TECHNICAL MEMO

Prepared by:

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Date: July 24, 2020

Re: Aurora Groundwater "Areas of Concern" mapping – v1

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1. Background – Information & Analysis System

The Oak Ridges Moraine Groundwater Program (ORMGP; Appendix A) has developed and maintains a Groundwater Information and Analysis System. The ORMGP information system contains data and mapping related to, but not limited to, geology, groundwater levels and quality, streamflow and climate. The information system also contains a digital library of documents related to the ORMGP study area (Figure A1) that includes consultant and agency reports, journal articles, etc. Interpretive products are also available such as the three-dimensional arrangement of geologic units as depicted on the cross-sections shown on Figure 1 and Figure 5.

All information managed by the ORMGP is available to all partner agencies (Regions of York, Peel, Durham, City of Toronto, and the nine Conservation Authorities on the Oak Ridges Moraine) and their designates (e.g., consultants). Information related to borehole locations, climate stations and permit to take water locations are available to the public and some information is password protected on the Program website (www.oakridgeswater.ca). Since late 2015, technical staff at other government agencies (e.g., Ontario Geological Survey,

Geological Survey of Canada, and Ontario Ministry of the Environment, Conservation and Parks (MECP; Central Region) have also been provided with full access to the Program's password protected website, and more recently the Program has started a subscription access to the consulting community. The goal is to increase the user-base which is seen as a key aspect of the continual improvement philosophy of the information and analysis system.

In order to facilitate increased utilization of water-related information into the decision-making process, work is being conducted to prepare mapping of known/expected areas where groundwater issues (i.e. shallow groundwater and/or artesian (flowing) conditions) may be encountered. The goal is to avoid groundwater 'surprises' when undertaking infrastructure/development construction and/or maintenance projects. The main objective, from a groundwater perspective, is to proactively assess, understand and map areas that might pose a concern related to infrastructure prior to any on-site construction activity. A key aspect of this mapping is that the interpretations can be refined as new information is incorporated. It should be noted that a groundwater issue (e.g. too much groundwater, or groundwater under pressure) from an infrastructure/development perspective may also be viewed as an opportunity from another perspective (e.g., heat exchange, water supply).

2. Regional Groundwater Issues – ORMGP Study Area

The ORMGP study area covers much of south-central Ontario (Figure A1). A working hypothesis is that groundwater issues or potential areas of concern for south-central Ontario generally relate to four types of hydrogeologic settings (Figure 1) as follows:

1) Confined Oak Ridges Aquifer Complex (ORAC; or other regional/local aquifers). Example areas include Richmond Hill and Stouffville;
2) Areas of aquifer outcrop/subcrop along steep topographic slopes. Examples include along deep river valleys, along the Lake Iroquois shoreline, and on the north slope of the Oak Ridges Moraine (e.g., Uxbridge) where discharge from aquifers to the surface occurs or is restricted by confining units on the slopes;
3) Coarse-grained sand and gravel deposits (channels) within sediments beneath the Lower Newmarket Till, or more generally in the shallow subsurface. Examples include the 'Yonge Street Aquifer' in the communities of Aurora, Newmarket, Holland Landing and Queensville and in the Markham-Stouffville area such as at 16th Avenue and Highway 48;
4) Gravel zones within bedrock valleys (e.g. western part of the City of Toronto).

It is acknowledged that there may be miscellaneous local areas with thin aquifers of limited lateral extent that may be under confined conditions. It is also acknowledged that much of the study area may contain shallow water table conditions that will need to be controlled during excavation and construction. Also, locations situated near large lakes (e.g. Lake Ontario) may need groundwater control in perpetuity. The groundwater "Areas of Concern" presented herein are considered areas where groundwater control may pose problems (and likely financial costs) beyond the typical situations of water table control during and/or post construction.

3. Local Groundwater "Areas of Concern" – Town of Aurora

3.1 Physical Setting

The Town of Aurora is situated on the north flank of the Oak Ridges Moraine, bounded by Bathurst Street on the west, Bloomington Road on the south, Highway 404 on the east, and just north of St. John's Sideroad in the north (Figure 2). The ground elevation ranges from a high of 335 metres above sea level (masl) along the west, south and east boundaries to a low of 240 masl in the north central part of the Town (north of St Johns Sideroad) within the valley of the East Branch of the Holland River. The Town is situated within a horseshoe-shaped valley opening northward with surface water drainage towards the central part of the Town to Tannery Creek and the East Branch of the Holland River. Much of the northern part of the Town (north of Henderson Drive and Vandorf Sideroad) is mapped as being covered with silt and clay (Figure 3). The southern part of the Town (south of Henderson Drive and Vandorf Sideroad) is mapped as sand, gravel and till associated with the Oak Ridges Moraine (Ontario Geological Survey, 2010). A groundwater divide is interpreted to occur along the southern boundary of the Town along Bloomington Road as shown on Figure 4.

Aquifers situated beneath Aurora can be considered as either shallow or deep aquifers, separated by the Lower Newmarket Till (LNt) and Channel Silt that form an intervening aquitard (Figure 5; and Figure 6 for a more detailed view). The shallow aquifer system beneath Aurora, herein termed the 'upper aquifer', occurs within deposits of the Oak Ridges Moraine and the Inter-Newmarket sediments (Figure 5). This aquifer is greater than 30 m thick beneath the southern part of Aurora and thins north of Henderson Drive. Local confining conditions can be created by overlying fine-grained surficial deposits of Halton Till, Upper Newmarket till, and Glaciolacustrine silt and clay. The water table exists within all five geologic units mentioned above, depending on location. The interpreted thicknesses of the sediments that comprise the upper aquifer system are shown on Figure 7.

The major deep aquifer system, herein termed the 'deep aquifer', situated beneath Aurora is the Yonge Street Aquifer (YSA) which occurs within deposits of the Thorncliffe Formation. The Yonge Street Aquifer is a channelized sand and gravel deposit occurring at elevations below 200 masl trending roughly north-south through Aurora, Newmarket, Holland Landing and then trending northeast through Queensville. The deep aquifer system is replenished by vertical groundwater flow through the overlying aquitard (Lower Newmarket Till and Channel-silt) beneath topographically elevated areas to the south (i.e. along the Oak Ridges Moraine). When Aurora PW1 was installed in 1957 (~95 metres below ground surface (mbgs) and screened within the deep aquifer), the vertical hydraulic gradient in this lower elevation area (on the west side of Yonge Street just north of Wellington Street) of Aurora was upward from the deep aquifer to the upper aquifer (Hydrology Consultants Limited, 1970; 1977). The ensuing pumping for groundwater supply from the deep aquifer has reversed the vertical hydraulic gradients to downwards from the upper aquifer to the deep aquifer. Further discussion regarding the geology and hydrogeology of the Aurora area can be found in International Water Consultants Ltd. (1991), Earthfx Inc. (2006; 2014) and Gerber *et al*. (2018).

The Town of Aurora obtains a portion of its municipal water supply from 6 wells situated north of Wellington Street (Figure 2). All six wells are screened greater than 80 mbgs within the deep aquifer (i.e. Yonge Street Aquifer). Five of the wells (Aurora PW1 to 4 at the same location, and Aurora PW5) are shown on Figure 5. Starting in 2008, this municipal groundwater supply was augmented with water from Lake Ontario.

3.2 Factors/Considerations

Groundwater “Areas of Concern” within the Town of Aurora generally occur in lower topographic areas where groundwater levels within the upper aquifer occur near or above ground surface. These conditions predominantly exist north of Henderson Drive/Vandorf Sideroad as the upper aquifer sediments become thinner. Locally confined conditions occur where the upper aquifer sediments are overlain by finer-grained aquitard materials with the driving energy created by elevated groundwater levels to the south beneath the Oak Ridges Moraine (groundwater flow is south to north, Figure 4 and Figure 5). These areas of elevated groundwater levels can lead to excavation instability and/or groundwater control concerns during and post-construction. Over the southern part of Aurora between Bloomington Road and Henderson Drive the water table can be up to 40 mbgs (Figure 8; Figure 5) and therefore there is minimal potential for “Areas of Concern” to be found here. Shallow perched water table conditions may exist in some areas, particularly beneath the Oak Ridges Moraine, but these are not considered here.

The driving factor to delineating groundwater “Areas of Concern” within Aurora is the presence of groundwater levels near or above ground surface within the upper aquifer. The factors incorporated into the “Areas of Concern” mapping presented below are as follows:

a) The upper aquifer occurs within sediments that exist above the Lower Newmarket Till or Top of Channel Silts. In general, the upper aquifer occurs throughout Aurora at thicknesses exceeding 5 m (Figure 7). Areas of Concern can be anticipated where groundwater levels (water table or potentiometric surface) within the upper aquifer occur either above ground or within 4 m of ground surface (Figure 8). The depth of 4 m was chosen here to reflect the approximate depth of typical infrastructure excavations (e.g. sanitary sewer depths) or basement structures with one or two levels of underground parking. Obviously site-specific subsurface details need to be considered depending on the final construction depth and type of construction proposed. The methodology used to interpret the water table is included in Appendix C;
b) Known well locations screened in the upper aquifer where groundwater levels are at or above ground surface (i.e. ‘flowing wells’; Figure 8);
c) Groundwater Knowledge locations. These are known locations where previous activities (e.g. drilling, construction) have encountered groundwater-related issues. Many of these locations required groundwater control, either during construction or in perpetuity. These locations are being compiled through discussions between senior practitioners and ORMGP staff. Within the Town of Aurora, known locations of flowing wells and/or groundwater issues have been augmented with information from the Town of Aurora and York Region staff. These locations are shown on Figure 9; and
d) Long-term groundwater level trends. Long-term is defined here as being time frames longer than seasonal changes in upper aquifer groundwater levels, where highs occur in spring and lows occur in the fall.

Factor d) is seen as an important consideration for Aurora due to the presence of observed long-term (longer term than seasonal) changes in upper aquifer groundwater levels. Long-term municipal pumping from the deep aquifer has resulted in a decline in deep groundwater levels. Locally, this is suspected to have also induced a decline in upper aquifer groundwater levels. This transient change in groundwater levels may affect “Areas of Concern” mapping, with the upper aquifer groundwater levels being partially dependent on the amount of groundwater being pumped from the deep aquifer (along with climatic and by extension groundwater recharge changes). Of particular importance to this exercise are changes within the upper aquifer. Figure 10 shows locations of eight groundwater monitoring wells within the Town of Aurora that regularly measure groundwater levels within the upper aquifer. As

mentioned previously, lake-sourced water (Lake Ontario) was added to the existing groundwater municipal supply system for Aurora starting in early 2008. The changes to the deep aquifer pumping regime are illustrated by groundwater levels measured at Aurora MW 01 which is screened within the deep aquifer (i.e. YSA; Figure 11).

Observed long-term groundwater levels for the upper aquifer system are available for the locations listed in Table 1. Many of the upper aquifer locations do not have long histories of water level measurements. Groundwater levels at five of these locations also monitor groundwater levels within the deep aquifer (multi-depth installations at a monitoring location are termed monitoring nests). Two of these locations, MW09 and MW15, are nest locations where groundwater level observations exist from both the upper and deep aquifers prior and subsequent to the 2008 deep aquifer groundwater pumping changes in Aurora. Well screen locations are shown on cross section on Figure 12 with groundwater level hydrographs for these two nest locations provided on Figure 13 and Figure 14. Observed groundwater levels for the remaining six upper aquifer monitors are provided on Figure 15. Observed upper aquifer groundwater levels in Aurora show a slight response (i.e. increase of approximately 1 to 2 metres) to the 2008 reduction of deep aquifer groundwater pumping. Some locations situated near municipal pumping wells (Aurora MW 18s and Aurora MW 16s) suggest that shallow water level fluctuations in response to deep aquifer pumping changes may exceed 2 m in magnitude. These upper aquifer groundwater level changes in response to deep aquifer groundwater pumping may provide a transient nature to the interpreted average water table used for this "Areas of Concern" mapping. Upper aquifer observed groundwater level hydrographs are provided here to illustrate the magnitude of historical observed changes within the upper aquifer. The transient nature of upper aquifer groundwater levels needs to be an ongoing consideration for the Town, and the monitoring of both deep and shallow groundwater levels should continue to be a priority for Region/Town staff.

Table 1: Long-term groundwater monitoring locations in Aurora that monitor groundwater levels in the upper aquifer. Aurora MW01 added because it provides history of groundwater levels within the deep aquifer. Monitors are listed in order of installation date. Monitoring locations shown on Figure 10.

Upper Aquifer Monitor Name	**Upper Aquifer Monitor Name**	**Deep Aquifer Monitor Name**	**Monitor Installation Date**	**Start Date - Regular Groundwater Levels**
-	-	Aurora MW01	15-Feb-1957	23-May-1984
Aurora MW11	-	-	09-Nov-1959	23-Apr-2009
Aurora MW09s	Aurora MW09d	Aurora MW 08	22-Feb-1995	27-Jul-2001
Aurora MW15-1	Aurora MW15-2	Aurora MW15-4	01-Apr-1998	04-Aug-2011
PGMN-LSRCA-W283	-	-	11-Feb-2003	25-Mar-2003
Aurora MW16	-	-	03-Oct-2012	14-Jan-2013
Aurora MW18s	-	Aurora MW18d	06-Nov-2012	05-Mar-2013
Aurora MW20s	-	Aurora MW20d	29-May-2013	17-Jun-2013
Aurora MW22s	-	Aurora MW22d	16-Oct-2015	16-Oct-2015

An additional consideration related to groundwater "Areas of Concern" are those locations where an upward vertical hydraulic gradient exists between the deep aquifer and the upper aquifer. A preliminary investigation of these areas within Aurora revealed that they are coincident with the areas of shallow water table and flowing conditions within the upper aquifer so they have not been independently mapped, nor have they been considered as an additional factor.

Another data set that could be considered in future versions of Aurora's "Areas of Concern" mapping is the MECP Permit to Take Water (PTTW) locations (Figure 16), particularly those permits related to construction dewatering activities that might be indicative of groundwater problem areas. These locations have not been considered in this 2020 mapping exercise (version 1) owing to uncertainty regarding the actual source and quantity of takings (surface water versus groundwater) in the currently available MECP PTTW database.

In summary, the proposed methodology to delineate groundwater 'Areas of Concern' within the Town of Aurora includes:

1) Factor a): The upper aquifer system is present throughout Aurora at thicknesses ranging from approximately 100 m in the south beneath the Oak Ridges Moraine, to approximately 5 m thick within river valleys along the northern boundary of Aurora. Coarser-grained aquifer sediments are associated with Oak Ridges Moraine and Inter-Newmarket sediment geologic units. These are overlain by finer-grained sediments mapped as Glaciolacustrine silt and clay, Upper Newmarket Till and Halton Till, which can locally create confined aquifer conditions. Groundwater "Areas of Concern" for Aurora are expected to occur where the water table/potentiometric surface within the upper aquifer system is either above, or within 4 m of ground surface; and
2) Factors b), c) and d): The locations considered in Factors b) and c) are seen as checks on the interpreted water table/potentiometric surface for the upper aquifer system (Factor 'a'). If the area delineated by Factor 'a' did not include the locations listed in Factors 'b' ('flowing' wells in upper aquifer) and 'c' (groundwater knowledge), then the mapping was adjusted to incorporate these locations. The mapping area was also informed by considering Factor 'd'.

3.3 Mapping & Summary

Figure 17 illustrates where the interpreted water table or potentiometric surface is within 4 m of ground surface, or above ground surface (Factor 'a'). Two point sources of data (Factors 'b' and 'c') are also shown on Figure 17 as a check of the areas delineated by Factor 'a'. Some of the flowing well locations (Factor 'b') and a groundwater knowledge location (Factor 'c'; Springmaple Chase) situated along and south of Henderson Drive and Vandorf Sideroad are not fully encompassed by this area. It is proposed that the areas of concern be increased by delineating areas of water table depth from 4 m to 6 m to encompass all of the flowing well and all but one of the groundwater knowledge locations. This 2 m difference in water table depth is proposed based on Factor 'd' (the transient long-term groundwater level trends). With this adjustment in the mapping, all flowing wells and all but one groundwater knowledge location are incorporated within the delineated "Areas of Concern" map (Figure 18). The one exception is for the 'Mark Street sump' location which requires additional details or work before being considered further. The interpreted water table in this area of slight ground elevation rise between Tannery Creek and the Holland River East Branch is largely based on river elevations, as water well information is not available.

The groundwater "Areas of Concern" map (Figure 18) should be regularly updated and refined as more information is obtained (e.g. if site specific construction details are different than the assumptions listed here). The groundwater "Areas of Concern" mapping presented here represents a 'snap shot' summary that synthesizes Aurora's existing subsurface groundwater level data and understanding at the time of preparation. A qualifying statement accompanying the mapping is included in Appendix B. Given the reliance of this mapping on the interpreted water table surface, Appendix C includes the metadata summary for the preparation of the water table mapping.

This memo has outlined the various factors that have been considered to prepare "Areas of Concern" mapping for the Town of Aurora. The map can be used by the Town and Region to inform developers and land holders of this unique groundwater setting, and to better direct Aurora's planning approval process by triggering certain pre and post development groundwater investigation/control requirements.

Should you have any questions or wish to discuss further please do not hesitate to contact any of the undersigned.
Sincerely,

Oak Ridges Moraine Groundwater Program

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Regional Municipality of York

Mike Fairbanks
Manager Water Resources

Scott Lister
SWP Program Manager

Blythe Reiha
Hydrogeologic Modeller

4. References

Earthfx Inc. 2006. Groundwater Modelling of the Oak Ridges Moraine Area. York-Peel-Durham-Toronto (YPDT) Groundwater Management Study, Toronto, Ontario. Available at www.oakridgeswater.ca.

Earthfx Inc. 2014. Tier 3 water budget and local area risk assessment for the Region of York municipal systems. Regional Municipality of York, Newmarket, Ontario.

Gerber, R.E., Sharpe, D.R., Russell, H.A.J., Holysh, S., Khazaei, E. 2018. Conceptual hydrogeological model of the Yonge Street Aquifer, south-central Ontario: a glaciofluvial channel-fan setting. Canadian Journal of Earth Sciences, 55, 730-767.

Hydrology Consultants Limited. 1970. Town of Aurora, summary report of the construction and testing of production well #2. Regional Municipality of York, Newmarket, Ontario.

Hydrology Consultants Limited. 1977. Groundwater exploration program interim report Regional Municipality of York, Town of Aurora. Regional Municipality of York, Newmarket, Ontario.

International Water Consultants Ltd. 1991. Regional Municipality of York, aquifer performance assessment. Regional Municipality of York, Newmarket, Ontario.

Ontario Geological Survey. 2010. Surficial geology of southern Ontario. Ontario Geological Survey Miscellaneous Release – Data 128 – Revised.

Version History

Version	Changes
v1: 24-July-2020	

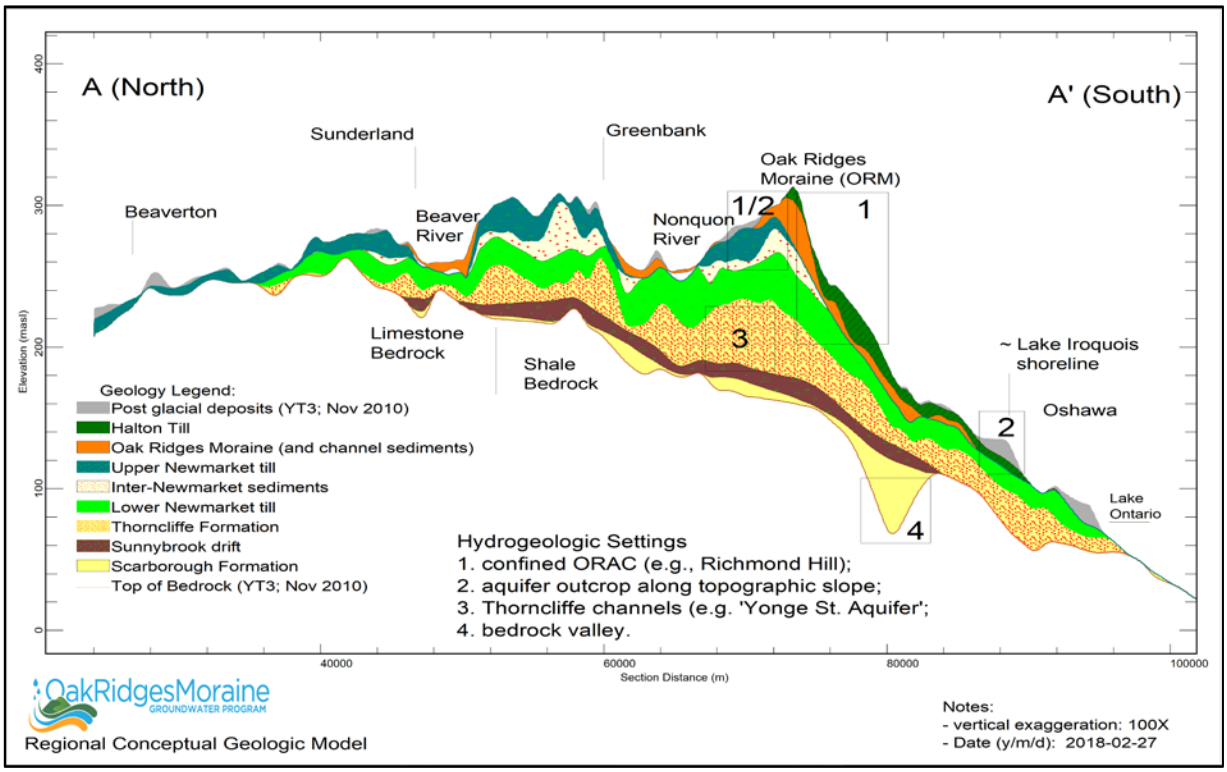


Figure 1: North-south cross-section through the ORMGP study area from Lake Simcoe (north) to Lake Ontario (south). The numbered areas depict example locations of where hydrogeologic settings may relate to areas of potential groundwater concern. Refer to Section 2 for further description.

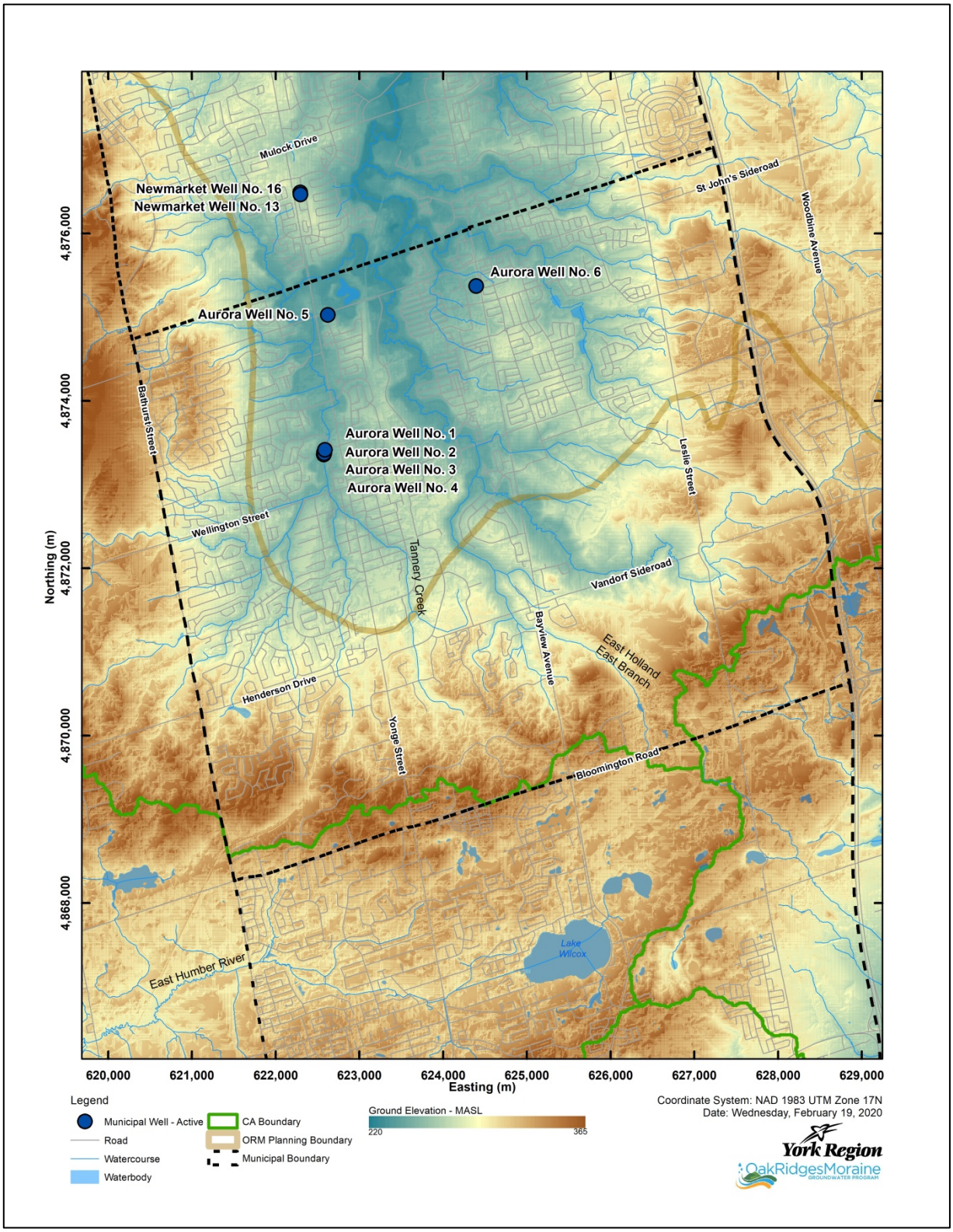


Figure 2: Town of Aurora study area and ground surface topography.

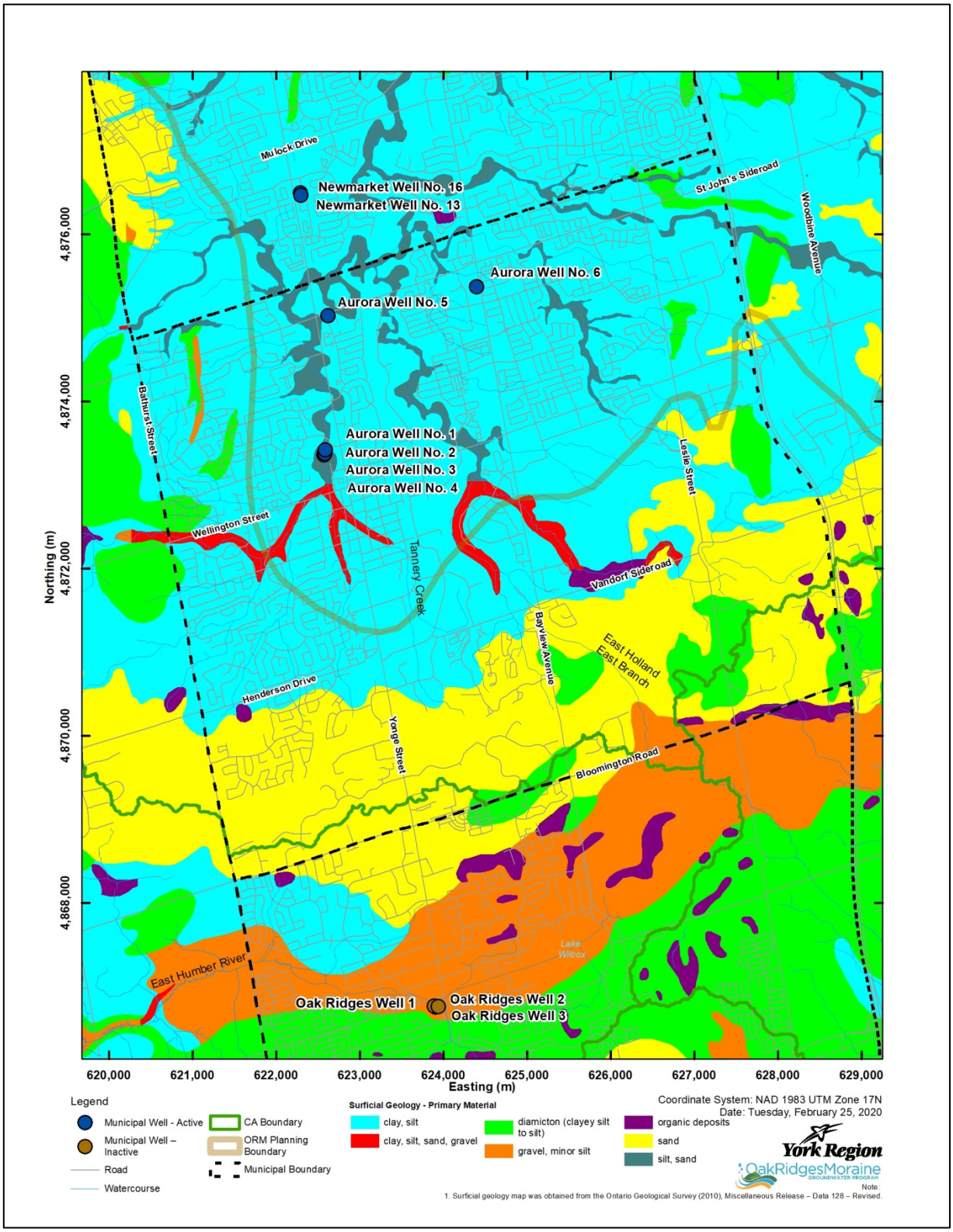


Figure 3: Surficial geology (OGS, 2010).

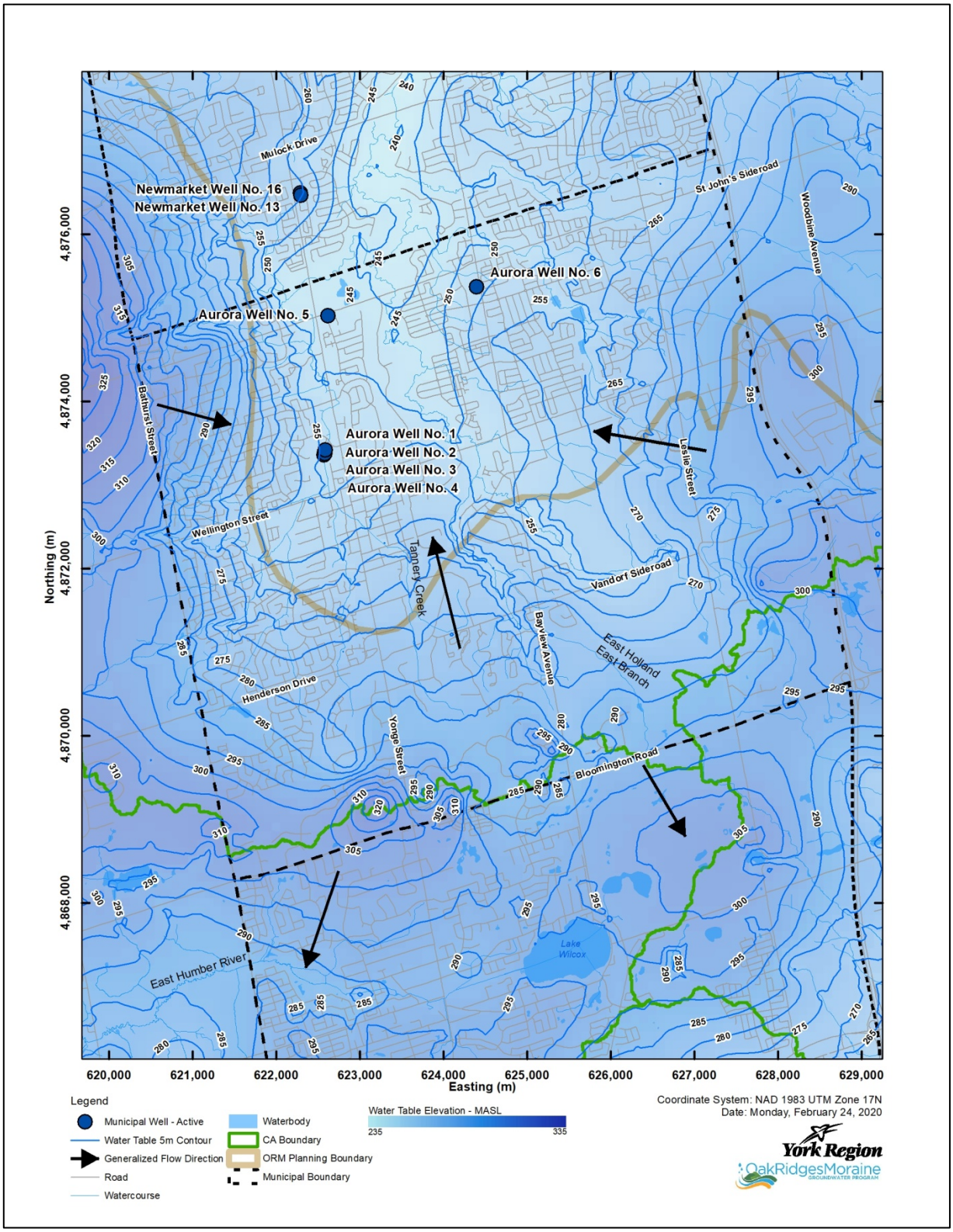


Figure 4: Interpreted water table elevation and direction of shallow groundwater flow. Details on how the water table was constructed (metadata) are included as Appendix C.

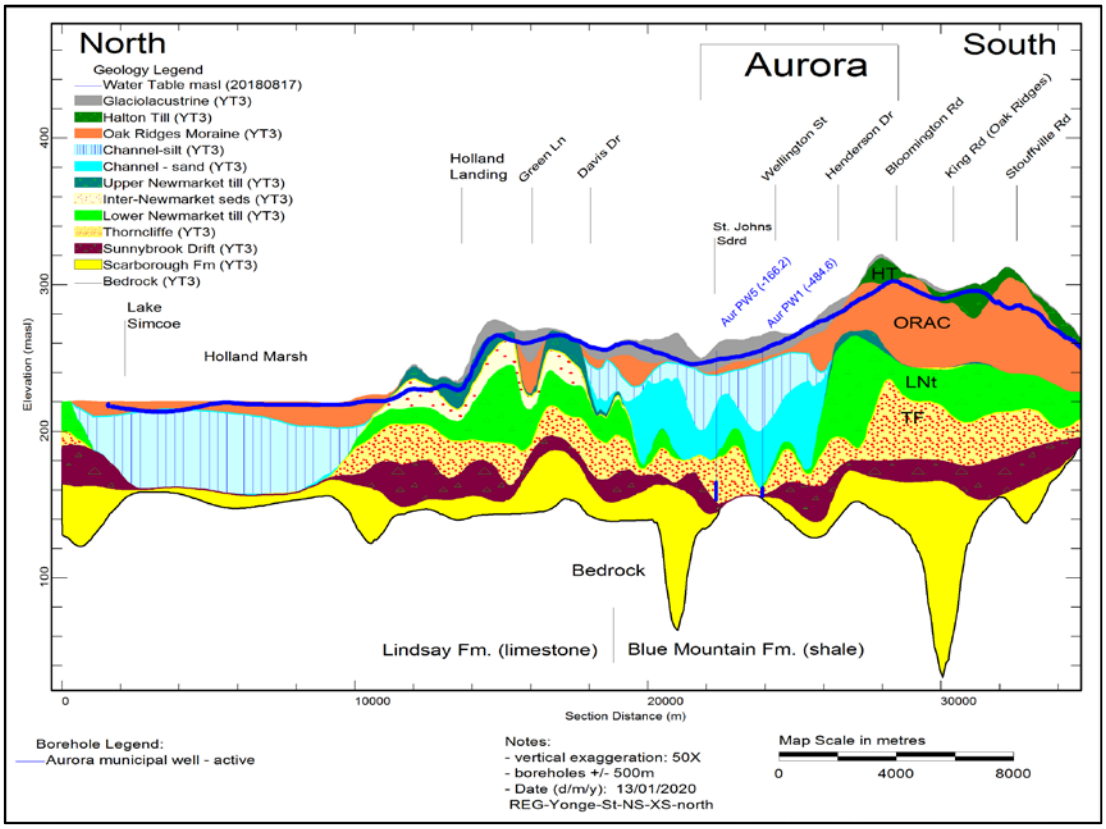


Figure 5: Regional north-south cross-section along Yonge Street through Aurora.

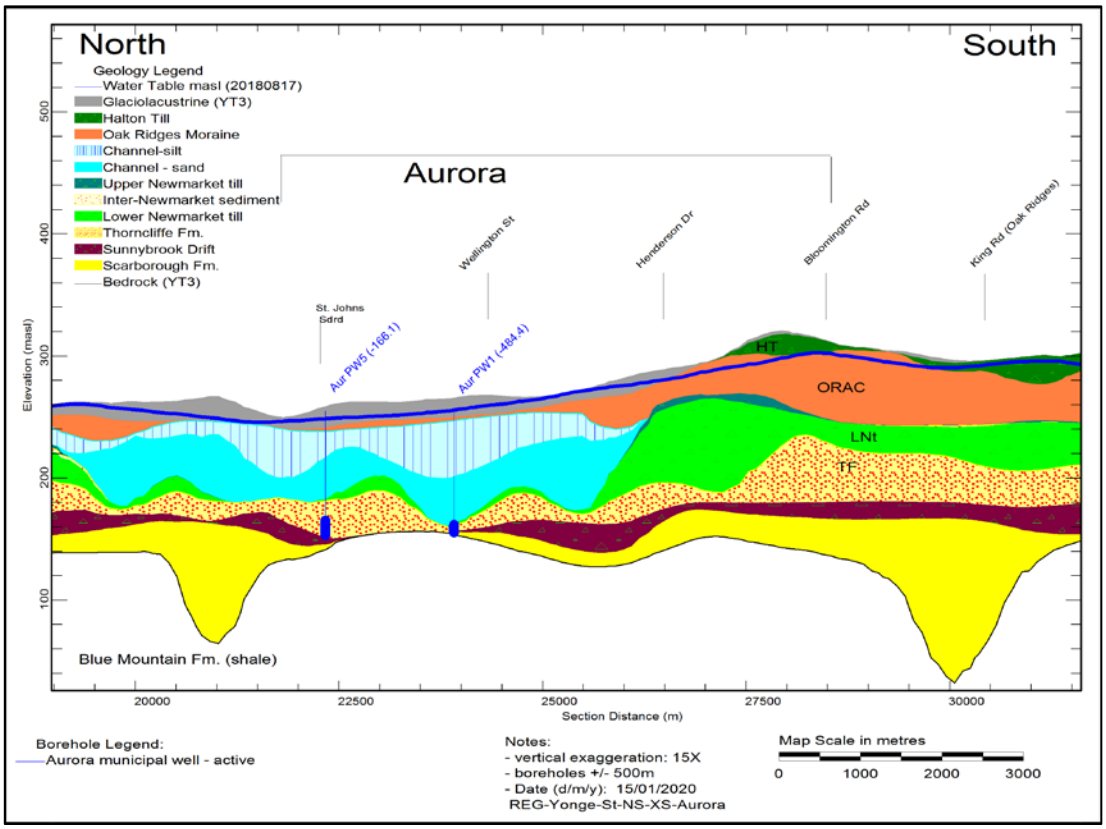


Figure 6: Local north-south cross-section along Yonge Street through Aurora.

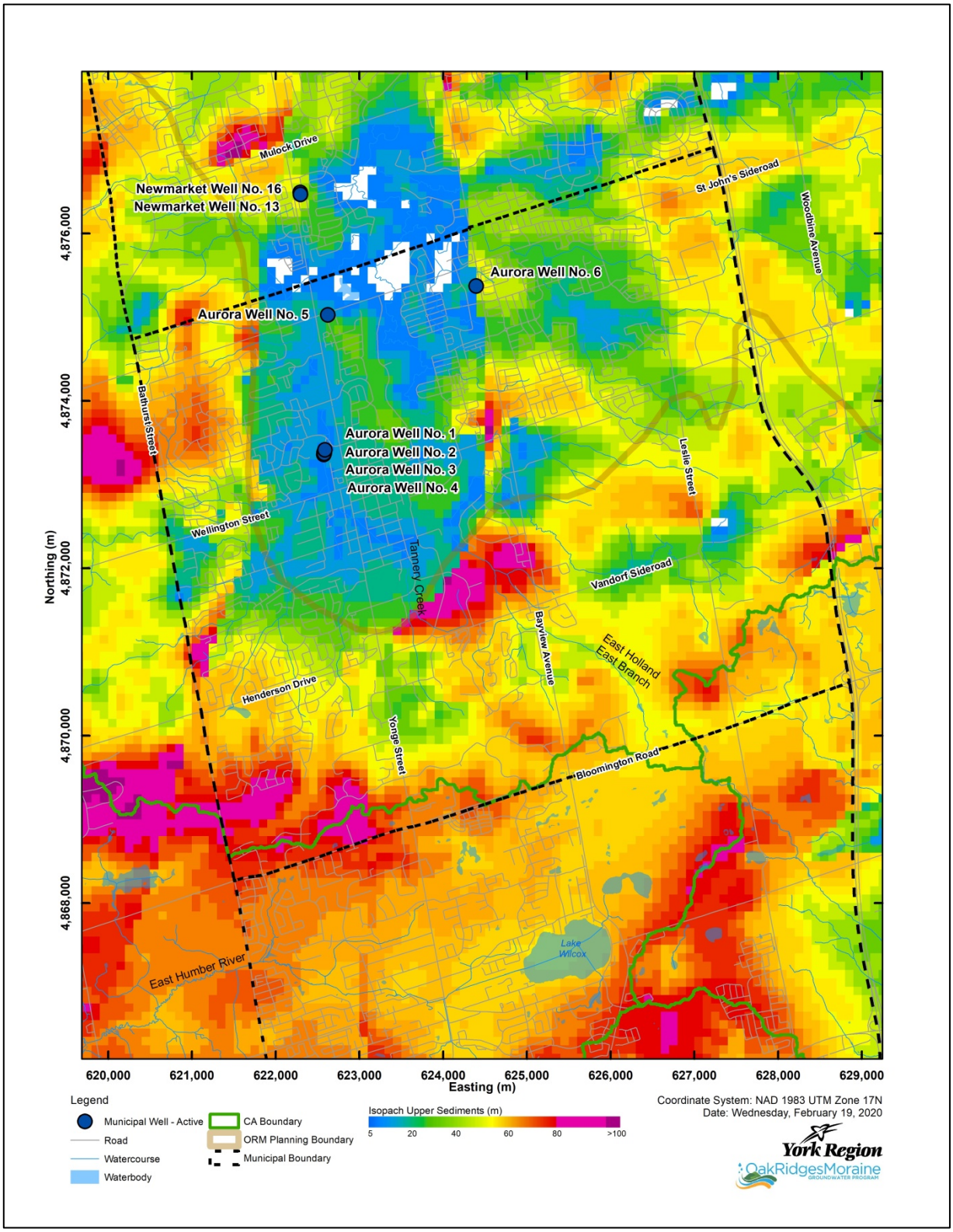


Figure 7: Interpreted thickness of sediment above Lower Newmarket Till and ORM Channel silt that contain the upper aquifer. Interpretation from geologic layers described in Earthfx Inc., 2014.

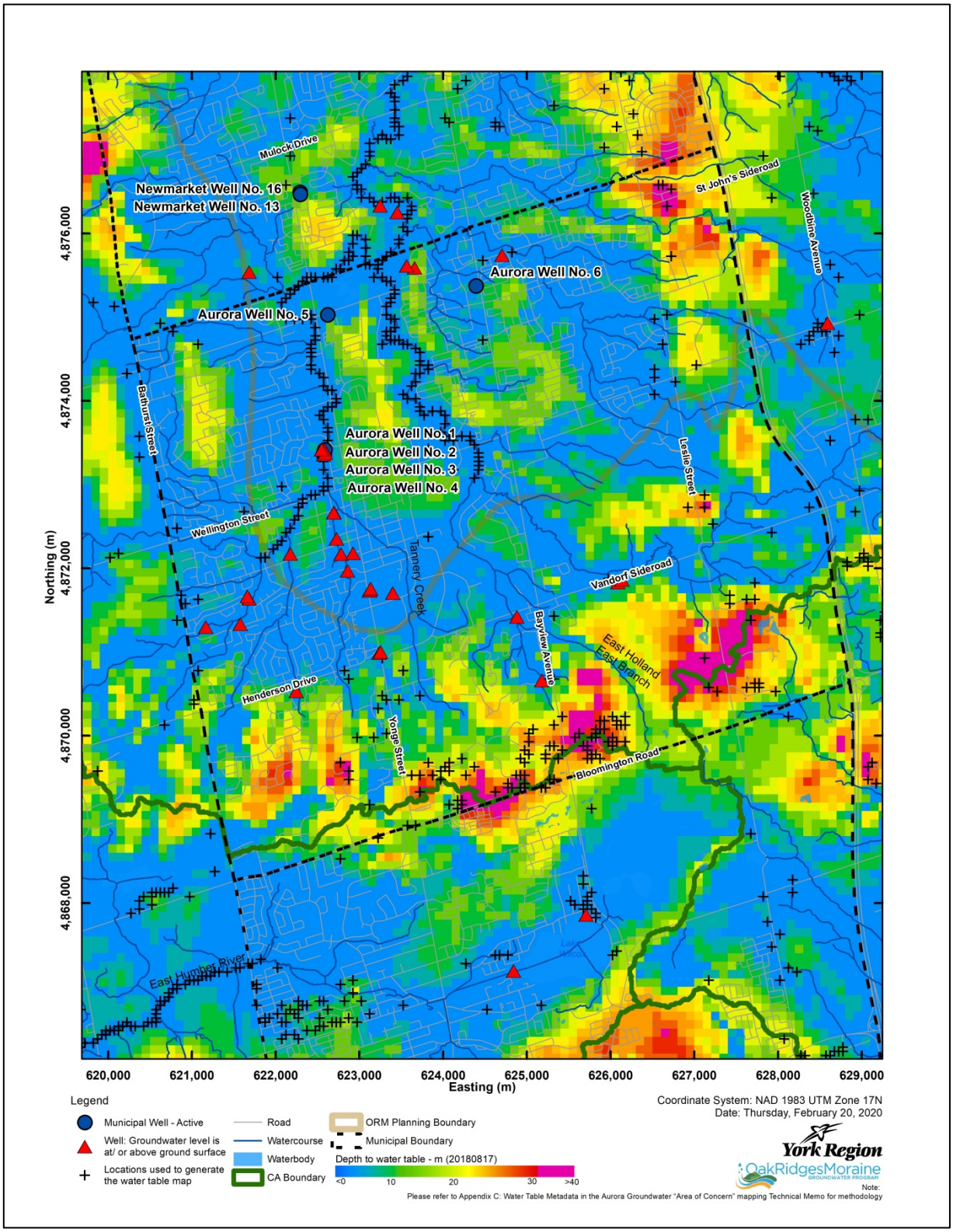


Figure 8: Interpreted depth to average water table in metres. Also shown are locations of known shallow wells with groundwater levels at or above the ground surface. '+' = data locations used to generate the water table map (water levels from wells and river elevations).

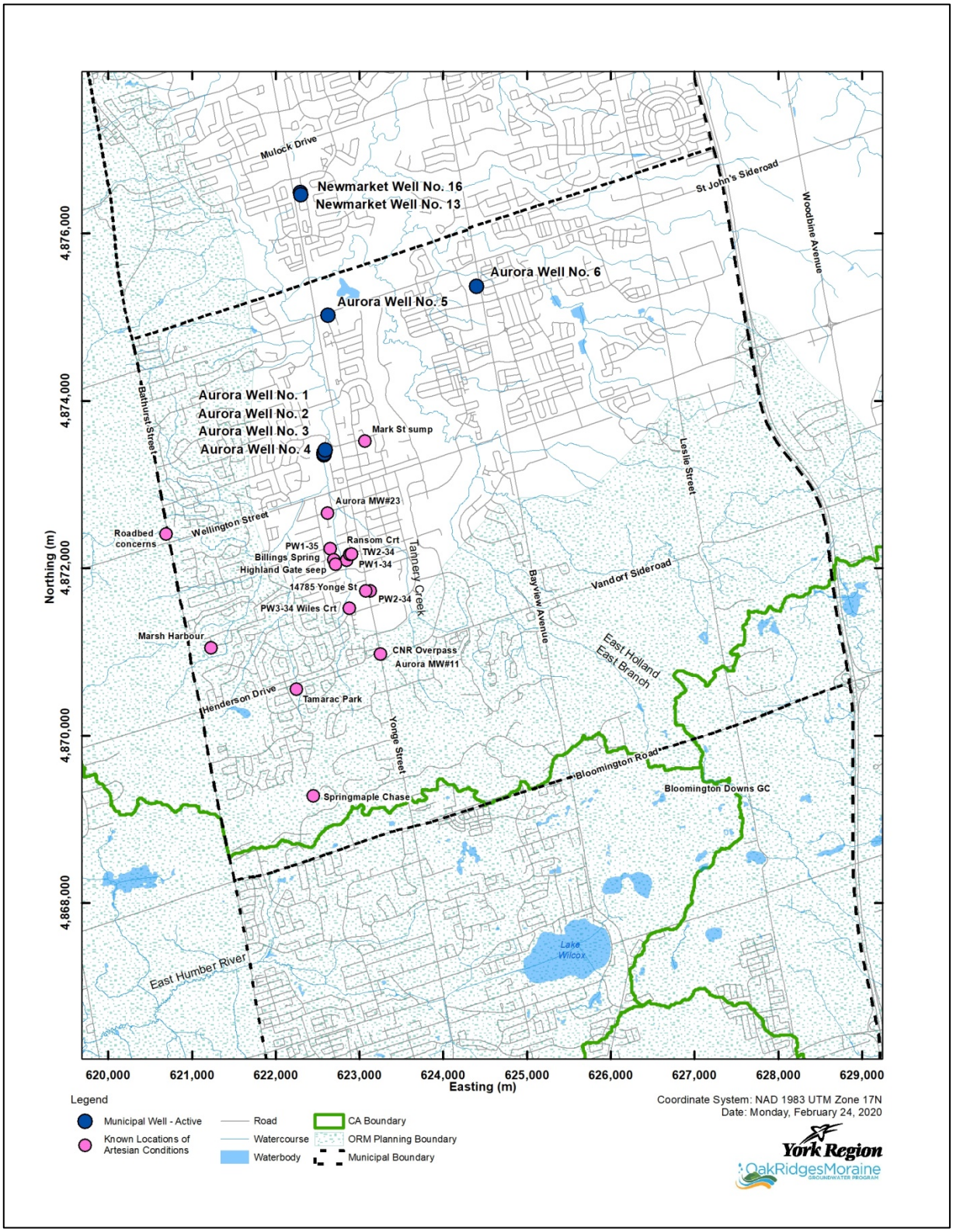


Figure 9: Groundwater Knowledge (artesian) locations where known flowing wells, groundwater issues or control measures have historically occurred. Locations provided by York Region and Town of Aurora staff, and ORMGP database.

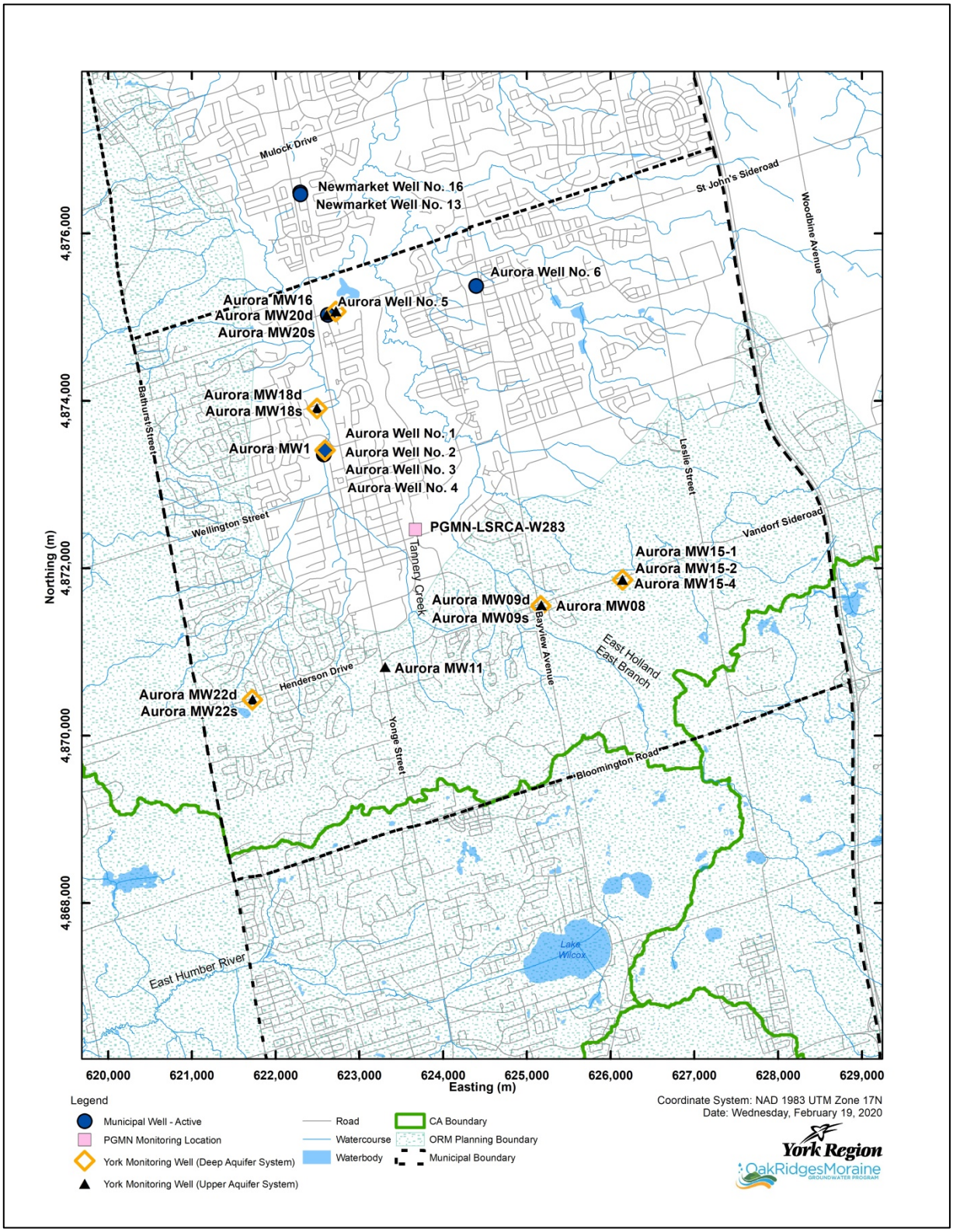


Figure 10: Groundwater monitoring locations operated by York Region. PGMN monitoring well operated by Lake Simcoe Region Conservation Authority.

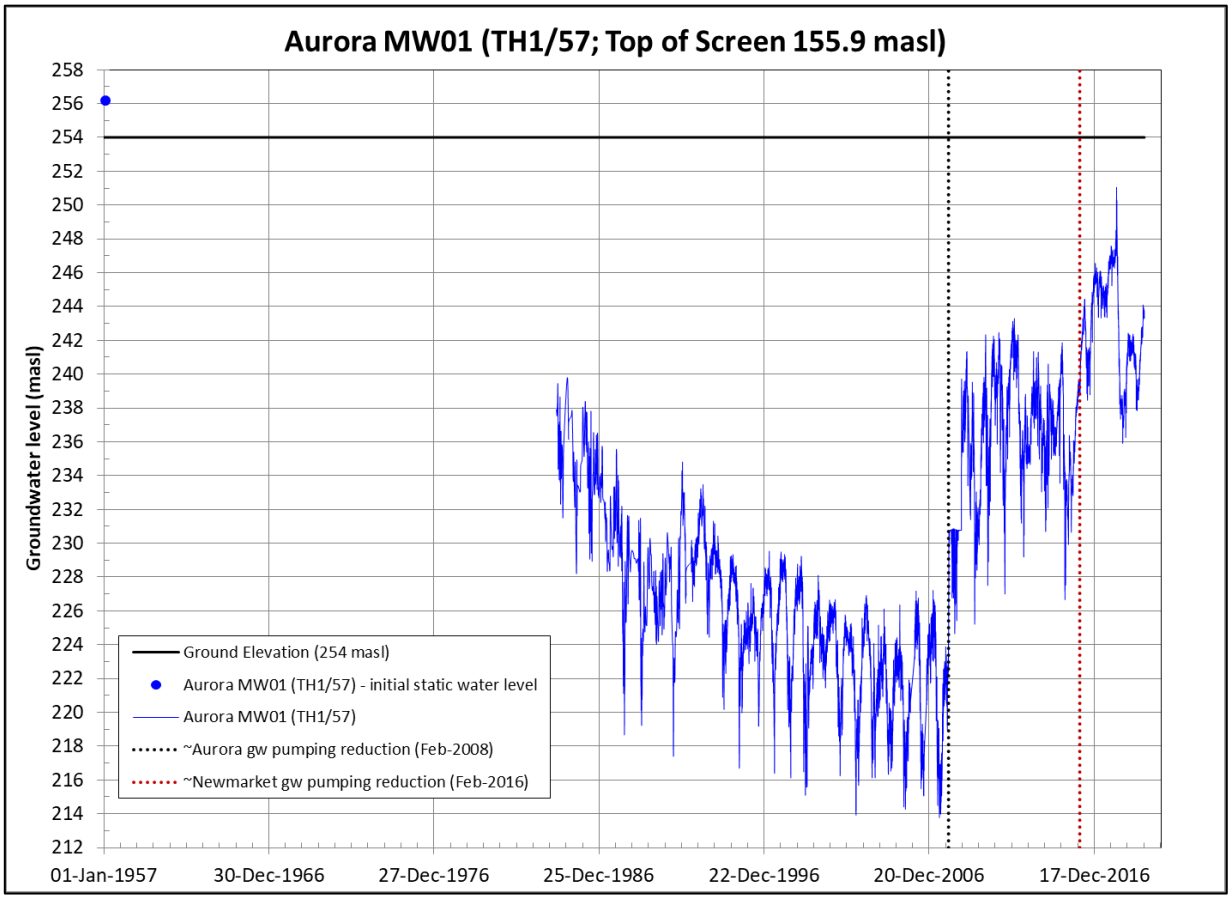


Figure 11: Aurora MW 01 groundwater level hydrograph. Monitoring well screened in the deep aquifer (‘Yonge Street Aquifer’). Data from York Region. Monitoring well location shown on Figure 10.

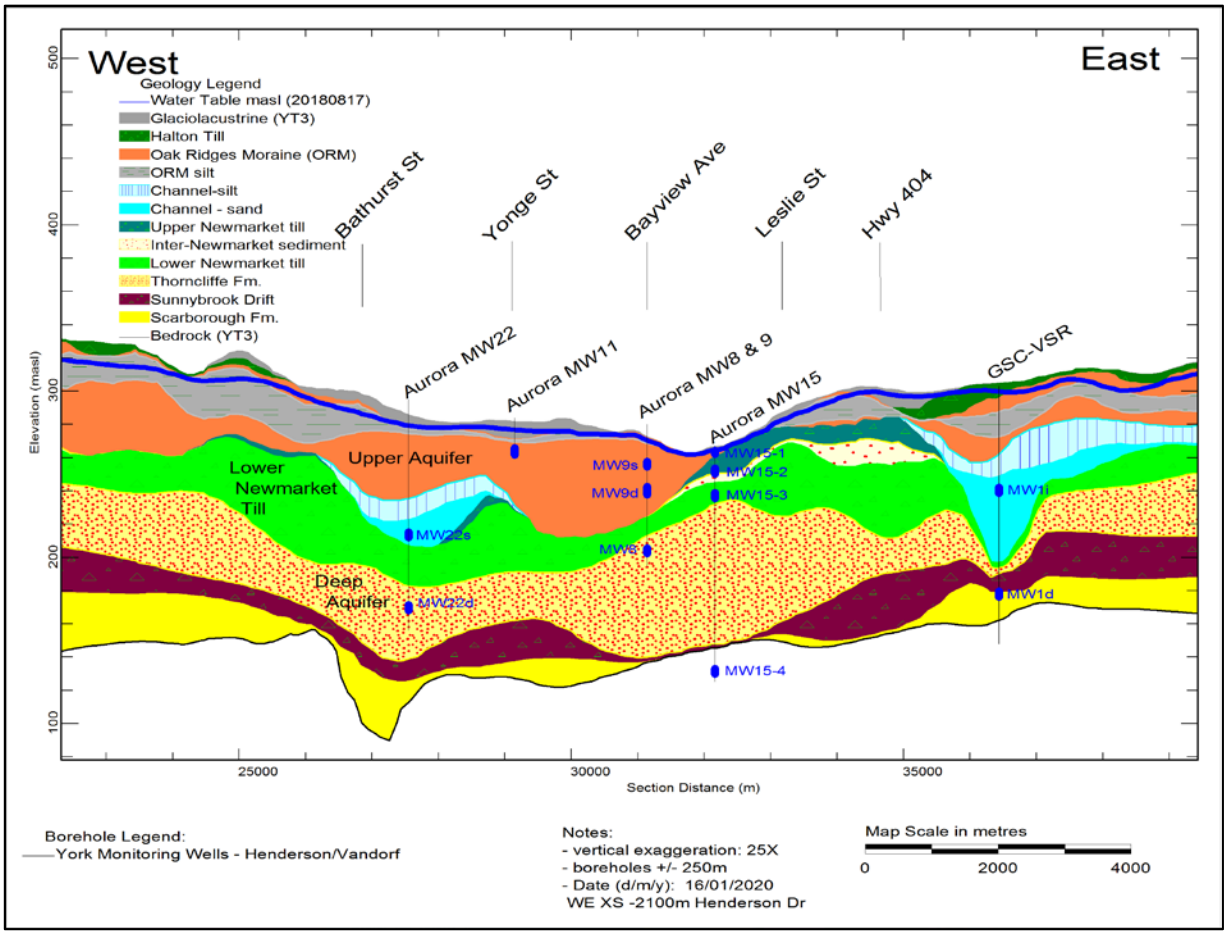


Figure 12: West-East cross-section along Henderson Drive and Vandorf Sideroad. Interpreted geology layers from Earthfx Inc., 2014. Monitoring well locations shown on Figure 10.

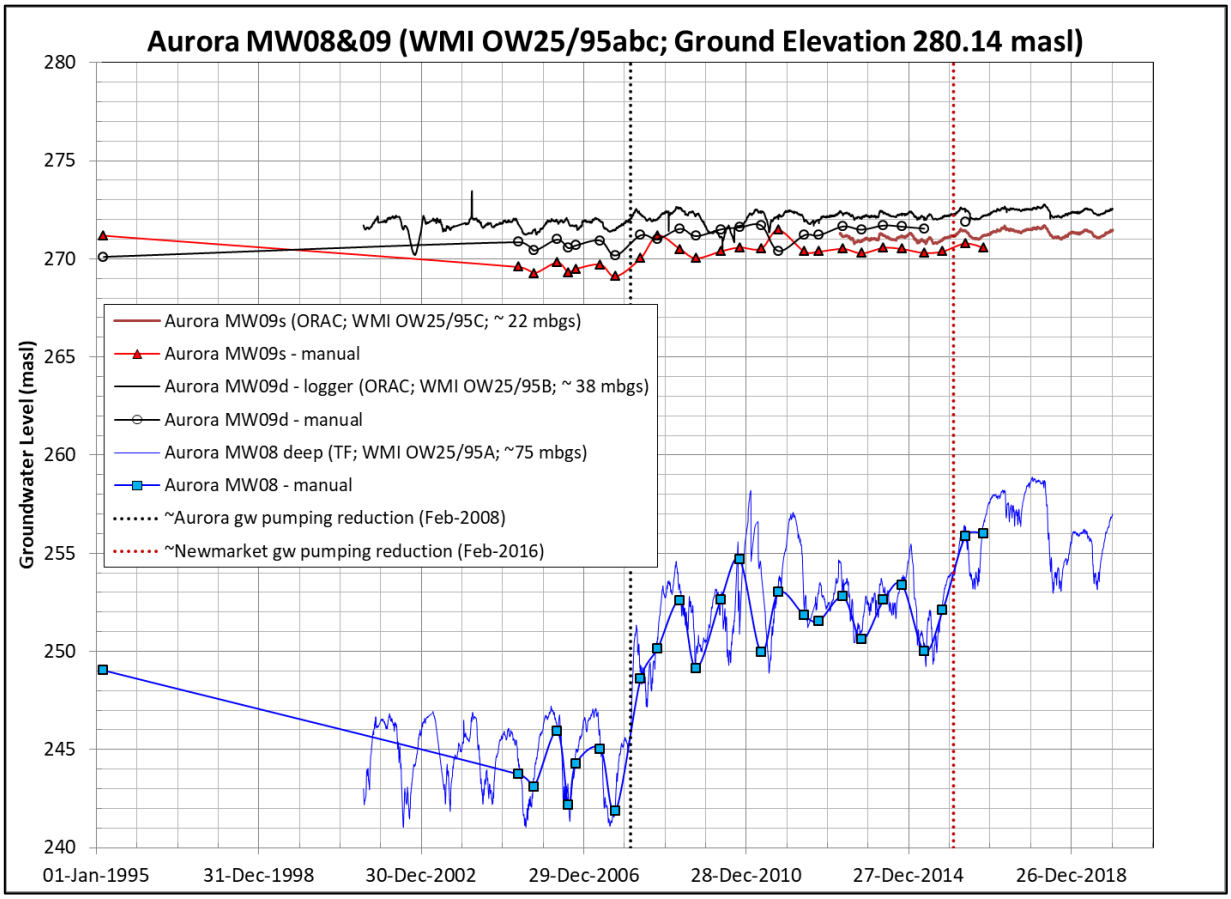


Figure 13: Observed daily average groundwater levels at Aurora MW08 and MW09. Data from York Region. Monitoring well location shown on Figure 10.

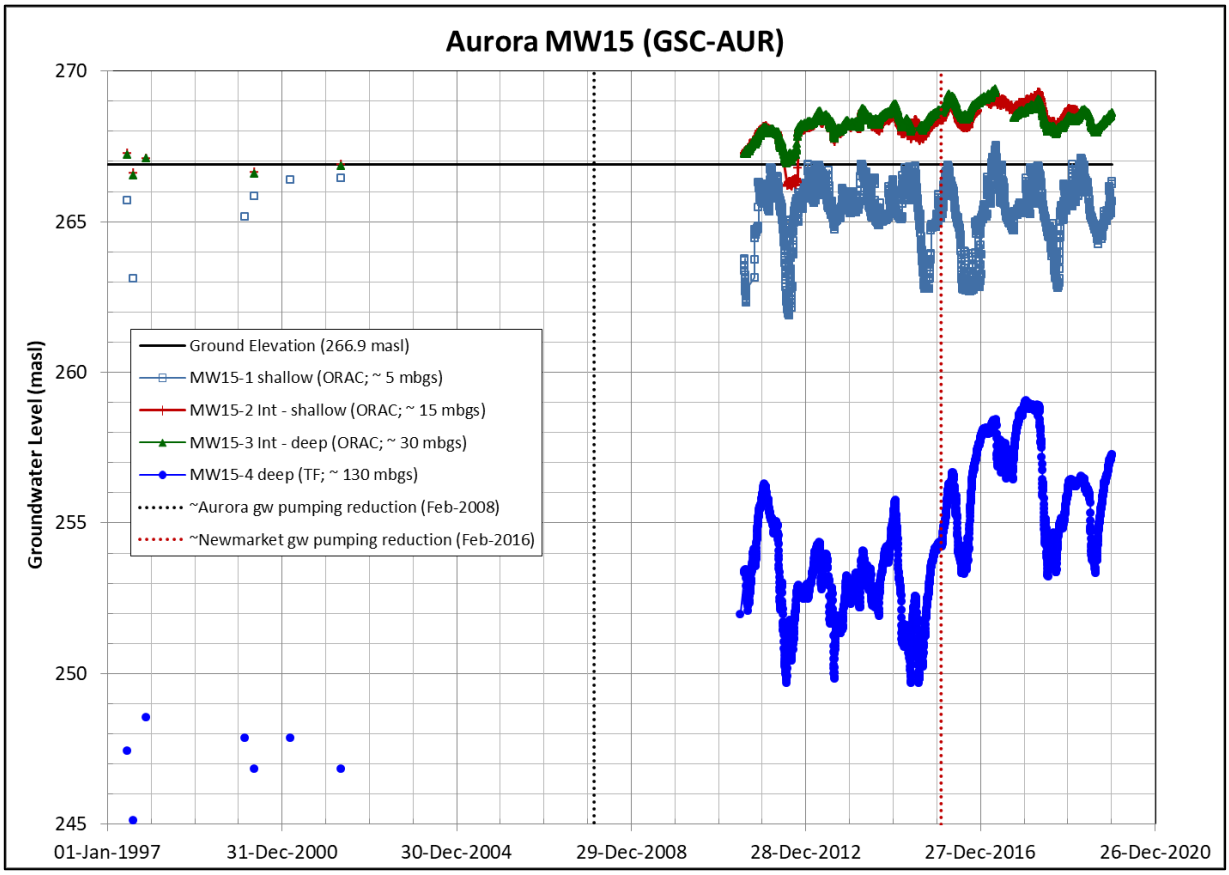


Figure 14: Observed daily average groundwater levels at Aurora MW15. Data from York Region. Monitoring well location shown on Figure 10.

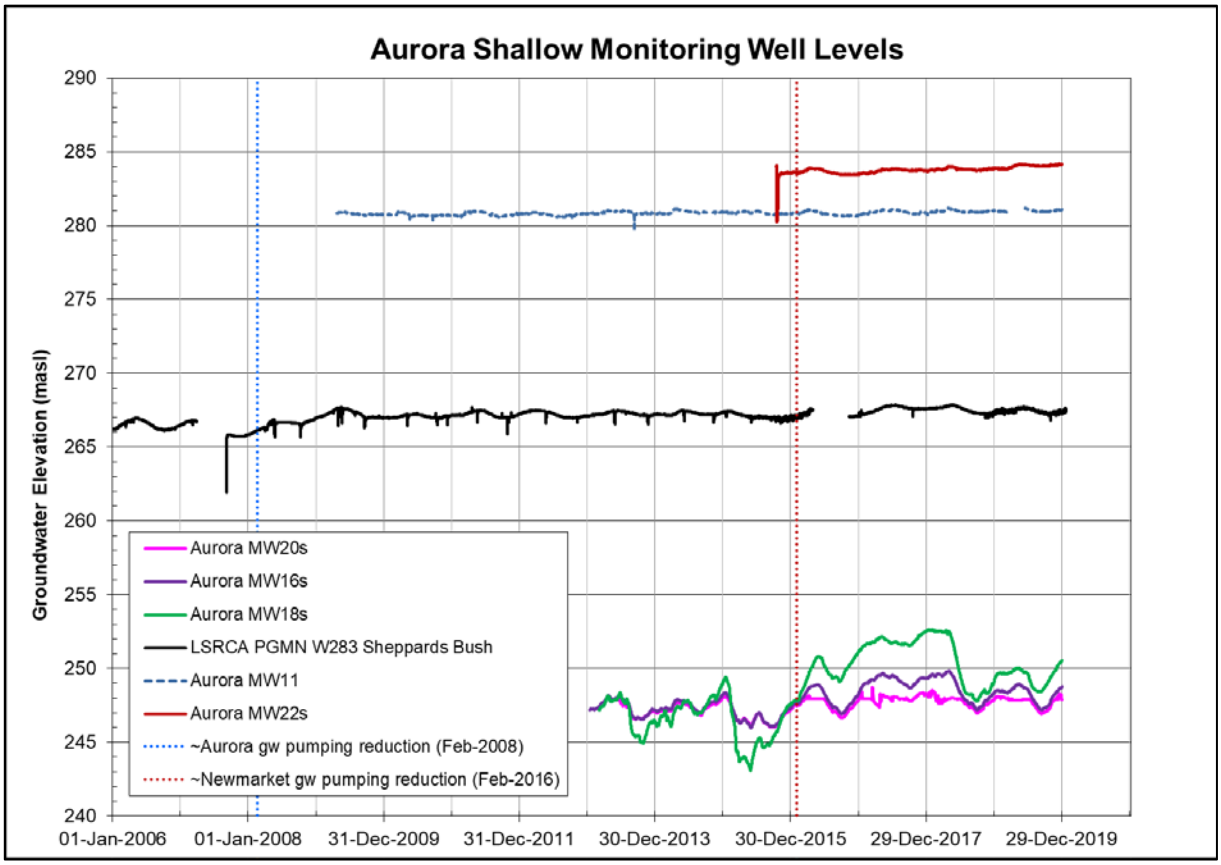


Figure 15: Observed groundwater levels for various shallow monitors located within Aurora. Data from York Region for Aurora locations and from LSRCA for PGMN W283. Monitoring well locations shown on Figure 10.

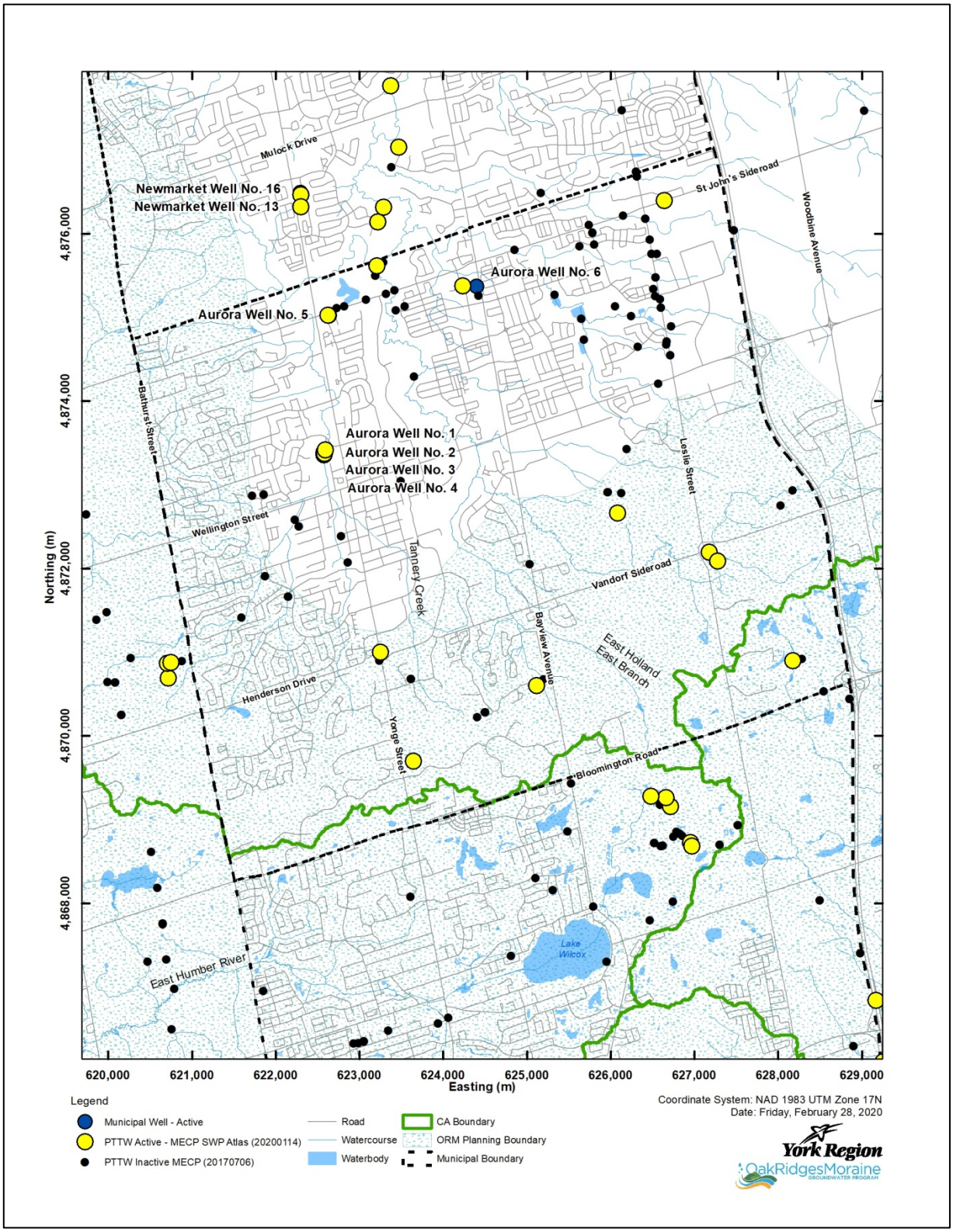


Figure 16: MECP Permit To Take Water (PTTW) locations – historical and active. Active permit locations from Ontario Source Protection Information Atlas (Ministry of Environment, Conservation and Parks) downloaded on January 14, 2020.

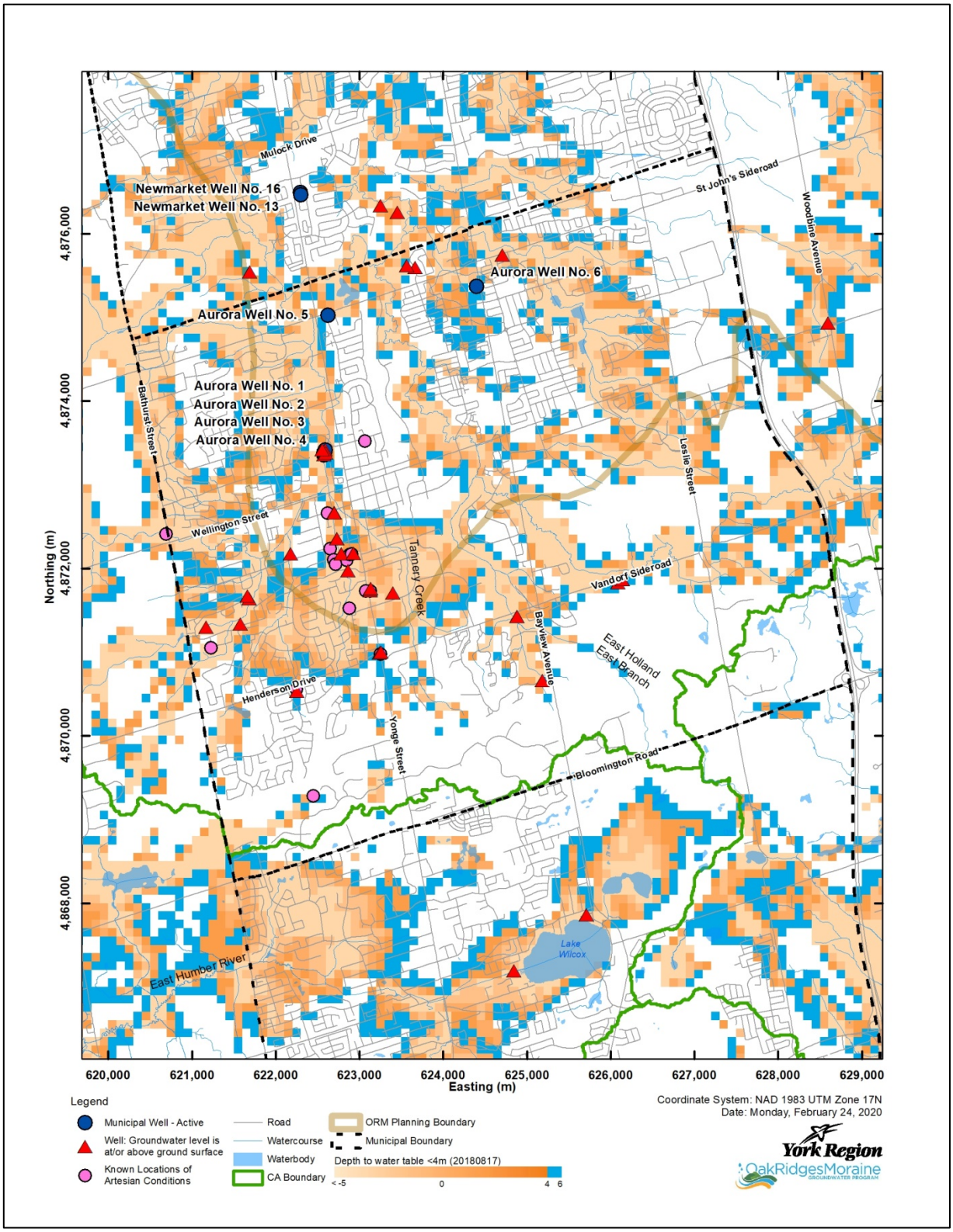


Figure 17: Comparison of areas where interpreted water table is within 4 m of ground surface (orange shading) and within 6 m of ground surface (blue shading).

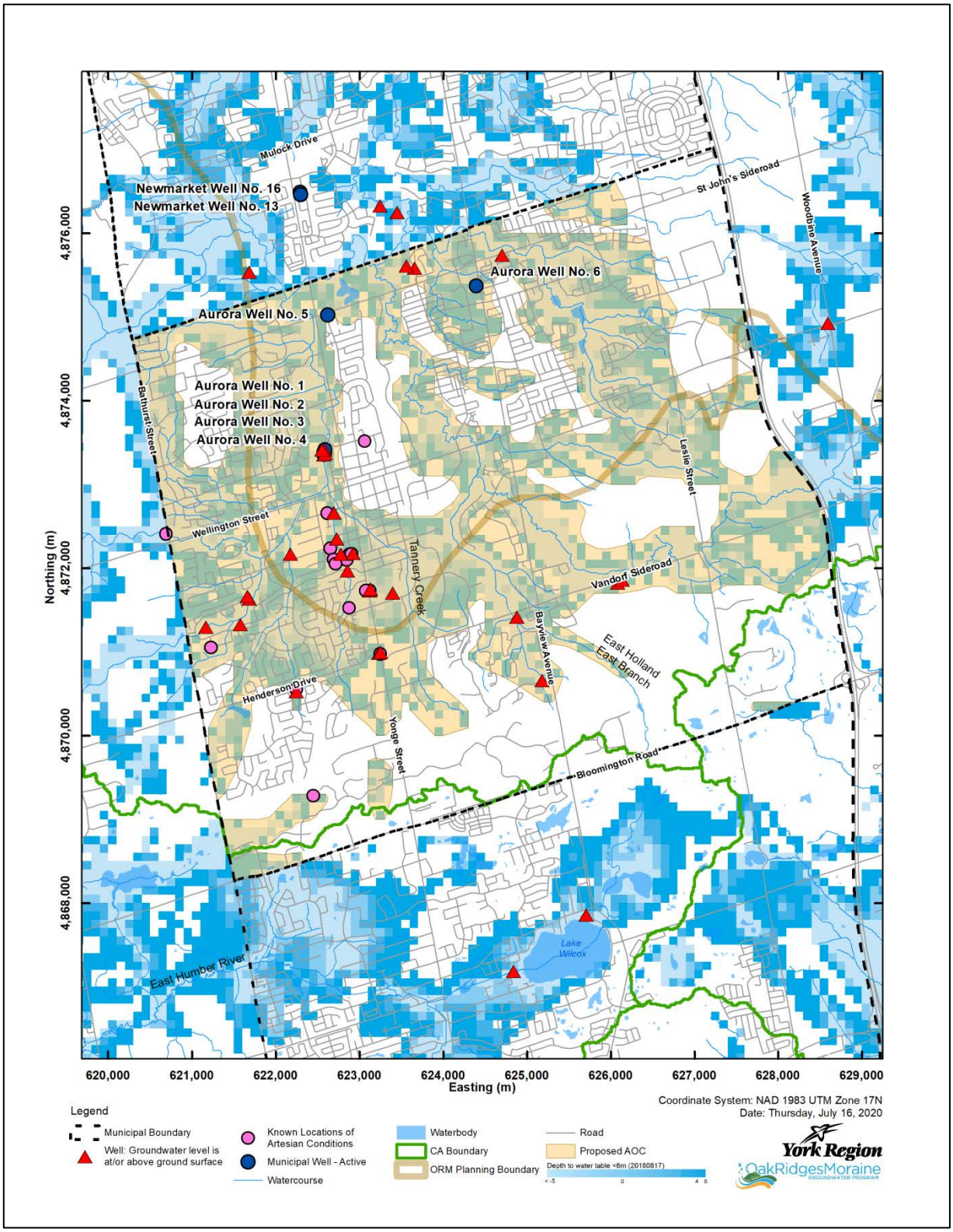
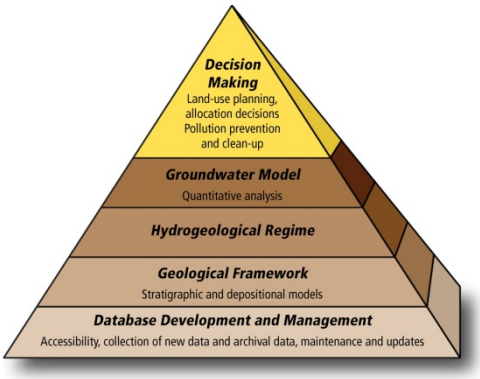


Figure 18: Town of Aurora groundwater "Areas of Concern" (tan shading).

Appendix A: Oak Ridges Moraine Groundwater Program

The Oak Ridges Moraine Groundwater Program (ORMGP) was initiated in 2001, driven by the encroachment of development onto the Oak Ridges Moraine and the recognition of an absence of high quality environmental data and analyses, particularly with respect to groundwater. Since inception, the program has provided partner agencies with an actively managed water-related database and the regional geological and groundwater context for on-going day-to-day water resource management activities (e.g. development review, PTTW review, watershed management, source water protection, etc.). The framework for the program is succinctly summarized in the adjacent figure, taken from the Council of Canadian Academies 2009 report "The Sustainable Management of Groundwater in Canada."



Mandate

The mandate of the ORMGP partnership is to provide a multi-agency, collaborative approach to collecting, analyzing and disseminating water resource data as a basis for effective stewardship of water resources. The ORMGP builds, maintains and provides to partnered agencies the regional geological and hydrogeological context for ongoing groundwater studies and management initiatives within the partnership area.

As such the program will:

- Build and maintain a master database of water-related information that is accessible to all partner agencies;
- Build and maintain a digital geological construction of the subsurface layers that is accessible to all partner agencies;
- Build and maintain a numerical groundwater flow model(s) that can be used to address any number of issues that arise at any of the partner agencies;
- Coordinate and lead investigations that will acquire new field data that will strategically infill key data gaps;
- Provide technical support to Source Water Protection Teams to ensure that interpretations used in source water are consistent with the regional understanding;
- Provide technical support to planning authorities to ensure that Official Plan policies are developed in a manner which makes them consistent with up to date groundwater science as derived from the project; and
- Provide technical support to all partnered agencies for addressing other Provincial legislation.

Further information regarding the program can be found at www.oakridgeswater.ca.

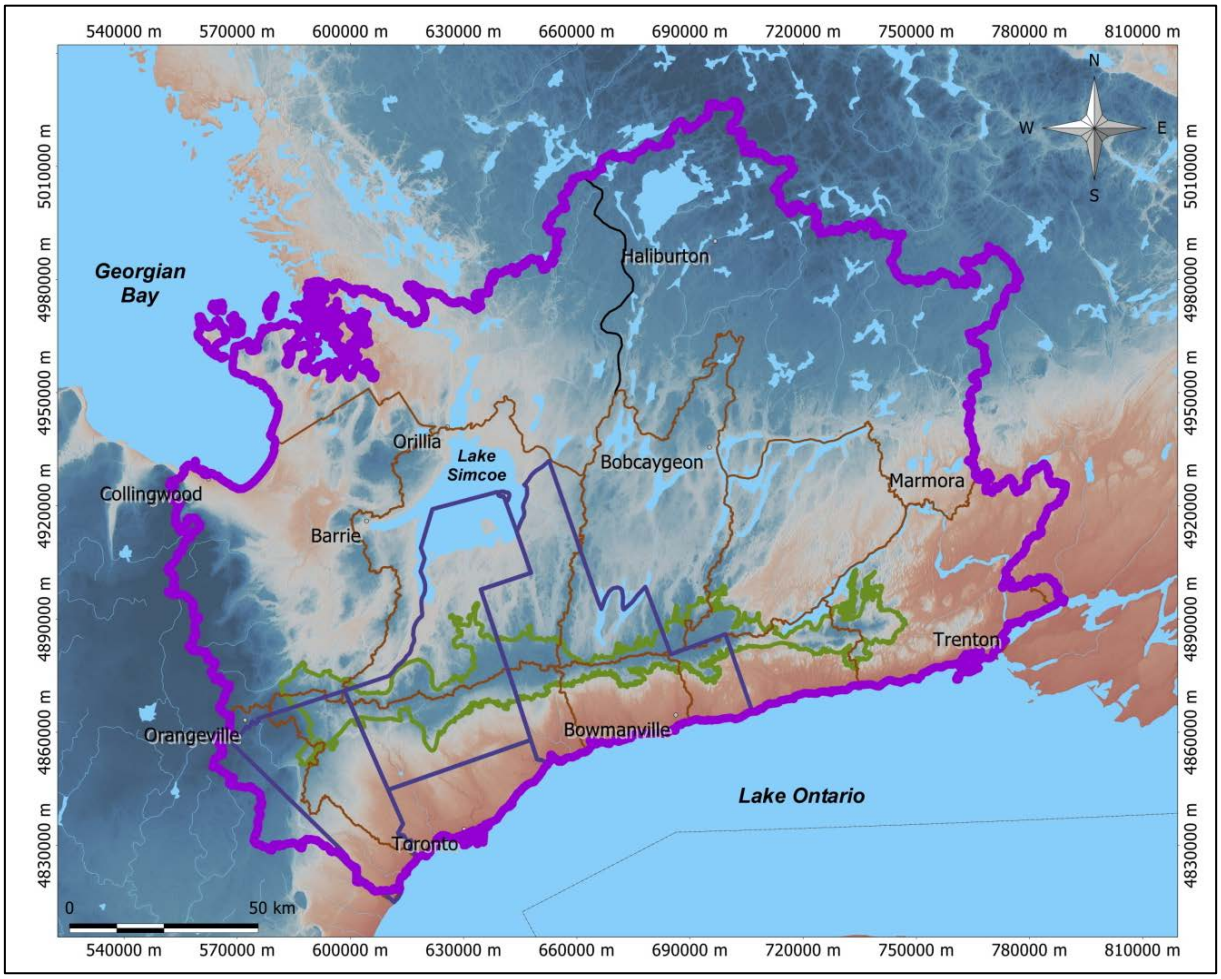


Figure A1: Oak Ridges Moraine Groundwater Program (ORMGP) area. Note that for data management purposes the program area comprises the entirety of three Source Water Protection Regions: 1) Credit/Toronto/Central Lake Ontario (CTC); 2) Southern Georgian Bay – Lake Simcoe (SGBLS); and 3) Lower Trent (TCC). Focus of work is largely directed to the GTA municipalities (York, Peel, Durham, and Toronto) and their associated Conservation Authorities (CA).

Appendix B: Areas of Concern Mapping Qualifying Statement

The purpose of this map is to provide generalized information for discussion and planning purposes only. It is intended to act as a flag of possible areas where hydrogeologic conditions exist that the user (planners, project managers, decision-makers) should be made aware of, as these conditions may have cost implications. It must not be used for actual design purposes. Due diligence must be exercised in any site specific undertaking. This map was prepared utilizing existing information which was available at the time the mapping was conducted. New information may alter the interpretation shown. The information sources used and the assumptions made regarding the preparation of this mapping are included in the accompanying descriptive text. Locations situated outside of mapped Areas of Concern may contain unknown conditions that are of concern.

Appendix C: Water Table Metadata

NAME	Water Table Surface August 2018
Description	The Water Table surface reflects the position of the saturated water table beneath the ground surface and can be used in many ways, for example as a guide for estimating whether subsurface excavations might require dewatering.
Type	Raster - Gridded on 100 m Cells. 50 m cell working resolution translated to 100 m cell final grid.
Geographic Extent	Entire ORMGP Area (+25 km buffer).
Maintenance Standard	Periodically updated as new wells come into ORMGP database
GEOREFERENCING AND ACCURACY	
Horizontal Datum	North American Datum 1983
Vertical Datum	Well elevations set to MNR DEM (based on well locations (see Horizontal Accuracy below)
Spatial Projection	NAD83 UTM Zone 17N
Horizontal Accuracy	Based on accuracy of well locations - see ORMGP Database Manual
DATA SOURCES AND RESTRICTIONS	
Access Constraint	
Use Constraint	None - in accordance with ORMGP Disclaimer
Citation	Oak Ridges Moraine Groundwater Program (2018b) Water Table.
Agency Originator	Oak Ridges Moraine Groundwater Program (ORMGP)
Agency Distributor	Oak Ridges Moraine Groundwater Program (ORMGP)
Online Link	
METHODOLOGY	
Data source: wells	The Water Table was created by contouring the static water levels from all wells (ORMGP database, as of 20180801) where the bottom of the well is less than 20 m deep. As per row 35 (see below), wells up to 50 m deep were incorporated in some areas. It should be noted that the measured static water levels reflect measurements from wells that were drilled in all seasons as well as in wetter and dryer years. So the water table presented here is the average water table. For wells with more than one measurement all water levels are averaged. Given the dynamic nature of the groundwater system, it should be noted that the actual water table at any given time of year may be on the order of up to 2 or 3 metres higher or lower than reflected in the map.
Data source: water bodies (lakes)	Each of Lake Ontario, Lake Simcoe and Georgian Bay were extracted from the 'Ontario Hydrographic Network - Water Bodies' dataset (20110623). These were converted from polygons to points and assigned a standard elevation (Georgian Bay - 176 masl; Lake Simcoe - 219 masl; Lake Ontario - 74 masl).
Data source: rivers	The river network was found in the 'Water Virtual Flow - Seamless Provincial Data Set, 2008'. This dataset was divided into two sets based upon the river segment Strahler Code: one set comprised of Strahler Codes greater than 3; and the second set comprised of Strahler Codes of either 3 or 2. Both sets were converted from polylines to points and tagged with elevations based upon the 'MNR DEM 10m v2' surface for the ORMGP study area. Strahler Class The sampling distance for this dataset was approximately 100m (along-stream). Points found within Georgian Bay, Lake Simcoe or Lake Ontario were removed (these would have been part of the original virtual flow network).
Rasterization	Each of the input datasets (i.e. shallow groundwater levels, water body shoreline points and river network points (Strahler Code > 3) were rasterized at a 50m resolution, then combined and averaged (for points falling within any particular raster cell).
Point density (for areas above Niagara Escarpment and north of Canadian Shield)	Because the water table appeared to be quite deep in some areas to the north and above the escarpment a routine was run to see if additional stream points could assist to reasonably raise the water table. A point density surface was created using bins/grids of 1000, 2000 and 5000m. The 2000m grid density surface provided a balance between the loose (1000m) and tight (5000m) surfaces (i.e. large unsampled areas versus small unsampled areas). Areas west of the escarpment and north of the Canadian Shield were found to have a low density of points to reasonably reflect the water table surface.
River network (Strahler codes 3, 2; for areas above Niagara Escarpment and north of Canadian Sheild)	Based upon the vectorized 2000m density surface, additional river network points (Strahler Codes 3 and 2) were added and rasterized to 50m resolution.
Interpolation: Surfer	Interpolated in Surfer using Kriging (with the 'auto' model setting).
Depth correction (to curb Water Table from being above ground surface)	To select a reasonable depth for Water Table 'correction', an examination of the distribution/count of values across the depth range of 0 to 0.5m was undertaken. Given the fairly constant set of counts across the range, a 0.5m 'correction depth' was selected. At a 50m resolution, the Water Table was 'corrected' to a depth of 0.5 m below the DEM (DEM-0.5) in all areas with a negative depth values (i.e. the uncorrected surface exceeds the DEM).
Source/Cautions	The database of wells in the ORMGP includes all of the MOECC water well records as well as additional geotechnical/hydrogeological wells that have been entered into the database from other sources (consultant reports, Ontario Geological Survey, consultant databases, partner agency staff, etc.). Water levels are measured at nearly all wells at the time of drilling. The recorded static water level may or may not effectively reflect the water table position, depending upon when it was measured. Usually upon completion of drilling the well is pumped to estimate well capacity - sometimes insufficient time has passed to record a 'true' static water level (i.e. the well has fully recovered after pumping).
ATTRIBUTES	
REPLACES OR UPDATES	Oak Ridges Moraine Groundwater Program (2018) Water Table.
SIGNIFICANT CHANGES FROM PREVIOUS VERSION	**When compared with known water table depths, it was noted that the June 2018 Water Table surface was lower than anticipated, particularly beneath the Oak Ridges Moraine. To further 'correct' the water table surface, all areas where the Water Table was greater than 20 m deep were further examined. In these areas water levels from wells that were 20 to 50 m deep were added to the above 'Data Source Wells' and the above procedure was re-undertaken.**
CONTACT INFORMATION	
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