APPENDIX H

Peer Review Record

Golder Comments on Version R0A (letter dated June 7, 2010)		Geofirma Response
General		
1	With respect to the WHPA, in our opinion (from the information provided) there remains a high degree of uncertainty with respect to their extent and the groundwater times of travel to the supply well. This is in contrast to the low uncertainty classification concluded by Geofirma on page 26 of the report.	Based on the comment, and on further work done to address the comment, WHPA Zones B and C were assigned a high uncertainty rating, due to their strong dependence on bedrock porosity, a highly uncertain value.
WHPA and Vulnerability Mapping		
1	***Section 2.2, paragraph:*** States that the sewage treatment ponds were constructed with an "impermeable clay liner". Considering the proximity of the treatment ponds to the supply wells and their estimated capture zones, the hydraulic performance of the liners is of interest. In Section 2.3.1 Geofirma indicates that faecal coliform bacteria was detected in shallow overburden monitoring wells located near the ponds and attributes the presence of the bacteria in the monitoring wells to adjacent farming practices. Additional detail regarding this interpretation should be provided, and Geofirma should consider the possibility that the ponds are not impermeable. A discussion on the degree of confidence I uncertainty related to the treatment ponds being within the capture zone of the supply wells would be a useful addition to the report.	A discussion on the degree of confidence/uncertainty related to the treatment ponds has been added to the report.
2	***Section 3.5, 1 st paragraph:*** States that there is 2 metres of overburden at the municipal wells, and that the hydraulic conductivity of the overburden is assumed to be $1x10^{-7}$ m/s. The hydraulic conductivity of glacial till can vary considerably and the hydraulic conductivity of weathered clay can be significantly higher than $1x10^{-7}$ m/s. Any data supporting the chosen hydraulic conductivity values should be referenced in the report, and variation of these values should be considered during sensitivity analysis.	Given the fact that the overburden is a relatively thin upper unit, groundwater flow within it is anticipated to be predominantly vertical (i.e., downwards) as unsaturated flow from the ground surface to the water table, and to the bedrock below. Notwithstanding this, an analysis of the impact of increasing the overburden hydraulic conductivity to $1x10^{-5}$ m/s was carried out. It was determined that this value is unsupported by the available hydraulic head information (i.e., the model fell significantly out of

		calibration), and that the effect on WHPA delineation was negligible. Given the latter conclusion, it was considered unnecessary to report on this analysis.
3	***Section 3.5, 2nd paragraph:*** States that the vertical hydraulic conductivity of the sandstone aquifer was conceptualized to be approximately $1x10^{-9}$ mis, based on straddle packer testing, water level measurements and numerical modelling. The appendix regarding the straddle packer testing (Appendix E) does not include information on vertical hydraulic conductivity. I ntera should present and discuss the data supporting the assigned vertical hydraulic conductivity.	Section 3.5 has been modified to better reflect the assumptions built into the groundwater flow model and the method of WHPA delineation.
4	***Section 3.5, 4th paragraph:*** States that the porosity of the Precambrian bedrock is assumed to be 5%. Golder is aware of previous WHPA studies by Geofirma that have utilized Precambrian bedrock porosities of less than 1 %, and it is our understanding that the effective porosity is typically on the order of 0.1 to 1 %. It would be our expectation that, as part of the overall uncertainty analysis approach adopted by Geofirma to develop the WHPA, consideration would have been given to using lower porosity values for Precambrian bedrock.	The value of bedrock porosity has been changed from 0.05 to 0.01, which is a conservative value. To include bedrock porosity as a sensitivity parameter is unnecessary because, using the multi-scenario approach and considering that with a lack of groundwater residence time information, there is no way of determining which bedrock porosity value is correct, the lowest bedrock porosity value chosen will control the WHPA delineation.
5	***Section 5.1.2, 2nd paragraph:*** A uniform recharge rate was simulated for 3 of 4 simulations. However, in Section 3.4, 3rd paragraph, Geofirma states that, "Near Landsdowne recharge is interpreted to be highest where the Palaeozoic sandstone exists and lowest where a significant thickness of clay is present." The modelling approach I assumptions appear to be inconsistent with this statement. Additional clarification andlor justification should be provided to justify the uniform recharge rate used for simulations 1, 2, and 3.	Section 3.5 has been modified to better reflect the assumptions built into the groundwater flow model and the method of WHPA delineation. The justification for the uniform recharge rate is that there is insufficient data to support a variable rate, except in the context of an alternate calibration, as in Case 4.
6	***Section 4.2, 6th paragraph:*** Geofirma states that, "More data is required for a more meaningful understanding of the Lansdowne subwatershed groundwater chemistry." Is Geofirma recommending collection of more isotope data, and that such data may affect the extent of the WHPA?	Yes Geofirma is recommending further isotope data from the cascading water in the municipal well. This additional data is not expected to affect the extent of the WHPA but rather provide a better understanding of the source of cascading water in the Lansdowne municipal well, although this is not within the scope of

		this study.
7	***Section 5.1.2, 5th paragraph:*** States that pumping from the municipal wells was not simulated during model calibration. However, recently collected groundwater levels (e.g., from the monitoring wells) may have been influenced by pumping. It is unclear as to how this may influence model calibration.	The calibration plots have been modified to show calibration for the WWIS data assuming zero pumping, and calibration for the MW data assuming present day pumping conditions (Section 5.1.2 has been modified to indicate these variable boundary conditions). A discussion of the results is included in Section 5.2.
8	***Section 5.1.4, paragraph:*** Geofirma has utilized four scenarios to encompass the potential range of uncertainty in the capture zones. It is not clear why Geofirma feels that these four scenarios are sufficient to bound the range of uncertainty. For example, the four scenarios considered do not reflect variability in effective porosity, or the potential influence of nearby surface water bodies (including the sewage treatment lagoons) which are two uncertainties associated with the flow system. Local flow directions and the correlation of groundwater and surface water divides is another uncertainty that we feel might be worthy of investigation in such an approach.	Four scenarios are used assess those uncertainties considered to be the most significant. We agree that the bedrock porosity is a significant uncertainty, and to address this comment, we have lowered the value from 5% to 1%. To address uncertainty in the recharge rate through the lagoons, additional simulations were performed and reported on. See Figure 5-6 and associated text. Given the conservatism built into the multi-scenario approach, the conservatism built into the use of multiple pumping scenarios, and the conservatism of using a bedrock porosity value of 1%, additional uncertainty scenarios are considered unwarranted.
9	***Section 5.1.2, 1 st paragraph:*** States that all exterior lateral boundaries are no-flow boundaries. This is in contradiction with their conceptual statement that regional flow is to the south towards the St. Lawrence River.	The text in Section 3.4 has been modified to indicate that, for the modelling conducted for WHPA delineation in this study, only the local, shallow groundwater flow is considered.
10	***Section 5.2.1, 1 st paragraph***: Geofirma does not state how many particles were released and in what layers they were released. This information should be included in the report. Additional details regarding how "weighting" was used to draw the polygons should also be provided so that it can be reproduced by others.	Text has been added to report to address this comment.
11	***Section 5.3.1 2nd paragraph:*** States that the ISI was calculated using the depth to the water table and that the ISI was determined to be 30 throughout the	The text has been modified and a figure added (Figure 5-8) to provide further details of the ISI

	entire WHPA. Additional detail regarding the ISI calculation should be provided (i.e., was it calculated on a grid throughout the WHPA?). The K-factors assigned for the weathered clay (3) and the bedrock (1) are not consistent with the vertical hydraulic conductivities of these units in the numerical model. The report should include an overburden isopach map, and a map illustrating the depth to the water table from ground surface to support the ISI calculations.	calculation, the requested isopach map, and the justification for the use of 3 as a K-factor for the entire overburden.
12	***Section 8, recommendation 6:*** Geofirma should expand on why straddle packer testing in the municipal wells is recommended. Would data from straddle packer testing affect the delineation of the WHPA or the vulnerability scoring within the WHPA?	Additional hydraulic testing is recommended to better estimate the bedrock aquifer parameters and provide an opportunity to collect groundwater samples from isolated intervals in an attempt to better understand the source of the bacteriological contamination in the municipal well. The additional hydraulic data is not expected to alter the WHPA delineation beyond that already incorporated into the sensitivity analysis but would provide an opportunity to fine tune the conceptual model and input parameters, thereby reducing uncertainty.
Terms of Reference		
1	***Figure 2-2:*** What is a "truthed well"? Are other wells not "truthed"? Were GPS coordinates obtained for all visible/accessible wells as per the terms of reference (TOR) for the WHPA?	A truthed well is a well where UTM coordinates were collected with a GPS either by Geofirma or previously by Malroz. GPS coordinates were obtained for all visible/accessible wells, however most visible wells were already “truthed” by Malroz.
2	The TOR for the WHPA study includes the identification and mapping of transport pathways (see section 4.2, Task 2.3). The report does not include this information. According to the TOR, Geofirma was to expand on the inventory of land use, activities and transport pathways in the Village of Lansdowne (see Section 4.2, Task 2.1 for detailed specifications). The report does not include this information.	Section 5.4 added to address this comment. Identified transport pathways include: improperly abandoned domestic wells, poor well seals for municipal wells, and municipal service trenches.
General Comments and Questions		
1	***Section 2.2, 3rd paragraph:*** States that the casing of the municipal wells is set	Text added to report.

	approximately 1.5 metres into bedrock. What are the total casing lengths for the municipal wells?	
2	***Section 3.3, 1st paragraph:*** Includes a discussion of overburden and clay thickness, but the report does not include overburden or clay isopach maps. These maps should be included in the report.	The overburden thickness isopach map is now included in Figure 5-8.
3	***Section 3.3, 2nd paragraph:*** States that, "a single fault is mapped south of Landsdowne in the Precambrian bedrock". Figure 3-3 does not show the referenced fault.	Fault added to figure.
4	***Section 4.1, 1st paragraph:*** States that water level data was collected at 8 locations shown on Figure 2-3. Figure 2-3 shows more than 8 locations. The specific water level monitoring locations and the data collected should be included in the report.	Additional text added for clarification and data included in Table 4-1.
5	***Section 4.1, 3rd paragraph:*** States that the degree of water level change in monitoring wells is dependant on the open interval of the borehole and the hydraulic properties of the screened formations. We note that other factors could also affect water level fluctuations (e.g., local recharge and proximity to the supply wells).	Agreed, statement in text was not meant to be exclusive of other factors, text clarified.
6	***Section 4.2, paragraph 5:*** States that sample SS1 from a shallow ditch/creek is the most depleted and thus may not be representative of surface water. Is Geofirma suggesting a sampling or analytical error, or some other reason that SS1 does not represent surface water? If SS1 is not representative of surface water, why is this result used to interpret results from the municipal well (MUN1)? Geofirma also states that holding times for stable isotopes were exceed for some samples. D and ^{18}O are stable isotopes and therefore should not be affected by storage time.	Text clarified.
7	***Section 4.4, 3rd paragraph:*** Indicates that the K of the sandstone as determined by the straddle packer testing was 1.7 x 10-7 m/s. Elsewhere in the report the K of the sandstone is reported to be 1 x 10^{-6} m/s.	Text clarified (1.7e-6 m/s)
8	***Section 4.5, 2nd paragraph 2:*** States that, "there is no evidence of surface	Text clarified.

	water at ground surface". However, the TOR indicates that there are water courses, as well as ponded areas within the previously defined WHPA. Figure 2-3 indicates surface water within approximately 400 metres of MUN1 and within approximately 500 metres of MUN2. Therefore, Geofirma should clarify what area they are referring to in the section 4.5, and report what evidence they considered (ie., OBM mapping, municipal mapping, air photos, field reconnaissance) to make their assessment of surface water.	
9	***Section 4.5, 1st paragraph:*** Golder notes that the MOE GUDI TOR also state that a well is potentially GUDI if the source of groundwater (Le., water bearing zone) is within 15 metres of ground surface.	This is only true if the bedrock well is located within 500 of a surface water body, which is not the case for Lansdowne, however additional text added for clarification.
10	***Section 5.2.1, 1 st paragraph:*** Justification for the municipal well pumping rate used for WHPA delineation (85,239 m 3/year) is not clearly stated.	The justification for the selected rate is now included in the text.
11	***Section 5.3.2, 2nd paragraph:*** The last sentence is likely a typographical error.	The sentence has been deleted from the report.
12	***Section 5.5, 1 st paragraph***: States that the potential GUDI status of the wells increases vulnerability due to transport pathways. However, the vulnerability scoring of Zone A is 10 and the vulnerability scoring of Zones E and Fare 9, which is not higher than 10.	Addressed through a text edit.
13	***Figure 3-2:*** The legend is lacking information. For example, unit 8a is "Massive-well laminated". This is not sufficient as a description of soil type. The soil description should include the major grain size with appropriate modifiers (e.g., silty sand, or sand and gravel).	The legend has been corrected, as requested.
14	***Figure 3-3:*** Many of the rock units in the legend do not appear on the map, and the legend is not presented in stratigraphic order (youngest on top, oldest on bottom).	The legend has been corrected, as requested.
15	***Figure 5-1:*** Is a poor quality figure. There is a lack of detail and it is difficult to locate key features in the study area. This figure does not include a north arrow, and distance units are not indicated.	The figure has been split into two, and additional information has been added.

16	***Figure 5-2:*** It is unclear which hydrostratigraphic unit the hydraulic head is from. Regarding Figure 5-2b, Geofirma should increase the size of the figure and it should include the entire model domain. A north arrow and labelling of key features would be helpful, and it would also be helpful to present this as a simple lined contour map, A similar map, generated using well records completed only within this hydrostratigraphic unit, would be helpful to review calibration. Regarding Figure 5-2a, the statistical plots shown do not provide any confidence with respect to local flow patterns around the pumping wells. The results at the monitoring wells located near the supply wells should be identified.	Changes to the figure and text have been made to address the comment.
17	***Figure 5-3:*** There is no geographic referencing and no scale or north arrow. It is difficult to assess the results without base map information.	The figure has been modified to address the comment.
18	***Figure 7.3:*** Indicates a steady decline in water levels at the Landsdowne well. Was this data considered during development of the conceptual model, and was data used for steady state calibration?	Data was used for transient calibration and selection of a representative specific storage coefficient.
19	***Appendix C:*** Includes well logs for MW3 and MW5 only. Well logs for the other monitoring wells should be included for completeness.	Additional well logs included in Appendix E.
Scott Bates Comments on Version R0A (memo dated February 5, 2010)		**Geofirma Response**
1	***General:*** For the purposes of receiving separate deliverables under the MNR's transfer payment program and the MOE's technical studies program please consider preparing two separate reports for the Tier 2 Water Budget assessment and the Groundwater Vulnerability assessment. Having these two assessments combined in one report is somewhat confusing for the reader.	Requested by CRCA to keep as one report.
2	***General:*** At several points in the report the Assessment Report Technical Rules are referenced. Please make a minor correction to indicate that the assessments were undertaken in accordance with the most recent release of the Assessment Report Technical Rules dated November 16, 2009. There were only minor changes made to the Water Budget portion of the technical rules which should not change your methodology or results.	References updated.

3	***Page iii***: The Executive Summary will require rewording based on a number of the comments provided below.	Text clarified as necessary.
4	***Page 12:*** In the report it states, "*Important assumptions made during the Tier 1 WB study included: Municipal Well consumptive factor = 1.0 (i.e. 100% of water that is pumped leaves subwatershed)*". Please make a minor clarification in the wording for this assumption to state that consumptive factors are based on the 'source' from which the water is pumped (e.g. an aquifer) and not the subwatershed. For example the determination of consumption is not evaluated in relation to the water leaving the subwatershed, but rather the water being taken from the subsurface and not returned to the subsurface within a reasonable time.	Text clarified in report.
5	***Page 28:*** On this page of the report the water budget term G_{NET} is discussed and used in the water budget equation. As discussed further below, the calculation of the water supply term (Q_{SUPPLY}) should be undertaken using only the groundwater recharge ($Q_{RECHARGE}$) and the groundwater flow in (Q_{IN}) to each subwatershed. The primary reason for not using the G_{NET} approach is that the stress thresholds for the stress assessment have been designed and tested to work using the approach outlined in the Water Budget Guidance and Technical Rules. Using the Q_{NET} approach would require redesigning the stress thresholds (on a monthly basis) and would contribute to inconsistent results when compared to other stress assessments being undertaken across the province. Please update the text in the report and the water budget equation to reflect these technical requirements.	Although I disagree with this approach for calculating groundwater stress, the requested changes have been made to the report. Only using groundwater flow into each subwatershed assumes that all water is available for consumption and that none of this water is needed to supply downgradient subwatersheds.
6	***Page 30:*** Please make a minor modification to the text to clarify that the future scenario is not based on a fixed 25-year time horizon but rather should be based on local municipal Official Plan population projections out to their existing time horizon whatever it may be (e.g. 2015, 2020, etc.). Using this method we ensure that the future scenario is based on an officially approved municipal document rather than other estimated projections. Demand should be determined using a per capital rate with appropriate consumptive factors applied.	Text clarified with appropriate reference.
7	***Page 33: In Section 7.5.1*** it states, "*The average annual municipal water pumping rate is approximately 71,000 m^3/yr and this value was used in the*	With the exception of 2001, water use in from the Lansdowne municipal system has been relatively

	WHPA modelling for current conditions." Please revise the calculation of municipal demand for water budgeting purposes to reflect pumping during the "Study Year" as defined in the Technical Rules. Rather than using the 10-year average between 1998-2008 the Technical Rules require the use of pumping rates during the study year. This requirement is primarily to ensure we are using the most recent and representative pumping from the municipal system.	consistent, at between 60,000 – 80,000 m^3 per year and consistently alternating between high 60K and low 70K m^3/year each year over the past five years. Therefore, although the Technical Rules request an estimation of municipal demand for the "Study Year", defined as the most recent full year of data, to ensure that the most representative pumping rates are being used, this is not the most representative pumping rate for the Lansdowne municipal supply wells. The most recent and representative municipal well pumping reates for Lansdowne is an average annual municipal water pumping rate over the most recent two years of reported data (2007 and 2008). This value, approximately 71,000 m^3/yr, was used in the WHPA modelling for current conditions.
8	***Page 36:*** Please consider removing the terminology "super drought" from the report, it is not a common term used in either the Water Budget Guidance or the Assessment Report Technical Rules.	Text revised.
9	***Page 37:*** In the report it states, "*This results in a moderate stress with respect to both current and future pumping rates, further emphasizing the high level of uncertainty in the percent water demand classification."* Please be cautious with the use of language related to the uncertainty in the report. Using statements like "*further emphasizing the high level of uncertainty*" runs the risk of having the assessment dismissed/diminished technically or scientifically. While the percent water demand calculations do have their inherent uncertainties, they do use the most recent information in a technically and scientifically defensible manner. You may wish to consider adding a section that discusses your overall certainty with assigning a specific stress level (e.g. how certain are you that you have assigned the stress level correctly). The Source Protection Teams and Source Protection Committees may also wish to consider both the benefits and risks associated with the use of this language in the reports.	Text revised.
10	***Page 38:*** Please remove the discussion in Section 7.8.3 of the report related to the use of G_{NET} versus G_{IN} for the reasons stated above in Comment 5.	Although this alternate analysis is considered useful information, this section has been removed and will

	Additionally, the argument that, "*if the subwatershed upstream consumed all of the water that laterally flowed into it, there would be no lateral groundwater flow into the Lansdowne subwatershed.*" is not particularly valid because if this was actually the case it would be incorporated into the groundwater model and be evident in the MODFLOW calculations. The fact that the subwatershed upstream currently does not consume this water confirms that the G_{IN} is available as additional supply for the Lansdowne subwatershed. As new water takings or land use changes occur in and around the subwatershed they will be built into the model and proportionately affect the G_{IN} calculations.	be submitted to CRCA under separate cover letter.
11	***Page 38:*** Please remove Section 7.8.4 from the report as there is no requirement to undertake this evaluation in the Assessment Report Technical Rules. Similar to reasons stated above, using this approach would require redesigning the stress thresholds (on a monthly basis) and would contribute to inconsistent results when compared to other stress assessments being undertaken across the province. This being said, it may be useful for CRCA to receive this information in a separate supplementary report for their consideration in other programs.	Although these monthly stress calculations are considered useful information, this section has been removed and will be submitted to CRCA under separate cover letter.
12	***Page 40:*** The discussion and determination of the groundwater stress level on this page is not consistent with Technical Rule 35(2)(h) that requires all three sub-clauses to be true. Specifically the percent water demand calculation does not meet the requirement of 35(2)(h)(i) where the annual percent water demand must be between 8% and 10% inclusive.	Text changed to reflect the removal of Sections 7.8.3 and 7.8.4 in the report as discussed above.
13	***Page 165:*** Although Appendix H "Percent Groundwater Demand – Alternate Approach" is useful in demonstrating the calculations of the water budget components and the percent water demand using an alternative approach it should be removed from the final water budget report because there is no requirement to undertake this evaluation in the Assessment Report Technical Rules. This being said, it may be useful for CRCA to receive this information in a separate supplementary report for their consideration in other programs.	Although the "Percent Groundwater Demand – Alternate Approach" is considered useful information, Appendix H has been removed and will be submitted to CRCA under separate cover letter.
Darrin Burr Comments on Version R0A		**Geofirma Response**
1	***Pg 11, 1st paragraph and other locations:*** In many locations within the report, reference is made to the well being "potentially" GUDI. This conclusion is based	A limited GUDI assessment was a requirement in the CRCA TOR for this study. The assessment of a poor

	on the observation of cascading water in the well around 6 mbgs, and bacteriological problems. However, a GUDI study has been conducted previously, and the system declared non-GUDI. Based on the data in the report, it appears that the problem is more of an impacted shallow groundwater problem /poor well casing seal than a connection with nearby surface water, especially considering that no surface water is reported to be in the nearby area. Therefore, I suggest that the report's reference to "GUDI" in numerous locations be reviewed, and that comments on the GUDI status of the system not be included in the water budget report, as it is outside of the reports purpose (such issues could be raised separately)	well seal being a more logical explanation for the bacteriological problems is exactly how it is described in the report. The inclusion of WHPA zones E and F were included for completeness in case this interpretation is clarified in the future.
2	***Pg 20, Section 5.1.2, 1st paragraph:*** The paragraph states that no-flow boundaries were assigned to the exterior of the model domain. Were any boundaries assigned constant head? How were the lagoons included in the model?	Additional text added for clarification.
3	***Pg 22, Section 5.1.4 1st paragraph:*** The sentence "The corresponding simulated hydraulic heads were interpolated ..." is not clear. The way the sentence reads, it appears that observed heads were compared to water found elevations in the domestic wells (rather than static elevations). If this was done, more rationale is needed, as model calibration is usually performed to the static heads (not water found elevations). Perhaps the water found elevations were used to identify which layer the static elevations applied to?	Reviewers assumptions are correct. Text clarified.
4	***Pg 23, 2nd paragraph from top:*** The paragraph states that there is no spatial bias in the calibration residuals. When I look at Figure 5-2, it appears that the orange, red and yellow dots correlate with the higher hydraulic heads on the topographic high in the NW part of the village, and that dots are more green to the SE off the topographic high. I also note that there are very few calibration wells on the topographic high. In the future, drilling of additional wells in this area would be useful to improve the calibration. I also note that the relatively good RMS calculations for Lansdowne can be misleading when large model domains are used where topography difference are large. For Lansdowne, the simulated vs observed hydraulic head data shows a large scatter, suggesting that calibration is not as good as the RMS	Model calibration was completed using a variety of pumping conditions (static water levels measured after the installation of the pumping wells) and non-pumping conditions (MOE water well record levels before the municipal wells were installed). Overall the model calibration is considered sufficient, given the data set. The authors agree with the comment pertaining to location of future monitoring wells.

	calculations would appear. I suggest that the model be calibrated to the wells that are in close proximity of the pumping wells; however, this would still not remove the problem of no water level control data to the north , west and east of the pumping wells	
5	***Pg 24, Section 5.2.2:*** It is difficult to develop WHPA E/F when no surface water is present, therefore I suggest it not be included. You may want to talk to QC about their experience with Tweed.	See response to DB comment # 1.
6	***Pg 25, 3rd paragraph:*** The report states that adjustment of vulnerability to account for transport pathways is not necessary. I understand that the Technical Rules still require transport pathways to be identified, even if the data is not used to increase vulnerability.	Section 5.4 added to summarize transport pathways.
7	***Pg 26, Section 5.4:*** I suggest that the uncertainty rating be high (not low). The rationale is provided in Section 5.5, where there is significant data gaps (geological understanding, recharge estimates, vertical K etc) that would affect the results. Even though a very thorough uncertainty analysis was done with the model, groundwater flow will still be controlled by fractures, which are largely unpredictable with the existing field data. In addition, there are few calibration wells in key locations (on topographic high north and west of village).	Based on further sensitivity analysis, WHPA Zones B and C were assigned a high uncertainty rating, due to their strong dependence on bedrock porosity, a highly uncertain value.
8	***Pg, 33 Section 7.5.1:*** How was non-permitted private well demand incorporated into the model?	This was not incorporated into the model; the water budget shows that non-permitted takings (agricultural and domestic) were small relative to the municipal takings
9	***Pg 32, Section 7.4.1, 3rd paragraph:*** It would be useful to show a potentiometric surface map for Lansdowne so we can see natural flow directions. I presume that since there is a Gin component, than there is an ambient gradient direction? Capture zones are generally circular, suggesting there is no ambient gradient direction. Why the difference? A potentiometric map would perhaps explain this.	Figure 5-4 includes a potentiometric surface map. Capture zones are generally circular because the municipal wells are situated on a local topographic high.
10	***Pg 36, Section 7.7.1:*** It appears that the rationale for going to the 10 year drought, rather than stopping at the 2-year drought scenario was because of the	Agreed, however this analysis was completed out of interest.

	concern that the well pump efficiency would decrease, even though the stress at the 2-year drought level was okay. I don't think pump efficiency (as this is speculative) is one of the criteria in the Technical Rules, and the analysis should be based on Technical Rules criteria only. Should the pump not be able to pump at the required volumes (because of lower heads), then the municipality could change the pump.	
11	***Pg 38, Section 7.8.3 1st paragraph:*** There appears to be a trend of decreasing water levels; however, comments should be made in the report on whether this is in part a result of well fouling because of bacteriological or mineralization problems. How do water levels compare to what was observed at time of initial drilling in 1975 (or perhaps these records are not available). Also, the decrease is in the pumping well, rather than data from an observation well, so the results may not be representative of actual aquifer conditions.	Water levels in 2009 were about 2 m lower than when wells were initially drilled – but they are never allowed to fully recover once pump is turned off so it may not be appropriate to compare these.
12	***Pg 40, Section 7.10*:** Another data gap would be the lack of calibration water levels on the topographic high west and north of the village	Agreed, added to report.
13	***Pg 41, Recommendation 2:*** More data is needed prior to implementation of a Tier 3 water budget model. This information should include a) confirmation of water level decreases in the aquifer (not just the well). b) confirmation that reduction in water levels in the well are caused by mineralization/bacteriological buildup c) if a model is to be performed, reduce the model domain to be more local rather than regional, and calibrate to wells in close proximity of well field. Additional well control points are recommended to the north, west and north east of the well field d) performance of a pumping test to calculate average K, T and S values for aquifer e) confirm recharge values by looking at variations in water levels with precipitation patterns.	Upon removal of Sections 7.8.3 and 7.8.4, Tier 3 Water Budget is not considered necessary.
Ed Watt Comments on Version R0A		**Geofirma Response**

1	***General:*** I found the Executive Summary and Main Report to be generally well-written and nicely presented.	No response necessary.
2	***General:*** There are a few places where corrections of an editorial nature are required. These include spelling mistakes (e.g. "great Lakes" and "Village"), typos (see paragraph 2 of section 2.1), departures from convention (e.g. the SI abbreviation for hour is h, not hr or hrs) and poor form (the equations are barely legible).	Revisions completed as appropriate.
3	***General:*** I fully agree with the discussion in section 7.8.3 regarding the use of G_{net} for supply.	No response necessary – see MNR comment # 5.
4	***Section 5.1.4:*** I realize that some groundwater modellers use the term residual to denote the difference between modelled and observed heads or water levels, but will leave a discussion of the appropriateness of this terminology to another day. In order to evaluate the success of the calibration (mean of absolute differences = 3.4 - 5.4 m), it would be helpful to have an estimate of the error in top of casing elevations for two categories of well: 1) those that have been leveled in and 2) those for which casing elevation have been taken from a DEM or topographic map, and how many of the 153 observation are in each category. However, for category 2 wells, one would not expect a bias in ground elevation estimates by an experienced geologist or engineer, so without additional information, I must conclude that the cause of the difference between modelled and observed heads is modelling error. If this is the case, and if there is a bias towards "over-prediction", why would one not vary another parameter (such as specific storage) to eliminate this bias, insofar as possible? Maybe just address this point. Finally, the correlation coefficient is not the appropriate statistic in this case.	Specific storage was varied to better calibrate the transient model (i.e. best match to annual fluctuations in municipal pumping wells).
5	***Section 7.3:*** I agree with the 'professional judgment' approach to estimating monthly values of recharge.	No response necessary.
6	***Section 7.4.2:*** Table 7-3. Wow, 7 significant figures for annual supply! Are you confident that the supply is not 1,095,878 rather than 1,095,879? I don't think	Monthly values are calculated as described in text and therefore presented to nearest 1 m^3/month not to

	so.	indicate level of precision but rather to remain consistent with text and resulting calculations using the estimated values. Annual values reported as sum of monthly values for consistency and transparency of calculations.
7	***Section 7.5.4:*** Table 7-4. 5 significant figures are still a bit much.	Monthly values are calculated as described in text and therefore presented to nearest 1 m^3/month not to indicate level of precision but rather to remain consistent with text and resulting calculations using the estimated values. Annual values reported as sum of monthly values for consistency and transparency of calculations.
8	***Section 7.6:*** Table 7-5. Wow, again.	Monthly values are calculated as described in text and therefore presented to nearest 1 m^3/month not to indicate level of precision but rather to remain consistent with text and resulting calculations using the estimated values. Annual values reported as sum of monthly values for consistency and transparency of calculations.
9	***References***: Check the date for the technical rules. I think that it should be 2009.	Reference updated.

Ed Watt Comments on Version R1A				**Geofirma Response**
Page	**Para**	**Line**	**Comment**	
iii	2	1	village not Village.	Text changed to address comment.
1	4	7	CSPA not CRCA SPA.	Text changed to address comment.
3	1	1	Village not village to agree with page 1.	Text changed to address comment.

3	4	6	500 m^3 not 500m^3.	Text changed to address comment.
3	3	5	m not metres.	Text changed to address comment.
5	1	9	I don't believe that the Raisin-South Nation folks were involved in the conceptual WB studies.	Change made.
5	4	3	Replace Gin with Gnet for the WB. Gin was used for stress calculations as mandated by the rules.	Change made.
7	1	5	Wilson (1946) is not in the list of references.	Added.
9	1	1	The not teh.	Text changed to address comment.
12	6	1	Should clarify method of solution, that is Theis method (log-log matching procedure) or Jacob approximation (semi-log method).	The Theis curve matching procedure was used, and Appendix F has been updated to make this more apparent.
12	6	3	1. Why is there a difference in the number of significant figures reported for T for the two wells? An explanation is required. 2. $3.4x10^{-6}$, $1.3x10^{-6}$.	The numbers have been rounded to eliminate the noted difference.
13	1	5	Should identify the responsible unit within Queen's University. Also, confirm that manual levels were taken to confirm that the transducer was functioning properly.	Text changed to address comment. We cannot confirm that manual levels were taken.
13	2	2	Delete "of".	Change made.
13	4	1	Hvorslev (1951) is not in the list of references.	Added appropriate citation and reference. Removed reference to (1951).
14	Table 4.4	1	1. m^2/day not m2/day. 2. How can you justify four significant figures for S? 3. Values for S estimated from pumping tests appear to be too high by at least an order of magnitude. This should be	1. Change made. 2. All values of S removed, as there is insufficient data to calculate them

			clarified and a comment added.	3. See 2.
14	Table 4.4		Wilson (1974) and Thompson (1991) are not in the list of references.	Reference added.
15	5	1	Wilson (1974) is not in the list of references.	Reference added.
16	1	1	MOE (2001) is not in the list of references.	Reference added.
17	4	5, 6	Here and elsewhere, should be consistent regarding use of metres and m.	Metres changed to m
19	2	5	Delete “a”.	Done
20	Table 5.2	6	1) Does “RMS” stand for RMS residual? 2) If so, are there not units for “RMS”?	RMS is defined in the text above. It does have units of m, and this has been added to the table.
20	2	all	This paragraph should be rewritten to justify the observations/conclusions. How does the claim that case 1 simulations are unbiased match up with a residual mean of 1.6 m? Perhaps there is a bias in the observed hydraulic head. In any event, the fact that a residual mean significantly different from zero is deemed an acceptable calibration should be addressed in the text accompanying Table 5.2. In addition, the large over-predictions should be addressed. As it stands, without explanation, the table does not tend to inspire confidence in the modeller/report writer. Could include a brief discussion of the problems with the available calibration points as well as a discussion regarding the cluster of points that are over-predicted for all cases.	Text has been changed to address comment. The largest over-predictions are not actually so, but reflect artificially low observed hydraulic heads. Reference is made to the new Figure 5-1, which shows observed hydraulic heads, including a “bulls-eye” at an artificially low measured value.
21	3	2	simulations not simulation.	Change made.

25	1	3	Either change Gin to Gnet on LHS or add Gout to RHS.	Changed Gin to Gnet on LHS
25	5	1	Either add Gout or deal with Gnet for WB.	Dealt with Gnet for WB.
26	3	1, 2	Water is usually referred to as above surface, surface and subsurface storage. Some folks might take groundwater as not including the unsaturated zone.	No change made. Groundwater is the term used by the Technical Rules. A similar amount of confusion may be raised by introducing the term subsurface water since the reader may not be sure if subsurface water is addressed by the Technical Rules.
26	Table 6.1		Change Gin to Gnet or add Gout, and revise numbers accordingly.	Change made.
27	1	4	Font problem with QReserve?	Fixed
28	3	5	metre or m, not metres.	Metres changed to m
28	4	1	In the interest of completeness, average monthly recharge rates and average monthly values of Gin should be tabulated.	The paragraph has been reworded to place more emphasis on the fact that average annual results were used. As the monthly values are not used beyond taking their average, we do not include them in the report.
29	2	2	Cite Technical Rules, not Guidance.	Change made.
29	6	1	Cite Technical Rules, not Guidance.	Change made.
29	6	1, 2	This discussion applies to tables 7.3, 7.4 and 7.5. The explanation given is not the generally accepted interpretation. Reported values reflect the precision by the number of significant figures. Google “number of significant figures” to get When reporting values that were the result of a measurement or calculated using measured values, it is important to have a way to indicated the certainty of the measurement. This is accomplished through the use of significant figures. Significant figures are the digits in a value that are known with some degree	Values in the tables have been rounded to reflect measurement uncertainty.

			of confidence. As the number of significant figures increases, the more certain the measurement. As precision of a measurement increases, so does the number of significant figures.	
30	Table 7.3		Why is Storage included in this table?	It has been removed.
30	2	7	60,000 and 70,000 not 60K and 70K.	Change made.
30	3	3	Cite Technical Rules, not Guidance.	No change made. While the Technical Rules discuss consumptive use, the Rules do not discuss a consumptive factor or provide a list of consumptive factors. The consumptive factor was obtained from the Guidance.
31	2	11	Cite Technical Rules, not Guidance.	No change made. While the Technical Rules discuss consumptive use, the Rules do not discuss a consumptive factor or provide a list of consumptive factors. The consumptive factor was obtained from the Guidance.
31	4	2	Cite Technical Rules, not Guidance.	No change made. While the Technical Rules discuss consumptive use, the Rules do not discuss a consumptive factor or provide a list of consumptive factors. The consumptive factor was obtained from the Guidance.
31	5	2	Cite Technical Rules, not Guidance.	Changes made to the text to clarify the definition of future demand and the assumptions associated with calculating future demand.
31	6	2	1% per year for 20 years is a 22% increase over 20 years!	The bracketed text referring to the increase over 20 years has been removed. We have retained a 20% increase over 20 years for our calculations as this is a reasonable value.

34	2	1	Cite Technical Rules, not Guidance.	Change made.
Fig 5.3			1. m^3/year not m3/year 2. Figure is not very reader-friendly. Maybe replace with Box-Whisker plots for various sub-areas. 3. Alternatively, just show plot for one case, and if possible colour code dots according to location so that the reader can determine the location of the gross over-predictions.	1. Done 2. The figure format is standard in the industry, and we would prefer not to change it. 3.
Fig 5.4			1. Small dots for municipal wells are not visible. 2. The coloured dots superimposed on the coloured areas of simulated hydraulic head are somewhat difficult to interpret. The text on page 20 makes no reference to simulated hydraulic head, but refers to" particular areas". Maybe coloured dots on a white background with contours would be more reader-friendly.	1. Change shape and size of symbol 2. Changed colour flood to grey scale.
Fig 7.2			1) The caption says 2001 -2010, but the points go from 1998-2008. 2) Why are fit lines employed? Bars or stacked bars would be more appropriate.	1) Caption edited to address comment 2) Fit lines replaced with bars.
Fig 7.3			1) The caption is not accurate; the chart shows depths below ground, not levels. 2) Why is a linear regression line shown? It detracts from the plot and the regression accounts for only 43% of the variance. The line should be removed unless some discussion is added justifying the linear mode. 3) How can 5 significant figures be justified for the intercept?	1) Caption changed to address comment 2) Regression line removed. 3) Regression equation removed.
OCWA Comments on Version R1A				**Geofirma Response**
Conclusions				
On Conclusion 1 that "Despite a recent study concluding that the Lansdowne municipal wells are not GUDI, the recent bacteriological contamination, the shallow well casing and the cascading water suggest that this issue be re-visited." "Lansdowne's municipal wells are being treated as GUDI. As such, treatment				We acknowledge that the recently installed treatment makes the issue of GUDI versus non-GUDI a moot point. We do conclude, however, that a better well seal would result in better overall reliability of the

equivalent to chemically assisted filtration (suitable for surface water) has recently been installed."	water supply.
On Conclusion 2 that "Long-term groundwater levels in the Lansdowne municipal wells show a steady decline of approximately 2 m over 9 years." "The apparent decline in water level can be attributed to faulty instrumentation. This issue was noted in the minutes of the meeting held on December 22, 2010."	Text modified to address comment.
Recommendations	
On Recommendation 1 to "Deepen the steel casing within the municipal wells to block off any cascading water from entering the municipal system" "Treatment equivalent to chemically assisted filtration (suitable for surface water) has been installed on the municipal water supply. As such, deepening the steel casing to block cascading water will not provide any added benefit to the system and would be costly for the municipality to implement."	Text modified to address comment. Since the system does not treat for chemical contamination, we have retained a recommendation that "consideration be given" to deepening the casing as part of the "multi-barrier approach" to source protection.
On Recommendation 3 to "Initiate a long term continuous groundwater monitoring program in accessible monitoring wells." "New well level transducers are to be installed on Lansdowne's municipal wells as part of the upgrades to the treatment system. The transducers will be incorporated into the SCADA system which can provide historical records from the time of installation."	Acknowledged.
On Recommendation 4 to "Complete depth discrete hydraulic testing within municipal well when there is a scheduled pump removal for maintenance. Although not required by the Technical Rules, additional hydraulic testing is recommended to better estimate the bedrock aquifer parameters and provide an opportunity to collect groundwater samples from isolated intervals in an attempt to better understand the source of the bacteriological contamination in the municipal well. The additional hydraulic data is not expected to alter the WHPA delineation beyond that already incorporated into the sensitivity analysis but would provide an opportunity to fine tune the conceptual model and input parameters, thereby reducing uncertainty."	Acknowledged.

"This may be costly for the municipality to implement."	
Additional Notes	
The most recent population estimate provided to us by the Township for Lansdowne (in 2008) was approximately 590.	The population figures reported in the text have been updated.
It is noted in the study that the "Lansdowne municipal wells appear to show impact from surface contamination due to a poor well seal". However, the attached report by Malroz Eng. from 2003 concluded there was no infiltration or leakage around the bottom of the casing of Well #2.	Text modified to address comment.
Darrin Burr Comments on Version R1B	**Geofirma Response**
Pg 1, Section 1.2: I understand that consideration of the GUDI issue was part of the project TOR. I suggest that if this discussion is to remain in this report, reference to the scope of this assessment should be added to this section.	Text has been added to Section 1.2 and 1.3 to address this comment.
Ph 9. 1st sentence : "the" is spelled incorrectly in 1st sentence	Fixed
Pg 9, Section 4.2: Please make reference to the source of the top of casing elevation. Was it surveyed, or was it based on MOE records? If the latter, some discussion of the expected accuracy of the top of casing elevation should be added.	The top of casing elevation was estimated from a digital elevation model of the area, based on well coordinates determined using a GPS.
Pg 16, Section 4.5: I suggest that any reference to GUDI in the context of the Safe Drinking Water Act be issued as a separate letter, rather than including it in this report which focuses on the Clean Water Act. The last sentence states that because the wells are considered "potentially" GUDI for the purpose of this assessment, that WHPA-E and WHPA-F are required. My understanding is that the need for WHPA-E/F is defined in Technical Rule 49. I don't believe Rule 49(3) is met, and therefore WHPA-E/F is not needed. I suggest that the report authors discuss this issue with MOE. In addition, WHPA-F is only required if a water quality issue is identified and that the source of the issue is not in WHPA-A to E.	GUDI is discussed in this report for completeness, and to be consistent with other studies in the Cataraqui Source Protection Region. With respect to WHPA-E, CRCA has taken the precautionary approach, and delineated this WHPA, despite the fact that no surface water is mapped close to the wellhead. WHPA-F is delineated here, but is not presented in the Assessment report, for the reasons stated by the Peer Reviewer.
Pg 21, Section 5.2.1, last paragraph: I recommend adding a map that shows contoured potentiometric surface data from wells. This map could be included/discussed in Section 4. I understand that Figure 5-4 shows the modeled results and residuals but does not show the contoured actual data. A comment should be made on whether the contoured MOE data supports the conclusion of no regional flow system being present in the portion	The requested map of contoured hydraulic head from the WWIS has been included (Figure 5-1). Text has been added to the first paragraph of Section 5.1.2 to support the approach.

of aquifer that is pumped by the municipal wells.		
Pg 21, Section 5.2.2: See comment above for Section 4.5		See response above for Section 4.5
Pg 23, Section 5.3.2: See comment above for Section 4.5. Since there is no surface water, I don't think WHPA-E/F can be defined, and vulnerability assessment performed. I recommend that the authors clarify the approach with the MOE.		See response above for Section 4.5
Pg 24, Section 5.4: I suggest that some text be added that states that an increase in vulnerability is not required as the aquifer vulnerability is already set at high.		Text added to address comment.
Pg 33, Section 7.7: I recommend that MOE be contacted for interpretation with respect to 35(2) ii. Can a moderate level of stress be assigned to a well for purely a mechanical reason (i.e., well pump too high?)		Since the Lansdowne subwatershed is assigned a low stress level, clarification of this point is not required at this time.
Pg 35, Section 7.8.3: The response to Dillon's original comments implied that there was some uncertainty in the significance of the 2 m decrease. The response stated that the wells are never allowed to fully recover when the pump is turned off. I suggest that this uncertainty be mentioned in the text of the report		New information suggests that the water level decline was the result of instrument drift. Text has been added to the report, and the significance of 2 m decrease has been reduced in terms of the conclusions and recommendations.
Pg 38, Recommendations: I suggest you mention the need for additional monitoring wells to improve calibration of model. Key areas would be on topographically high areas west and north of village.		Agreed. Text added to the recommendations to address comment.
Golder Comments on Version R1A (as provided in Teleconference notes prepared by Sean Watt)		**Geofirma Response**
1	• Brian's comment is about how the change was presented in the report specifically, where the text seems to suggest that a value of 10%, while high, is still a reasonable value. He doesn't think this is true, but rather that 10% porosity is much too high for sandstone or precambrian rock. This statement is on page 8 of the report, last paragraph. • Perhaps a revision to the text, stating more along the lines that 1% is an appropriate value, without implying that 10% is also an appropriate.	The paragraph has been reworded.
2	• Brian's first comment related to the hydrostatigraphy, the bedrock geology map of Figure 3-3, and the extent of the Nepean formation. The map from the previous draft of the report had the central Nepean area divided into three pieces. • ***Sean W is checking in the details of the map layers.** I was able to recreate both maps using two bedrock layers. The first shows the northern portion of the*	Figure 1 shows the sandstone thickness used in the model, along with the outlines of the sandstone as mapped in the report, and after some minor modifications were made during model pre-processing. The latter modifications were made to incorporate the southern tip of the topographic high

	Nepean area, and identifies it as "Potsdam Gp.; Nepean Fm.; Covey Hill Fm.". The second shows the two southern portion, identifying them as "Nepean" and "Potsdam". It would appear that the grouping of these areas in the most recent version of the report is acceptable, and that they are the same formations. Attached is the metadata for the mapping files, the Bedrock Geology layer of Ontario, and the Paleozoic Geology layer of Ontario. • Ant noted that the geology areas are thin layers, and may not make a difference to the model overall. Ant was also going to check the details of that data.	(see Figure 3.1 in the report) which was felt to be as accurate a indicator of sandstone presence as the geological mapping, which appeared then, as now, to be subject to error. Importantly, Figure 1 indicates that the sandstone thickness in the entire westerly lobe of the mapped "Nepean/Potsdam" was modelled with zero thickness, which is consistent with the idea that this western lobe may in fact be conglomerate.
3	• Brian asked about the overburden, in particular the area of clay west of town that is 20 m thick. He asked whether it was included in the model. Ant confirmed that yes, it is. • Ant noted that the overburden in general matters very little from a GW flow perspective, as the flow is really in the bedrock, not the overburden. • Brian also asked whether the area of sand noted on page 20 was included in the model? • Ant noted that there are some small inconsistent layers of coarse grained materials shown in some wells, but that these were not included in all the wells, and that all overburden was made the same in terms of model parameters, instead of having small clusters of coarse grained estimations. • Those small areas make pockets in the model, and are difficult to build in the model, and have limited effect, so basically they are ignored. • A suggestion that maybe adding a sentence about why these coarse grained areas were not included in the model, where the sand is discussed on page 20.	The 1st paragraph of Section 3.3, the 1st paragraph of Section 3.5, and the 2nd paragraph of Section 5.1.1 were reworded to address comment
4	• It was recommended to add text into the report on the alternative ISI method in the guidance, and add text to the rationale.	Text was added to the first paragraph of Section 5.3.1 indicating that the guidance allows for the calculation of ISI from the ground surface to the supply aquifer rather than from the ground surface to the water table. Also the second paragraph was edited to indicate that the overburden was interpolated from the WWIS prior to calculation of ISI, which minimizes the effect of spurious data.
5	• On the top of page 8, the Brian noted the text states the overburden unit has high porosity, and low and isotropic hydraulic conductivity. He suggested adding maybe another sentence to explain why no others were included?	See response to Comment #3.
6	• Brian also noted that maybe not all surficial fields are present in map, and many may be above the water table too. He recommended adding that statement to the text of report. It was also noted that the overburden is generally unsaturated.	See response to Comment #3.

7	• Brian asked about including a water table contour map from the raw data, showing the well record levels, and the simulated contours on top.	The requested map of contoured hydraulic head from the WWIS has been included (Figure 5-1). Inclusion of the simulated hydraulic heads on this figure would make it very difficult to read.
8	• Brian asked about Figure 5-4, and whether all wells with water levels are included. And if so, why do so many more wells appear on Figure 2-2? Ant noted it must be that many of the 2-2 wells don't have water levels, so aren't shown on 5-4.	Figure 2 provides an explanation for the differences between Figure 2-2 and Figure 5-4. The green dots are calibration targets in the model (based on the MOW WWIS, unmodified by CRCA). The large red dots are wells included in the CRCA version of the database with enough information to support their use as calibration targets, and the small brown dots are all wells included in the CRCA version of the database regardless of their data quality and completeness. (Small brown dots on their own represent wells with missing information that cannot be used as calibration targets.) There are perhaps 4 potential calibration targets that could provide information to the model (i.e., are in areas not well covered by the green dots), but this additional information would not be sufficient to support any changes to the model, and would not influence WHPA delineation. Incorporation of these few additional data into the model is not justified at this time.
9	• It was also noted that, with respect to transport pathways in Section 5.4, the vulnerability as allowed in the Technical Rules cannot be adjusted any more than one category, from Low to Moderate or Moderate to High. In this case, with the ISI showing High vulnerability across the WHPA, each zone was raised one category. Even though there are various transport pathways across the WHPA, wells, service trenches, lagoons, etc., the vulnerability cannot be raised for the study. However, the reality is that every hole in the overburden does increase the actual vulnerability of the aquifer to contamination. It was recommended that perhaps some text along these lines could be added to the report in this section.	Text added to report to address comment.

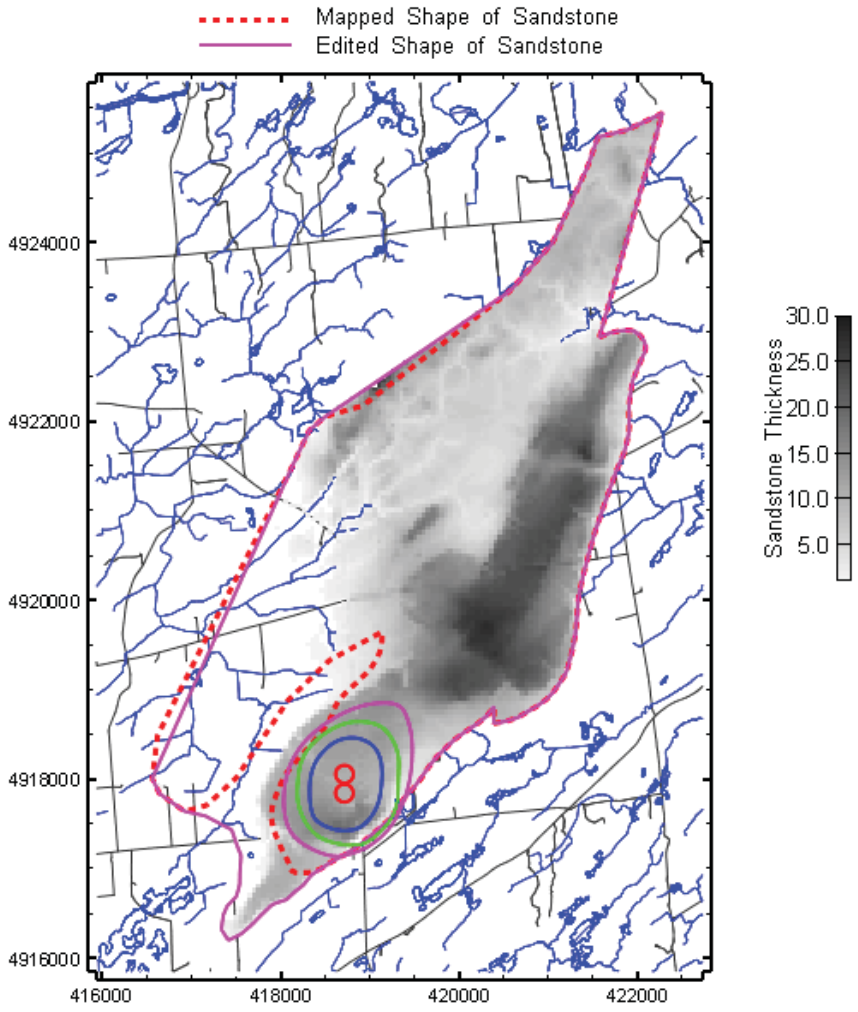

Figure 1 Sandstone Thickness as Used to Construct the Groundwater Flow Model

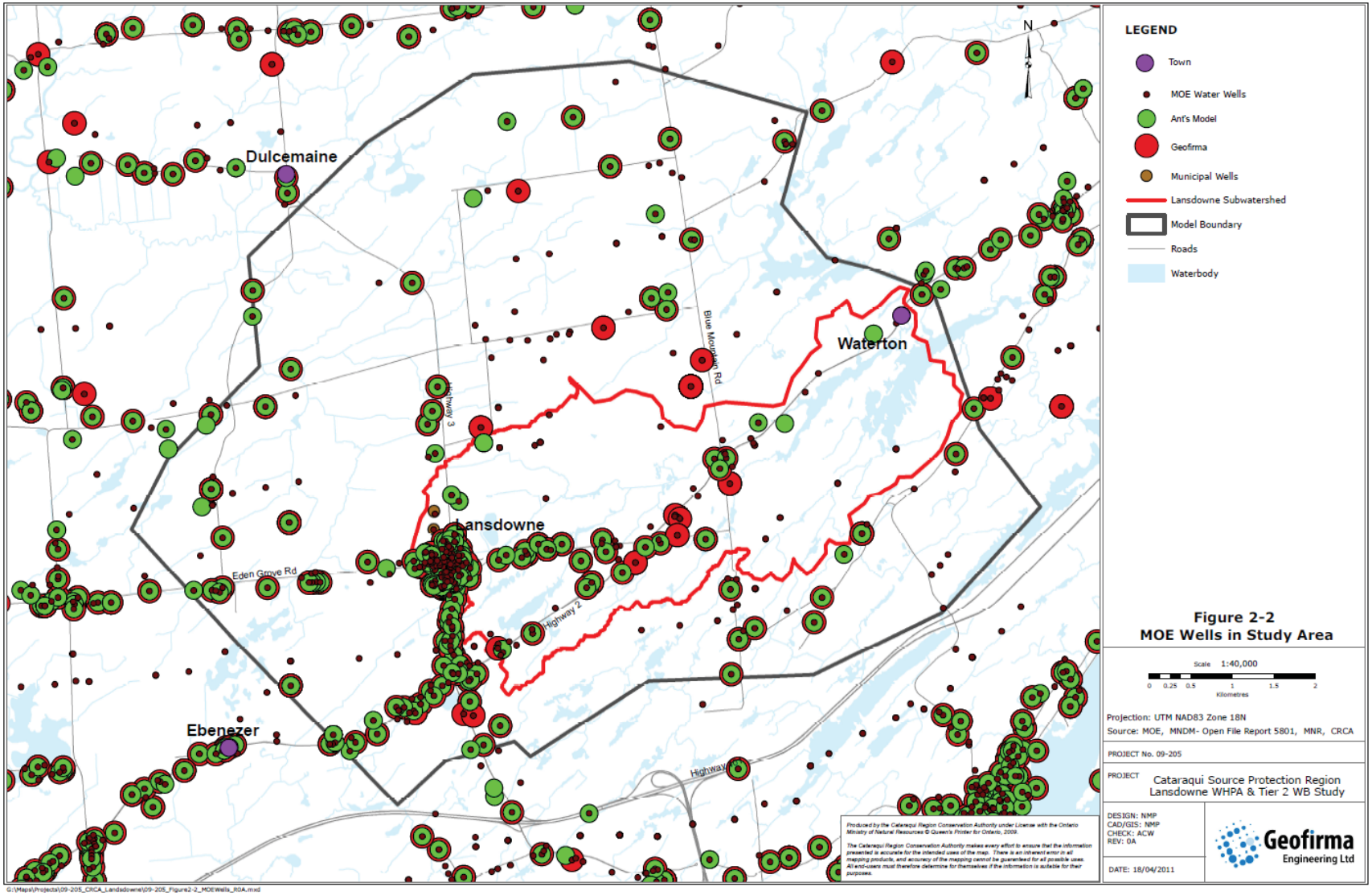

Figure 2 Analysis of Water Well Data Used in the Lansdowne Study