COMMUNITY OF SIMCOE, ONTARIO WATER QUANTITY RISK MANAGEMENT MEASURES EVALUATION PROCESS

Report Prepared for:
GRAND RIVER CONSERVATION AUTHORITY

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We certify that this report is accurate and complete and accords with the information available during the site investigation. Information obtained during the site investigation or provided by third parties is believed to be accurate but is not guaranteed. We have exercised reasonable skill, care, and diligence in assessing the information obtained during the preparation of this report.

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1 INTRODUCTION

The *Clean Water Act*, which came into effect in July 2007, sets the legal framework that ensures communities are able to protect their municipal drinking water supplies by developing collaborative, locally-driven, science-based protection plans. Communities will identify potential risks to local water sources and take action to reduce or eliminate these risks.

In October 2006, the Ministry of the Environment issued the document called *Assessment Report: Draft Guidance Modules* (Guidance Modules; MOE 2006) to guide the tasks being undertaken for the source protection technical studies in advance of the *Technical Rules: Assessment Report, Clean Water Act, 2006* (Technical Rules; MOE 2013).

To assist the Source Protection Committees (SPC) and the municipalities in formulating water quantity policies, the province developed a *Guide Water Quantity Risk Management Measures Evaluation Process* (RMM Evaluation Process; TRCA 2013a) and a *Water Quality and Quantity Risk Management Measures Catalogue* (RMM Catalogue; TRCA 2013b).

The RMM Evaluation Process is undertaken in the planning and implementation phases to inform the policy development process. This process is used to select and evaluate Water Quantity Risk Management Measures (RMM), using the Water Budget models developed in the *Tier Three Water Budget and Local Area Risk Assessment* (Tier Three Assessment), to determine what measures can be used to manage the Water Quantity Risks to drinking water within the Local Area.

The conclusion of the RMM Evaluation Process is recommendations for a Threats Management Strategy that gives guidance to the SPC to ensure the sustainability of the water resource that supplies the municipal drinking water system.

In the long term, the RMM Evaluation Process, the Water Quantity RMM Catalogue and the Threats Management Strategy will assist risk management officials with the establishment of policies where required by Source Protection Plans.

For this current study, the RMM Evaluation Process approach was applied to the municipal water supplies within the Community of Simcoe, Ontario (Simcoe). This study represents the next step in the Lake Erie SPC's mandate to manage the water quality and quantity in the area, following the completion of the Tier Three Assessments. This report outlines the RMM Evaluation approach used, the ranking of the Significant Water Quantity Threats identified in the Long Point Region Tier Three Water Budget and Local Area Risk Assessment (Matrix 2015), the application of the Water Quantity RMM Catalogue and web-tool, and the evaluation of RMM using the Tier Three Assessment Water Budget models. The results of this study were used to develop recommendations for a Threats Management Strategy to address the Significant Water Quantity Threats and minimize the Water Quantity Risk to the municipal water supplies.

1.1 Community of Simcoe Tier Three Local Area Risk Assessment

A Tier Three Assessment was completed for the communities of Waterford, Simcoe, and Delhi in Norfolk County (Matrix 2015) to estimate the likelihood that the municipal drinking water wells and surface water intake will be able to supply their Allocated pumping rates while considering future land development, drought conditions, and other water uses.

As part of that study, six Local Areas (designated Local Areas A through F), were delineated following the Technical Rules (MOE 2013) and Guidance Modules (MOE 2014), based on a combination of the cone of influence of each municipal well, land areas where recharge has the potential to have a measurable impact on water levels at the municipal wells, the surface drainage areas, which may contribute water to surface water intakes and the surface water bodies that contribute significant recharge to municipal wells. These Local Areas are areas on the landscape where increases in municipal pumping and reductions in recharge due to land use development (relative to the existing condition) have the potential to cause water levels at the municipal wells and intake to fall below safe water level elevations, or to reduce groundwater discharge to cold water streams that exceed the Province's thresholds.

A prescribed set of Risk Assessment Scenarios were run using a calibrated FEFLOW groundwater flow model and local-scale, integrated surface water/groundwater MIKE SHE models to estimate the changes in water levels in the Lehman Reservoir and in the municipal supply aquifers under average and drought conditions, and considering increased municipal demand and recharge reductions due to land use development. Results of the Risk Assessment Scenarios led to the designation of a Moderate Risk level for Local Area A (Chapel St. and Cedar St. well fields in Simcoe) due to predicted impacts to baseflow and a Provincially Significant Wetland (PSW) near Kent Creek and the Cedar St. Well Field. The Risk Level was elevated to a Significant Risk Level due to predicted drawdown exceeding the amount of safe additional available drawdown in Cedar St. wells 2A, 3, 4, and 5 under all groundwater Risk Assessment Scenarios. As a result, all consumptive water users and potential reductions to groundwater recharge within Local Area A were classified as Significant Water Quantity Threats (Figure 1).

The RMM Evaluation Process was applied in this study to rank those Significant Threats, and to evaluate potential RMM using the Tier Three Assessment local-scale MIKE SHE Water Budget model that encompasses the Chapel St. and Cedar St. well fields in Simcoe (the Simcoe South Local Model).

1.2 Organization

This report has been organized into the following sections corresponding to the RMM Evaluation Process approach detailed in Appendix A:

Section 2: Selecting the Water Budget Model

- Evaluation of the Tier Three Assessment model
- Update the Tier Three Assessment model

Section 3: Ranking Water Quantity Threats

- Identification of Significant Drinking Water Quantity Threats
- Threats Ranking Scenarios
- Percentage Impacts and Threats Ranking

Section 4: Evaluating Water Quantity RMM

- Evaluation of Historical Conservation Measures
- Identification of RMM
- Evaluation of the RMM
- Selection of Preferred RMM

Section 5: Recommendations for Threats Management Strategy

2 SELECTING THE WATER BUDGET MODEL

The Water Budget model created in the Tier Three Assessment for the Simcoe South study area (encompassing the Chapel St. and Cedar St. well fields) was developed using a local-scale integrated surface water/groundwater MIKE SHE flow model. This model was calibrated and verified against field observations of hydraulic head and streamflow, and used for the Tier Three Assessment (Matrix 2015).

2.1 Evaluation of the Tier Three Model

The Tier Three Assessment local-scale Simcoe South MIKE SHE model was examined and found to be suitable for the RMM Evaluation Process. The hydrogeologic and hydrologic characterization and conceptualization reported in the Tier Three Assessment was based on the most recent understanding, and no new geologic information or monitoring results have changed the conceptualization applied in this numerical model. Additionally, there are no new permitted pumping wells, or intakes that are not already represented in the model.

2.2 FEFLOW Tier Three Assessment Model Update

The regional FEFLOW Tier Three Assessment groundwater flow model was updated near the proposed municipal wells currently undergoing a Class Environmental Assessment (EA) northeast of Simcoe. This area is outside the boundaries of the local-scale Simcoe South MIKE SHE model and the boundaries of the other MIKE SHE models developed for the Tier Three Assessment, but it is located within the regional FEFLOW model that was also used to assess the Delhi municipal wells. For the RMM Evaluation Process, the FEFLOW model was calibrated transiently using a 72-hour constant rate aquifer test dataset consisting of water levels from 26 wells/piezometers used as calibration targets. The horizontal and vertical hydraulic conductivity of the simulated lower aquifer unit were refined through model calibration and guided by estimates of conductivity derived using pumping test data. Appendix B provides a full description of the model update, calibration dataset, and results.

The refinement and improvement of the FEFLOW model calibration in this area was necessary to test an RMM scenario where pumping from the Cedar St. wells was transferred to the future northeast wells in order to potentially reduce the Risk Level of Local Area A from Significant to Moderate. This is presented in Section 4.3.

3 WATER QUANTITY THREATS RANKING PROCESS

A Water Quantity Threats Ranking Process was undertaken for Simcoe as part of this study. The RMM Evaluation Process is undertaken for a municipality where the Tier Three Assessment estimated a Moderate or Significant Water Quantity Risk Level (TRCA 2013a). Significant and Moderate Drinking Water Quantity Threats are evaluated and ranked according to the impact they create, relative to the safe available drawdown (SADD), at a municipal well or intake. Through the Tier Three Assessment, Local Area A within the Simcoe South study area was assigned a Water Quantity Risk Level of Significant.

A detailed methodology for the ranking of the Moderate and Significant Drinking Water Quantity Threats is presented in the *Water Quantity Threats Ranking Scenarios Guide* (MOE and MNR 2009).

3.1 Identification of Significant Drinking Water Quantity Threats

As outlined in the Technical Rules (MOE 2013), a Drinking Water Quantity Threat is defined as 1) any consumptive water demand, or 2) any activity that reduces groundwater recharge to an aquifer. Consumptive demands are activities that extract water from an aquifer or surface water body without returning that water to the same aquifer or surface water body.

3.1.1 Consumptive Water Demands

For each vulnerable area identified under clause 15 (2) (d) or (e) of the *Clean Water Act*, Drinking Water Threats that are or would be classified as Moderate or Significant need to be identified within each vulnerable area. In the Tier Three Assessment, Local Area A within the Simcoe South study area was assigned a Water Quantity Risk Level of Significant; as such, all consumptive demands within Local Area A are classified as Significant Water Quantity Threats.

Figure 1 illustrates the permitted and non-permitted consumptive water uses within the Simcoe South study area. The only permitted water takers within Local Area A are municipal water supply wells, which are summarized in Table 1. The Tier Three Assessment identified additional permitted water takers found outside of Local Area A include three commercial takings and 25 agricultural takings. Permits for the three commercial takings have since expired and have not been renewed. Although only municipal water supply wells are found within Local Area A, Threats Ranking Scenarios were conducted for these previously permitted and non-permitted takings to understand the sensitivity of the municipal wells to these types of takings.

Table 1 Consumptive Water Uses and Water Quantity Threats

Local Area	Local Area Risk Level	Permitted Consumptive Demand (Threat)	Threat Classification
A	Significant	Cedar St. Well 1A	Significant
		Cedar St. Well 2A	Significant
		Cedar St. Well 3	Significant
		Cedar St. Well 4	Significant
		Cedar St. Well 5	Significant
		Infiltration Gallery	Significant
		Chapel St. Well	Significant

3.1.2 Reductions in Recharge

The Technical Rules (MOE 2013) specify that land use development activities that have the potential to reduce groundwater recharge are potential Water Quantity Threats within the Local Area. The Tier Three Assessment scenarios considered the impact of future land use development activities on water levels in the municipal wells. All reductions in groundwater recharge within Local Area A are also classified as Significant Water Quantity Threats and are shown on Figure 1.

3.2 Threats Ranking Scenarios

A series of scenarios were conducted using the transient Simcoe South MIKE SHE model. These scenarios were designed to evaluate and rank the Significant Threats according to the impact they create relative to the SADD at the well or intake.

The first scenario evaluated was the baseline scenario, which was the benchmark against which all modelling results were compared. When a municipal system has been assigned a Significant Risk Level for existing demands, the baseline scenario is to be one with no pumping (MOE and MNR 2009). This situation exists for this Local Area and thus the baseline scenario included the existing land use conditions and no groundwater pumping.

The Threats Ranking Scenarios are described in Sections 3.2.1 and 3.2.2 are summarized in Table 2.

Table 2 Threats Ranking Scenarios

Scenario	Description	Municipal Takings	Permitted Takings	Non-Permitted Takings	Land Use	Rationale
Baseline	Baseline Scenario	None	None	None	Existing	This scenario forms the baseline against which the model scenarios below are compared
I-A	Municipal Water Use (Allocated Rates)	Future Rates (Allocated)	None	None	Existing	Quantify the impact of increasing municipal pumping to Allocated Rates (from Existing rates) on the municipal water supplies
I-B	Non-permitted Takings (Unmetered Water Takings)	None	None	Existing	Existing	Quantify the impact of non-permitted demands on the municipal supplies
I-C	Permitted Non- municipal, Non-agricultural Takings	None	Existing	None	Existing	Quantify the impact of permitted water demands on municipal water supplies
I-D	Recharge Reduction - Official Plan	None	None	None	Official Plan	Quantify the cumulative impact of recharge reduction from all developments in the Official Plan on municipal water supplies
II-B-i	Agricultural Water Takings	None	Existing	None	Existing	Quantify the impact of agricultural water takings on municipal water supplies
III-A-i	Chapel St. Well	Future Rates (Allocated)	None	None	Existing	Quantify the impact of the Chapel St. Well takings on municipal water supplies
III-A-ii	Cedar St. Wells	Future Rates (Allocated)	None	None	Existing	Quantify the impact of Cedar St. wells takings on municipal water supplies
III-A-ii	Infiltration Gallery	Future Rates (Allocated)	None	None	Existing	Quantify the impact of Infiltration Gallery on municipal water supplies

3.2.1 Level I Scenarios

Level I Scenarios are mandatory scenarios that examined the cumulative impact of all current or future consumptive water uses, or future land use developments, on the municipal water supplies. Level I Scenarios identified which groups of takings or land use developments warrant a more detailed level of investigation.

3.2.1.1 Scenario I-A

Scenario I-A quantified the impact of the increased municipal pumping on the municipal water supplies. Municipal wells were pumped at their Allocated Rates as defined in the Tier Three Assessment (Table 3), while all other water takings were turned off. Existing land use development was used for this scenario.

Table 3 Municipal Water Takings

<table>
<tr><th>Well / Intake Name</th><th>Maximum Permitted Rate (m^3/day)</th><th>Existing Rate (m^3/day)</th><th>Committed Rate (m^3/day)</th><th colspan="2">Allocated Rate – Existing plus Committed (m^3/day)</th></tr>
<tr><td>Cedar St. Well 1A</td><td rowspan="5">6,819</td><td>401</td><td>102</td><td>503</td><td rowspan="5">Total = 2,270</td></tr>
<tr><td>Cedar St. Well 2A</td><td>257</td><td>102</td><td>359</td></tr>
<tr><td>Cedar St. Well 3</td><td>447</td><td>102</td><td>549</td></tr>
<tr><td>Cedar St. Well 4</td><td>282</td><td>102</td><td>383</td></tr>
<tr><td>Cedar St. Well 5</td><td>374</td><td>102</td><td>476</td></tr>
<tr><td>Infiltration Gallery</td><td>5,236</td><td>569</td><td>0</td><td colspan="2">569</td></tr>
<tr><td>Chapel St. Well</td><td>3,437</td><td>1,482</td><td>102</td><td colspan="2">1,584</td></tr>
<tr><td>Total</td><td>15,492</td><td>3,812</td><td>612</td><td colspan="2">4,423</td></tr>
</table>

3.2.1.2 Scenario I-B

Scenario I-B quantified the impact of non-permitted demands on the water supplies. In the area of the Chapel St. and Cedar St. well fields, non-permitted demands only consist of seasonal water takings for lawn irrigation. Other uses such as livestock watering were not identified in the Tier Three Assessment and thus are not included in this study.

A portion of residents are estimated to withdraw water from the near-surface Norfolk Sand Plain Deposits, using drive point wells, for the purposes of irrigation. As the number of these wells is unknown, and as these water takings are unmetered, an estimate of water use associated with lawn irrigation was computed using results from the Simcoe South MIKE SHE model and assumptions of typical residential irrigation practices. This is summarized in Appendix C. Consumptive use estimates were derived on a monthly basis for Simcoe during the typical lawn irrigation period (June through September). Average total consumption was estimated to range from 100 to 300 m^3/day during June to September depending on the number of residents assumed to be using drive point wells (5% to 15%; see Appendix C).

Upon review of that work, it was suggested that an estimate of the spatial distribution of these takings could be made that considered the location of Norfolk Sand Plain Deposits, socio-economic, and demographic data, residential property locations, residential water consumption data, and Google Street-View imagery of lawns in the Town of Simcoe. This was conducted by the Grand River Conservation Authority and four residential "quadrants" (Figure 1) were identified where the majority of unmetered takings are likely to be occurring (Etienne 2016, Pers. Comm.).

For this scenario, single wells (screened 2 to 3 m below ground surface) were added to the model to represent aggregates of the takings in each residential quadrant. The highest estimate of total unmetered water usage (300 m^3/day; Appendix C) was distributed evenly amongst the well. No other pumping was simulated and existing land use conditions were applied in this scenario.

3.2.1.3 Scenario I-C

Scenario I-C quantified the impact of three expired, non-municipal, previously permitted takings (Table 4) in the Simcoe South study area. These non-municipal takings were included in the Tier Three Assessment as they were permitted at the time of that study. Although they are not currently permitted, and do not fall within Local Area A, they were close to the Local Area and this scenario was evaluated to understand the sensitivity of the municipal wells to these types of takings. Existing land use conditions and only the three non-municipal, non-agricultural, previously permitted takings at the pumping rates defined for the Tier Three Assessment were represented in this scenario.

Table 4 Expired Non-Municipal, Non-Agricultural Previously Permitted Takings

Permit Number	Tier Three Rate (m^3/day)
99-P-2086	163
99-P-2086	163
99-P-2090	159
Total	**485**

3.2.1.4 Scenario I-D

Scenario I-D quantified the impact of recharge reduction from future land developments specified in the Official Plans. Future land use throughout the Simcoe South study area, not just within Local Area A, was considered in this scenario to evaluate the sensitivity of municipal wells to land use changes occurring nearby (Figure 1). All water takings were inactive in this scenario.

3.2.2 Level II and III Scenarios

Level II scenarios examine sector-based scenarios, which identify the potential impact that classes of permitted and non-permitted water takings and future land development have on municipal water supplies.

Level III scenarios are locally-relevant scenarios, which estimate the influence of specific water users or land use changes on municipal water supplies. Level III scenarios are designed to represent site-specific conditions and address existing or future water demands.

- Scenario II-B-i quantified the impact of agricultural takings on the municipal water supplies. While the agricultural takings do not occur within Local Area A, they occur to the west and south-west of the municipal water supplies (Figure 1). A total of 25 permitted agricultural takings were simulated with a total permitted rate of 43,618 m^3/day. The actual pumping rates in this scenario were based on the modelled irrigation demand as described in the Tier Three Assessment (Matrix 2015). On an annual average basis, 1,040 m^3/day was required to satisfy the irrigation demand for these 25 permits. As the MIKE SHE model accounted for the seasonality of these takings and only pumped water as needed to satisfy the irrigation demand, the majority of takings occurred during the summer months. This scenario was evaluated to understand the sensitivity of the municipal water supply to nearby agricultural takings under the pumping rates estimated in the Risk Assessment. This scenario considered existing land use, and all other water takings were inactive for this scenario.

- Scenario III-A-i quantified the impact of takings at the Chapel St. Well on municipal water supplies within Local Area A. This scenario considered existing land use, and only the water taking at the Chapel St. Well was represented at its Allocated pumping rate (1,584 m^3/day).

- Scenario III-A-ii quantified the impact of takings at the Cedar St. wells on municipal water supply within Local Area A. The Cedar St. wells were assessed as a group due to the close proximity of these wells to one another and the potential for mutual interference. This scenario considered existing land use, and only water takings at the Cedar St. wells were represented in the model. Allocated pumping rates (Table 3) were assigned to the Cedar St. wells (a total of 2,270 m^3/day).

- Scenario III-A-iii quantified the impact of takings at the Infiltration Gallery on the municipal wells within Local Area A. This scenario considered existing land use, and only water takings at the Infiltration Gallery were represented. Allocated pumping rates were assigned to the Infiltration Gallery (569 m^3/day).

3.3 Percentage Impacts and Threats Ranking

After the scenarios described in Section 3.2 were completed, the percentage impacts at each municipal well for each scenario were calculated according to the following formula:

$$Percent\ Impact = \frac{Incremental\ Drawdown\ Scenario\ 'a'}{Safe\ Available\ Drawdown\ (non-pumping)} \times 100\%$$

Where: ***Percent Impact*** is the modelled drawdown in a municipal well resulting from the simulation of Scenario 'a', relative to the total SADD (in this case, non-pumping) of that municipal well.

Incremental Drawdown Scenario 'a' is the difference between the simulated water level in a municipal well under baseline (in this case, non-pumping) conditions, and the simulated water level for a particular scenario.

Safe Available Drawdown (non-pumping) is the average distance between the water level at a municipal well in the baseline condition (in this case, non-pumping) and the minimum elevation at which the well can pump at an unrestricted rate. This is different from the Safe Additional Available Drawdown used for the Risk Assessment that was based on the average pumped water level in the wells. For the wells in this study, the minimum pumping elevation (safe water level) was set as the elevation of the top of the screen plus 1 m. For the Infiltration Gallery, the average floor elevation of the manholes was used as the safe water level.

The results for the Level I, II, and III Threat Ranking Scenarios are given in Table 5 and described below.

Table 5 Threats Ranking Scenario Impacts

Municipal Supply Well		Cedar St. Well 1A		Cedar St. Well 2A		Cedar St. Well 3		Cedar St. Well 4		Cedar St. Well 5		Infiltration Gallery		Chapel St. Well		Greatest Percent Impact
Safe Available Drawdown from Baseline Scenario (m)		6.1		0.4		1.0		-0.2*		1.4		2.4		6.1		
Threats Ranking Scenario		Incremental Drawdown														
		M	Impact	m	Impact	m	Impact	m	Impact	m	Impact	m	Impact	m	Impact	
I-A	Municipal Water Use (Allocated Rates)	1.2	19%	1.4	340%	1.6	162%	0.9	450%	2.1	152%	0.8	32%	2.1	34%	450%
I-B	Non-permitted Takings (Unmetered Water Takings)	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0%
I-C	Permitted Non-municipal, Non-agricultural Takings	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0%
I-D	Recharge Reduction - Official Plan	0.1	1%	0.0	6%	0.0	2%	0.0	8%	0.0	2%	0.0	1%	0.1	2%	8%
?																
II-B-i	Agricultural Water Takings	0.0	0%	0	0%	0	0%	0.0	0%	0.0	0%	0.0	0%	0.04	1%	1%
?																
III-A-i	Chapel St. Well	0.0	0%	0.0	7%	0.0	5%	0.0	20%	0.1	4%	0.1	3%	1.8	30%	30%
III-A-ii	Cedar St. Wells	0.9	15%	1.0	262%	1.3	126%	0.5	255%	1.8	125%	0.4	15%	0.1	2%	262%
III-A-iii	Infiltration Gallery	0.1	1%	0.1	14%	0.1	7%	0.1	62%	0.1	5%	0.2	7%	0.0	0%	62%

*negative safe available drawdown indicates the baseline scenario exceeded the safe water level.

3.3.1 Level I Scenario Impacts

Scenario I-A simulated all municipal supplies pumping at Allocated Rates, which resulted in a significant impact on the SADD within the municipal wells. The greatest percent impact (450%) occurs at Cedar St. well 4 where the SADD was -0.2 m indicating that the non-pumping condition exceeded the safe water level by 0.2 m. Pumping all the municipal wells and the Infiltration Gallery at Allocated Rates caused well 4 to drawdown 0.9 m from the baseline scenario or 450% of the already exceeded SADD. The next greatest impact was modelled at Cedar St. well 2A where 1.4 m of drawdown from the baseline non-pumping scenario was predicted, which represents 340% of the SADD at that well (0.4 m). Cedar St. wells 3 and 5 also had significant impacts due to municipal pumping (162% and 152%, respectively). These results were expected as the Risk Assessment showed that these four wells exceeded the safe water levels at the existing pumping rates and thus, the higher Allocated Rates also caused exceedances of the safe water levels. Given these results, Level III Threats Ranking Scenarios were undertaken to more closely examine the impacts of the individual municipal supplies (see Section 3.3.2).

Scenario I-B simulated the non-permitted water takings within the Simcoe South study area which, in this case, were estimated, unmetered water takings for irrigation. These takings had negligible impacts on the municipal wells with no measurable drawdown.

Scenario I-C simulated non-municipal, non-agricultural, previously permitted takings in the Simcoe South study area. These takings resulted in no measurable drawdown and thus had negligible effects on the municipal wells.

Scenario I-D simulated the impact of all future land use developments (Official Plan) and the associated recharge reductions in the Simcoe South study area. The reduced recharge had limited effect on the municipal wells with less than 0.1 m of increased drawdown at any municipal wells. Percent impact was up to 8% at the wells with less than 1.0 m SADD (Cedar St. wells 2A and 4), but 1% to 2% for most of the wells.

3.3.2 Level II and III Scenario Impacts

Scenario II-B-i simulated the impact of permitted, agricultural water takings in the Simcoe South study area. These takings had limited effects and did not exceed 1% impact at any of the municipal wells.

The Level III scenarios results showed that pumping at each of the municipal wells had the greatest percent impact on the wells themselves and a lesser impact on the nearby surrounding wells.

Increased pumping at the Chapel St. Well (Scenario III-A-i) had a 30% impact on itself and a 3% impact at the Infiltration Gallery. The Cedar St. wells were impacted by 0 to 20% of their respective SADD.

Pumping at Cedar St. wells (Scenario III-A-ii) had a percent impact on themselves ranging from 15% to 262%, a 15% impact at the nearby Infiltration Gallery, and only 2% impact at the Chapel St. Well.

Scenario III-A-iii simulated the impact of water takings from the Infiltration Gallery. The gallery impacted itself by 7% of its SADD or 0.2 m. Drawdown of 0.1 m occurred at the Cedar St. wells, corresponding to percent impacts from 1% to 62% of the respective SADD. Well 4 was most impacted by this withdrawal (62% impact) with others impacted by 1% to 14%. The Chapel St. Well was not impacted by the taking at the Infiltration Gallery.

3.3.3 Threats Ranking

The results from the Threats Ranking Scenarios listed in Table 5 allow the Significant Water Quantity Threats in Local Area A to be ranked according to the greatest percent impact they caused relative to the SADD at the municipal wells. This serves to identify the Threats that have the greatest potential to benefit from measures to reduce the overall impact. The Threats Ranking is summarized in Table 6.

Table 6 Threats Ranking – Local Area A

Water Quantity Threat	Greatest Percent Impact	Threats Ranking
Cedar St. Wells	262%	1
Infiltration Gallery	62%	2
Chapel St. Well	30%	3
Recharge Reduction - Official Plan	8%	4
Agricultural Water Takings	1%	5
Non-permitted Takings (Unmetered Water Takings)	0%	N/A
Permitted Non-municipal, Non-agricultural Takings	0%	N/A

From this ranking, it is clear that the Cedar St. wells were the Water Quantity Threats that had the most impact in the Local Area. The Infiltration Gallery was ranked second, and the Chapel St. Well was ranked third. Recharge reductions due to land use development to the Official Plan are ranked fourth related to the impacts at Cedar St. well 4. The remaining Threats did not have notable impacts on the municipal wells.

The results of the Threats Ranking were used to inform the next tasks, which involved selecting and evaluating the Water Quantity RMM and conducting RMM scenarios.

4 EVALUATING WATER QUANTITY RISK MANAGEMENT MEASURES

The purpose of this task is to evaluate the potential for RMM to mitigate the Water Quantity Threats and reduce the Water Quantity Risk Level identified through the Tier Three Assessment. This task makes use of the RMM Catalogue (TRCA 2013b), a web-based tool that is used to select RMM. It presently contains about 80 Water Quantity RMM, that are grouped into one or more of the following water conservation and “terrain” (e.g., land-use and land-practice) Management Targets to address Water Quantity Threats:

- indoor water use reduction
- outdoor water use reduction
- industrial, commercial, and institutional (ICI) water efficiencies
- municipal water loss management
- water resource awareness
- increase in recharge
- increase in water supply
- municipal water efficiencies
- agricultural water efficiencies - crop management
- agricultural water efficiencies - livestock management

The RMM Catalogue contains a dataset that is divided into these groups to allow the user to search for measures that are most applicable for managing the Water Quantity Threats activities in the Local Areas and that will be evaluated under the RMM Evaluation Process. The Tier Three Assessment Water Budget model may be used to evaluate certain measures, while other previously implemented measures may be evaluated with historical data.

4.1 Evaluation of Historical Conservation Measures

In evaluating the potential for RMM to mitigate the identified Water Quantity Risks, the water conservation measures implemented in the Local Area should be documented and the success of those conservation measures characterized. This will determine if other conservation-related RMM may have the potential to succeed in reducing the water demand, and in turn, reducing the Risk Level assigned to the Local Area.

Discussions with Norfolk County regarding conservation efforts that have been implemented by the County revealed that no further reduction in water use would be possible (Fields 2016, Pers. Comm.). The County is relying mainly on water metering and water pricing rates to encourage conservation by their customers and to control water demand. They have implemented outdoor water use restrictions, programs that encourage commercial and residential efficiencies, and customer education programs.

The water demand has reached a minimum level below, which would cause maintenance issues for the water distribution system. The system requires a minimum level of flow-through to ensure there is enough turnover in the system to prevent sedimentation. If the current level of water use was lower, the County would have to increase preventative flushing of the system, thereby increasing water use. Flushing in response to increased conservation would create an economically unviable situation where loss of revenue due to decreased customer use would be accompanied by the increased costs of maintenance.

4.2 Identification of Risk Management Measures

The RMM Catalogue web-tool was used to identify measures to be re-revaluated with the Tier Three Assessment model. Based on the results of the Threats Ranking, the RMM Catalogue was consulted under the specific category of Threat: “Consumptive water use–wells.” As the impacts from land use changes and recharge reductions were not significant, RMM related to the Threat from recharge reductions were not explored.

From this category of Threat, two RMMs were selected from the RMM Catalogue to be used to re-evaluate the risk to the Local Area using the Tier Three Assessment model. These measures fall within the “Municipal Water Efficiencies” Management Target, and are all applicable to the “Municipal Sector.” The selection of these measures was based on the results of the ranking process, which showed a high percent of impact from Cedar St. wells. Table 7 lists the measures chosen from the catalogue. Detailed information sheets from the RMM Catalogue for these RMM are provided in Appendix D.

Table 7 Selected Water Quantity Risk Management Measures

Reference ID	Measure Name	Measure Description
QT067	Optimization of Pumping Rates for Sustainable Yield	Optimization is a process of re-allocating pumping rates considering a target of maximum amount of groundwater that could be withdrawn from aquifers without violating hydraulic-head constraints, thus determining the “sustainable yield” for the source of water. Water budgets - optimization modelling can be used for the purpose of evaluating potential pumping scenarios and optimizing maximum groundwater withdrawal rates to determine sustainable yield for the aquifer while maintaining desirable hydraulic heads in the aquifer. Additionally, the optimization models can determine the maximum available withdrawals from major streams for supplementing groundwater to meet the total water demand.
QT004	Increase of supply - addition of new supplies	Finding a well or intake located outside of the WHPA-Q or IPZ-Q to supplement the existing supply if there is a shortage of water available in a community, without interfering with supply of drinking water for any other community.

4.3 Risk Management Measures Scenarios

Based on the above choices of RMM, three RMM scenarios were designed to evaluate the ability for the municipal system to supply the Allocated Quantity of water at a lower level of risk to the Local Area than identified in the Tier Three Assessment.

The RMM scenarios were designed based on discussions with Norfolk County (Fields 2016, Pers. Comm.). These discussions highlighted the following:

1. An opportunity for system optimization is to shift demand away from Cedar St. wells 1A and 2A which the County are planning to decommission in the future. Well 1A suffers from high turbidity and iron fouling leading to issues of iron sedimentation in the reservoir. Well 2A has very low yield that the County has tried to address by switching from a turbine pump to a submersible pump to allow for slightly increased pumping rates.

2. Cedar St. well 3 could also be decommissioned (in addition to wells 1A and 2A) and its demand shifted away from the Cedar St. Well Field. Well 3 will likely experience the same problems as wells 1A and 2A in future and decommissioning it will leave the remaining wells 4 and 5 with more spacing between them. This could help to reduce the Risk Level for the remaining wells.

3. Demand could be increased at the Chapel St. well, which has been pumping at 1,500 to 1,600 m^3/day and there is 800 to 900 m^3/day of additional capacity. Although this would be enough to accommodate the additional future demand from wells 1A and 2A (total Allocated Rate of 862 m^3/day), it would not be enough to sustainably accommodate the addition of the future demand of well 3 (549 m^3/day).

4. Demand could also be shifted to an alternate water source, such as the Northeast wells that are currently undergoing a Class EA.

4.3.1 Transfer of Pumping from Cedar St. Well Field to Chapel St. Well Field

The first two RMM scenarios were designed to explore RMM QT067 - “Optimization of Pumping Rates for Sustainable Yield” to see if shifting pumping away from the Cedar St. Well Field could reduce the Risk Level of the Local Area.

For the RMM Scenario 1, all pumping from Cedar St. wells 1A and 2A (total Allocated Rate 862 m^3/day) was shifted to the Chapel St. Well increasing the Allocated Rate at that well from 1,584 to 2,446 m^3/day. All other pumping in the scenario was the same as the Threats Ranking Scenario I-A with municipal pumping at the Allocated Rates.

For RMM Scenario 2, the Allocated Rate for Cedar St. well 3 (549 m^3/day) was moved to the Chapel St. Well in addition to that from wells 1A and 2A (total Allocated Rate of 1,411 m^3/day), thus increasing the rate of pumping at Chapel St. from 1,584 to 2,995 m^3/day.

The results for these scenarios are summarized in Table 8.

Table 8 Results of RMM Scenarios 1 and 2

Municipal Supply Well	Cedar St. Well 3		Cedar St. Well 4		Cedar St. Well 5		Infiltration Gallery		Chapel St. Well	
Safe Available Drawdown (m)	1.0		-0.2		1.4		2.4		6.1	
Model Scenario	Incremental Drawdown									
	m	Impact	m	Impact	m	Impact	m	Impact	m	Impact
Scenario 1: Cedar St. wells 1A & 2A pumping shifted to Chapel St. Well	1.1	112%	0.6	298%	1.6	114%	0.6	23%	3.3	54%
Scenario 2: Cedar St. 1A, 2A, and 3 pumping shifted to Chapel St. Well			0.4	223%	0.7	52%	0.5	19%	3.6	59%

With Scenario 1, by removing the pumping from Cedar St. wells 1A and 2A, the drawdown at the remaining Cedar St. wells and the Infiltration Gallery is reduced from that of Threats Ranking Scenario I-A (Table 5). The drawdown at well 3 drops from 1.6 to 1.1 m, well 4 decreases from 0.9 to 0.6 m, well 5 declines from 2.1 to 1.6 m and the Infiltration Gallery reduces from 0.8 to 0.6 m. The increase in pumping at Chapel St. Well causes the drawdown to increase from 2.1 to 3.3 m. Although, there were decreases in drawdown for the three remaining Cedar St. wells, they still exceeded the SADD from the baseline condition. Additional reductions in pumping from the Cedar St. wells are necessary to achieve a lower Risk Level where no wells exceed their SADD.

Scenario 2 showed improvements over Scenario 1 whereby the drawdown at the two remaining Cedar St. wells 4 and 5 was reduced further. A reduction in drawdown was achieved at well 5 such that the safe water level was not exceeded and the Risk Level is reduced to Low at that well. However, the reduction of drawdown at well 4 was not enough to reduce its Risk Level and the SADD was still exceeded. The increase of pumping at Chapel St. led to drawdown of 3.6 m which was within the SADD of 6.1 m.

4.3.2 Transfer of Pumping to Proposed Northeast Well Field

The RMM Scenario 3 was designed to test RMM QT004 – "Increase of supply - addition of new supplies." A Municipal Class EA is in process for a proposed Northeast Well Field that is outside of the Simcoe

South study area and the current Local Areas. This scenario was modelled to determine the potential extent of the new Well Head Protection Area for Water Quantity (WHPA-Q1) and subsequent Local Area) of a hypothetical new municipal well at the SW11/09 site northeast of Simcoe.

4.3.2.1 Model Refinement in the Proposed Northeast Well Field

The regional Tier Three Assessment groundwater flow model (FEFLOW) was refined northeast of Simcoe to explore the option of transferring demand from the Cedar St. Well Field to the proposed Northeast Well Field. As introduced in Section 2.2 above, the conceptual and numerical models were improved in this area through a transient calibration exercise, which utilized monitoring well drawdown data from 26 wells and piezometers for a 72-hour constant rate aquifer test conducted at a test well, SW11/09, at the site of a proposed new municipal well (Banks 2015). Hydraulic conductivity values in the numerical model were refined and guided by conductivity estimates derived using pumping test data. The calibration and verification results are summarized in Appendix B.

4.3.2.2 Local Area Delineation of the Proposed Northeast Well Field

The potential WHPA-Q1 of the proposed Northeast Well Field was delineated to assess its extent and to evaluate the possibility of the proposed site to take on some of the water demand from the Cedar St. Well Field. Existing Local Areas in Simcoe (Local Area A, B, and C; **Figure 2**) were originally delineated as part of the Tier Three Assessment (Matrix 2015). These areas were delineated using the 1 m drawdown contour of the WHPA-Q1 around the Cedar St. and Chapel St. well fields. The WHPA-Q1 is defined as the difference in model-predicted heads between two model scenarios:

1. Steady-state model simulating existing land use and no pumping, which established water levels that would exist without pumping.

2. Steady-state model simulating existing land use, existing pumping for all non-municipal permitted and non-permitted water takings, and Allocated (future) municipal pumping rates (Risk Assessment Scenario G[2]).

For more information on the WHPA-Q1, Local Area, Allocated Rates, and Risk Assessment Scenarios from the Tier Three Assessment, see Matrix (2015).

A safe perennial aquifer yield (4,560 m^3/day) was estimated by Banks (2015) based on the results of the aquifer test. This yield was used as the Allocated Rate at SW11/09 in the scenarios. All other Allocated Rates remained unchanged from the original G(2) Risk Assessment Scenario. The difference in model-predicted heads between the no-pumping and G(2) scenario was calculated and the maximum extent of the 1 m drawdown contour surrounding SW11/09 was selected following the methodology of the Tier Three Assessment. The predicted Local Area (in this case equivalent to the WHPA-Q1) for the SW11/09 site (Local Area D – Proposed Well) is shown on **Figure 2**, along with the other Local Areas previously delineated for the Tier Three Assessment (Local Areas A, B, and C).

This scenario indicated that a new municipal well at the proposed Northeast Well Field location would create a Local Area that is separate and distinct from the other Local Areas. This provides support for the RMM option to transfer pumping from the Cedar St. Well Field, to the proposed Northeast Well Field and possibly lower the Risk Level of Local Area A.

4.4 Selection of Preferred Risk Management Measures

Based on the above RMM scenarios results, the preferred RMM is QT004 – "Increase of supply - addition of new supplies." Attempts to optimize the existing system were not successful at reducing the Risk Level of Local Area A which would require all wells to not exceed their safe water levels while maintaining the ability to pump at the Allocated Rate. Thus, sourcing additional water supplies outside of the current Local Areas to supplement the existing supply is the preferred measure to manage the Water Quantity Risk.

5 RECOMMENDATIONS FOR THREATS MANAGEMENT STRATEGY

The RMM Evaluation Process is not intended to prescribe an entire policy development process for managing the Significant Drinking Water Quantity Threats. Once the RMM have been selected and evaluated, the most effective solutions are then suggested as the preferred RMM and a Threats Management Strategy can be developed to help municipalities understand how these measures could be implemented.

A Threats Management Strategy will address the Significant Threats identified in the Assessment Reports and ranked in this study. Matrix recommends the following be included in a Threats Management Strategy for Local Area A:

- Identify Local Area A as under a Significant Water Quantity Risk Level, and in particular, the Cedar St. wells as under the greatest risk in their ability to supply the Allocated Rates.

- Identify Cedar St. wells as Significant Drinking Water Quantity Threats to the sustainability of the Simcoe water supply.

- Identify the preferred RMM: QT004 – "Increase of supply - addition of new supplies."

- Provide a summary of expected policy outcomes that would result from the Water Quantity Source Protection Plan Policies. Matrix recommends the following:

    - PTTW Policies: Ensure future water takings do not impact the municipal supplies through the Permit to Take Water (PTTW) process. Where a future water taking could be a Significant Water Quantity Threat, require the Ministry of the Environment and Climate Change (MOECC) to ensure that the PTTW process includes use of the most recent Tier Three Water Budget findings, the Tier Three models and other available data to demonstrate that the taking can be maintained on a sustainable basis and will not affect the ability of the aquifer to meet municipal water supply requirements.

    - Land Use Planning Policies: Restrict future land development to the Official Plan and require that the relevant planning approval authority ensures that new developments 1) do not require a new or amended PTTW, 2) are only approved once the MOECC has determined that any proposed water taking meets the requirements of any PTTW policies, 3) conduct a water balance assessment of the proposed development, and 4) implement best management practices such as Low Impact Development (LID) to maintain pre-development groundwater recharge.

    - Growth Management Policies: Ensure that the Ministry of Municipal Affairs and Housing in consultation with the MOECC and Norfolk County use the findings of the Tier Three Assessment to ensure that growth forecasts or plans will not worsen the Significant Water Quantity Risk Level by increase water demand.

    - Source Protection Tools Policies: Ensure that the MOECC fund maintenance of the Tier Three Water Budget models as the primary model to review existing and future PTTWs and to facilitate the use of the models by other regulating and planning bodies as decision-making tools. This could include policies regarding the funding of surface and groundwater monitoring and additional data collection to enhance the conceptual and numerical models and verify the long-term predictions of the Tier Three Assessment.

- Provide a summary of timelines (including public consultation) for the implementation of the preferred RMM, and include a history of work done that supports the RMM. This could include a summary report on the Class EA currently for the Northeast Well Field currently in progress.

With the Threats Management Strategy, based on the information obtained through this RMM Evaluation Process, the Source Protection Committee can draft policies to address the Significant Water Quantity Threats, which can then be consulted on with stakeholders. These policies may then be included in the Source Protection Plan.

6 SUMMARY

The Long Point Region Tier Three Water Budget and Local Area Risk Assessment (Matrix 2015) delineated six Local Areas with Local Area A in Simcoe being assigned a Significant Water Quantity Risk Level. This Risk Level led to the designation of any consumptive water use or any activity that reduces groundwater recharge within the Local Area as a Significant Water Quantity Threat.

The Significant Threats were identified and ranked through a series of Threats Ranking Scenarios using the South Simcoe Tier Three Assessment (MIKE SHE) model to identify the percentage impact a Threat has on neighboring municipal wells.

Two RMM were selected from the RMM Catalogue and reviewed for their potential to mitigate the Water Quantity Risk and manage the Significant Threats.

Three RMM scenarios incorporating the selected RMM were evaluated using the Tier Three Assessment models under long-term average climate conditions:

1. Pumping was shifted from Cedar St. wells 1A and 2A to Chapel St. Well
2. Pumping was shifted from Cedar St. wells 1A, 2A, and 3 to Chapel St. Well
3. Pumping of a new well field northwest of Simcoe that is currently undergoing a Municipal Class EA was assessed

Scenarios 1 and 2 were not able to manage the Risk Level as some of the Cedar St. wells still exceeded their safe water levels under the future pumping conditions. Scenario 3 would be able to manage the Risk Level of Local Area A provided that enough pumping demand was transferred from the Cedar St. Well Field to the new source.

This RMM Evaluation Process demonstrated that there are few options for Norfolk County to mitigate the Water Quantity Risk that has been assigned to Local Area A through the Tier Three Assessment. An increase in water conservation measures is not viable, and attempts to optimize the pumping of the current system were not successful. Matrix recommends that the County continues to pursue additional water supplies outside of Local Area A. The Northeast Well Class EA currently in progress represents the best measure at this time for managing the Significant Water Quantity Risk Level.

The results of this RMM Evaluation Process are valuable to inform a Threats Management Strategy and any policies drafted by the Source Protection Committee or the municipalities to address the Water Quantity Threats.

6.1 LIMITATIONS

- The Threats Management Strategy suggested in this study represents only a few of the possible measures that could be considered by the local municipality. The final Threats Management Strategy for this area should be developed in consultation with all stakeholders and should consider all of the potential Water Quantity RMM.
- These evaluations are based on modelling and provide our best estimate of how the complex aquifer and surface water systems may respond to land use and pumping changes. The accuracy of

the model predictions can be confirmed, and refinements made as new data becomes available, and as understanding of the area improves.

- Climate changes and related hydrologic impacts are still uncertain and, depending on the future climatic conditions, climate change effects will likely affect the assignment of Risk Level in the Local Area. More certainty in climate change research and long-term monitoring of the affected municipal system is required.

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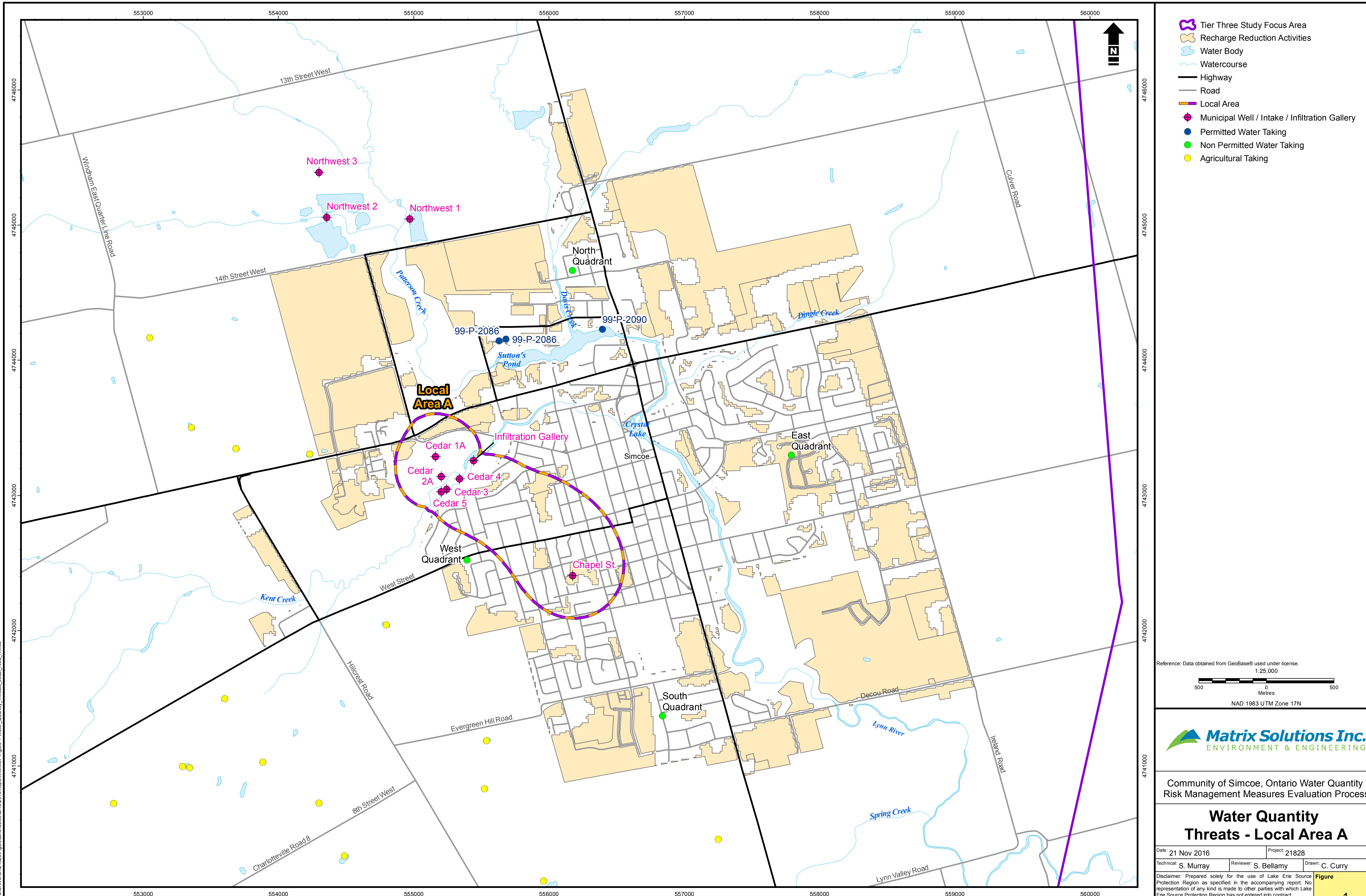

Tier Three Study Focus Area
Recharge Reduction Activities
Water Body
Watercourse
Highway
Road
Local Area
Municipal Well / Intake / Infiltration Gallery
Permitted Water Taking
Non Permitted Water Taking
Agricultural Taking
Local Area A
Northwest 3
Northwest 2
Northwest 1
Cedar 1A
Cedar 2A
Cedar 4
Cedar 3
Cedar 5
Infiltration Gallery
Chapel St.
99-P-2086
99-P-2086
99-P-2090
North Quadrant
East Quadrant
West Quadrant
South Quadrant
Simcoe
13th Street West
14th Street West
Windham East Quarter Line Road
Culver Road
Hillcrest Road
West Street
Evergreen Hill Road
8th Street West
Charlotteville Road 8
Decou Road
Ireland Road
Lynn Valley Road
Patterson Creek
Davis Creek
Sutton's Pond
Crystal Lake
Dingle Creek
Kent Creek
Lynn River
Spring Creek
553000
554000
555000
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Reference: Data obtained from GeoBase® used under license.
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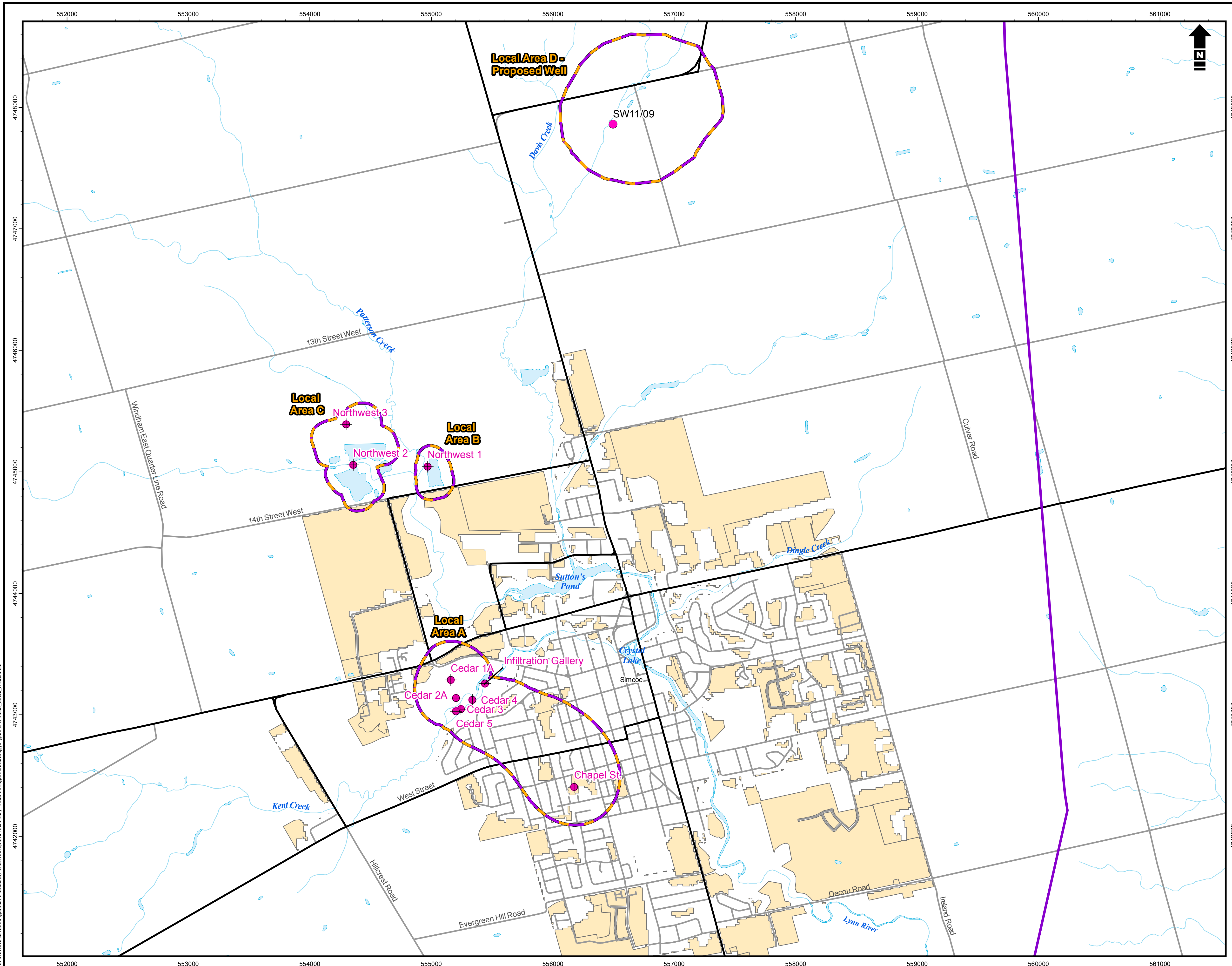
Metres
NAD 1983 UTM Zone 17N
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING
Community of Simcoe, Ontario Water Quantity Risk Management Measures Evaluation Process
Water Quantity Threats - Local Area A
Date: 21 Nov 2016
Project: 21828
Technical: S. Murray
Reviewer: S. Bellamy
Drawn: C. Curry
Disclaimer: Prepared solely for the use of Lake Erie Source Protection Region as specified in the accompanying report. No representation of any kind is made to other parties with which Lake Erie Source Protection Region has not entered into contract.
Figure
1



Tier Three Study Focus Area
Recharge Reduction Activities
Water Body
Watercourse
Highway
Road
Local Area
Municipal Well / Intake / Infiltration Gallery
Proposed Supply Well

Reference: Data obtained from GeoBase® used under license.

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500 0 500
Metres

NAD 1983 UTM Zone 17N

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Community of Simcoe, Ontario Water Quantity Risk Management Measures Evaluation Process

Simcoe Local Areas

Date: 21 Nov 2016	Project: 21828	
Technical: J. Melchin	Reviewer: P. Chin	Drawn: C. Curry

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Figure 2

APPENDIX A

Approach for the Water Quantity Risk Management Measures Evaluation Process

APPENDIX A

APPROACH FOR THE WATER QUANTITY RISK MANAGEMENT MEASURES EVALUATION PROCESS

The *Clean Water Act*, which came into effect in July 2007 sets the legal framework that ensures communities are able to protect their municipal drinking water supplies by developing collaborative, locally driven, science-based protection plans. Communities will identify potential risks to local water sources and take action to reduce or eliminate these risks.

In October 2006, the Ministry of the Environment issued the document called *Assessment Report: Draft Guidance Modules* (MOE 2006) to guide the tasks being undertaken for the source protection technical studies in advance of the technical rules and regulations under the *Clean Water Act* (MOE 2006a).

To assist the Source Protection Committees (SPC) and the municipalities to formulate water quantity policies, the province developed a *Risk Management Measures Evaluation Process* (RMM Evaluation Process; TRCA 2013a) and a *Water Quality and Quantity Risk Management Measures Catalogue* (RMM Catalogue; TRCA 2013b).

The RMM Evaluation Process will be undertaken in the planning and implementation phases to inform the policy development process. This process is used to select and evaluate measures, using the Tier Three Water Budget model, to determine what measures can be used to manage the Water Quantity Risks to drinking water within the Local Area.

The objective of the process is to help prepare a "Threats Management Strategy" that would give guidance for SPC to assuring the sustainability of the water source to the municipal drinking water system.

In the long term, the RMM Evaluation Process, RMM Catalogue and Threats Management Strategy will assist risk management officials with the establishment of strategies, where required by Source Protection Plans.

The following approach is a tested and consistent alternative approach that can be applied by any Source Protection Committee (SPC) in the province to rank Water Quantity Threats, consider impacts of climate change, and make use of the Water Quantity Risk Management Measures database and web-tool.

This Technical bulletin has been organized into the following sections:

Task 1: Selecting Water Budget Model

- Task 1.1: Evaluate applicability of existing Tier Three Assessment model
- Task 1.2: Evaluate possible new modelling tools

- Task 1.3: Update the Tier Three model or select new model, as required

Task 2: Ranking of Water Quantity Threats

- Task 2.1: Identify Significant Drinking Water Quantity Threats
- Task 2.2: Run Threats Ranking Scenarios
- Task 2.3: Identify Percentage Impacts and Rank Threats

Task 3: Evaluating Water Quantity Risk Management Measures

- Task 3.1: Document historical municipal water usage and implementation and success of conservation measures
- Task 3.2: Use the RMM Catalogue Database to Identify Preliminary Risk Management Measures
- Task 3.3: Evaluate the Risk Management Measures using the Water Budget Models and Part IX Technical Rules to mitigate Water Quantity Threats
- Task 3.4: Select Preferred Risk Management Measures

Task 4: Re-Evaluating Water Quantity Risk Management Measures for Climate Change Adaptation

Task 5: Develop Threats Management Strategy

Detailed descriptions of these tasks are given below.

TASK 1: SELECTING THE WATER BUDGET MODEL

- Task 1.1: Evaluate applicability of existing Tier Three Assessment model

  - Identify new municipal pumping wells or intakes.
  - Update hydrogeologic and hydrologic characterization or conceptualization based on new geologic understanding, pumping wells, and/or monitoring results.
  - Input any new permits to take water (PTTW) that were not previously included in the model.

- Task 1.2: Evaluate possible new modelling tools

  - Why was (were) the previous model(s) developed?
  - How does (do) the current model(s) perform?

- Task 1.3: Update the Tier Three model or select new model, as required

TASK 2: RANKING OF THE TIER THREE LOCAL AREA MODERATE AND SIGNIFICANT THREATS

Significant Drinking Water Quantity Threats identified in the Tier Three process are then evaluated and ranked according to the impacts created relative to the safe additional drawdown at a well or intake. In some instances, there may be no requirement for the Threats to be ranked (e.g., if the Local Area contains only municipal systems that belong to a single municipality); therefore, appropriate preliminary Risk Management Measures may be selected.

Detailed methodology to undertake the ranking of the Moderate and Significant Drinking Water Quantity Threats in a Local Area is presented in the *Water Quantity Threats Ranking Scenarios Guide* (MOE and MNR 2009).

- Task 2.1: Identify Significant Drinking Water Quantity Threats
- Task 2.2: Run Threats Ranking Scenarios

    - A series of scenarios are run (Table A-1) using the Tier Three Water Budget model for areas where more than one demand(s) and/or land use development(s) were identified as Significant Threats in a Local Area.

    - In all instances, the first model scenario run is the baseline scenario; the results of this scenario set the benchmark against which all modelling results will be compared.

    - Numerical groundwater or surface water flow models developed in a Tier Three Water Budget will be used to examine the impact of land use changes, or increased water demands, on the municipal water supplies and other water uses, in a tiered approach similar to the Water Quantity Risk Assessment:

        - Level 1 Scenarios examine the cumulative impact of all current or future consumptive water uses, or land use developments, on municipal water supplies.

        - Sector-based (Level II) scenarios are designed to examine the impact of each sector of water use or land use development (e.g., industrial, agricultural, etc.) on the municipal water supplies and other uses.

        - Locally Relevant (Level III) Scenarios are used to rank the impact of individual water takings or land use development changes on municipal water supplies or other water users.

In summary, ranking scenarios may have to be evaluated for areas where there are several types of water demands and/or land use developments. Table A-1 summarizes the model scenarios that should be run using the Water Budget tools (calibrated surface water or groundwater models). In all instances, the first model scenario run is the baseline scenario; the results of this scenario set the benchmark against which all modelling results will be compared.

Numerical groundwater or surface water flow models developed in a Tier Three Assessment will be used to examine the impact of land use changes, or water demands, on the municipal water supplies and other water uses. Scenarios that examine the cumulative impact of all current or future consumptive water uses, or land use developments, on municipal water supplies are termed Level I Scenarios. If a Level I scenario predicts an adverse impact on drinking water supplies or other water users, sector-based (Level II) scenarios or locally relevant (Level III) scenarios will be required to estimate the relative impact from specific consumptive water users.

Sector-based (Level II) scenarios are designed to examine the impact of each sector of water use or land use development (e.g., industrial, agricultural, etc.) on the municipal water supplies and other uses. Locally Relevant (Level III) Scenarios are used to rank the impact of individual water takings or land use development changes on municipal water supplies or other water users.

The scenarios include permitted, non-permitted, current, and future water uses as identified in the Tier Three Water Budget and Local Area Risk Assessment (Tier Three Assessment). For this Guide, the term "non-permitted" refers to wells or intakes that extract water at a rate less than 50,000 L per day; wells that were active prior to the start of the Ontario Permit to Take Water process (grandfathered), livestock watering, fire control, and those wells or intakes awaiting a new or renewed permit should be considered as permitted wells in this assessment.

TABLE A-1 Threats Ranking Scenarios

Scenario	Description	Municipal Takings	Permitted Takings	Non-Permitted Takings	Land Use	Rationale
Baseline	Baseline Scenario	Existing or None	None	None	Existing	This scenario forms the baseline to which the model scenarios below will be compared.
I-A	Municipal Water Use (Allocated Rates)	Allocated Rates	None	None	Existing	Quantify the impact of increasing municipal pumping to Allocated Rates (from existing rates) on the municipal supplies.
I-B	All Non-Permitted Takings	Existing or None	None	Existing, Max Practical, or Future Consumptive	Existing	Quantify the impact of all non-permitted demands on the water supplies.
I-C	All Permitted Takings	Existing or None	Existing, Max Practical, or Future Consumptive	None	Existing	Quantify the impact of all permitted water demands on municipal water supplies.
I-D	Recharge Reduction - Official Plan	Existing or None	None	None	Official Plan	Quantify the cumulative impact of recharge reduction from all developments in the Official Plan on municipal water supplies.
II-A-x	Non-Permitted Takings - Sector Based -Sector X	Existing or None	Consumptive Sector X^2	None	Existing	Quantify the impact of each non-permitted sector (e.g. agricultural, domestic, etc.) on municipal water supplies.
II-B-x	Permitted Takings - Sector Based -Sector X	Existing or None	Consumptive Sector X	None	Existing	Quantify the impact of each permitted sector (e.g., industrial, commercial) on municipal water supplies.
II-C-x	Recharge Reduction - Sector Based (Official Plan)	Existing or None	None	None	Official Plan Land Use Section X	Quantify the impact due to recharge reduction from each development sector (e.g. industrial, commercial) on municipal water supplies.
III-A-X	Local Water Demand Scenario - Consumptive Water Taking X	Existing or one	Consumptive User X	None	Existing	Quantify the impact of individual consumptive takings on the municipal water supplies.
III-B-Y	Local Groundwater Recharge Reduction Scenario- Activity Y	Existing or None	None	None	Official Plan Land Use Section Y	Quantify the impact of individual developments on the municipal water supplies.

- Task 2.3: Identify Percentage Impacts and Rank Threats

    - After the scenario runs have been completed, the percentage impact changes to the safe additional drawdown at the wells or intakes are calculated by comparing the drawdown of each scenario with the baseline scenario drawdown.

    - Water users and proposed development(s) are tabulated in ranked order. This will identify the Threats that have the greatest potential to reduce the overall percent of impact on water quantity.

TASK 3: EVALUATING WATER QUANTITY RISK MANAGEMENT MEASURES

The purpose of this task is to evaluate the potential for Risk Management Measures to mitigate the Water Quantity Risks identified through the Tier Three Local Area Risk Assessment. Presently the RMM Catalogue contains about 80 Water Quantity Risk Management Measures which can be grouped into one or more of the following water conservation and "terrain" Management Targets to deal with the prescribed Water Quantity Threats:

- Indoor water use reduction
- Outdoor water use reduction
- Industrial, commercial, and institutional (ICI) water efficiencies
- Municipal water loss management
- Water resource awareness
- Increase in recharge
- Increase in water supply
- Municipal water efficiencies
- Agricultural water efficiencies - crop management
- Agricultural water efficiencies - livestock management

The dataset was divided into these groups to allow the user to search for measures that are most applicable to manage the activities in the source protection areas. The Management Targets related to water conservation align with actions listed in other provincial initiatives.

- Task 3.1: Document historical municipal water usage and implementation and success of conservation measures.

    - Compile municipal water demands since completion of Tier Three.

    - Prepare list of water conservation measures implemented by municipality. Provide description or analysis of the success of these implementation measures.

- Task 3.2: Use the RMM Catalogue Database to Identify Preliminary Additional Risk Management Measures
  - After considering the ranked Threats and previously implemented Risk Management Measures, select additional Risk Management Measures from the catalogue to re-evaluate the risk to the Local Area using the Tier Three Water Budget Models.
  - Filter or group the Risk Management Measures by Sector or by Management Target. The purpose of this grouping is to direct and help focus the selection and analysis of measures based on the analysis of the results of the ranking process.
- Task 3.3: Evaluate the Risk Management Measures using the Water Budget Models and Part IX Technical Rules to mitigate Water Quantity Threats
  - Update the Tier Three Water Budget Models to reflect the selected preliminary Risk Management Measures and re-evaluate the Water Quantity Risk scenarios and the level of risk assigned to the Local Area.
  - Once the Water Budget models are modified to reflect the inclusion of the RMM, the models are re-run for the Tier Three risk scenarios to determine if the measure(s) will lower the risk assigned to the Local Area. If so, the user proceeds to the next step.
  - If the assigned Risk Level to the Local Area does not change, the user returns to the catalogue to select new or additional Risk Management Measures. This process is repeated iteratively until the Moderate and Significant Water Quantity Threats and Risk Level of the Local Area are effectively managed.
  - The minimum requirement of this task is to re-run the Tier Three Scenarios to evaluate risk under average and drought conditions. Depending on the number of Risk Management Measures and the number and types of Moderate or Significant Threats, the number of scenarios may be expanded to isolate the risk evaluation.
  - The selection of conservation measures applied to residential, ICI and municipal sectors are expected to lead to a cumulative reduction in water demand. The cumulative amount of water saved through conservation efforts will depend on local factors such as the estimated number of existing and planned residents, planned development and relevant conservation measures such as the installation of low flush toilets, recycling of water and water returned to the source in a reasonable time period.
- Task 3.4: Select Preferred Risk Management Measures

- Once the preliminary Risk Management Measures have been selected and evaluated, the most effective solutions are then identified as the "Preferred Risk Management Measures."

TASK 4: RE-EVALUATING WATER QUANTITY RISK MANAGEMENT MEASURES FOR CLIMATE CHANGE ADAPTATION

If required or recommended, a Climate Change Adaptation assessment may be conducted using multiple climate scenarios on the preferred Risk Management Measures.

TASK 5: DEVELOP THREATS MANAGEMENT STRATEGY

The "Threats Management Strategy" will be developed to deal with Moderate or Significant Threats identified in the Assessment Reports. The Threats Management Strategy could include the following key elements:

- identification of Moderate and/or Significant Drinking Water Quantity Threats
- identification of preferred Risk Management Measures
- summary of expected Management Targets and/or policy outcomes that would comply with the water quantity Source Protection Plan Policies
- summary of timelines, including public consultation, for implementation of the Risk Management Measures
- a summary of consultations held with the affected stakeholder(s)

Once the evaluation process is complete and the Significant Water Quantity Threats have been identified, ranked and the preferred Risk Management Measures for those Threats have been selected, planning and implementation activities should be undertaken.

A Threats Management Strategy that outlines an approach that is best for the specific Threats that have been identified should be developed. For example, this strategy could include a plan of how a municipality could optimize the use of all of their municipal wells or intakes and minimize risk to their supply.

Based on the information obtained through the evaluation process, the Source Protection Committee can draft policies to address these Water Quantity Threats which can then be consulted on with stakeholders. These policies may then be included in the Source Protection Plan.

APPENDIX B

Updates to the Long Point Region Tier Three Assessment Regional Groundwater Flow Model (FEFLOW)

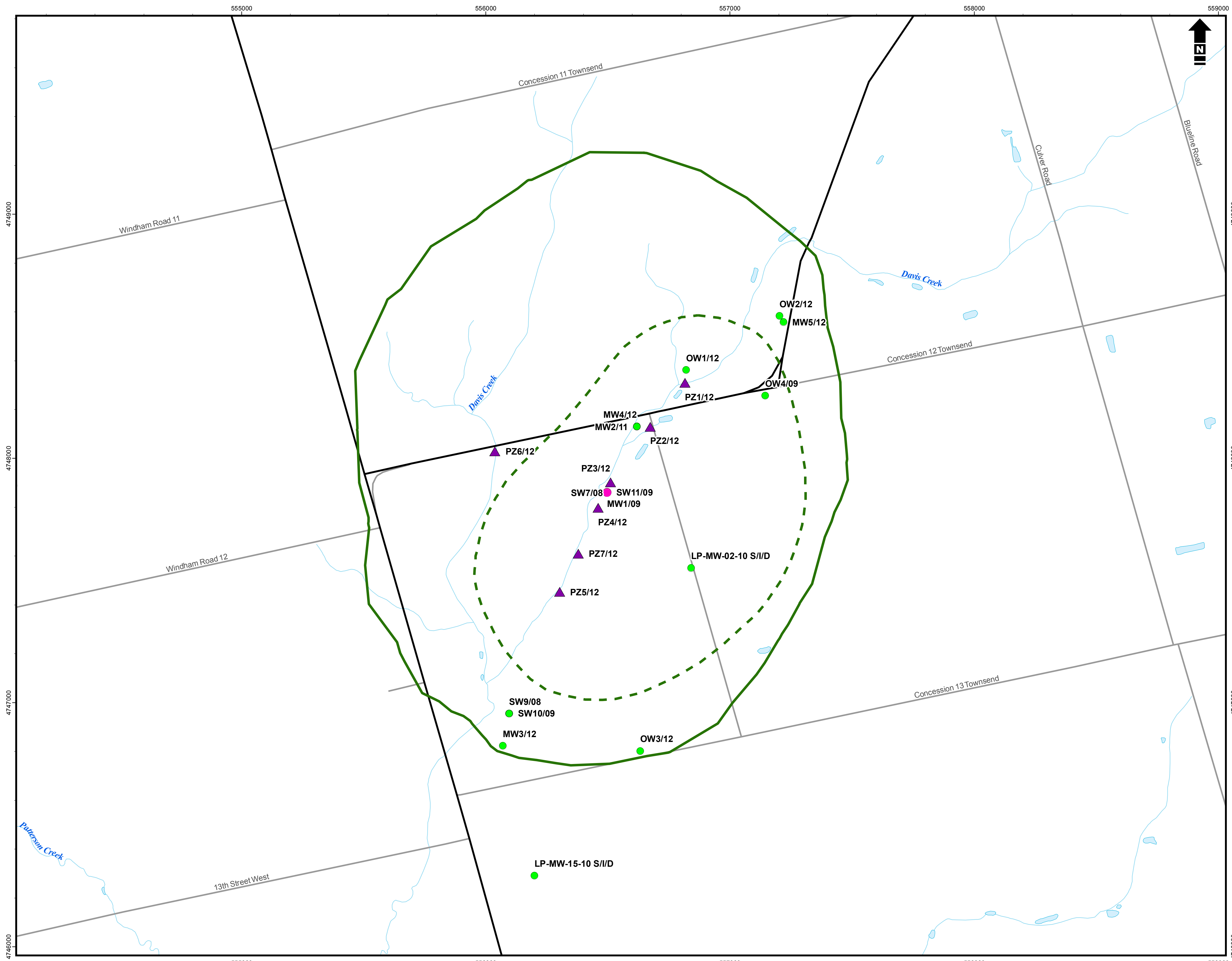
APPENDIX B

UPDATES TO THE LONG POINT REGION TIER THREE ASSESSMENT REGIONAL GROUNDWATER FLOW MODEL (FEFLOW)

1 INTRODUCTION

As part of the Simcoe Risk Management Measures (RMM) Evaluation Process, a preliminary RMM scenario was selected to evaluate the ability for the municipal system to supply the Allocated Quantity of Water at a lower level of risk to the Local Area than identified in the Long Point Region Tier Three Risk Assessment (Matrix 2015). The results of that scenario suggested that additional reductions in pumping from the Cedar St. wells would be necessary to achieve a lower Risk Level where no wells exceed their Safe Additional Drawdown (SADD). One option from that analysis was to transfer pumping from some of the Cedar St. wells to the proposed Northeast wells currently undergoing a Municipal Class Environmental Assessment (EA).

To explore this option and assess the performance of the Tier Three Assessment FEFLOW groundwater flow model in this area, the 2012 Monitoring and Aquifer Testing Program details for the Class EA (Banks 2015) were applied to improve model calibration northeast of the Town of Simcoe (**Figure B-1**). The following sections of this appendix describe a transient model calibration to the 72-hour constant rate aquifer test at SW11/09 and the verification of the model at the estimated safe perennial yield of the aquifer.



Water Body
Watercourse
Highway
Road
Simulated Area of Influence – Drawdown = >0.0 m
Interpreted Area of Influence – Drawdown = 0.0 m (Banks 2012)
Piezometer
Monitoring Well
Proposed Supply Well

Reference: Data obtained from GeoBase® used under license.

1:15,000

250 0 250

Metres

NAD 1983 UTM Zone 17N

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Community of Simcoe, Ontario Water Quantity Risk Management Measures Evaluation Process

Interpreted vs. Simulated Area of Influence

Date: 21 Nov 2016	Project: 21828	
Technical: J. Melchin	Reviewer: P. Chin	Drawn: C. Curry

Disclaimer: Prepared solely for the use of Lake Erie Source Protection Region as specified in the accompanying report. No representation of any kind is made to other parties with which Lake Erie Source Protection Region has not entered into contract.

Figure B-1

I:\GrandRiverCA\21828\FiguresandTables\QHG\2016\Report\PreliminaryThreatManagementStrategy\Figure-B-1-Interpreted_vs_Simulated_Area_of_Influence.mxd

2 CALIBRATION TO 72-HOUR CONSTANT RATE AQUIFER TEST

Total drawdown data from a constant rate aquifer test conducted on Test Well SW11/09 in May and June 2012 (Banks 2015) was used to assess and refine the calibration of the Tier Three FEFLOW model in the area northeast of the Town of Simcoe. The test took place over a period of 72 hours at a rate of 2,620 m^3/day. A total of 26 wells/piezometers were monitored during the test (**Figure B-1**) and the total observed drawdown at these monitors were used as calibration targets.

The horizontal hydraulic conductivity of the confined / semi-confined lower overburden aquifer in this area of the Tier Three model was 8.8×10^{-4} m/s with a vertical hydraulic conductivity 8.7 times lower (i.e., the anisotropy ratio [Kh/Kv] = 8.7). This was increased locally during model calibration to ensure a match between the simulated and observed total drawdown response. The resultant horizontal hydraulic conductivity was 1.8×10^{-3} m/s. This is comparable to the hydraulic conductivity calculated from the estimated transmissivity of that hydrogeologic unit determined from the pumping test by Banks (2015). An interpreted aquifer thickness of 12 m near the pumping well was used to convert the transmissivity estimate (5,330 m^2/day) into horizontal hydraulic conductivity (5.1×10^{-3} m/s). The anisotropy ratio between horizontal and vertical conductivity (Kh/Kv) that existed prior to recalibration was maintained at a ratio of 8.7.

The observed and simulated drawdown, as well as the difference between the two (i.e., residual), at the end of the 72-hour test are presented in **Table B-1** for the 26 monitors. **Chart 1** also shows the degree of fit between the target (observed) and simulated heads. Points that are closer to the 1:1 line represent simulated heads that are closer to target heads. Overall, an excellent fit was achieved to the observed data with a mean absolute difference of 0.18 m and a root mean squared error of 0.25 m.

As shown on **Chart 1**, heads in the piezometers at the end of the 72-hour test were slightly under-predicted by the model (i.e., too much drawdown). This is likely due to the lack of representation of the branch of Davis Creek present in this area in the Tier Three model. While a branch of Davis Creek, just west of the pumping test, is represented in the model using boundary conditions, the branch near the majority of the piezometers is not represented as it had a Strahler Number that was below the threshold for inclusion in the Tier Three model. If this surface water feature were represented, it would likely provide water to the shallow subsurface and buffer the amount of drawdown simulated.

Table B-1 Calibration Results at End of 72-hour Aquifer Test

Monitoring Well Name	Observed Drawdown (m)	Simulated Drawdown (m)	Residual (Obs-Sim) (m)
SW11/09	4.69	4.41	0.28
SW7/08	1.51	2.08	-0.57
MW1/09	1.40	1.61	-0.21
MW2/11	0.46	0.22	0.24
MW4/12	0.45	0.22	0.23
OW1/12	0.36	0.10	0.26
LP-MW-02-10I	0.22	0.10	0.12
LP-MW-02-10D	0.22	0.10	0.12
OW4/09	0.11	0.03	0.08
PZ5/12	0.10	0.16	-0.06
LP-MW-02-10S	0.06	0.09	-0.03
SW10/09	0.00	0.02	-0.02
SW9/08	0.00	0.02	-0.02
MW3/12	0.00	0.01	-0.01
MW5/12	0.00	0.02	-0.02
OW2/12	0.00	**	**
OW3/12	0.00	0.01	-0.01
PZ1/12	0.00	0.11	-0.11
PZ2/12	0.00	0.20	-0.20
PZ3/12	0.00	0.60	-0.60
PZ4/12	0.00	0.53	-0.53
PZ6/12	0.00	0.14	-0.14
PZ7/12	0.00	0.26	-0.26
LP-MW-15-10D/I/S	0.00*	0.00*	0.00

* Observed drawdown result did not specify whether it was from D/I/S interval. Assumed deep interval for the purposes of model calibration

** Well not simulated in model as screen details were not available

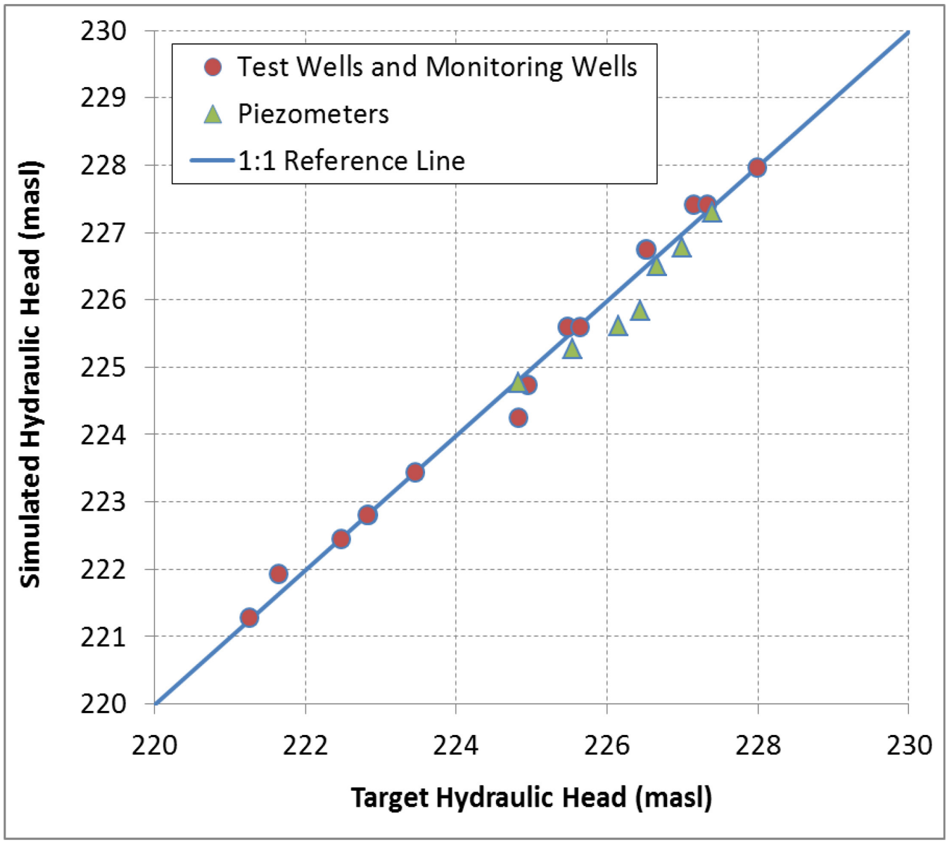


Chart 1 Scatter Plot of Calibration Results at End of 72-hour Aquifer Test

Figure B-1 shows the interpreted area of influence of the 72-hour aquifer test (Banks 2015) compared in plan view to the area of influence simulated by the model. As shown on **Figure B-1**, the simulated area of influence is larger than the area interpreted from the field data and oriented slightly more towards north-south rather than northeast-southwest. However, the interpreted 0 m drawdown line based on the field data is an approximate line placed between data points and could be larger or smaller, or trend in a different orientation depending on the interpreter. This is especially relevant towards the north, northwest, and west where there is a lack of any deep monitoring data in these areas. As mentioned above, the lack of representation of Davis Creek in the model at the site of the pumping test could impact the amount of simulated drawdown. For example, if added to the model, Davis Creek may be simulated as adding a small amount of additional recharge to the groundwater system along its length, thereby decreasing the amount of drawdown and the size of the area of influence.

Overall, for the purposes of this analysis, these transient calibration results suggest that the updated model appropriately represents the drawdown response in the area of SW11/09.

3 MODEL VERIFICATION AT ESTIMATED SAFE PERENNIAL AQUIFER YIELD

Based on the results of aquifer testing, a safe perennial yield (4,560 m^3/day) for the aquifer at SW11/09 was estimated by Banks (2015). Banks subsequently estimated what the drawdown would be at nine of the monitoring wells after pumping SW11/09 at a rate of 4,560 m^3/day for 72-hours, by increasing drawdown by a factor that is equal to the increase in pumping (1.74x).

As an additional check of model calibration, the 72-hour test was replicated in the Tier Three model at a rate of 4,560 m^3/day. The simulated total drawdown was compared to the estimated total drawdown presented by Banks (2015). The results are summarized in **Table B-2**.

Table B-2 Model Verification Results at Safe Perennial Aquifer Yield

Monitoring Well Name	Estimated Drawdown* (m)	Simulated Drawdown (m)	Residual (Est-Sim) (m)
SW7/08	2.63	3.56	-0.93
MW1/09	2.44	2.73	-0.29
MW2/11	0.80	0.36	0.44
MW4/12	0.78	0.36	0.42
LP-MW-02-10S	0.10	0.15	-0.05
LP-MW-02-10D	0.38	0.16	0.22
OW1/12	0.63	0.15	0.48
OW4/09	0.19	0.05	0.14
PZ5/12	0.17	0.25	-0.08

* (Banks 2015)

The model predicts similar drawdown to that estimated by Banks (2015). The mean absolute difference was 0.34 m and the root mean squared error was 0.42 m. Given the empirical nature of the method used by Banks to estimate drawdown at the higher pumping rates, the simulated results suggest that the updated model appropriately represents drawdown response at the safe perennial aquifer yield, in the vicinity of SW11/09.

4 SUMMARY AND RECOMMENDATIONS

A 72-hour constant rate aquifer test was used to improve the calibration of the Long Point Region Tier Three Assessment FELOW groundwater flow model in the area of a proposed municipal groundwater supply well located northeast of the Simcoe. Based on this aquifer test, a safe perennial aquifer yield was estimated and applied in a second 72-hour constant rate model simulation to verify that the newly calibrated model can adequately simulate total drawdown at the higher rate. The results of this exercise indicate that the model is satisfactorily calibrated to simulate pumping for the proposed municipal well location.

While the transient calibration to the 72-hour aquifer test was adequate for the objectives of this assessment, the over-estimation of drawdown at the shallow piezometer locations indicates that a refinement of the conceptual and numerical models of the shallow subsurface in this area may be necessary. The following updates to the model are recommended to improve the calibration at these points:

1. The lower order stream segment(s) of Davis Creek be represented by boundary conditions in the Tier Three FEFLOW model in the area of SW11/09.
2. The finite element mesh be refined using a fine resolution DEM in the area to accommodate:
    a. the new delineation of the lower order stream segment(s) of Davis Creek;
    b. to more accurately delineate the higher order stream segments of Davis Creek that are currently represented in the model; and
    c. to ensure that the simulated streams accurately follow the ground surface topography (i.e., are always flowing down-gradient).

It is anticipated that the addition of the lower order stream(s) to the model in the area of the SW11/09 aquifer test will provide a source of water to the shallow subsurface that may buffer and reduce the magnitude of drawdown that was simulated and reported in this appendix.

It is further recommended that non-linear well losses be considered in future calibration assessments. Non-linear well losses are the portion of the total drawdown in a pumping well that is due to well inefficiencies. The Tier Three model does not explicitly simulate non-linear well losses within the well itself and thus, the amount of drawdown due to non-linear well losses should be added to the simulated drawdown to most accurately represent drawdown at the pumping well. Therefore, the drawdown simulated at the pumping well in this Appendix would be considered an under-prediction.

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APPENDIX C

Estimate of Unmetered Domestic Water Use for Lawn Irrigation in the Community of Simcoe

MEMORANDUM

TO: Bob Fields, Jason Godby - Norfolk County

Martin Keller, James Etienne – GRCA

Scott Bates, Lynne Milford – MNRF

Kathryn Baker – MOECC

Craig Jacques - LPRCA

FROM: Steven Murray, Paul Chin and Sam Bellamy, Matrix Solutions Inc.

SUBJECT: Estimate of Unmetered Domestic Water Use for Lawn Irrigation in the Community of Simcoe
Simcoe Risk Management Measures Evaluation Process (RMMEP)

DATE: December 10, 2015

1 INTRODUCTION

As part of the Community of Simcoe (Simcoe) Local Area Risk Management Measures Evaluation Process (RMMEP), an estimate has been made of the quantity of unmetered domestic water being extracted through sand points in Simcoe. The goal of this exercise was to determine if the unmetered takings constitute a water quantity threat that needs to be considered in the RMMEP.

The presence of a shallow water table, associated with the Norfolk Sand Plain, allows residents of Simcoe to have relatively easy access to groundwater. It is expected that a proportion of Simcoe residents have installed shallow sand point or drive point wells on their property to obtain water for lawn irrigation purposes. As wells of this nature are not metered by Norfolk County (the County), the impact of these domestic water takings on the groundwater flow system is uncertain. This memorandum describes an approach used to estimate the volume associated with these takings. The approach used results from the water budget models developed for the Long Point Tier Three Water Budget and Local Area Risk Assessment (Matrix 2013) and spatial data provided by the County.

2 METHODOLOGY

An estimate of unmetered water taking in Simcoe was developed based on existing geospatial data, water budget model results, and supplemental calculations. The irrigation requirements of lawns in Simcoe were estimated from the modelled soil-water deficit during the summer months. The irrigation requirement was then combined with an assumed percentage of lots with active irrigation. Due to insufficient data on the number of homes with sand points supplying lawn irrigation water, a range of percentages were investigated. Various assumptions were used to account for building footprints, imperviousness, surficial geology, and seasonal requirements. These are described below.

2.1 Evapotranspiration

The calibrated South Simcoe Local Area Water Budget model results (Matrix 2013) were used to determine an estimate of evapotranspiration rates on pervious urban land use classes within Simcoe. The simulated evapotranspiration rates taken from the model served as a reasonable estimate of actual evapotranspiration rates that occur on residential properties in Simcoe.

Water Budget model indicates evapotranspiration rates on pervious urban land use areas averaged 483 mm/year for 1960 to 2009. The monthly evapotranspiration rates simulated by the Water Budget model for pervious urban land use classes during June to September are presented in Table 1.

Table 1 – Evapotranspiration Rates and Crop Evapotranspiration Deficit

Month	Simulated Evapotranspiration – Pervious Urban Areas (mm/month)	Kentucky Blue Grass Crop Evapotranspiration Rate (mm/month)	Evapotranspiration Deficit (mm/month)
June	86	109	24
July	77	124	47
Aug.	64	95	31
Sept.	39	59	20

It was assumed that domestic unmetered water takings were being used to irrigate residential lawns within Simcoe. Kentucky Blue grass, a commonly planted grass, was assumed to be representative of residential vegetation for the purposes of this estimate (OMAFRA 2008). The monthly crop evapotranspiration rates for Kentucky Blue Grass are presented in Table 1 (Meyer et al. 1985).

The monthly evapotranspiration deficit was calculated by subtracting the maximum crop evapotranspiration rates from the simulated evapotranspiration rates for the pervious urban areas (Table 1). The evapotranspiration deficit is the additional water that the plant could evapotranspire, should sufficient water be available; assuming there are no other limiting factors on growth (e.g., nutrients, disease). To maximize plant growth and vigor, home owners would need to irrigate at a rate that would equal the evapotranspiration deficit. The crop evapotranspiration deficit for Kentucky Blue Grass in Simcoe is summarized in Table 1.

2.2 Potential Area of Irrigation

To estimate the volume of unmetered water takings in Simcoe, the crop evapotranspiration deficit estimate generated in the previous section was combined with an approximation of the potential areas of irrigation. An estimate of potential irrigation areas in Simcoe was developed through analysis of geospatial data for the Town and is described in this section.

All residential class lots in Simcoe were identified using Parcel Fabric mapping supplied by the County. This mapping identified the location, dimensions and zoning of lots throughout Simcoe (Figure 1). For the purposes of this estimate, it was assumed that unmetered domestic water use was occurring only on residential properties with built structures. The total area of these residential lots was 3.1 km^2.

The County also provided a detailed map of building footprints throughout Simcoe. As building footprints represent impervious areas where no irrigation would occur, the area associated with the building footprints were subtracted from the residential lot areas. The total area of residential lots after removing building footprints was 2.5 km^2. Other impervious surfaces such as driveways were not mapped as part of the building footprint. To account for the additional impervious area in lots, a factor has been included in the irrigation estimate and is detailed in Section 2.3.

Finally the surficial geology of Simcoe may play a limiting factor in the use of sand points. A substantial number of the residential properties in the town are located on silt deposits which have relatively poor hydraulic conductivity and well yields. Depending on the thickness of the silt deposits this may preclude the use sand points in these areas and thus it was assumed that residential areas found on silt (0.9 km^2) would not be included in the calculation of the potential area of irrigation. The residential lots and surficial geology of Simcoe are presented in Figure 2.

After considering building footprints and surficial geology within Simcoe the total potential irrigation area is 1.6 km^2 as shown on Figure 3 (residential lots not found on silt).

2.3 Unmetered Water Usage Estimate

An unmetered water usage estimate was determined on a monthly basis using the following equation:

$$UWU = (A_R \times I \times \frac{ET_D}{1000} \times SP) \div EF$$

Where

- UWU – Unmetered water usage (m^3/month)
- A_R – Total residential areas not on silt less building footprints (m^2)
- I – Factor to account for areas in addition to building footprints that are not irrigated (e.g. driveways, assumed to be 0.75)
- ET_D – Evapotranspiration deficit for Kentucky Blue Grass (mm/month)
- SP – Subset of residential area that are irrigated by a sand point. Scenarios of high usage (15%), medium usage (10%), and low usage (5%) were considered.
- EF – Irrigation efficiency factor. Assumed to be 60% which is appropriate for sprinkler type systems (Howell 2003).

For the purposes of this estimate it was assumed that unmetered water use occurs primarily during June to September. The mean monthly unmetered water use estimates for Simcoe are summarized in

Table 2.

Table 2 - Unmetered Water Use Estimate

	Water Taking (m^3/day)		
	Usage Scenario		
Month	High	Medium	Low
June	240	160	80
July	460	310	150
Aug.	310	200	100
Sept.	200	140	70

2.4 Individual Residence Estimates Of Unmetered Water Usage

To provide a more tangible estimate of unmetered water usage the above estimates (based on total residential area not on silt regions) were converted into estimates of unmetered water use by individual residences.

Simcoe Parcel Fabric had 4,072 residential lots with a mean area of approximately 760 m^2. The number of potentially irrigated lots ranged from 407 to 136 depending on the scenario (15% to 5% of the residential areas not on silt). These represent 10% to 3% of all residential lots (out of 4,072). This is summarized in Table 3. A visual representation of the different usage scenarios was generated by randomly selecting residential lots corresponding to the total area associated with each scenario (Figure 4).

Table 3 – Irrigated Residential Lots According To Usage Scenario

	Usage Scenario		
	High	Medium	Low
Number of Irrigated Lots	407	272	136
Percent of Residential Area Not on Silt Regions	15%	10%	5%
Percent of Total Residential Lots	10%	7%	3%

Dividing the total estimated monthly unmetered water takings for Simcoe (Table 2) by the number of residential lots (Table 3) provides a lot-level water taking estimate and is presented in Table 4. Note that the rate of taking for individual residences is the same for the different usage scenarios as these scenarios only vary the number of lots using sand points.

Table 4 – Individual Residence Water Taking Estimate

Month	m^3/day	liters per minute
June	0.6	0.4
July	1.1	0.8
Aug.	0.7	0.5
Sept.	0.5	0.4

The expected yield of a sand point ranges from 10 to 150 liters per minute (USDA 2012) and thus sand points could reasonably deliver the estimated lawn irrigation needs. If we assume a worst case yield of 10 liters per minute, a home owner could apply the maximum (July) daily irrigation need of 1.1 m^3 (1,100 liters) in 110 minutes of irrigation. Given the worst case yield assumption, it is probable that sand point users could easily extract the estimated water takings in a reasonable time frame.

2.5 Uncertainty

There are a number of variables used in the estimation of unmetered water takings which are uncertain. Sources of uncertainty in this estimate include but are not limited to the following:

- Number of lots with unmetered takings – It is unclear how many residents are using unmetered water for irrigation. The usage scenarios consider a range of potential users but the actual number could be higher or lower than this range.

- Crop evapotranspiration rate - Kentucky Blue grass has been assumed as representative of residential vegetation. In reality a variety of grasses and plants exist in residential lots which may have different evapotranspiration needs.

- Irrigation efficiency - 60% efficiency has been assumed in these calculations. A higher or lower efficiency could be possible depending on the irrigation equipment employed and when home owners are watering.

- Human behaviour - The estimate assumes resident are acting as perfect irrigators and always watering when plants need water. In reality, residents may fail to water when needed, or apply too much water when irrigating.

- Spatial data accuracy - The calculations are contingent on using parcel fabric, building footprint and surficial geology data which contain various levels of inaccuracy due to the scale of mapping, age of the data, and the data collection methods.

In spite of these sources of uncertainty, the methodology was able to provide a reasonable estimate of unmetered takings to determine if these takings represent a water quantity threat that needs to be further considered in the RMMEP.

3 DISCUSSION AND CONCLUSIONS

To evaluate the significance of the estimated unmetered takings, we compared it to other water takings in the Town of Simcoe. Municipal pumping and other permitted water takings averaged 5,000 m^3/day during June to September based on 2010 pumping rates. Unmetered consumption for lawn irrigation was estimated to range from 200 to 460 m^3/day in the “high usage scenario” (15%). Thus this unmetered water taking is equivalent to 4 to 9% of the permitted water takings in Simcoe.

An additional consideration in evaluating the significance of these takings is the spatial and temporal distribution of the unmetered takings. Takings of this nature would be spatially distributed across a large area throughout Simcoe and would occur at different times throughout the day. This temporal and spatial distribution of these takings will likely mitigate their impact.

An alternative means of evaluating the significance of the unmetered takings is to convert the total volume extracted by these shallow sand points into the equivalent amount of groundwater recharge over the area of Simcoe. The range of unmetered takings is equivalent to less than 3 mm/year. This is less than 1% of the average estimated groundwater recharge on the Norfolk Sand Plain of 400 mm/year and thus the range of unmetered takings is within the uncertainty in the recharge estimates.

It is unlikely that these unmetered takings represent a quantity threat when we consider the existing permitted takings in the Town of Simcoe and the significant groundwater recharge in the region. We recommend that they not be considered as part of the Simcoe RMMEP scenarios.

4 SUMMARY

An estimate of unmetered domestic water takings from sand points was calculated for Simcoe in support of the RMMEP. In the "high usage scenario" total consumption for Simcoe was estimated at 200 to 460 m^3/day from June to September. In the "low usage scenario" total consumption estimates ranged from 70 to 150 m^3/day for the same period. A range of usage scenarios was evaluated to address uncertainty in the number of residents using unmetered takings. Given the magnitude of estimated unmetered consumption and the distributed nature of the takings, it is unlikely that they represent a quantity threat to the Simcoe municipal water supply. As such, it is recommended that they not be considered as part of the Simcoe RMMEP scenarios.

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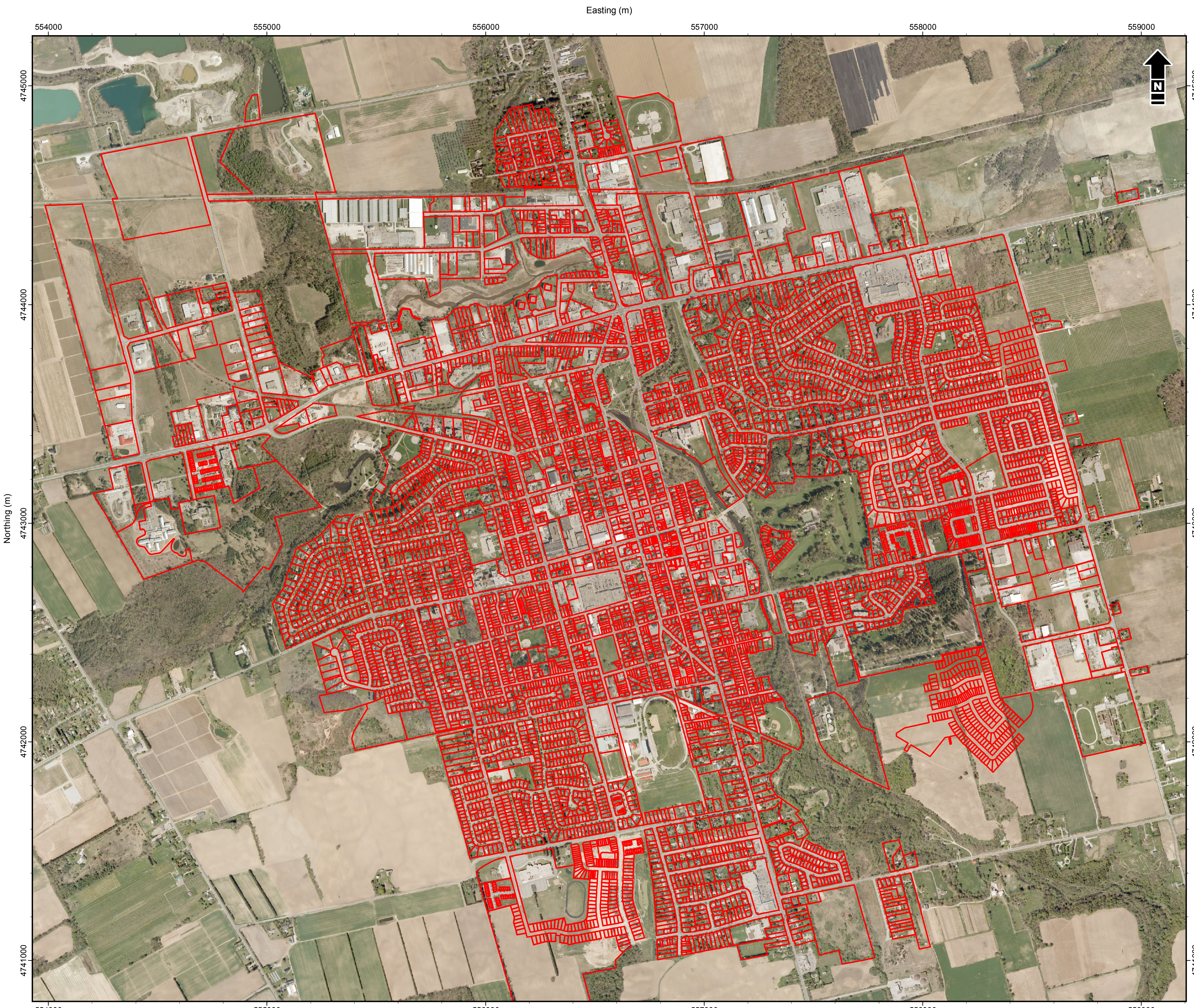

Parcel Fabric

1:18,000
m
180 0 180 360
NAD 1983 UTM Zone 17N

Reference: Imagery (2015) obtained from Long Point Region Conservation Authority used under license.
Parcel Fabric, Norfolk County, 2015

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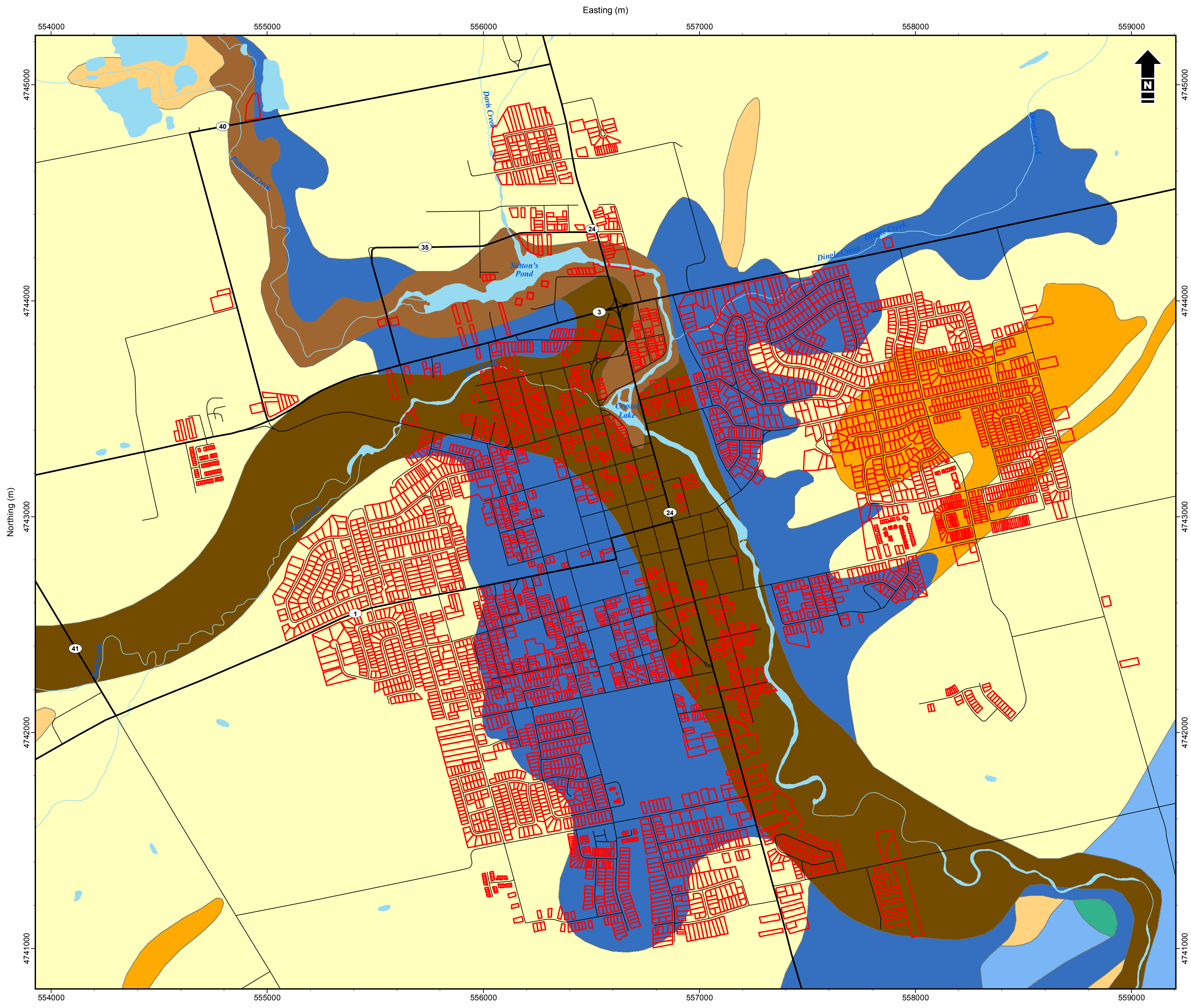
Norfolk County
Risk Management Measures Evaluation Process

Community of Simcoe - Parcel Fabric

Date:	Project:	Technical:	Reviewer:	Drawn:
14 Oct 2015	21828	S. Murray	P. Chin	C. Curry

Figure
1

I:\CountyofNorfolk\21828\FiguresandTables\QHG\2015\Report\RMMEP\Figure-1_Community_of_Simcoe_Parcel_Fabric.mxd



- Residential Parcel Fabric
- Water Body
- Watercourse
- Highway
- Road

Surficial Geology

- Fine Sand
- Medium Sand
- Gravel
- Modern Alluvium
- Older Alluvium
- Clay
- Silt
- Wentworth Till

Reference: Data obtained from GeoBase® used under license. GDM transportation infrastructure data provided by IHS © 2015 used under license.
Ontario Geological Survey 2010. Surficial geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128-REV ISBN 978-1-4435-2482-7.
Parcel Fabric, Norfolk County, 2015

1:18,000 m
180 0 180 360
NAD 1983 UTM Zone 17N

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Norfolk County
Risk Management Measures Evaluation Process

Community of Simcoe - Surficial Geology and Residential Lots

Date:	Project:	Technical:	Reviewer:	Drawn:
14 Oct 2015	21828	S. Murray	P. Chin	C. Curry

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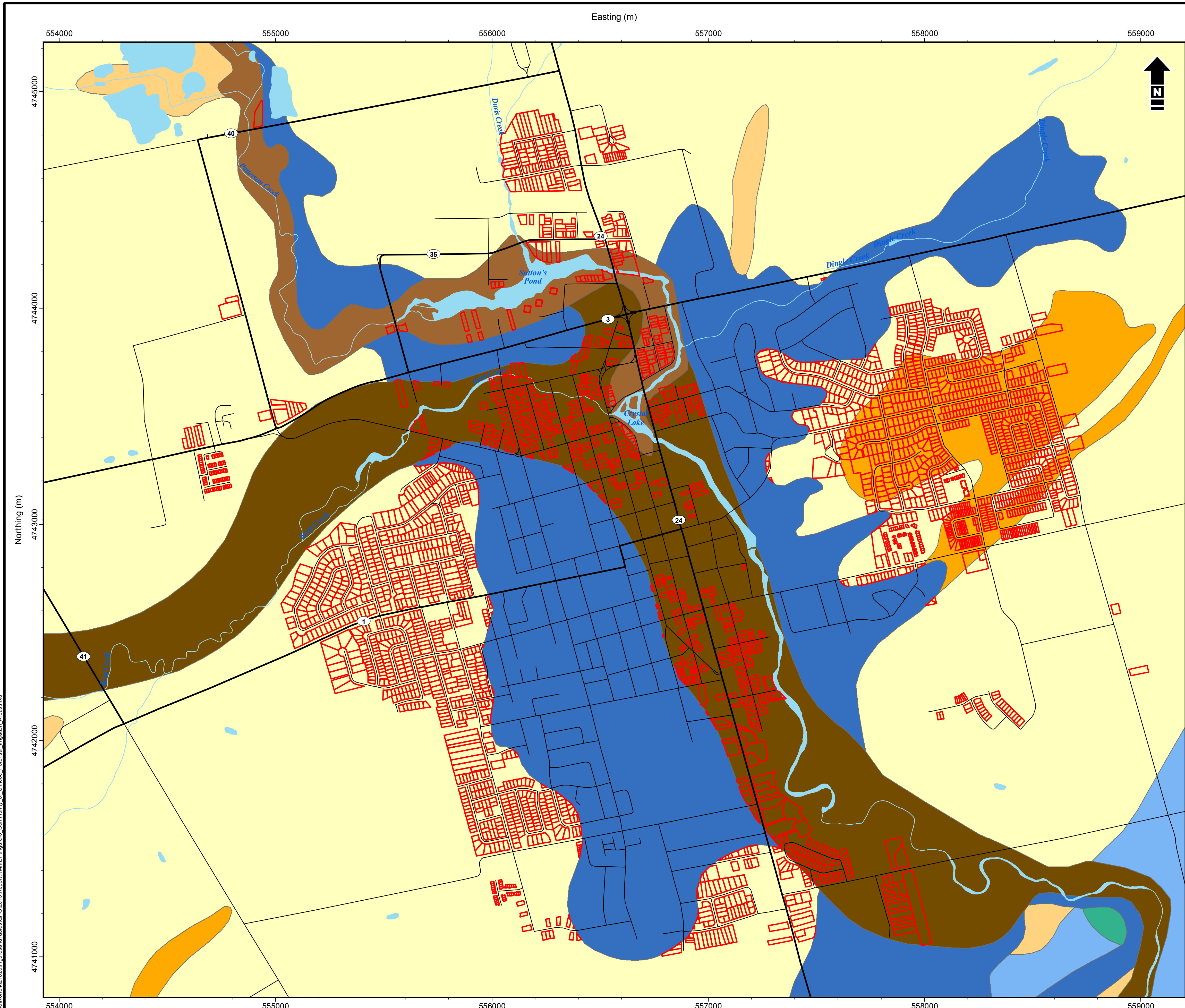
Figure 2

I:\CountyofNorfolk\21828\FiguresandTables\QHG\2015\Report\RMMEP\Figure-2_Community_of_Simcoe_Surficial_Geology_and_Residential_Lots.mxd



Residential Parcel Fabric Not Found on Silt
Water Body
Watercourse
Highway
Road

Surficial Geology

Fine Sand
Medium Sand
Gravel
Modern Alluvium
Older Alluvium
Clay
Silt
Wentworth Till

Reference: Data obtained from GeoBase® used under license. GDM transportation infrastructure data provided by IHS © 2015 used under license.
Ontario Geological Survey 2010. Surficial geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128-REV ISBN 978-1-4435-2482-7.
Parcel Fabric, Norfolk County, 2015

1:18,000

180 0 180 360 m

NAD 1983 UTM Zone 17N

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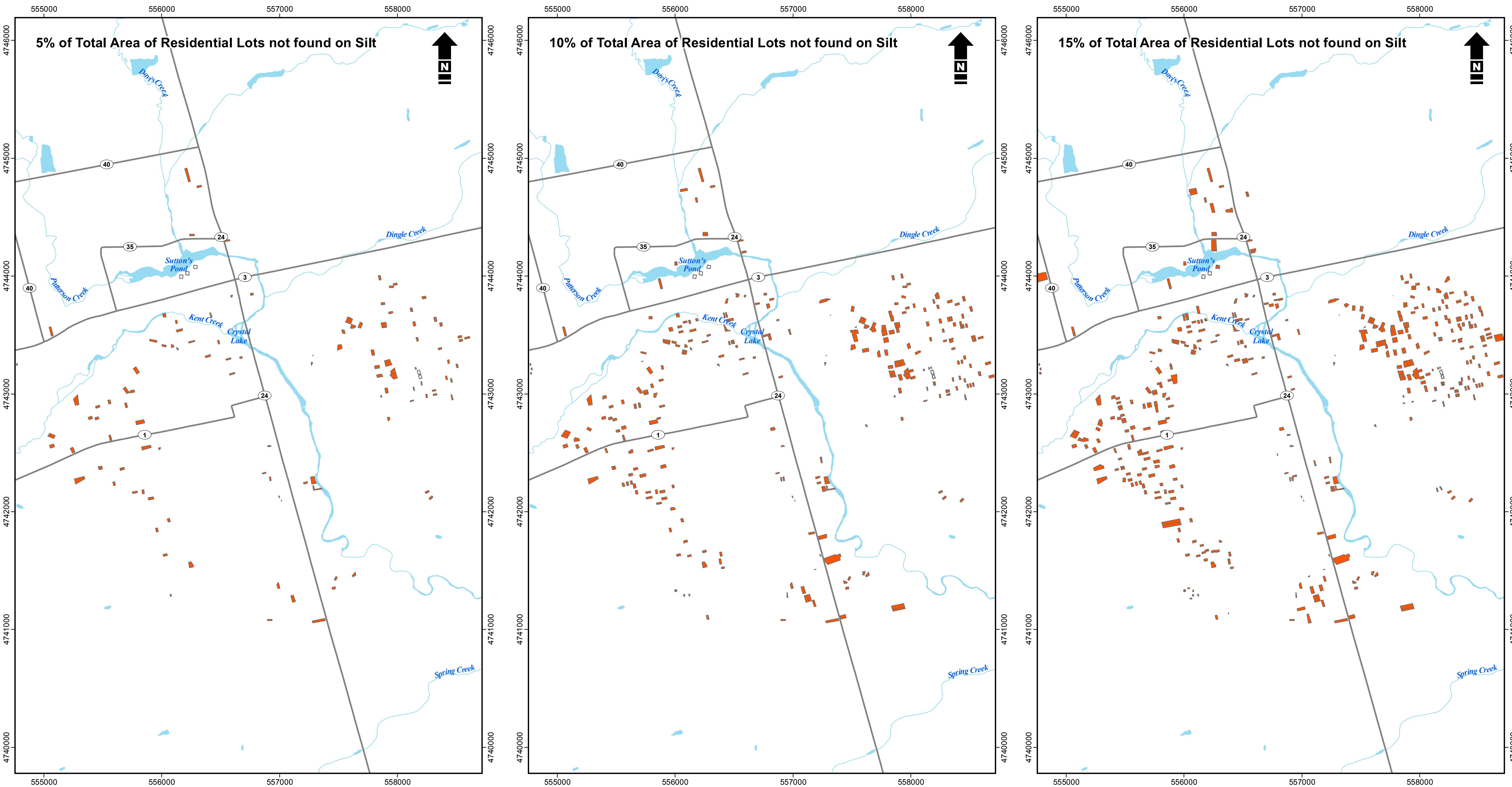
Norfolk County
Risk Management Measures Evaluation Process

Community of Simcoe - Potential Irrigation Areas

Date:	Project:	Technical:	Reviewer:	Drawn:
14 Oct 2015	21828	S. Murray	P. Chin	C. Curry

Figure
3



Hypothetically Irrigated Residential Lots
Water Body
Watercourse
Highway

1:32,500
m
330 0 330 660
NAD 1983 UTM Zone 12N

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Norfolk County
Risk Management Measures Evaluation Process

Community of Simcoe - Irrigation Application Scenarios

Date: October, 2015	Project: 21828	Technical: S. Murray	Reviewer: P. Chin	Drawn: C. Curry

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Figure 4

Reference: Data obtained from GeoBase® used under license. GDM transportation infrastructure data provided by IHS © 2015 used under license. Parcel Fabric, Norfolk County, 2015

I:\CountyofNorfolk\21828\FiguresandTables\QHG\2015\Report\RMMEP\Figure-4_Community_of_Simcoe_Irrigation_Application_Scenarios.mxd

APPENDIX D

Information Sheets from the Water Quantity Risk Management Measures Catalogue

Risk Management Measures: Measure Information Sheet

Reference ID	**QT067**
Measure Name	**Optimization of Pumping Rates for Sustainable Yield**
Measure Description	**Optimization is a process of re-allocating pumping rates considering a target of maximum amount of ground water that could be withdrawn from aquifers/streams without violating hydraulic-head or stream-discharge constraints, thus determining the “sustainable yield” for the source of water. Water budgets - optimization modeling can be used for the purpose of evaluating potential pumping scenarios and optimizing maximum ground-water withdrawal rates to determine sustainable yield for the aquifer while maintaining desirable hydraulic heads in the aquifer and streamflow in the outcrop. Additionally, the optimization models can determine the maximum available withdrawals from major streams for supplementing ground water to meet the total water demand.**
Climate Change Adaptation	**Yes**

Management Targets:

- Municipal Water Efficiencies
- Water supply increase

Applicable Sectors:

- Municipal

Associated Threats:

Order	Threat Name	Effectiveness Comments	Applicability
19.2	Consumptive water use - wells		Groundwater: No Surface Water: No
19.1	Consumptive water use - surface water intakes		Groundwater: No Surface Water: No

Additional Information Sources:

Literature Review - USGS, 2004 (North America)
CONJUNCTIVE-USE OPTIMIZATION MODEL AND SUSTAINABLE-YIELD ESTIMATION FOR THE SPARTA AQUIFER OF SOUTHEASTERN ARKANSAS AND NORTHCENTRAL LOUISIANA (http://pubs.usgs.gov/wri/wri03-4231/WRIR03-4231.pdf)
Reference:

Journal Article - Nato Science Series, 2002 (North America)
Managing Groundwater Supplies to Meet Municipal Demands — The Role of Simulation — Optimisation — Demand Models and Data Issues (http://link.springer.com/content/pdf/10.1007%2F978-94-010-0409-1_10.pdf)
Reference:

Risk Management Measures: Measure Information Sheet

Reference ID	**QT004**
Measure Name	**Increase of supply - addition of new supplies**
Measure Description	**Finding a well or intake located outside of the WHPA-Q or IPZ-Q to supplement the existing supply if there is a shortage of water available in a community, without interfering with supply of drinking water for any other community.**
Climate Change Adaptation	**Yes**

Management Targets:

- Municipal Water Efficiencies
- Water supply increase

Applicable Sectors:

- Agriculture

Associated Threats:

Order	Threat Name	Effectiveness Comments	Applicability
19.1	Consumptive water use - surface water intakes	Potential negative impact on GW levels in new extraction site; high initial cost	Groundwater: No Surface Water: Yes
19.2	Consumptive water use - wells	Potential negative impact on GW levels in new extraction site; high initial cost	Groundwater: Yes Surface Water: No

Additional Information Sources:

No data available.