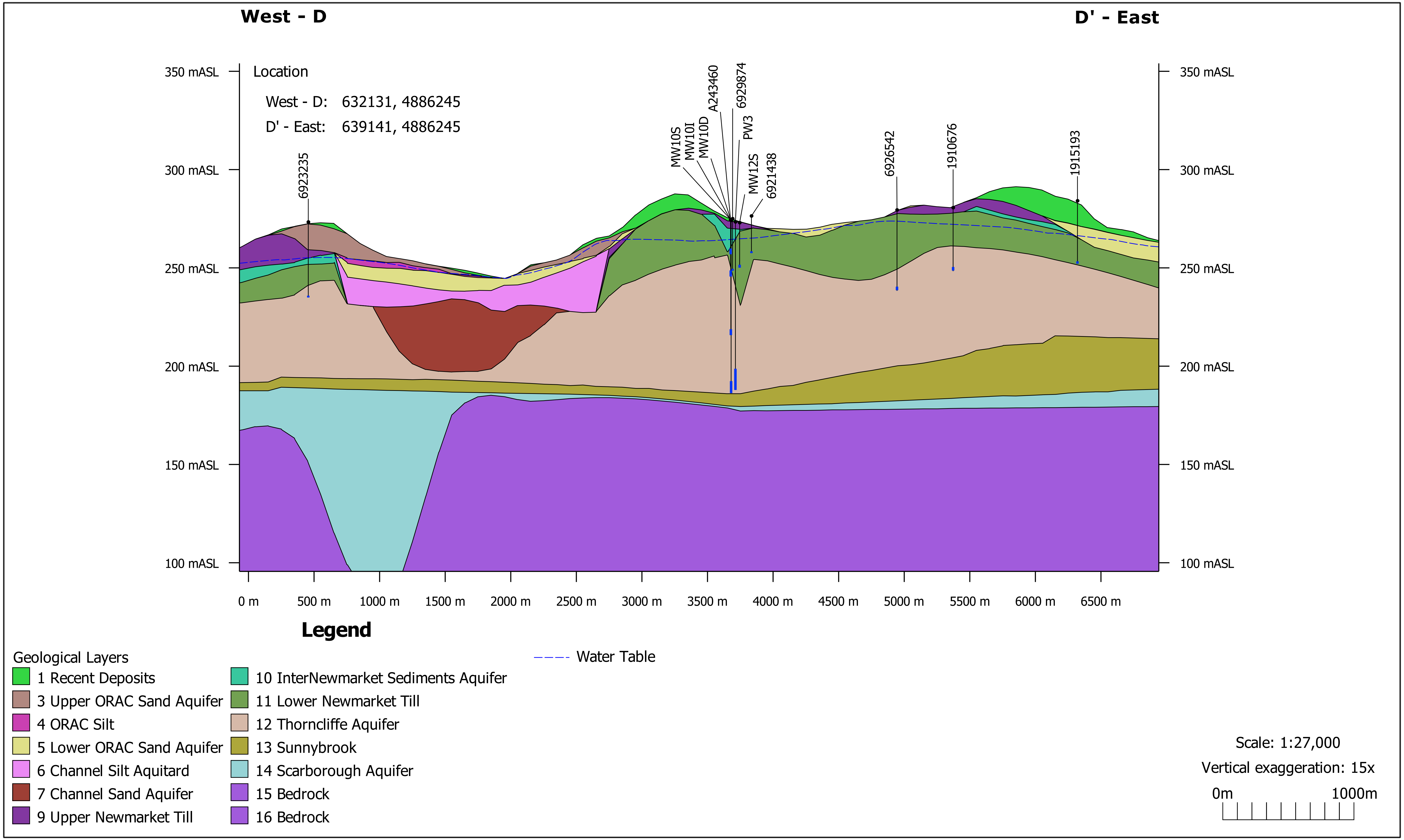


FIGURE 2.9
Tier 3 Conceptual Geological Cross Section D - D'
Mt Albert Water Supply System Upgrades EA
York Region

JACOBS

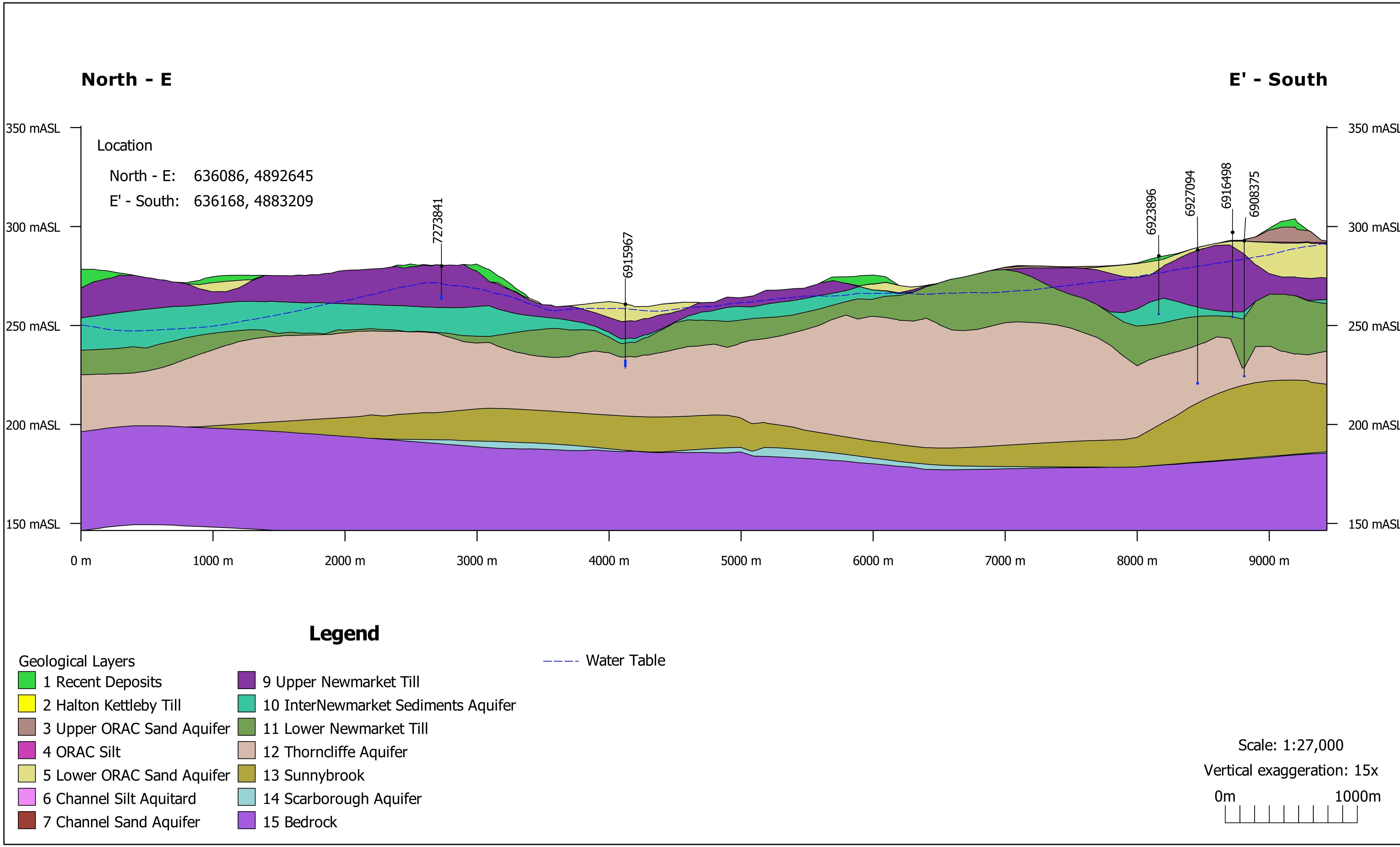


FIGURE 2.10
Tier 3 Conceptual Geological Cross Section E - E'
Mt Albert Water Supply System Upgrades EA
York Region

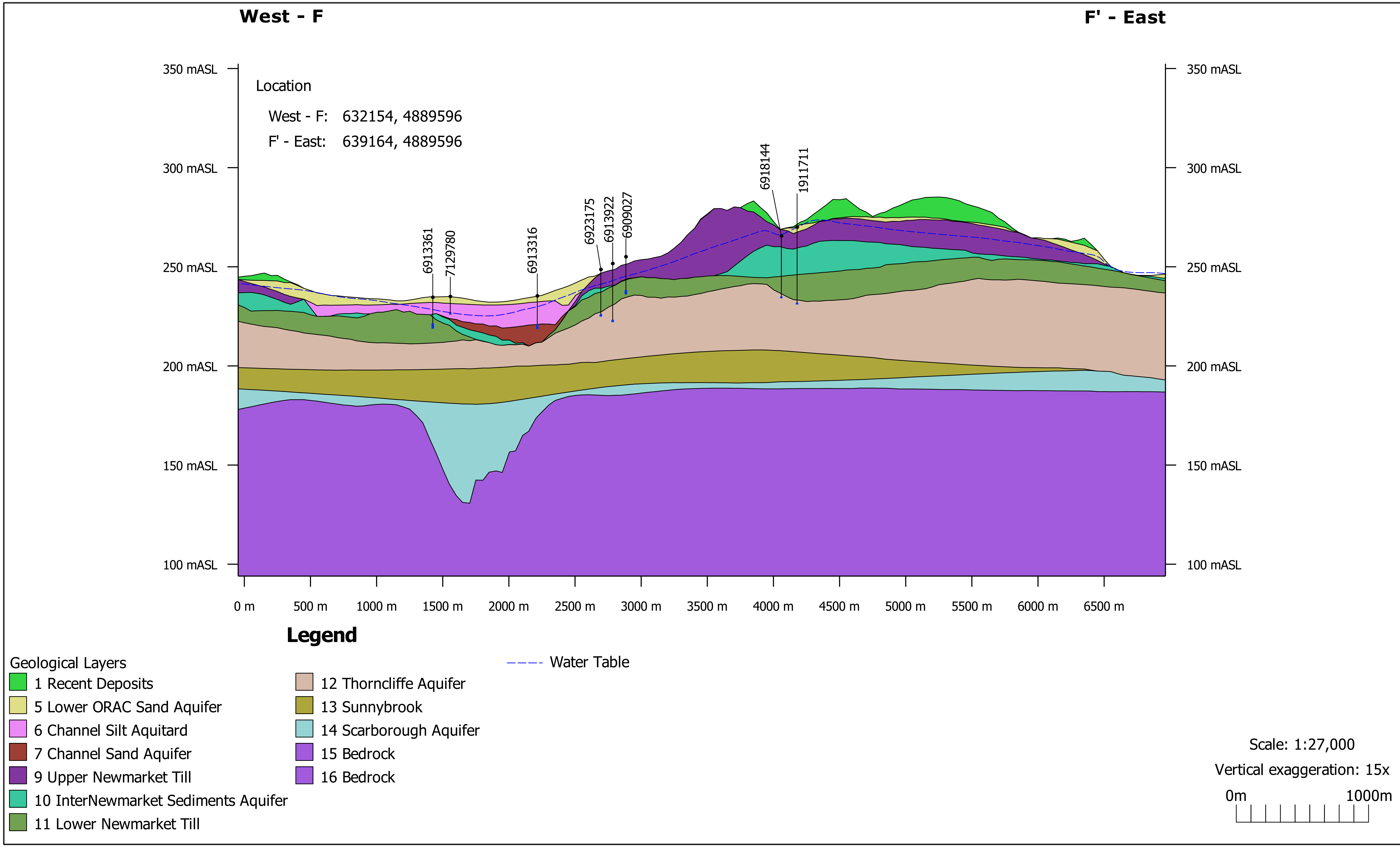


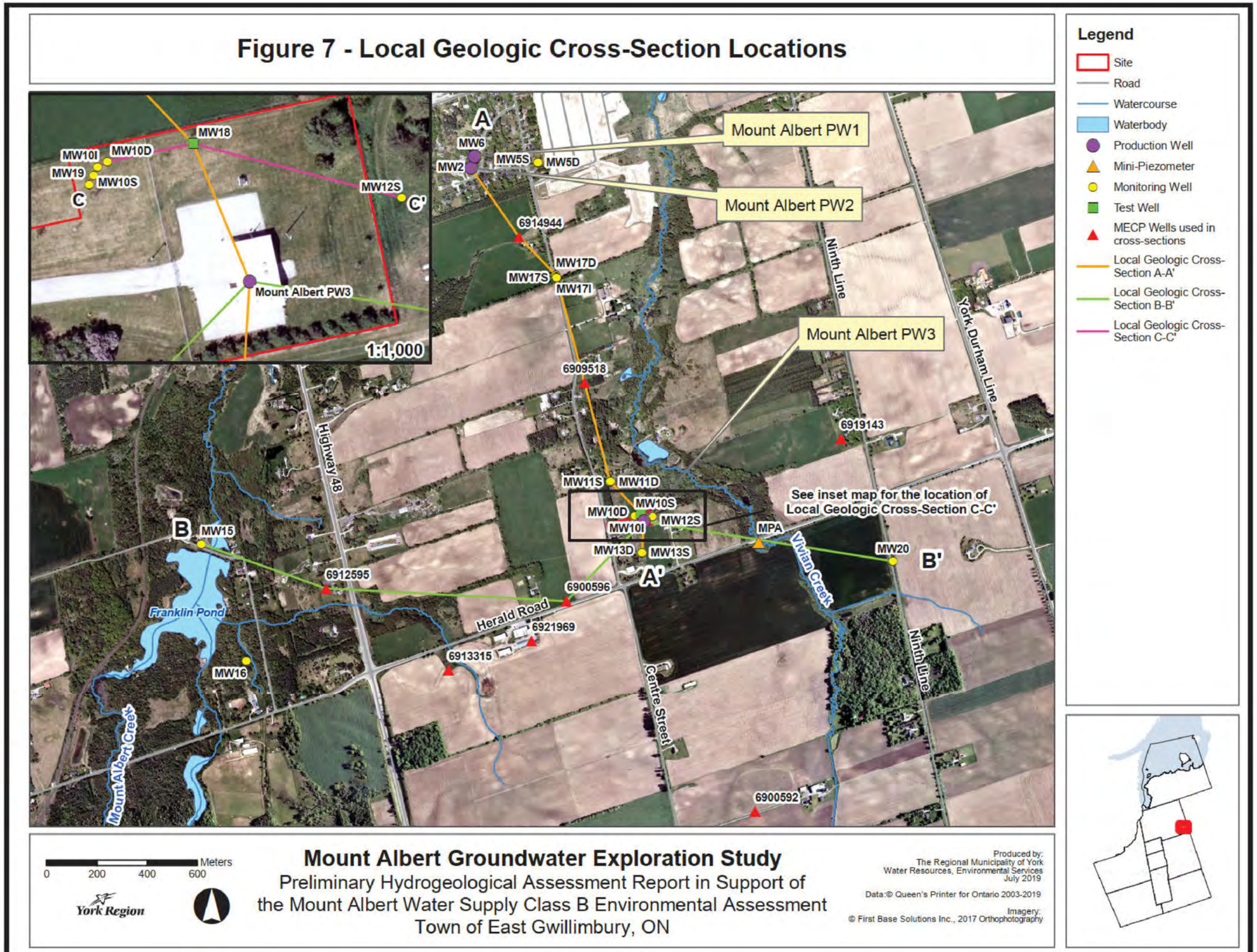
FIGURE 2.11
Tier 3 Conceptual Geological Cross Section F - F'
Mt Albert Water Supply System Upgrades EA
York Region

JACOBS

3. Local Hydrostratigraphic Units

As part of recent investigations for a new water supply well (MW18) at the Well No 3 Facility, York Region prepared three locally refined geological cross-sections (Figure 3.1 though Figure 3.4). The interpretations used to prepare the cross sections by York Region (2019) differ slightly from the regional cross-sections created using the York Region Tier 3 conceptual geological model, with several geological units (Halton Kettleby Till and ORAC) not included in the regional cross-sections, interpreted to be present with local refinement in the vicinity of PW1 and PW2 Facility, and PW3 Facility. York Region (2019) have interpreted that the Halton Kettleby Till and ORAC are present within the shallow depths that are typically shown on the regional cross-sections as the UNT, INS and LNT. It is York Region’s interpretation that the Halton Kettleby Till and ORAC are relatively continuous in the areas of the PW1 and PW2, and PW3 Facilities.

York Region (2019) developed local cross-sections based on available borehole logs and water well records for monitoring wells and municipal water supply wells that are part of the York Region network, and MECP water well records. York Region (2019) states that where deviations from the regional geological and hydrogeological understanding were identified, the interpretation of the local geological and hydrogeological setting presented in Figure 3.2 through Figure 3.4 were considered more accurate. It should be noted that the quality of geological data recorded in the MECP water well records is subject to potential interpretation errors due to the inconsistency of geological logging by multiple companies that have submitted borehole records. Therefore, detailed interpretation from typically non-detailed borehole logs can lead to subjective stratigraphic interpretation.



Notes:
1. Figure taken from York Region, 2019. Mount Albert Groundwater Exploration Study Preliminary Hydrogeological Assessment Report in Support of the Mount Albert Water Supply Class B Environmental Assessment

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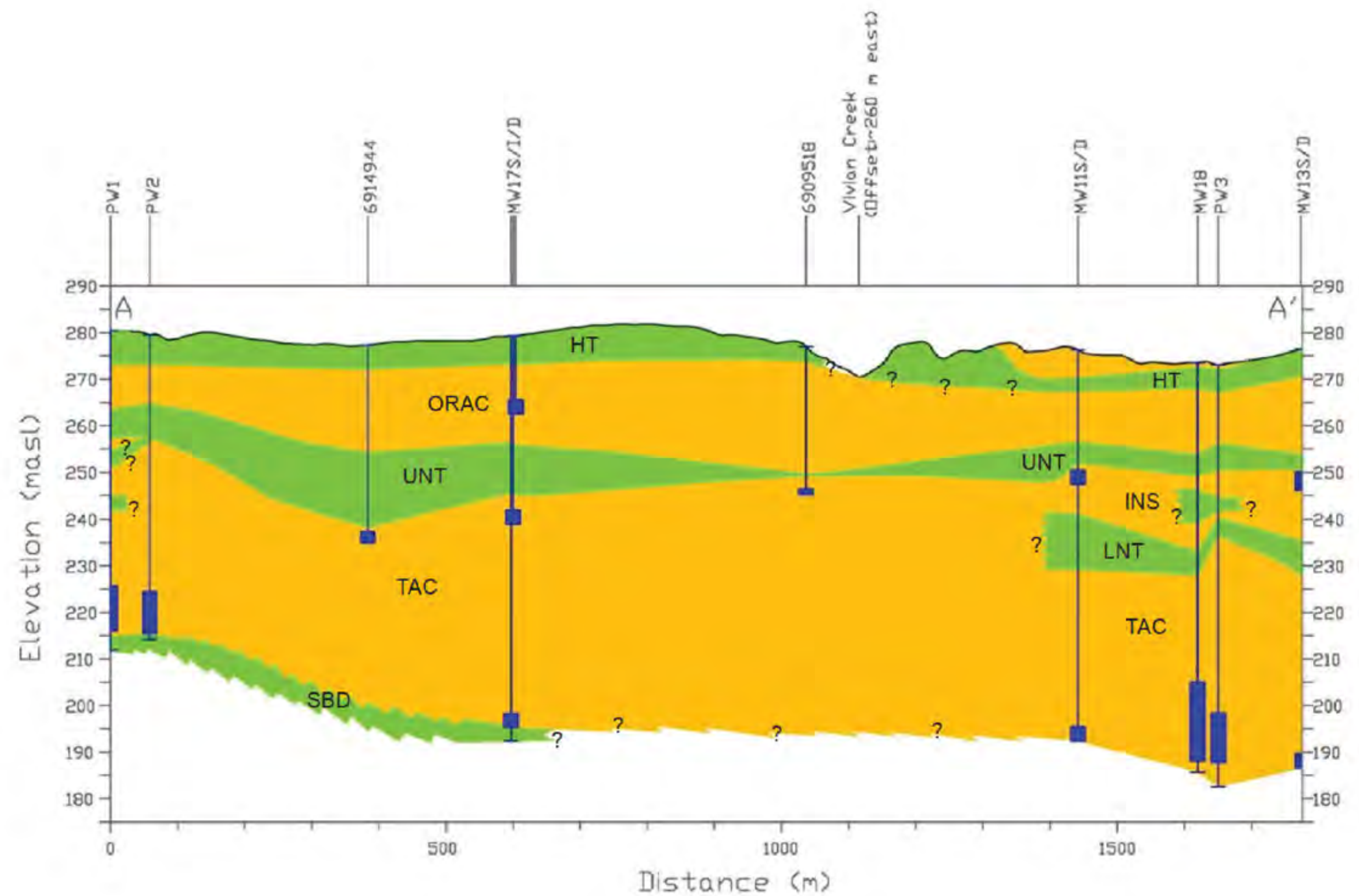
Figure 3.1
Local Geological Cross-Section Locations
Mount Albert Water Supply System Upgrades Class EA
Region of York
Mount Albert, Ontario

Figure 7a - Local Geologic Cross-Section A - A'



Legend

Interpreted Ground Profile (based on 10 m cell 2016 Digital Elevation Model)

Fine-Textured Till (Silt, Clay, Silty Clay to Sandy Clay, Clayey Silt Till to Sandy Silt)

Sand and/or Gravel (Silty to Fine Sand, Medium to Coarse Sand, Gravel)

Bedrock (Limestone, Shale)

Well ID

Well

Well Screen (Diameter is not to scale)

Notes:
HT = Halton Till
UNT = Upper Newmarket Till
LNT = Lower Newmarket Till
INS = Inter-Newmarket Sediments
ORAC = Oak Ridges Aquifer Complex
TAC = Thorncliffe Aquifer Complex
SBD = Sunnybrook Drift

Horizontal Scale: As shown
Vertical Scale: As shown
Vertical Exaggeration: 14.5

York Region

Mount Albert Groundwater Exploration Study

Preliminary Hydrogeological Assessment Report in Support of
the Mount Albert Water Supply Class B Environmental Assessment
Town of East Gwillimbury, ON

Produced by:
The Regional Municipality of York
Water Resources, Environmental Services
July 2019

Notes:
1. Figure taken from York Region, 2019. Mount Albert Groundwater Exploration Study Preliminary Hydrogeological Assessment Report in Support of the Mount Albert Water Supply Class B Environmental Assessment

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Figure 3.2
Local Geological Cross-Section A - A'
Mount Albert Water Supply System Upgrades Class EA
Region of York
Mount Albert, Ontario

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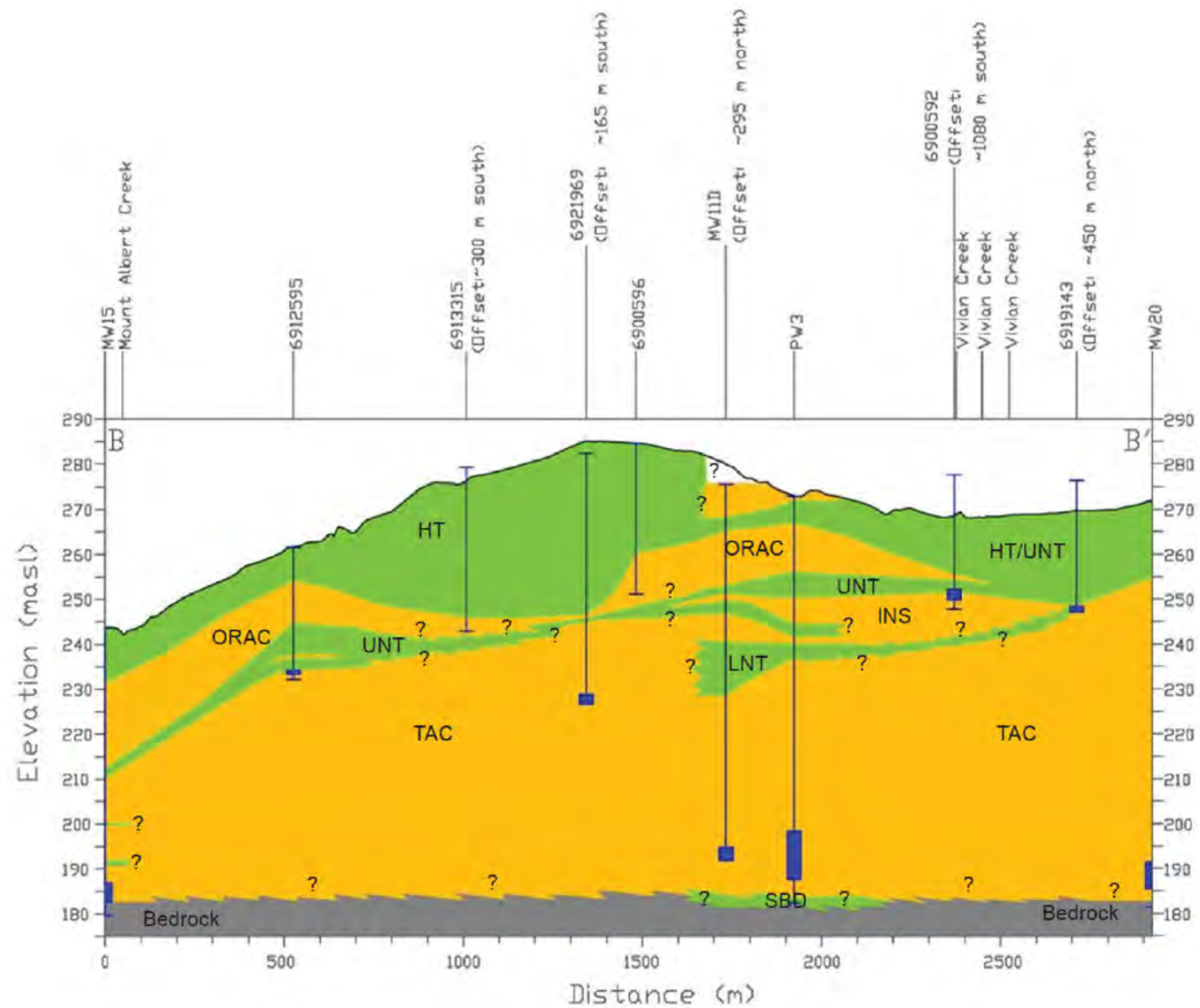
Figure 7b - Local Geologic Cross-Section B - B'



Legend

Interpreted Ground Profile (based on 10 m cell 2016 Digital Elevation Model)

Fine-Textured Till (Silt, Clay, Silty Clay to Sandy Clay, Clayey Silt Till to Sandy Silt)

Sand and/or Gravel (Silty to Fine Sand, Medium to Coarse Sand, Gravel)

Bedrock (Limestone, Shale)

Well ID

Well

Well Screen (Diameter is not to scale)

Notes:
HT = Halton Till
UNT = Upper Newmarket Till
LNT = Lower Newmarket Till
INS = Inter-Newmarket Sediments
ORAC = Oak Ridges Aquifer Complex
TAC = Thorncliffe Aquifer Complex
SBD = Sunnybrook Drift

Horizontal Scale: As shown
Vertical Scale: As shown
Vertical Exaggeration: 13.3

York Region

Mount Albert Groundwater Exploration Study

Preliminary Hydrogeological Assessment Report in Support of the Mount Albert Water Supply Class B Environmental Assessment
Town of East Gwillimbury, ON

Produced by:
The Regional Municipality of York
Water Resources, Environmental Services
July 2019

Notes:
1. Figure taken from York Region, 2019. Mount Albert Groundwater Exploration Study Preliminary Hydrogeological Assessment Report in Support of the Mount Albert Water Supply Class B Environmental Assessment

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Figure 3.3
Local Geological Cross-Section B - B'
Mount Albert Water Supply System Upgrades Class EA
Region of York
Mount Albert, Ontario

JACOBS

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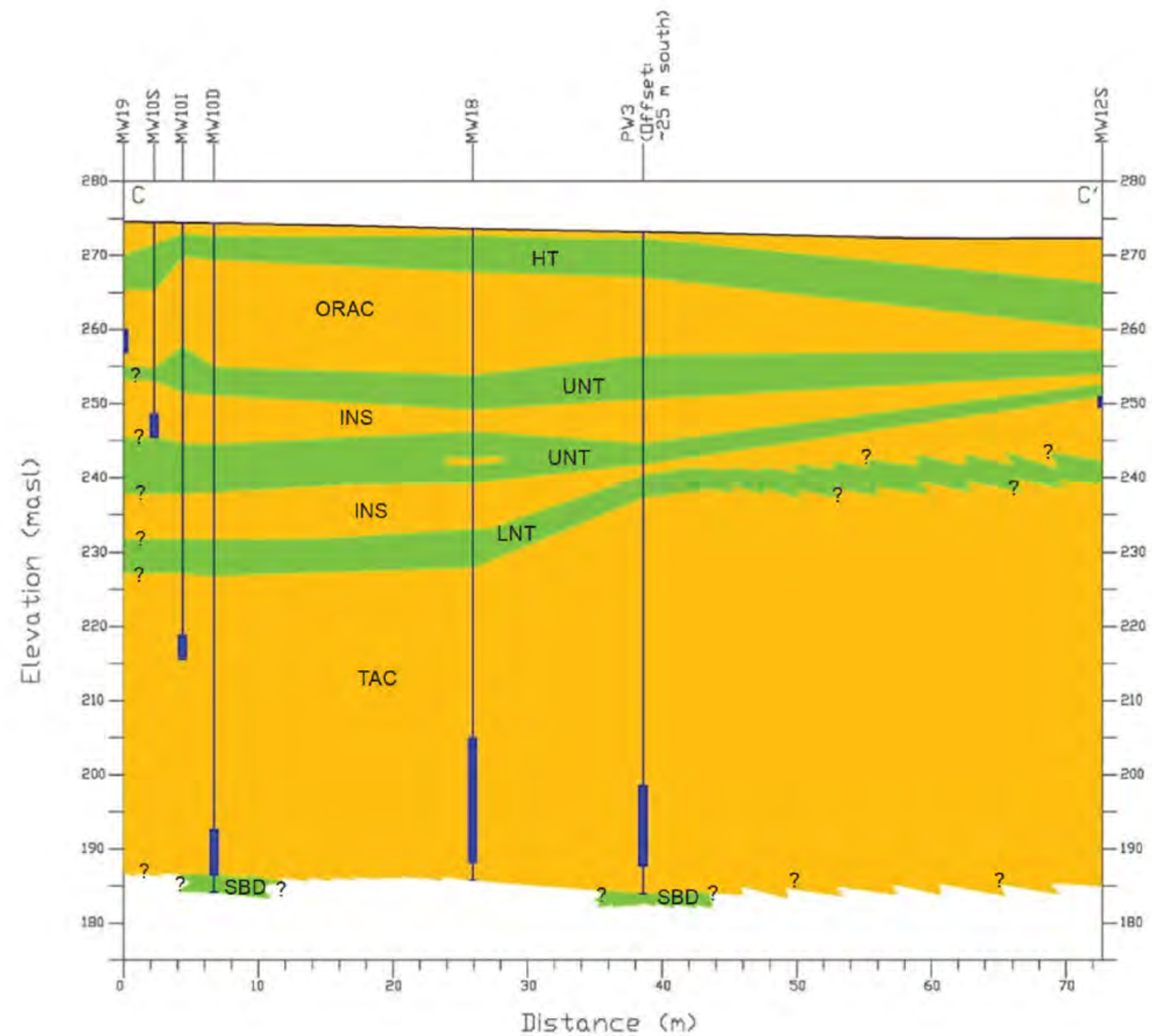
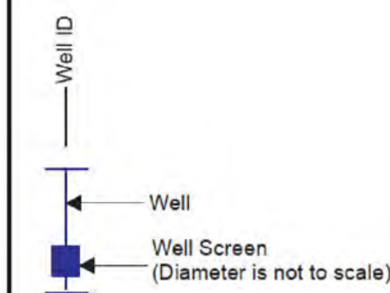
Figure 7c - Local Geologic Cross-Section C - C'



Legend

- Interpreted Ground Profile (based on 10 m cell 2016 Digital Elevation Model)
- Fine-Textured Till (Silt, Clay, Silty Clay to Sandy Clay, Clayey Silt Till to Sandy Silt)
- Sand and/or Gravel (Silty to Fine Sand, Medium to Coarse Sand, Gravel)
- Bedrock (Limestone, Shale)



Notes:
HT = Halton Till
UNT = Upper Newmarket Till
LNT = Lower Newmarket Till
INS = Inter-Newmarket Sediments
ORAC = Oak Ridges Aquifer Complex
TAC = Thorncliffe Aquifer Complex
SBD = Sunnybrook Drift

Horizontal Scale: As shown
Vertical Scale: As shown
Vertical Exaggeration: 0.5

York Region

Mount Albert Groundwater Exploration Study

Preliminary Hydrogeological Assessment Report in Support of
the Mount Albert Water Supply Class B Environmental Assessment
Town of East Gwillimbury, ON

Produced by:
The Regional Municipality of York
Water Resources, Environmental Services
July 2019

Notes:
1. Figure taken from York Region, 2019. Mount Albert Groundwater Exploration Study Preliminary Hydrogeological Assessment Report in Support of the Mount Albert Water Supply Class B Environmental Assessment

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Figure 3.4
Local Geological Cross-Section C - C'
Mount Albert Water Supply System Upgrades Class EA
Region of York
Mount Albert, Ontario

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4. Hydrogeology

4.1 Groundwater Flow

Regional shallow groundwater flow within the water table determined from water table contour data sourced from the York, Peel, Durham, Toronto and The Conservation Authorities Moraine Coalition (CAMC-YPDT) database (Oak Ridges Moraine Groundwater Program) tends to follow surface topography (Figure 4.1). Within the study area, shallow groundwater typically flows north and northwest with some localized radial flow.

York Region (2019) states that groundwater elevations in the wells interpreted to be screened in the INS are generally consistently higher than that in wells interpreted to be screened in the TAC, which indicates a downward hydraulic gradient and recharge conditions from the INS to the TAC. York Region (2019) also notes that the groundwater level response to pumping at Mount Albert PW3 is typically quite evident in the deeper monitoring wells believed to be screened in the TAC, while the response in the shallower wells interpreted to be screened in the INS is more subdued but still notable. This suggests that the till layer (believed to correspond to the LNT) separating the two aquifer units in the vicinity of PW3 Facility is likely a leaky aquitard, causing some degree of hydraulic connection between the INS and TAC. Similar observations were noted by MMM (2006) based on the results of the aquifer testing which was completed as part of the Groundwater Exploration Study for the purposes of siting, constructing and testing Mount Albert PW3.

4.2 Aquifer Properties and Aquifer Yield

The hydraulic properties of the overburden aquifers and confining units within York Region can be extremely variable (Earthfx. 2013). Reported transmissivity and storativity values for the INS and TAC range from 164 m^2/d to 1,500 m^2/d, and 1 x 10^{-6} to 1 x 10^{-3}, respectively (Earthfx, 2013).

On April 26, 2019, Aquatech and York Region completed a Step-Rate pumping test at well MW18, which is screened within the TAC. The results of the Step-Rate pumping test indicate transmissivity and storativity values of 939 m^2/day and 1 x 10^{-5}, respectively. The storativity estimate falls within the range of values that are typical of a confined aquifer and indicates that the TAC behaves more as a confined aquifer than a semi-confined aquifer locally at the PW3 Facility. The aquifer hydraulic properties estimated by York Region (2019) during testing of MW18 compare reasonably well with the range of transmissivity (1000 m^2/d to 1500 m^2/d) and storativity (1 x 10^{-6} to 1 x 10^{-3}) values reported by MMM based on the results of aquifer performance testing conducted at the PW3 Facility in 2005 (MMM, 2016).

No influence from the 75-hour pumping test was observed by York Region in monitoring wells interpreted to be screened in the shallower ORAC, inferring the confined nature of the TAC, though the pumping test duration may have been too short to identify and confirm a hydraulic connection. No drawdown from the pumping test was observed at MPA, the upstream streamside piezometer located at Vivian Creek.It is interpreted that Vivian Creek and its riparian wetland, have very limited to no hydraulic connection to the TAC near the PW3 Site, and are unlikely to be impacted by long-term pumping at the Site under the two pumping scenarios (York Region, 2019).

4.2.1 Hydraulic Connection

Where the Oak Ridges Moraine deposits are unconfined, typically at the crest of the moraine, the aquifer may be susceptible to surface sources of contamination. The deep aquifers used by York Region are the TAC and the deeper SAC. The TAC and Scarborough Formation units are confined above by the Upper and Lower Newmarket Till, and Sunnybrook Drift aquitards, respectively. These deep aquifers are generally well protected from anthropogenic contaminant sources due to the overlying till units but in places, the deep aquifers may be in direct contact with the Oak Ridges Moraine deposits and therefore may be more susceptible to surface sources of contaminants (CH2M, 2017).

During the pumping tests at MW18 in 2019, York Region staff monitored and compared groundwater chemistry in different aquifers and surface water within Vivian Creek to assess surface water and groundwater interaction, as well as the hydraulic connection between different aquifer units, namely the TAC, and overlying INS, and ORAC. Within the vicinity of PW3 and MW18, it is inferred through groundwater chemistry comparison, and through the monitoring of drawdown within monitoring wells screened within the different aquifer units during the pumping of MW18 screened in the TAC, that there is a hydraulic connection between the TAC and INS aquifer units, though no apparent hydraulic connection with the TAC or INS aquifer units with the ORAC aquifer unit (York Region, 2019).

Chemical comparison of Vivian Creek surface water and groundwater sampled from ORAC and TAC monitoring wells indicates no direct hydraulic connection between surface water and groundwater within the vicinity of PW3 and MW18. The chemical signature of surface water sampled from Vivian Creek is similar to that of the TAC, but not the shallower ORAC unit. York Region (2019) suggest that due to the classification of Vivian Creek being a permanent cold-water stream, that the TAC may contribute baseflow further upgradient or near the Vivian Creek headwaters.

Results from short-term testing programs may vary from long-term continuous pumping. Long-term pumping will induce downward gradients and may draw water from the shallow groundwater and surface waters.

4.3 Water Quality Trends

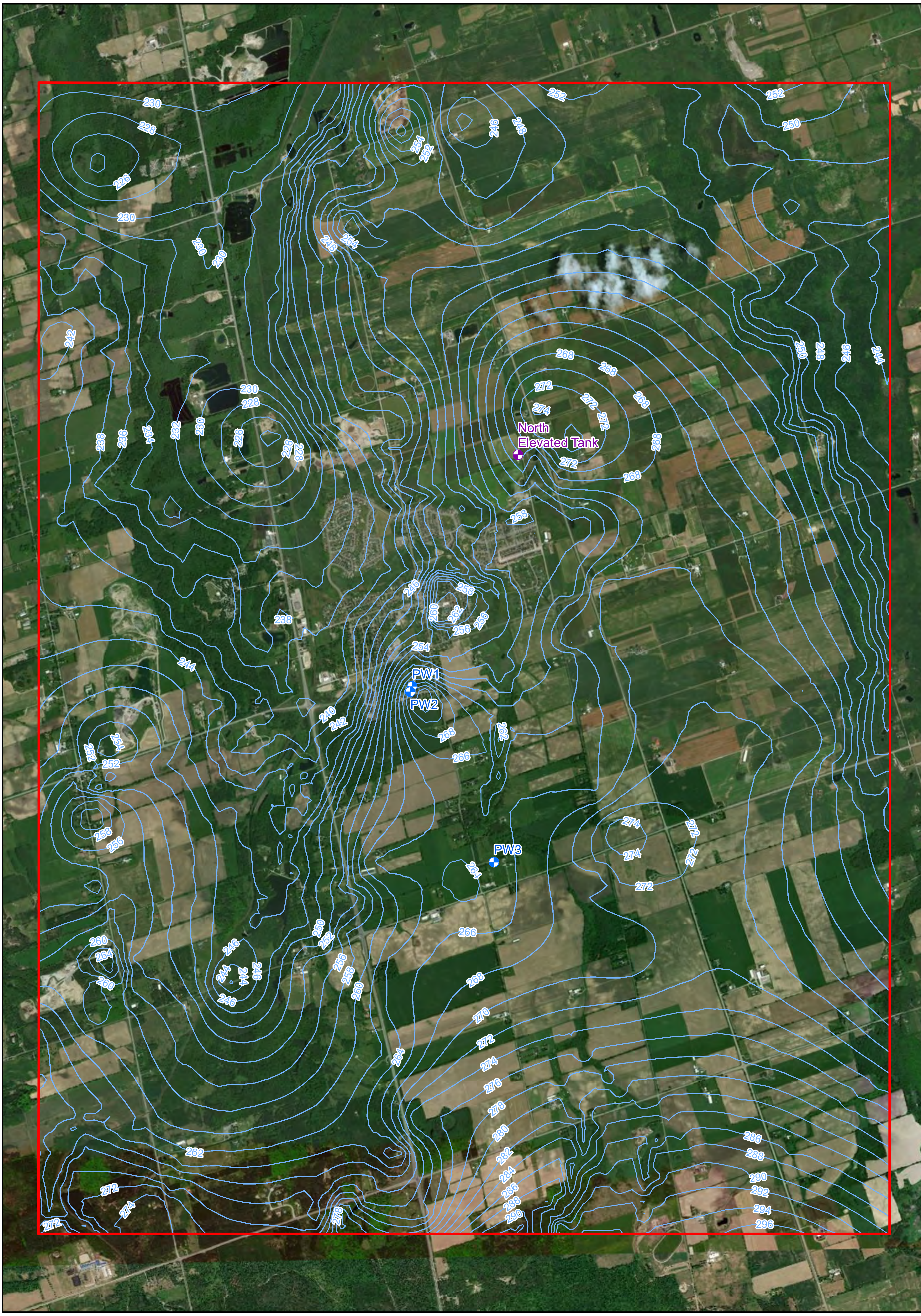
The wellfields of York Region have generally good water quality with most wells meeting the Ontario Drinking Water Quality Standards (ODWQS) although some wells have routine exceedances of aesthetic objectives for iron and manganese. Iron and manganese are common constituents in York Region groundwater. It is derived from iron and manganese in the hydrostratigraphic units and, as the groundwater in the aquifer contacts these minerals, they are dissolved resulting in elevated concentrations of iron and manganese in the groundwater. In Ontario, the Aesthetic Objective for iron is 0.3 mg/L and for manganese is 0.05 mg/L. Recently, Health Canada has proposed a maximum acceptable concentration (MAC) of 0.1 mg/L (100 µg/L) for total manganese in drinking water and an aesthetic objective (AO) of 0.02 mg/L (20 µg/L) is also proposed for total manganese in drinking water. At concentrations above the AO, iron and manganese can impart a metallic taste and cause brown or black staining on plumbing fixtures and laundry.

The extent to which iron and manganese may be found in groundwater is dependent on the composition of the aquifer materials, the amount of oxygen in the groundwater and the acidity of the water. In deep groundwater systems, oxygen is generally depleted, and iron is present as ferrous iron (Fe^{2+}). In more oxygenated groundwater, greater than 1 to 2 mg/L oxygen, the iron occurs as ferric iron (Fe^{3+}). Ferrous iron is very soluble while ferric iron is relatively insoluble. In the deep aquifers of York Region for example, the oxygen content is likely to be low and therefore the iron is in the soluble form of ferrous iron and is found in the groundwater at appreciable concentrations. In the shallow aquifer, such as the unconfined Oak Ridges Moraine deposits, the groundwater is likely to be more oxygenated and the iron is more likely to be in the ferric form and generally at low concentrations. Similar processes exist for Manganese with Mn^{2+} as the more soluble form and Mn^{4+} as the insoluble form.

In general, the raw groundwater quality observed in production wells screened in the deeper aquifers (TAC and SAC) meets the Ontario Drinking Water Quality Standards (ODWQS), with the exception of iron and manganese where the aesthetic ODWQS are routinely exceeded at some wells (CH2M, 2017). The elevated levels of iron and manganese are typical of the York Region deeper aquifers and are attributed to naturogenic sources (CH2M, 2017).

As noted above, the iron and manganese concentrations are dependent on the pH of the groundwater. Low pH will likely result in higher iron and manganese concentrations. However, the aquifer source materials are most likely carbonate materials (i.e. limestones and dolomites) and therefore the groundwater will be buffered with pH in the 7.7 to 8.3 range. A review of the pH and iron and manganese concentration trends indicates some seasonality and correlation with pH and metal concentrations

(CH2M, 2017). However, the cause of the pH fluctuations is unknown. It may be related to recharge events (i.e. high recharge in the spring and fall, low recharge in the summer and winter) or to wellfield production (i.e. higher demand in dry summer months, lower demand in the winter) (CH2M, 2017).



N

0 500

Metres

- Municipal Well
- North Elevated Tank
- Groundwater Contour (2 m interval)
- Study Area Boundary

Notes:
1. Image Source: Esri, DigitalGlobe, Earthstar Geographics
2. Water table contour data sourced from the York, Peel, Durham, Toronto and The Conservation Authorities Moraine Coalition (CAMC-YPDT) database (Oak Ridges Moraine Groundwater Program)

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Figure 4.1
Regional Water Table Elevation Contours
Mount Albert Water Supply System Upgrades Class EA
Region of York
Mount Albert, Ontario

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The iron concentrations in the TAC production wells (PW1, PW2 and PW3) are generally at concentrations above the ODWQS AO of 0.3 mg/L. The concentration trends are generally stable indicating that the water quality is at equilibrium with the aquifer material (Figure 4.2; Figure 4.3; Figure 4.4).

PW1, PW2, PW3 and MW18 typically have manganese concentrations in exceedance of the ODWQS AO of 0.05 mg/L. In general, the concentration trends are relatively stable indicating the groundwater is at general equilibrium with the aquifer materials.

Chloride and nitrate concentrations are used in the York Region monitoring program as indicators of anthropogenic impacts on water quality. Where chloride and nitrate are found in appreciable quantities, the groundwater may be vulnerable to surface contaminant sources. Chloride sources are most likely due to winter de-icing and road salts while nitrates can be attributed to agricultural fertilizers and to a lesser extent septic systems (CH2M, 2017). Chloride concentrations within the Mt Albert municipal production wells and monitoring wells are less than the ODWQS AO of 250 mg/L. The deep aquifers (TAC and SAC) generally have lower chloride concentrations indicative of confined aquifer conditions. Several of the production wells, have increasing chloride trends, albeit at low concentrations. The gradual increase in chloride concentrations likely represents the slow migration of chloride from surface sources as a result of ongoing production from the wellfields (CH2M, 2017).

Nitrates are generally non-detect in the deep aquifers, again showing the well-confined nature of the Thorncliffe and Scarborough Formations. Shallower formations such as the ORAC and INS are more susceptible to nitrate sources with evidence of nitrate in measurable quantities in shallow monitoring wells MW5S, MW10S, MW12S and MW17S,

Groundwater chemistry samples were collected from new municipal test well MW18 during the constant rate pumping test. (1-hour, 6-hour, 24-hour, 48-hour and 72-hour) for 30 indicator parameters (York Region, 2019). At the 72-hour sampling interval a large suite of parameters were tested based on Tables 1, 2, 3 and 4 of the ODWQS. Water quality results were compared to the ODWQS, with all parameters being below the corresponding criteria limit/range, with the notable exception of hardness and manganese.

Water quality results from MW18, collected after 72-hours of continuous pumping, were compared to historical water quality results from the three existing production wells (Mount Albert PW1, Mount Albert PW2 and Mount Albert PW3) from 1999 to 2019. Select indicator parameters iron, manganese and nitrate+nitrite were used in this analysis, and found that all parameter concentrations were similar or better at MW18 than Mount Albert PW3. As these two wells draw water from the same parts of the TAC, the water chemistry would be expected to be the same, therefore any differences in chemistry are likely due to the short-term pumping effects of new well MW18. Long-term pumping of MW18 may show different groundwater chemistry.

A comparison of water quality results from MW18 to those collected at Mount Albert PW1 between 1999 and 2019, for key indicator parameters, showed an improvement in water quality for iron, manganese, though nitrate+nitrite concentrations at MW18 are slightly higher than PW1, where nitrate+nitrite concentrations are generally reported below the laboratory detection limit.

Laboratory analysis of groundwater samples collected during the 72-hour pumping test confirm no indication of faecal contamination or indication of the presence of enteric protozoa and other microorganisms including Cryptosporidium spp., Giardia spp. and photosynthetic, pigment-bearing algae and/or diatoms (PBADs), supporting the interpretation that MW18 is not a Groundwater Under Direct Influence of surface water (GUDI) well.

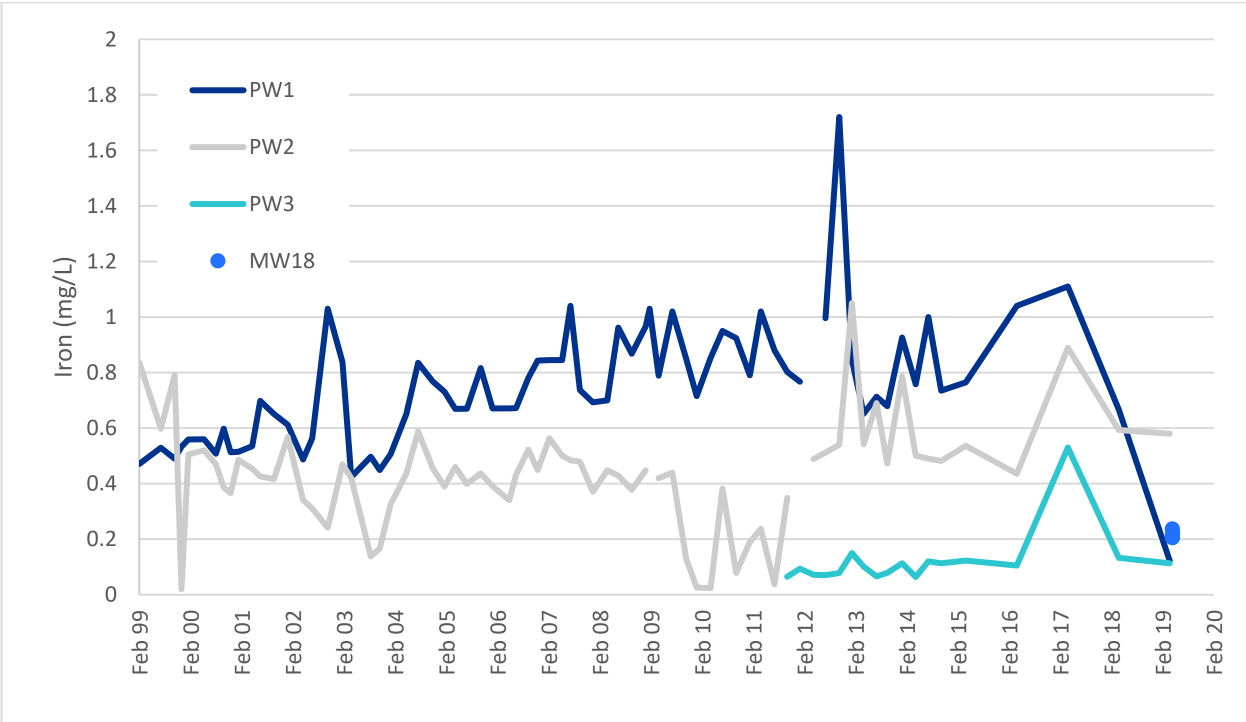


Figure 4.2: Municipal Well Iron Concentrations

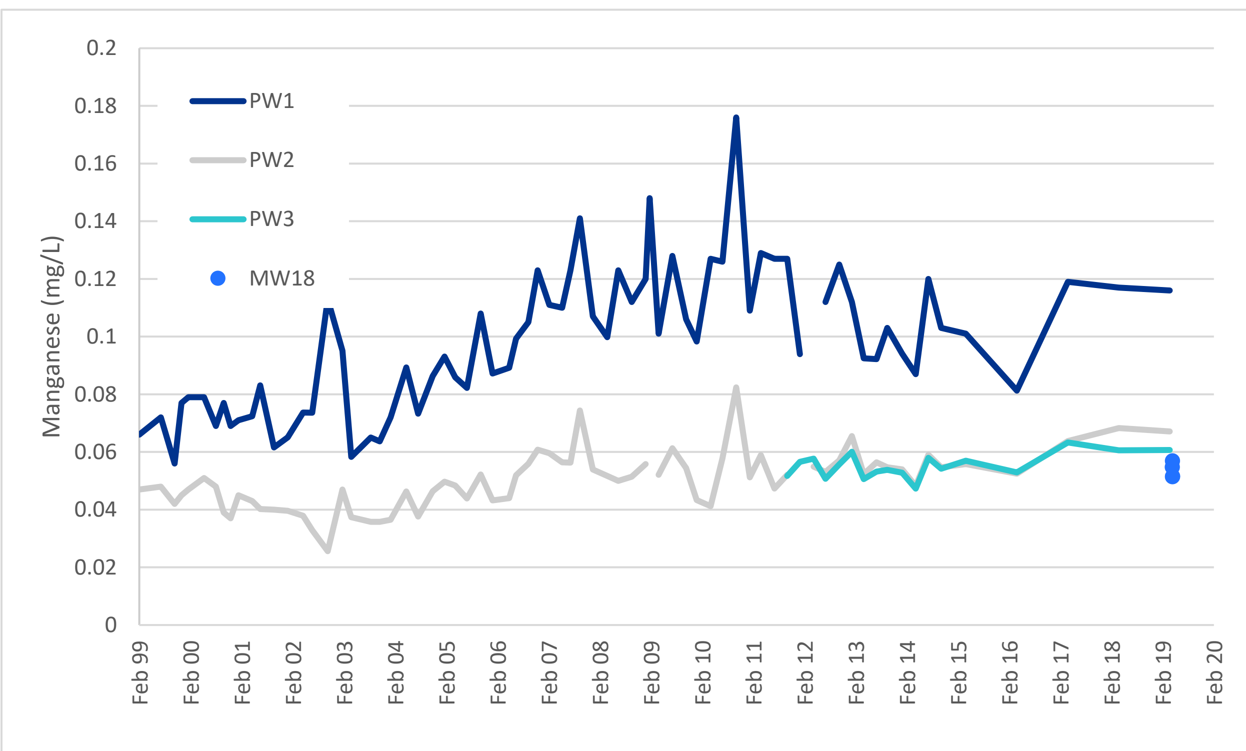


Figure 4.3: Municipal Well Manganese Concentrations

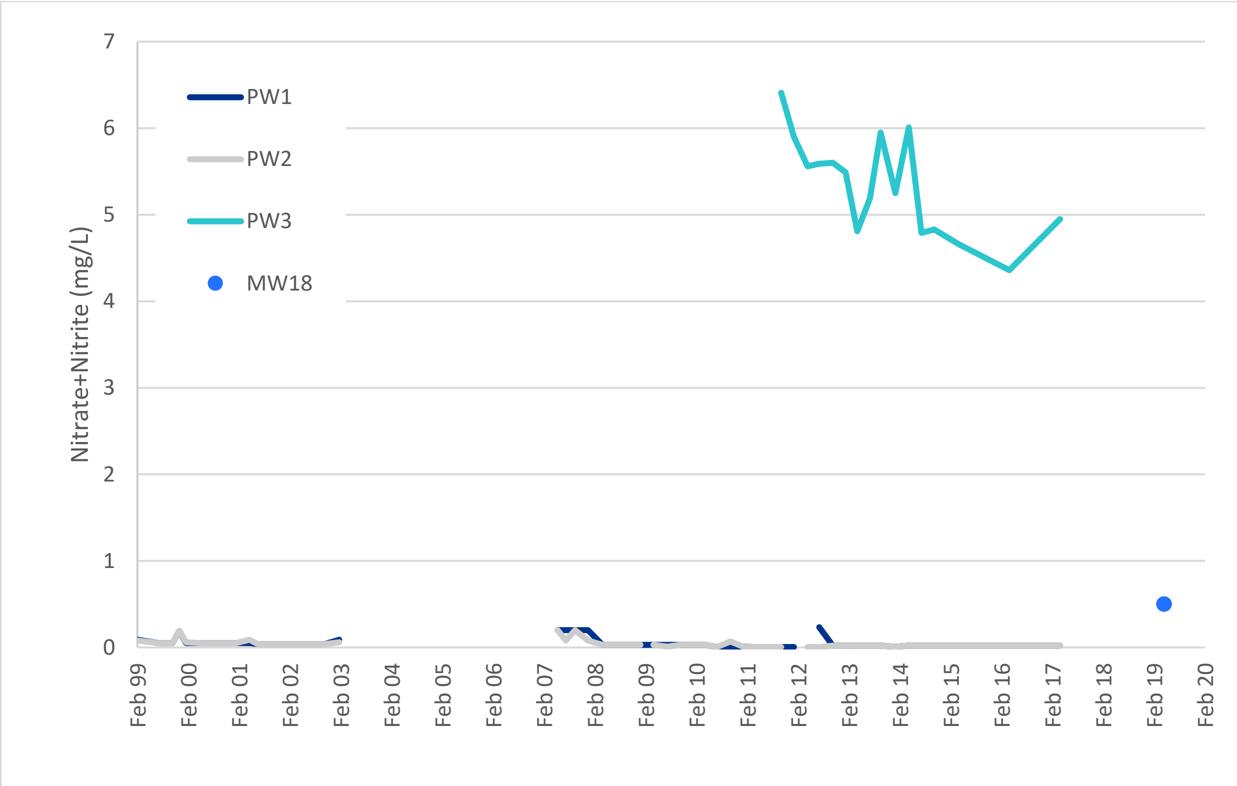


Figure 4.4: Municipal Well Nitrate and Nitrite Concentrations

5. Water Use

Within the study area, a review of the Ministry of the Environment, Conservation and Parks (MECP) Water Well Records database identifies approximately 400 well records. Primary use information indicates that most wells are associated with domestic use, followed by livestock and commercial use. A summary of the primary use is provided in Table 5.1, and well record locations are shown in Figure 5.1.

Table 5.1: MECP Well Records Summary

Primary Use	Number of MECP Well Records
Domestic	291
Livestock	40
Not Specified	29
Commercial	10
Public	7
Monitoring	6
Irrigation	5
Municipal	5
Monitoring and Test Hole	3
Industrial	2

Primary Use	Number of MECP Well Records
Not Used	1
Other	1

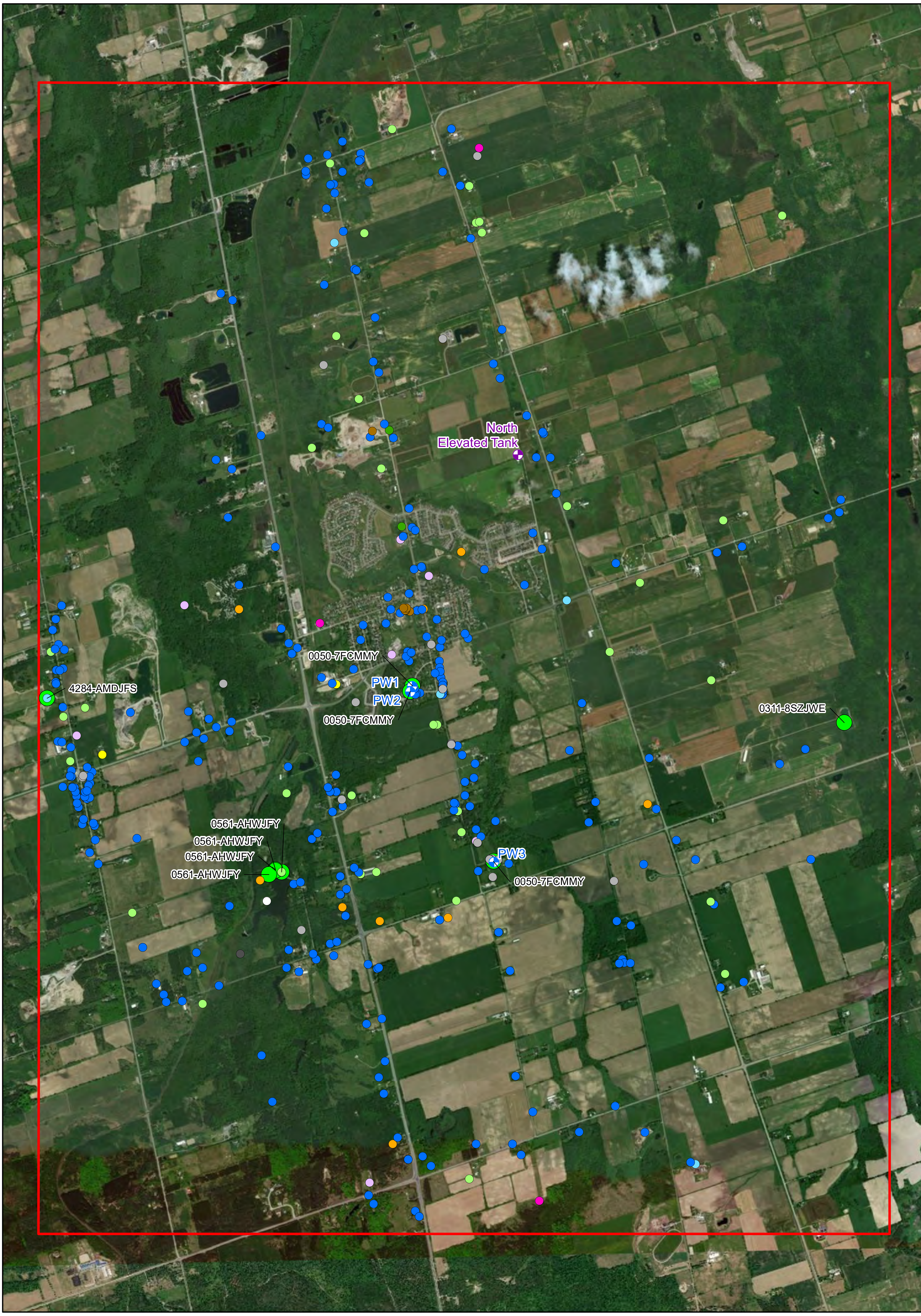
Municipal water usage in the Mt Albert wellfield is permitted at 4,990 cubic metres per day (m^3/d) (Table 5.2). Other permitted water usage through Permit To Take Water (PTTW) records for commercial, irrigation and industrial use totals 10,193 m^3/d across six active PTTW records (Table 5.3).

Table 5.2: Mount Albert Production Well Details

Well or System ID	MECP Well Record Number	Interpreted Screened Aquifer	Maximum Permitted Rate (m^3/d)	Average Daily Production Volume 2018 (m^3/d)	Average Daily Production Volume 2014 - 2018 (m^3/d)
Mount Albert PW1	6914352	TAC	3273.1	7.7	165.1
Mount Albert PW2	6922568	TAC	3273.1	467.5	345.6
Mount Albert PW3	-	TAC	3273.1	621.8	552.1
Mount Albert System	-		4990	1097.1	1062.7

Table 5.3: Active Groundwater Permit To Take Water Records

Permit Number	Purpose	Secondary Purpose	Maximum Permitted Rate (m^3/d)	Permit Issued	Permit Expiry
0311-8SZJWE	Agricultural	Field and Pasture Crops	3677.4	04/11/2012	03/31/2022
0561-AHWJFY	Commercial	Aquaculture	2880	02/17/2017	02/28/2022
0561-AHWJFY	Commercial	Aquaculture	1244.16	02/17/2017	02/28/2022
0561-AHWJFY	Commercial	Aquaculture	786.24	02/17/2017	02/28/2022
0561-AHWJFY	Commercial	Aquaculture	393.12	02/17/2017	02/28/2022
4284-AMDJFS	Industrial	Food Processing	1211.04	05/25/2017	06/01/2027



N

0 500
Metres

- Municipal Well
- North Elevated Tank

Water Well - Primary Use

- Commercial
- Domestic
- Industrial
- Irrigation
- Livestock
- Monitoring
- Monitoring and Test Hole
- Municipal
- Public
- Other
- Not Specified
- Not Used
- Permit to Take Water Record
- Study Area Boundary

Notes:
1. Image Source: Esri, DigitalGlobe, Earthstar Geographics

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Figure 5.1
MECP Well Records
Mount Albert Water Supply System Upgrades Class EA
Region of York
Mount Albert, Ontario

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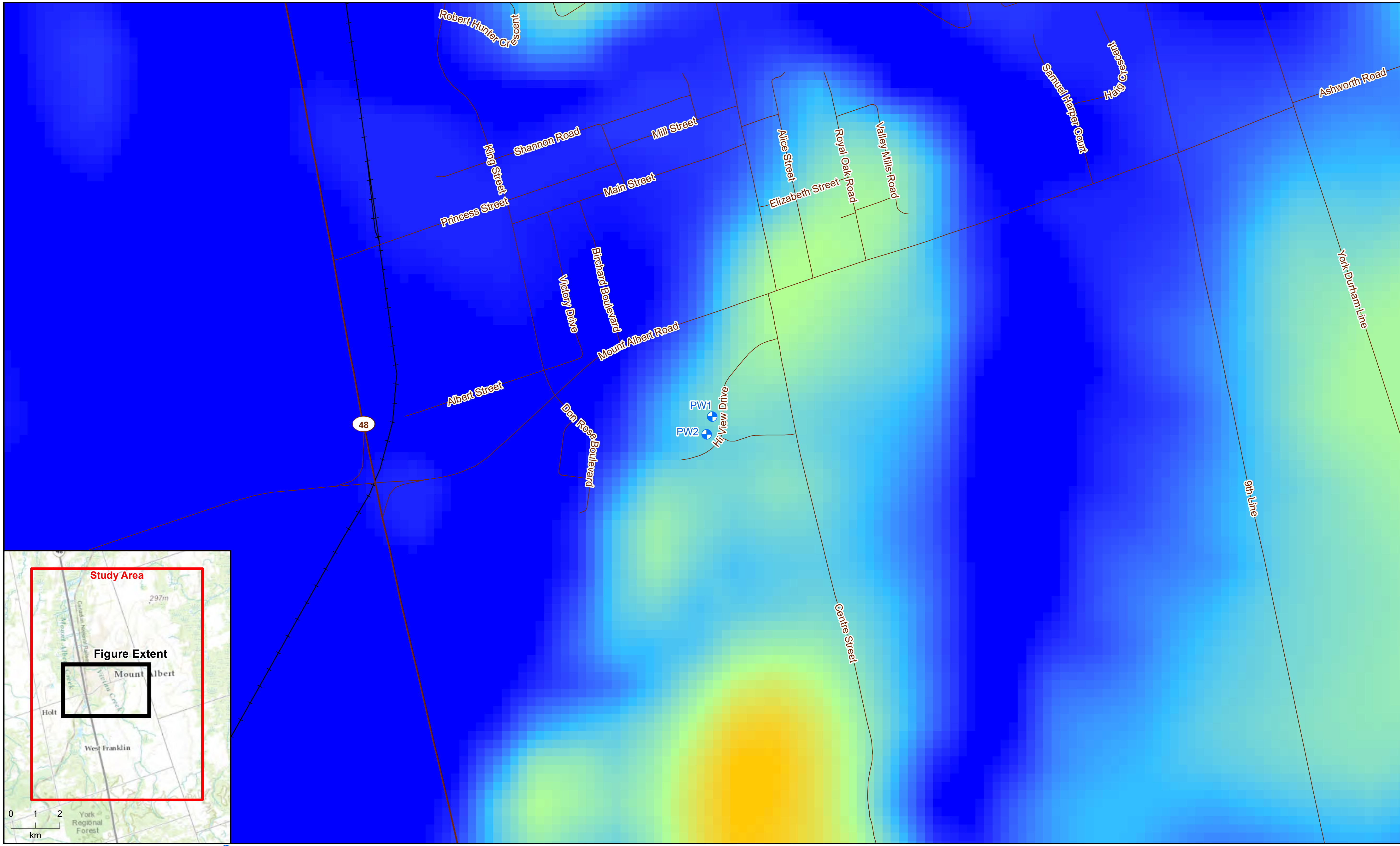
6. Preliminary Construction Dewatering Assessment

As a preliminary assessment of the potential for groundwater dewatering during construction excavation, an evaluation of depth to the water table data sourced from the Oak Ridges Moraine Groundwater Program (ORMGP) was completed at each of the facility areas. This preliminary assessment will be re-visited later in the project as part of the evaluation of alternatives.

Within the vicinity of municipal production wells PW1, PW2, and PW3, MW18, the depth to the water table is estimated to be between 12 and 14 metres bgs (Figure 6.1), and 7 and 10 metres bgs (Figure 6.2), respectively. Within the vicinity of the North Elevated Tank, the depth to the water table is estimated to be between <1 and 22 metres bgs (Figure 6.3).

Assuming an excavation depth of no more than 12 metres in the vicinity of wells PW1 and PW2, construction dewatering requirements are not anticipated to be significant. Groundwater elevations within the vicinity of wells PW3 and MW18 are anticipated to be higher than at PW1 and PW2, though construction dewatering requirements are not anticipated to be significant assuming an excavation depth of no more than 7 m. Due to the potential for shallow groundwater elevations within the vicinity of the North Elevated Tank, substantial construction dewatering volumes are anticipated assuming an excavation depth below 1 metre.

Prior to excavation at these sites, the installation of shallow monitoring wells screened across the water table should be included as part of geotechnical investigations to allow, in relation to construction designs, a detailed construction dewatering assessment and determination whether a permit to take water application is required, and the applicable permit category (Category 2 or 3).



N

0 100 200 300 400
Metres

Municipal Well
Highway
Road
Railway

Depth To Water Table (m)
37
30
20
10
1

DRAFT

Figure 6.1
Depth To Water Table - PW1/PW2 Area
Mount Albert Water Supply System Upgrades Class EA
Region of York
Mount Albert, Ontario

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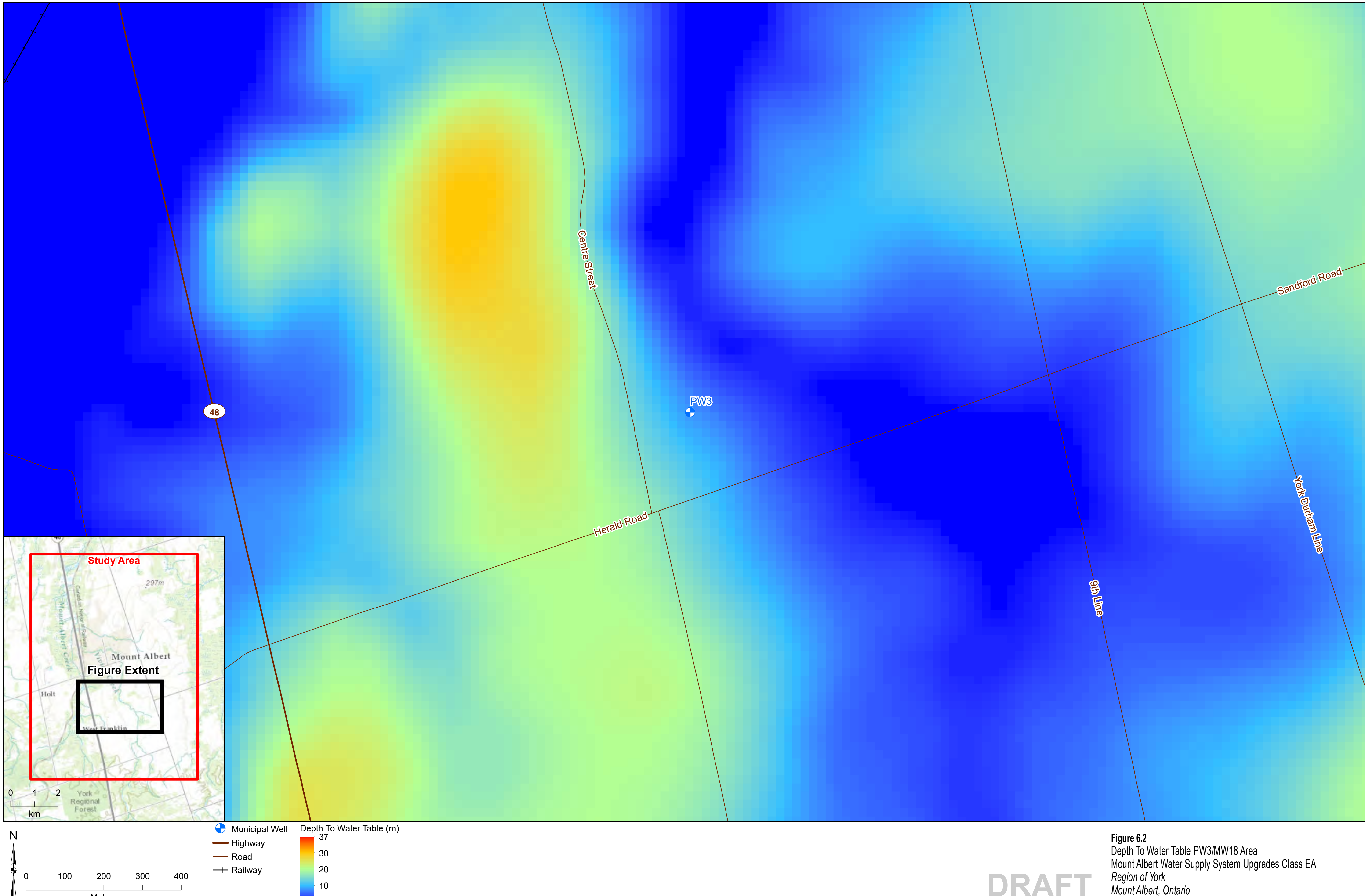

Figure 6.2
Depth To Water Table PW3/MW18 Area
Mount Albert Water Supply System Upgrades Class EA
Region of York
Mount Albert, Ontario

JACOBS

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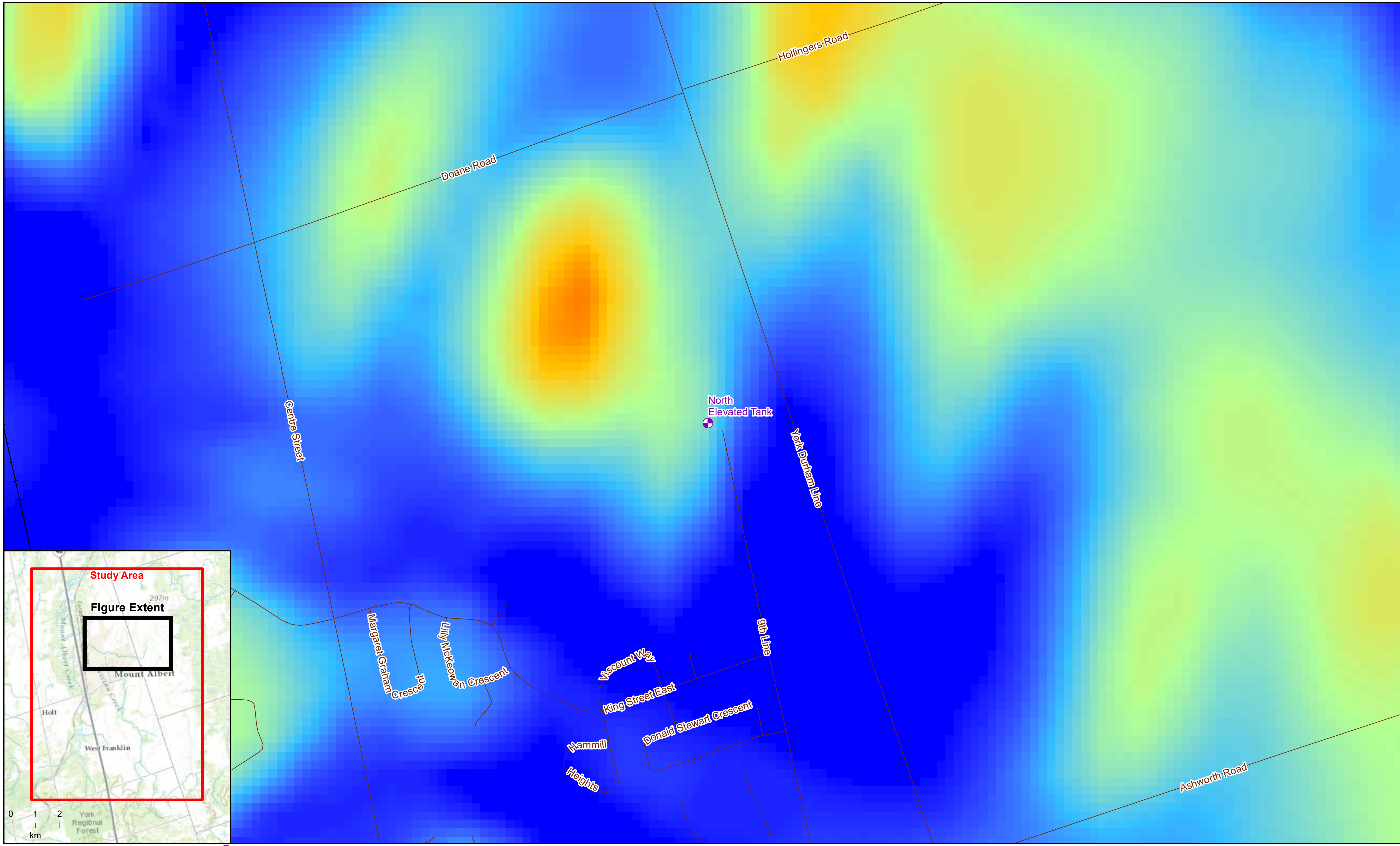

N

0 100 200 300 400
Metres

North Elevated Tank
Road
Railway

Depth To Water Table (m)
37
30
20
10
1

DRAFT

Figure 6.3
Depth To Water Table - North Elevated Tank Area
Mount Albert Water Supply System Upgrades Class EA
Region of York
Mount Albert, Ontario

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7. References

Barnett, P.J., W.R. Cowan, A.P. and Henry. 1991. Quaternary Geology of Ontario, Southern Sheet; Ontario Geological Survey, Map 2556, scale 1:1 000 000.

Chapman, L.J. and D.F. Putnam. 1984. The Physiography of Southern Ontario. Ontario Geological Survey Special Volume 2, 270 pp. Accompanied by Map P.2715 (coloured), scale 1:600,000.

Chapman, L.J. and D.F. Putnam, 2007. Physiography of Southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 228.

CH2M, 2017. York Region – Groundwater Treatment Strategy: Hydrogeology Summary.

Earthfx, 2013. Tier 3 Water Budget - Water Quantity Risk Level Assignment Study Regional Municipality of York Phase 1 Model Development Report.

Earthfx, 2014. Tier 3 Water Budget and Local Area Risk Assessment for the Region of York Municipal Systems, Risk Assessment Report.

Eyles, N. 2002. Ontario Rocks: Three Billion Years of Environmental Change. Fitzhenry and Whiteside, Markham, Ontario.

Ministry of Environment, Conservation and Parks (MECP). Map: Well records. [online]. Available at: https://www.ontario.ca/environment-and-energy/map-well-records.

Ontario Geological Survey (OGS). 2010. Surficial Geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release – Data 128 – Revised.

Ontario Geological Survey (OGS). 2011. 1:250,000 scale, Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release – Data 126 – Revision 1.

Sharpe, D.R. and Russell, H.A.J., 2013. A revised hydrostratigraphic framework model of Halton Till in the Greater Toronto Area, Ontario; Geological Survey of Canada, Current Research 2013-9, 27p. doi:10.4095/292098

York Region, 2019. Mount Albert Groundwater Exploration Study Preliminary Hydrogeological Assessment Report in Support of the Mount Albert Water Supply Class B Environmental Assessment.

Appendix D. Surface Water Study

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Memorandum

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Subject	**Surface Water Study**	**Project Name**	Mount Albert Water Supply System Upgrades
Attention	York Region	**Project No.**	CE731500
From	Jacobs		
Date	November 27, 2020		

1. Introduction

The Mount Albert community (located within the Town of East Gwillimbury) is supplied drinking water from wells owned and operated by the Regional Municipality of York (York Region). The Mount Albert drinking water system has historically experienced aesthetic water quality issues related to iron and manganese as a result of the presence of these constituents in the source water. The Region has engaged Jacobs to undertake a Schedule 'B' Class Environmental Assessment (EA) to identify the best approach to resolve customer complaints with current water quality, meet anticipated changes in manganese regulations and provide system redundancy and reliability (including optimization of system storage).

Alternative solutions to address the problem statement have been developed and are documented in Technical Memorandum No. 2 (TM-2). Several of these alternatives involve the implementation of iron and manganese removal technologies, which will generate residuals, such as filter backwash wastewater, that will need to be managed and disposed.

The purpose of this study is to document baseline information related to nearby natural receiving waters and to provide an initial assessment of potential surface water impacts from the management and disposal of residuals from the iron and manganese removal technology. This study does not address potential groundwater dewatering needs or impacts due to construction; these needs and impacts will be assessed during future design stages.

2. Overview of Facilities and Alternative Solutions

The Mount Albert Water Supply System has two water treatment facilities: Wells 1&2 Facility and Well 3 Facility. Both facilities currently treat groundwater using sodium silicate sequestration for iron and manganese control and chlorination for primary and secondary disinfection. Details of each facility are outlined in Table 2-1.

Table 2-1. Water Treatment Facility Overview

Parameter	Wells 1&2 Facility	Well 3 Facility
Municipal Address	20 Hi-View Drive, East Gwillimbury, ON	18371 Centre Street, Mount Albert, ON
Wells	Well 1: MTA PW 1 Well 2: MTA PW 2	Well 3: MTA PW 3
PTTW (per well)[1]	Well 1: 3,273 m^3/d (37.88 L/s) Well 2: 3,273 m^3/d (37.88 L/s)	3,273 m^3/d (37.88 L/s)
PTTW (system)[1]	PTTW maximum taking is 4,990 m^3/d (57.75 L/s) from any combination of the 3 wells in the system.	
Rated Capacity[2]	6,530 m^3/d (75.58 L/s)	3,280 m^3/d (38.00 L/s)
Well Pump Capacity[3]	Well 1: 3262 m^3/d (37.75 L/s) at 100 m TDH Well 2: 3262 m^3/d (37.75 L/s) at 100 m TDH	3,283 m^3/d (38.00 L/s) at 79 m TDH
Treatment Process	sequestration, disinfection (free chlorine)	sequestration, disinfection (free chlorine)
Chemicals Used	sodium silicate, sodium hypochlorite	sodium silicate, chlorine gas
Sanitary Connection	None	None
Surrounding Area[4]	Suburban Residential properties to the north and west of the site. Hi-View Drive to the east and south of the site.	Rural Surrounded by farmland
Nearby Surface Water Bodies	Vivian Creek	Vivian Creek

Notes:

1. Per Permit to Take Water 0147-AU2SBC, dated February 12, 2018.
2. Per Drinking Water License 013-103 Issue 04, dated September 12, 2017. Where a single rated capacity is listed for more than one well, it is the rated capacity for the facility as a whole.
3. Per Drinking Water Works Permit 013-203 Issue 04, dated September 12, 2017.
4. Based on satellite imagery from Google Maps.

Viable alternatives to improve water quality that were carried forward for further evaluation in TM-2 are summarized in Table 2-2.

Table 2-2 Summary of Short-Listed Alternative Solutions to Improve Water Quality

Alternative	Description
A4	Continue sequestration at both treatment facilities and optimize operation and maintenance of existing infrastructure
A5a	Provide centralized iron and manganese removal technology at Wells 1&2 Facility. Raw water from Well 3 is pumped to Wells 1&2 Facility for treatment. Wells 1&2 Facility is upgraded with iron and manganese removal technology.
A5b	Provide iron and removal technology at both Wells 1&2 Facility and Well 3 Facility.
A6	Provide Wells 1&2 Facility with iron and manganese removal technology and continue sequestration at Well 3 Facility
A7a	Take Well 1 out of service and replace the capacity with a new well (MW18) at Well 3 Facility. Continue sequestration at both treatment facilities.
A7b	Take Wells 1 and 2 out of service. Replace the capacity by re-rating Well 3 and installing a new well (MW18) at Well 3 Facility. Continue sequestration for all wells.
A7c	Take Well 1 out of service and replace the capacity with a new well (MW18) at Well 3 Facility. Provide iron and manganese removal technology for Well 2 at Wells 1&2 Facility.

Alternatives A5a, A5b, A6, and A7c incorporate iron and manganese removal technology. For the purpose of the Class EA study, the removal technology considered was adsorptive filtration using a continuously regenerated adsorptive media for removal and chlorine as oxidant. As a result, iron and manganese particles accumulate in the filters over time, and the filters need to be periodically backwashed with water to remove the accumulated particles. This generates a residual backwash wastewater stream that needs to be managed and disposed.

An analysis of residual management alternatives was undertaken and is documented in TM-2. The options considered viable for implementation in the Mount Albert Water Supply System are summarized in Table 2-3, and the sections that follow document the calculation of backwash wastewater quality and quantity generated by each alternative to enable an estimation of the potential impact on surface water through disposal and potential impact on Mount Albert Water Resource Recovery Facility (WRRF).

Table 2-3 Summary of Short-Listed Alternative Solutions to Residual Management for Alternatives with Iron and Manganese Removal Technology

Alternative	Description
R1	Direct connection to local sanitary sewer collection system The backwash wastewater is directed to an equalization tank, pumped to the wastewater collection system, and treated at the Mount Albert WRRF. This would require the installation of a forcemain from the well facilities to the nearest point in the wastewater collection system.
R2	On-site treatment with supernatant discharged to Vivian Creek and sludge discharged to the wastewater collection system An on-site treatment system would be installed to treat the backwash wastewater to a quality that would allow it to be discharged to the environment. Such a system would, at a minimum, incorporate a settling tank to settle out particulate iron and manganese. The sludge generated is pumped to the sanitary sewer collection system and treated at the Mount Albert WRRF. This would require the installation of a forcemain from the well facilities to the nearest point in the sanitary sewer collection system and a forcemain from the well facilities to the stormwater system or directly to Vivian Creek.
R3	On-site treatment with supernatant discharged to Vivian Creek and sludge hauled off-site. An on-site treatment system would be installed to treat the backwash wastewater to a quality that would allow it to be discharged to the environment. Such a system would, at a minimum, incorporate a settling tank to settle out particulate iron and manganese. The sludge is then pumped to tanker trucks and hauled to the Duffin Creek Water Pollution Control Plant (WPCP) for further treatment and disposal. This would require the installation of a forcemain from the well facilities to the stormwater system or directly to Vivian Creek.

Figure 2-1 illustrates conceptual discharge points for Alternatives R2 and R3 and conceptual forcemain routes for sludge from Alternative R2.

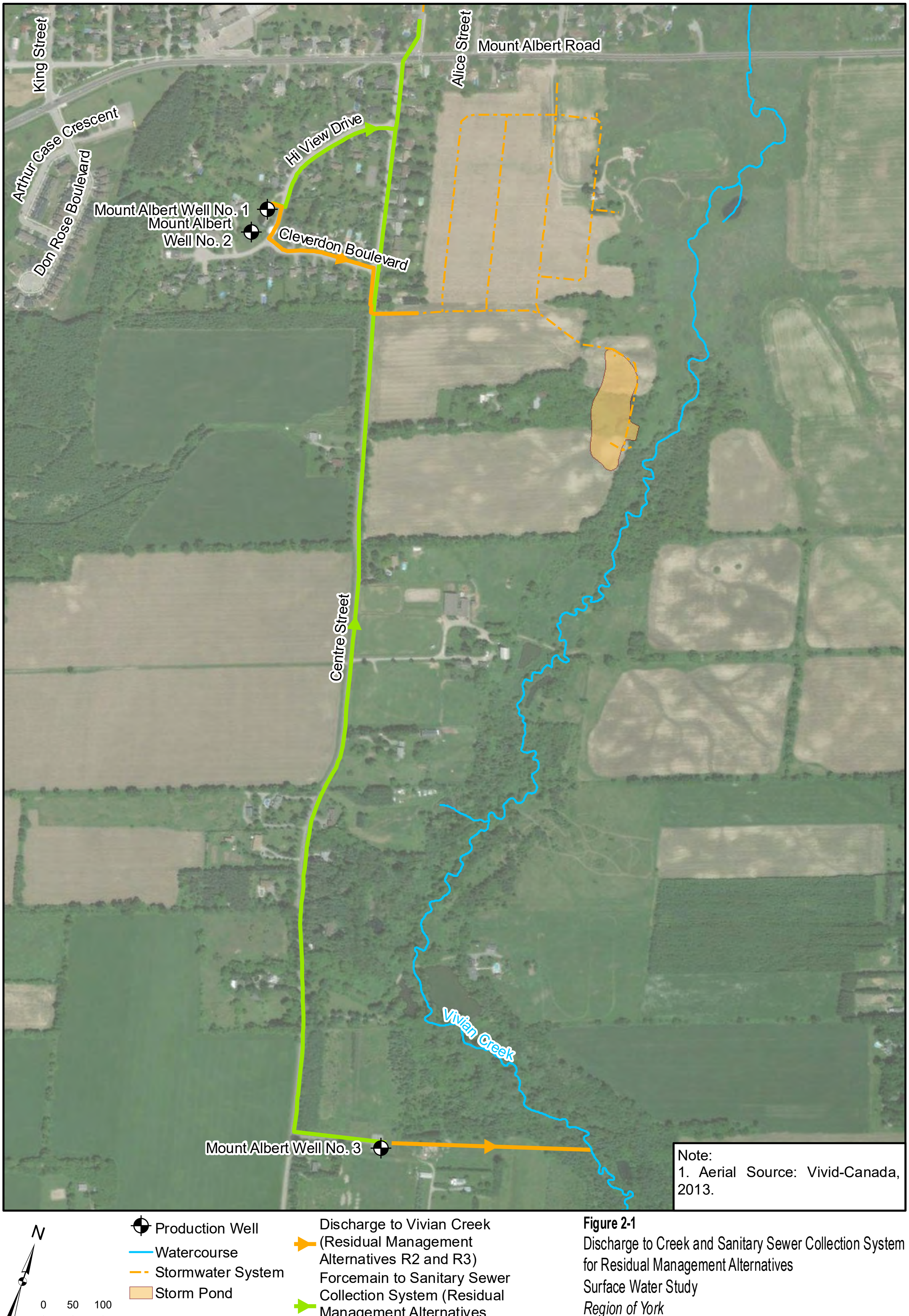


Figure 2-1
Discharge to Creek and Sanitary Sewer Collection System for Residual Management Alternatives
Surface Water Study
Region of York
Mount Albert, Ontario

Jacobs

\\DC1VS01\GISPROJ\Y\YORKREGION\MOUNTALBERTWATERSUPPLY\MAPFILES\SURFACEWATERSTUDY\DISCHARGE_CREEK_SEWERCOLLECTIONSYSTEM_RESIDUALMANAGEMENTALTS_85X11.MXD VM048279 10/23/2020 5:53:35 PM

3. Backwash Wastewater Characteristics

3.1 Quantity

The filter backwash wastewater quality for this assessment was developed based on backwashing once per 24-hour period for filters in operation. The filter area that will be needed and that will be backwashed is dependent on each facility's design capacity. Table 3-1 summarizes the design capacity, design basis, filter area, and projected backwash volume for each facility and alternative solution. The removal technology will be piloted by the Region, which will confirm the backwash characteristics and inform the type of on-site treatment required.

Table 3-1 Design Basis and Backwash Wastewater Quantity

Design Parameter	Wells 1&2 Facility (Alternatives A5a, A5b, A6)	Wells 1&2 Facility (Alternative A7c) Well 3 Facility (Alternative A5b)
Design Capacity (m^3/d) [1]	4,990[2]	3,273[3]
Design Capacity (L/s)	57.75	37.88
Hydraulic Loading Rate During Production (m/h)	18	18
Operational Filter Area (m^2)	11.8	9.4
Backwash Wastewater Volume per Facility Based on All Operational Filters Being Backwashed (m^3/d)	80	65

Notes:

1. Design capacity is the maximum water taking from the PTTW.
2. In Alternative A5a, water from Wells 1, 2, and 3 is treated at Wells 1&2 Facility. In Alternatives A5b and A6, water from Wells 1 and 2 is treated at Well 1&2 Facility.
3. In Alternative A7c, water from Well 2 is treated at Wells 1&2 Facility. In Alternatives A5b, water from Wells 1 and 2 is treated at Well 1&2 Facility.

3.2 Quality

The filters at each facility will be backwashed using treated water from the facility. It is also anticipated that the particulate matter in the backwash wastewater will primarily be particulate iron and manganese removed during filtration. Therefore, the backwash wastewater is anticipated to have a similar water quality to the treated water quality from that facility, albeit with higher iron and manganese concentrations. The approaches used to estimate the concentration of various water quality parameters are summarized in the subsections below.

Iron and Manganese Concentrations

Iron and manganese concentrations in backwash wastewater depend on the mass of iron and manganese removed from the raw water by the filters, and then subsequently backwashed out of the filters. Each well has a different raw water iron and manganese concentration, as shown in Table 3-2.

Table 3-2 Historical Raw Water Iron and Manganese Concentrations in Mount Albert Wells (2014-2018)

Parameter	Well 1		Well 2		Well 3	
	Average	Range	Average	Range	Average	Range
Iron, total, mg/L	0.89	0.67 - 1.11	0.6	0.44 - 0.89	0.192	0.067 - 0.522
Manganese, total, mg/L	0.104	0.081 - 0.120	0.059	0.048 - 0.068	0.048	0.040 - 0.056

Depending on which wells are used and the amount of iron and manganese removed by the filters, the concentration of iron and manganese in the backwash wastewater will differ. To assess potential water quality impacts, the assessment was based on the following:

- The amount of water treated for all facilities is the maximum 4,990 m^3/d allowed by the PTTW.
- The facilities are operated for 24 hours before backwashing.
- All iron and manganese present in the raw water are removed during filtration, and this entire mass is washed out of the filter with the backwash wastewater.
- The well with the highest iron and manganese concentration at a given facility is used at its maximum capacity. The remaining flows are provided by the well or wells with the next highest iron and manganese concentrations. This will result in a conservative estimate of the backwash wastewater iron and manganese concentrations.
- Only the operational filters are backwashed (i.e., standby filters are not backwashed).
- The historical raw water iron and manganese concentrations from a given well will be used to estimate the amount of iron and manganese removed.

Iron and manganese concentrations and the total mass of iron and manganese present in the backwash wastewater for each 24-hour period were estimated for three different operational scenarios.

Table 3-3 Operational Scenarios for Which Backwash Wastewater Concentrations were Calculated

Scenario	Description	Water Supplied from Each Well	Backwash Volume	Applicable to Alternatives
Scenario 1	Wells 1 and 2 supply all treated water to the system. Wells 1 and 2 treated using iron and manganese removal technology. All filters at Wells 1 & 2 Facility are in operation and backwashed. Well 3 and Well 3 Facility are not in operation.	*Well 1& 2 Facility:* Well 1: 3,262 m^3/d Well 2: 1,728 m^3/d *Well 3 Facility:* Well 3: 0 m^3/d	Well 1&2 Facility: 80 m^3 Well 3 Facility: 0 m^3	A5a, A5b, and A6
Scenario 2	Well 3 is operated at maximum capacity supplies treated water to the system. Well 1 provides the remaining treated water to the system. Iron and manganese removal technology is used at all well facilities. All filters at Well 3 Facility are in operation and backwashed. A third of the filters are operational and backwashed at Well 1&2 Facility.	*Well 1&2 Facility:* Well 1: 1,717 m^3/d Well 2: 0 m^3/d *Well 3 Facility:* Well 3: 3,273 m^3/d	Well 1&2 Facility: 30 m^3 Well 3 Facility: 65 m^3	A5b
Scenario 3	Well 2 is operated at maximum capacity supplies treated water to the system using iron and manganese removal technology. Sequestration is practiced at Well 3 and/or Well MW18 for the remaining treated water supply. All filters at Well 1&2 Facility are operational and backwashed.	*Well 1&2 Facility:* Well 1: Decommissioned Well 2: 3,262 m^3/d *Well 3 Facility:* Well 3, MW 18, or a combination of the two: 1,728 m^3/d	Well 1&2 Facility: 80 m^3 Well 3 Facility: 0 m^3	A7c

The concentration of iron and manganese in the backwash wastewater for each facility, for each scenario, was calculated using the following equations:

$$C_{rw} = \frac{C_1 \times Q_1 + C_2 \times Q_2 + C_3 \times Q_3}{Q_1 + Q_2 + Q_3}$$

$$Q_{fac} = Q_1 + Q_2 + Q_3$$

$$M_{rem} = C_{rw} \times Q_{fac} \times 24\ hours$$

$$C_{bww} = \frac{M_{rem}}{V_{bw}}$$

Where C_{rw} is the concentration in the combined raw water at a given facility; C_1, C_2, and C_3 are the raw water concentrations from Wells 1, 2, and 3, respectively; Q_1, Q_2, and Q_3 are the flow rates to the facility from Wells 1, 2, and 3 respectively; Q_{fac} is the total flow rate treated by the facility; M_{rem} is the mass of iron or manganese removed by the facility over a 24-hour period; C_{bww} is the concentration of iron or manganese in the backwash wastewater; and V_{bw} is the volume of backwash wastewater used.

Total Suspended Solids

The total suspended solids concentration in the backwash wastewater was estimated from the iron and manganese concentrations. For the purposes of calculating an approximate TSS concentration, the following was assumed:

- All iron and manganese in the backwash wastewater are in the particulate form.
- The total suspended solids (TSS) present in the backwash wastewater is primarily particulate iron and manganese removed from the filter.
- Particulate iron is in the form of $Fe(OH)_3$.
- Particulate manganese is in the form of MnO_2.

The TSS concentration, therefore, was calculated using the following equations:

$$TSS_{Fe} = \frac{C_{Fe,bww} \times MW_{Fe(OH)3}}{MW_{Fe}}$$

$$TSS_{Mn} = \frac{C_{Mn,bww} \times MW_{MnO2}}{MW_{Mn}}$$

$$TSS = TSS_{Fe} + TSS_{Mn}$$

Where TSS_{Fe} is the TSS from particulate iron; $C_{Fe,sbw}$ is the concentration of iron in the backwash wastewater (in mg/L-Fe), MW_{Fe} is the molecular weight of iron, $MW_{Fe(OH)3}$ is the molecular weight of $Fe(OH)_3$, TSS_{Mn} is the TSS from particulate manganese, $C_{Mn,sbw}$ is the concentration of manganese in the backwash wastewater (in mg/L-Mn), MW_{Mn} is the molecular weight of manganese, MW_{MnO2} is the molecular weight of MnO, and TSS is the total TSS concentration.

Chlorine Concentrations

The average treated water chlorine concentrations for the well facilities have historically been 1.5 to 1.6 mg/L. Concentrations have ranged from 0.5 to 3.63 mg/L at Wells 1&2 Facility and from 0.76 to 4.3 mg/L at Well 3 Facility (see Table 4.5, Technical Memorandum No. 1). Similar average chlorine residual of 1.6 mg/L will be targeted and present in the backwash wastewater. Instantaneous chlorine concentrations may range from 0.5 to 4.3 mg/L based on historical data.

Temperature

The temperature of the backwash wastewater is expected to be similar to the groundwater temperature and assumed to be between 7-10°C.

Other Water Quality Parameters

It is anticipated that the treatment processes will have minimal impact on most other water quality parameters. Therefore, the raw water quality for each well was used as the primary basis for estimating the anticipated treated and backwash wastewater quality parameters, with the exception of sodium for Wells 1 and 2 and pH for all wells, given that these parameters can be affected by the disinfection process used. The historical treated water quality for each facility was used as the basis for sodium concentrations at Wells 1 and 2 and as the basis for pH concentrations. Table 3-4 summarizes the historical raw water quality for each well for major water quality parameters. Unionized ammonia concentrations were estimated based on a water temperature of 10°C and the measured pH of the water. Table 3-5 summarized the historical treated water sodium and pH concentrations for each facility.

Table 3-4 Historical Raw Water Quality Parameters in Mount Albert Wells (2014-2018, unless otherwise noted)

Parameter	Well 1		Well 2		Well 3	
	Average[1]	Range	Average[1]	Range	Average[1]	Range
Alkalinity, mg/L as $CaCO_3$	242	233 - 254	229	225 - 235	238	231 - 248
Total Ammonia Ammonium and Ammonia (TAN), mg/L as N[2]	0.28	0.09 - 0.38	0.17	<0.05 -- 0.25	0.05	0.03 - 0.09
Unionized Ammonia, mg/L as N[3]	0.004	0.001-0.009	0.003	<0.001-0.007	0.001	0.000-0.002
Calcium, mg/L	84.8	57.0 - 100.0	73.5	46.4 - 85.0	96.6	94.9 - 99.8
Chloride, mg/L	29.3	20.6 - 41.2	13.8	8.2 - 21.5	27.5	26.0 - 31.4
Dissolved Organic Carbon, mg/L	0.78	0.48 -1.18	0.72	0.46 - 1.16	0.8	0.5 - 1.0
Hardness, mg/L as $CaCO_3$	292	192 - 345	259	162 - 299	338	330 - 349
Iron, total, mg/L	0.89	0.67 - 1.11	0.6	0.44 - 0.89	0.192	0.067 - 0.522
Magnesium, mg/L	19.1	11.9 - 22.9	18.3	11.1 - 21.1	23.6	22.7 - 24.3
Manganese, total, mg/L	0.104	0.081 - 0.120	0.059	0.048 - 0.068	0.048	0.040 - 0.056
Methane[4], L/m^3	0.015	0.01 - 0.026	0.018	0.011 - 0.052	0.058	0.050 - 0.071
Nitrate, mg/L as N	<0.005	<0.005	<0.005	<0.005	4.83	4.31 - 5.96
Nitrite, mg/L as N[5]	0.038	<0.008 - <0.25	0.038	<0.008 - <0.25	0.077	0.049 - <0.25
pH	7.94	7.8 - 8.1	8.02	7.8 - 8.2	7.9	7.7 - 8.1
Phosphate, mg/L[6]	0.028	<0.005 - 0.090	0.026	<0.01 - 0.060	<0.02	<0.005 - <0.02
Sodium, mg/L	8.1	5.8 - 10.1	4.4	3.8 - 6.0	10.3	9.1 - 11.3
Sulfate, mg/L	39.9	23.4 - 61.6	30.7	19.8 - 36.1	57	37.3 - 62.1
Sulfide, mg/L as H_2S[7]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Notes:

1. Where some of the measured values were reported as less than the Method Detection Limit (MDL), the average was calculated by assigning half the MDL to those values. If all measured values were less than MDL or if the average was less than the MDL, the average is indicated as being less than the MDL.

2. The data reported for ammonia for 2016 to 2018 for Wells 1 and 2 had a single value of 0.2 mg/L with a Reportable Detection Limit (RDL) of <1.25 mg/L. The data reported for ammonia for 2016 to 2018 for Well 3 ranged from a MDL of <0.1 to a RDL of <1.25 mg/L. This unusually high RDL of 1.25 mg/L would skew the results if used as described in Note 1, and therefore, the historical values for 2010 to 2015 are presented for this parameter.
3. Unionized ammonia concentrations were calculated for the average, minimum, and maximum ammonia concentrations using the calculation from Emerson et al. (1975), as noted in MECP (2019). The unionized ammonia concentrations were calculated assuming the average, minimum, or maximum pH values, respectively, and a water temperature of 10°C.
4. Methane results from two sampling events conducted between 2002 and 2018.
5. The Nitrite concentrations were determined as described in Note 1, including the values reported as the MDL of <0.25 mg/L.
6. The data reported for phosphate for 2016 to 2018 for Wells 1, 2 and 3 from the MDL of <0.01 to RDL of <2.5 mg/L. The unusually high RDL of 2.5 mg/L would skew the results if used as described in Note 1, and therefore, the historical values for 2010 to 2015 are presented for this parameter using the method described in Note 1 for values reported as less than the MDL for this time period.
7. Sulfide results from six sampling events conducted between 2001 and 2019.

Table 3-5 Historical Treated Water Quality Parameters in Mount Albert Wells (2014-2018, unless otherwise noted)

Parameter	Wells 1&2 Facility		Well 3 Facility	
	Average	Range	Average	Range
Sodium, mg/L	11.4	8.5 - 16.0	8.9	6.3 - 11.1
pH	8.1	7.9 - 8.3	7.8	7.6 - 8.1

The water data provided in the tables above was used with the following equation to calculate the concentration in the backwash wastewater for each facility:

$$C = \frac{C_1 \times Q_1 + C_2 \times Q_2 + C_3 \times Q_3}{Q_1 + Q_2 + Q_3}$$

Where C is the concentration of the parameter in the water of a given facility; C_1, C_2, and C_3 are the raw water concentrations from Wells 1,2, and 3 respectively; Q_1, Q_2, and Q_3 are the flow rates to the facility from Wells 1, 2, and 3 respectively.

In situations where the raw water concentration was less than the method detection limit for the parameter, a raw water concentration of half the detection limit was used to calculate the backwash wastewater concentration. If the calculated value was less than the method detection limit for the parameter, the backwash wastewater concentration was reported as less than the method detection limit.

Carbonaceous Biological Oxygen Demand

Information on the carbonaceous biological oxygen demand (cBOD) of the raw water from Mount Albert Wells 1 to 3 is not available. In order to estimate the potential cBOD, the oxygen demand of the backwash wastewater was calculated as the amount of oxygen required to full oxidize the DOC in the backwash wastewater to CO_2. This is a conservative approach given that the calculation provides the ultimate theoretical cBOD rather than the commonly used 5-day cBOD, some of the DOC would be oxidized during chlorination, and a fraction of the DOC may not be biodegradable.

3.3 Summary of Backwash Wastewater Characteristics

The resulting backwash wastewater quality for each operating scenario outlined in Table 3-3 has been estimated based on these assumptions and is summarized in Table 3-6. Table 3-7 provides the associated daily mass generation rates of six key parameters to be applied in the surface water assessment.

Table 3-6 Backwash Wastewater Quality

Parameter	Scenario 1		Scenario 2				Scenario 3	
	Well 1& 2 Facility		Well 1& 2 Facility		Well 3 Facility		Well 1& 2 Facility	
	Average	Range	Average	Range	Average	Range	Average	Range
Alkalinity, mg/L as $CaCO_3$	237	230 - 247	242	233 - 254	238	231 - 248	229	225 - 235
Carbonaceous Biological Oxygen Demand, mg/L O_2	2.0	1.3 - 3.1	2.1	1.3 - 3.1	2.1	1.3 - 2.7	1.9	1.2 - 3.1
Total Ammonia Ammonium and Ammonia, mg/L as N	0.24	0.07 - 0.29	0.28	0.09 - 0.38	0.05	0.03 - 0.09	0.17	<0.05 - 0.25
Unionized Ammonia, mg/L as N	0.004	0.001 - 0.007	0.004	0.001 - 0.009	0.001	0.000 - 0.002	0.003	<0.001 - 0.004
Calcium, mg/L	81	53 - 95	85	57 - 100	97	95 - 100	74	46 - 85
Chloride, mg/L	24	16 - 34	29	21 - 41	28	26 - 31	14	8 - 22
Chlorine, mg/L Cl_2	Typical: 1.6 mg/L Maximum: 4.3 mg/L							
Dissolved Organic Carbon, mg/L	0.8	0.5 - 1.2	0.8	0.5 - 1.2	0.8	0.5 - 1.0	0.7	0.5 - 1.2
Hardness, mg/L as CaCO3	281	182 - 329	292	192 - 345	338	330 - 349	259	162 - 299
Iron, mg/L	50	37 - 66	50	37 - 66	10	3 - 27	25	18 - 37
Magnesium, mg/L	19	12 - 22	19	12 - 23	24	23 - 24	18	11 - 21
Manganese	5.6	4.4 - 6.9	5.6	4.4 - 6.9	1.3	1.1 - 1.5	2.4	2.0 - 2.8
Methane, L/m^3	0.016	0.010 - 0.035	0.043	0.010 - 0.026	0.058	0.05 - 0.071	0.018	0.011 - 0.052
Nitrate, mg/L as N	<0.005	<0.005	<0.005	<0.005	4.80	4.31 - 5.96	<0.005	<0.005
Nitrite, mg/L as N	0.038	<0.008 - <0.25	0.038	<0.008 - <0.25	0.077	0.049 - 0.125	0.038	<0.008 - <0.25
pH	8.1	7.9 - 8.3	8.1	7.9 - 8.3	7.8	7.6 - 8.1	8.0	7.8 - 8.2

Parameter	Scenario 1		Scenario 2				Scenario 3	
	Well 1& 2 Facility		Well 1& 2 Facility		Well 3 Facility		Well 1& 2 Facility	
	Average	Range	Average	Range	Average	Range	Average	Range
Phosphate, mg/L-P	0.027	<0.010 - 0.080	0.028	<0.010 - 0.090	<0.02	<0.005 - <0.020	0.026	<0.010 - 0.060
Sodium, mg/L	11.4	8.5 - 16.0	11.4	8.5 - 16.0	10.3	9.1 - 11.3	11.4	8.5 - 16.0
Sulfate, mg/L	37	22 - 53	40	23 - 62	57	37 - 62	31	20 - 36
Sulfide, mg/L as H2S	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total Suspended Solids, mg/L	105	80 - 136	82	80 - 136	23	10 - 57	52	38 - 75
Temperature, °C	7-10							

Table 3-7 Mass Generation Rate of Key Water Quality Parameters in Backwash Wastewater

Parameter	Mass Produced						
	Scenario 1		Scenario 2			Scenario 3	
	Wells 1&2 Facility	Well 3 Facility	Wells 1&2 Facility	Well 3 Facility	Total[1] (all facilities)	Wells 1&2 Facility	Well 3 Facility
Iron (kg/d-Fe)	3.9	0	1.5	0.6	2.2	2.0	0
Manganese (kg/d-Mn)	0.44	0	0.18	0.08	0.34	0.19	0
cBOD (kg/d-O_2)	0.16	0	0.08	0.13	0.22	0.15	0
TSS (kg/d)	8.2	0	3.2	1.4	4.7	4.0	0
Total Ammonia (kg/d-N)	0.019	0	0.011	0.003	0.014	0.013	0
Phosphate (kg/d-P)	0.0021	0	0.0011	0.0006	0.0017	0.0020	0

3.4 Potential Impact of Disposal of Residual Management Alternatives

Table 3-8 provides the anticipated characteristics of the discharge for each residual management alternative, considering the worst-case operating scenario (Scenario 1).

For Alternative R1, the backwash wastewater is discharged directly to the sanitary sewer collection system to be treated at the Mount Albert WRRF. The backwash wastewater is treated on-site by gravity settling tank for Alternatives R2 and R3. It is considered the gravity settling tank can typically achieve 90% removal of suspended solids along with iron and manganese, which are in particulate form. The other constituents are mainly in dissolved form and are not removed by the on-site treatment.

Table 3-8 Anticipated Supernatant Disposal Characteristics for each Residual Management Alternatives for Scenario 1

Parameter	Unit	Alternative R1	Alternative R2[1]		Alternative R3[1]	
		Backwash Wastewater Discharge to Mount Albert WRRF	Supernatant Discharge to Vivian Creek	Sludge Discharge to Mount Albert WRRF	Supernatant Discharge to Vivian Creek	Sludge Haulage to Duffin Creek WPCP
Flow	m^3/d	80	72	8	72	8
Iron	kg/d-Fe	3.9	0.4	3.5	0.4	3.5
	mg/L	50	4.9	440	4.9	440
Manganese	kg/d-Mn	0.44	0.04	0.4	0.04	0.4
	mg/L	5.6	0.55	49.5	0.55	49.5
cBOD	kg/d-O_2	0.16	0.144	0.016	0.144	0.016
	mg/L	2.0	2.0	2.0	2.0	2.0
TSS	kg/d	8.2	0.8	7.4	0.8	7.4
	mg/L	105	10.3	923	10.3	923
Total Ammonia	kg/d-N	0.019	0.0017	0.0002	0.0017	0.0002
	mg/L	0.24	0.24	0.24	0.24	0.24
Phosphate	kg/d-P	0.0021	0.0019	0.0002	0.0019	0.0002
	mg/L	0.027	0.027	0.027	0.027	0.027

Notes:

1. Considering 10% of the backwash wastewater is the solid stream from the settling process (sludge), per AWWA Iron and Manganese Removal Handbook.

4. Assessment of Natural Receiving Waters

4.1 Overview

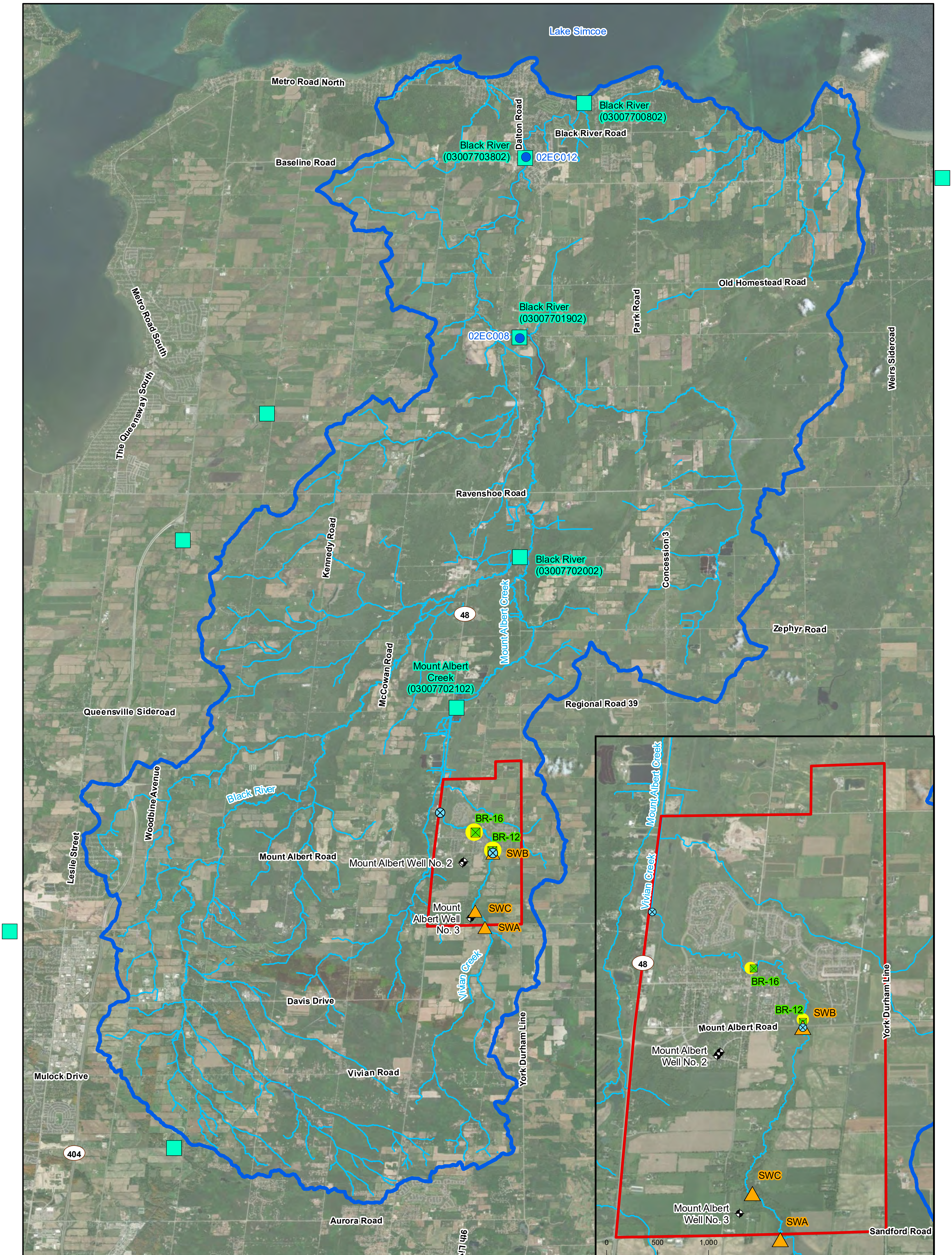
Vivian Creek is a tributary to Mount Albert Creek and Black River and generally flows in a north and westerly direction from south of the Study Area until it discharges into Mount Albert Creek near the intersection of Highway 48and Queensville Sideroad.

Vivian Creek is situated in the Lake Simcoe Watershed and the Black River subwatershed. Figure 4-1 shows the study area in the subwatershed and major features. Upstream and downstream of the section of Vivian Creek adjacent to Wells 1&2 Facility and Well 3 Facility, the creek is considered to be a cool water habitat based on the thermal regime and the fish community (LSCRA, 2010). Fish species found in waterbody include Brook Trout, Largemouth Bass, Pumpkinseed, Rock Bass, White Sucker, Northern Redbelly Dace, Fathead Minnow, Eastern Blacknose Dace, Longnose Dace, Creek Chub, Central Mudminnow, Mottled Sculpin, Brook Stickleback, and Johnny Darter. None of these species are endangered, threatened, or special concern per O. Reg. 230/08: Species at Risk in Ontario List. Reaches upstream and downstream of this section were also scored as being in a transitional state or state of adjustment based on rapid geomorphic assessments (c.f. LSRCA, 2010). Preliminary assessment of benthic macroinvertebrate data from 2011 to 2018 indicates the water quality at Vivian Creek ranges from Excellent to Fair.

4.2 Data Sources

The following data sources were reviewed for information on the natural receiving waters.

- General
  - Black River Subwatershed Plan (LSRCA, 2010)
  - LSRCA Subwatershed map (LSRCA, 2017)
  - Capacity Assessment of the Mount Albert WRRF (Blue Sky Energy Engineering & Consulting Inc. (2018)
  - Fish Data from 2003 to 2018 and Benthic Invertebrate Tallies Data from 2011 to 2018 at Monitoring Station BR-12 (LSRCA) – **Appendix A**
- Water Quantity
  - Environment Canada Real-Time and Historical Hydrometric Data (Environment Canada 2020a, 2020b)
  - Streamflow data for Vivian Creek collected by York Region from November 2018 to May 2019
- Water Quality
  - Ontario Provincial Water Quality Network Map (MECP, 2020a)
  - Data from Ontario Provincial Water Quality Network Data, Mount Albert Creek, Station 03007702102 (MECP, 2019b-2019o; 2020a-2020b)
  - Water Quality data for Vivian Creek collected by York Region from November 2018 to May 2109



N

0 500 1,000
Metres

- Production Well
- Stream Gauge Station
- Water Temperature Monitoring Site
- Provincial Stream Water Quality Monitoring Station
- Region of York Water Quality and Flow Monitoring Location (Approximate)
- Benthic Invertebrate Sampling Location
- Fish Sampling Location
- Watercourse
- Black River Watershed Boundary
- Study Area

Note:
1. Aerial Source: Vivid-Canada, 2013.
2. Stream Gauge Stations data is from Environment Canada.
3. Water Temperature Monitoring Sites, Benthic Invertebrate Sampling Locations and Fish Sampling Locations data is from Lake Simcoe Region Conservation Authority.
4. Provincial Stream Water Quality Monitoring Stations, Black River Watershed Boundary and Watercourses data is from Land Information Ontario.

Figure 4-1
Overview of Subwatershed and Major Features
Surface Water Study
Region of York
Mount Albert, Ontario

Jacobs

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4.3 Water Quantity

No permanent Environment Canada or LSRCA stream gauges are present on sections of Vivian Creek near Mount Albert Wells 1&2 or Well 3 facilities. There is one active and one discontinued Environment Canada stream gauge station in the Black River watershed downstream of Vivian Creek: Black River at Baldwin (Station 02EC008) and Black River at Sutton (Station 02EC012); however, both of these gauge stations are downstream from a dam and are significantly downstream of Mount Albert and the Study Area. The closest LSRCA gauge station to Vivian Creek is on Mount Albert Creek and does not include flows from Vivian Creek. There is one water quantity monitoring station near Vivian Creek, on Mount Albert Creek downstream of the confluence of Mount Albert Creek and Vivian Creek.

A limited amount of stream flow information was collected by York Region from November 2018 to May 2019 from three monitoring locations as part of a groundwater exploration study. It should be noted these SWA and SWB monitoring stations are still active and continue recording the surface water levels, but the raw data has not yet been analyzed. Figure 4-1 shows the location of these monitoring stations in relation to Well 1&2 Facility and Well 3 Facility, and Figure 4-2 shows the measured stream flows at each location. Summary statistics for the flows are presented in Table 4-1.

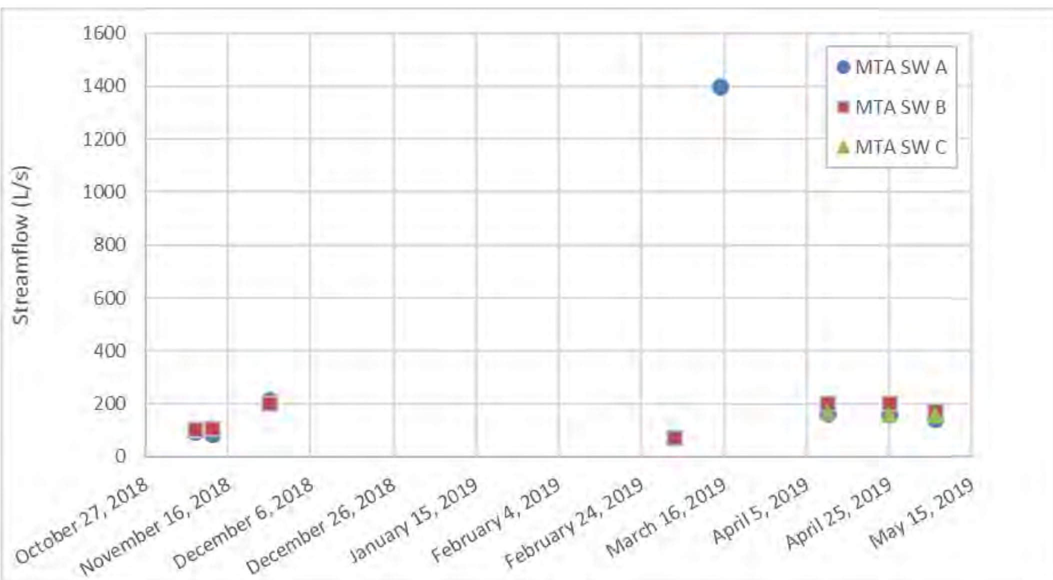

Figure 4-2 Streamflow Monitoring Data for Vivian Creek (York Region)

Table 4-1 Summary Statistics for Streamflow Monitoring Data from York Region

Summary Statistic	Location		
	MTA SW A	MTA-SW-B	MTA-SW-C
Median (L/s)	160	170	160
Minimum (L/s)	85	74	150
Maximum (L/s)	1400[1]	200	170
Count	7	7	3

Notes:

1. Measurement from March 15, 2019. High flow could be associated with a rain event and/or freshet.

4.4 Water Quality

There were no provincial or LSRCA water quality monitoring stations on the branch of Vivian Creek near the Mount Albert Wells; however, there was a provincial water quality monitoring station on Mount Albert Creek, downstream of the confluence of Vivian Creek and Mount Albert Creek near the intersection of Highway 48 and Queensville Sideroad E (Station 03007702102). York Region also collected water samples from Vivian Creek from two locations: MTA SWA and MTA SWB. Samples were collected on four days between November 2018 to May 2019 from MTA SWA and on three days between November 2018 to March 2019. Summary statistics for water quality parameters monitored at Station 0300702102 from 2003 to 2018, the results from the water samples collected by York Region, and corresponding PWQOs are presented in **Appendix B**. Review of the data and comparison to the PWQOs indicated that the median and 75th percentile of the data collected from Mount Albert Creek and the data collected by York Region were within the PWQOs, with the exception of aluminium, cadmium, iron, one field pH measurement, total phosphorus, and zinc. PWQOs and measured concentrations for these parameters for both Mount Albert Creek and Vivian Creek are summarized in Table 4-2 below.

Table 4-2 Parameters at Concentrations Exceeding PWQOs in Mount Albert Creek and Vivian Creek

Parameter	PWQO	Mount Albert Creek				Vivian Creek[1]
		Median	75th Percentile	Range	Number of Samples and Collection Period	Range
Aluminium (mg/L)	At pH >6.5 to 9.0, the Interim PWQO is 0.075 mg/L based on total aluminum measured in clay-free samples. If natural background aluminum concentrations in water bodies unaffected by manmade inputs are greater than the numerical Interim PWQO (above), no condition is permitted that would increase the aluminum concentration in clay-free samples by more than 10% of the natural background level.	0.0633	0.13625	0.00802-3.080	71 Mar 2003-Nov 2018	0.064-7.08
Cadmium (µg/L)	0.2 (PWQO) Hardness 0-100 mg/L-$CaCO_3$: 0.1 (Interim PWQO) Hardness >100 mg/L-$CaCO_3$: 0.5 (Interim PWQO)	0.555	1.34	0.0264-2.46	59 Mar 2009-Nov 2018	<0.5-<3
Iron (mg/L)	0.300 (Interim PWQO)	0.254	0.40975	0.121-2.25	72 Mar 2003-Nov 2018	0.232-6.06

Parameter	PWQO	Mount Albert Creek				Vivian Creek[1]
		Median	75th Percentile	Range	Number of Samples and Collection Period	Range
pH (Field)	6.5-8.5	7.88	8.05	7.01-8.68	78 Mar 2003-Dec 2018	7.42-9.05
Phosphorus, total (mg/L)	Interim PWQO: The following phosphorus concentrations should be considered as general guidelines which should be supplemented by site-specific studies: To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L; A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 µg/L or less. This should apply to all lakes naturally below this value; Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 µg/L.	0.045	0.068	0.015-0.52	85 Mar 2003-Dec 2018	0.116-1.12
Silver (µg/L)	0.1 (PWQO)	1.10	1.46	0.518-3.01	11 Mar 2013-Oct 2018	-
Zinc (µg/L)	30 (PWQO) 20 (Interim PWQO)	8.96	12.45	0.114-44.7	72 Mar 2003-Nov 2018	1.8-37

Notes:

1. Data for Vivian Creek collected from two sampling locations: SWA and SWB. Samples collected from SWA on four sampling dates between November 2018 and May 2019 and from SWB on three samplings between November 2018 and March 2019. Measurements from March 2019 could be associated with a rain event and/or freshet and the results could be skewed.

It should be noted that two field pH measurements for Vivian Creek exceeded the maximum PWQO value for pH, and the highest pH observed for Mount Albert Creek also slightly exceeded the maximum PWQO value; however, the median and 75th percentile of pH measurements for Mount Albert Creek were within the PWQO range.

There are no PWQO for BOD_5, TSS, or total ammonia nitrogen; however, these are common water quality parameters, and the Mount Albert WRRF, which is on a separate nearby branch of Vivian Creek, has effluent objectives and limits specified for these parameters in its ECA. Data collected from Mount Albert Creek and Vivian Creek for these parameters are provided in Table 4-3. Water temperature and manganese concentrations are also summarized in Table 4-3 because they are relevant to the subsequent discussion of potential water quality impacts.

Table 4-3 Additional Relevant Water Quality Parameters for Mount Albert Creek and Vivian Creek

Parameter	Mount Albert Creek				Vivian Creek
	Median	75th Percentile	Range	Number of Samples and Collection Period	Range
BOD_5 (mg/L)[1,2]	1.6			1 May 2003	-
TSS (mg/L)	-	-	-	-	26.8-395
Total Ammonia Nitrogen (mg/L-N)	0.045	0.079	0.003-0.386	81 Mar 2003-Dec 2018	0.10-0.80
Total Phosphorus	0.045	0.068	0.015-0.52	11 Mar 2003-Dec 2016	0.116-1.12
Manganese (mg/L)	0.054	0.077	0.014-0.472	72 Mar 2003-Nov 2018	0.058-0.312
Temperature (°C)	12.4	19.8	0-24.7	86 Mar 2003-Dec 2018	-0.2-2.2

Notes:

1. Data for Vivian Creek collected from two sampling locations: SWA and SWB. Samples collected from SWA on four sampling dates between November 2018 and May 2019 and from SWB on three samplings between November 2018 and March 2019. Noted as "BOD_5, Total Demand" in the original data set.

5. Impact Assessment and Discharge Requirements

5.1 Discharge to Mount Albert WRRF

The discharge limits for sewer discharge established by the Region's By-Law No. 2011-56, entitled "Discharge of Sewage, Storm Water and Land Drainage Bylaw", must be followed. For Alternative R1, the backwash wastewater concentrations are expected to be within the By-law No. 2011-56. For Alternative R2, the sludge concentrations are expected to be within the By-law No. 2011-56, except for manganese, which can reach up to 49.5 mg/L, in comparison with the 5 mg/L limit required by the By-law No. 2011-56; thus, the relaxation of this parameter by the Region is required. It should be noted iron is not regulated by the By-law No. 2011-56.

The Mount Albert WRRF, located at 5866 Doane Road, Mount Albert, has a design capacity of 2.04 ML/d to service a population of 6,000 based on a per capital flow of 340 L/cap/d. From 2015 to 2017, the maximum raw wastewater flowrate was 74.47 L/s, while the total influent flow ranged from 0.8 ML/d to 1.8 ML/d, with and average daily flow of 1.15 ML/d. The Mount Albert WRRF generally meets its effluent compliance limits, except for some historical monthly exceedances of TSS, Total Phosphorous and TAN.

The treatment process consists of screening, grit removal, aeration tanks, secondary clarifier, tertiary filtration, UV disinfection, post aeration and sludge thickening, with sludge stored in a sludge holding tank before hauling the thickened sludge to Duffin Creek WPCP for further treatment.

The capacity assessment of Mount Albert WRRF completed in 2018 (Blue Sky) reported the liquid train estimated equivalent capacity as 1.90 ML/d limited by the oxygenation system and the solid train estimated equivalent capacity as 1.18 ML/d (or 295 kg/d of dry solids) limited by the sludge holding tank.

The oxygenation system was assessed based on the BOD_5 and Total Kjeldahl Nitrogen (TKN). The estimated BOD and TKN (as total ammonia) loadings presented in Section 3 represent the equivalent of up to 0.9% and 0.02%, respectively, of the design capacity. It is therefore considered that treatment of the residuals discharged to the sanitary sewer collection system would have negligible impact on the oxygen transfer efficiency.

Iron and manganese concentrations are recommended to be less than 0.1 mg/L at the inlet of the UV disinfection units to avoid fouling. A loading of 3.9 kg/d of iron represents an inlet concentration of 3.0 mg/L based on the projected average daily flow of 1.3 ML/d. Similarly, for manganese, a loading of 0.44 kg/d of manganese represents an inlet concentration of 0.34 mg/L based on the projected average daily flow of 1.3 ML/d. The Mount Albert WRRF historical solids removal in the clarifier is 94%, which would reduce the concentration of iron added from the residual management disposal to 0.18 mg/L and the manganese concentration to 0.02 mg/L. Additional removal would be achieved through the tertiary treatment process, reducing the concentrations below the recommended limit. Therefore, there are no concerns with regards to achieving the required iron and manganese levels prior to the UV reactors.

The anticipated generation of solids from the iron and manganese removal technology varies from 1.4 to 8.2 kg/d of dry solids depending on the well in service. This represents up to 0.1% of the estimated suspended solids capacity in the bioreactors and up to 2.8% of the estimated capacity of the solid train of 295 kg/d. The sludge holding tank capacity assessment considered a minimum of 4-day storage to allow for the storage over a long weekend. It is therefore considered that the addition of the solids generated by the residual management system would have minimal impact on the overall WRRF process, including the solids handling capacity but may require some modification of hauling frequency.

The estimated flow rates presented in Section 3 represent the equivalent of up to 4.6% of the design capacity of 2.04 ML/d. Considering only the marginal increase of the future water demand (3%) and no hydraulic limitations observed at the Mount Albert WRRF, it is considered the Mount Albert WRRF can accommodate the discharge flows.

For the purpose of this study, it is considered that Mount Albert WRRF has sufficient capacity to collect, treat and discharge the backwash wastewater under its current Environmental Compliance Approval (ECA) and, therefore, would have negligible additional impact on surface water.

5.2 Discharge to Vivian Creek

The potential water quality and water quantity impacts of discharging supernatant to Vivian Creek were assessed as presented in the subsections below. Recommendations related to discharge requirements, including treatment recommendations based on the potential impacts, are also provided.

5.2.1 Water Quantity

Given the lack of monitoring data for Vivian Creek and Mount Albert Creek downstream of Vivian Creek, it was not possible to estimate a low flow value (e.g., the 7Q20 flows noted in MOEE, 1994) for Vivian Creek. For the purposes of this study, the assessment of relative percentage contribution from backwash is calculated using the lowest reported Creek stream flow, as presented in Table 5-1. It is unknown if this reporting is indicative of actual flow conditions, long-term and as a result, additional sampling and analysis would be required prior to placing reliance on this analysis.

The calculations assume backwash wastewater generated from filtration at all wells as outlined in Scenario 2 and discharge to Vivian Creek is at a constant rate over 24 hours post-backwash for comparison purposes only. It should be noted the supernatant would be intermittently pumped to Vivian Creek at a higher flowrate over a shorter period of time; the maximum allowable pumping rate would depend on impact to stream geomorphology, sediment transport, erosion or habitat.

Table 5-1. Comparison of Backwash Discharge Rates to Streamflow

Backwash Wastewater Discharged	Minimum Observed Streamflow	Percentage of minimum streamflow
95 m^3/d (1.1 L/s)	6,400 m^3/d (74 L/s)	1.5%

Based on these assumptions, the backwash wastewater could increase the overall minimum streamflow in Vivian Creek by up to 1.5%, based on available data. This is considered a relatively small increase to the reported background Creek flow and, at this rate, is likely to have little impact on flooding, stream geomorphology, sediment transport, erosion or habitat. However, given the limited data available, it is recommended that further data be collected to validate the assessment of potential impacts. At a minimum, this would include:

- Additional flow data for Vivian Creek to characterize stream flows, especially low flows relevant to water quality impact assessment. Raw data from MTA SWA and MTA SWB monitoring stations could be reviewed for analysis.
- A geomorphologic assessment to assess the potential for detrimental changes to sediment transport, erosion, geomorphology, and any associated impacts on habitat.

Consideration should be given whether such additional discharge would benefit the creek and whether there are any seasonal implications such as discharge in the winter during frozen conditions.

5.2.2 Water Quality

The anticipated supernatant water quality data were compared to the PWQOs and the natural water quality data for Mount Albert and Vivian Creeks. Where available, the 75th percentile of the natural water quality data was used as the primary basis for comparison between natural and backwash wastewater qualities. A table summarizing these comparisons can be found in **Appendix B**.

Potential concerns with discharging the supernatant were identified for ten water quality parameters. These parameters, associated PWQOs and natural water qualities, are summarized in Table 5-2 and discussed in subsequent subsections. For each parameter, the 75th percentile from Mount Albert Creek data, the range of values observed at Vivian Creek, and the anticipated average supernatant concentrations are provided.

Preliminary proposed effluent limits for the discharge to Vivian Creek were developed for consideration and are summarized in Table 5-3. The required level of reduction to achieve these limits is identified and compared to typical removal rates for the residual management solution proposed to assess the potential for impact on Vivian Creek.

Table 5-2 Water Quality Parameters in the Supernatant Discharge with Potential to Impact to Vivian Creek

Parameter	Unit	PWQO/Interim PWQO[1]	Mount Albert Creek	Vivian Creek	Scenario 1 (Well 1&2)	Scenario 2 (Well 1, Well 3)		Scenario 3 (Well 2)
			75th Percentile	Range	Well 1&2 Facility	Well 1&2 Facility	Well 3 Facility	Well 1&2 Facility
Chlorine	mg/L	0.002 (PWQO)	ND[2]	ND[2]	Typical: 1.6 mg/L Maximum: 4.3 mg/L	Typical: 1.6 mg/L Maximum: 4.3 mg/L	Typical: 1.6 mg/L Maximum: 4.3 mg/L	Typical: 1.6 mg/L Maximum: 4.3 mg/L
Dissolved Oxygen	mg/L	5-8 mg/L for cold-water biota (PWQO)	12.47	ND[2]	0.8	0.8	0.8	0.7
Iron	mg/L	0.3 (Interim PWQO)	0.409	0.232-6.06	4.9	4.9	1.0	2.5
Manganese	mg/L	N/A	0.077	0.057-0.312-	0.55	0.55	0.12	0.24
Nitrate	mg/L-N	N/A	1.44	ND[2]	<0.005	<0.005	4.8	<0.005
Total Ammonia Nitrogen	mg/L-N	N/A	0.079	0.09-0.80	0.24	0.28	0.05	0.17
Total Suspended Solids	mg/L	N/A	ND	26.8-395	10.3	10.3	2.2	5.0
Temperature	°C	<10°C change at the edge of the mixing zone	19.8 (Range: 0-24.7)	-0.2-2.2[3]	7-10			
Total Phosphorus	mg/L	<0.01-0.03 (Guideline Interim PWQO)	0.068	0.20-1.12	ND[2]	ND[2]	ND[2]	ND[2]
Turbidity	FTU/NTU[4]	≤ 10% change in Secchi disc reading	13.8	34-166	ND[2]	ND[2]	ND[2]	ND[2]

Notes:

1. PWQOs and Interim PWQOs are summarized here for reference. Refer to MECP (2019a) for the PWQOs and associated details.
2. ND indicates that there was no data collected or available for this parameter. There is likely no chlorine present in the natural waters.
3. November 2018-May 2019.
4. Mount Albert Creek measurements reported as Formazin Turbidity Units. York Region results reported as Nephelometric Turbidity Units

Table 5-3 Proposed Preliminary Effluent Limits, Objectives, and Treatment Levels

Parameter	Unit	Proposed Preliminary Effluent Limit or Objective	Basis	Anticipated Worst Case Concentration in the Supernatant	Treatment Level to Meet Limit or Objective
Chlorine	mg/L	0.002 (Limit)	Ontario PWQO	4.3 (maximum)	100% Removal
Iron	mg/L	To be defined	Limited data available to assess the impact on Vivian Creek	4.9 (maximum)	90% removal anticipated by the gravity settling process.
Manganese	mg/L	To be defined	Limited data available to assess the impact on Vivian Creek	0.55 (maximum)	90% removal anticipated by the gravity settling process.
Total Suspended Solids	mg/L	15 (Limit)	Low range of typical effluent discharge limit set by Ministry of the Environment, Conservation and Parks (MECP)	10.3 (maximum)	90% removal anticipated by the gravity settling process is able to achieve the proposed limit

Chlorine

Treated water used to backwash the filters will be chlorinated, and the residual chlorine concentration in the backwash wastewater will be above the Ontario PWQO. Therefore, backwash wastewater will need to be dechlorinated prior to discharge to achieve an effluent limit of 0.002 mg/L as part of the on-site treatment.

Dissolved Oxygen

The dissolved oxygen concentration in the backwash wastewater is anticipated to be low, given the low dissolved oxygen concentration in the raw groundwater from Mount Albert wells. Discharge of the supernatant with low dissolved oxygen concentrations has the potential to decrease dissolved oxygen concentrations in Vivian Creek near the area of discharge. The magnitude of the impact will depend on the base flow in Vivian Creek. However, it is anticipated that Vivian Creek will be able to assimilate the low dissolved oxygen given low volume of the supernatant that would be discharged in comparison to the water flow in the Creek. For example, the dissolved oxygen concentration in Vivian Creek would only decrease by approximately 0.15 mg/L after mixing with the minimum recorded flow (6,400 m^3/d), considering the 75^{th} percentile of natural background dissolved oxygen concentrations observed for Mount Albert Creek (12.8 mg/L) and the supernatant dissolved oxygen concentration of 0.7 mg/L. In this case, Vivian Creek dissolved oxygen levels would remain above Ontario PWQO.

Iron

Iron concentrations in the supernatant will be significantly higher than the Ontario Interim PWQO for iron and the natural background concentrations. Assuming that an iron effluent limit of 0.409 mg/L is established based on the 75^{th} percentile of iron concentrations observed in Mount Albert Creek, the on-site treatment would need to achieve 99% removal efficiency, which is unlikely to be obtained with the gravity settling process. Given the low volume of the supernatant that would be discharged in comparison to the water flow in the Creek, there is potential for acceptable assimilation. For example, the iron concentration in Vivian Creek would increase by approximately 0.06 mg/L (15%) after mixing with the minimum recorded flow (6,400 m^3/d), considering the 75^{th} percentile of natural background iron concentrations observed for Mount Albert Creek (0.409 mg/L) and the supernatant iron concentration of 4.9 mg/L. It is recommended additional data is gathered, mostly related to Vivian Creek low flow, to properly assess the impact of elevated iron in the discharge and the effluent discharge limit for iron.

Manganese

There is no PWQO for manganese; however, manganese concentrations in the supernatant are expected to be significantly higher than the natural background concentrations in Vivian Creek. Assuming that a manganese effluent limit of 0.07 mg/L is established based on the 75^{th} percentile of manganese concentrations observed in Mount Albert Creek, the on-site treatment would need to achieve 99% removal efficiency, which is unlikely to be obtained with the gravity settling process. Given the low volume of the supernatant that would be discharged in comparison to the water flow in the Creek, there is potential for acceptable assimilation. For example, the manganese concentration in Vivian Creek would increase by approximately 0.007 mg/L (9%) after mixing with the minimum recorded flow (6,400 m^3/d), considering the 75^{th} percentile of natural background manganese concentrations observed for Mount Albert Creek (0.077 mg/L) and the supernatant manganese concentration of 0.55 mg/L. It is recommended additional data is gathered, mostly related to Vivian Creek low flow, to properly assess the impact of elevated manganese in the discharge and the effluent discharge limit for iron.

Nitrate

There is no PWQO for nitrate, and nitrate concentrations in the supernatant produced from Wells 1 and 2 are expected to be lower than the natural background concentration; however, nitrate concentrations in the supernatant from Well 3 Facility are expected to be higher than the natural background concentration. It is anticipated that Vivian Creek will be able to assimilate the additional nitrate given the low volume of the supernatant that would be discharged in comparison to the water flow in the Creek. For example, the nitrate concentration in Vivian Creek would only increase by approximately 0.05 mg/L after mixing with the minimum recorded flow (6,400 m^3/d), considering the 75th percentile of natural background nitrate concentrations observed for Mount Albert Creek (1.44 mg/L), and the supernatant nitrate concentration of 4.8 mg/L. At higher Creek flows, the nitrate increase would be even smaller.

Temperature

The PWQO for temperature specifies that there be less than a 10°C temperature change at the edge of the mixing zone. It is anticipated that this PWQO will be met given that the temperature of the supernatant is anticipated to be 7-10°C, relatively unchanged from groundwater temperatures, and the volume of the supernatant to be discharged is small in comparison to the flow in Vivian Creek. Additional temperature information for Vivian Creek during Winter would be required to verify this assessment. Consideration should be given to whether there is any seasonal implication.

Total Ammonia Nitrogen

There is no PWQO for total ammonia nitrogen (TAN), and TAN concentrations in the supernatant produced from Well 3 are expected to be below natural background concentrations; however, TAN concentrations from Wells 1&2 facility are expected to be above the 75th percentile value for Mount Albert Creek. As with nitrate, it is anticipated that Vivian Creek will be able to assimilate the additional ammonia given the low volume of the supernatant that would be discharged relative to the water flow in the Creek. For example, the nitrate concentration in Vivian Creek would only increase by approximately 0.004 mg/L after mixing with the minimum recorded flow (6,400 m^3/d), considering the 75th percentile of natural background ammonia concentrations observed for Mount Albert Creek (0.079 mg/L), and the supernatant nitrate concentration of 0.28 mg/L.

Total Suspended Solids

There is no PWQO for suspended solids; however, there is a PWQO for turbidity and increases in suspended solids can contribute to an increase in turbidity. Total suspended solids concentrations in the supernatant backwash water are anticipated to be in the same range as values observed by York Region. The typical effluent discharge limit prescribed by MECP for TSS is between 15 to 25 mg/L. Given the low volume of the supernatant that would be discharged in comparison to the water flow in the Creek, it is anticipated the setting the discharge limit to the low range (15 mg/L) would have low impact.

It was also noted that the ECA for the nearby Mount Albert WRRF, which discharges to a separate branch of Vivian Creek, specifies an effluent limit of 6 mg/L for TSS. To achieve this limit, the on-site treatment would have to reach 95% removal, which is unlikely to be obtained with the gravity settling process.

Total Phosphorus

It was not possible to estimate the total phosphorus concentration in the supernatant since phosphorus concentration data are not available for Mount Albert well raw water. It was also noted that total phosphorus data are not available for Vivian Creek.

It is anticipated that the total phosphorus concentrations present in the supernatant will be lower than the natural Creek background phosphorus concentrations given that the estimated average phosphate concentrations for the supernatant (0.026-0.028 mg/L, see Section 3.2) are below the 75th percentile phosphate concentration observed at Mount Albert Creek (0.034 mg/L; as presented in **Appendix B**).

Given the limited data related to total phosphorus concentrations, the following is recommended to inform the subsequent design of on-site treatment:

- Confirmation of the total phosphorus concentration in the raw waters from Wells 1, 2, and 3;
- Monitoring of total phosphorus concentrations in Vivian Creek to characterize the natural background concentrations;
- During process piloting, confirmation of total phosphorus concentrations in the supernatant.

Turbidity

The turbidity of the supernatant is not known. It is expected the PWQO for turbidity will be met if the effluent limits for iron, manganese, and total suspended solids are achieved. However, it is recommended that the turbidity of the supernatant is assessed during piloting and that the flows and turbidity levels in Vivian Creek be further characterized.

By-Law No. 2011-56

For Alternatives R2 and R3, the supernatant from Wells 1 & 2 Facility will be discharged to Vivian Creek via the stormwater system. The discharge limits for storm discharge established by the Region's By-Law No. 2011-56 must be followed. The supernatant constituent concentrations are expected to be within the By-law No. 2011-56, except for manganese. Manganese levels in the supernatant can reach up to 0.55 mg/L, in comparison with the 0.15 mg/L limit required by the By-law No. 2011-56; thus, the relaxation of this parameter by the Region is required. It should be noted iron is not regulated by the By-law No. 2011-56.

5.3 Haulage to Duffin Creek WPCP

The Duffin Creek WPCP, located at 901 McKay Rd, Pickering, has a design capacity of 630 ML/d and it is operated by the Regional Municipality of Durham. From 2017 to 2019, the maximum raw wastewater flow was 787 ML/d, while the average daily flow was 339 ML/d. The Duffin Creek WPCP generally meets its effluent compliance limits.

The Duffin Creek WPCP includes a septage receiving station and also imports sludges from facilities within the Regional of Municipality of York and the Regional Municipality of Durham. The anticipated sludge of up to 7.4 kg/d of dry solids represents up to 0.05% of the average septage and imported dry solids received by Duffin Creek WPCP from 2017 to 2019.

For the purpose of this study, it is presumed Duffin Creek WPCP has sufficient capacity to receive and treat the anticipated sludge volumes under its current Environmental Compliance Approval (ECA) and, therefore, would have negligible additional impact on surface water.

6. Summary and Recommendations

Backwash wastewater from the iron and manganese removal processes are anticipated to contain chlorine, high concentrations of iron and manganese, low concentrations of dissolved oxygen, and total suspended solids.

The discharge of the residuals to Mount Albert WRRF or Duffin Creek WPCP has no significant impact on surface water.

To prevent impacts from the discharging of the residuals to Vivian Creek, available data analysis indicates that levels of chlorine, iron, manganese, and total suspended solids would need to be reduced prior to discharge. Effluent limits for chlorine and total suspended solids parameters are proposed for consideration based on the available data for the purpose of the Class EA study. However, limited Vivian Creek stream flow and water quality data are available near the proposed discharge points for the supernatant to assess the impact of iron and manganese discharge. Total phosphorus from existing Mount Albert wells is also not available and the supernatant quality was estimated. Given these data limitations, the following are recommended to further assess the treatment requirements for the backwash wastewater and effluent discharge limits in case Alternatives R2 or R3 are deemed preferred:

- Additional stream flow data from Vivian Creek be collected and low flows relevant to water quality impact assessment be characterized and confirmed.
- Additional water quality monitoring at Vivian Creek be conducted to better characterize natural background levels of water quality parameters, especially for dissolved oxygen, iron, manganese, nitrate, total ammonia nitrogen, total suspended solids, total phosphorus, and turbidity.
- The total phosphorus concentrations present in the raw water from the Mount Albert Wells 1, 2, and 3 be confirmed.
- During iron and manganese removal technology piloting, the backwash wastewater and the supernatant quality be characterized, and treatment requirements identified to assess the feasibility of meeting the proposed effluent limits.
- A geomorphologic assessment be conducted to assess the potential for detrimental changes to sediment transport, erosion, geomorphology, and any associated impacts on habitat.
- Effluent limits, conclusions, and recommendations of this study be evaluated using the new data.

Once the new assessment is available, a pre-consultation with MECP is recommended to review potential effluent discharge limits to minimize the impacts to Vivian Creek. In the event that required effluent limits cannot be achieved with the gravity settling process alone, enhanced on-site treatment of the residuals would be required. The degree of on-site treatment required would be further identified based on the piloting results, but it can vary from a filter bag to nanofiltration depending on the effluent limits established by MECP.

References

Blue Sky Energy Engineering & Consulting Inc. (2018). *Capacity Assessment of the Mount Albert WRRF*. Mississauga, ON: Blue Sky Energy Engineering & Consulting Inc.

Emerson,K. Russo, R.C., Lund, R.E, & Thurston, R.V. (1975). Aqueous ammonia equilibrium calculations: Effect of pH and temperature. *J. Fish. Res. Board Can*. 32:2379-2383 as cited in Ontario Ministry of Environment, Conservation, and Parks (2019, March 28). *Water management: policies, guidelines, provincial water quality objectives.* Retrieved June 29, 2020 from https://www.ontario.ca/page/water-management-policies-guidelines-provincial-water-quality-objectives

Environment Canada. (2020a, February 3). *Historical Hydrometric Data Map Search*. Retrieved June 15, 2020 from https://wateroffice.ec.gc.ca/google_map/google_map_e.html?map_type=historical&search_type=province&province=ON

Environment Canada. (2020b, February 3b). *Real-Time Hydrometric Data Map Search*. Retrieved June 15, 2020 from https://wateroffice.ec.gc.ca/google_map/google_map_e.html?map_type=real_time&search_type=region&region=ONT

Lake Simcoe Region Conservation Authority [LSRCA]. (2010). *Black River Subwatershed Plan*. Newmarket, ON: LSRCA.

Lake Simcoe Region Conservation Authority [LSRCA]. (2017). *Lake Simcoe Subwatershed Map.* Retrieved June 15, 2020 from https://www.lsrca.on.ca/Shared%20Documents/Lake-Simcoe-Watershed-Map.pdf

Ontario Ministry of Environment, Conservation, and Parks (2019a, March 28). *Water management: policies, guidelines, provincial water quality objectives.* Retrieved June 29, 2020 from https://www.ontario.ca/page/water-management-policies-guidelines-provincial-water-quality-objectives

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019b, December 31a). *pwqmn_rawdata_2003* [excel file in 2000-2011 dataset]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/fa10d01b-8b65-4d62-a79c-8d7f1de417d2?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019c, December 31b). *pwqmn_rawdata_2004* [excel file in 2000-2011 dataset]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/fa10d01b-8b65-4d62-a79c-8d7f1de417d2?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019d, December 31c). *pwqmn_rawdata_2005* [excel file in 2000-2011 dataset]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/fa10d01b-8b65-4d62-a79c-8d7f1de417d2?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019e, December 31d). *pwqmn_rawdata_2006* [excel file in 2000-2011 dataset]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/fa10d01b-8b65-4d62-a79c-8d7f1de417d2?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019f, December 31). *Pwqmn_rawdata_2007* [excel file in 2000-2011 dataset]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/fa10d01b-8b65-4d62-a79c-8d7f1de417d2?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019g, December 31). *Pwqmn_rawdata_2008* [excel file in 2000-2011 dataset]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/fa10d01b-8b65-4d62-a79c-8d7f1de417d2?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019h, December 31). *Pwqmn_rawdata_2009* [excel file in 2000-2011 dataset]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/fa10d01b-8b65-4d62-a79c-8d7f1de417d2?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019i, December 31). *Pwqmn_rawdata_2010* [excel file in 2000-2011 dataset]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/fa10d01b-8b65-4d62-a79c-8d7f1de417d2?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019j, December 31). *Pwqmn_rawdata_2011* [excel file in 2000-2011 dataset]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/fa10d01b-8b65-4d62-a79c-8d7f1de417d2?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019k, December 31). *Pwqmn_rawdata_2012* [excel file]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/d21bfcfe-fa3f-4154-9fb2-83e5fcc0987f?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019l, December 31). *Pwqmn_rawdata_2013* [excel file]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/db0d2e61-c52d-491a-82b2-54554b43da6e?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019m, December 31). *Pwqmn_rawdata_2014* [excel file]. Retrieved June 8, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/343125a5-f6d9-48f6-b4f1-ead252d1ceb4?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019n, December 31). *Pwqmn_rawdata_2015* [excel file]. Retrieved June 3, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/9e253438-5a9b-4170-9456-49696b200faa?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2019o, December 31). *Pwqmn_rawdata_2016* [excel file]. Retrieved June 3, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/5ca51192-1c49-428d-afda-f4feb00b2eef?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2020a, January 24). *Map: Provincial (Stream) Water Quality Monitoring Network).* Retrieved June 15, 2020 from https://wateroffice.ec.gc.ca/google_map/google_map_e.html?map_type=real_time&search_type=region&region=ONT

Ontario Ministry of Environment Conservation and Parks [MECP]. (2020b, April 30). *pwqmn_rawdata_2017* [excel file]. Retrieved June 3, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/289f71ad-7b08-4beb-8e74-bcc02d7c2a5e?inner_span=True

Ontario Ministry of Environment Conservation and Parks [MECP]. (2020c, April 30). *pwqmn_rawdata_2018* [excel file]. Retrieved June 3, 2020 from https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network/resource/1f565f5c-0585-40cc-b87e-bb52a2053408?inner_span=True

Ontario Ministry of Environment and Energy [MOEE]. (1994). Deriving Receiving-Water Based, Point-Source Effluent Requirements for Ontario Waters. Ontario: Queen’s Printer for Ontario.

Regional Municipality of Durham. (2017 to 2019). *Duffin Creek Water Pollution Control Plant Annual Performance Report*.

Regional Municipality of York. 2011. *Bill No. 56. By-Law No. 2011-56. Discharge of Sewage, Storm Water and Land Drainage Bylaw*. https://www.york.ca/wps/portal/yorkhome/yorkregion/yr/bylaws/

Soil & Water Conservation Society of Metro Halifax. (2015). Taxa Tolerance Values. Retrieved September 29, 2020 from http://lakes.chebucto.org/ZOOBENTH/BENTHOS/tolerance.html#Coelenterata

Appendix A

Fish and Benthic Invertebrate Tallie Data

Site	Sample Date	Scientific Name	Common Name	Group Number	Number Of Fish	Total Weight (g)	Comments
BR12	8/25/2003	Semotilus atromaculatus	Creek Chub 212	1	27	112	
BR12	8/25/2003	Rhinichthys atratulus	Eastern Blacknose Dace 210	1	28	81	
BR12	8/25/2003	Rhinichthys cataractae	Longnose Dace 211	1	24	61	
BR12	8/25/2003	Cottus bairdii	Mottled Sculpin 381	1	13	20	
BR12	8/25/2003	Catostomus commersonii	White Sucker 163	1	20	22	
BR12	6/29/2011	Semotilus atromaculatus	Creek Chub 212	1	8	214	
BR12	6/29/2011	Rhinichthys atratulus	Eastern Blacknose Dace 210	1	19	118	
BR12	6/29/2011	Etheostoma nigrum	Johnny Darter 341	1	6	17	
BR12	6/29/2011	Rhinichthys cataractae	Longnose Dace 211	1	27	95	
BR12	6/29/2011	Cottus bairdii	Mottled Sculpin 381	1	35	188	
BR12	6/29/2011	Catostomus commersonii	White Sucker 163	1	9	14	
BR12	8/7/2012	Semotilus atromaculatus	Creek Chub 212	1	70	725	
BR12	8/7/2012	Rhinichthys atratulus	Eastern Blacknose Dace 210	1	22	96	
BR12	8/7/2012	Etheostoma nigrum	Johnny Darter 341	1	5	12	
BR12	8/7/2012	Rhinichthys cataractae	Longnose Dace 211	1	32	70	
BR12	8/7/2012	Cottus bairdii	Mottled Sculpin 381	1	29	78	
BR12	8/7/2012	Chrosomus eos	Northern Redbelly Dace 182	1	1	4	
BR12	8/7/2012	Lepomis gibbosus	Pumpkinseed 313	1	1	8	
BR12	8/7/2012	Catostomus commersonii	White Sucker 163	1	12	186	
BR12	7/29/2013	Culaea inconstans	Brook Stickleback 281	1	21	91	
BR12	7/29/2013	Semotilus atromaculatus	Creek Chub 212	1	27	198	
BR12	7/29/2013	Rhinichthys atratulus	Eastern Blacknose Dace 210	1	7	38	
BR12	7/29/2013	Etheostoma nigrum	Johnny Darter 341	1	5	9	
BR12	7/29/2013	Micropterus salmoides	Largemouth Bass 317	1	1	1	
BR12	7/29/2013	Rhinichthys cataractae	Longnose Dace 211	1	34	136	
BR12	7/29/2013	Lepomis gibbosus	Pumpkinseed 313	1	1	8	
BR12	7/29/2013	Catostomus commersonii	White Sucker 163	1	3	33	
BR12	8/5/2014	Semotilus atromaculatus	Creek Chub 212	1	21	406	CREEK CHUB
BR12	8/5/2014	Rhinichthys atratulus	Eastern Blacknose Dace 210	1	6	9	BLACKNOSE DACE
BR12	8/5/2014	Etheostoma nigrum	Johnny Darter 341	1	4	12	JOHNNY DARTER
BR12	8/5/2014	Rhinichthys cataractae	Longnose Dace 211	1	20	93	LONGNOSE DACE
BR12	8/5/2014	Cottus bairdii	Mottled Sculpin 381	1	56	99	MOTTLED SCULPIN
BR12	8/5/2014	Catostomus commersonii	White Sucker 163	1	1	91	WHITE SUCKER
BR12	7/3/2015	Umbra limi	Central Mudminnow 141	1	6	12	JOHNNY DARTER
BR12	7/3/2015	Semotilus atromaculatus	Creek Chub 212	1	8	231	CREEK CHUB
BR12	7/3/2015	Rhinichthys atratulus	Eastern Blacknose Dace 210	1	3	23	BLACKNOSE DACE
BR12	7/3/2015	Rhinichthys cataractae	Longnose Dace 211	1	7	21	LONGNOSE DACE
BR12	7/3/2015	Cottus bairdii	Mottled Sculpin 381	1	49	157	MOTTLED SCULPIN
BR12	7/7/2016	Semotilus atromaculatus	Creek Chub 212	1	61	234	Creek Chub
BR12	7/7/2016	Rhinichthys atratulus	Eastern Blacknose Dace 210	1	55	67	Blacknose Dace
BR12	7/7/2016	Etheostoma nigrum	Johnny Darter 341	1	6	12	Johnny Darter
BR12	7/7/2016	Rhinichthys cataractae	Longnose Dace 211	1	5	8	Longnose Dace
BR12	7/7/2016	Cottus bairdii	Mottled Sculpin 381	1	74	105	Mottled Sculpin
BR12	7/7/2016	Catostomus commersonii	White Sucker 163	1	35	17	White Sucker
BR12	6/28/2017	Semotilus atromaculatus	Creek Chub 212	1	6	47	
BR12	6/28/2017	Rhinichthys atratulus	Eastern Blacknose Dace 210	1	11	62	
BR12	6/28/2017	Pimephales promelas	Fathead Minnow 209	1	23	3	
BR12	6/28/2017	Etheostoma nigrum	Johnny Darter 341	1	7	11	
BR12	6/28/2017	Rhinichthys cataractae	Longnose Dace 211	1	39	124	
BR12	6/28/2017	Cottus bairdii	Mottled Sculpin 381	1	46	149	
BR12	6/28/2017	Catostomus commersonii	White Sucker 163	1	1	19	
BR12	6/19/2018	Semotilus atromaculatus	Creek Chub 212	1	22	215	
BR12	6/19/2018	Rhinichthys atratulus	Eastern Blacknose Dace 210	1	7	34	
BR12	6/19/2018	Etheostoma nigrum	Johnny Darter 341	1	1	3	
BR12	6/19/2018	Rhinichthys cataractae	Longnose Dace 211	1	24	97	
BR12	6/19/2018	Cottus bairdii	Mottled Sculpin 381	1	5	19	

Site	BR-12	BR-12
Sample#	Riffle	Pool
Replicate #		
Date	19-Sep-11	19-Sep-11
Crew		
Taxonomist	RG	RG
Bankfull		
% Sampled		
Taxa		
Hydrozoa (Class)	0	0
Anthoathecata (Order)	0	0
Hydridae (Family)	0	0
Insects - Insecta (Class)	0	0
Alderflies - Megaloptera (Order)	0	0
Corydalidae (Family)	0	0
Sialidae (Family)	0	0
Aquatic Moths - Lepidoptera (Order)	0	0
Crambidae (Family)	0	0
Pyralidae (Family)	1	0
Beetles - Coleoptera (Order)	0	0
Chrysomelidae (Family)	0	0
Circulionidae (Family)	0	0
Dryopidae (Family)	1	0
Dytiscidae (Family)	0	0
Elmidae (Family)	7	1
Gyrinidae (Family)	0	0
Haliplidae (Family)	0	0
Hydraenidae (Family)	0	0
Hydrophilidae (Family)	0	0
Psephenidae (Family)	0	0
Scirtidae (Family)	0	0
Bugs - Hemiptera (Order)	0	0
Belostomatidae (Family)	0	0
Corixidae (Family)	0	0
Gerridae (Family)	0	0
Hebridae (Family)	0	0
Nepidae (Family)	0	0
Notonectidae (Family)	0	0
Pleidae (Family)	0	0
Saldidae (Family)	0	0
Veliidae (Family)	0	0
Caddisflies - Trichoptera (Order)	0	0
Brachycentridae (Family)	0	0
Dipseudopsidae (Family)	0	0
Glossosomatidae (Family)	0	0
Goeridae (Family)	0	0
Helicopsychidae (Family)	18	0
Hydropsychidae (Family)	16	1
Hydroptilidae (Family)	0	0
Lepidostomatidae (Family)	0	0
Leptoceridae (Family)	0	0
Limnephilidae (Family)	27	10
Molannidae (Family)	0	0
Philopotamidae (Family)	3	0
Phryganeidae (Family)	0	0
Polycentropodidae (Family)	0	0
Psychomyiidae (Family)	0	0
Rhyacophilidae (Family)	0	0
Uenoidae (Family)	0	0
Damselflies & Dragonflies - Odonata (Order)	0	0
Damselflies - Zygoptera (Suborder)	0	0
Calopterygidae (Family)	1	0
Coenagrionidae (Family)	0	0
Lestidae (Family)	0	0
Dragonflies - Anisoptera (Suborder)	0	0
Aseshnidae (Family)	0	0
Cordulegasteridae (Family)	0	0
Corduliidae (Family)	0	0
Gomphidae (Family)	0	0
Libellulidae (Family)	0	0
Mayflies - Ephemeroptera (Order)	0	0
Ameletidae (Family)	0	0
Baetidae (Family)	37	1
Baetiscidae (Family)	0	0
Caenidae (Family)	0	0
Ephemerellidae (Family)	0	0
Ephemeridae (Family)	0	0
Heptageniidae (Family)	6	0
Isonychiidae (Family)	0	0
Leptohyphidae (Family)	0	0
Leptophlebiidae (Family)	0	1
Metretopodidae (Family)	0	0
Oligoneuriidae (Family)	0	0
Siphlonuridae (Family)	0	0
Tricorythidae (Family)	0	0
Stoneflies - Plecoptera (Order)	0	0
Capniidae (Family)	0	0
Chloroperlidae (Family)	0	0
Leuctridae (Family)	0	0
Nemouridae (Family)	0	0
Perlidae (Family)	0	0
Perlodidae (Family)	0	0
Taeniopterygidae (Family)	0	0
True Flies - Diptera (Order)	0	0
Athericidae (Family)	0	0
Ceratopogonidae (Family)	0	0
Chaoboridae (Family)	0	0
Chironomidae (Family)	66	264
Culicidae (Family)	0	0
Dixidae (Family)	0	0
Empididae (Family)	0	0

Site	BR-12	BR-12
Sample#	Riffle	Pool
Replicate #		
Date	19-Sep-11	19-Sep-11
Crew		
Taxonomist	RG	RG
Bankfull		
% Sampled		
Taxa		
Ephydridae (Family)	0	0
Muscidae (Family)	0	0
Phoridae (Family)	0	0
Psychodidae (Family)	0	0
Ptychopteridae (Family)	0	0
Simuliidae (Family)	13	0
Stratiomyidae (Family)	0	0
Syrphildae (Family)	0	0
Tabanidae (Family)	0	0
Tipulidae (Family)	5	0
Anthropods - Arthropoda (Phylum)	0	0
Springtails - Collembola (Class)	0	0
Crustaceans - Crustacea (Subphylum)	0	0
Amphipods - Amphipoda (Order)	0	0
Crangonyctidae (Family)	1	0
Gammaridae (Family)	0	0
Hyalellidae (Family)	0	0
Crayfishes - Decapoda (Order)	0	0
Cambaridae (Family)	0	0
Orconectes (Genus)	0	0
Orconectes propinquus (Species)	0	0
Orconectes rusticus (Species)	0	0
Orconectes virilis (Species)	0	0
Isopods - Isopoda (Order)	0	0
Asellidae (Family)	1	0
Arachnids - Arachnida (Class)	0	0
Acari (Order)-Acarina - Hydrocarina	0	0
Mites - Trombidiformes (Order)	0	0
Arrenuridea (Family)	0	0
Hygrobatidea (Family)	0	0
Lebertiidea (Family)	0	0
Limnesiidae (Family)	0	0
Limnocharidae (Family)	0	0
Pionidae (Family)	0	0
Sperchonidae (Family)	0	0
Unionicolidae (Family)	0	0
Molluscs - Mollusca (Phylum)	0	0
Bivalves - Bivalvia - Pelecypoda (Class)	0	0
Dreisennidae (Family)	0	0
Unionidae (Family)	0	0
Pisidiidae (Sphaeriidae) (Family)	2	0
Snails - Gastropoda (Class)	0	0
Ancylidae (Family)	0	0
Hydrobiidae (Family)	0	0
Lymnaeidae (Family)	27	0
Physidae (Family)	7	0
Planorbidae (Family)	0	0
Pleuroceridae (Family)	0	0
Valvatidae (Family)	0	0
Viviparidae (Family)	0	0
Annelids - Annelida (Phylum)	0	0
Leeches - Hirudinea (Class)	0	0
Erpobdellidae (Family)	0	0
Glossiphonidae (Family)	0	0
Hirudinidae (Family)	0	0
Piscicolidae (Family)	0	0
Worms - Oligochaeta (Class)	0	0
Branchiobdellida (Order)	0	0
Haplotaxida (Order)	0	0
Enchytraeidae (Family)	0	0
Lumbricidae (Family)	0	0
Naididae (Family)	38	7
Sparganophilidae (Family)	0	0
Lumbriculida (Order)	0	0
Lumbriculidae (Family)	0	0
Platyhelminthes (flatworms) (Phylum)	0	0
Turbellaria (Class)	0	0
Tricladida (Order)	0	0
Dugesiidae (Family)	1	1
Plagiostomidae (Family)	0	0
Planariidae (Family)	0	0
Nemata (Phylum)	0	0
Adenophorea (Class)	0	0
Secernetea (Class)	0	0
Nemertea (Phylum)	0	0
Unknown	0	0
Total Taxa	**20**	**8**
Number of individuals	**278**	**286**

Site	BR-12
Sample#	Riffle
Replicate #	
Date	27-Sep-12
Crew	RB, KB
Taxonomist	RB
Bankfull	
% Sampled	66
Taxa	
Coleoptera (Order) - Beetles	0
Chrysomelidae (Family)	0
Curculionidae (Family)	1
Dryopidae (Family)	0
Dytiscidae (Family)	0
Elmidae (Family)	31
Gyrinidae (Family)	0
Haliplidae (Family)	0
Hydraenidae (Family)	0
Hydrophilidae (Family)	0
Psephenidae (Family)	0
Scirtidae (Family)	0
Sraphylinidae	0
Diptera (Order) - True Flies	0
Athericidae (Family)	0
Ceratopogonidae (Family)	0
Chaoboridae (Family)	0
Chironomidae (Family)	74
Culicidae (Family)	0
Dixidae (Family)	0
Empididae (Family)	1
Ephydridae (Family)	0
Muscidae (Family)	0
Phoridae (Family)	0
Psychodidae (Family)	0
Ptychopteridae (Family)	0
Sciomyzidae (Family)	0
Simuliidae (Family)	0
Stratiomyidae (Family)	1
Syrphildae (Family)	0
Tabanidae (Family)	0
Thaumaleidae (Family)	0
Tipulidae (Family)	3
Ephemeroptera (Order) - Mayflies	0
Ameletidae (Family)	0
Baetidae (Family)	2
Baetiscidae (Family)	0
Caenidae (Family)	0
Ephemerellidae (Family)	0
Ephemeridae (Family)	0
Heptageniidae (Family)	0
Isonychiidae (Family)	0
Leptohyphidae (Family)	1
Leptophlebiidae (Family)	0
Metretopodidae (Family)	0
Oligoneuriidae (Family)	0
Siphlonuridae (Family)	0
Tricorythidae (Family)	0
Hemiptera (Order) - Bugs	0
Belostomatidae (Family)	0
Corixidae (Family)	0
Gerridae (Family)	1
Hebridae (Family)	0
Nepidae (Family)	0
Notonectidae (Family)	0
Pleidae (Family)	0
Saldidae (Family)	0
Veliidae (Family)	1
Lepidoptera (Order) - Aquatic Moths	0
Crambidae (Family)	0
Pyralidae (Family)	0
Neuroptera (Order) - Net Winged Insects	0
Sisyridae (Family)	0
Megaloptera (Order) - Alderflies	0
Corydalidae (Family)	0
Sialidae (Family)	0
Odonata (Order) - Damselflies & Dragonflies	0
Zygoptera (Suborder) - Damselflies	0
Calopterygidae (Family)	0
Coenagrionidae (Family)	0
Lestidae (Family)	0
Anisoptera (Suborder) - Dragonflies	0
Aseshnidae (Family)	0
Cordulegasteridae (Family)	0
Corduliidae (Family)	0
Gomphidae (Family)	0
Libellulidae (Family)	0
Plecoptera (Order) - Stoneflies	0
Capniidae (Family)	0
Chloroperlidae (Family)	0
Leuctridae (Family)	0
Nemouridae (Family)	0
Perlidae (Family)	0
Perlodidae (Family)	0
Pteronarcyidae (Family)	0
Taeniopterygidae (Family)	0
Trichoptera (Order) - Caddisflies	0
Brachycentridae (Family)	0

Site	BR-12
Sample#	Riffle
Replicate #	
Date	27-Sep-12
Crew	RB, KB
Taxonomist	RB
Bankfull	
% Sampled	66
Dipseudopsidae (Family)	0
Glossosomatidae (Family)	0
Goeridae (Family)	0
Helicopsychidae (Family)	24
Hydropsychidae (Family)	28
Hydroptilidae (Family)	0
Lepidostomatidae (Family)	0
Leptoceridae (Family)	0
Limnephilidae (Family)	14
Molannidae (Family)	0
Philopotamidae (Family)	3
Phryganeidae (Family)	2
Polycentropodidae (Family)	0
Psychomyiidae (Family)	1
Rhyacophilidae (Family)	0
Uenoidae (Family)	0
Amphipoda (Order) - Amphipods	0
Crangonyctidae (Family)	0
Gammaridae (Family)	0
Hyalellidae (Family)	0
Bivalvia (Class) - Bivalves	0
Dreisennidae (Family)	0
Unionidae (Family)	0
Sphaeriidae (Pisidiidae) (Family)	2
Decapoda (Order) - Crayfishes	0
Cambaridae (Family)	0
Orconectes (Genus)	0
Orconectes propinquus (Species)	0
Orconectes rusticus (Species)	0
Orconectes virilis (Species)	0
Gastropoda (Class) - Snails	0
Ancylidae (Family)	0
Hydrobiidae (Family)	0
Lymnaeidae (Family)	3
Physidae (Family)	3
Planorbidae (Family)	0
Pleuroceridae (Family)	0
Valvatidae (Family)	0
Viviparidae (Family)	0
Hirudinea (Sub Class) - Leeches	0
Erpobdellidae (Family)	0
Glossiphonidae (Family)	0
Haemopidae (Family)	0
Hirudinidae (Family)	0
Piscicolidae (Family)	0
Isopoda (Order) - Isopods	0
Asellidae (Family)	0
Nemata (Phylum) - Roundworms	0
Adenophorea (Class)	0
Secernetea (Class)	0
Oligochaeta (Class) - Worms	117
Haplotaxida (Order)	0
Enchytraeidae (Family)	0
Lumbricidae (Family)	0
Naididae (Family)	0
Sparganophilidae (Family)	0
Lumbriculida (Order)	0
Lumbriculidae (Family)	0
Tricladida (Order) - Free Living Flatworms	3
Dugesiidae (Family)	0
Plagiostomidae (Family)	0
Planariidae (Family)	0
Trombidiformes (Order) - Mites	0
Arrenuridea (Family)	0
Hygrobatidea (Family)	0
Lebertiidea (Family)	0
Limnesiidae (Family)	0
Limnocharidae (Family)	0
Pionidae (Family)	0
Sperchonidae (Family)	0
Unionicolidae (Family)	0
Unknown	0
Unknown	0
Unknown	0
Branchiobdellida (Order) - Maggot Sucker	0
Bryozoa (Phylum) - Moss Animals	0
Nematomorpha (Phylum) - Horsehair Worms	0
Nemertea (Phylum) - Ribbon Worms	0
Polychaeta (Class) - Bristle Worms	0
Porifera (Phylum) - Sponges	0
Hydrozoa (Class) - Hydra	0
Anthoathecata (Order)	0
Hydridae (Family)	0
Collembola (Class) - Springtails	0
Platyhelminthes (Phylum) - Flatworms	0
Turbellaria (Class)	0
Coelenterata	0
Ostracods	0
Total Taxa	**21**
Number of individuals	**316**

Site	BR-12
Sample#	Riffle
Replicate #	
Date	18-Sep-13
Crew	RB, KB
Taxonomist	RB
Bankfull	
% Sampled	6
Taxa	No
Coleoptera (Order) - Beetles	0
Chrysomelidae (Family)	0
Curculionidae (Family)	0
Dryopidae (Family)	0
Dytiscidae (Family)	0
Elmidae (Family)	40
Gyrinidae (Family)	0
Haliplidae (Family)	0
Hydraenidae (Family)	0
Hydrophilidae (Family)	0
Psephenidae (Family)	0
Scirtidae (Family)	0
Staphylinidae	0
Diptera (Order) - True Flies	0
Athericidae (Family)	0
Ceratopogonidae (Family)	0
Chaoboridae (Family)	0
Chironomidae (Family)	59
Culicidae (Family)	0
Dixidae (Family)	0
Empididae (Family)	3
Ephydridae (Family)	0
Muscidae (Family)	0
Phoridae (Family)	0
Psychodidae (Family)	0
Ptychopteridae (Family)	0
Sciomyzidae (Family)	0
Simuliidae (Family)	6
Stratiomyidae (Family)	0
Syrphildae (Family)	0
Tabanidae (Family)	0
Thaumaleidae (Family)	0
Tipulidae (Family)	4
Ephemeroptera (Order) - Mayflies	0
Ameletidae (Family)	0
Baetidae (Family)	38
Baetiscidae (Family)	0
Caenidae (Family)	0
Ephemerellidae (Family)	0
Ephemeridae (Family)	0
Heptageniidae (Family)	0
Isonychiidae (Family)	0
Leptohyphidae (Family)	0
Leptophlebiidae (Family)	0
Metretopodidae (Family)	0
Oligoneuriidae (Family)	0
Siphlonuridae (Family)	0
Tricorythidae (Family)	0
Hemiptera (Order) - Bugs	0
Belostomatidae (Family)	0
Corixidae (Family)	0
Gerridae (Family)	0
Hebridae (Family)	0
Nepidae (Family)	0
Notonectidae (Family)	0
Pleidae (Family)	0
Saldidae (Family)	0
Veliidae (Family)	0
Lepidoptera (Order) - Aquatic Moths	0
Crambidae (Family)	0
Pyralidae (Family)	0
Neuroptera (Order) - Net Winged Insects	0
Sisyridae (Family)	0
Megaloptera (Order) - Alderflies	0
Corydalidae (Family)	0
Sialidae (Family)	0
Odonata (Order) - Damselflies & Dragonflies	0
Zygoptera (Suborder) - Damselflies	0
Calopterygidae (Family)	0
Coenagrionidae (Family)	0
Lestidae (Family)	0
Anisoptera (Suborder) - Dragonflies	0
Aseshnidae (Family)	0
Cordulegasteridae (Family)	0
Corduliidae (Family)	0
Gomphidae (Family)	0
Libellulidae (Family)	0
Plecoptera (Order) - Stoneflies	0
Capniidae (Family)	0
Chloroperlidae (Family)	0
Leuctridae (Family)	0
Nemouridae (Family)	0
Perlidae (Family)	0
Perlodidae (Family)	0
Pteronarcyidae (Family)	0
Taeniopterygidae (Family)	0
Trichoptera (Order) - Caddisflies	0
Brachycentridae (Family)	0

Site	BR-12
Sample#	Riffle
Replicate #	
Date	18-Sep-13
Crew	RB, KB
Taxonomist	RB
Bankfull	
% Sampled	6
Dipseudopsidae (Family)	0
Glossosomatidae (Family)	3
Goeridae (Family)	0
Helicopsychidae (Family)	11
Hydropsychidae (Family)	117
Hydroptilidae (Family)	0
Lepidostomatidae (Family)	0
Leptoceridae (Family)	0
Limnephilidae (Family)	0
Molannidae (Family)	0
Philopotamidae (Family)	45
Phryganeidae (Family)	0
Polycentropodidae (Family)	0
Psychomyiidae (Family)	0
Rhyacophilidae (Family)	0
Uenoidae (Family)	0
Amphipoda (Order) - Amphipods	0
Crangonyctidae (Family)	0
Gammaridae (Family)	0
Hyalellidae (Family)	0
Bivalvia (Class) - Bivalves	0
Dreisennidae (Family)	0
Unionidae (Family)	0
Sphaeriidae (Pisidiidae) (Family)	0
Decapoda (Order) - Crayfishes	0
Cambaridae (Family)	0
Orconectes (Genus)	0
Orconectes propinquus (Species)	0
Orconectes rusticus (Species)	0
Orconectes virilis (Species)	0
Gastropoda (Class) - Snails	0
Ancylidae (Family)	0
Hydrobiidae (Family)	0
Lymnaeidae (Family)	0
Physidae (Family)	2
Planorbidae (Family)	0
Pleuroceridae (Family)	0
Valvatidae (Family)	0
Viviparidae (Family)	0
Hirudinea (Sub Class) - Leeches	0
Erpobdellidae (Family)	0
Glossiphonidae (Family)	0
Haemopidae (Family)	0
Hirudinidae (Family)	0
Piscicolidae (Family)	0
Isopoda (Order) - Isopods	0
Asellidae (Family)	0
Nemata (Phylum) - Roundworms	0
Adenophorea (Class)	0
Secernetea (Class)	0
Oligochaeta (Class) - Worms	1
Haplotaxida (Order)	0
Enchytraeidae (Family)	0
Lumbricidae (Family)	0
Naididae (Family)	0
Sparganophilidae (Family)	0
Lumbriculida (Order)	0
Lumbriculidae (Family)	0
Tricladida (Order) - Free Living Flatworms	15
Dugesiidae (Family)	0
Plagiostomidae (Family)	0
Planariidae (Family)	0
Trombidiformes (Order) - Mites	0
Arrenuridea (Family)	0
Hygrobatidea (Family)	0
Lebertiidea (Family)	0
Limnesiidae (Family)	0
Limnocharidae (Family)	0
Pionidae (Family)	0
Sperchonidae (Family)	0
Unionicolidae (Family)	0
Branchiobdellida (Order) - Maggot Sucker	0
Bryozoa (Phylum) - Moss Animals	0
Nematomorpha (Phylum) - Horsehair Worms	0
Nemertea (Phylum) - Ribbon Worms	0
Polychaeta (Class) - Bristle Worms	0
Porifera (Phylum) - Sponges	0
Hydrozoa (Class) - Hydra	0
Anthoathecata (Order)	0
Hydridae (Family)	0
Collembola (Class) - Springtails	0
Platyhelminthes (Phylum) - Flat Worms	0
Turbellaria (Class)	0
Coelenterata	0
Ostracods	0
Unknown	0
Unknown	0
Unknown	0
Total Taxa	**13**
Number of individuals	**344**

Site	BR-12
Sample#	Riffle
Replicate #	
Date	3-Oct-14
Crew	KC
Taxonomist	KC
Bankfull	
% Sampled	43
Taxa	No
Coleoptera (Order) - Beetles	0
Chrysomelidae (Family)	0
Curculionidae (Family)	0
Dryopidae (Family)	0
Dytiscidae (Family)	0
Elmidae (Family)	24
Gyrinidae (Family)	0
Haliplidae (Family)	0
Hydraenidae (Family)	0
Hydrophilidae (Family)	0
Psephenidae (Family)	0
Scirtidae (Family)	0
Staphylinidae	0
Diptera (Order) - True Flies	0
Athericidae (Family)	0
Ceratopogonidae (Family)	0
Chaoboridae (Family)	0
Chironomidae (Family)	69
Culicidae (Family)	0
Dixidae (Family)	0
Empididae (Family)	1
Ephydridae (Family)	0
Muscidae (Family)	0
Phoridae (Family)	0
Psychodidae (Family)	0
Ptychopteridae (Family)	0
Sciomyzidae (Family)	0
Simuliidae (Family)	0
Stratiomyidae (Family)	0
Syrphildae (Family)	0
Tabanidae (Family)	0
Thaumaleidae (Family)	0
Tipulidae (Family)	5
Ephemeroptera (Order) - Mayflies	0
Ameletidae (Family)	0
Baetidae (Family)	74
Baetiscidae (Family)	0
Caenidae (Family)	0
Ephemerellidae (Family)	1
Ephemeridae (Family)	0
Heptageniidae (Family)	0
Isonychiidae (Family)	0
Leptohyphidae (Family)	0
Leptophlebiidae (Family)	1
Metretopodidae (Family)	0
Oligoneuriidae (Family)	0
Potamanthideae (Family)	0
Siphlonuridae (Family)	0
Tricorythidae (Family)	0
Hemiptera (Order) - Bugs	0
Belostomatidae (Family)	0
Corixidae (Family)	0
Gerridae (Family)	0
Hebridae (Family)	0
Nepidae (Family)	0
Notonectidae (Family)	0
Pleidae (Family)	0
Saldidae (Family)	0
Veliidae (Family)	0
Lepidoptera (Order) - Aquatic Moths	0
Crambidae (Family)	0
Pyralidae (Family)	0
Neuroptera (Order) - Net Winged Insects	0
Sisyridae (Family)	0
Megaloptera (Order) - Alderflies	0
Corydalidae (Family)	0
Sialidae (Family)	0
Odonata (Order) - Damselflies & Dragonflies	0
Zygoptera (Suborder) - Damselflies	0
Calopterygidae (Family)	0
Coenagrionidae (Family)	0
Lestidae (Family)	0
Anisoptera (Suborder) - Dragonflies	0
Aseshnidae (Family)	0
Cordulegasteridae (Family)	0
Corduliidae (Family)	0
Gomphidae (Family)	0
Libellulidae (Family)	0
Plecoptera (Order) - Stoneflies	0
Capniidae (Family)	0
Chloroperlidae (Family)	0
Leuctridae (Family)	0
Nemouridae (Family)	0
Perlidae (Family)	0
Perlodidae (Family)	0
Pteronarcyidae (Family)	0
Taeniopterygidae (Family)	0

Site	BR-12
Sample#	Riffle
Replicate #	
Date	3-Oct-14
Crew	KC
Taxonomist	KC
Bankfull	
% Sampled	43
Trichoptera (Order) - Caddisflies	0
Brachycentridae (Family)	1
Dipseudopsidae (Family)	0
Glossosomatidae (Family)	0
Goeridae (Family)	0
Helicopsychidae (Family)	3
Hydropsychidae (Family)	90
Hydroptilidae (Family)	0
Lepidostomatidae (Family)	0
Leptoceridae (Family)	0
Limnephilidae (Family)	11
Molannidae (Family)	0
Philopotamidae (Family)	15
Phryganeidae (Family)	1
Polycentropodidae (Family)	0
Psychomyiidae (Family)	0
Rhyacophilidae (Family)	0
Uenoidae (Family)	0
Amphipoda (Order) - Amphipods	0
Crangonyctidae (Family)	0
Gammaridae (Family)	0
Hyalellidae (Family)	0
Bivalvia (Class) - Bivalves	0
Dreisennidae (Family)	0
Dreissena polymorpha (Species)	0
Unionidae (Family)	0
Sphaeriidae (Pisidiidae) (Family)	0
Decapoda (Order) - Crayfishes	0
Cambaridae (Family)	0
Orconectes (Genus)	0
Orconectes propinquus (Species)	0
Orconectes rusticus (Species)	2
Orconectes virilis (Species)	0
Gastropoda (Class) - Snails	0
Ampullaridea (Family)	0
Ancylidae (Family)	0
Bithyniidae (Family)	0
Hydrobiidae (Family)	0
Lymnaeidae (Family)	3
Physidae (Family)	1
Planorbidae (Family)	0
Pleuroceridae (Family)	0
Valvatidae (Family)	0
Viviparidae (Family)	0
Hirudinea (Sub Class) - Leeches	0
Erpobdellidae (Family)	0
Glossiphonidae (Family)	0
Haemopidae (Family)	0
Hirudinidae (Family)	0
Piscicolidae (Family)	0
Isopoda (Order) - Isopods	0
Asellidae (Family)	1
Nemata (Phylum) - Roundworms	0
Adenophorea (Class)	0
Secernetea (Class)	0
Oligochaeta (Class) - Worms	4
Haplotaxida (Order)	0
Sparganophilidae (Family)	0
Lumbricida (Order)	0
Lumbricidae (Family)	0
Lumbriculida (Order)	0
Lumbriculidae (Family)	0
Tubificida (Order)	0
Enchytraeidae (Family)	0
Naididae (Family)	0
Turbellaria (Class)	0
Tricladida (Order) - Free Living Flatworms	5
Dugesiidae (Family)	0
Plagiostomidae (Family)	0
Planariidae (Family)	0
Trombidiformes (Order) - Mites	0
Arrenuridea (Family)	0
Hygrobatidea (Family)	0
Lebertiidea (Family)	0
Limnesiidae (Family)	0
Limnocharidae (Family)	0
Pionidae (Family)	0
Sperchonidae (Family)	0
Unionicolidae (Family)	0
Branchiobdellida (Order) - Maggot Sucker	0
Bryozoa (Phylum) - Moss Animals	0
Nematomorpha (Phylum) - Horsehair Worms	0
Nemertea (Phylum) - Ribbon Worms	0
Polychaeta (Class) - Bristle Worms	0
Porifera (Phylum) - Sponges	0
Hydrozoa (Class) - Hydra	0
Anthoathecata (Order)	0
Hydridae (Family)	0
Collembola (Class) - Springtails	0

Site	BR-12
Sample#	Riffle
Replicate #	
Date	3-Oct-14
Crew	KC
Taxonomist	KC
Bankfull	
% Sampled	43
Platyhelminthes (Phylum) - Flatworms	0
Coelenterata (unranked) - Comb Jellies/Coral Animals	0
Branchiopoda (Class)	0
Cladocera (Order)	0
Daphniidae (Family)	0
Daphnia (Genus)	0
Ostracoda (Class)	0
Unknown	0
Unknown	0
Unknown	0
Total Taxa	**19**
Number of individuals	**312**

Site	BR-12
Sample#	Riffle
Replicate #	
Date	5-Nov-15
Crew	AL
Taxonomist	KC
Bankfull	
% Sampled	17
Taxa	No
Coleoptera (Order) - Beetles	0
Chrysomelidae (Family)	0
Curculionidae (Family)	0
Dryopidae (Family)	0
Dytiscidae (Family)	0
Elmidae (Family)	40
Gyrinidae (Family)	0
Haliplidae (Family)	0
Hydraenidae (Family)	0
Hydrophilidae (Family)	0
Psephenidae (Family)	0
Scirtidae (Family)	0
Staphylinidae	0
Diptera (Order) - True Flies	0
Athericidae (Family)	0
Ceratopogonidae (Family)	0
Chaoboridae (Family)	0
Chironomidae (Family)	76
Culicidae (Family)	0
Dixidae (Family)	0
Empididae (Family)	1
Ephydridae (Family)	0
Muscidae (Family)	0
Phoridae (Family)	0
Psychodidae (Family)	0
Ptychopteridae (Family)	0
Sciomyzidae (Family)	0
Simuliidae (Family)	29
Stratiomyidae (Family)	0
Syrphildae (Family)	0
Tabanidae (Family)	0
Thaumaleidae (Family)	0
Tipulidae (Family)	9
Ephemeroptera (Order) - Mayflies	0
Ameletidae (Family)	0
Baetidae (Family)	8
Baetiscidae (Family)	0
Caenidae (Family)	0
Ephemerellidae (Family)	0
Ephemeridae (Family)	0
Heptageniidae (Family)	1
Isonychiidae (Family)	0
Leptohyphidae (Family)	0
Leptophlebiidae (Family)	3
Metretopodidae (Family)	0
Oligoneuriidae (Family)	0
Potamanthideae (Family)	0
Siphlonuridae (Family)	0
Tricorythidae (Family)	0
Hemiptera (Order) - Bugs	0
Belostomatidae (Family)	0
Corixidae (Family)	0
Gerridae (Family)	0
Hebridae (Family)	0
Nepidae (Family)	0
Notonectidae (Family)	0
Pleidae (Family)	0
Saldidae (Family)	0
Veliidae (Family)	0
Lepidoptera (Order) - Aquatic Moths	0
Crambidae (Family)	0
Pyralidae (Family)	0
Neuroptera (Order) - Net Winged Insects	0
Sisyridae (Family)	0
Megaloptera (Order) - Alderflies	0
Corydalidae (Family)	0
Sialidae (Family)	0
Odonata (Order) - Damselflies & Dragonflies	0
Zygoptera (Suborder) - Damselflies	0
Calopterygidae (Family)	0
Coenagrionidae (Family)	0
Lestidae (Family)	0
Anisoptera (Suborder) - Dragonflies	0
Aseshnidae (Family)	0
Cordulegasteridae (Family)	0
Corduliidae (Family)	0
Gomphidae (Family)	0
Libellulidae (Family)	0
Plecoptera (Order) - Stoneflies	0
Capniidae (Family)	0
Chloroperlidae (Family)	0
Leuctridae (Family)	0
Nemouridae (Family)	0
Perlidae (Family)	0
Perlodidae (Family)	0

Site	BR-12
Sample#	Riffle
Replicate #	
Date	5-Nov-15
Crew	AL
Taxonomist	KC
Bankfull	
% Sampled	17
Pteronarcyidae (Family)	0
Taeniopterygidae (Family)	0
Trichoptera (Order) - Caddisflies	0
Brachycentridae (Family)	0
Dipseudopsidae (Family)	0
Glossosomatidae (Family)	10
Goeridae (Family)	0
Helicopsychidae (Family)	3
Hydropsychidae (Family)	111
Hydroptilidae (Family)	0
Lepidostomatidae (Family)	0
Leptoceridae (Family)	1
Limnephilidae (Family)	1
Molannidae (Family)	0
Philopotamidae (Family)	16
Phryganeidae (Family)	0
Polycentropodidae (Family)	0
Psychomyiidae (Family)	0
Rhyacophilidae (Family)	0
Uenoidae (Family)	0
Amphipoda (Order) - Amphipods	0
Crangonyctidae (Family)	0
Gammaridae (Family)	0
Hyalellidae (Family)	0
Bivalvia (Class) - Bivalves	0
Dreisennidae (Family)	0
Dreissena polymorpha (Species)	0
Unionidae (Family)	0
Sphaeriidae (Pisidiidae) (Family)	1
Decapoda (Order) - Crayfishes	0
Cambaridae (Family)	0
Orconectes (Genus)	0
Orconectes propinquus (Species)	0
Orconectes rusticus (Species)	0
Orconectes virilis (Species)	0
Gastropoda (Class) - Snails	0
Ampullaridea (Family)	0
Ancylidae (Family)	0
Bithyniidae (Family)	0
Hydrobiidae (Family)	0
Lymnaeidae (Family)	0
Physidae (Family)	0
Planorbidae (Family)	0
Pleuroceridae (Family)	0
Valvatidae (Family)	0
Viviparidae (Family)	0
Hirudinea (Sub Class) - Leeches	0
Erpobdellidae (Family)	0
Glossiphonidae (Family)	0
Haemopidae (Family)	0
Hirudinidae (Family)	0
Piscicolidae (Family)	0
Isopoda (Order) - Isopods	0
Asellidae (Family)	1
Nemata (Phylum) - Roundworms	0
Adenophorea (Class)	0
Secernetea (Class)	0
Oligochaeta (Class) - Worms	0
Haplotaxida (Order)	0
Sparganophilidae (Family)	0
Lumbricida (Order)	0
Lumbricidae (Family)	0
Lumbriculida (Order)	0
Lumbriculidae (Family)	0
Tubificida (Order)	0
Enchytraeidae (Family)	0
Naididae (Family)	0
Turbellaria (Class)	0
Tricladida (Order) - Free Living Flatworms	1
Dugesiidae (Family)	0
Plagiostomidae (Family)	0
Planariidae (Family)	0
Trombidiformes (Order) - Mites	0
Arrenuridea (Family)	0
Hygrobatidea (Family)	0
Lebertiidea (Family)	0
Limnesiidae (Family)	0
Limnocharidae (Family)	0
Pionidae (Family)	0
Sperchonidae (Family)	0
Unionicolidae (Family)	0
Branchiobdellida (Order) - Maggot Sucker	0
Bryozoa (Phylum) - Moss Animals	0
Nematomorpha (Phylum) - Horsehair Worms	0
Nemertea (Phylum) - Ribbon Worms	0
Polychaeta (Class) - Bristle Worms	0
Porifera (Phylum) - Sponges	0

Site	BR-12
Sample#	Riffle
Replicate #	
Date	5-Nov-15
Crew	AL
Taxonomist	KC
Bankfull	
% Sampled	17
Hydrozoa (Class) - Hydra	0
Anthoathecata (Order)	0
Hydridae (Family)	0
Collembola (Class) - Springtails	0
Platyhelminthes (Phylum) - Flatworms	0
Coelenterata (unranked) - Comb Jellies/Coral Animals	0
Branchiopoda (Class)	0
Cladocera (Order)	0
Daphniidae (Family)	0
Daphnia (Genus)	0
Ostracoda (Class)	0
Unknown	0
Unknown	0
Unknown	0
Total Taxa	**17**
Number of individuals	**312**

Site	BR-12
Sample#	Riffle
Replicate #	
Date	5-Oct-16
Crew	RW
Taxonomist	KC
Bankfull	
% Sampled	15
Taxa	
Coleoptera (Order) - Beetles	0
Chrysomelidae (Family)	0
Curculionidae (Family)	0
Dryopidae (Family)	0
Dytiscidae (Family)	0
Elmidae (Family)	44
Gyrinidae (Family)	0
Haliplidae (Family)	0
Hydraenidae (Family)	0
Hydrophilidae (Family)	0
Psephenidae (Family)	0
Scirtidae (Family)	0
Staphylinidae	0
Diptera (Order) - True Flies	0
Athericidae (Family)	0
Ceratopogonidae (Family)	0
Chaoboridae (Family)	0
Chironomidae (Family)	8
Culicidae (Family)	0
Dixidae (Family)	0
Empididae (Family)	0
Ephydridae (Family)	0
Muscidae (Family)	0
Phoridae (Family)	0
Psychodidae (Family)	0
Ptychopteridae (Family)	0
Sciomyzidae (Family)	0
Simuliidae (Family)	0
Stratiomyidae (Family)	0
Syrphildae (Family)	0
Tabanidae (Family)	0
Thaumaleidae (Family)	0
Tipulidae (Family)	18
Ephemeroptera (Order) - Mayflies	0
Ameletidae (Family)	0
Baetidae (Family)	1
Baetiscidae (Family)	0
Caenidae (Family)	0
Ephemerellidae (Family)	0
Ephemeridae (Family)	0
Heptageniidae (Family)	0
Isonychiidae (Family)	0
Leptohyphidae (Family)	0
Leptophlebiidae (Family)	0
Metretopodidae (Family)	0
Oligoneuriidae (Family)	0
Potamanthideae (Family)	0
Siphlonuridae (Family)	0
Tricorythidae (Family)	0
Hemiptera (Order) - Bugs	0
Belostomatidae (Family)	0
Corixidae (Family)	0
Gerridae (Family)	0
Hebridae (Family)	0
Nepidae (Family)	0
Notonectidae (Family)	0
Pleidae (Family)	0
Saldidae (Family)	0
Veliidae (Family)	0
Lepidoptera (Order) - Aquatic Moths	0
Crambidae (Family)	0
Pyralidae (Family)	0
Neuroptera (Order) - Net Winged Insects	0
Sisyridae (Family)	0
Megaloptera (Order) - Alderflies	0
Corydalidae (Family)	1
Sialidae (Family)	0
Odonata (Order) - Damselflies & Dragonflies	0
Zygoptera (Suborder) - Damselflies	0
Calopterygidae (Family)	0
Coenagrionidae (Family)	0
Lestidae (Family)	0
Anisoptera (Suborder) - Dragonflies	0
Aseshnidae (Family)	0
Cordulegasteridae (Family)	0
Corduliidae (Family)	0
Gomphidae (Family)	0
Libellulidae (Family)	0
Plecoptera (Order) - Stoneflies	0
Capniidae (Family)	0
Chloroperlidae (Family)	0
Leuctridae (Family)	0
Nemouridae (Family)	0
Perlidae (Family)	0
Perlodidae (Family)	0

Site	BR-12
Sample#	Riffle
Replicate #	
Date	5-Oct-16
Crew	RW
Taxonomist	KC
Bankfull	
% Sampled	15
Pteronarcyidae (Family)	0
Taeniopterygidae (Family)	0
Trichoptera (Order) - Caddisflies	0
Apataniidae (Family)	0
Brachycentridae (Family)	0
Dipseudopsidae (Family)	0
Glossosomatidae (Family)	0
Goeridae (Family)	0
Helicopsychidae (Family)	3
Hydropsychidae (Family)	186
Hydroptilidae (Family)	0
Lepidostomatidae (Family)	0
Leptoceridae (Family)	0
Limnephilidae (Family)	1
Molannidae (Family)	0
Philopotamidae (Family)	33
Phryganeidae (Family)	0
Polycentropodidae (Family)	0
Psychomyiidae (Family)	2
Rhyacophilidae (Family)	0
Uenoidae (Family)	0
Amphipoda (Order) - Amphipods	0
Crangonyctidae (Family)	0
Gammaridae (Family)	1
Hyalellidae (Family)	0
Bivalvia (Class) - Bivalves	0
Dreisennidae (Family)	0
Dreissena polymorpha (Species)	0
Unionidae (Family)	0
Sphaeriidae (Pisidiidae) (Family)	0
Decapoda (Order) - Crayfishes	0
Cambaridae (Family)	0
Orconectes (Genus)	0
Orconectes propinquus (Species)	0
Orconectes rusticus (Species)	1
Orconectes virilis (Species)	0
Gastropoda (Class) - Snails	0
Ampullaridea (Family)	0
Ancylidae (Family)	0
Bithyniidae (Family)	0
Hydrobiidae (Family)	0
Lymnaeidae (Family)	0
Physidae (Family)	0
Planorbidae (Family)	0
Pleuroceridae (Family)	0
Valvatidae (Family)	0
Viviparidae (Family)	0
Hirudinea (Sub Class) - Leeches	0
Erpobdellidae (Family)	0
Glossiphonidae (Family)	0
Haemopidae (Family)	0
Hirudinidae (Family)	0
Piscicolidae (Family)	0
Isopoda (Order) - Isopods	0
Asellidae (Family)	1
Nemata (Phylum) - Roundworms	0
Adenophorea (Class)	0
Secernetea (Class)	0
Oligochaeta (Class) - Worms	0
Haplotaxida (Order)	0
Sparganophilidae (Family)	0
Lumbricida (Order)	0
Lumbricidae (Family)	0
Lumbriculida (Order)	0
Lumbriculidae (Family)	0
Tubificida (Order)	0
Enchytraeidae (Family)	0
Naididae (Family)	0
Turbellaria (Class)	0
Tricladida (Order) - Free Living Flatworms	3
Dugesiidae (Family)	0
Plagiostomidae (Family)	0
Planariidae (Family)	0
Trombidiformes (Order) - Mites	0
Arrenuridea (Family)	0
Hygrobatidea (Family)	0
Lebertiidea (Family)	0
Limnesiidae (Family)	0
Limnocharidae (Family)	0
Pionidae (Family)	0
Sperchonidae (Family)	0
Unionicolidae (Family)	0
Branchiobdellida (Order) - Maggot Sucker	0
Bryozoa (Phylum) - Moss Animals	0
Nematomorpha (Phylum) - Horsehair Worms	0
Nemertea (Phylum) - Ribbon Worms	0
Polychaeta (Class) - Bristle Worms	0

Site	BR-12
Sample#	Riffle
Replicate #	
Date	5-Oct-16
Crew	RW
Taxonomist	KC
Bankfull	
% Sampled	15
Porifera (Phylum) - Sponges	0
Hydrozoa (Class) - Hydra	0
Anthoathecata (Order)	0
Hydridae (Family)	0
Collembola (Class) - Springtails	0
Platyhelminthes (Phylum) - Flatworms	0
Coelenterata (unranked) - Comb Jellies/Coral Animals	0
Branchiopoda (Class)	0
Cladocera (Order)	0
Daphniidae (Family)	0
Daphnia (Genus)	0
Ostracoda (Class)	0
Delphacidae (Family)	0
Lutrachidae (Family)	0
Staphylinidae (Family)	0
Total Taxa	**14**
Number of individuals	**303**

Site	BR-12
Sample#	Riffle
Date	25-Oct-17
Crew	KC
Taxonomist	KC
% Sampled	30
Taxa	No
Coleoptera (Order) - Beetles	0
Chrysomelidae (Family)	0
Curculionidae (Family)	0
Dryopidae (Family)	0
Dytiscidae (Family)	0
Elmidae (Family)	58
Gyrinidae (Family)	0
Haliplidae (Family)	0
Hydraenidae (Family)	0
Hydrophilidae (Family)	0
Psephenidae (Family)	0
Scirtidae (Family)	0
Staphylinidae	0
Diptera (Order) - True Flies	0
Athericidae (Family)	0
Ceratopogonidae (Family)	0
Chaoboridae (Family)	0
Chironomidae (Family)	24
Culicidae (Family)	0
Dixidae (Family)	0
Empididae (Family)	0
Ephydridae (Family)	0
Muscidae (Family)	0
Phoridae (Family)	1
Psychodidae (Family)	0
Ptychopteridae (Family)	0
Sciomyzidae (Family)	0
Simuliidae (Family)	2
Stratiomyidae (Family)	0
Syrphildae (Family)	0
Tabanidae (Family)	0
Thaumaleidae (Family)	0
Tipulidae (Family)	0
Ephemeroptera (Order) - Mayflies	0
Ameletidae (Family)	0
Baetidae (Family)	10
Baetiscidae (Family)	0
Caenidae (Family)	0
Ephemerellidae (Family)	1
Ephemeridae (Family)	0
Heptageniidae (Family)	1
Isonychiidae (Family)	0
Leptohyphidae (Family)	0
Leptophlebiidae (Family)	3
Metretopodidae (Family)	0
Oligoneuriidae (Family)	0
Potamanthideae (Family)	0
Siphlonuridae (Family)	0
Tricorythidae (Family)	0
Hemiptera (Order) - Bugs	0
Belostomatidae (Family)	0
Corixidae (Family)	0
Gerridae (Family)	0
Hebridae (Family)	0
Nepidae (Family)	0
Notonectidae (Family)	0
Pleidae (Family)	0
Saldidae (Family)	0
Veliidae (Family)	0
Lepidoptera (Order) - Aquatic Moths	0
Crambidae (Family)	0
Pyralidae (Family)	0
Neuroptera (Order) - Net Winged Insects	0
Sisyridae (Family)	0
Megaloptera (Order) - Alderflies	0
Corydalidae (Family)	0
Sialidae (Family)	0
Odonata (Order) - Damselflies & Dragonflies	0
Zygoptera (Suborder) - Damselflies	0
Calopterygidae (Family)	0
Coenagrionidae (Family)	0
Lestidae (Family)	0
Anisoptera (Suborder) - Dragonflies	0
Aeshnidae (Family)	0
Cordulegasteridae (Family)	0
Corduliidae (Family)	0
Gomphidae (Family)	0
Libellulidae (Family)	0
Plecoptera (Order) - Stoneflies	0
Capniidae (Family)	0
Chloroperlidae (Family)	0
Leuctridae (Family)	0
Nemouridae (Family)	0
Perlidae (Family)	0
Perlodidae (Family)	0
Pteronarcyidae (Family)	0
Taeniopterygidae (Family)	1

Site	BR-12
Sample#	Riffle
Date	25-Oct-17
Crew	KC
Taxonomist	KC
% Sampled	30
Taxa	No
Trichoptera (Order) - Caddisflies	0
Apataniidae (Family)	0
Brachycentridae (Family)	0
Dipseudopsidae (Family)	0
Glossosomatidae (Family)	1
Goeridae (Family)	0
Helicopsychidae (Family)	1
Hydropsychidae (Family)	127
Hydroptilidae (Family)	0
Lepidostomatidae (Family)	0
Leptoceridae (Family)	0
Limnephilidae (Family)	3
Molannidae (Family)	0
Philopotamidae (Family)	36
Phryganeidae (Family)	0
Polycentropodidae (Family)	0
Psychomyiidae (Family)	0
Rhyacophilidae (Family)	0
Uenoidae (Family)	1
Amphipoda (Order) - Amphipods	0
Crangonyctidae (Family)	0
Gammaridae (Family)	0
Hyalellidae (Family)	0
Bivalvia (Class) - Bivalves	0
Dreisennidae (Family)	0
Dreissena polymorpha (Species)	0
Unionidae (Family)	0
Sphaeriidae (Pisidiidae) (Family)	2
Decapoda (Order) - Crayfishes	0
Cambaridae (Family)	0
Orconectes (Genus)	0
Orconectes propinquus (Species)	0
Orconectes rusticus (Species)	0
Orconectes virilis (Species)	0
Gastropoda (Class) - Snails	0
Ampullaridea (Family)	0
Ancylidae (Family)	0
Bithyniidae (Family)	0
Hydrobiidae (Family)	0
Lymnaeidae (Family)	0
Physidae (Family)	0
Planorbidae (Family)	0
Pleuroceridae (Family)	0
Valvatidae (Family)	0
Viviparidae (Family)	0
Hirudinea (Sub Class) - Leeches	0
Erpobdellidae (Family)	0
Glossiphonidae (Family)	0
Haemopidae (Family)	0
Hirudinidae (Family)	0
Piscicolidae (Family)	0
Isopoda (Order) - Isopods	0
Asellidae (Family)	6
Nemata (Phylum) - Roundworms	0
Adenophorea (Class)	0
Secernetea (Class)	0
Oligochaeta (Class) - Worms	31
Haplotaxida (Order)	0
Sparganophilidae (Family)	0
Lumbricida (Order)	0
Lumbricidae (Family)	0
Lumbriculida (Order)	0
Lumbriculidae (Family)	0
Tubificida (Order)	0
Enchytraeidae (Family)	0
Naididae (Family)	0
Turbellaria (Class)	0
Tricladida (Order) - Free Living Flatworms	5
Dugesiidae (Family)	0
Plagiostomidae (Family)	0
Planariidae (Family)	0
Trombidiformes (Order) - Mites	0
Arrenuridea (Family)	0
Hygrobatidea (Family)	0
Lebertiidea (Family)	0
Limnesiidae (Family)	0
Limnocharidae (Family)	0
Pionidae (Family)	0
Sperchonidae (Family)	0
Unionicolidae (Family)	0
Branchiobdellida (Order) - Maggot Sucker	0
Bryozoa (Phylum) - Moss Animals	0
Nematomorpha (Phylum) - Horsehair Worms	0
Nemertea (Phylum) - Ribbon Worms	0
Polychaeta (Class) - Bristle Worms	0
Porifera (Phylum) - Sponges	0
Hydrozoa (Class) - Hydra	0

Site	BR-12
Sample#	Riffle
Date	25-Oct-17
Crew	KC
Taxonomist	KC
% Sampled	30
Taxa	No
Anthoathecata (Order)	0
Hydridae (Family)	0
Collembola (Class) - Springtails	0
Platyhelminthes (Phylum) - Flatworms	0
Coelenterata (unranked) - Comb Jellies/Coral Animals	0
Branchiopoda (Class)	0
Cladocera (Order)	0
Daphniidae (Family)	0
Daphnia (Genus)	0
Ostracoda (Class)	0
Delphacidae (Family)	0
Lutrachidae (Family)	0
Staphylinidae (Family)	0
Total Taxa	**19**
Number of individuals	**314**

Site	BR-12
Sample#	Riffle
Date	27-Sep-18
Crew	RW
Taxonomist	RB
% Sampled	92

Taxa	No
Coleoptera (Order) - Beetles	0
Chrysomelidae (Family)	0
Curculionidae (Family)	0
Dryopidae (Family)	0
Dytiscidae (Family)	0
Elmidae (Family)	32
Gyrinidae (Family)	0
Haliplidae (Family)	0
Hydraenidae (Family)	0
Hydrophilidae (Family)	0
Psephenidae (Family)	0
Scirtidae (Family)	0
Staphylinidae	0
Diptera (Order) - True Flies	0
Athericidae (Family)	0
Ceratopogonidae (Family)	0
Chaoboridae (Family)	0
Chironomidae (Family)	67
Culicidae (Family)	0
Dixidae (Family)	0
Empididae (Family)	0
Ephydridae (Family)	0
Muscidae (Family)	0
Phoridae (Family)	0
Psychodidae (Family)	0
Ptychopteridae (Family)	0
Sciomyzidae (Family)	0
Simuliidae (Family)	0
Stratiomyidae (Family)	0
Syrphildae (Family)	0
Tabanidae (Family)	0
Thaumaleidae (Family)	0
Tipulidae (Family)	17
Ephemeroptera (Order) - Mayflies	0
Ameletidae (Family)	0
Baetidae (Family)	10
Baetiscidae (Family)	0
Caenidae (Family)	0
Ephemerellidae (Family)	0
Ephemeridae (Family)	0
Heptageniidae (Family)	7
Isonychiidae (Family)	0
Leptohyphidae (Family)	0
Leptophlebiidae (Family)	0
Metretopodidae (Family)	0
Oligoneuriidae (Family)	0
Potamanthideae (Family)	0
Siphlonuridae (Family)	0
Tricorythidae (Family)	0
Hemiptera (Order) - Bugs	0
Belostomatidae (Family)	0
Corixidae (Family)	0
Gerridae (Family)	0
Hebridae (Family)	0
Nepidae (Family)	0
Notonectidae (Family)	0
Pleidae (Family)	0
Saldidae (Family)	0
Veliidae (Family)	0
Lepidoptera (Order) - Aquatic Moths	0
Crambidae (Family)	0
Pyralidae (Family)	0
Neuroptera (Order) - Net Winged Insects	0
Sisyridae (Family)	0
Megaloptera (Order) - Alderflies	0
Corydalidae (Family)	0
Sialidae (Family)	0
Odonata (Order) - Damselflies & Dragonflies	0
Zygoptera (Suborder) - Damselflies	0
Calopterygidae (Family)	1
Coenagrionidae (Family)	0
Lestidae (Family)	0
Anisoptera (Suborder) - Dragonflies	0
Aseshnidae (Family)	0
Cordulegasteridae (Family)	0
Corduliidae (Family)	0
Gomphidae (Family)	0
Libellulidae (Family)	0
Plecoptera (Order) - Stoneflies	0
Capniidae (Family)	0
Chloroperlidae (Family)	0
Leuctridae (Family)	0
Nemouridae (Family)	0
Perlidae (Family)	0
Perlodidae (Family)	0
Pteronarcyidae (Family)	0
Taeniopterygidae (Family)	0

Site	BR-12
Sample#	Riffle
Date	27-Sep-18
Crew	RW
Taxonomist	RB
% Sampled	92
Taxa	No
Trichoptera (Order) - Caddisflies	0
Apataniidae (Family)	0
Brachycentridae (Family)	0
Dipseudopsidae (Family)	0
Glossosomatidae (Family)	0
Goeridae (Family)	0
Helicopsychidae (Family)	22
Hydropsychidae (Family)	77
Hydroptilidae (Family)	0
Lepidostomatidae (Family)	0
Leptoceridae (Family)	0
Limnephilidae (Family)	9
Molannidae (Family)	0
Philopotamidae (Family)	0
Phryganeidae (Family)	0
Polycentropodidae (Family)	0
Psychomyiidae (Family)	1
Rhyacophilidae (Family)	0
Uenoidae (Family)	0
Amphipoda (Order) - Amphipods	0
Crangonyctidae (Family)	0
Gammaridae (Family)	0
Hyalellidae (Family)	0
Bivalvia (Class) - Bivalves	0
Dreisennidae (Family)	0
Dreissena polymorpha (Species)	0
Unionidae (Family)	0
Sphaeriidae (Pisidiidae) (Family)	0
Decapoda (Order) - Crayfishes	0
Cambaridae (Family)	0
Orconectes (Genus)	0
Orconectes propinquus (Species)	0
Orconectes rusticus (Species)	1
Orconectes virilis (Species)	0
Gastropoda (Class) - Snails	0
Ampullaridea (Family)	0
Ancylidae (Family)	0
Bithyniidae (Family)	0
Hydrobiidae (Family)	0
Lymnaeidae (Family)	0
Physidae (Family)	12
Planorbidae (Family)	0
Pleuroceridae (Family)	0
Valvatidae (Family)	0
Viviparidae (Family)	0
Hirudinea (Sub Class) - Leeches	0
Erpobdellidae (Family)	0
Glossiphonidae (Family)	0
Haemopidae (Family)	0
Hirudinidae (Family)	0
Piscicolidae (Family)	0
Isopoda (Order) - Isopods	0
Asellidae (Family)	0
Nemata (Phylum) - Roundworms	0
Adenophorea (Class)	0
Secernetea (Class)	0
Oligochaeta (Class) - Worms	45
Haplotaxida (Order)	0
Sparganophilidae (Family)	0
Lumbricida (Order)	0
Lumbricidae (Family)	0
Lumbriculida (Order)	0
Lumbriculidae (Family)	0
Tubificida (Order)	0
Enchytraeidae (Family)	0
Naididae (Family)	0
Turbellaria (Class)	0
Tricladida (Order) - Free Living Flatworms	0
Dugesiidae (Family)	0
Plagiostomidae (Family)	0
Planariidae (Family)	0
Trombidiformes (Order) - Mites	2
Arrenuridea (Family)	0
Hygrobatidea (Family)	0
Lebertiidea (Family)	0
Limnesiidae (Family)	0
Limnocharidae (Family)	0
Pionidae (Family)	0
Sperchonidae (Family)	0
Unionicolidae (Family)	0
Branchiobdellida (Order) - Maggot Sucker	0
Bryozoa (Phylum) - Moss Animals	0
Nematomorpha (Phylum) - Horsehair Worms	0
Nemertea (Phylum) - Ribbon Worms	0
Polychaeta (Class) - Bristle Worms	0
Porifera (Phylum) - Sponges	0
Hydrozoa (Class) - Hydra	0

Site	BR-12
Sample#	Riffle
Date	27-Sep-18
Crew	RW
Taxonomist	RB
% Sampled	92
Taxa	No
Anthoathecata (Order)	0
Hydridae (Family)	0
Collembola (Class) - Springtails	0
Platyhelminthes (Phylum) - Flatworms	0
Coelenterata (unranked) - Comb Jellies/Coral Animals	0
Branchiopoda (Class)	0
Cladocera (Order)	0
Daphniidae (Family)	1
Daphnia (Genus)	0
Ostracoda (Class)	0
Delphacidae (Family)	0
Lutrachidae (Family)	0
Staphylinidae (Family)	0
Total Taxa	**15**
Number of individuals	**304**

Appendix B

Water Quality Data and Comparisons

Table B-1 Comparison of Natural Water Quality to Provincial Water Quality Objectives

Parameter	Unit	PWQO[1]	Mount Albert Creek					Vivian Creek							Comparison of Natural Waters to PWQO
			Summary Statistics Station 03007702102					York Region Station MTA SWA				York Region Station MTA SWB			
			Median	75th percentile	Range	Collection Period	n[5]	Nov 26, 2018	Mar 15, 2019	Apr 25, 2019	May 3, 2019	Nov 26, 2018	Mar 4, 2019	Mar 15, 2019	
Alkalinity	mg/L-$CaCO_3$	Alkalinity should not be decreased by more than 25% of the natural concentration.	191	203	66.4-220	Mar 2003-Dec 2018	81	-	105	196	191	-	-	106	N/A
Aluminum	mg/L	At pH >6.5 to 9.0, the Interim PWQO is 0.075 mg/L based on total aluminum measured in clay-free samples. If natural background aluminum concentrations in water bodies unaffected by man-made inputs are greater than the numerical Interim PWQO (above), no condition is permitted that would increase the aluminum concentration in clay-free samples by more than 10% of the natural background level.	0.0633	0.13625	0.00802-3.080	Mar 2003-Nov 2018	71	0.396	7.08	0.153	1.97	0.181	0.0637	5.86	75th percentile of concentrations measured at Mount Albert Creek and most measurements taken on Vivian Creek are above the Interim PWQO.
Total Ammonia	mg/L-N	-	0.045	0.079	0.003-0.386	Mar 2003-Dec 2018	81	0.1	0.72	<0.62	<0.5	0.15	0.09	0.80	No PWQO
Ammonia (un-ionized)[2]	*mg/L-N*	0.020	*0.0009*	*0.0015*	*0.0001-0.0070*		*77*	*0.006*	*0.001*	[3]	[3]	*0.014*		*0.002*	Below the PWQO
Antimony	µg/L	20 (Interim PWQO)	-	-	-	-	-	0.5	<50	<50	<50	0.6	0.6	<50	Below the PWQO
Arsenic	µg/L	100 (PWQO) 5 (Interim PWQO)	-	-	-	-	-	0.5	<5	<5	<5	<0.5	<0.5	<5	Below the PWQO
Barium	µg/L	-	51.65	55.175	19.6-95.3	Mar 2003-Nov 2018	72	-	-	-	-	-	-	-	No PWQO
Beryllium	µg/L	Hardness <75 mg/L-$CaCO_3$: 11 (PWQO) Hardness >75 mg/L-$CaCO_3$: 1100 (PWQO)	0.0218	0.0492	0.00198-0.322	Mar 2003-Nov 2018	42	-	-	-	-	-	-	-	Below the PWQO
Bicarbonate	mg/L	-	-	-	-	-	-	-	105	196	191	-	-	106	No PWQO
Bismuth	µg/L	-	1.4	2.0	0.0612-2.37	Apr 2014-Oct 2017	12	-	-	-	-	-	-	-	No PWQO
BOD, 5-day, total demand	mg/L	-	1.6	N/A	1.6-1.6	May 2003-May 2003	1	-	-	-	-	-	-	-	No PWQO
Bromide	mg/L-Br	-	-	-	-	-	-	-	-	<1.25	<1	-	-	-	No PWQO
Cadmium	µg/L	0.2 (PWQO) Hardness 0-100 mg/L-$CaCO_3$: 0.1 (Interim PWQO) Hardness >100 mg/L-$CaCO_3$: 0.5 (Interim PWQO)	0.555	1.34	0.0264-2.46	Mar 2003-Nov 2018	59	<0.5	<3	<3	<3	<0.5	<0.5	<3	Median, 75th percentile, and maximum concentrations are above the PWQO and interim PWQO.
Calcium	mg/L	-	71	77.4	22.1-92.1	Mar 2003-Nov 2018	93	-	41.8	89.6	81.8	-	-	42.8	No PWQO
Chloride	mg/L	-	45.6	53.6	0.6-172	Mar 2003-Dec 2018	82	51.2	25.2	35	34.3	39.9	40	27.6	No PWQO
Chromium	µg/L	Hexavalent chromium (Cr VI): 1 (PWQO) Trivalent chromium (Cr III): 8.9 (PWQO)	0.55	0.99	0.01-3.4	Mar 2003-Nov 2018	47	<0.5	<20	<20	<20	<0.5	<0.5	<20	Median and 75th percentile are below the PWQOs. Chromium oxidation state not measured – unknown whether maximum values exceed the PWQO.

Table B-1 Comparison of Natural Water Quality to Provincial Water Quality Objectives

Parameter	Unit	PWQO[1]	Mount Albert Creek					Vivian Creek							Comparison of Natural Waters to PWQO
			Summary Statistics Station 03007702102					York Region Station MTA SWA				York Region Station MTA SWB			
			Median	75th percentile	Range	Collection Period	n[5]	Nov 26, 2018	Mar 15, 2019	Apr 25, 2019	May 3, 2019	Nov 26, 2018	Mar 4, 2019	Mar 15, 2019	
Cobalt	µg/L	0.9 (Interim PWQO)	0.4275	0.68425	0.0708-2.95	Mar 2003-Nov 2018	52	<0.5	<50	<50	<50	<0.5	<0.5	<50	Median and 75th percentile values measured at Mount Albert Creek are below the Interim PWQO.
Conductivity, 25C	µS/cm	-	562	609.5	189-996	Mar 2003-Dec 2018	81	-	-	-	-	-	-	-	No PWQO
Conductivity, Ambient	µmho/cm	-	563	594.75	191-719	Mar 2003-Dec 2018	86	-	-	-	-	-	-	-	No PWQO
Copper	µg/L	Hardness 0-20 mg/L-$CaCO_3$: 1 (Interim PWQO) Hardness >20 mg/L-$CaCO_3$: 5 (Interim PWQO)	1.2	1.65	0.0467-9.29	Mar 2003-Nov 2018	69	1.1	<20	<20	<20	0.7	<0.5	<20	Median and 75th percentile values measured at Mount Albert Creek are below the Interim PWQO. York Region measurement for Vivian Creek on November 26, 2018 below the Interim PWQO.
Dissolved Oxygen	mg/L	Dissolved oxygen concentrations should not be less than the values specified below for cold and warm water biota:[6]	10.775	12.47	0.1-14.35	Apr 2003-Dec 2018	82	-	-	-	-	-	-	-	Median and 75th percentile values measured at Mount Albert Creek are better than the PWQO for cold-water biota.
Fluoride	mg/L	-	-	-	-	-	-	-	-	<0.12	<0.1	-	-	-	No PWQO
Hardness	mg/L-$CaCO_3$	-	236.5	249.75	98.6-288	Mar 2003-Nov 2018	74	-	122	258	234	-	-	125	No PWQO
Iron (Total)	mg/L	0.300 (Interim PWQO)	0.254	0.40975	0.121-2.250	Mar 2003-Nov 2018	72	0.417	6.060	0.195	1.94	0.232	0.106	5.220	75th percentile values measured at Mount Albert Creek exceed the Interim PWQO. York Region measurements for Vivian Creek exceed the Interim PWQO, except for November 26, 2018 at SWA and November 26, 2018 and March 4, 2019 at SWB. Concentrations collected from Vivian Creek by York Region during March are substantially higher than the maximum concentration observed at Mount Albert Creek.

Table B-1 Comparison of Natural Water Quality to Provincial Water Quality Objectives

Parameter	Unit	PWQO[1]	Mount Albert Creek					Vivian Creek							Comparison of Natural Waters to PWQO
			Summary Statistics Station 03007702102					York Region Station MTA SWA				York Region Station MTA SWB			
			Median	75th percentile	Range	Collection Period	n[5]	Nov 26, 2018	Mar 15, 2019	Apr 25, 2019	May 3, 2019	Nov 26, 2018	Mar 4, 2019	Mar 15, 2019	
Lead	µg/L	Alkalinity <20 mg/L-$CaCO_3$: 5 (PWQO) Alkalinity 20-40 mg/L-$CaCO_3$: 10 (PWQO) Alkalinity 40-80 mg/L-$CaCO_3$: 20 (PWQO) Alkalinity >80 mg/L- $CaCO_3$: 25 (PWQO) Hardness <30 mg/L-$CaCO_3$: 1 (Interim PWQO) Hardness 30-80 mg/L-$CaCO_3$: 3 (Interim PWQO) Hardness >80 mg/L-$CaCO_3$: 5 (Interim PWQO)	2.5	4.25	0.364-10.7	Apr 2003-Oct 2017	27	0.8	<20	-	-	<0.5	<0.5	<20	All values meet the PWQO. The median and 75th percentile meet the Interim PWQO.
Lithium	µg/L	-	4.49	7.57	0.04-39	Apr 2013-Nov 2018	31	-	-	-	-	-	-	-	No PWQO
Manganese (Total)	mg/L	-	0.05425	0.077075	0.0137-0.472	Mar 2003-Nov 2018	72	0.0958	0.312	0.025	0.103	0.0575	0.0339	0.241	No PWQO
Magnesium	mg/L	-	12.5	14	3-17.5	Mar 2003-Nov 2018	92	-	4.28	8.39	7.25	-	-	4.35	No PWQO
Molybdenum	µg/L	40 (Interim PWQO)	0.9615	1.2725	0.01-2.91	Jun 2003-Nov 2018	58	<2.5	<50	<50	<50	<2.5	<2.5	<50	All values meet the Interim PWQO.
Nickel	µg/L	25 (PWQO)	0.311	0.9095	0.011-2.97	Mar 2003-Aug 2013	29	<0.5	<20	<20	<20	<0.5	<0.5	<20	All values meet the Interim PWQO.
Nitrates	mg/L-N	-	1.14	1.445	0.363-4.95	Mar 2003-Dec 2018	81	-	1.69	3.04	2.66	-	4.52	1.66	No PWQO
Nitrite	mg/L-N	-	0.016	0.021	0-0.092	Mar 2003-Dec 2018	82	-	0.0019	<0.12	<0.1	-	0.019	0.02	No PWQO
pH	-	6.5-8.5	8.26	8.36	7.27-8.66	Mar 2003-Dec 2018	81	7.9	7.6	8.2	8.0	8	8.2	7.6	Median and 75th percentile are within the PWQO pH range for Mount Albert Creek/ All values are within the pH range for Vivian Creek.
pH Field	-	6.5-8.5	7.88	8.05	7.01-8.68	Mar 2003-Dec 2018	85	8.78	7.42	-	-	9.05	-	7.52	All values, except measurements at York Region sampling locations SWA and SWB on November 26, 2018 are within the PWQO pH range.
Phenols	mg/L	0.001 (PWQO) Determined by the total reactive phenols test - the 4-AAP (4-amino-antipyrine) test. This objective should be used primarily as a screening tool. The isomer specific PWQOs for various phenolics should be employed where possible.	-	-	-	-	-	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	All measurements were below the reporting limit. It is presumed that the concentrations meet the PWQO; however, however, the reporting limit is above the PWQO.
Phosphate (Filtered)	mg/L-P	-	0.0171	0.0341	0-0.186	Mar 2003-Dec 2018	82	-	0.343	<0.12	<0.1	-	0.026	0.314	No PWQO for phosphate specifically. See PWQO for total phosphorus.

Table B-1 Comparison of Natural Water Quality to Provincial Water Quality Objectives

Parameter	Unit	PWQO[1]	Mount Albert Creek					Vivian Creek							Comparison of Natural Waters to PWQO
			Summary Statistics Station 03007702102					York Region Station MTA SWA				York Region Station MTA SWB			
			Median	75th percentile	Range	Collection Period	n[5]	Nov 26, 2018	Mar 15, 2019	Apr 25, 2019	May 3, 2019	Nov 26, 2018	Mar 4, 2019	Mar 15, 2019	
Phosphorus (Total)	mg/L-P	Interim PWQO: The following phosphorus concentrations should be considered as general guidelines which should be supplemented by site-specific studies: • To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L; • A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 µg/L or less. This should apply to all lakes naturally below this value; • Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 µg/L.	0.045	0.068	0.015-0.52	Mar 2003-Dec 2018	115	0.202	1.12	0.046	0.242	0.116	0.046	0.925	The current water quality for total phosphorus does not meet the general guidelines specified in the Interim PWQO.
Potassium	mg/L	-	2.3	2.75	1.14-5.85	Mar 2003-Nov 2018	59	-	7.47	2.07	5.31	-	-	7.88	No PWQO
Selenium	µg/L	100 (PWQO)	-	-	-	-	-	<0.5	<10	<10	<10	<0.5	<0.5	<10	All values are below the PWQO
Silver	µg/L	0.1 (PWQO)	1.1	1.46	0.518-3.01	Mar 2013-Oct 2018	11	-	-	-	-				All values are above the PWQO.
Sodium	mg/L	-	26.1	28.9	7.32-35.1	Mar 2003-Nov 2018	59	-	13.7	17.8	19.7	-	-	15	No PWQO
Strontium	µg/L	-	198	204	54.2-237	Mar 2003-Nov 2018	72	-	-	-	-	-	-	-	No PWQO
Sulfate	mg/L-SO4	-	26.6	30.9	24.4-31.1	Oct 2004-Jun 2007	7	-	-	20.1	16.5	-	-	-	No PWQO

Table B-1 Comparison of Natural Water Quality to Provincial Water Quality Objectives

Parameter	Unit	PWQO[1]	Mount Albert Creek					Vivian Creek							Comparison of Natural Waters to PWQO
			Summary Statistics Station 03007702102					York Region Station MTA SWA				York Region Station MTA SWB			
			Median	75th percentile	Range	Collection Period	n[5]	Nov 26, 2018	Mar 15, 2019	Apr 25, 2019	May 3, 2019	Nov 26, 2018	Mar 4, 2019	Mar 15, 2019	
Temperature	°C	PWQO: *General:* The natural thermal regime of any body of water shall not be altered so as to impair the quality of the natural environment. In particular, the diversity, distribution and abundance of plant and animal life shall not be significantly changed. Waste Heat Discharge: a. Ambient Temperature Changes The temperature at the edge of a mixing zone shall not exceed the natural ambient water temperature at a representative control location by more than 10°C (18°F). However, in special circumstances, local conditions may require a significantly lower temperature difference than 10°C (18°F). Potential dischargers are to apply to the MOEE for guidance as to the allowable temperature rise for each thermal discharge. This ministry will also specify the nature of the mixing zone and the procedure for the establishment of a representative control location for temperature recording on a case-by-case basis. b. Discharge Temperature Permitted The maximum temperature of the receiving body of water, at any point in the thermal plume outside a mixing zone, shall not exceed 30 °C (86 °F) or the temperature of a representative control location plus 10°C (18°F) or the allowed temperature difference, which ever is the lesser temperature. These maximum temperatures are to be measured on a mean daily basis from continuous records. c. Taking and Discharging of Cooling Water Users of cooling water shall meet both the Objectives for temperature outlined above and the "Procedures for the Taking and Discharge of Cooling Water" as outlined in the MOEE publication Deriving Receiving-Water Based, Point-Source Effluent Requirements for Ontario Waters (1994).	12.4	19.775	0-24.7	Mar 2003-Dec 2018	86	2.2	-0.2	-	-	1.2		0.2	N/A
Tin	µg/L	-	1.06	4.6	0.569-5.14	Mar 2013-Jul 2015	5	-	-	-	-	-	-	-	No PWQO
Titanium	µg/L	-	2.17	4.14	0.0977-15.7	Mar 2003-Nov 2018	71	-	-	-	-	-	-	-	No PWQO
TKN	mg/L	-	0.77	0.925	0.23-1.73	Mar 2003-Apr 2015	47	-	3.87	0.57	1.26	-	0.47	3.68	No PWQO

Table B-1 Comparison of Natural Water Quality to Provincial Water Quality Objectives

Parameter	Unit	PWQO[1]	Mount Albert Creek – Summary Statistics Station 03007702102					Vivian Creek – York Region Station MTA SWA				Vivian Creek – York Region Station MTA SWB			Comparison of Natural Waters to PWQO
			Median	75th percentile	Range	Collection Period	n[5]	Nov 26, 2018	Mar 15, 2019	Apr 25, 2019	May 3, 2019	Nov 26, 2018	Mar 4, 2019	Mar 15, 2019	
Total Suspended Solids	mg/L	-	-	-	-	-	-	76.5	395	8.7	119	26.8	12.5	230	No PWQO
Turbidity	FTU/ NTU[4]	Suspended matter should not be added to surface water in concentrations that will change the natural Secchi disc reading by more than 10%. (PWQO)	5.06	13.82	1.56-27.3	Mar 2003-Sep 2006	9	-	-	-	-	-	-	-	N/A
Turbidity, Field	FTU/ NTU[4]	Suspended matter should not be added to surface water in concentrations that will change the natural Secchi disc reading by more than 10%. (PWQO)	2.5	5.4	0-16.7	Jan 2017-Dec 2018	19	70 (NTU)	166 (NTU)	-	-	34	-	159	N/A
Vanadium	µg/L	6	0.669	1.7	0.0738-8.92	Mar 2003-Nov 2018	71	-	-	-	-	-	-	-	Median and 75th percentile are below the PWQOs.
Zinc	µg/L	30 (PWQO) 20 (Interim PWQO)	8.96	12.45	0.114-44.7	Mar 2003-Nov 2018	72	3.6	37	<5	9	1.8	<1	30	Median and 75th percentile of samples collected at Mount Albert Creek below the PWQO and Interim PWQO. Some values above the PWQO and Interim PWQO were observed both in Mount Albert Creek and Vivian Creek.
Zirconium	µg/L	4 (Interim PWQO)	0.237	0.32525	0.133-0.326	Mar 2013-Apr 2015	4	-	-	-	-	-	-	-	All values are below the PWQO.

Notes:

1. Relevant PWQOs for the water quality parameters that were measured are taken or summarized from MECP (2019a). See MECP for full PWQOs for each of these parameters.
2. Unionized ammonia concentrations calculated using the calculations from Emerson et al. (1975), as noted in MECP (2019), using the measured pH and temperature
3. Temperature data were not available on this sampling day. Unionized ammonia concentration could not be calculated
4. Mount Albert Creek measurements reported as Formazin Turbidity Units. York Region results reported as Nephelometric Turbidity Units
5. Number of samples
6. In waters inhabited by sensitive biological communities, or in situations where additional physical or chemical stressors are operating, more stringent criteria may be required. In some hypolimnetic waters, dissolved oxygen is naturally lower than the concentrations specified in the above table. Such a condition should not be altered by adding oxygen demanding materials causing a depletion of oxygen.

Temp. °C	Cold-Water Biota: % Saturation	Cold-Water Biota: mg/L	Warm-Water Biota: % Saturation	Warm-Water Biota: mg/L
0	54	8	47	7
5	54	7	47	6
10	54	6	47	5
15	54	6	47	5
20	54	5	47	4
25	54	5	48	4

Table B-2 Comparison of Supernatant Water Quality to Provincial Water Quality Objectives and The Natural Background Water Quality

Parameter	Unit	PWQO[1]	Natural Water Quality						Supernatant Water Quality								Primary MECP Policy[2]	Comparisons
			Mount Albert Creek Station 03007702102				Vivian Creek Stations		Scenario 1		Scenario 2				Scenario 3			
			Median	75th Percentile	Range	n[5]	MTA SWA	MTA SWB	Wells 1&2 Facility		Wells 1&2 Facility		Well 3 Facility		Wells 1&2 Facility			
									Avg	Range	Avg	Range	Avg	Range	Avg	Range		
Alkalinity	mg/L-$CaCO_3$	Alkalinity should not be decreased by more than 25% of the natural concentration.	191	203	66.4-220	81	105-196	106	237	230 - 247	242	233 - 254	238	231 - 248	229	225 - 235	N/A	Alkalinity in backwash wastewater/ supernatant is higher than the alkalinity in the natural waters and is less than 25% higher when compared to 75th percentile for Mount Albert Creek water quality. Backwash wastewater/supernatant anticipated to meet PWQO.
Aluminum	mg/L	At pH >6.5 to 9.0, the Interim PWQO is 0.075 mg/L based on total aluminum measured in clay-free samples. If natural background aluminum concentrations in water bodies unaffected by manmade inputs are greater than the numerical Interim PWQO (above), no condition is permitted that would increase the aluminum concentration in clay-free samples by more than 10% of the natural background level.	0.0633	0.13625	0.00802-3.080	71	0.396-7.08	0.0637-5.86	-	-	-	-	-	-	-	-	Policy 2	No data available to estimate backwash wastewater/supernatant quality.
Total Ammonia	mg/L-N	-	0.045	0.079	0.003-0.386	81	0.1-0.72	0.09-0.80	0.24	0.07 - 0.29	0.28	0.09 - 0.38	0.05	0.03 - 0.09	0.17	<0.05 - 0.25	N/A	No PWQO. Average backwash wastewater/supernatant concentrations for Well 1&2 Facility higher than the 75th percentile for Mount Albert Creek, but is within the range of values observed for Mount Albert and Vivian Creek. It is anticipated that Vivian Creek will be able to assimilate the additional ammonia given the low volume of supernatant that would be discharged relative to the water flow in the Creek and that ammonia concentration would only increase by a small amount. Low flows and ammonia concentrations in the creek should be confirmed to verify this.
Ammonia (un-ionized)[2]	*mg/L-N*	0.020	*0.0009*	*0.0015*	*0.0001-0.0070*	*77*	*0.001-0.006*	*0.002-0.014*	0.004	0.001 - 0.007	0.004	0.001 - 0.009	0.001	0.000 - 0.002	0.003	<0.001 - 0.004	Policy 1	Average backwash wastewater unionized ammonia slightly higher than 75th percentile for Mount Albert Creek, but well below the PWQO and within the range of values observed for Vivian Creek. Backwash wastewater/supernatant anticipated to meet PWQO.
Antimony	µg/L	20 (Interim PWQO)	-	-	-	-	0. 5- <50	0. 6-<50	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.

Parameter	Unit	PWQO[1]	Natural Water Quality						Supernatant Water Quality								Primary MECP Policy[2]	Comparisons
			Mount Albert Creek Station 03007702102				Vivian Creek Stations		Scenario 1		Scenario 2				Scenario 3			
			Median	75th Percentile	Range	n[5]	MTA SWA	MTA SWB	Wells 1&2 Facility		Wells 1&2 Facility		Well 3 Facility		Wells 1&2 Facility			
									Avg	Range	Avg	Range	Avg	Range	Avg	Range		
Arsenic	µg/L	100 (PWQO) 5 (Interim PWQO)	-	-	-	-	0.5- <5	<0.5 - <5	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.
Barium	µg/L	-	51.65	55.175	19.6-95.3	72	-	-	-	-	-	-	-	-	-	-	N/A	No PWQO.
Beryllium	µg/L	Hardness <75 mg/L-$CaCO_3$: 11 (PWQO) Hardness >75 mg/L-$CaCO_3$: 1100 (PWQO)	0.0218	0.0492	0.00198-0.322	42	-	-	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.
Bicarbonate	mg/L	-	-	-	-	-	105-196	106	-	-	-	-	-	-	-	-	N/A	No PWQO.
Bismuth	µg/L	-	1.4	2.0	0.0612-2.37	12	-	-	-	-	-	-	-	-	-	-	N/A	No PWQO
BOD, 5-day, total demand	mg/L	-	1.6	N/A	1.6-1.6	1	-	-	2.0	1.3 - 3.1	2.1	1.3 - 3.1	2.1	1.3-2.7	1.9	1.2 - 3.1	N/A	No PWQO Only one measurement on natural waters. BOD of backwash wastewater/supernatant is estimated as the total theoretical carbonaceous BOD. Given the limited data available, not possible to do a proper comparison or draw any firm conclusions. However, it was noted that the theoretical carbonaceous BOD is relatively low.
Bromide	mg/L-Br	-	-	-	-	-	<1 - <1.25	-	-	-	-	-	-	-	-	-	N/A	No PWQO. Limited data available.
Cadmium	µg/L	0.2 (PWQO) Hardness 0-100 mg/L-$CaCO_3$: 0.1 (Interim PWQO) Hardness >100 mg/L-$CaCO_3$: 0.5 (Interim PWQO)	0.555	1.34	0.0264-2.46	59	<0.5-<3	<0.5-<3	-	-	-	-	-	-	-	-	Policy 2	No data available to estimate backwash wastewater/supernatant quality
Calcium	mg/L	-	71	77.4	22.1-92.1	93	41.8-89.6	42.8	81	53 - 95	85	57 - 100	97	95 - 100	74	46 - 85	N/A	Calcium concentrations in the backwash wastewater/supernatant are anticipated to be slightly higher than the natural water quality; however, these are not considered to be a cause for concern.
Chloride	mg/L	-	45.6	53.6	0.6-172	82	25.2-51.2	27.6-40	24	16 - 34	29	21 - 41	28	26 - 31	14	8 - 22	N/A	Chloride concentrations in the backwash wastewater/supernatant are anticipated to be lower than the natural water quality, and are not considered to be a cause for concern.
Chlorine	mg/L	0.002 (PWQO)	-	-	-	-	-	-	Typical: 1.6 mg/L Maximum: 4.3 mg/L								ND; Policy 1	Chlorine concentration in backwash wastewater is well above the PWQO. Supernatant need to be dechlorinated in order to be discharged.
Chromium (total)	µg/L	Hexavalent chromium (Cr VI): 1 (PWQO) Trivalent chromium (Cr III): 8.9 (PWQO)	0.55	0.99	0.01-3.4	47	<0.5-<20	<0.5-<20	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.
Cobalt	µg/L	0.9 (Interim PWQO)	0.4275	0.68425	0.0708-2.95	52	<0.5-<50	<0.5-<50	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.

Parameter	Unit	PWQO[1]	Natural Water Quality						Supernatant Water Quality								Primary MECP Policy[2]	Comparisons
			Mount Albert Creek Station 03007702102				Vivian Creek Stations		Scenario 1		Scenario 2				Scenario 3			
			Median	75th Percentile	Range	n[5]	MTA SWA	MTA SWB	Wells 1&2 Facility		Wells 1&2 Facility		Well 3 Facility		Wells 1&2 Facility			
									Avg	Range	Avg	Range	Avg	Range	Avg	Range		
Conductivity, 25C	µS/cm	-	562	609.5	189-996	81	-	-	-	-	-	-	-	-	-	-	-	-
Conductivity, Ambient	µmho/cm	-	563	594.75	191-719	86	-	-	-	-	-	-	-	-	-	-	-	-
Copper	µg/L	Hardness 0-20 mg/L-$CaCO_3$: 1 (Interim PWQO) Hardness >20 mg/L-$CaCO_3$: 5 (Interim PWQO)	1.2	1.65	0.0467-9.29	1.2	1.1-<20	<0.5-<20	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.
Dissolved Oxygen	mg/L	Dissolved oxygen concentrations should not be less than the values specified below for cold water biota (e.g. salmonid fish communities) and warm water biota (e.g. centrarchid fish communities):[6]	10.775	12.47	0.1-14.35	82	-	-	0.8	0.5 - 1.2	0.8	0.5 - 1.2	0.8	0.5 - 1.0	0.7	0.5 - 1.2	Policy 1	Anticipated dissolved oxygen concentrations in the backwash wastewater/supernatant are significantly below the concentration in the natural waters and specified by the PWQO. However, it is anticipated that Vivian Creek will be able to assimilate the low dissolved oxygen given low volume of the supernatant that would be discharged in comparison to the water flow in the Creek, and Vivian Creek dissolved oxygen final concentration would far exceed the Ontario PWQO.
Fluoride	mg/L	-	-	-	-	-	<0.1 - <0.12	-	-	-	-	-	-	-	-	-	N/A	No PWQO. Limited data.
Hardness	mg/L-$CaCO_3$	-	236.5	249.75	98.6-288	74	122-258	125	281	182 - 329	292	192 - 345	338	330 - 349	259	162 - 299	N/A	Hardness in the backwash wastewater/ supernatant are anticipated to be higher than the natural water quality, particularly for Well 3 Facility in Scenario 2; however, the higher hardness concentrations are not considered to be a cause for concern.
Iron (Total)	mg/L	0.300 (Interim PWQO)	0.254	0.40975	0.121-2.250	72	0.417-6.060	0.106-5.220	50	37 - 66	39	29 - 48	10	3 - 27	25	18 - 37	Policy 2	Iron concentrations in the supernatant are significantly above the interim PWQO and the natural water quality. Iron will need to be removed prior to discharge, but limited data to assess impact to Vivian Creek at the moment.
Lead	µg/L	Alkalinity <20 mg/L-$CaCO_3$: 5 (PWQO) Alkalinity 20-40 mg/L-$CaCO_3$: 10 (PWQO) Alkalinity 40-80 mg/L-$CaCO_3$: 20 (PWQO) Alkalinity >80 mg/L- $CaCO_3$: 25 (PWQO) Hardness <30 mg/L-$CaCO_3$: 1 (Interim PWQO) Hardness 30-80 mg/L-$CaCO_3$: 3 (Interim PWQO) Hardness >80 mg/L-$CaCO_3$: 5 (Interim PWQO)	2.5	4.25	0.364-10.7	27	0.8-<20	<0.5-<20	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.

Parameter	Unit	PWQO[1]	Natural Water Quality						Supernatant Water Quality								Primary MECP Policy[2]	Comparisons
			Mount Albert Creek Station 03007702102				Vivian Creek Stations		Scenario 1		Scenario 2				Scenario 3			
			Median	75th Percentile	Range	n[5]	MTA SWA	MTA SWB	Wells 1&2 Facility		Wells 1&2 Facility		Well 3 Facility		Wells 1&2 Facility			
									Avg	Range	Avg	Range	Avg	Range	Avg	Range		
Lithium	µg/L	-	4.49	7.57	0.04-39	31	-	-	-	-	-	-	-	-	-	-	N/A	No PWQO.
Manganese (Total)	mg/L	-	0.05425	0.077075	0.0137-0.472	72	0.025-0.312	0.0339-0.241	5.6	4.4 – 6.5	4.6	3.6 – 5.3	2.5	2.1 – 2.9	2.4	2.0 – 2.8	N/A	Manganese concentrations in backwash wastewater/supernatant are significantly higher than the natural water quality. To prevent possible surface water quality impacts, manganese should be removed prior discharge, but limited data to assess impact to Vivian Creek at the moment.
Magnesium	mg/L	-	12.5	14	3-17.5	92	4.28-8.39	4.35	19	12 - 22	19	12 - 23	24	23 - 24	18	11 - 21	N/A	Magnesium concentrations in the backwash wastewater/supernatant are anticipated to be slightly higher than the natural water quality; however, they are not high enough to be considered a cause for concern.
Molybdenum	µg/L	40 (Interim PWQO)	0.9615	1.2725	0.01-2.91	58	<2.5-<50	<2.5-<50	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.
Nickel	µg/L	25 (PWQO)	0.311	0.9095	0.011-2.97	29	<0.5-<20	<0.5-<20	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.
Nitrates	mg/L-N	-	1.14	1.445	0.363-4.95	81	1.69-3.04	1.66-4.52	<0.005	<0.005	<0.005	<0.005	4.8	4.31 - 5.96	<0.005	<0.005	N/A	Nitrate concentrations in backwash wastewater/ supernatant from Wells 1&2 Facility are anticipated to be lower than those in the natural waters. Nitrate concentrations in backwash wastewater/ supernatant from Well 3 Facility is anticipated to have a higher nitrate concentration than the natural waters. It is anticipated that Vivian Creek will be able to assimilate the additional nitrate given the low volume of supernatant that would be discharged relative to the water flow in the creek. The nitrate concentration would only increase by a small amount. Low flows in the creek should be confirmed to verify this.
Nitrite	mg/L-N	-	0.016	0.021	0-0.092	82	0.0019-<0.12	0.0019-0.02	0.038	<0.008 - <0.25	0.038	<0.008 - <0.25	0.077	0.049 - 0.125	0.038	<0.008 - <0.25	N/A	Nitrite concentrations in the backwash wastewater/ supernatant are anticipated to be slightly higher than the natural water quality; however, they are low enough that they are not considered a cause for concern.
pH	-	6.5-8.5	8.26	8.36	7.27-8.66	81	7.6-8.2	7.6-8.2	8.0	7.8 - 8.1	7.9	7.8 - 8.1	7.9	7.7 - 8.1	8.0	7.8 - 8.2	Policy 1	Backwash wastewater/supernatant pH concentrations are anticipated to be within the PWQO and natural water pH ranges. Backwash wastewater/supernatant anticipated to meet PWQO.

Parameter	Unit	PWQO[1]	Natural Water Quality						Supernatant Water Quality								Primary MECP Policy[2]	Comparisons
			Mount Albert Creek Station 03007702102				Vivian Creek Stations		Scenario 1		Scenario 2				Scenario 3			
			Median	75th Percentile	Range	n[5]	MTA SWA	MTA SWB	Wells 1&2 Facility		Wells 1&2 Facility		Well 3 Facility		Wells 1&2 Facility			
									Avg	Range	Avg	Range	Avg	Range	Avg	Range		
pH Field	-	6.5-8.5	7.88	8.05	7.01-8.68	85	7.42-8.78	7.52-9.05									Policy 1	-
Phenolics	mg/L	0.001 (PWQO) Determined by the total reactive phenols test - the 4-AAP (4-amino-antipyrine) test. This objective should be used primarily as a screening tool. The isomer specific PWQOs for various phenolics should be employed where possible.	-	-	-	-	<0.004-<0.004	<0.004-<0.004									LD; Policy 1	No data available to estimate backwash wastewater/supernatant quality.
Phosphate (Filtered)	mg/L-P	-	0.0171	0.0341	0-0.186	82	<0.1-0.343	0.026-0.314	0.027	<0.010 - 0.080	0.028	<0.010 - 0.090	<0.02	<0.005 - <0.020	0.026	<0.010 - 0.060	N/A	Anticipated average backwash wastewater/ supernatant concentration is similar or lower than concentrations in the natural waters.
Phosphorus (Total)	mg/L-P	Interim PWQO: The following phosphorus concentrations should be considered as general guidelines which should be supplemented by site-specific studies: To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L; A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 µg/L or less. This should apply to all lakes naturally below this value; Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 µg/L.	0.045	0.068	0.015-0.52	115	0.046-1.12	0.046-0.925	-	-	-	-	-	-	-	-	Policy 2	Total Phosphorus data for the wells was not available and it was not possible to estimate the backwash wastewater/supernatant quality. Given that the anticipated filtered phosphate concentrations for backwash wastewater/ supernatant was similar to that of the natural waters, it is anticipated that the total phosphorus concentrations will also be similar; however, this should be confirmed.
Potassium	mg/L	-	2.3	2.75	1.14-5.85	59	2.07-7.47	7.88	-	-	-	-	-	-	-	-	-	No PWQO
Selenium	µg/L	100 (PWQO)	-	-	-	-	<0.5-<10	<0.5-<10	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.
Silver	µg/L	0.1 (PWQO)	1.1	1.46	0.518-3.01	11	-	-	-	-	-	-	-	-	-	-	Policy 2	No data available to estimate backwash wastewater/supernatant quality.
Sodium	mg/L	-	26.1	28.9	7.32-35.1	59	13.7-19.7	15	6.8	5.1 - 8.7	8.1	5.8 - 10.1	10.3	9.1 - 11.3	4.4	3.8 - 6.0	-	No PWQO. Sodium concentrations in the backwash wastewater/supernatant are anticipated to be lower than the sodium concentrations in the natural waters.
Strontium	µg/L	-	198	204	54.2-237	72	-	-	-	-	-	-	-	-	-	-	N/A	No PWQO

Parameter	Unit	PWQO[1]	Natural Water Quality						Supernatant Water Quality								Primary MECP Policy[2]	Comparisons
			Mount Albert Creek Station 03007702102				Vivian Creek Stations		Scenario 1		Scenario 2				Scenario 3			
			Median	75th Percentile	Range	n[5]	MTA SWA	MTA SWB	Wells 1&2 Facility		Wells 1&2 Facility		Well 3 Facility		Wells 1&2 Facility			
									Avg	Range	Avg	Range	Avg	Range	Avg	Range		
Sulfate	mg/L	-	26.6	30.9	24.4-31.1	7	16.5-20.1		37	22 - 53	40	23 - 62	57	37 - 62	31	20 - 36	N/A	Sulfate concentrations in the backwash wastewater/supernatant are anticipated to be slightly higher than the natural water quality; however, they are not high enough to be considered a cause for concern.
Temperature	°C	PWQO: *General:* The natural thermal regime of any body of water shall not be altered so as to impair the quality of the natural environment. In particular, the diversity, distribution and abundance of plant and animal life shall not be significantly changed. Waste Heat Discharge: a. Ambient Temperature Changes The temperature at the edge of a mixing zone shall not exceed the natural ambient water temperature at a representative control location by more than 10°C (18°F). However, in special circumstances, local conditions may require a significantly lower temperature difference than 10°C (18°F). Potential dischargers are to apply to the MOEE for guidance as to the allowable temperature rise for each thermal discharge. This ministry will also specify the nature of the mixing zone and the procedure for the establishment of a representative control location for temperature recording on a case-by-case basis. b. Discharge Temperature Permitted The maximum temperature of the receiving body of water, at any point in the thermal plume outside a mixing zone, shall not exceed 30 °C (86 °F) or the temperature of a representative control location plus 10°C (18°F) or the allowed temperature difference, whichever is the lesser temperature. These maximum temperatures are to be measured on a mean daily basis from continuous records. c. Taking and Discharging of Cooling Water Users of cooling water shall meet both the Objectives for temperature outlined above and the "Procedures for the Taking and Discharge of Cooling Water" as outlined in the MOEE publication Deriving Receiving-Water Based, Point-Source Effluent Requirements for Ontario Waters (1994).	12.4	19.775	0-24.7	86	-0.2-2.2	0.2-1.2	-	-	-	-	-	-	-	-	Policy 1	It is anticipated that the backwash wastewater/supernatant will meet the PWQO given that: a) the anticipated backwash wastewater/ supernatant temperature (10 degrees C) is close to 10 degrees C from the min and max temperatures observed for the natural waters and b) the total amount of supernatant discharged to the creek is anticipated to be small in comparison to the natural streamflow.
Tin	µg/L	-	1.06	4.6	0.569-5.14	5	-	-	-	-	-	-	-	-	-	-	N/A	No PWQO

Parameter	Unit	PWQO[1]	Natural Water Quality						Supernatant Water Quality								Primary MECP Policy[2]	Comparisons
			Mount Albert Creek Station 03007702102				Vivian Creek Stations		Scenario 1		Scenario 2				Scenario 3			
			Median	75th Percentile	Range	n[5]	MTA SWA	MTA SWB	Wells 1&2 Facility		Wells 1&2 Facility		Well 3 Facility		Wells 1&2 Facility			
									Avg	Range	Avg	Range	Avg	Range	Avg	Range		
Titanium	µg/L	-	2.17	4.14	0.0977-15.7	71	-	-	-	-	-	-	-	-	-	-	N/A	No PWQO
TKN	mg/L	-	-	-	-	-	0.57-3.87	0.47-3.68	-	-	-	-	-	-	-	-	N/A	No PWQO
Total Suspended Solids	mg/L	-	-	-	-	-	8.7-395	12.5-230	105	79 - 136	82	62 - 101	23	10 - 57	52	38 - 75	N/A	Total suspended solids concentrations in the supernatant are anticipated to be in the same range as values observed by York Region; however, the additional suspended solids should not increase the turbidity of the creek water beyond the PWQO for turbidity. The typical effluent discharge limit prescribed by MECP for TSS is between 15 to 25 mg/L. Given low volume of the supernatant that would be discharged in comparison to the water flow in the Creek, it is anticipated the setting the discharge limit to the low range (15 mg/L) would have low impact. The Mount Albert WRRF ECA, which is on a separate nearby branch of Vivian Creek, has an effluent limit of 6 mg/L for TSS.
Turbidity	NTU	Suspended matter should not be added to surface water in concentrations that will change the natural Secchi disc reading by more than 10%. (PWQO)	5.06	13.82	1.56-27.3	9	-	-	-	-	-	-	-	-	-	-	N/A	The anticipated turbidity of the supernatant is unknown.
Turbidity, Field	NTU	Suspended matter should not be added to surface water in concentrations that will change the natural Secchi disc reading by more than 10%. (PWQO)	2.5	5.4	0-16.7	19	70 (NTU)-166 (NTU)	34-159	-	-	-	-	-	-	-	-	N/A	See above
Vanadium	µg/L	6	0.669	1.7	0.0738-8.92	71	-	-	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.
Zinc	µg/L	30 (PWQO) 20 (Interim PWQO)	8.96	12.45	0.114-44.7	72	3.6-37	<1-30	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.
Zirconium, Unfiltered Total	µg/L	4 (Interim PWQO)	0.237	0.32525	0.133-0.326	4	-	-	-	-	-	-	-	-	-	-	Policy 1	No data available to estimate backwash wastewater/supernatant quality.

Notes:

1. Relevant PWQOs for the water quality parameters that were measured are taken or summarized from MECP (2019a). See MECP for full PWQOs for each of these parameters.
2. MECP policy from MOEE (1994), based on comparison of PWQOs to the natural water qualities.
3. Unionized ammonia concentrations calculated using the calculations from Emerson et al. (1975), as noted in MECP (2019)
4. Mount Albert Creek measurements reported as Formazin Turbidity Units. York Region results reported in Nephelometric Turbidity Units.
5. Number of samples
6. In waters inhabited by sensitive biological communities, or in situations where additional physical or chemical stressors are operating, more stringent criteria may be required. For example, a sensitive species such as lake trout may require more specific water quality objectives. In some hypolimnetic waters, dissolved oxygen is naturally lower than the concentrations specified in the above table. Such a condition should not be altered by adding oxygen demanding materials causing a depletion of oxygen.

Temp. °C	Cold Water Biota: % Saturation	Cold Water Biota: mg/L	Warm Water Biota: % Saturation	Warm Water Biota: mg/L
0	54	8	47	7
5	54	7	47	6
10	54	6	47	5
15	54	6	47	5
20	54	5	47	4
25	54	5	48	4

Appendix E. Stage 1 Archeological Assessment

ARCHEOWORKS INC.

Stage 1 Archaeological Assessment for the
Mount Albert Water Supply System Upgrades
Municipal Class Environmental Assessment
Within Part of Lots 6-17, Concessions 8-9
And Road Allowances In Between
In the Geographic Township of East Gwillimbury
Former County of York
Now in the Town of East Gwillimbury
Regional Municipality of York
Ontario

Project #: 043-MA8082-18
Licensee (#): Kassandra Aldridge (P439)
PIF#: P439-0089-2020

Original Report

December 4, 2020

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EXECUTIVE SUMMARY

Archeoworks Inc. was retained by *Jacobs* to conduct a Stage 1 Archaeological Assessment (AA) in support of the Mount Albert Water Supply System Upgrades Class Environmental Assessment (Class EA) study area. To support the proposed upgrades within the study area, an Environmental Impact Buffer and adjacent lands within 120 metres of this Buffer were identified, extending along Centre Street from approximately Herald Road to Elizabeth Street. This area will herein be referred to as the "Impact Buffer". The study area is located in part of Lots 6-17, Concessions 8-9 – as well as the road allowances in between – in the Geographic Township of East Gwillimbury, former County of York, now in the Town of East Gwillimbury, Regional Municipality of York, Ontario.

Stage 1 AA background research established elevated potential for the recovery of archaeologically significant materials within the study area as a whole due to the presence of several previously identified archaeological sites, designated and non-designated heritage resources, primary and secondary water sources (Vivian Creek, Mount Albert Creek, their tributaries and wetlands) and documented pre-ca. 1900 Euro-Canadian settlement.

To determine if the archaeological potential classification is relevant within the Impact Buffer, a detailed desktop review of ground conditions using recent aerial imagery was undertaken, followed by a visual property inspection. A portion of this area was determined to have been subjected to deep and extensive disturbances (i.e., existing roadways and rights-of-ways, buried utilities, structural footprints, previous grading and construction activities, etc.) that have removed archaeological potential. Several areas have also been subject to previous archaeological assessment and cleared of further archaeological concern. Vivian Creek and steeply sloping areas were identified as features of no or low archaeological potential. The remaining balance of the Impact Buffer was identified as retaining archaeological potential and requires further archaeological assessment. The Mount Albert Wesleyan Methodist Pioneer Cemetery and the Birchard Family Burying Ground are also noted to be within the Impact Buffer and require further archaeological assessment.

Considering the findings detailed in the succeeding sections, the following recommendations are presented:

1. Lands that were subjected to previous archaeological assessments (AMICK Consultants Limited, 2013; ASI, 2015a) and deemed free of further archaeological concern are recommended to be exempt from further assessment.

2. All areas that were identified as having archaeological potential removed are exempt from requiring Stage 2 AA.

3. All areas that were identified as having no or low archaeological potential are exempt from requiring Stage 2 AA.

4. All areas identified as retaining archaeological potential must be subjected to a Stage 2 AA. These areas must be subjected to pedestrian or test pit survey at five-metre intervals in accordance with the standards set within *Sections 2.1.1* and *2.1.2* of the *2011 S&G.*

5. As per the *Cemeteries Act*, R.S.O. 1990 c. C.4 and the *Funeral, Burial and Cremation Services Act*, 2002, S.O. 2002, c.33 no intrusive activity may occur within the limits of the Mount Albert Wesleyan Methodist Pioneer Cemetery (also designated under Part IV of the *Ontario Heritage Act* according to by-law 2004-20) or the Birchard Family Burying Ground without consent from the *Bereavement Authority of Ontario*.
    a. Should the area within the current cemetery limits be impacted, additional archaeological investigation consisting of Stage 2 test pit survey followed by Stage 3 mechanical topsoil removal is required. An Investigation Order issued by the *Bereavement Authority of Ontario* is also required and needs to be obtained prior to conducting any soil-intrusive work (e.g., Stage 2/3/4 investigations; construction monitoring).

6. Lands within the 20-metre cemetery investigation area surrounding the Mount Albert Wesleyan Methodist Pioneer Cemetery and the Birchard Family Burying Ground that were identified as having low potential for unmarked burials are considered free of further cemetery investigations.

7. Should proposed construction impacts occur within the swaths of land adjacent to the Mount Albert Wesleyan Methodist Pioneer Cemetery or Birchard Family Burying Ground identified as having moderate or high potential for the recovery of unmarked burials, the following archaeological/cemetery investigations are required:
    a. As there is the potential for both the Mount Albert Wesleyan Methodist Pioneer Cemetery and the Birchard Family Burying Ground to extend into the Impact Buffer, an Investigation Authorization issued by the *Bereavement Authority of Ontario* is required and needs to be obtained prior to conducting any soil-intrusive work (e.g., Stage 2/3/4 investigations; construction monitoring).
    b. As there is the potential to encounter both deeply buried archaeological resources and for archaeological resources to be present near the surface, per *Section 2.1.7*, *Standard 2* of the *2011 S&G*, surface survey methods (Stage 2 test pit survey) must occur within the grassed and wooded areas adjacent to the cemeteries prior to mechanical excavation.
    c. Following the completion of the Stage 2 AA, regardless of the results, per *Section 2.2*, *Guideline 4* of the *2011 S&G*, and in accordance with the *Registrar's Directive: Archaeological Assessments & Investigations on Cemetery Lands* (dated April 11, 2018) and the *Registrar's Directive: Authorization of Archaeological Assessments & Investigations on Cemetery Lands* (dated March 1, 2019), further cemetery investigations are required. The recommendations for further cemetery investigations are as follows:

i. Per *Section 3.3.3, Standard 2* of the *2011 S&G*, a Stage 3 investigation consisting of mechanical topsoil removal (MTR) must be undertaken following the lands immediately adjacent to the current cemetery limits, where feasible, to confirm the presence or absence of deeply buried human remains. Mechanical excavation must employ a flat-edged bucket and should begin at the furthest extent from the cemetery that will be investigated and move inward towards the known cemetery limits. Unless human remains are encountered, mechanical stripping of topsoil is to reach sterile subsoil depths.
ii. Where mechanical topsoil removal is not feasible due to existing roadway infrastructure or accessibility issues (i.e., in steeply sloped areas), these areas will require on-site monitoring by a licensed archaeologist during any construction or other soil disturbing activities per *Section 2.1.7, Standard 4* of the *2011 S&G*, to confirm the presence or absence of deeply buried human remains.

8. Should construction activities associated with this project, including construction laydown areas, extend beyond the assessed limits, further archaeological investigation will be required prior to construction activities in order to minimize impacts to cultural heritage resources.

No construction activities shall take place within the study area, and specifically the identified Impact Buffer, prior to the *Ministry of Heritage, Sport, Tourism and Culture Industries* (Archaeology Programs Unit) confirming in writing that all archaeological licensing and technical review requirements have been satisfied.

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PROJECT PERSONNEL

Project Director..Kassandra Aldridge – MHSTCI licence P439

Field Director (Property Inspection) .... Kim Slocki – MHSTCI licence P029

Historical Research.. Lee Templeton – MHSTCI licence R454

Graphics ....Cassandra Lamoureux
Lee Templeton – MHSTCI licence R454

Report Preparation ....Cassandra Lamoureux

Report Review.. Kim Slocki – MHSTCI licence P029

1.0 PROJECT CONTEXT

1.1 Objective

The objectives of a Stage 1 Archaeological Assessment (AA), as outlined by the 2011 *Standards and Guidelines for Consultant Archaeologists* (‘*2011 S&G*’) published by the *Ministry of Heritage, Sport, Tourism and Culture Industries (MHSTCI)* (2011), are as follows:

- To provide information about the property’s geography, history, previous archaeological fieldwork and current land condition;
- To evaluate in detail, the property’s archaeological potential, which will support recommendations for a Stage 2 survey for all parts of the property; and
- To recommend appropriate strategies for a Stage 2 survey.

1.2 Development Context

The Regional Municipality of York is undertaking a Schedule B, Municipal Class Environmental Assessment (Class EA) study to identify improvements to the water supply system and water quality in the community of Mount Albert. To facilitate this study, *Archeoworks Inc.* was retained by *Jacobs* to conduct a Stage 1 AA of the Water Supply System Upgrades Class EA and Preliminary Design project area, located in the community of Mount Albert, in the Town of East Gwillimbury. The project area is roughly bounded by Herald Road, Highway 48, Doane Road, extending approximately 465 metres north of Doane Road, and York Durham Line. This entire parcel of land will herein be referred to as the “study area.” The study area is located in part of Lots 6-17, Concessions 8-9 – as well as the road allowances in between – in the Geographic Township of East Gwillimbury, former County of York, now in the Town of East Gwillimbury, Regional Municipality of York, Ontario (***see Appendix A – Map 1***).

To support the proposed upgrades within the study area, an Environmental Impact Buffer and adjacent lands within 120 metres of this Buffer were identified, extending along Centre Street from approximately Herald Road to Elizabeth Street. This area will herein be referred to as the “Impact Buffer” (***also see Map 1***).

The Stage 1 AA documented herein will provide an overall review of archaeological potential for the Mount Albert Water Supply System Upgrades Class EA project area (“study area”), with specific review, analysis and recommendations for the 120 metre Impact Buffer located along Centre Street (“Impact Buffer”).

This study was triggered by the *Environmental Assessment Act* in support of Schedule ‘B’ of the Municipal Class EA regulatory process. It was conducted under the project direction of Ms. Kassandra Aldridge, under the archaeological consultant licence number P439, in accordance with the *Ontario Heritage Act* (1990; amended 2019) and *2011 S&G*. Permission to investigate the study area was granted by *Jacobs* on January 9th, 2019.

The Regional Municipality of York has an archaeological management plan (AMP), founded on the principles of archaeological potential modeling, and developed using a Geographic Information System (GIS). Per the Regional Municipality of York AMP, portions of the study area have archaeological potential (Regional Municipality of York, 2020a; ***see Map 2***).

1.3 Historical Context

To establish the historical context and archaeological potential of the study area, *Archeoworks Inc.* conducted a review of Indigenous and Euro-Canadian settlement history, and a review of available historic mapping.

The results of this background research are documented below and summarized in **Appendix B – Summary of Background Research**.

1.3.1 Pre-Contact Period

The pre-contact period of Southern Ontario includes numerous Indigenous groups that continually progressed and developed within the environment they inhabited (Ferris, 2013, p.13). **Table 1** includes a brief overview and summary of the pre-contact Indigenous history of Southern Ontario.

Table 1: Pre-Contact Period

Period (Date Range)	Overview and Attributes
Early Paleo-Indian (ca. 11000 to 8500 BC) Late Paleo-Indian (ca. 8500 to 7500 BC)	Small groups of nomadic hunter-gathers who utilized seasonal and naturally available resources; sites are rare; hunted in small family groups who periodically gathered into larger groups/bands during favourable periods in the hunting cycle; campsites used during travel episodes and found in well-drained soils in elevated situations; sites found primarily along glacial strandlines due to current understanding of regional geological history; artifacts include fluted and lanceolate stone points, scrapers and dart heads. - Gainey, Barnes, Crowfield Fluted Points (Early Paleo-Indian) - Holcombe, Hi-Lo, Lanceolates (Late Paleo-Indian) (Ellis and Deller, 1990, pp.37-64; Wright, 1994, p.25; Ellis, 2013, p.37).
Early Archaic (ca. 7800 to 6000 BC) Middle Archaic (ca. 6000 to 2000 BC) Late Archaic (ca. 2500 to 500 BC)	Descendants of Paleo-Indian ancestors; lithic scatters are the most commonly encountered site type; trade networks appear; artifacts include reformed fluted and lanceolate stone points with notched bases to attach to wooden shaft; ground-stone tools shaped by grinding and polishing; stone axes, adzes and bow and arrow; Shield Archaic in Northern Ontario introduced copper tools. - Side-notched, corner-notched, bifurcate projectile points (Early Archaic) - Stemmed, Otter Creek/Other Side-notched, Brewerton side and corner-notched projectile points (Middle Archaic) - Narrow Point, Broad Point, Small Point projectile points (Late Archaic) (Ellis et al., 1990, pp.65-124; Wright, 1994, pp.26-28; Ellis, 2013, pp.41-46; Dawson, 1983, pp.8-14).

Period (Date Range)	Overview and Attributes
Early Woodland (ca. 800 BC to AD 1)	Evolved out of the Late Archaic Period; introduction of pottery (ceramic) where the earliest were coil-formed, under fired and likely utility usage; two primary cultural complexes: Meadowood (broad extent of occupation in southern Ontario) and Middlesex (restricted to Eastern Ontario); poorly understood settlement-subsistence patterns; artifacts include cache blades, and side-notched points that were often recycled into other tool forms; primarily Onondaga chert; commonly associated with Saugeen and Point Peninsula complexes; oral traditions of the present-day Michi Saagiig (Mississauga Anishinaabeg), an Algonquian-speaking First Nation group, state that they, "are the descendants of the ancient peoples who lived in Ontario during the Archaic and Paleo-Indian periods" (Migizi and Kapyrka, 2015, p.1). - Meadowood side-notched projectile points (Spence et al., 1990, pp.125-142; Wright, 1994, pp.29-30; Ferris and Spence, 1995, pp.89-97; Williamson, 2013, pp.48-61; Dawson, 1983, pp.15-19).
Middle Woodland (ca. 200 BC to AD 700)	Three primary cultural complexes: Point Peninsula (generally located throughout south-central and eastern Southern Ontario), Saugeen (generally located southwestern Southern Ontario), and Couture (generally located in southwestern-most part of Ontario); introduction of large "house" structures and substantial middens; settlements have dense debris cover indicating increased degree of sedentism; incipient horticulture; burial mounds present; shared preference for stamped, scallop-edged or tooth-like decoration, but each cultural complex had distinct pottery forms; Laurel Culture (ca. 500 BC to AD 1000) established in boreal forests of Northern Ontario. - Saugeen Point projectile points (Saugeen) - Vanport Point projectile points (Couture) - Snyder Point projectile points - Laurel stemmed and corner-notched projectile points (Spence et al., 1990, pp.142-170; Wright, 1994, pp.28-33; Ferris and Spence, 1995, pp.97-102; Wright, 1999, pp.629-649; Williamson, 2013, pp.48-61; Wright, 1994, p.28; Hessel, 1993, pp.8-9; Dawson, 1983, pp.15-19; Gagné, 2015).
Late (Transitional) Woodland (ca. AD 600 to 1000)	The north shore of Lake Ontario in Southern Ontario was occupied throughout the entire Late Woodland Period by the Mississauga Anishinaabeg (Michi Saagiig), an Algonquian-speaking group; their territory extended north where they would hunt and trap during the winter months, followed by a return to Lake Ontario in the spring and summer; "the traditional territories of the Michi Saagiig span from Gananoque in the east, all along the north shore of Lake Ontario, west to the north shore of Lake Erie at Long Point. The territory spreads as far north as the tributaries that flow into these lakes, from Bancroft and north of the Haliburton highlands" (Migizi and Kapyrka, 2015, p.1); the Mississauga were highly mobile and often traveled great distances to obtain resources; Mississauga oral traditions speak of people (the Iroquoian) coming into their territory between AD 500-1000 who wished to establish villages and grow corn; treaties were made and the Mississauga allowed the Iroquois to stay in their traditional territories. Earliest Iroquoian development in Southern Ontario is Princess Point which exhibits few continuities from earlier developments with no apparent predecessors; hypothesized to have migrated into Ontario; the settlement data is limited, but oval houses are present; artifacts include 'Princess Point Ware' vessels that are cord roughened, with horizontal lines and exterior punctation; smoking pipes and ground stone tools are rare; introduction of maize/corn horticulture; continuity of Princess Point and Late Woodland Iroquoian groups. - Triangular projectile points

Period (Date Range)	Overview and Attributes
	(Fox, 1990, pp.171-188; Ferris and Spence, 1995, pp.102-106; Migizi and Kapyrka, 2015, pp.1-3).
Early Late Woodland (ca. AD 900 to 1300)	Two primary Iroquoian cultures in Southern Ontario: Glen Meyer (located primarily in southwestern Ontario from Long Point on Lake Erie to southwestern shore of Lake Huron) and Pickering (encompassed north of Lake Ontario to Georgian Bay and Lake Nipissing); well-made and thin-walled clay vessels with stamping, incising and punctation; multi-family longhouses and some small, semi-permanent palisade villages; adoption of greater variety of harvest products; increase in corn-yielding sites; crudely made smoking pipes, and worked bone/antler present; evolution of the ossuary burials - Triangular-shaped, basally concave projectile points with downward projecting corners or spurs (Williamson, 1990, pp.291-320; Ferris and Spence, 1995, pp.106-109).
Middle Late Woodland (ca. AD 1300 to 1400)	Two primary Iroquoian cultures in Southern Ontario: Uren and Middleport; decorated clay vessels decrease; well-developed clay pipe complex that includes effigy pipes; increase in village sizes (0.5 to 1.7 hectares) and campsites (0.1 to 0.6 hectares) appear with some palisades; classic longhouse takes form; increasing reliance on maize and other cultigens such as beans and squash; intensive exploitation of locally available land and water resources; from Middleport emerged the Huron-Wendat, Petun, Neutral Natives and the Erie. - Triangular and (side of corner or corner removed) notched projectile points - Middleport Triangular and Middleport Notched projectile points (Dodd el al., 1990, pp.321-360; Ferris and Spence, 1995, pp.109-115).
Late Woodland (ca. AD 1400 to 1600)	The Mississauga Anishinaabeg "were the negotiators, the messengers, the diplomats, and they successfully meditated peace throughout this area of Ontario for countless generations" (Migizi and Kapyrka, 2015, p.1); the Mississauga Anishinaabeg, along with the Odawa Nation, continued to meet with the Huron-Wendat, Neutral Nation and Petun Nation to ensure their friendly political and economic relations remained strong while the Iroquoian groups continued to establish villages in the Mississauga traditional territory. Two major Iroquoian groups: the Neutral Natives to the west of the Niagara Escarpment, and the Huron-Wendat to the east; Huron-Wendat "concentrations of sites occur in the areas of the Humber River valley, the Rouge and Duffin Creek valleys, the lower Trent valley, Lake Scugog, the upper Trent River and Simcoe County" (Ramsden, 1990, p.363); Toronto Carrying Place Trail connecting Lake Ontario to Lake Simcoe by way of the Humber and Rouge River, overland to the Holland River; longhouses; villages enlarged to 100 longhouses clustered together as horticulture (maize, squash and beans) gained importance in subsistence patterns; villages chosen for proximity to water, arable soils, available fire wood and defendable position; diet supplemented with fish; ossuaries; tribe/band formation; relocation to north of Lake Simcoe. - Huron-Wendat points are limited but change from predominantly side-notched to unnotched triangular (Heidenreich, 1978, pp.368-388; Ramsden, 1990, pp.361-384; Ferris and Spence, 1995, pp.115-122; Warrick, 2000, p.446; Warrick, 2008, p.15; Migizi and Kapyrka, 2015, pp.1-3; TRCA, 2007, p.9).

1.3.2 Contact Period

The contact period of Southern Ontario is defined by European arrival, interaction and influence with the established Indigenous communities of Southern Ontario. **Table 2** includes an overview of some of the main developments that occurred during the contact period of Southern Ontario.

Table 2: Contact Period

Period (Date Range)	Overview and Attributes
European Contact (ca. AD 1600s)	The Mississauga Anishinaabeg focused on hunting/fishing/gathering with little emphasis on agriculture; highly mobile within their traditional territory; temporary and moveable houses (wigwam); inter-marriage between Algonquian-speaking groups (such as the Ojibway, Chippewa, Nipissing, Algonquin, Odawa, Mississauga and others) and Iroquois groups likely occurred; Algonquian-speaking groups often wintered with Iroquois neighbours, resulting in a complex archaeological record; oral traditions of the Mississauga Anishinaabeg state that at the time of European Contact, the Mississauga Anishinaabeg retreated to their winter grounds in the north, thus avoiding disease and warfare. Multiple (Iroquoian-speaking) Huron-Wendat villages and campsites north of Lake Simcoe; French arrival into Ontario; trade relationship with Huron and French established; trade goods begin to replace traditional tools/items; Jesuit missionaries; epidemics (Heidenreich, 1978, pp.368-388; Trigger, 1994, pp.47-55; Warrick, 2008, pp.12, 245; Fox and Garrad, 2004, p.124; McMillian and Yellowhorn, 2004, pp.110-111).
Five Nations of Iroquois (Haudenosaunee) Arrival (ca. AD 1650s)	The Five (later Six) Nations of Iroquois (or Haudenosaunee), originally located south of the Great Lakes, engaged in warfare with Huron-Wendat neighbours as their territory no longer yielded enough furs; the Five Nations, armed with Dutch firearms, attacked and destroyed numerous Huron-Wendat villages in 1649-50; the small groups that remained became widely dispersed throughout the Great Lakes region, ultimately resettling in Quebec, in southwestern Ontario and in America; to prevent the revival of Huron-Wendat settlements, the Five Nations of Iroquois attacked and destroyed the villages of the Huron-Wendat allies, the Petun Natives; in 1650, what remained of the Petun Natives migrated through Neutral Native territory; the Five Nations of Iroquois attacked Neutrals ca. 1650s and caused their dispersal; the Five Nations, particularly the Seneca, established settlements along the northern shoreline of Lake Ontario at strategic locations along canoe-and-portage routes and used territory for extensive fur trade; Five Nations believed to have established a settlement near Orillia after driving out the Huron-Wendat, but this is unconfirmed; European fur trade and exploration continues (Hunter, 1909, p.10; Robinson, 1965, pp.15-16; Abler and Tooker, 1978, p.506; Schmalz, 1991, pp.12-34; Trigger, 1994, pp.53-59; Williamson, 2013, p.60; Migizi and Kapyrka, 2015, p.2).
Anishinaabe Return (ca. AD 1650s to 1700s)	Algonquian-speaking groups within the Anishinaabe (Ojibway, Chippewa, Odawa, Mississauga and others) returned from the north to their traditional territory of Southern Ontario; by 1690s, the Five Nations settlements were abandoned; battles fought throughout Southern Ontario; by 1701, the Five Nations were driven out by the returning Anishinaabe; the Five Nations returned to their homelands south of the Great Lakes, and some remained in parts of Southern Ontario; the Ojibway settled to the north in the County of Simcoe by the 18th century (Hunter, 1909, p.10; Hathaway, 1930, p.433; Trigger, 1994, pp.57-59; Johnston, 2004, pp.9-10; Gibson, 2006, pp.35-41; Smith, 2013, pp.16-20; Williamson, 2013, p.60).

Period (Date Range)	Overview and Attributes
Trade, Peace and Conflict (ca. AD 1700 to 1770s)	Great Peace negotiations of 1701 in Montreal established peace around the Great Lakes; collectively referred to Anishinaabe and Five Nations of Iroquois as the First Nations; European commerce and exploration resumed; the Anishinaabe continued to trade with both the English and the French; genesis of the Métis and their communities; France and Britain were the basis of the Seven Years' War; French defeat transferred the territory of New France to Britain; Treaty of Paris (1763); Royal Proclamation of 1763 established the government administration of the North American territories ceded by France to Britain and established the framework for the negotiation of treaties with First Nation inhabitants; Pontiac's War; fur trade continued until Euro-Canadian settlement (Schmalz, 1991, pp.35-62, 81; Surtees, 1994, pp.92-97; Johnston, 2004, pp.13-14; Jaenen, 2013; Hall, 2015).
Early British Administration and Euro-Canadian Settlement (ca. AD 1760s to 1790s)	American Revolution (1775 to 1783) caused large numbers of United Empire Loyalists, military petitioners, immigrants from the British Isle/European locations, and groups who faced persecution in the United States to arrive in Upper Canada; Treaty of Paris (1783) and formally recognized the independence of the United States; Province of Quebec divided in 1791 into sparsely populated Upper Canada (now southern Ontario) and culturally French Lower Canada (now southern Quebec); Jay's Treaty of 1795 established American/Canadian border along the Great Lakes; large parts of Upper Canada opened to settlement after land cession treaties were secured with various First Nations groups by the British Crown (Department of Indian Affairs, 1891; Government of Ontario, 2014; Jaenen, 2014; Hall, 2019; Surtees, 1994, p.110; Sutherland, 2014).
British Land Treaties (ca. AD 1780s to 1800s)	In 1787, senior officials from the Indian Department met with representatives of certain Anishinaabe groups to acquire land along the northern shores of Lake Ontario extending northward to Lake Simcoe; sometimes referred to as the "Gunshot Treaty"; the documentation which formalized the 1787 transaction did not include a description of the area surrendered and these irregularities resulted in Lieutenant-Governor John Graves Simcoe invalidating the surrender; in 1805, William Claus, the Deputy Superintendent of Indian Affairs, entered into negotiations with the Mississauga to purchase a greater tract of land consisting of 100,000 hectares in and around the Town of York; the matter of land cession in parts of York Region remained a legal issue until the Williams Treaty of 1923 (Department of Indian Affairs, 1891, pp.xxii, xxvii; Surtees, 1986, p.19; Surtees, 1994, p.107; Government of Ontario, 2014; Government of Ontario, 2019).

1.3.3 Euro-Canadian Settlement Period (1800s to present)

1.3.3.1 Township of East Gwillimbury

The Township of East Gwillimbury was first surveyed by John Stegman in 1800 and was completed in 1865 by Surveyor Gossage (Miles & Co., 1878, p.xvii). The Township of East Gwillimbury is bounded on the south by the Township of Whitchurch, on the east by the Township of Scott, the north by the Township of North Gwillimbury and the west by the Township of King, and there is one concession west of Yonge Street which was formerly part of West Gwillimbury (Miles & Co., 1878, p.xvii). The first settlements in the township were made in 1798, two years before the official survey of the township commenced (Mulvany and Adams, 1885, p.170). The Holland Marsh and its associated marsh land is the predominate feature in East Gwillimbury, with soil conditions varying across the township to include sandy loam, sand, clay loam and heavy clay, producing first-class agricultural land equal to approximately one-quarter the total township acreage (Mulvany and Adams, 1885, p.172).

By 1842, 28,380 acres of land had been purchased, 9,215 acres were under cultivation, and many farms were located throughout the township. A total of 1,796 individuals resided within the township and was a mixed population consisting primarily of Pennsylvanian Dutch and their descendants, Canadian and Irish with few English or Scottish individuals. By 1850, the population had increased to 2,616 individuals, and by 1871, 3,934 individuals resided in the township (Smith, 1846, p.73; Mulvany and Adams, 1885, p.172).

1.3.3.2 Village of Mount Albert

The area now known as Mount Albert, situated within the study area, was first settled in 1821 by Quakers. Prior to this, an Algonquin trail traveled through the eastern portion of East Gwillimbury and ran north-south over 'the hill' which would become Mount Albert. Growth continued in the community and the former trail was widened and became Centre Street. The community was originally known as Newland but was renamed Mount Albert and by the mid-1800s, "the village included several houses, grist, flour, wool and lumber mills, a tannery, churches, schools, several shops and two hotels" (Town of East Gwillimbury, 2020). The community was described in Lovell's 1873 Gazetteer as, "Mount Albert, or Newland, a post village in York co., Ont., 11½ miles from Newmarket. It contains several flouring mills, a cheese factory, a tannery and 6 stores. Pop. 150" (Lovell, 1873, p.204).

1.3.3.3 Hamlet of Franklin

The area known as Franklin, or West Franklin, at the intersection of Highway 48 and Herald Road, was settled by 1878 and appears in the *Illustrated Atlas of the County of York* as a small cluster of homesteads near a saw mill, a grist mill and a church. A post office was established in 1904 and was closed by 1913 (LAC, 2020).

1.3.4 Past Land Use

1.3.4.1 Pre-1900 Land Use

Several documents were reviewed to gain an understanding of the land use history and of the study area's potential for the recovery of historic pre-1900 remains, namely G.R. Tremaine's 1860 *Map of the County of York* and Miles & Co.'s 1878 *Illustrated Historical Atlas of the County of York* (***see Maps 3-4; Tables 3-4***). The study area primarily encompassed farmland and multiple homesteads. The village of Mount Albert and Vivian Creek were also depicted within the study area.

Table 3: Summary of Structures and Property Owners/Occupants documented in the 1860 *Tremaine's Map* and the 1878 *Illustrated Historical Atlas* within the Study Area for Concession 8

Lot	Part	Owner/Occupant 1860	Owner/Occupant 1878	Structure(s) in the Study Area 1860	Structure(s) in the Study Area 1878
6	W½	W. M. P. Manners	Jno. Wagg	1 homestead	1 homestead; 1 church
6	E½	Wm. Mainprize	Wm. Mainprize	-	1 homestead
6	E pt.	Unlisted	-	1 Steam saw mill (S.S.M.)	-
7	W pt.	Joel Crone	Joel Crone	-	1 homestead
7	W pt.	R. Cockerline	Robert Cockerline Est.	-	1 homestead
7	E½	R. Cockerline	Robert Cockerline Est.	1 homestead	1 homestead
8	NW¼	W. M. P. Manners	S. Stokes	-	-
8	SW¼	Ann Weddle	Wm. Pover	-	-
8	E½	Ann Weddle	Newton Graham	-	1 homestead
9	W½	Samuel Shuttleworth	Samuel Shuttleworth	1 homestead	1 homestead
9	E½	H. Shuttleworth	Edmond Shuttleworth	1 Saw Mill	1 homestead
10	W½	George Stokes	Sidney Stokes	1 homestead	2 homesteads; village lots of Mount Albert
10	E½	Alexander Fletcher	Alexander Fletcher	1 homestead; 1 inn	2 homesteads; village lots of Mount Albert
11	W pt.	J. Boutun	Thomas Rear	-	-
11	W pt.	T. Rear	Thomas Rear	Village lots of Mount Albert	Village lots of Mount Albert
11	W pt.	J. Allison	Thomas Rear	-	-
11	E½	George Rear	George Rear	1 homestead; Village lots of Mount Albert	3 homesteads; village lots of Mount Albert; 1 church; 1 grist mill
12	W pt.	William Miller	Al Gould	1 Saw Mill	1 saw mill; 1 homestead
12	W pt.	T. Shannon	Jno. Miller	Village lots of Mount Albert	Village lots of Mount Albert
12	E½	J. Lanson	Jno. lanson	-	2 homesteads; 1 cheese factory
12	E pt.	J. Lanson	W.S.	Village lots of Mount Albert; 1 grist mill	Village lots of Mount Albert; 1 grist mill
13	W½	William Miller	Est. of Mary Miller	-	1 homestead
13	E½	William Miller	Est. of Mary Miller	1 homestead	1 homestead; wool factory
14	NW¼	Jos. Pegg	Jos. Pegg	-	1 homestead
14	SW¼	Jos. Pegg	Thomas Rear	-	1 homestead
14	NE¼	H. Pegg	Jos. Pegg	-	-
14	SE¼	J. Pegg	Jos. Pegg	-	-
15	NW¼	Thomas Fox	Lawrence Boland	-	-
15	SW¼	Nathaniel O'Brien	Nathaniel O'Brien	-	1 homestead
15	NE¼	Thomas Fox	Lawrence Boland	1 schoolhouse	1 homestead
15	WSE pt.	N. O'Brien	Nathaniel O'Brien	-	Chalmers Church
15	ESE pt.	Wm. Mainprise	W.M.	-	-
16	N½	Robert Shuttleworth	Robert Shuttleworth	-	-
16	S½	John Shuttleworth	Elijah Lake	-	-

Lot	Part	Owner/Occupant 1860	Owner/Occupant 1878	Structure(s) in the Study Area 1860	Structure(s) in the Study Area 1878
17	E½	John Dunn	John Dunn	-	-

"-" denotes details not applicable

Table 4: Summary of Structures and Property Owners/Occupants documented in the 1860 *Tremaine's Map* and the 1878 *Illustrated Historical Atlas* within the Study Area for Concession 9

Lot	Part	Owner/Occupant 1860	Owner/Occupant 1878	Structure(s) in the Study Area 1860	Structure(s) in the Study Area 1878
6	All	Thompson Cuyler	Thompson Cuyler	-	1 homestead
7	All	Thompson Cuyler	Thompson Cuyler	-	-
8	N½	A. Terry	William Harrison	-	-
8	S½	Thompson Cuyler	Thompson Cuyler	-	-
9	N½	T. Harrison	William Harrison	-	1 homestead
9	S½	A. Terry	William Harrison	-	-
10	All	T. Harrison	Thomas Harrison	-	-
11	N½	T. Harrison	Thomas Harrison	-	-
11	S½	T. Harrison	Thomas Harrison	-	1 homestead
12	N½	T. Harrison	G.S.	-	-
12	S½	T. Harrison	Thomas Harrison	-	-
13	All	Unlisted	Jos. Cook	-	1 homestead
14	All	Unlisted	Jos. Cook	-	-
15	All	Unlisted	Unlisted	-	-
16	All	Unlisted	Unlisted	-	-
17	All	Unlisted	Unlisted	-	-

"-" denotes details not applicable

Additionally, four homesteads and one schoolhouse are depicted falling within 300 metres of the study area in the 1860 *Tremaine's Map.* By 1878, 27 homesteads, two schoolhouses and the Lake Simcoe Junction Railway were depicted within 300 metres of the study area.

Additionally, the study area encompasses present-day Highway 48, Centre Street, Ninth Line, York Durham Line, Herald Road, Mount Albert Road, and Doane Road, which were originally laid out during the survey of the Township of East Gwillimbury. In Ontario, the *2011 S&G* considers areas of early Euro-Canadian settlements (e.g., pioneer homesteads, isolated cabins, farmstead complexes, early wharf or dock complexes, pioneer churches, and early cemeteries), early historic transportation routes (e.g., trails, passes, roads, railways, portage routes), and properties that local histories or informants have identified with possible archaeological sites, historical events, activities, or occupations, as features or characteristics that indicate archaeological potential (per *Section 1.3.1*). Therefore, based on the proximity of early Euro-Canadian settlements, and early historic transportation routes, these features contribute in establishing the archaeological potential of the study area.

1.3.4.2 Post-1900 Land Use

To facilitate further evaluation of the established archaeological potential within the study area, a detailed review of topographic maps from 1929 and 1939 (***see Map 5***) and aerial imagery from 1954 to 2019 was undertaken (***see Maps 6-8***).

The 1929 *Topographic Map* depicted the study area primarily within land that had been cleared of overgrown vegetation that was likely agricultural lands as well as pockets of treed areas. Numerous houses, a sports field, three cemeteries, a school, a hotel, two blacksmiths/garages and two railways routes of the Canadian National Railway were depicted in the study area. Vivian Creek and Mount Albert Creek were also depicted within the study area. The study area remained unchanged to 1939.

By 1954, the study area primarily consisted of open agricultural fields and blocks of forested areas. Numerous houses were constructed within Mount Albert, primarily north and west of Mount Albert Road, and several farmsteads were also located within the study area. The railway tracks, Vivian Creek, Mount Albert Creek and their tributaries continued to be depicted within the study area. By 1988, Mount Albert Road had been realigned at the intersection of Highway 48. The village saw continued growth and subdivision development between 1954 and 2019, with the majority of expansion focused north of Mount Albert Road. Lands within the Impact Buffer remained predominantly rural and largely undeveloped to 2019, with the exception of two larger subdivisions constructed just south of Mount Albert Road.

1.3.5 Present Land Use

The present land use of the study area is categorized as Prime Agricultural Area, ORM Countryside Area, General Employment, Low Density Residential, Medium Density Residential, Village Core Area, Community Commercial, Neighbourhood Commercial, Institutional, Environmental Protection Area, and Parks and Open Space (Town of East Gwillimbury, 2018).

1.4 Archaeological Context

To establish the archaeological context and further establish the archaeological potential of the study area, *Archeoworks Inc*. conducted a comprehensive review of designated and listed heritage properties, commemorative markers and pioneer churches and early cemeteries in relation to the study area. Furthermore, an examination of registered archaeological sites and previous AAs in proximity to the study area limits, and a review of the physiography of the study area were performed.

The results of this background research are documented below and summarized in **Appendix B – Summary of Background Research**.

1.4.1 Designated and Listed Cultural Heritage Resources

Per *Section 1.3.1* of the *2011 S&G*, properties listed on a municipal register or designated under the *Ontario Heritage Act*, or that is a federal, provincial, or municipal historic landmark or site, are considered features or characteristics that indicate archaeological potential. Numerous designated and listed heritage resources are located in and within 300 metres of the study area; only those designated and listed properties located within the Impact Buffer are included in **Table 5** (Town of East Gwillimbury, 2019). Non-designated properties (or "listed" properties) are properties that have cultural heritage value or interest to the community but have not been formally designated. Therefore, this feature contributes in establishing the archaeological potential of the study area.

Table 5: Designated and Listed Heritage Resources in the Impact Buffer

Address	Description	Heritage Status
6 Alice Street	Robert Hunter (Postmaster & J.P.) house ca. 1884	Listed
9 Alice Street	Ca. 1880	Listed
10 Alice Street	Ca. 1890	Listed
16 Alice Street	Ca. 1870	Listed
19014 Centre Street	Ca. 1875	Listed
19015 Centre Street	Mount Albert Methodist (Wesleyan) Pioneer Cemetery	Designated
19052 Centre Street	Ca. 1865	Listed
19059 Centre Street	Ca. 1856	Listed
5503 Mount Albert Road	Ca. 1856	Listed
5590 Mount Albert Road	Birchard Family Burying Ground (Centennial Park)	Listed
5623 Mount Albert Road	Ca. 1850	Listed
5631 Mount Albert Road	South portion of Royal Oak Hotel moved to this site; ca. 1870	Listed
5664 Mount Albert Road	Ca. 1880	Listed
5688 Mount Albert Road	Janet Willson Forest House ca. 1878	Listed

1.4.2 Heritage Conservation Districts

Per *Section 1.3.1* of the *2011 S&G*, heritage resources listed on a municipal register or designated under the *Ontario Heritage Act* are considered features or characteristics that indicate archaeological potential. The study area is not located in or within 300 metres of a Heritage Conservation District (MHSTCI, 2020a). Therefore, this feature does not contribute to establishing the archaeological potential of the study area.

1.4.3 Commemorative Plaques or Monuments

Per *Section 1.3.1* of the *2011 S&G,* commemorative markers of Indigenous and Euro-Canadian settlements and history which may include local, provincial, or federal monuments, cairns or plaques, or heritage parks are considered features or characteristics that indicate archaeological potential. The study area is not located in or within 300 metres of a commemorative plaque or monument (Ontario Historical Plaques, 2019; OHT, 2020). Therefore, this feature does not contribute to establishing the archaeological potential of the study area.

1.4.4 Pioneer/Historic Cemeteries

Per *Section 1.3.1* of the *2011 S&G,* pioneer churches and early cemeteries are considered features or characteristics that indicate archaeological potential. Four cemeteries are located in the study area: Franklin Pioneer Cemetery at 5548 Herald Road; Mount Albert Cemetery at 19675 Centre Street; Mount Albert Wesleyan Methodist Pioneer Cemetery at 19015 Centre Street; and

Birchard Family Burying Ground at 5590 Mount Albert Road (Birchard Parkette also known as Centennial Park). All four cemeteries are considered early cemeteries and therefore, these features contribute to establishing the archaeological potential of the study area.

1.4.4.1 Franklin Pioneer Cemetery

The Franklin Pioneer Cemetery was associated with a church that was established on Lot 6, Concession 8 and served those of the Bible Christian faith of Franklin and Mount Albert. In 1863 William P. Manners sold ¾ of an acre of Brooks N. Howard, around the same time as the cemetery was established. The church has long since been demolished and lumber from the church was used in the construction of a neighbour's house located west of Mount Albert. The church was located within the current delineated property limits of the cemetery. The gravestones have been broken over time, and what remained were gathered and placed in a small area near the western part of the cemetery boundaries, with older and newer headstones laid together. Of the gravestones that have survived, the earliest burial appears to have occurred in 1861. There are unmarked graves on the cemetery property, however the burials are very likely confined to the present-day cemetery boundaries (OGS, 1989; Sharon Temple National Historic Site & Museum, 2020).

1.4.4.2 Mount Albert Cemetery

The Mount Albert Cemetery was established in 1864 when Nathaniel O'Brien gave a quarter acre of his farm to build a Presbyterian Church. The first burial in the cemetery grounds occurred that same year. The church was later moved in 1881. By 1898, the cemetery was enlarged when T. O'Brian sold 3.75 acres of his land allowing 5,554 graves to be organized within the cemetery. A burial vault was established in 1905 and a second vault was built near Centre Street in 1957. The cemetery has been active and well-maintained since its establishment and it is not likely for there to be unmarked graves within or adjacent to the cemetery grounds (OGS, 2015; Sharon Temple National Historic Site & Museum, 2020).

1.4.4.3 Mount Albert Wesleyan Methodist Pioneer Cemetery

Mount Albert Wesleyan Methodist Pioneer Cemetery (alternatively known as Wesleyan Methodist Pioneer Cemetery) was established on property formerly owned by George Rear at 19015 Centre Street. There are conflicting reports surrounding the dates of establishment and closure of the cemetery: the plaque on the site erected by the Horticultural Society gives dates of 1830-1894 while the by-law for heritage designation states 1850's to 1892. The land was officially granted for the creation of a cemetery in 1857 and many of the early settlers in Mount Albert were buried at the cemetery. A small frame church was also once located immediately south of the cemetery, likely at what is currently recognized as 5646 Mount Albert Road (OGS, 2014; Sharon Temple National Historic Site & Museum, 2020; Town of East Gwillimbury, 2004). This cemetery is also located within the Impact Buffer; for further details, see ***Section 3.5.1***.

1.4.4.4 Birchard Family Burying Ground

The Birchard Family Burying Ground is currently located within Birchard Parkette, also known as Centennial Park. In 1850, Israel Birchard, a pioneer of Mount Albert, sold a quarter of an acre of his land on the condition that the land never be used for anything but a school and burying grounds. The school that was built has since been removed and "there were originally a few burials there which likely still remain" (Sharon Temple National Historic Site & Museum, 2020). This cemetery is also located within the Impact Buffer; for further details, see ***Section 3.5.2***.

1.4.5 Registered Archaeological Sites

Per *Section 1.1, Standard 1* and *Section 7.5.8, Standard 1* of the *2011 S&G*, the *Ontario Archaeological Sites Database* (OASD) maintained by the *MHSTCI* was consulted in order to provide a summary of registered or known archaeological sites within a minimum one-kilometre distance of the study area limits.

According to the OASD, five registered archaeological sites are located within a one-kilometre radius of the study area (MHSTCI, 2020b) (***see Table 6***). All five registered archaeological sites are located in the study area; none are located in or within proximity to the Impact Buffer.

Table 6: Registered Archaeological Sites within One Kilometre of the Study Area

Borden #	Name	Cultural Affiliation	Type
BaGt-1	Victoria	Early Woodland	Findspot
BaGt-15	Loon	Paleo-Indian	Findspot
BaGt-16	Hawk	Pre-Contact (Indigenous)	Findspot
BaGt-40	Mount Albert	Pre-Contact (Indigenous)	Scatter
BaGt-41	BaGt-41	Pre-Contact (Indigenous)	Scatter

Per *Section 1.3.1* of the *2011 S&G*, previously registered archaeological sites in close proximity are considered to be features or characteristics that indicate archaeological potential. Therefore, given the presence of five registered archaeological sites in the study area, this feature contributes in establishing archaeological potential of the study area.

1.4.6 Previous Archaeological Assessments

Per *Section 1.1, Standard 1* and *Section 7.5.8, Standards 4-5* of the *2011 S&G*, to further establish the archaeological context of the study area, a review of previous AAs carried out within the limits of, or immediately adjacent (i.e., within 50 metres) to the study area — as documented by all available reports — was undertaken. Ten archaeological reports were identified (***see Table 7***):

Table 7: Previous Archaeological Assessments

Company, Report Date	Stage of Work	Relation to Study Area	Details and Recommendation
Amick Consultants Limited, 2013	Stage 1-2 AA	Within the general study area and Impact Buffer	Located at 5751 Mount Albert Road. During the Stage 2 AA no archaeological resources were encountered. Recommended that the areas assessed and documented be considered clear of further archaeological concern.
Amick Consultants Limited, 2015	Stage 1-2 AA	Within the general study area	Located at 19267 & 19259 Centre Street. During the Stage 2 AA, no archaeological resources were encountered. Recommended that no further archaeological assessment of the subject area is warranted, and the proposed undertaking is clear of any archaeological concerns.

Company, Report Date	Stage of Work	Relation to Study Area	Details and Recommendation
Archeoworks Inc., 2005	Stage 1 AA	Within the general study area and Impact Buffer	Associated with the exploration of water resources for water supply in the Community of Mount Albert that includes four proposed watermain routes (a. along Herald Road from McCowan Road to Centre Street; b. along Centre Street from Herald Road to Mount Albert Road; c. along Mount Albert Road from Centre Street to McCowan Road and; d. along McCowan Road from Mount Albert Road to Herald Road; and e. along Highway 48 from Mount Albert Road to Herald Road) and two test well locations (Test Well A and Test Well B). It was recommended that once the preferred watermain alignment, test well location and final construction limits have been determined, a Stage 2 archaeological field assessment in the areas noted as retaining archaeological potential should be undertaken.
ASI Archaeological and Cultural Heritage Services, 1990	Stage 1-2 AA (equivalent)	Within the general study area and Impact Buffer	Associated with Phases 2 and 3 of the Master Plan of Archaeological Resources for the Town of East Gwillimbury. During Phase 2 (systematic field research), over 1200 hectares of ploughed land and woodlot were surveyed and a total of 32 new archaeological sites were discovered. Of the total 51 sites within the Town boundaries, three sites fall within the study area: the Victoria Site (BaGt-1), the Loon Site (BaGt-15), and the Hawk Site (BaGt-16). Further archaeological investigations were recommended on the Loon Site (BaGt-15). No further archaeological investigations were warranted for the Victoria Site (BaGt-1) and the Hawk Site (BaGt-16). Additionally, those lands that have already been subjected to archaeological survey where no archaeological sites were found are of no further archaeological concern. Note: It appears as if the east half of Lot 10, Concession 8 (partially located within the Impact Area) was previously assessed. However, due to the date of the report and the lack of clear detailed mapping delineating surveyed areas, further AA is required in this parcel of land to confirm the presence or absence of archaeological resources.
ASI Archaeological and Cultural Heritage Services, 2008	Stage 1 AA	Within the general study area	Located at 19190 Ninth Concession Road. The field review identified the tree lined residential portion of the subject area to have archaeological potential and Stage 2 AA was recommended in this area. The remainder of the subject area was determined to be disturbed and considered to have no archaeological potential.
ASI Archaeological and Cultural	Stage 1-2 AA	Within the general study	Located at 5715 Mount Albert Road. During the Stage 2 AA, two pre-contact lithic sites, P2 (BaGt-40) and P6 (BaGt-41), and four pre-contact lithic findspots were

Company, Report Date	Stage of Work	Relation to Study Area	Details and Recommendation
Heritage Services, 2015a		area and Impact Buffer	encountered. Given the isolated and undiagnostic ephemeral nature of findspots P1, P3, P4 and P5 these findspots do not represent any further archaeological significance. Stage 3 AA was recommended on pre-contact lithic sites P2 (BaGt-40) and P6 (BaGt-41).
ASI Archaeological and Cultural Heritage Services, 2015b	Stage 3 AA	Within the general study area	Associated with the Stage 3 AA of BaGt-40. A controlled surface pickup (CSP) was initially conducted yielding nine artifacts. This was followed by the excavation of 15 one metre square units over an area measuring 36 metres by 13 metres. One potential invisible or "ghost" cultural feature was discovered which contained a number of lithic flakes. A total of 60 lithic artifacts were recovered and were of five different raw materials (Onondaga, Blois Blanc, Kettle Point, Haldimand and unknown cherts). It was recommended that site BaGt-40 has demonstrated cultural heritage value or interest and as this site cannot be avoided and protected within the final development plan, it therefore must be subject to comprehensive Stage 4 archaeological salvage excavation.
ASI Archaeological and Cultural Heritage Services, 2015c	Stage 4 Mitigation	Within the general study area	Associated with the mitigation of BaGt-40 (renamed to Mount Albert site). A total of 71 one metre square units were excavated during the block excavation. One, large irregular subsurface cultural feature (or complex of features) was identified based on artifact patterning (Feature 1). A total of 685 lithic artifacts were recovered from the block excavation and 2,162 artifacts were recovered during the process of piece-plotting and excavating the "invisible" subsurface feature. Although questions remain concerning the Mount Albert site, the Stage 4 salvage excavations have resulted in the documentation and removal of all significant archaeological deposits associated with this circa 4000-2500 BC occupation. It was recommended that the Mount Albert site (BaGt-40) is of no further cultural heritage value or interest.
ASI Archaeological and Cultural Heritage Services, 2015d	Stage 3 AA	Within the general study area	Associated with the Stage 3 AA of BaGt-41. A controlled surface pickup (CSP) was initially conducted yielding three artifacts. This was followed by the excavation of 16 one metre square units over an area measuring 26 metres by 32 metres. A total of four lithic artifacts were recovered and were of Onondaga chert. No cultural features were encountered. It was recommended that given the low density of artifacts and the ephemeral nature of site BaGt-41, it does not represent any further cultural heritage value or interest and may be considered free of any further archaeological concern.
Earthworks Archaeological Services, 2010	Stage 2 AA	Within the general study area	Located at 19190 Ninth Concession Road (Ninth Line). During the Stage 2, no artifacts were recovered, and no subsoil features were noted in any test pits. No further archaeological work is required for the subject property.

1.4.7 Physical Features

1.4.7.1 Physiographic Region

The study area is located primarily within the Peterborough Drumlin Field physiographic region of Southern Ontario, with the western limits falling within the Simcoe Lowlands physiographic region of Southern Ontario.

The Peterborough Drumlin Field region lies between the Oak Ridges Moraine and the area of shallow overburden on the limestones of the Gull River Formation. There is a rolling till plain, extending from Hastings County in the east to Simcoe County in the west, and includes the drumlins south of the moraine in Northumberland County. For the most part, the rock underlying this region is limestone of the Lindsay and Verulam Formations which are somewhat softer and less massive formations than the Gull River Formation. The Peterborough Drumlin Field is notable for its eskers as well as its drumlins. While the eskers are perhaps the most striking features of the plain, apart from the drumlins themselves, they are not as important in respect to soils as the deposits of clay which lie between the drumlins in some areas (Chapman & Putnam, 1984, pp.169-172).

The portion of the study area that falls within the Simcoe Lowlands is located in a portion of the physiographic region that is known as the Lake Simcoe Basin. On the northern and western shores of Lake Simcoe, the lowland consists of a narrow bouldery terrace for the most part confined by a low bluff cut by the highest stage of Lake Algonquin. On the south and east of Lake Simcoe are broader plains. On the whole, the Lake Simcoe basin is a poorer farm district than the Nottawasaga Basin (located on the west side of Lake Simcoe). Extensive areas of bogs and wet sand permeate the basin but these soils may become useful as population grows, since both can be drained and developed for vegetables, like the Holland Marsh (Chapman & Putnam, 1984, pp.181-182).

1.4.7.2 Soil Types and Topography

Several soil types are found within the study area including Bottom Lands, Brighton sandy loam, Bondhead sandy loam, Dundonald sandy loam, Granby sandy loam, Pontypool sand, Schomberg clay loam, Smithfield clay loam and Tecumseth sandy loam over gravel (***see Map 9***). A description of their characteristics may be found in **Table 8** (Ontario Agricultural College, 1954).

Table 8: Study Area Soil Types

Soil Series & Type	Great Soil Group	Drainage	Topography and Stoniness	Parent Material
Bottom Lands	Alluvial	Variable	Variable; stonefree	Irregularly stratified alluvial deposits
Brighton sandy loam	Grey-Brown Podzolic	Good	Smooth very gently sloping; stonefree	Well sorted grey, calcareous sand or stratified sand and gravel
Bondhead sandy loam	Grey-Brown Podzolic	Good	Smooth moderately sloping; few stones	Medium textured grey stony, strongly calcareous till

Soil Series & Type	Great Soil Group	Drainage	Topography and Stoniness	Parent Material
Dundonald sandy loam	Grey-Brown Podzolic	Good	Smooth moderately sloping; stonefree	Sandy outwash over loamy, grey, calcareous till
Granby sandy loam	Dark Grey Gleysolic	Poor	Smooth very gently sloping; stonefree	Well sorted slightly calcareous sandy outwash
Pontypool sand	Grey-Brown Podzolic	Good	Irregularly steeply sloping; few stones	Poorly sorted, calcareous sandy outwash
Schomberg clay loam	Grey-Brown Podzolic	Good	Smooth, moderately sloping to irregularly steeply sloping; stonefree	Lacustrine, grey, calcareous, clay or silty clay
Smithfield clay loam	Grey-Brown Podzolic	Imperfect	Smooth gently sloping; stonefree	Lacustrine, grey, calcareous, clay or silty clay
Tecumseth sandy loam over gravel	Grey-Brown Podzolic	Imperfect	Smooth very gently sloping; stonefree	Well sorted grey, calcareous sandy of stratified sand and gravel

The topography is gently rolling with an elevation range of 234-292 metres above sea level.

1.4.7.3 Hydrological Features

Hydrological features such as primary water sources (i.e., lakes, rivers, creeks, streams) and secondary water sources (i.e., intermittent streams and creeks, springs, marshes, swamps) would have helped supply plant and food resources to the surrounding area and are indicators of archaeological potential (per *Section 1.3.1* of the *2011 S&G*). Vivian Creek, Mount Albert Creek and their tributaries bisect the study area. Therefore, this feature contributes to establishing the archaeological potential of the study area.

1.4.8 Current Land Conditions

The study area is situated mainly within a rural setting of the Town of East Gwillimbury encompassing and surrounding the suburban setting of Mount Albert. The study area encompasses typical features associated with a suburban community (residential properties, school, churches and cemeteries, business plazas, local small businesses, grocery store, restaurants, parks and community centre, public library, post office, fire station, etc.). The majority of development is located north of Mount Albert Road. The study area also encompasses largely undeveloped rural areas consisting of open agricultural fields, woodlots, and several farm complexes. As previously mentioned, railway tracks, Vivian Creek, Mount Albert Creek and their tributaries also bisect the study area.

The Impact Buffer is primarily located in a rural area, also encompassing the southernmost portion of the village at the intersection of Centre Street and Mount Albert Road.

1.4.9 Dates of Desktop Review and Fieldwork

A desktop review of field conditions using aerial imagery from 1954 to 2019, available through the Regional Municipality of York, was undertaken on July 1st, 2020.

A property inspection was carried out for the Impact Buffer on November 27th, 2020 (***see Section 2.0 for further details***). The purpose of a property inspection is to identify and describe areas of high potential requiring additional archaeological survey; identify and describe areas of no/low potential not warranting further archaeological concern; and to help gather information to formulate appropriate Stage 2 AA strategies.

1.5 Confirmation of Archaeological Potential

Based on the information gathered from the background research documented in the preceding sections, elevated archaeological potential has been provisionally established within the study area limits. Features contributing to archaeological potential are summarized in **Appendix B**. Specific review and assessment of conditions within the Impact Buffer will be addressed in **Section 3.0**.

2.0 PROPERTY INSPECTION

The property inspection was conducted in compliance with the standards set forth in *Section 1.2* of the *2011 S&G*. The weather and lighting conditions (average of 5°C and overcast) during the Stage 1 property inspection permitted good visibility of all parts of the Impact Buffer and were conducive to the identification of features of archaeological potential.

The property inspection involved a visual inspection only and did not include excavation or collection of archaeological resources. The inspection was carried out by random spot-checking features previously identified during the desktop review, reviewing the Impact Buffer to gain first-hand knowledge of the area's geography, topography, and current condition, and to evaluate and map archaeological potential. The Impact Buffer was inspected from publicly accessible lands only or where permission was granted to access private lands.

The results of the property inspection and location and orientation information associated with a selection of photographs taken in the field are illustrated within **Maps 10-18**. Photographic images are presented within **Appendix C***.* An inventory of the documentary record generated in the field can be found within **Appendix D***.*

3.0 ANALYSIS AND CONCLUSIONS

In combination with data gathered from the background research (***see Sections 1.3 and 1.4***), a desktop review of aerial imagery, and the property inspection (***see Section 2.0***), an evaluation of the established archaeological potential of the Impact Buffer was performed. The results of this evaluation are presented in **Maps 10-18**.

3.1 Previous Archaeological Assessments

Lands within the Impact Buffer which have already been subjected to an archaeological assessment (AMICK Consultants Limited, 2013; ASI, 2015a), and deemed free of further archaeological concern are recommended to be exempt from further assessment (***see Section 1.4.6, Table 7; Maps 10, 12, 13***).

3.2 Identified Deep and Extensive Disturbances

The Impact Buffer was evaluated for deep and extensive land alterations – commonly referred to as disturbances – that have severely impacted the integrity of any archaeological resources. Per *Section 1.3.2* of the *2011 S&G*, these include, but are not limited to: quarrying, major landscaping involving grading below topsoil, building footprints, or sewage and infrastructure development.

Disturbances documented within the Impact Buffer from the desktop review of aerial imagery and property inspection include: the existing paved roadways (Centre Street, Mount Albert Road, Alice Street, Hi-View Drive and Cleverdon Boulevard), rights-of-ways (ROWs) (shallow and deep drainage ditching, utilities, concrete curbs and sidewalks, paved and gravel shoulders, embankments and cut slopes, concrete barriers, and culverts), former and existing structures (residential houses, outbuildings, barns, etc.), existing regional infrastructure (such as water production wells and elevated tanks), paved and gravel access driveways and parking areas, extensive landscaping (e.g., inground pools, man-made ponds, tennis court, etc.), and manicured areas previously subjected to grading and construction activities (***see Maps 10-17; Images 1-26***).

The construction of these features would have resulted in severe damage to the integrity of any archaeological resources which may have been present within their footprints and, as such, are exempt from Stage 2 survey.

3.3 Physiographic Features of No or Low Archaeological Potential

The Impact Buffer was also evaluated for physical features of no or low archaeological potential. These usually include but are not limited to: permanently wet areas, exposed bedrock, and steep slopes (greater than 20º) except in locations likely to contain pictographs or petroglyphs, as per *Section 2.1, Standard 2.a* of the *2011 S&G.* Physical features of low or no archaeological potential documented within the Impact Buffer include steeply sloping areas and the low-lying and wet terrain associated with Vivian Creek (***see Maps 10, 11, 13, 15, 17; Images 27-33***).

Due to the no to low archaeological potential classification of these features, all areas documented in this section are exempt from Stage 2 survey.

3.4 Identified Areas of Archaeological Potential

Portions of the Impact Buffer that neither exhibit extensively disturbed conditions nor contain physical features of no or low archaeological potential are therefore considered to retain the established archaeological potential. These areas include: open agricultural fields, manicured lawns dotted with trees, areas of overgrown vegetation, wooded areas, rowed tree plantation (reforested areas), grassed areas within and between horse paddocks and corrals, and minor landscaping and gardens (***see Maps 10-17; Images 10-18, 34-36***).

Given the established potential to recover archaeological resources within these identified areas, a Stage 2 AA will be required. Actively or recently cultivated agricultural land must be subjected to pedestrian survey, in accordance with the standards outlined in *Section 2.1.1* of the *2011 S&G*. In areas where ploughing is not possible or viable due to the presence of overgrown vegetation or existing infrastructure and landscaping, a Stage 2 test pit survey at five metre intervals must be performed, in accordance with the standards outlined in *Section 2.1.2* of the *2011 S&G*.

3.5 Cemeteries

As per the *Cemeteries Act*, R.S.O. 1990 c. C.4 and the *Funeral, Burial and Cremation Services Act*, 2002, S.O. 2002, c.33 no intrusive activity may occur within the limits of the Mount Albert Wesleyan Methodist Pioneer Cemetery or the Birchard Family Burying Ground without consent from the *Bereavement Authority of Ontario (BAO)*. The Wesleyan Methodist Pioneer Cemetery is also designated under Part IV of the *Ontario Heritage Act* according to by-law number 2004-20 in the Town of East Gwillimbury and the Birchard Family Burying Ground is a listed ("non-designated") heritage resource (Town of East Gwillimbury, 2019).

It is recommended by the *MHSTCI* and the *BAO* that a cemetery investigation begin at least 20 metres from the current cemetery property limits. To gain a better understanding of the land use history within and immediately adjacent to the Mount Albert Wesleyan Methodist Pioneer Cemetery and Birchard Family Burying Ground, the *Cemetery Operator* (Town of East Gwillimbury) was contacted. The *Cemetery Operator* provided a brief overview of the history of the cemeteries as well as an evaluation on the likelihood of unmarked burials (Sharon Temple National Historic Site & Museum, 2020).

3.5.1 Mount Albert Wesleyan Methodist Pioneer Cemetery

The Mount Albert Wesleyan Methodist Pioneer Cemetery (established between ca. 1830s-1850s), located at 19015 Centre Street, is a currently inactive mid- to late nineteenth century cemetery within the study area (***see Map 18***). This pioneer cemetery is considered a sensitive cultural resource of high archaeological potential.

Nineteenth century historic cemeteries were not highly regulated, and burials may have occurred outside the property limits, often employing markers of little substance that have since disappeared. The possible absence of grave markers can result in inaccurate depictions of the currently recognized cemetery property limits. In addition, according to the Ontario Genealogical Society (OGS) cemetery transcript, since the last internment around 1890, the Wesleyan Methodist Cemetery became neglected and overgrown with weeds. In the 1950s the Horticultural Society cleaned up the cemetery grounds, removing the brush and old headstones, many of which were broken, and several were difficult to read. The stones were then arranged in a row in the northeast corner of the property and set in cement (OGS, 2014; Sharon Temple National Historic Site & Museum, 2020). "The Society leveled the ground, planted grass and erected a monument honouring the pioneers" (OGS, 2014).

Given that burials may have occurred outside the cemetery limits, and that many of the burial markers were removed from their original locations indicating the potential for unmarked graves, further cemetery investigations are required to confirm the presence or absence of burial features extending beyond the current cemetery limits.

The property inspection and a review of available background research and aerial imagery revealed portions of the Impact Buffer as falling within the 20-metre cemetery investigation area of the Mount Albert Wesleyan Methodist Pioneer Cemetery. These portions were then determined to have either low, moderate or high potential for unmarked burials (***see Map 18***).

3.5.1.1 Areas of Low Potential

The western portion of the 20-metre cemetery investigation area encompassing Centre Street, a historic roadway, exhibits deep and extensive disturbances related to the highly destructive nature of roadway construction. The historic limits of the Mount Albert Wesleyan Methodist Pioneer Cemetery would also have coincided with the boundaries of this historic roadway, making it unlikely that any burials extended into the roadway or into the lands on the west side of this roadway. Therefore, there is low potential to encounter unmarked burials and further cemetery investigation is not required in this area.

In addition, the right-of-way (ROW) of Centre Street and several building footprints and access driveways within the 20-metre cemetery investigation area also exhibit extensive land alterations. However, the access driveway and parking area located at 19031 Centre Street (also identified as a listed heritage resource), and the Centre Street ROW are immediately adjacent to the current cemetery limits (within 10 metres) and will require further cemetery investigation to evaluate the presence of deeply buried remains (***see Sections 3.5.1.2 and 3.5.1.3***).

3.5.1.2 Areas of Moderate Potential

As mentioned, the western edge of the cemetery within the Centre Street ROW consists of a concrete barrier, sidewalk and part of the paved roadway shoulder (approximately four metres) (***see Images 3-4***). Although exhibiting roadside disturbances, due to the unknown layout and location of the original graves, this swath of land retains moderate potential for the presence of deeply buried remains and unmarked burials. Given this, further cemetery investigations are required in this area.

Although Mechanical Topsoil Removal (MTR) is the preferred method for investigating unknown historic cemetery limits, MTR is not feasible due to existing roadway infrastructure within the previously identified four-metre swath of land. Therefore, construction monitoring is recommended for this area, the requirements for which are listed within ***Section 4.0 - Recommendations***.

3.5.1.3 Areas of High Potential

Due to the early date of establishment of the cemetery (ca. 1830s-1850s) and the removal and rearrangement of the original markers and monuments, lands encompassed within the Impact Buffer directly adjacent to the current cemetery limits (within 10 metres to the north, east and south) have a high potential to encounter unmarked burials, with the exception of all previously mentioned areas determined to have low or moderate potential. These areas consist of manicured lawn dotted with trees, hedges, and gardens, an access driveway and parking area. Further cemetery investigations of these areas is required to confirm the presence or absence of burial features extending beyond the current cemetery limits.

Given the established potential to recover archaeological resources within these areas, any construction related soil-intrusive work here must be preceded by additional archaeological assessment. These areas must be subjected to Stage 2 test pit survey followed by mechanical topsoil removal, the requirements for which are listed within ***Section 4.0 - Recommendations***. Furthermore, should the area within the current cemetery limits (***see Image 37***) be impacted, additional archaeological investigation is also required.

3.5.2 Birchard Family Burying Ground

The Birchard Family Burying Ground (established ca. 1850), located at 5590 Mount Albert Road, also known as Birchard Parkette or Centennial Park, is a currently inactive mid- to late nineteenth century cemetery within the study area (***see Map 18***). This pioneer cemetery is considered a sensitive cultural resource of high archaeological potential.

Birchard Parkette was once the location of a schoolhouse and a small burying ground; the property is currently used as a public park and there are likely unmarked graves still on the grounds (Sharon Temple National Historic Site & Museum, 2020). Furthermore, nineteenth century historic cemeteries were not highly regulated, and burials may have occurred outside the property limits, often employing markers of little substance that have since disappeared. The possible absence of grave markers can result in inaccurate depictions of the currently recognized cemetery property limits.

Given that burials may have occurred outside the cemetery limits, and that the original locations of grave markers within the property is unknown, further cemetery investigations are required to confirm the presence or absence of burial features extending beyond the current cemetery limits.

The property inspection and a review of available background research and aerial imagery revealed portions of the Impact Buffer as falling within the 20-metre cemetery investigation area of the Birchard Family Burying Ground. These portions were then determined to have either low, moderate or high potential for unmarked burials (***see Map 18***).

3.5.2.1 Areas of Low Potential

The eastern and southern portions of the 20-metre cemetery investigation area encompassing Centre Street and Mount Albert Road, both historic roadways, exhibit deep and extensive disturbances related to the highly destructive nature of roadway construction. A portion of Centre Street extends into the cemetery property (***see Image 38***). The cemetery also sits at the top of a hill and Mount Albert Road has been significantly altered and the grade lowered for the construction of the roadway; a cut slope and barrier wall can be seen along the southern edge of the cemetery (***see Image 26***). The historic limits of the Birchard Family Burying Ground would also have coincided with the boundaries of these historic roadways, making it unlikely that any burials extended into the roadway or into the lands on the east or south sides of the roadways.

There are several other areas within the 20-metre cemetery investigation area that also exhibit extensive land alterations of low potential. The property at 5576 Mount Albert Road adjacent to the western edge of the cemetery has been graded, cutting into the original slope of the land, for the construction of the house, driveway and garage (Google Maps, 2020).

To the north, the property at 19014 Centre Street, also a listed heritage property, within the cemetery investigation area includes a portion of a house structure, asphalt parking area, and an inground pool. Although the inground pool lies immediately adjacent to the Birchard Family Burying Ground (within 10 metres), this feature exhibits deep and extensive disturbances that have removed the potential to encounter unmarked burials within its footprint.

Therefore, there is low potential to encounter unmarked burials and further cemetery investigation is not required in the areas discussed above. However, to the east, a small portion of the grassed right-of-way, although exhibiting roadside disturbances, is immediately adjacent to the current cemetery limits (within 10 metres) and will require further cemetery investigation (***see Section 3.5.2.2***).

3.5.2.2 Areas of Moderate Potential

The right-of-way adjacent to the northeastern edge of the cemetery consists of a grassed margin (1-2 metres wide) (***see Image 39***). Although exhibiting roadside disturbances, due to the unknown layout and location of the original graves, this swath of land retains moderate potential for the presence of deeply buried remains and unmarked burials. Given this, further cemetery investigations are required in this area.

Although Mechanical Topsoil Removal (MTR) is the preferred method for investigating unknown historic cemetery limits, MTR is not feasible due to the narrowness of the swath of land and the presence of existing roadway infrastructure in close proximity. Therefore, construction monitoring is recommended for this area, the requirements for which are listed within ***Section 4.0 - Recommendations***.

3.5.2.3 Areas of High Potential

Due to the early date of establishment of the cemetery (ca. 1850) and the unknown location of the original graves, lands encompassed within the Impact Buffer directly adjacent to the current cemetery limits (within 10 metres to the north) have a high potential to encounter unmarked burials, with the exception of all previously mentioned areas determined to have low or moderate potential. This area consists of manicured lawn dotted with trees and gardens and wooded sloping terrain at 19014 Centre Street (***see Image 39***). Further cemetery investigations of these areas is required to confirm the presence or absence of burial features extending beyond the current cemetery limits.

The northwest portion of the cemetery investigation area within 19014 Centre Street consists of a treed area in sloping terrain. Similarly, the cemetery investigations of the Albion Congregational Church Burial Ground in Bolton (Archeoworks Inc., 2013) identify the cemetery extending into the slope edge. During the course of the Stage 3 cemetery investigation, burial features were encountered in the slope. Although the northwestern limits of the Birchard Family Burying Ground consists of a steep slope, previous similar cemetery investigations suggests that this area retains high potential for unmarked burials.

Given the established potential to recover archaeological resources within these areas, any construction related soil-intrusive work here must be preceded by additional archaeological assessment. These areas must be subjected to Stage 2 test pit survey followed by mechanical topsoil removal or construction monitoring, the requirements for which are listed within ***Section 4.0 - Recommendations***. Furthermore, should the area within the current cemetery limits be impacted, additional archaeological investigation is also required.

4.0 RECOMMENDATIONS

Considering the findings outlined within this report, the following recommendations are presented:

1. Lands that were subjected to previous archaeological assessments (AMICK Consultants Limited, 2013; ASI, 2015a) and deemed free of further archaeological concern are recommended to be exempt from further assessment.

2. All areas that were identified as having archaeological potential removed are exempt from requiring Stage 2 AA.

3. All areas that were identified as having no or low archaeological potential are exempt from requiring Stage 2 AA.

4. All areas identified as retaining archaeological potential must be subjected to a Stage 2 AA. These areas must be subjected to pedestrian or test pit survey at five-metre intervals in accordance with the standards set within *Sections 2.1.1* and *2.1.2* of the *2011 S&G.*

5. As per the *Cemeteries Act*, R.S.O. 1990 c. C.4 and the *Funeral, Burial and Cremation Services Act*, 2002, S.O. 2002, c.33 no intrusive activity may occur within the limits of the Mount Albert Wesleyan Methodist Pioneer Cemetery (also designated under Part IV of the *Ontario Heritage Act* according to by-law 2004-20) or the Birchard Family Burying Ground without consent from the *Bereavement Authority of Ontario*.
    a. Should the area within the current cemetery limits be impacted, additional archaeological investigation consisting of Stage 2 test pit survey followed by Stage 3 mechanical topsoil removal is required. An Investigation Order issued by the *Bereavement Authority of Ontario* is also required and needs to be obtained prior to conducting any soil-intrusive work (e.g., Stage 2/3/4 investigations; construction monitoring).

6. Lands within the 20-metre cemetery investigation area surrounding the Mount Albert Wesleyan Methodist Pioneer Cemetery and the Birchard Family Burying Ground that were identified as having low potential for unmarked burials are considered free of further cemetery investigations.

7. Should proposed construction impacts occur within the swaths of land adjacent to the Mount Albert Wesleyan Methodist Pioneer Cemetery or Birchard Family Burying Ground identified as having moderate or high potential for the recovery of unmarked burials, the following archaeological/cemetery investigations are required:
    a. As there is the potential for both the Mount Albert Wesleyan Methodist Pioneer Cemetery and the Birchard Family Burying Ground to extend into the Impact Buffer, an Investigation Authorization issued by the *Bereavement Authority of*

Ontario is required and needs to be obtained prior to conducting any soil-intrusive work (e.g., Stage 2/3/4 investigations; construction monitoring).

b. As there is the potential to encounter both deeply buried archaeological resources and for archaeological resources to be present near the surface, per *Section 2.1.7*, *Standard 2* of the *2011 S&G*, surface survey methods (Stage 2 test pit survey) must occur within the grassed and wooded areas adjacent to the cemeteries prior to mechanical excavation.

c. Following the completion of the Stage 2 AA, regardless of the results, per *Section 2.2*, *Guideline 4* of the *2011 S&G*, and in accordance with the *Registrar's Directive: Archaeological Assessments & Investigations on Cemetery Lands* (dated April 11, 2018) and the *Registrar's Directive: Authorization of Archaeological Assessments & Investigations on Cemetery Lands* (dated March 1, 2019), further cemetery investigations are required. The recommendations for further cemetery investigations are as follows:

    i. Per *Section 3.3.3, Standard 2* of the *2011 S&G*, a Stage 3 investigation consisting of mechanical topsoil removal (MTR) must be undertaken following the lands immediately adjacent to the current cemetery limits, where feasible, to confirm the presence or absence of deeply buried human remains. Mechanical excavation must employ a flat-edged bucket and should begin at the furthest extent from the cemetery that will be investigated and move inward towards the known cemetery limits. Unless human remains are encountered, mechanical stripping of topsoil is to reach sterile subsoil depths.

    ii. Where mechanical topsoil removal is not feasible due to existing roadway infrastructure or accessibility issues (i.e., in steeply sloped areas), these areas will require on-site monitoring by a licensed archaeologist during any construction or other soil disturbing activities per *Section 2.1.7, Standard 4* of the *2011 S&G*, to confirm the presence or absence of deeply buried human remains.

8. Should construction activities associated with this project, including construction laydown areas, extend beyond the assessed limits, further archaeological investigation will be required prior to construction activities in order to minimize impacts to cultural heritage resources.

No construction activities shall take place within the study area, and specifically the identified Impact Buffer, prior to the *MHSTCI* (Archaeology Programs Unit) confirming in writing that all archaeological licensing and technical review requirements have been satisfied.

5.0 ADVICE ON COMPLIANCE WITH LEGISLATION

1. This report is submitted to the *MHSTCI* as a condition of licensing in accordance with Part VI of the *Ontario Heritage Act*, R.S.O. 1990, c 0.18. The report is reviewed to ensure that it complies with the standards and guidelines that are issued by the Minister, and that the archaeological fieldwork and report recommendations ensure the conservation, protection and preservation of the cultural heritage of Ontario. When all matters relating to archaeological sites within the project area of a development proposal have been addressed to the satisfaction of the *MHSTCI*, a letter will be issued by the ministry stating that there are no further concerns with regard to alterations to archaeological sites by the proposed development.

2. It is an offence under Sections 48 and 69 of the *Ontario Heritage Act* for any party other than a licensed archaeologist to make any alteration to a known archaeological site or to remove any artifact or other physical evidence of past human use or activity from the site, until such time as a licensed archaeologist has completed archaeological fieldwork on the site, submitted a report to the Minister stating that the site has no further cultural heritage value or interest, and the report has been filed in the Ontario Public Register of Archaeology Reports referred to in Section 65.1 of the *Ontario Heritage Act*.

3. Should previously undocumented archaeological resources be discovered, they may be a new archaeological site and therefore subject to Section 48 (1) of the *Ontario Heritage Act*. The proponent or person discovering the archaeological resources must cease alteration of the site immediately and engage a licensed consultant archaeologist to carry out archaeological fieldwork, in compliance with Section 48 (1) of the *Ontario Heritage Act*.

4. The *Cemeteries Act*, R.S.O. 1990 c. C.4 and the *Funeral, Burial and Cremation Services Act*, 2002, S.O. 2002, c.33 require that any person discovering human remains must notify the police or coroner and the Registrar of Cemeteries at the *Ministry of Consumer Services*.

6.0 BIBLIOGRAPHY AND SOURCES

Abler, T. S. and Tooker, E. (1978). The Seneca. In B.G. Trigger (Ed.). *Volume 15: Northeast*. Washington: Smithsonian Institution, pp. 505-517.

Amick Consultants Limited (2013). *Stage 1-2 Archaeological Assessment of the Lot 9 Portion of the Proposed Oxford Homes Subdivision, 5751 Mount Albert Road, Part of Lots 9 & 10, Concession 8 (Geographic Township of East Gwillimbury, County of York), Town of East Gwillimbury (Mount Albert), Regional Municipality of York* (PIF# P038-470-2012).

Amick Consultants Limited (2015). *2014 Stage 1-2 Archaeological Assessment of 19267 & 19259 Centre Street, Part of Lot 12, Concession 8 (Geographic Township of East Gwillimbury, County of York), Town of Mount Albert, R.M. of York* (PIF# P384-0184-2014).

Archeoworks Inc. (2005). *Stage 1 Archaeological Assessment Water Resource Exploration for Water Supply in the Community of Mount Albert Class EA Community of Mount Albert* Town of East Gwillimbury, Regional Municipality of York Ontario (PIF# P029-195).

Archeoworks Inc. (2013). *Stage 3 Archaeological Assessment: Cemetery Investigation of the Albion Congregational Church Burial Ground, Lot 9, Concession 7, For the Proposed Bolton Elevated Tank and Feedermain, Class EA Study, Town of Caledon, Regional Municipality of Peel, Ontario* (PIF#s P029-769-2010; P029-779-2011).

ASI Archaeological and Cultural Heritage Services (1990). *Final Report on Phases 2 and 3 of the Master Plan of Archaeological Resources for the Town of East Gwillimbury, Ontario* (License No. 88-17; 89-130B; 90-021).

ASI Archaeological and Cultural Heritage Services (2008). *Stage 1 Archaeological Assessment of the Draft Plan of Subdivision 19190 Ninth Concession Road Located on Part Block D, Judge's Plan 403 Part of Lot 12, Concession 8, Geographic Township of East Gwillimbury, County of York, Now the Regional Municipality of York* (CIF# P049-363-2008).

ASI Archaeological and Cultural Heritage Services (2014). *Planning for the Conservation of Archaeological Resources in York Region*. [Online]. Available at: http://www.york.ca/wps/wcm/connect/yorkpublic/b8461c7d-fed7-4f21-b1c2-8693efb596a0/17054_ArchaeologicalManagementPlan2014.pdf?MOD=AJPERES [Accessed 01 July 2020].

ASI Archaeological and Cultural Heritage Services (2015a). *Stage 1 and 2 Archaeological Assessment of 5751 Mount Albert Road, Part of Lot 10, Concession 8, Village of Mount Albert, Town East Gwillimbury, Regional Municipality of York* (PIF# P347-019-2011).

ASI Archaeological and Cultural Heritage Services (2015b). *Stage 3 Site-Specific Archaeological Assessment of Pre-Contact Site BaGt-40, 5751 Mount Albert Road, Part of Lot 10, Concession 8, Village of Mount Albert, Town East Gwillimbury, Regional Municipality of York* (PIF# P125-061-2011).

ASI Archaeological and Cultural Heritage Services (2015c). *Stage 4 Salvage Excavation of the Mount Albert Site (BaGt-40), 5751 Mount Albert Road, Part of Lot 10, Concession 8, Village of Mount Albert, Town East Gwillimbury, Regional Municipality of York* (PIF# P372-032-2013).

ASI Archaeological and Cultural Heritage Services (2015d). *Stage 3 Site-Specific Archaeological Assessment of Pre-Contact Site BaGt-41, 5751 Mount Albert Road, Part of Lot 10, Concession 8, Village of Mount Albert, Town East Gwillimbury, Regional Municipality of York* (PIF# P047-347-2011).

Bereavement Authority of Ontario (BAO) (2018). *REGISTRAR'S DIRECTIVE Archaeological Assessments & Investigations on Cemetery Lands April 11, 2018*. [Online]. Available at: https://thebao.ca/Documents/April%2011%20-%20Registrars%20Directive%20-%20Archaeological%20Assessments%20-%20Final.pdf [Accessed 03 July 2020].

Bereavement Authority of Ontario (BAO) (2019). REGISTRAR's DIRECTIVE *Authorization for Archaeological Assessments & Investigations on Cemetery Lands March 1, 2019*. Toronto: Bereavement Authority of Ontario.

Chapman, L. J. and Putnam, D. F. (1984). Physiography of Southern Ontario. 3rd ed. Ontario Geological Survey, Special Volume 2. Toronto: Ministry of Natural Resources.

Dawson, K. C. A. (1983). *Prehistory of Northern Ontario*. Thunder Bay, Ontario: Thunder Bay Historical Museum Society.

Department of Indian Affairs (1891). *Indian Treaties and Surrenders from 1680 to 1890*. Ottawa: Browns Chamberlin Printers.

Dodd, C. F., Poulton, D. R., Lennox, P. A., Smith, D. G., and Warrick, G. A. (1990). The Middle Ontario Iroquoian Stage. In C.J. Ellis and N. Ferris, (Eds.). *The Archaeology of Southern Ontario to A.D. 1650*. London, Ontario: Occasional Publication of the London Chapter, OAS, pp. 321-359.

Earthworks Archaeological Services (2010). *Stage 2 Archaeological Assessment Draft Plan of Subdivision File 19T-04002 19190 Ninth Concession Road Township of East Gwillimbury Regional Municipality of York* (CIF# P310-006-2009).

Ellis, C. J. and Deller, D. B. (1990). Paleo-Indians. In C.J. Ellis and N. Ferris, (Eds.). *The Archaeology of Southern Ontario to A.D. 1650*. London, Ontario: Occasional Publication of the London Chapter, OAS, pp. 37-64.

Ellis, C. J., Kenyon, I. T., and Spence, M. W. (1990). The Archaic. In C.J. Ellis and N. Ferris, (Eds.). *The Archaeology of Southern Ontario to A.D. 1650*. London, Ontario: Occasional Publication of the London Chapter, OAS, pp. 65-124.

Ellis, C. J. (2013). Before Pottery: Paleoindian and Archaic Hunter-Gathers. In M.K. Munson and S.M. Jamieson, (Eds.) *Before Ontario: The Archaeology of a Province*. Montreal & Kingston, Ontario: McGill Queen's University Press.

Ferris, N. (2013). Seeing Ontario's Past Archaeologically. In M.K. Munson and S.M. Jamieson, (Eds.) *Before Ontario: The Archaeology of a Province*. Montreal & Kingston, Ontario: McGill Queen's University Press, pp. 3-20.

Ferris, N. and Spence, M. W. (1995). The Woodland Traditions in Southern Ontario. *Revista de Arqueologia Americana* (9), pp. 83-138.

Fox, W. A. and Garrad C. (2004). Hurons in an Algonquian land. *Ontario Archaeology*, 77(78), pp. 121-134.

Fox, W. A. (1990). The Middle Woodland to Late Woodland Transition. In C.J. Ellis and N. Ferris, (Eds.). *The Archaeology of Southern Ontario to A.D. 1650*. London, Ontario: Occasional Publication of the London Chapter, OAS, pp. 171-188.

Gagné, M. (2015). *Woodland Culture*. [Online]. Available at: https://thecanadianencyclopedia.ca/article/woodland-culture [Accessed 01 July 2020].

Gibson, M. M. (2006). *In the Footsteps of the Mississaugas*. Mississauga, Ontario: Mississauga Heritage Foundation.

Google Maps (2020). *Google Maps Street View*. [Online]. Available at: https://www.google.ca/maps [Accessed 14 July 2020].

Government of Ontario (1990). *Ontario Heritage Act, R.S.O. 1990, c. O.18, amended 2019*. [Online]. Available at: https://www.ontario.ca/laws/statute/90o18 [Accessed 01 July 2020].

Government of Ontario (2014). *First Nations and Treaties Map*. [Online]. Available at: https://files.ontario.ca/firstnationsandtreaties.pdf [Accessed 01 July 2020].

Government of Ontario (2019). *Map of Ontario Treaties and Reserves*. [Online]. Available at: https://www.ontario.ca/page/map-ontario-treaties-and-reserves [Accessed 01 July 2020].

Hall, A. J. (2015). *Royal Proclamation of 1763*. [Online]. Available at: https://www.thecanadianencyclopedia.ca/article/royal-proclamation-of-1763 [Accessed 01 July 2020].

Hall, R. (2019). *Upper Canada*. [Online]. Available at: https://www.thecanadianencyclopedia.ca/en/article/upper-canada [Accessed 01 July 2020].

Hathaway, E. (1930). The River Credit and the Mississaugas. In *Ontario Historical Society Papers and Records Vol. xxvi*. Toronto: Ontario Historical Society.

Heidenreich, C. E. (1978). Huron. In B.G. Trigger (Ed.). *Volume 15: Northeast*. Washington: Smithsonian Institution, pp. 368-388

Hessel, P. (1993) *The Algonkin Nation – The Algonkins of the Ottawa Valley: An Historical Outline*. Arnprior, Ontario: Kichesippi Books.

Hunter, J. A. (1909). *A History of Simcoe County: Volume I, Its Public Affairs*. [Online]. Available at: https://archive.org/details/localhistory_2GN/page/n1 [Accessed 01 July 2020].

Jaenen, C. J. (2013). *Treaty of Paris 1763*. [Online]. Available at: https://www.thecanadianencyclopedia.ca/en/article/treaty-of-paris-1763 [Accessed 01 July 2020].

Jaenen, C. J. (2014). *Treaty of Paris 1783*. [Online]. Available at: https://www.thecanadianencyclopedia.ca/en/article/treaty-of-paris-1783 [Accessed 01 July 2020].

Johnston, D. (2004). *Connecting People to Place: Great Lakes Aboriginal History in Cultural Context*. [Online]. Available at: http://www.attorneygeneral.jus.gov.on.ca/inquiries/ipper wash/transcripts/pdf/P1_Tab_1.pdf [Accessed 01 July 2020].

Library and Archives Canada (LAC) (2010). *Item: 13716*. [Online]. Available at: https://www.bac-lac.gc.ca/eng/discover/postal-heritage-philately/post-offices-postmasters/Pages/item.aspx?IdNumber=13716& [Accessed 02 July 2020].

Lovell, J. (1873). *Gazetteer of British North America: Containing the Latest and Most Authentic Descriptions of over Six Thousand Cities, Towns and Villages*. [Online]. Available at: https://archive.org/details/lovellsgazetteer00cros_3 [Accessed 01 July 2020].

McMillan, A. D. and Yellowhorn, E. (2004). *First People in Canada*. Vancouver, B.C.: Douglas & McIntyre.

Migizi, G. and Kapyrka, J. (2015). Michi Saagiig Historical/Background Context. Unpublished manuscript courtesy of Gitiga Migizi and Dr. Julie Kapyrka of Curve Lake First Nation.

Mulvany, C. P. and Adam, G. M. (1885). *History of Toronto and County of York, Ontario: containing an outline of the history of the Dominion of Canada, a history of the city of Toronto and the county of York, with the townships, towns, villages, churches, schools; general and local* *statistics; biographical sketches, etc., etc. Volume 1*. [Online] Available at: https://archive.org/details/historyyork01unknuoft/page/n6 [Accessed 01 July 2020].

Ontario Agricultural College (1954). *Soil Map of York County, Soil Survey Report No. 19.* Guelph: Soil Research Institute.

Ontario Genealogical Society (OGS) (1989). *Franklin Pioneer Cemetery – Cemetery Transcript*. Toronto, Ontario: Ontario Genealogical Society, Toronto Branch.

Ontario Genealogical Society (OGS) (2014). *Mount Albert Methodist Pioneer Cemetery – Cemetery Transcript*. Richmond Hill, Ontario: Ontario Genealogical Society, Toronto Branch.

Ontario Genealogical Society (OGS) (2015). *Mount Albert Cemetery– Cemetery Transcript*. Richmond Hill, Ontario: Ontario Genealogical Society, Toronto Branch.

Ontario Heritage Trust (OHT) (2020). *Plaque Database*. [Online]. Available at: https://www.heritagetrust.on.ca/en/index.php/online-plaque-guide [Accessed 01 July 2020].

Ontario Historical Plaques (2019). *Plaque Map*. [Online]. Available at: http://www.ontarioplaques.com/Menu_Map.html [Accessed 01 July 2020].

Ontario Ministry of Heritage, Sport, Tourism and Culture Industries (MHSTCI) (2011). *Standards and Guidelines for Consultant Archaeologists*. Toronto: Ministry of Heritage, Sport, Tourism and Culture Industries.

Ontario Ministry of Heritage, Sport, Tourism and Culture Industries (MHSTCI) (2020a). *List of Heritage Conservation Districts.* [Online]. Available at: http://www.mtc.gov.on.ca/en/heritage/heritage_conserving_list.shtml [Accessed 01 July 2020].

Ontario Ministry of Heritage, Sport, Tourism and Culture Industries (MHSTCI) (2020b). *Sites within a One Kilometre Radius of the Study Area*, provided from the Ontario Archaeological Sites Database, 09 June 2020.

Ramsden, P. G. (1990). The Hurons: Archaeology and Culture History. In C.J. Ellis and N. Ferris, (Eds.). *The Archaeology of Southern Ontario to A.D. 1650*. London, Ontario: Occasional Publication of the London Chapter, OAS, pp. 361-384.

Robinson, P. J. (1965). *Toronto during the French Regime: 1615-1793.* Toronto: University of Toronto Press.

Schmalz, P. S. (1991). *The Ojibwa of Southern Ontario*. Toronto: University of Toronto Press.

Sharon Temple National Historic Site & Museum (2020). *Assessment of Pioneer and Historic Cemeteries in Mount Albert*. Sharon, Ontario: Sharon Temple Museum Society.

Smith, D. B. (2013). *Sacred Feathers: The Reverend Peter Jones (Kahkewaquonaby) and the Mississauga Indians*. Toronto: University of Toronto Press.

Smith, W. H. (1846). *Smith's Canadian Gazetteer; comprising Statistical and General Information Respecting All Parts of the Upper Province, or Canada West*. [Online]. Available at: https://archive.org/details/smithscanadianga00smitrich/page/n4/mode/2up [Accessed 01 July 2020].

Spence, M. W., Pihl, R. H., and Murphy, C. R. (1990). Cultural Complexes of the Early and Middle Woodland Periods. In C.J. Ellis and N. Ferris, (Eds.). *The Archaeology of Southern Ontario to A.D. 1650*. London, Ontario: Occasional Publication of the London Chapter, OAS, pp. 125-169.

Surtees, R. J. (1986). *Treaty Research Report: The Williams Treaties.* [Online] Available at http://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-HQ/STAGING/texte-text/traw_1100100029001_eng.pdf [Accessed 01 July 2020].

Surtees, R. J. (1994). Land Cessions, 1763-1830. In E.S. Rogers and D.B. Smith, (Eds.). *Aboriginal Ontario: Historical Perspectives on the First Nations*. Toronto, Ontario: Dundurn Press Limited, pp. 92-121.

Sutherland, S. R. J. (2014). *Jay's Treaty*. [Online]. Available at: https://www.thecanadianencyclopedia.ca/en/article/jays-treaty [Accessed 01 July 2020].

Templeton, L. (2020). Email to Town of East Gwillimbury re: Cemeteries in Mount Albert History, June 30, 2020.

Toronto and Region Conservation Authority (TRCA) (2007). *Rouge River State of the Watershed Report.* [Online]. Available at: http://www.trca.on.ca/dotAsset/37769.pdf [Accessed 01 July 2020].

Town of East Gwillimbury (2004). *By-Law #2004-20*. [Online]. Available at: https://eastgwillimbury.civicweb.net/document/1810 [Accessed 01 July 2020].

Town of East Gwillimbury (2018). *Official Plan: Schedules A – D*. [Online]. Available at: http://www.eastgwillimbury.ca/Assets/3+2015+Services/1.1+Planning/OP+Schedules+1.pdf [Accessed 01 July 2020].

Town of East Gwillimbury (2019). *Register of Cultural Heritage Properties*. [Online]. Available at: http://www.eastgwillimbury.ca/Assets/1+2015+About+Us/0.1+About+the+Town/0.4+Heritage/2019+08+13+Register+of+Heritage+Properties.pdf [Accessed 20 November 2020].

Town of East Gwillimbury (2020). *Mount Albert*. [Online]. Available at: http://www.eastgwillimbury.ca/About_Us/About_the_Town/Community_Information/Mount_Albert.htm [Accessed 01 July 2020].

Trigger, B. G. (1994). The Original Iroquoians: Huron, Petun and Neutral. In E.S. Rogers and D.B. Smith, (Eds.). *Aboriginal Ontario: Historical Perspectives on the First Nations*. Toronto, Ontario: Dundurn Press Limited, pp. 41-63.

Warrick, G. A. (2000). The Precontact Iroquoian Occupation of Southern Ontario. In *Journal of World Prehistory,* 14(4), pp. 415-466.

Warrick, G. (2008). *A Population History of the Huron-Petun, A.D. 500-1650*. New York: Cambridge University Press.

Williamson, R. F. (1990). The Early Iroquoian Period of Southern Ontario. In C.J. Ellis and N. Ferris, (Eds.). *The Archaeology of Southern Ontario to A.D. 1650*. London, Ontario: Occasional Publication of the London Chapter, OAS, pp. 291-320.

Williamson, R. F. (2013). The Woodland Period, 900 BCE to 1700 CE. In M.K. Munson and S.M. Jamieson, (Eds.) *Before Ontario: The Archaeology of a Province*. Montreal & Kingston, Ontario: McGill Queen's University Press.

Wright, J. V. (1994). Before European Contact. In E.S. Rogers and D.B. Smith, (Eds.). *Aboriginal Ontario: Historical Perspectives on the First Nations*. Toronto, Ontario: Dundurn Press Limited, pp. 21-40.

Wright, J. V. (1999). *A History of the Native People of Canada: Volume II (1,000B.C. – A.D. 500)*. Hull, Quebec: Museum of Civilization.

MAP SOURCES:

CANADIAN COUNTY ATLAS DIGITAL PROJECT, RARE BOOKS AND SPECIAL COLLECTIONS, MCGILL UNIVERSITY LIBRARY, MONTREAL - The Canadian County Digital Atlas Project (McGill University, 2001a-b)

- Miles & Co. (1878). *Illustrated Historical Atlas of the County of York*, *Ont*. Available at: https://digital.library.mcgill.ca/countyatlas/searchmapframes.php [Accessed 01 July 2020].
- J. H. Beers and Co. (1877). *Illustrated Historical Atlas of the County of Ontario*, *Ont*. Available at: https://digital.library.mcgill.ca/countyatlas/searchmapframes.php [Accessed 01 July 2020].

NATURAL RESOURCES CANADA – TOPORAMA

- Natural Resources Canada (2013). *Atlas of Canada – Toporama: Newmarket 031D03 and Oshawa 030M15*. [Online]. Available at: http://atlas.gc.ca/toporama/en/index.html. [Accessed 01 July 2020].

ONTARIO COUNCIL OF UNIVERSITY LIBRARIES, Historical Topographic Map Digitization Project

- Department of National Defence (1929). *Topographic Map, 1:63,360, Ontario, Newmarket Sheet No. 106*. [Digital]. https://ocul.on.ca/topomaps/collection/ [Accessed 01 July 2020].

- Department of National Defence (1939). *Topographic Map, 1:63,360, Ontario, Sheet No. 31 D/03.* [Online]. https://ocul.on.ca/topomaps/collection/ [Accessed 01 July 2020].

REGIONAL MUNICIPALITY OF YORK

- Regional Municipality of York (2020a). *Archaeological Potential Layer.* [Online]. Available at: https://ww6.yorkmaps.ca/Html5Viewer24/Index.html?configBase=https://ww6.yorkmaps.ca/Geocortex/Essentials/Essentials43/REST/sites/LandInformation/viewers/YorkMaps/virtualdirectory/Resources/Config/Default. [Accessed 01 July 2020].
- Regional Municipality of York (2020b). *1954 Orthophotograph*. [Online]. Available at: https://ww6.yorkmaps.ca/Html5Viewer24/Index.html?configBase=https://ww6.yorkmaps.ca/Geocortex/Essentials/Essentials43/REST/sites/CommunityServices/viewers/YorkMaps/virtualdirectory/Resources/Config/Default [Accessed 03 July 2020].
- Regional Municipality of York (2020c). *1988 Orthophotograph*. [Online]. Available at: https://ww6.yorkmaps.ca/Html5Viewer24/Index.html?configBase=https://ww6.yorkmaps.ca/Geocortex/Essentials/Essentials43/REST/sites/CommunityServices/viewers/YorkMaps/virtualdirectory/Resources/Config/Default [Accessed 03 July 2020].
- Regional Municipality of York (2020d). *1999 Orthophotograph*. [Online]. Available at: https://ww6.yorkmaps.ca/Html5Viewer24/Index.html?configBase=https://ww6.yorkmaps.ca/Geocortex/Essentials/Essentials43/REST/sites/CommunityServices/viewers/YorkMaps/virtualdirectory/Resources/Config/Default [Accessed 03 July 2020].
- Regional Municipality of York (2020e). *2007 Orthophotograph*. [Online]. Available at: https://ww6.yorkmaps.ca/Html5Viewer24/Index.html?configBase=https://ww6.yorkmaps.ca/Geocortex/Essentials/Essentials43/REST/sites/CommunityServices/viewers/YorkMaps/virtualdirectory/Resources/Config/Default [Accessed 03 July 2020].
- Regional Municipality of York (2020f). *2014 Orthophotograph*. [Online]. Available at: https://ww6.yorkmaps.ca/Html5Viewer24/Index.html?configBase=https://ww6.yorkmaps.ca/Geocortex/Essentials/Essentials43/REST/sites/CommunityServices/viewers/YorkMaps/virtualdirectory/Resources/Config/Default [Accessed 03 July 2020].
- Regional Municipality of York (2020g). *2019 Orthophotograph*. [Online]. Available at: https://ww6.yorkmaps.ca/Html5Viewer24/Index.html?configBase=https://ww6.yorkmaps.ca/Geocortex/Essentials/Essentials43/REST/sites/CommunityServices/viewers/YorkMaps/virtualdirectory/Resources/Config/Default [Accessed 03 July 2020].

UNIVERSITY OF TORONTO MAP & DATA LIBRARY and the ONTARIO HISTORICAL COUNTY MAPS PROJECT (OHCMP, 2019a-b)

- G. R. Tremaine (1860). *Map of the County of York, Canada West*. [Online]. Available at: http://maps.library.utoronto.ca/hgis/countymaps/maps.html [Accessed 01 July 2020].
- G. C. Tremaine (1860). *Map of the County of Ontario, Canada West*. [Online]. Available at: http://maps.library.utoronto.ca/hgis/countymaps/maps.html [Accessed 01 July 2020].

APPENDICES