heterogeneity, and spatial and temporal local variations in the regional hydraulic gradient.

The WHPAs have been delineated to represent what is believed to be the long term average conditions based on the available data. High-quality data to support the analysis of groundwater flow conditions in the vicinity of Richmond are limited to one point in time at four wells. To account for the uncertainty in the delineation of the WHPAs it is recommended that a buffer be added to the WHPAs to provide a margin of safety.

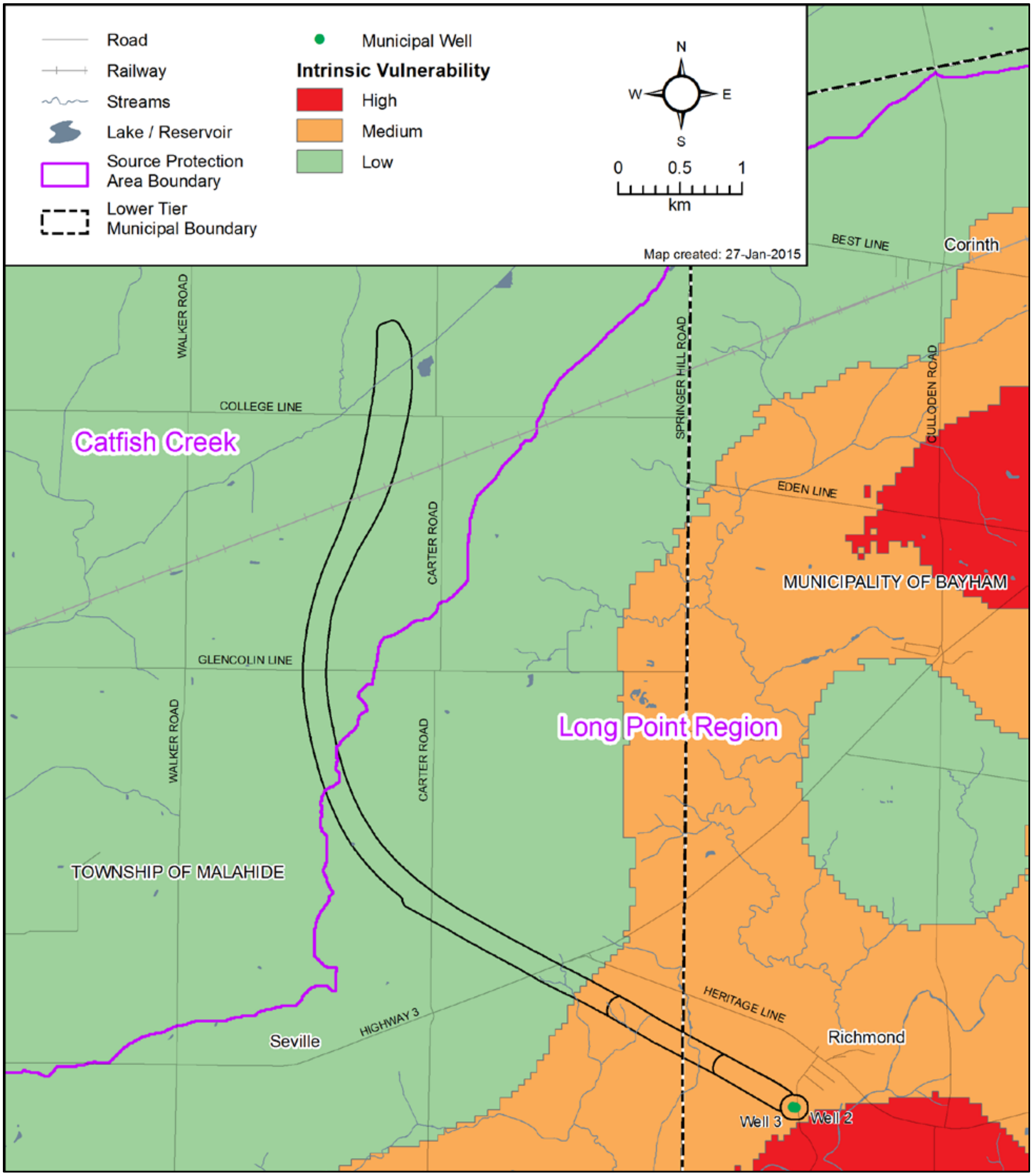
Map 7-1: Richmond Well Supply Serviced Areas



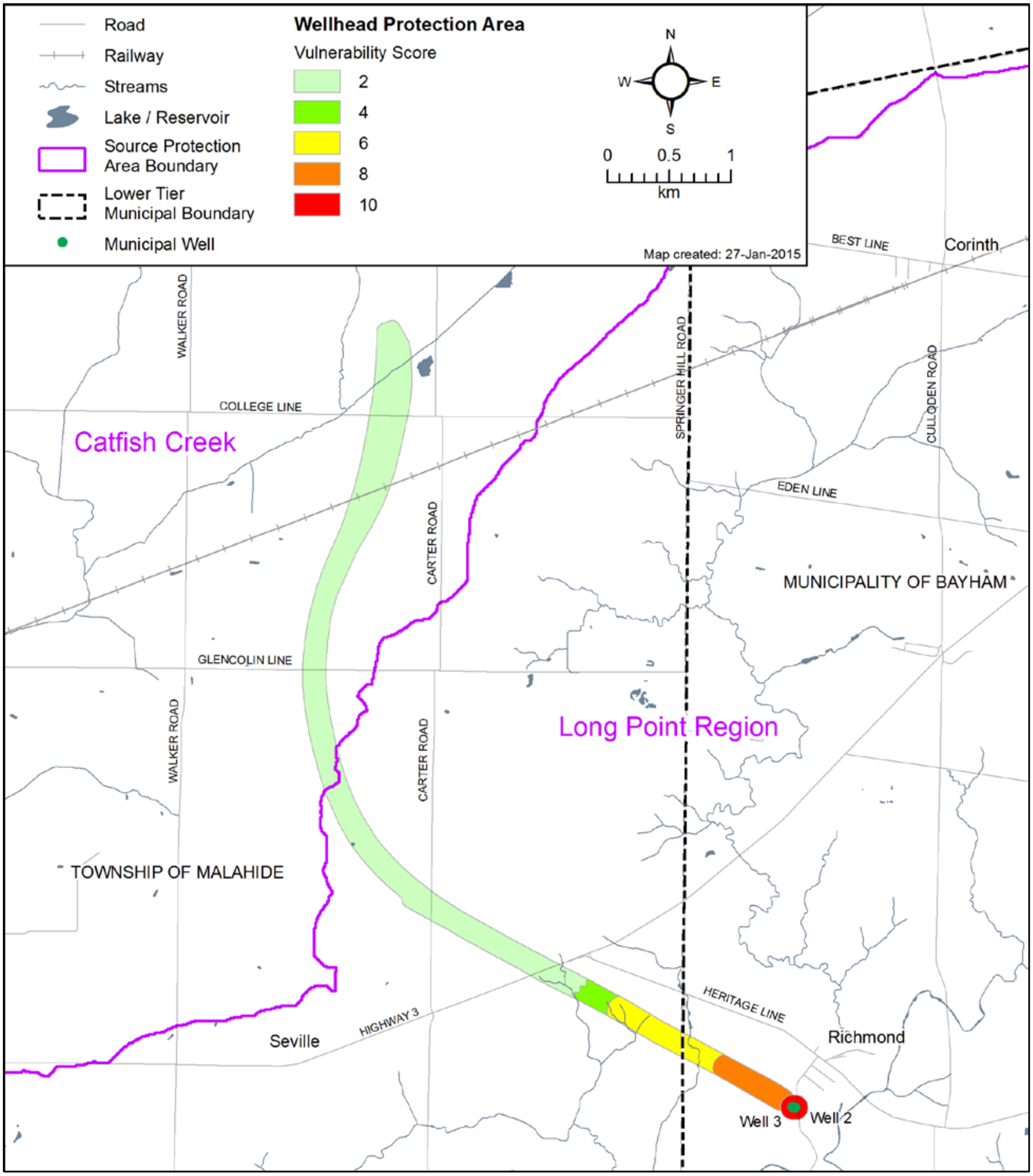
Map 7-2: Richmond Wellhead Protection Areas



Map 7-3: Richmond Wellhead Protection Area Intrinsic Vulnerability



Map 7-4: Richmond Wellhead Protection Area Vulnerability Scoring



7.1.2 Managed Lands and Livestock Density

Managed Lands are lands to which nutrients are applied. Managed lands can be categorised into two groups: agricultural managed land and non-agricultural managed land. Agricultural managed land incudes areas of cropland, fallow and improved pasture that may receive nutrients. Non-agricultural managed land included golf courses, sports fields, lawns and other grassed areas that may receive nutrients. Managed lands in the Richmond area were mapped based on a field visit (**Map 7-5**).

Livestock density is defined as nutrient units per acre of agricultural managed land within a vulnerable area. A nutrient unit is defined as the number of animals that will give the fertilizer replacement value of the lesser of 43 kilograms of nitrogen or 55 kilograms of phosphate per year as nutrients.

Livestock density was calculated using the MOE 2009 guidance “Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source of Material, Non-Agricultural Source of Material and Commercial Fertilizers”. Using aerial photography, livestock buildings were identified and square metre areas were measured for each structure. Each category of livestock was calculated into Nutrient Units as per the Barn/Nutrient Unit Relationship Table provided by the GRCA (2009) and area weighted given the amount of agricultural managed land that fell within each Wellhead Protection Area zone. The sum of the total Nutrient Units for each Wellhead Protection Area zone was then divided by the agricultural managed land area acreage to arrive at the NU/acre density for each Wellhead Protection Area zone. The Livestock Density values for the Village of Richmond are provided in **Map 7-6** and **Table 7-4**.

Table 7-3: Managed Lands Percentage in the Richmond Wellhead Protection Areas

Municipality	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Bayham	Richmond	TW2-12 and TW3-12	60%	90%	60%	N/A

Table 7-4: Livestock Density in the Richmond Wellhead Protection Area (Nutrient Units/Acre)

Municipality	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Bayham	Richmond	TW2-12 and TW3-12	0.0	1.1	0.0	N/A

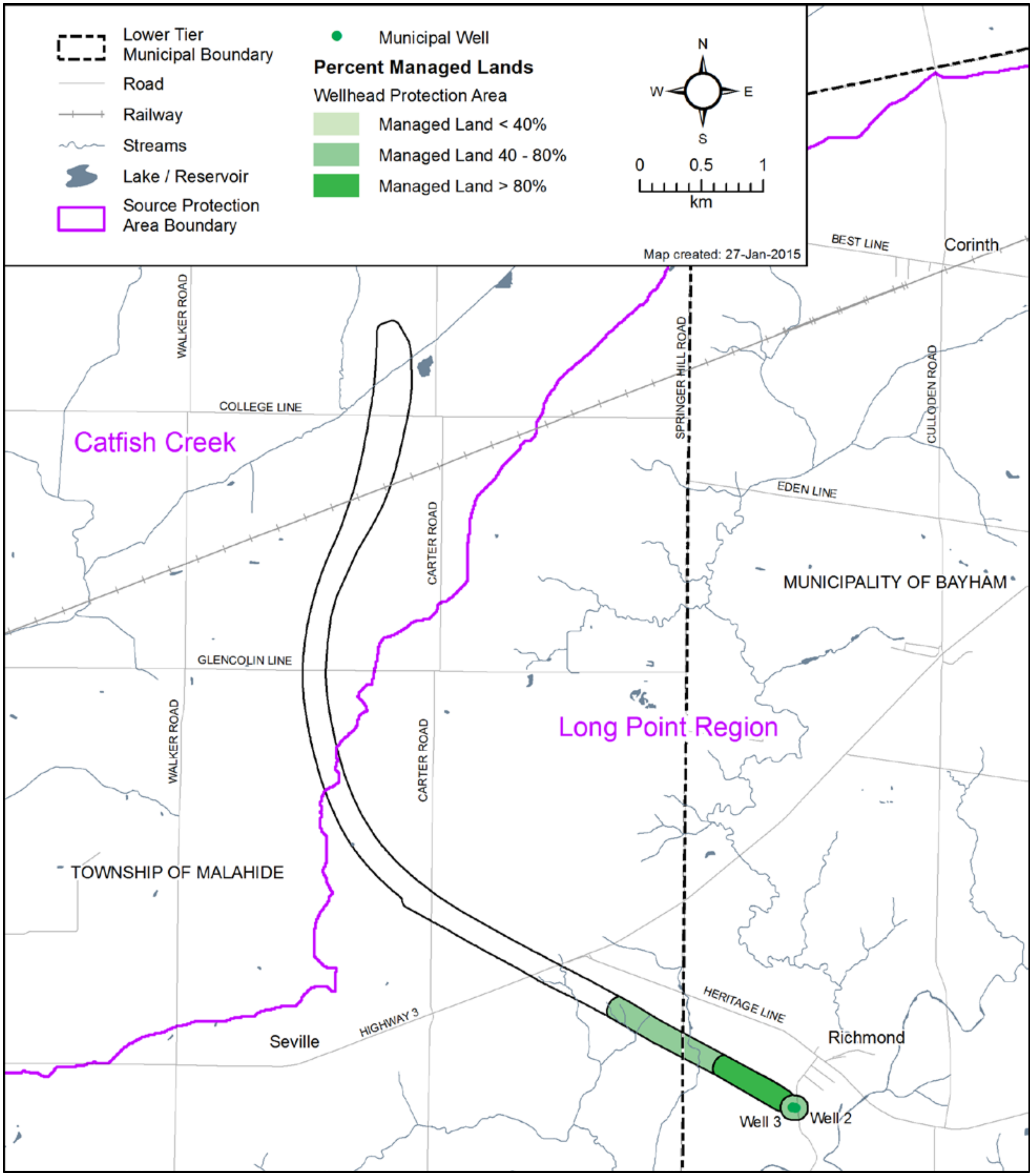
7.1.3 Percent Impervious Surface in Wellhead Protection Areas

To calculate the percent impervious surface, information on land cover classification from the Southern Ontario Land Resource Information system (SOLRIS) was used. This provided land use information, including road and highway transportation routes, as continuous 15x15 metre grid cells across the entire Source Protection Area. All the cells that represent highways and other impervious surfaces used for vehicular traffic were re-coded with a cell value of 1 and all other land cover classifications were given a value of 0, to identify impervious surface areas.

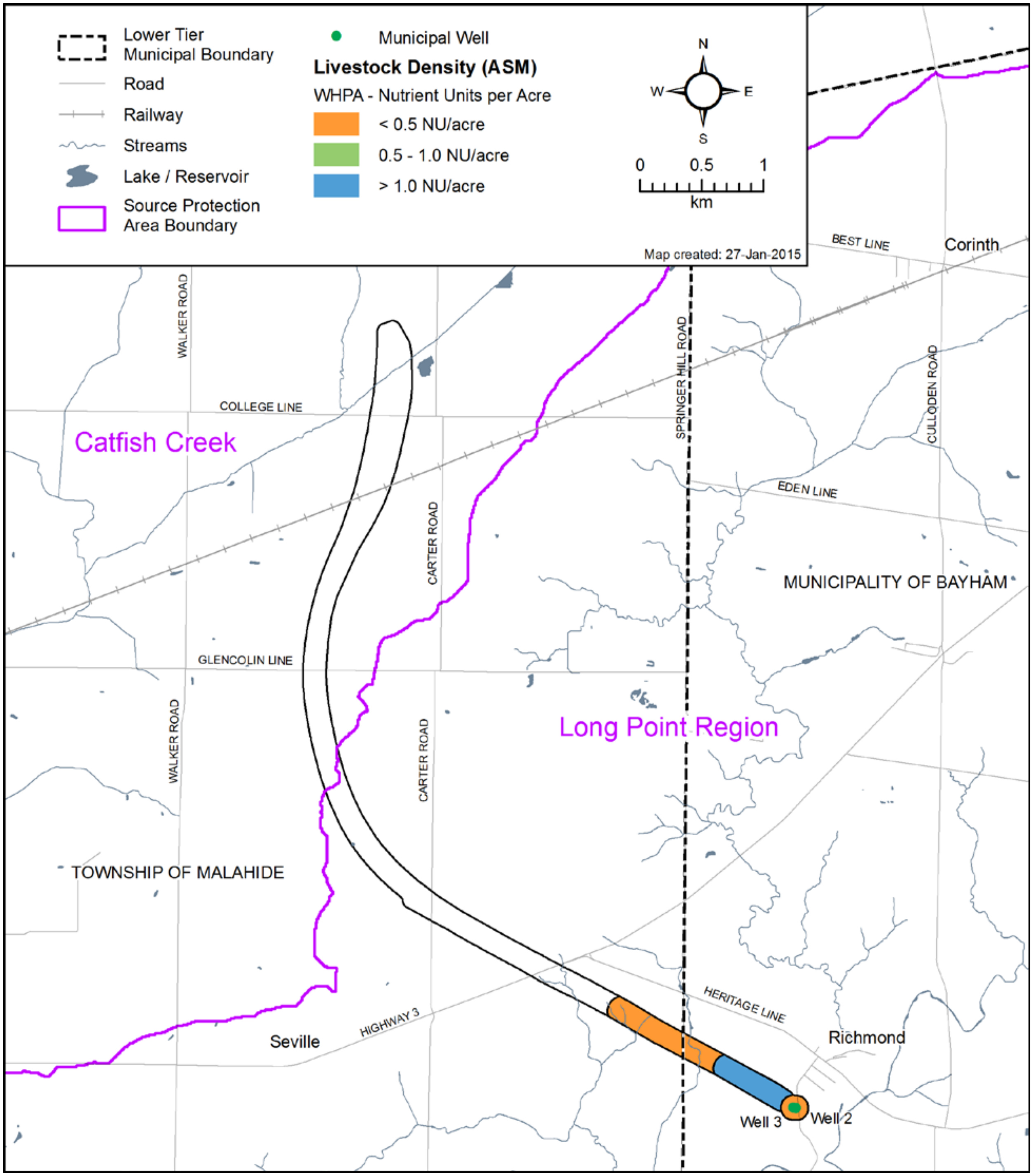
Then, a focal sum moving window average was applied using the Spatial Analyst module of the ArcGIS software. For each 15x15 metre cell, the total number of neighbouring grid cells coded as impervious, within a 1x1 kilometre search area, was calculated. This total was then converted into the percentage of impervious surface by land area, using the area of each cell (225 sq. m) and the area of the moving window (1 sq. km). This provides a 1x1 kilometre moving window calculation of percent impervious surface, represented in 15x15 metre spatial increments. This dataset was calculated for the entire Source Protection Area, but for Richmond was clipped to show those results only where the vulnerability score was 6 or above. The analysis is more representative of road density and is better than the method described in the Technical Rules. As per Technical Rule 15.1, the Director has confirmed his agreement with the departure. The Director's letter of confirmation can be found in **Appendix B**.

See **Map 7-7** for the impervious area percentages for the Richmond wellhead protection area.

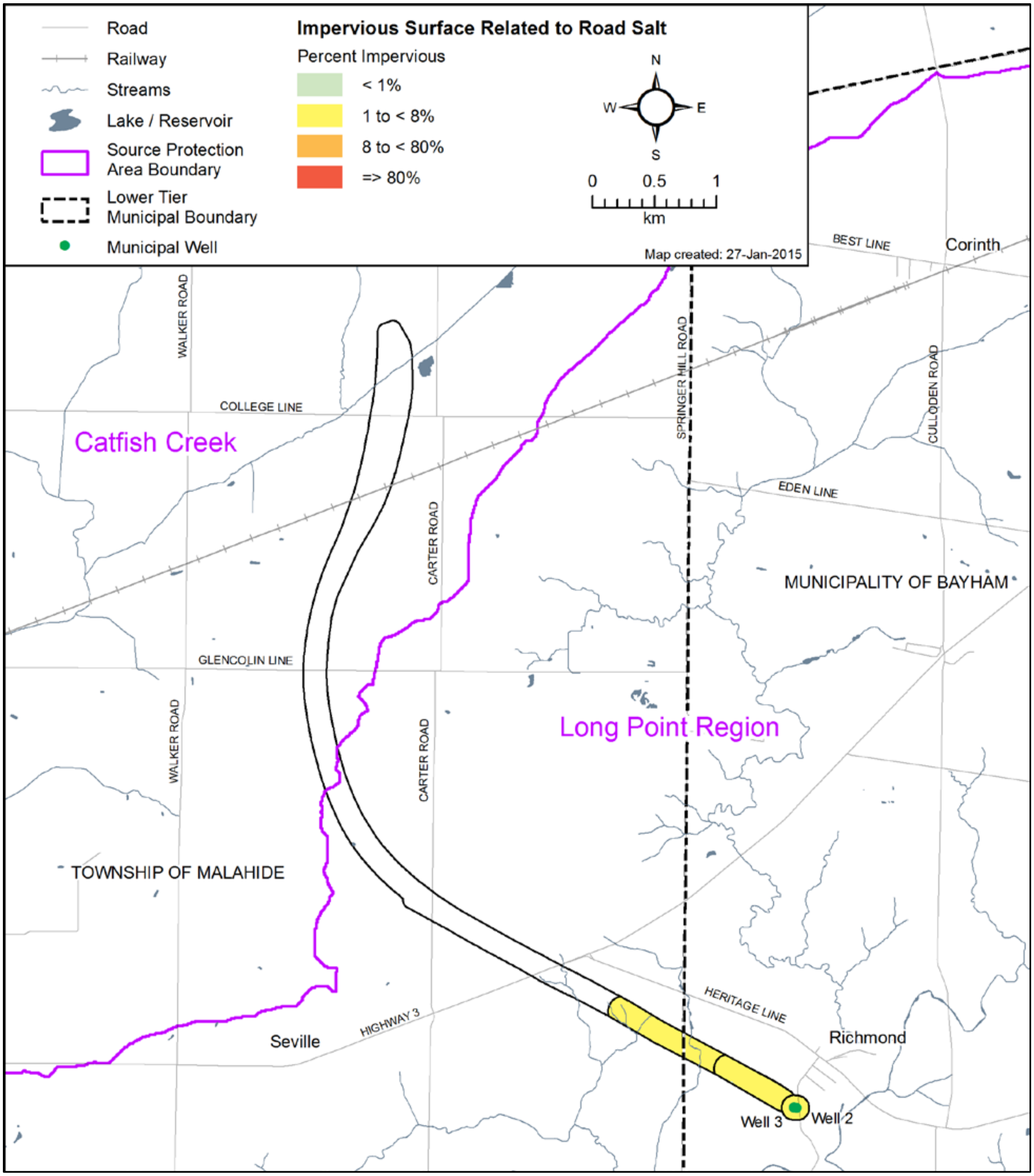
Map 7-5: Percent Managed Land within the Richmond Wellhead Protection Area



Map 7-6: Livestock Density within the Richmond Wellhead Protection Area



Map 7-7: Percent Impervious Surface within the Richmond Wellhead Protection Area



7.1.4 Richmond Water Quality Threats Assessment

The Ontario *Clean Water Act, 2006* defines a Drinking Water Threat as "an activity or condition that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water, and includes an activity or condition that is prescribed by the regulation as a drinking water threat."

The Technical Rules (MOE, 2009a) list five ways in which to identify a drinking water threat:

a) Through an activity prescribed by the Act as a Prescribed Drinking Water Threat;

b) Through an activity identified by the Source Water Protection Committee as an activity that may be a threat and (in the opinion of the Director) a hazard assessment confirms that the activity is a threat;

c) Through a condition that has resulted from past activities that could affect the quality of drinking water;

d) Through an activity associated with a drinking water issue; and

e) Through an activity identified through the events based approach (this approach has not been used in this Assessment Report).

Threats can fall into one of the following four categories:

- Chemical threats can include toxic metals, pesticides, fertilizers, petroleum products and industrial solvents;

- Pathogenic threats are microorganisms that could cause illness; and

- Dense non-aqueous phase liquids (DNAPLs) are chemicals which are denser than water and do not dissolve in water, such as chlorinated solvents.

- Through a condition that has resulted from past activities that could affect the quality of drinking water.

Significant threats to the Richmond water supply were assessed through the development of a desktop land use inventory. Following preliminary research a field assessment to verify the initial threats inventory was completed.

Activities that Are or Would be Drinking Water Threats in the Wellhead Protection Areas

Ontario Regulation 287/07, pursuant to the *Clean Water Act*, *2006* provides a list of Prescribed Drinking Water Quality Threats that could constitute a threat to drinking water sources. **Table 7-5** lists the activities that are prescribed drinking water threats. Listed beside the prescribed drinking water threats are the typical land use activities that are associated with the threat.

In addition, there is one local threat that has been identified in the Lake Erie Source Protection Region: the transportation of oil and fuel products through a pipeline.

A spill of oil and fuel products could result in the presence of petroleum hydrocarbons or BTEX in groundwater. The conveyance of oil by way of an underground pipeline that would be designated as transmitting or distributing "liquid hydrocarbons", including "crude oil", "condensate", or "liquid petroleum products", and not including "natural gas liquids" or "liquefied petroleum gas", within the meaning of Ontario Regulation 210/01 under the *Technical Standards and Safety Act* or is subject to the *National Energy Board Act,* was approved as a local threat. The letter of approval from the Director of the Source Protection Programs Branch and table of hazard ratings is found in **Appendix C**.

Table 7-5: Drinking Water Threats

Prescribed Drinking Water Threat Ontario Regulation 287/07 s.1.1.(1)		**Land Use / Activity**
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the *Environmental Protection Act.*	Landfills – Active, Closed Hazardous Waste Disposal Liquid Industrial Waste
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage Infrastructures Septic Systems, etc.
3	The application of agricultural source material to land.	e.g. manure, whey, etc.
4	The storage of agricultural source material.	e.g. manure, whey, etc.
5	The management of agricultural source material.	aquaculture
6	The application of non-agricultural source material to land.	Organic Soil Conditioning Biosolids
7	The handling and storage of non-agricultural source material.	Organic Soil Conditioning Biosolids
8	The application of commercial fertilizer to land.	Agriculture Fertilizer
9	The handling and storage of commercial fertilizer.	General Fertilizer Storage
10	The application of pesticide to land.	Pesticides
11	The handling and storage of pesticide.	General Pesticide Storage
12	The application of road salt.	Road Salt Application
13	The handling and storage of road salt.	Road Salt Storage
14	The storage of snow.	Snow Dumps
15	The handling and storage of fuel.	Petroleum Hydrocarbons
16	The handling and storage of a dense non-aqueous phase liquid.	DNAPLs
17	The handling and storage of an organic solvent	Organic Solvents
18	The management of runoff that contains chemicals used in the de-icing of aircraft.	De-icing
19	An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.	Private water taking
20	An activity that reduces the recharge of an aquifer.	Impervious Surfaces
21	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.	Agricultural Operations
Local Drinking Water Threat		**Land Use / Activity**
The conveyance of oil by way of an underground pipeline that would be designated as transmitting or distributing "liquid hydrocarbons", including "crude oil", "condensate", or "liquid petroleum products", and not including "natural gas liquids" or "liquefied petroleum gas", within the meaning of the Ontario Regulation 210/01 under the *Technical Standards and Safety Act* or is subject to the *National Energy Board Act.* [1]		Oil pipeline

[1]: As confirmed by the letter from the Director of the Source Protection Programs Branch in **Appendix C**.

Identification of Significant, Moderate and Low Drinking Water Quality Threats for the Richmond Well Supply

The identification of a land use activity as a significant, moderate, or low drinking water threat depends on its risk score, determined by considering the circumstances of the activity and the type and vulnerability score of any underlying protection zones, as set out in the Tables of Drinking Water Threats available through www.sourcewater.ca. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool: http://swpip.ca. For local threats, the risk score is calculated as per the Director's Approval Letter, as shown in **Appendix C**. The information above can be used with the vulnerability scores shown in **Map 7-4** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.

Table 7-6 provides a summary of the threat levels possible in the Richmond Well Supply for Chemical, Dense Non-Aqueous Phase Liquid (DNAPL), Pathogen, and Local Threats (Oil Pipelines). A checkmark indicates that the threat classification level is possible for the indicated threat type under the corresponding vulnerable area / vulnerable score; a blank cell indicates that it is not. The colours shown for each vulnerability score correspond to those shown in **Map 7-4**.

Table 7-6: Identification of Drinking Water Quality Threats in the Richmond Well Supply Wellhead Protection Areas

Threat Type	Vulnerable Area	Vulnerability Score	Threat Classification Level		
			Significant 80+	Moderate 60 to <80	Low >40 to <60
Chemicals	WHPA-A	10	✔	✔	✔
	WHPA-B	8	✔	✔	✔
	WHPA-C	6		✔	✔
	WHPA-D	2 & 4			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✔		
	WHPA-D	2 & 4			
Pathogens	WHPA-A	10	✔	✔	
	WHPA-B	8		✔	✔
	WHPA-C/D	Any Score			
Local Threat (Oil Pipelines)	WHPA-A	10	✔		
	WHPA-B	8		✔	
	WHPA-C	6			✔
	WHPA-D	2 & 4			

7.1.5 Conditions Assessment

Conditions are contamination that already exist and are a result of past activities that could affect the quality of drinking water. To identify a Condition, Part XI.3, Rule 126 of the CWA Technical Rules, lists the following two criteria for groundwater sources:

- The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area.

- The presence of a contaminant in groundwater in a highly vulnerable area, significant groundwater recharge area or a wellhead protection area, if the contaminant is listed in Table 2 of the Soil, Groundwater and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table.

The above listed criteria were used to evaluate potentially contaminated sites within the WHPAs to determine if such a Condition was present at a given site.

A review of available data regarding potential contamination within the WHPAs was completed. Data available included databases such as the National Environmental Emergencies System, Record of Site Condition and the Ontario Spills database. The search of available databases did not provide any evidence of a condition site within the Richmond WHPAs.

7.1.6 Drinking Water Quality Issues Evaluation

Raw water quality data obtained during pumping tests completed in 2013 was reviewed to determine if any parameters were in exceedance of the Ontario Drinking Water Quality Standards (ODWQS) (Stantec, 2013). It is worth noting when reviewing the following sections that TW1-10 is an 81.4 m deep well completed in a confined bedrock aquifer, whereas wells TW2-12 and TW3-12 are shallow overburden wells completed 17.4 m and 18.0 m below ground surface.

Microbiological Parameters

Samples were analyzed for *Escherichia coli (E. coli*.), fecal coliform, total coliforms, background bacteria and total aerobic spore formers. No bacteriological parameters exceeded the ODWQS Maximum Acceptable Concentration (MAC).

Inorganic Parameters

Results of the general chemistry/inorganic analysis indicated the following parameters exceeded the ODWQS MAC, the ODWQS Aesthetic Objectives (AO), the ODWQS Operation Guidelines (OG) and/or the Medical officer of Health Reporting Limit (MOH). These results are based on samples taken in 2010 for TW1-10, and 2012 for TW2-12 and TW3-12.

<u>TW1-10</u>

- Selenium (0.014 mg/L) slightly exceeded the ODWQS MAC of 0.01 mg/L.
- Hardness (550 mg/L) exceeded the ODWQS OG of 80 to 100 mg/L.
- Organic nitrogen (3.7 mg/L) exceeded the ODWQS OG of 0.15 mg/L.
- Chloride (450 mg/L) and sodium (300 mg/L) exceeded the ODWQS AO of 250 mg/L and 200 mg/L, respectively.
- Total dissolved solids (TDS) (1,300 mg/L) exceeded the ODWQS AO of 500 mg/L.
- Sulfide (150 mg/L) exceeded the ODWQS AO of 0.05 mg/L.
- Dissolved Methane (3.2 L/m^3) exceeded the ODWQS AO of 3 L/m^3.
- Turbidity (24 NTU) exceeded the ODWQS AO of 5.0 NTU.

<u>TW2-12</u>

- Nitrate (17 mg/L) exceeded the ODWQS MAC of 10 mg/L.

- Hardness (310 mg/L) exceeded the ODWQS OG of 80 to 100 mg/L.

<u>TW3-12</u>

- Nitrate (17 mg/L) exceeded the ODWQS MAC of 10 mg/L.
- Hardness (370 mg/L) exceeded the ODWQS OG of 80 to 100 mg/L.
- Organic nitrogen (0.3 mg/L) exceeded the ODWQS OG of 0.15 mg/L.
- Total dissolved solids (523 mg/L) exceeded the ODWQS AO of 500 mg/L.
- Sodium (41 mg/L) exceeded the ODWQS MOH of 20 mg/L.

Hardness concentrations were exceeded in groundwater pumped from each of the test wells, with these elevated concentrations being caused by dissolved calcium and magnesium. Water supplies having hardness concentrations greater than 200 mg/L are considered poor from a taste perspective; however, no aesthetic guideline has been established as the public acceptance of hardness may vary considerably according to the local conditions. Overall, elevated hardness concentrations are common to groundwater throughout southern Ontario and are not considered by the ODWS to be a health concern.

One sample was collected from each of the wells TW2-12 and TW3-12 in 2012 to be analyzed for nitrate along with other suites of parameters. Both wells had nitrate concentrations of 17 mg/L which exceeded the ODWQS of 10 mg/L. Additional samples were collected in 2013 and again in 2015 from both wells. TW2-12 had nitrate concentrations of 16.0 mg/L in 2013 and 16.7 mg/L in 2015. TW3-12 had nitrate concentrations of 6.99 mg/L in 2013 and 7.52 mg/L in 2015. The elevated concentrations in TW2-12 may be the result of nitrate leaching to the groundwater system from manure and/or fertilizers applied to the local agricultural lands, which are prevalent throughout the wellhead protection area. These agricultural practices may also be the source of the elevated concentration of organic nitrogen (0.3 mg/L) also detected in the water sampled from TW3-12.

Nitrate concentrations which exceed 10 mg/L in drinking water may cause blood related problems (i.e., methaemoglobinaemia); however, this condition has been shown to be restricted to babies and small children, whereas older children and adults drinking the same water are unaffected. Excess organic nitrogen in a water supply can result in operational difficulties in water treatment equipment (i.e., chlorination) and may be responsible for taste and odour problems; however, the presence of this parameter at elevated concentrations in the water supply is not considered to be a health-related risk. Organic nitrogen was also found to be notably high in the groundwater sampled from TW1-10 (3.7 mg/L).

The presence of elevated concentrations of total alkalinity (380 mg/L to 555 mg/L), ammonia (2.2 mg/L to 2.4 mg/L), iron (0.2 mg/L to 1 mg/L), methane (3.2 l/m_3), sulfide (150 mg/L) and non-detect concentrations of nitrate (<0.10 mg/L) in TW1-10 suggest that the groundwater system is characterized by anaerobic (i.e., reducing) conditions, providing further evidence that the bedrock aquifer is under confined conditions. Although a selenium concentration of 0.014 mg/L was detected in a groundwater sample that was obtained from TW1-10 during the pumping test, this concentration was only slightly over the MAC of 0.010 mg/L and, technically, could be considered to be at the ODWS.

Elevated concentrations of sodium were detected in the groundwater samples obtained from TW1-10 (300 mg/L) and TW3-12 (41 mg/L). These concentrations are in excess of the Medical

Officer of Health Report Limit of 20 mg/L and may pose a concern for individuals consuming the well water who are on a sodium-restricted diet.

Turbidity concentrations of 0.8 NTU and 24 NTU were detected in the groundwater samples obtained from TW3-12 and TW1-10, respectively. Where possible, water supplies that are treated should be equipped with filtration systems that are designed and operated to reduce turbidity levels to a target of less than 0.1 NTU.

Nitrate Assessment for the Richmond Water Supply

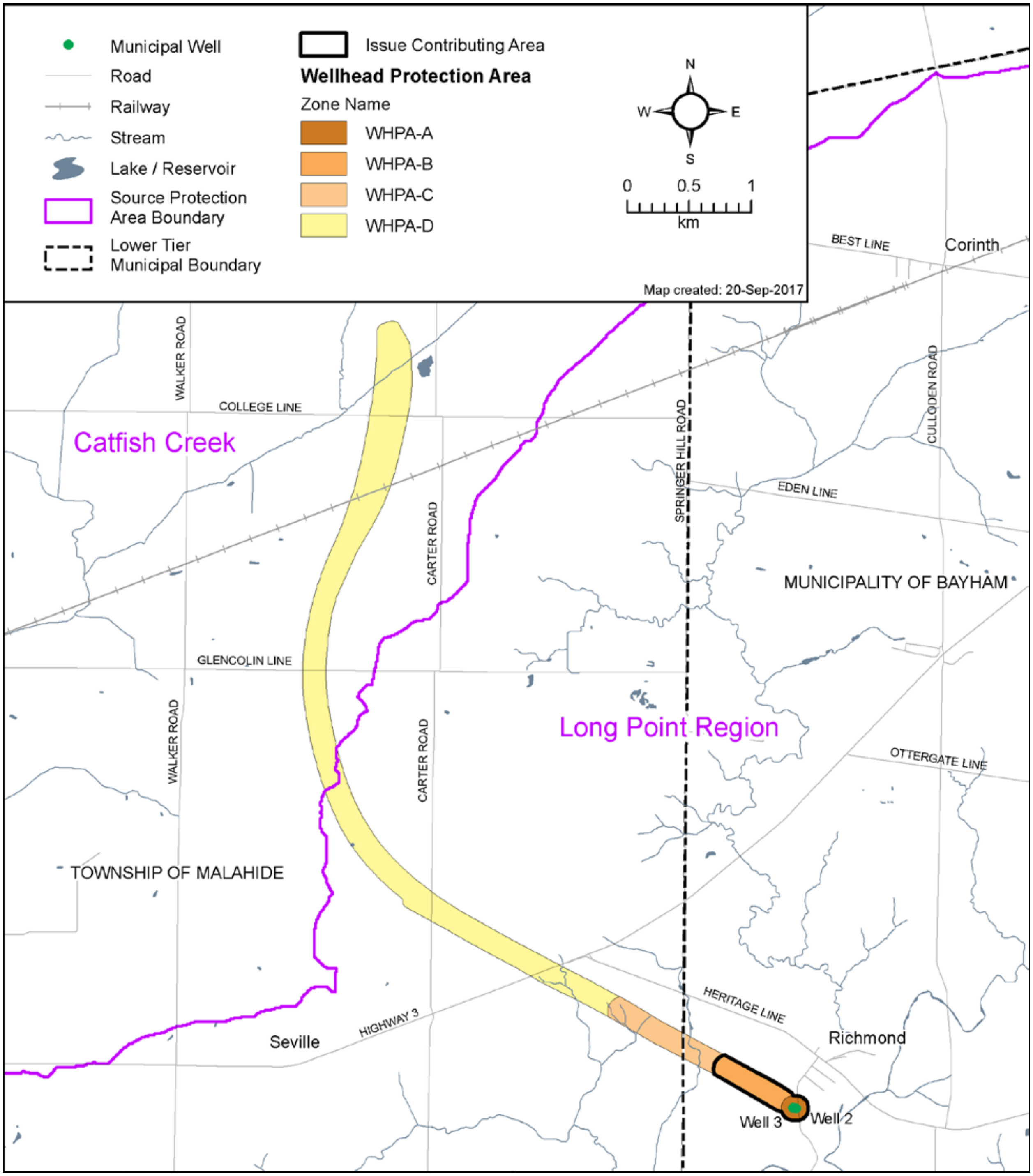
An additional nitrate investigation has been completed for municipal wells TW2-12 and TW3-12. As of February, 2015, both wells have been sampled on a monthly basis for nitrate and an annual monitoring report completed as per policy EC-CW-1.14 of the Long Point Source Protection Plan (BluMetric, 2017).

During the period February 2015 to June 2017, TW2-12 nitrate concentrations have ranged from 12.2 mg/L to 17.9 mg/L while TW3-12 nitrate concentrations have ranged from 5.58 mg/L to 17.2 mg/L. Nitrate concentrations in both wells have exceeded the ODWS of 10 mg/L on a consistent basis. Two raw water samples were submitted for isotope and artificial sweetener analysis in early 2015. Results indicated that nitrate is derived from the nitrification of ammonium; no artificial sweeteners were identified. The annual nitrate monitoring report (BluMetric, 2017), concluded that nitrate in wells TW2-12 and TW3-12 is most likely associated with nitrified fertilizers applied to the field immediately adjacent to the wells. It was recommended that monthly samples continue to be collected at both municipal wells to determine how pumping rates and total daily volumes being drawn at each well will influence nitrate levels at each well. In addition to the application of nitrified fertilizers, there is also the potential that nitrified fertilizers may be handled and stored adjacent to the wells.

Nitrate Issue Contributing Area for the Richmond Water Supply

As nitrate concentrations at the wells regularly exceed the nitrate MAC of 10 mg/L, nitrate was identified as a Drinking Water Issue under Technical Rule 114 of the *Clean Water Act, 2006,* and an Issue Contributing Area (ICA) delineated for the Richmond wellfield as shown on **Map 7-8**. Since wells TW2-12 and TW3-12 are screened in an unconfined overburden aquifer and classified as GUDI without effective in-situ filtration, and the pumping rate for the wellfield is comparatively small for a municipal wellfield, it is likely that the land uses located adjacent to the wells have the largest impact on nitrate concentrations in the groundwater. Therefore, the ICA for the Richmond wells extends to include only WHPAs A and B. The extent of the ICA was developed in consultation with the Municipality of Bayham’s Risk Management Official and municipal staff, based on conclusions from the annual monitoring report.

Map 7-8 Richmond Well Supply Issue Contributing Area



7.1.7 Enumeration of Significant Drinking Water Quality Threats

The Technical Rules require an estimation of the number of locations at which an Activity is a significant drinking water threat and the number of locations at which a Condition resulting from past activity is a significant drinking water threat.

The threats inventory was compiled using the data from various sources that were reviewed as part of this study. Following the preliminary research, field assessments were conducted to verify and complete the threats inventory process. As a conservative measure no effort to include the impact of management techniques that may be employed at any threat location was considered. It can therefore be concluded that the level of uncertainty associated with this inventory is high. It is through a re-evaluation of the prioritized threats that the level of uncertainty associated with the current results will be reduced.

Data Sources for the Activity Threats Assessment of the Richmond Well Supply

The threats inventory was compiled using the data and information sources outlined below. Following the preliminary research field assessments were completed to complete the threats inventory. All threats were recorded in a database provided by the MOE.

EcoLog Environmental Risk Information Services Ltd. (EcoLog ERIS) is a national database service, which provides specific environmental and real estate information for locations across Canada. A review of all available provincial, federal and private environmental databases was requested for the areas within a prescribed radius around the wells' Wellhead Protection Areas. The search included the following databases:

Federal Government Source Databases

- National PCB Inventory 1988-2008
- National Pollutant Release Inventory 1994-2012
- Environmental Issues Inventory System 1992-2001
- Federal Convictions 1988-June 2007
- Contaminated Sites on Federal Land June 2000-September 2015
- Environmental Effects Monitoring 1992-2007
- Fisheries & Oceans Fuel Tanks 1964-September 2003
- Indian & Northern Affairs Fuel Tanks 1950-August 2003
- National Analysis of Trends in Emergencies System (NATES) 1974-1994
- National Defense & Canadian Forces Fuel Tanks Up to May 2001
- National Defense & Canadian Forces Spills March 1999-August 2010
- National Defense & Canadian Forces Waste Disposal Sites 2001 – April 2007
- National Environmental Emergencies System (NEES) 1974-2003
- Parks Canada Fuel Storage Tanks 1920-January 2005
- Transport Canada Fuel Storage Tanks 1970-March 2007

Provincial Government Source Databases

- Certificates of Approval: 1985 – October 30, 2011
- Ontario Regulation 347 Waste Generators Summary: 1986 – April 2014
- Ontario Regulation 347 Waste Receivers Summary: 1986 - 2013
- Private and Retail Fuel Storage Tanks: 1989 - 1996
- TSSA Commercial Fuel Oil Tanks: 1948 – April 2013
- TSSA Fuel Storage Tanks: 2010 – May 2013
- Ontario Inventory of PCB Storage Sites: 1987 - Oct 2004

- Compliance and Convictions: 1989 – February 2014
- Waste Disposal Sites - MOE CA Inventory: 1970 – October 2014
- Waste Disposal Sites - MOE 1991 Historical Approval Inventory: Up to October 1990
- Pesticide Register: 1988 – June 2013
- Wastewater Discharger Registration Database: 1990 - 2011
- Non-Compliance Reports: 1992 (water only), 1994 - 2014
- Aggregate Inventory: Up to August 2012
- Abandoned Aggregate Inventory: Up to September 2002
- Record of Site Condition: 1997 - September 2001, October 2004 – October 2014
- Environmental Registry: 1994 – October 2014
- Ontario Spills: 1988- February 2014
- Abandoned Mine Information System: 1800 - January 2014
- Borehole: 1875 – August 2011
- Inventory of Coal Gasification Plants and Coal Tar Sites: April 1987 – November 1988
- Certificates of Property Use: 1994 – October 2014
- Drill Hole Database: 1886 – January 2014
- Environmental Activity and Sector Registry: October 31 2011 – October 2014
- Environmental Compliance Approval: October 31, 2011 – October 2104
- List of TSSA Expired Facilities: Current to May 2013
- Fuel Storage Tank Historic: Pre – January 2010
- TSSA Historic Incidents: 2006 – June 2009
- TSSA Incidents: June 2009 – April 2013
- Landfill Inventory Management Ontario: 2012
- Mineral Occurrences: 1846 – April 2013
- Ontario Oil and Gas Wells: 1800-2013
- Orders: 1994 – October 2014
- TSSA Pipeline Incidents June 2009 – March 2012
- Permit to Take Water: 1994 – October 2014
- TSSA Variances for Abandonment of Underground Storage Tanks: Current to June 2013
- Water Well Information System: 1955 – March 2014

Private Sources Databases

- Retail Fuel Storage Tanks: 1989 – July 2014
- Andersen's Waste Disposal Sites: 1860s to Present
- Scott's Manufacturing Directory: 1992 – March 2011
- Chemical Register: 1992,1999 – July 2014
- Automobile Wrecking & Supplies: 2001 – July 2014
- ERIS Historical Searches: 1999 – August 2014
    - Canadian Mine Locations: 1998 - 2009
    - Oil and Gas Wells: 1988 – September 2014
    - Canadian Pulp and Paper: 1999, 2002, 2004, 2005, 2009
    - Anderson’s Storage Tanks: 1915 – 1953

The database search identified numerous items within the search area. All threats identified have been mapped and compiled into the project database. Items identified by Ecolog ERIS included Certificates of Approval for municipal sewage, fuel storage tanks, registered waste generators under O.Reg. 347, registered pesticide vendors, manufacturing businesses and spills (Ecolog ERIS, 2014).

<u>Site Reconnaissance and Inspection</u>

Burnside conducted a drive-by roadside inspection of the WHPAs on November 10, 2014 to verify and compliment the dataset compiled during the records review portion of the assessment. The inspection consisted of a fence line/roadside documentation of the properties and their land uses included in the WHPA. Land uses within the WHPA include large areas of agricultural land and open space.

Significant Drinking Water Quality Threats for the Richmond Well Supply

As per the Technical Rules (MOE, 2009a), the enumeration of significant threats is required for the completion of the Assessment Report. **Table 7-7** summarizes the significant threats identified in the Richmond WHPAs as of September 2017.

Table 7-7: Richmond Well Supply Significant Drinking Water Quality Threats

PDWT #[1]	Threat Subcategory[2]	Number of Activities	Vulnerable Area
2	Sewage System Or Sewage Works - Septic System	2	WHPA-A
2	Sewage System Or Sewage Works - Septic System Holding Tank	2	WHPA-A
3	Application Of Agricultural Source Material (ASM) To Land	1	WHPA-A
6	Application Of Non-Agricultural Source Material (NASM) To Land (Including Treated Septage)	1	WHPA-A
8	Application Of Commercial Fertilizer to Land	1	WHPA-A ICA
10	Application Of Pesticide To Land	1	WHPA-A
Total Number of Properties		**3**	
Total Number of Activities		**8**	

1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07 s.1.1.(1).

2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.

Note: Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

Note: Storm sewer piping is not considered to be part of a storm water management facility.

Limitations and Uncertainty for the Enumeration of Significant Drinking Water Threats for the Richmond Well Supply

As part of the Richmond study, several databases were reviewed for the study area to collect information on the land use activities in the study area. There was no information available from the databases and the threats identified were enumerated solely on air photography interpretation and field reconnaissance. Both of these methods have a certain level of uncertainty as they are collected during a specific day and do not account for seasonal changes in land use. They also do not identify activities that are located within buildings or areas of the property not seen from the road.

In addition to the uncertainty associated with the threats inventory, the process of assigning a threat ranking was undertaken based on a number of simplifying assumptions. The uncertainty associated with the threat ranking is related to knowledge and understanding of the circumstances under which activities are conducted on a particular site. For this analysis, it was assumed that any possible threats associated with an activity were present and that all potential chemicals were present. This information was provided by the MOE in the form of look-up tables. The circumstances and quantity for each threat were assigned based on available knowledge such as typical storage practices, typical chemical quantities and typical waste disposal practices for that particular land use activity.

Based on the uncertainty involved in the threats inventory and the threat ranking for this study, the uncertainty for all of the threats has been classified as high. This level of uncertainty is expected in a desk top study. It is anticipated that additional information that is collected over time will allow for the uncertainty related to this assessment to be reduced.

The Technical Guidance outlines that each vulnerable area should be assigned an uncertainty of 'high' or 'low' to identify where information gaps exist. This process will assist in addressing data quality problems in future source water protection planning. **Table 7-8** summarizes the uncertainty assigned to each vulnerability area within the Richmond WHPAs.

Table 7-8: Richmond Wellhead Protection Area Vulnerability Uncertainty

	Uncertainty Type	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Threats Uncertainty	Location of Threats	Low	Low	High	High
	Circumstances of Threats	High	High	High	High
	Overall – Threats Uncertainty	High	High	High	High

Uncertainty of location of threats in the WHPAs is generally low as most were field verified. More effort was used to locate threats located in close proximity to the wells, therefore the uncertainty of locations of threats increases away from the wells.

The uncertainty of circumstances associated to threats located within the WHPAs can be decreased through additional threat verification and communication with land owners.

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