# 2025 Biennial Groundwater Monitoring Report - Branchton Meadows Well Field (BM2, BM3)

## The Region of Waterloo

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## The Region of Waterloo

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# 1.0 Introduction

The Regional Municipality of Waterloo (the Region) is unique in Ontario in that it is the largest urban municipality to rely almost exclusively on groundwater supplies for its drinking-water (Region of Waterloo, 2015). Figure 1 shows the location of municipal well fields within the Region.

Permit to Take Water (PTTW) No. 2481-DJKHVA was issued in July 2025 as a replacement for PTTW No. 2577-9TPMWL for the Branchton Meadows Well Field. The new permit was issued because, Production Well BM1 was decommissioned. PTTW 2481-DJKHVA requires submission of a well field specific biennial report to the Ministry of Environment, Conservation and Parks (MECP) which documents production well pumping volumes and water levels in specific monitoring wells during 2024 and 2025. This report has been prepared to meet the reporting condition of the PTTW for 2024 and 2025. A copy of the PTTW is included in Appendix A.

The location of the Branchton Meadows Well Field is shown in Figure 1 and the production wells in North Dumfries are shown in Figure 2 with the monitoring network for BM1, BM2 and BM3 shown in Figure 3. Well records for the production and monitoring wells are found in Appendix B.

## 1.1 Scope of Work

The Region records water levels on a regular basis within a network of monitoring wells to satisfy requirements of their PTTW and to confirm that water taking is sustainable in the long term. The monitoring wells are concentrated near the production wells.. The data from these wells and regular measurements of pumping volume obtained from the production wells are used to evaluate the impact of Region pumping on aquifers and potential impacts to private wells, other water takers and the natural environment.

The Region has developed a monitoring program for Branchton Meadows Well Field (BM2, BM3) in accordance with PTTW 2481-DJKHVA which consists of the following activities:

- Measuring the daily volume pumped from the BM2 and BM3 production wells (Condition 4.1 of the PTTW);
- Measuring the water levels in monitoring wells ND-BM-OW1-02-AB (Condition 4.2 of the PTTW);
- Review of precipitation data from the nearest GRCA/Environment Canada weather station (Condition 4.3 of the PTTW); and
- Completion of a biennial report (every 2 years) that presents data in compliance with condition 4.3 of the PTTW.

The Monitoring data (pumped volumes and hydrographs) are found in Appendix C and the precipitation data in Appendix D. The monitoring program procedures and methodology are included in Appendix E.

# 2.0 Site Setting

## 2.1 Well Field Description

The Branchton Meadows Well Field is located in the southeast portion of the Township of North Dumfries. Wells BM2 and BM3 are located to the north of the Branchton Meadows subdivision. The closest municipal well field is the Willard Well Field, located approximately 5.2 km to the northwest, with the Middleton and Elgin Street Well Fields located further to the north in Cambridge (Figure 2). The closest surface water feature to the BM2 and BM3 site is a provincially significant wetland located 100 m west and an intermittent stream is located 380 m to the north (Figure 3).

### 2.1.1 Pumping Wells

Well records for the production wells are found in Appendix B. BM1, constructed in 1983, was completed as an open hole from 28.7 to 28.9 metres below ground surface (mbgs), and is interpreted to be completed in sand and gravel conglomerate (ATC1) near the top of bedrock (Stantec, 2013). BM1 was decommissioned on November 11, 2018.

BM2, constructed in 1986, was completed as an open hole from 30.5 to 34.1 mbgs, and is interpreted to be completed in sand and gravel conglomerate (ATC1) near the top of bedrock (Stantec, 2013).

BM3, constructed in 2013, was completed as a 203 mm diameter open borehole from 39.3 to 47.0 mbgs within the Guelph Formation (Stantec, 2013). A fracture located at 40.9 mbgs accounts for a significant portion of the water pumped at BM3 (Stantec, 2013).

A summary of the production well construction details is provided in Table 1 below.

**Table 1: Production Well Construction Details**

| Well Name | Year Built | Casing Diameter (mm) | Open Hole Diameter (mm) | Open Hole interval (mbgs) | Aquifer |
|---|---|---|---|---|---|
| BM1 | 1983 | 203 | 203 | 28.96 – 29.26 | ATC1 Catfish Creek Till |
| BM2 | 1986 | 254 | 254 | 29.85 – 33.45 | ATC1 Catfish Creek Till |
| BM3 | 2013 | 219 | 203 | 39.3 - 47 | Upper Guelph Formation |

The water taking volumes for the Branchton BM2 and BM3 Well Field are regulated by Condition 3.2 of the PTTW and are summarized in Table 2 below.

**Table 2: Annual Water Taking 2024/2025**

| | PTTW Details | 2024 | | | 2025 | | |
|---|---|---|---|---|---|---|---|
| Well | Permitted Max. Daily Water Taking ($m^3$) | Avg. Daily Water Taking ($m^3$) | Max Taken per Day ($m^3$) | Total Volume Pumped ($m^3$) | Avg. Daily Water Taking ($m^3$) | Max Taken per Day ($m^3$) | Total Volume Pumped ($m^3$) |
| BM2 | 130 | 30 | 103 | 11,019 | 13 | 65 | 4,697 |
| BM3 | 130 | 18 | 91 | 6,536 | 13 | 70 | 4,883 |
| Combined | 130 | 48 | 103 | 17,555 | 26 | 70 | 9,580 |

Production wells BM2 and BM3 are pumped in alternation. The pumping volumes are based on the total daily volumes as recorded by the Region's SCADA system and are presented in Appendix C as total monthly volumes. Pumping volumes from the well field ranged from 904 $m^3$/month to 2,441 $m^3$/month in 2024, and from 654 $m^3$/month to 1,024 $m^3$/month in 2025. In total, 17,555 $m^3$ was produced at this well field in 2024 and 9,580 $m^3$ was produced in 2025. The total volume produced in 2025 (9,580 $m^3$) was consistent with production volumes observed in 2021 (9,176 $m^3$), 2022 (9,891 $m^3$), and 2023 (9,861 $m^3$). In contrast, the 2024 production volume (17,555 $m^3$) was elevated relative to recent years and the longer-term historical average but remained well below the permitted annual volume of 47,450 $m^3$ (Table C-1). The permitted combined volume has not changed between PTTW No. 2481-DJKHVA and 2577-9TPMWL.

### 2.1.2 Monitoring Wells

Observation wells ND-BM-OW1-02-A/B are located about 88 m northeast of wells BM2 and BM3 (Figure 3). ND-BM-OW1-02-A/B is a multi-level well that was drilled as a testing and monitoring well associated with the hydrogeologic assessment of the Branchton Meadows Well Field (Stantec, 2002) in accordance with the GUDI Terms of Reference (MOE, 2001).

Construction details of ND-BM-OW1-02-A and ND-BM-OW1-02-B are described in the table below. Well records for the monitoring wells are provided in Appendix B.

**Table 3: Monitoring Well Construction Details**

| Monitoring Well ID | Year Built | Screened Depth (mbgs) | Screened Formation | Distance to BM1 (m) | Distance to BM2 (m) | Distance to BM3 (m) |
|---|---|---|---|---|---|---|
| ND-BM-OW1-02-A | 2002 | 21.9 – 28.9 | Upper Bedrock (Guelph) | 88 | 85 | 75 |
| ND-BM-OW1-02-B | 2002 | 5.8 – 8.84 | ATA2 Wentworth Till<br>AFA2 Outwash Deposits | 88 | 85 | 75 |

## 2.2 Regional Geology and Hydrostratigraphy

The following sections provide a brief overview of the regional geology and hydrogeology of the Branchton Meadows Well Field. The surficial geology based on regional OGS mapping is provided in Figure 4. Representative cross-sections showing the stratigraphy in the vicinity of the Branchton Meadows Well Field (BM1, BM2, BM3) are included as Figures 5 and 6 to visualize the stratigraphy described in this section. The cross-section locations are provided in Figure 3.

The cross-sections are provided as a visual aid and do not necessarily contain all wells in the monitoring program for the Branchton Meadows Well Field. The layers displayed were generated from results of the Hydrogeological Characterization and Conceptual Model Tier 3 Assessment Update Project (Aqua Insight et al, 2023) and associated hydrogeological modelling work.

The most significant update is the reinterpretation of the elevation of the Guelph Formation in the vicinity of the production wells (BM1 and BM2). This represents a notable shift in the understanding of the local hydrostratigraphy and aquifer setting. The interpretation introduces greater unit definition and several localized refinements to both overburden and bedrock geology. Overall, the updates reflect reclassification and subdivision of previously grouped units, along with adjustments to unit extents and contacts.

- The upper surficial deposits have been more clearly defined as Whittlesey Sand (AFA1), Wentworth Till (ATA2).
- The top of the Guelph Formation has been lowered from about 260 masl to 245 masl in the immediate area of the production wells
- The area formerly identified as Guelph formation (245 to 260 masl) around the production wells has now been reinterpreted as pre Catfish Creek and Canning Drift-related units (AFD1, ATE1, AFF1, ATG1), with their position in the sequence more clearly defined.
- Further to the east, ATB1 has now been reinterpreted as AFB1, ATB2 and AFB2

- The Guelph Formation has been subdivided into Upper, Middle, and Lower units and is now about 10m thicker with the lower contact lowered from 245 masl to 225 masl.
- The Goat Island Formation is now much thicker with the Upper and Middle Gasport Formations commensurately thinner in the area of the production wells.

Overall, the updates represent unit-level refinement and reclassification, with improved separation of previously grouped deposits and greater detail in the bedrock stratigraphy.

### 2.2.1 Surficial Geology and Conceptual Hydrostratigraphy

The surficial geology of the Study Area has been mapped and described by Karrow (1987). Along the eastern side of the Grand River, the surficial geology (Figure 4) largely consists of sand and gravel outwash deposits (Units 7a and 7b in Figure 4). Silty to sandy till deposits (Unit 5b in Figure 4) are present east of the outwash deposits to just east of the Branchton Meadows Well Field. Further east, fine textured glaciolacustrine deposits (Unit 8a in Figure 4) predominate.

The thickness of overburden deposits generally ranges from approximately 5 to 10 m in areas of outwash deposits, however can be up to approximately 30 to 40 m thick in areas of the Paris and Galt moraines to the east of Cambridge. In the vicinity of the Branchton Well Field, the overburden thickness is approximately 24 m.

The Quaternary Geology of the Cambridge area includes the following units (Lotowater 1997, Karrow 1987 and Bajc and Shirota, 2007) described in more detail below.

**Aquitard ATA2 - Wentworth Till**

The Wentworth Till was deposited by the last glacier to advance in the area. It is described as a stony, sandy silt to sand textured till, and is often inter-bedded with sand and gravel. In the Cambridge area, the Wentworth Till is generally less than 10 m thick. Due to the loose, coarse-grained nature of the till, the unit behaves as a leaky aquitard or poor aquifer that is readily recharged from precipitation.

**Aquifer AFA1 - Whittlesey Sand**

This unit consists of very fine to coarse grained sand and is interpreted to be of glaciolacustrine origin (Bajc and Shirota, 2007). It is encountered at surface across the section and is laterally discontinuous.

**Aquifer AFA2 - Outwash Deposits**

The outwash sand and gravel sediments of AFA2 are present within the Grand River Valley and vicinity, however extensive deposits have also been identified underlying the Wentworth Till in the Paris and Galt moraines.

**Aquitard ATB1 - Port Stanley Till**

The Port Stanley Till is a sandy silt to silty sand till, with occasional stony texture. The Port Stanley Till was deposited by ice advancing from the Erie-Ontario ice lobe. In other parts of the Region, Bajc and Shirota (2007) have also used unit ATB1 to represent Tavistock, Mornington and Upper Maryhill Tills. In the Grand River and Speed River valleys this unit has been largely removed by erosion. This unit is generally finer grained than the Wentworth Till and behaves as an aquitard.

**Aquifer AFB1 - Upper Waterloo Moraine Stratified Sediments and Equivalents**

Significant thicknesses of aquifer AFB1 are interpreted to occur southeast of the Speed River and west of Puslinch Lake, and generally corresponds with mapped surficial ice-contact sands and gravels. AFB1 is generally fine sand with some gravel and is often slightly finer grained than unit AFA2, which typically contains greater amounts of gravel. Since AFB1 and AFA2 both behave as aquifers, differentiation of these units is not critical from a hydraulic perspective, although it is necessary to represent AFB1 separately from AFA2 to allow sequential layers for aquifer units both above and below the Port Stanley Till (ATB1), where this situation occurs. Where AFB1 is not present, Port Stanley Till may directly overlie Maryhill Till and Catfish Creek Till (described below), forming a single combined aquitard unit composed of these tills.

**Aquitard ATB3 - Lower Maryhill Till**

Fine grained till and glaciolacustrine deposits of the Lower Maryhill Till ATB3 generally separate AFB1 from the underlying Catfish Creek Till. The Lower Maryhill Till is described as a dense, dark brown, clayey silt to silty clay till and is interpreted to be present in the Fountain Street (Well P16) well field area above the Catfish Creek and below the Port Stanley Till. Aquitard ATB3 can be difficult to distinguish from ATB1 throughout most of the study area due to the similar lithologies of these units. Lotowater (1997) grouped the Port Stanley and Maryhill Tills as a single aquitard hydrostratigraphic unit, which is a reasonable approach where no significant thickness of sand and gravel separate these units.

**Aquitard ATC1 – Upper / Main Catfish Creek Till**

The Catfish Creek Till was deposited by a major glacial advance from the north to northeast that covered all of southern Ontario. The Catfish Creek Till is a dense, stony, sandy silt to silty sand till with little clay content. Although originally deposited over the entire Cambridge area, erosion, glaciations and meltwater events have removed areas of the Catfish Creek Till and it is now discontinuous. In the Cambridge Area, the thickness of this unit ranges from approximately 5 m in areas east of the Grand River, to approximately 20 m west of the Grand River, and is usually found immediately overlying bedrock and beneath clayey sediments. The hydrogeologic properties of the Catfish Creek Till are variable, ranging from a good aquitard to a poor aquifer, depending on local lithology, degree of compaction, and the presence of overlying aquitard units.

**Aquifer AFD1 - Pre-Catfish Sand and Gravel**

The Pre-Catfish Sand and Gravel is found directly overlying bedrock in the Branchton Meadows Well Field area and is hydraulically connected with the upper weathered portion of the bedrock aquifer. Aquifer AFD1 corresponds to sands and gravel re-worked from Catfish Creek and Pre-Catfish Creek Tills.

### 2.2.2 Bedrock Geology and Conceptual Hydrostratigraphy

The stratigraphy discussed below is consistent with the revised stratigraphic framework described by the OGS (Brunton, 2009) and is also used in the Tier 3 Study of the area (Golder, 2011). A brief description (from Stantec, 2013) of each bedrock formation and conceptual hydrostratigraphic units typically present in Cambridge is provided below (from youngest to oldest). The formations present in the vicinity of BM1, BM2 and BM3 are shown on the cross sections in Figures 5 and 6. The model layers displayed in Figures 5 and 6 do not reflect the findings of the BM3 construction report as the layers were generated prior to the construction of BM3.

#### Guelph Formation

The Guelph Formation is a cream-coloured fossiliferous dolostone that represents an important aquifer in the Cambridge and Guelph area, where it is most often the uppermost bedrock unit.

#### Eramosa Formation

The Upper Eramosa Formation is described by Brunton (2009) as light brown to cream coloured, pseudonodular, thickly bedded and coarsely crystalline dolostone. The formation consists of the Reformatory Quarry Member, and the Vinemount Member.

The Reformatory Quarry Member is susceptible to karstification due to its uniform fine dolomite crystallinity (Brunton, 2009), and also often contains mud-rich and microbial mat-bearing lithofacies. As a result, this unit generally represents a poor aquifer or poor aquitard. This unit was described as either the Guelph Formation or Eramosa Member in previous studies within the Region.

The Vinemount Member is comprised of thinly bedded, fine crystalline dolostone with shaley beds that give off a distinctive petroliferous odour when broken (Brunton, 2009). This unit represents an aquitard when present within the Cambridge and Guelph areas.

### Goat Island Formation

The Goat Island Formation consists of the upper Ancaster Member and lower Niagara Falls Member. The Ancaster Member is a chert rich, finely crystalline dolostone that is medium to ash grey in colour. The Niagara Falls Member is a finely crystalline and cross laminated crinoidal grainstone with small reef mounds. The finely crystalline nature of these Members results in a lower hydraulic conductivity and transmissivity compared to the underlying Gasport Formation (Brunton, 2009). Conceptually, the two members of the Goat Island Formation are treated as a single hydrostratigraphic unit.

### Gasport (Amabel) Formation

The Gasport Formation is a cross-bedded crinoidal grainstone-packstone with sequences of reef mound and coquina (shell bed) lithofacies. This unit has commonly been referred to as the Amabel Formation in previous studies in the Region. Upper, middle and lower hydrostratigraphic units of the Gasport have been defined to allow for general representation of the vertical distribution of the more transmissive reef mound and coquina bed lithofacies. Highly transmissive reef mounds, crinoidal grainstones and coquina beds are generally present in the upper and middle portions of the formation, and are largely absent from the lower 10 m to 20 m.

The lower portion of the Gasport Formation has been grouped with the Rochester, Irondequoit, Rockway, and Merriton Formations due to the difficulty in distinguishing the various units from available borehole data and geophysical logs. All four formations, as well as the base of the Gasport Formation, are relatively less permeable than the upper sections of the Gasport Formation.

## 2.3 Local Geology

Figure 3 displays the Branchton Meadows Well Field well plan and cross-section locations. Representative cross-sections are included as Figures 5 and 6 to visualize the stratigraphy described in this section. Borehole logs of the Branchton Meadows Well Field are included in Appendix B.

### 2.3.1 Overburden

The overburden at the well field is approximately 24 m thick and is documented in borehole logs to consist of surficial deposits of sandy outwash materials (AFA2) underlain with less permeable material associated with the Wentworth Till (ATA2).

Deposits documented as sandy till were encountered from grade to a depth of 24.7 mbgs at BM1, which likely corresponds with Wentworth Till (ATA2). A mixture of limestone, gravel and sand was identified from 24.7 to 28.0 mbgs which is interpreted to be associated with Catfish Creek Till (ATC1). Bedrock encountered at 28 mbgs was identified as limestone and documented as broken to the bottom of the borehole at 29.3 mbgs.

At BM3, gradational changes between silty sand to silt with trace gravel were encountered from surface to 9.1 m bgs, likely corresponding with Wentworth Till (ATA2). This unit is reported to be up to 10m thick in the Branchton Meadows area. Sand was encountered from 9.1 m to 24.4 m bgs corresponding with Outwash Deposits (AFA2). Overburden material from 24.5 m to the top of bedrock at 37.2 m bgs was comprised of very dense sand and gravel conglomerate associated with Catfish Creek Till (ATC1).

Borehole records for ND-OW1-02-AB indicate sandy silt till from surface to 0.9 mbgs underlain by stony silt till from 0.9 – 6.7 mbgs which likely corresponds with Wentworth Till (ATA2). Sand interlain with silt, clay, gravel, and cobbles was documented from 6.7 to 22.0 mbgs and is likely associated with Outwash Deposits (AFA2). Dolostone described as highly fractured and including sand and silt was documented from 22.0 to 27.1 mbgs where bedrock was interpreted to be encountered. The borehole was advanced through material described as possible bedrock, documented as dolomitic carbonate from 27.1 – 29.0 mbgs which likely represents the overburden / bedrock contact zone to the Guelph Formation.

Production wells BM1 and BM2 were drilled before the new OGS conceptual model was developed and as a result, the lithological descriptions do not reflect the revised OGS nomenclature. Based on well videos of BM1 and BM2 it is interpreted that the casings do not extend to bedrock and the wells are completed in the sand and gravel conglomerate (ATC1) near the top of bedrock (Stantec, 2013).

### 2.3.2 Bedrock Geology

Based on the results of drilling investigations at the site, the bedrock surface is encountered at approximately 24 mbgs (Appendix B). Based on the borehole log for BM3 (Stantec, 2012) the Guelph Formation, Eramosa Formation Reformatory Quarry Member, Eramosa Formation Vinemount Member, Goat Island Formation, and Gasport Formation were documented as per Table 4 below.

**Table 4: Summary of Bedrock Formations at Branchton Meadows Well Field**

| Formation | Description | Thickness (m) |
|---|---|---|
| Guelph | Dolostone – dark blue grey to light grey blue to tan, porous, some secondary minerals (possibly gypsum) | 42.2 |
| Eramosa/ Reformatory Quarry Member | Dolostone – brown, with shale partings, large and abundant gypsum nodules | 18.5 |
| Eramosa/ Vinemount Member | Dolostone – brown to black with shale partings, some small gypsum nodules | 3.9 |
| Goat Island | Dolostone – light to dark grey, no visible fractures | 4.2 |
| Gasport | Dolostone – light grey to light blue grey, porous (coquina) with sections of dark blue grey dolostone (reef mound) | >15.8 |

# 3.0 2024 / 2025 Results

## 3.1 Precipitation

Longer term precipitation trends can have an impact on water levels in the supply aquifer. To assess the potential influence, monthly precipitation is plotted for comparison to water levels and pumping and presented in Appendix C.

Since variations in precipitation totals can occur throughout the Region due to localized events, monthly precipitation data from the GRCA and Environment Canada stations located closest to the production wells are used. The closest GRCA weather station relative to the Branchton Meadows well field is the Shades Mills Dam station located 7.5 km north / northwest. The closest Environment Canada station is Roseville located about 17.5 km northwest from the well field. The locations of the meteorological stations are shown on Figure 1. Annual precipitation data from the past 10 years for all stations are compared with long term averages in Table D.1, Appendix D. Monthly precipitation data for the past 10 years at Shades Mills Dam are shown on Figure D.1, Appendix D. At the Shades Mills Dam station, the long-term average was calculated from when measurements started until the end of 2025. The Roseville has “Climate Normals” calculated by Environment Canada for 1981 to 2010.

Annual 2024 / 2025 precipitation data for the GRCA and Environment Canada meteorological stations closest to the Branchton Meadows well field are presented in Table 5 below. In 2024 Roseville was missing 5 days of data and 20 days in 2025. As a result, the precipitation totals may be under reported at this location.

**Table 5: Summary of Precipitation Data**

| Station | 2024 Precipitation (mm) | 2024 Deviation (mm) | Long-Term Average (mm) | 2025 Precipitation (mm) | 2025 Deviation (mm) |
|---|---|---|---|---|---|
| Shades Mills Dam (1) | 976 | +67 | 909(A) | 895 | -14 |
| Roseville Station (2) | 856 | -63 | 919(B) | 786 | -133 |

GRCA (1), **Sources:** Environment Canada (2),
A Average annual precipitation since monitoring began to the end of 2025 B 1981 to 2010 Normal

Water levels typically follow a seasonal trend with highest levels occurring in the spring with the depth and water content of the snowpack having a significant influence on water levels. Lowest levels occurring in July / August. Widespread synoptic rainfall events can also result in Region-wide water level responses. Summer thunderstorms tend to be short lived and occur over a smaller area resulting in short term, localized water level rises not typically seen in the monitoring wells.

The 2024 total precipitation at Shades Mills station was 976 mm, which is 67 mm above the long-term average, indicating 2024 was wetter-than-average at the well field. In 2024 the

Roseville Station was 856 mm, which is 63 mm below the long-term average. The March 1 GRCA snow survey indicated a snowpack across the Region that was low compared to normal. In 2025, the total precipitation at Shades Mills was 895 mm, which is 14 mm below the long-term average. Similarly, the total precipitation at the Roseville station was 133 mm below the long-term average, indicating 2025 was a drier-than-average year. However, Roseville was missing 25 days of data in 2024 / 2025 and as a result, precipitation totals may be under reported. The snow survey conducted by the GRCA on March 15, 2025, showed that the stations in the Region had a high to very high measured snow water equivalent.

## 3.2 Monitoring Results

Hydrographs showing the results of water level monitoring over the past 10 years are provided in Appendix C. The method used to collect the water levels (manual or electronic) is indicated on the graphs in Appendix C.

**ND-BM-OW1-02-AB**

Wells ND-BM-OW1-02-A and ND-BM-OW1-02-B have been monitored by the Region since 2006. Water level monitoring at the A and B screens was completed using dataloggers. The A and B screens are installed within the Upper Guelph Formation and Outwash Deposits (AFA2), respectively. Wells ND-BM-OW1-02-A and ND-BM-OW1-02-B are located approximately 90 m from BM2 and BM3. Water levels observed in 2024 / 2025 are consistent with historical values.

Water levels in screens A and B display similar patterns with a slightly more distinctive fluctuation in the shallower screen B. Based on monitoring results, the water levels in either unit do not show a clear response to pumping at BM2 and BM3. Historically, an annual seasonal pattern of water levels increasing during the spring season is seen in both screens. A historic decline was observed in the A screen in fall 2024 and 2025 with water levels in January 2023 the lowest seen in the past 10 years.

# 4.0 Impact Assessment

## 4.1 Well Interference

PTTW Condition 5.1 states, "The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1 800 268 6060."

PTTW Condition 5.2 states, “For Groundwater Takings - if the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water

equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of doing so. If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected."

There are no other non-municipal groundwater takings registered in the MECP PTTW database within 2 km of BM2 and BM3.

When a well interference complaint is received, the Region has a Well Interference Policy in place. A copy of the policy is presented in Appendix F of the 2019 Biennial Groundwater Monitoring Report – Multiple Well Fields (Burnside, 2020). There were no well interference complaints related to pumping of BM1, BM2 and BM3 received in 2024 and 2025.

### 4.2 Aquifer Impacts to Pumping and Precipitation

Groundwater levels in the Upper Guelph Formation and Outwash Deposits (AFA2) were monitored using wells ND-BM-OW1-02-A and ND-BM-OW1-02-B, respectively. Monitoring results indicate that groundwater levels in either unit do not exhibit a clear response to pumping at BM2 and BM3.

Analysis of 2024–2025 precipitation data from the Shade's Mills weather station indicates that water-level fluctuations in both monitoring wells are primarily responsive to both seasonal effects and short term storm events. Water levels in ND-BM-OW1-02-B, which is screened within the Outwash Deposits (AFA2), showed greater variability in response to precipitation, rising by approximately 0.6 m following the June 2025 storm event, compared to a rise of approximately 0.3 m in ND-BM-OW1-02-A, which is screened within the Catfish Creek Till (ATC1).

## 5.0 Conclusions

Impacts from pumping the municipal wells at the Branchton Meadows Well Field (BM2, BM3) were evaluated through implementation of the Groundwater Monitoring Program. Based on the information contained in the report, Burnside offers the following conclusions:

- The information presented in this report satisfies condition 4.3 of PTTW 2481-DJKVA;
- 2024 and 2025 pumping volumes were within the permitted range;
- There were no reported well interference complaints arising from water taking at the Branchton Meadows BM2, BM3 well field;
- Water levels in the monitoring wells do not respond to pumping at BM2 and BM3;
- Seasonal water level trends are observed in both overburden monitoring well screens; and
- Variations in water levels in the monitoring wells were observed following storm events.

## 6.0 References

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Aqua Insight Inc., Stantec Consulting Ltd, S.S. Papadopulos and Associates Inc. and WSP Canada Inc., 2023. Hydrogeologic Characterization and Conceptual Model Updates, Region of Waterloo Tier Three Update Project. Final Report, June 2023.

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R.J. Burnside & Associates Limited, 2025. Seasonal Water Level Report, Region of Waterloo, June 27, 2025.

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Stantec, 2013. Construction and Testing of Test Production Well ND-BM-TW1-11, Branchton Meadows Well Field, Regional Municipality of Waterloo, August 6, 2013.

Terraqua Investigations Ltd., 1995. The Study of the Hydrogeology of the Waterloo Moraine. Regional Municipality of Waterloo Water Services Division Report. (Four volumes: Executive Summary, Text, Figures, Appendices).

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BURNSIDE

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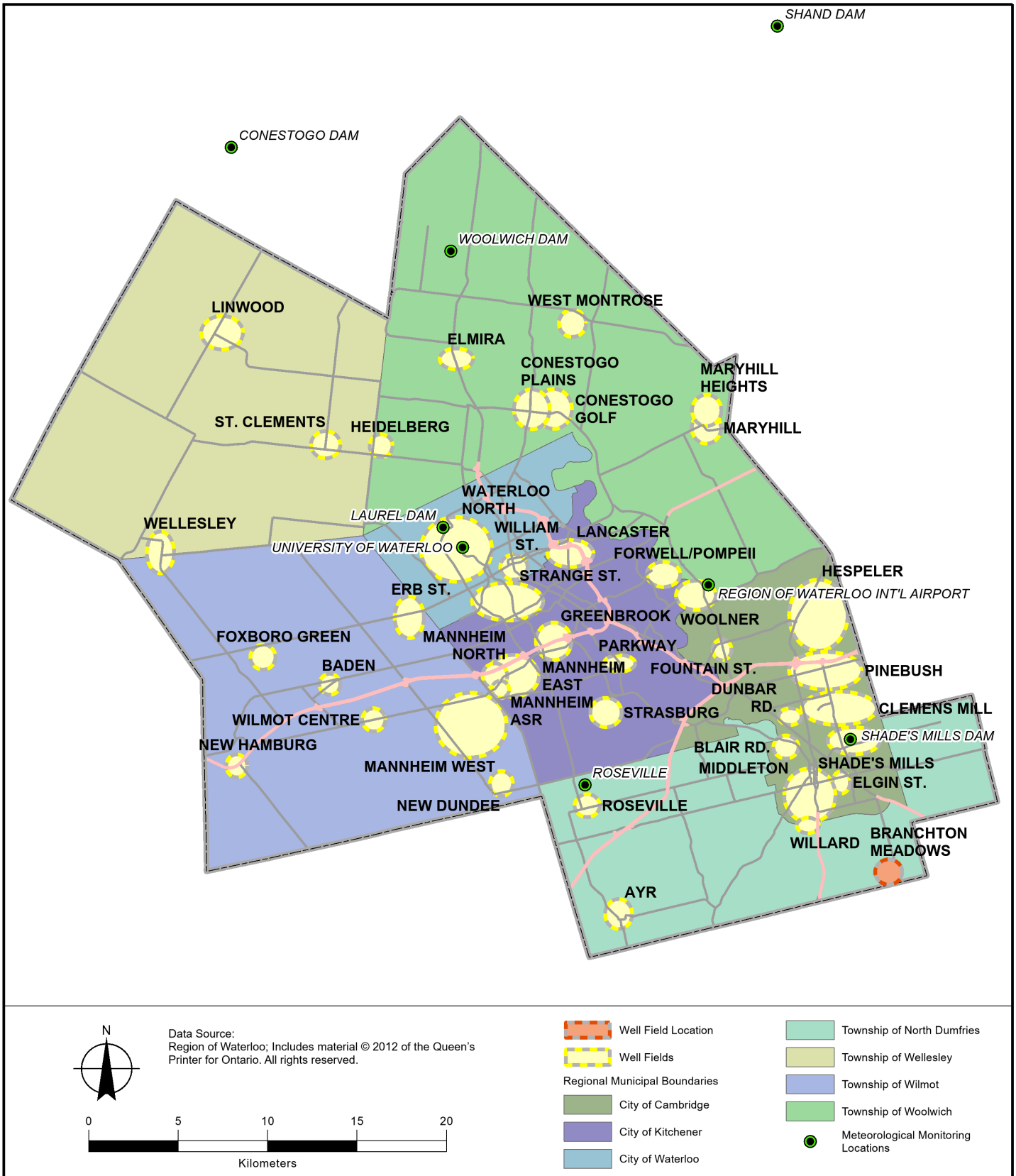
# Figures

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Map Title

**2025 GROUNDWATER MONITORING REPORT - BRANCHTON MEADOWS WELL FIELD**

WELL FIELD LOCATION MAP

Client

**REGION OF WATERLOO**

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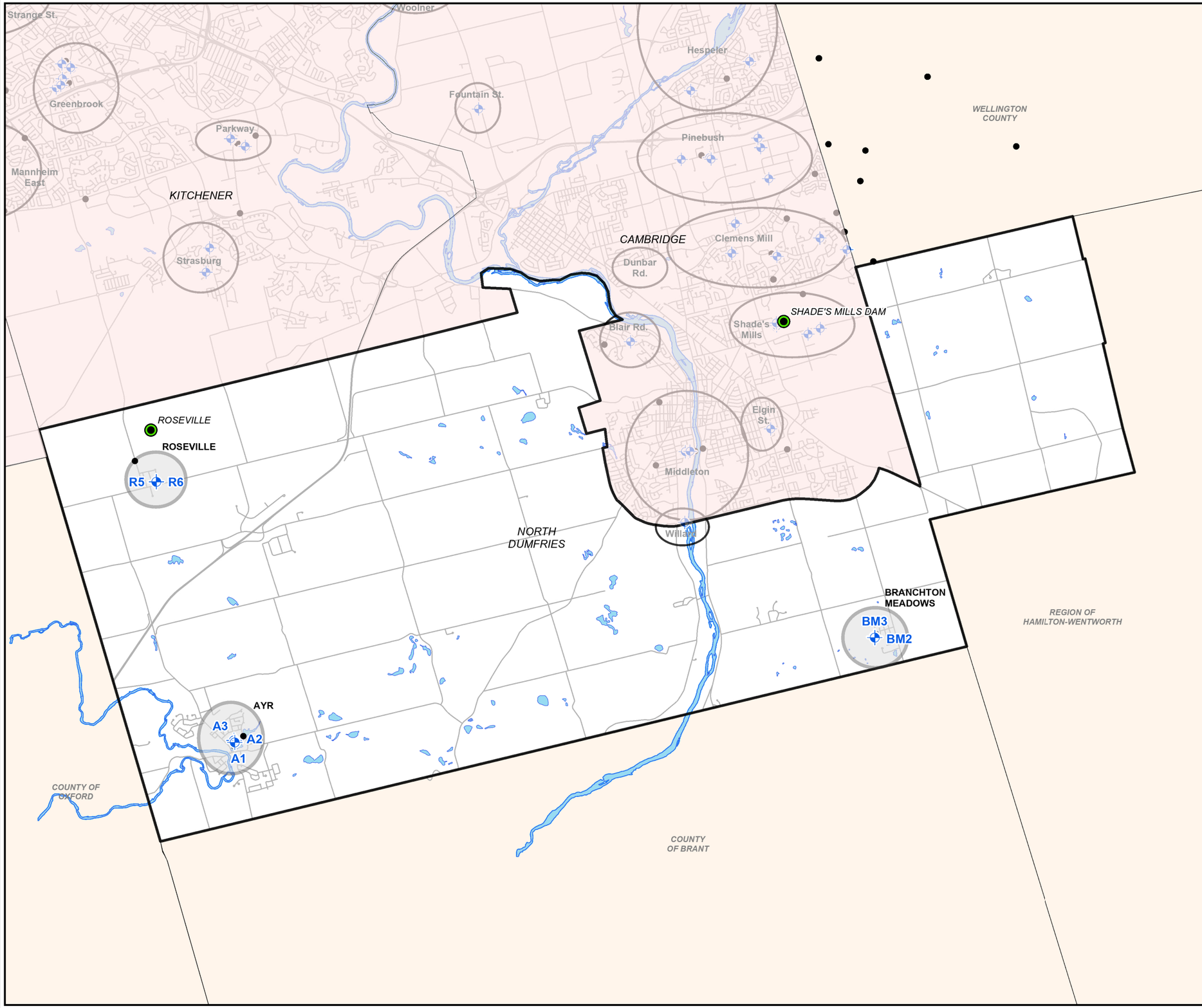


## LEGEND

- Production Well Location
- Monitoring Well Location
- North Dumfries Municipal Boundary
- Well Fields
- Meteorological Monitoring Locations

**Sources:**

1. Ministry of Natural Resources, © Queen's Printer for Ontario
2. Natural Resources Canada © Her Majesty the Queen in Right of Canada.

Datum: North American 1983 CSRS

Coord. System: NAD 1983 CSRS UTM Zone 17N

N

0 1 2 3 4 5 6 7

Kilometers

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Client

**REGION OF WATERLOO**

Figure Title

**2025 GROUNDWATER MONITORING REPORT - BRANCHTON MEADOWS WELL FIELD**

NORTH DUMFRIES WELL FIELDS AND MONITORING NETWORK

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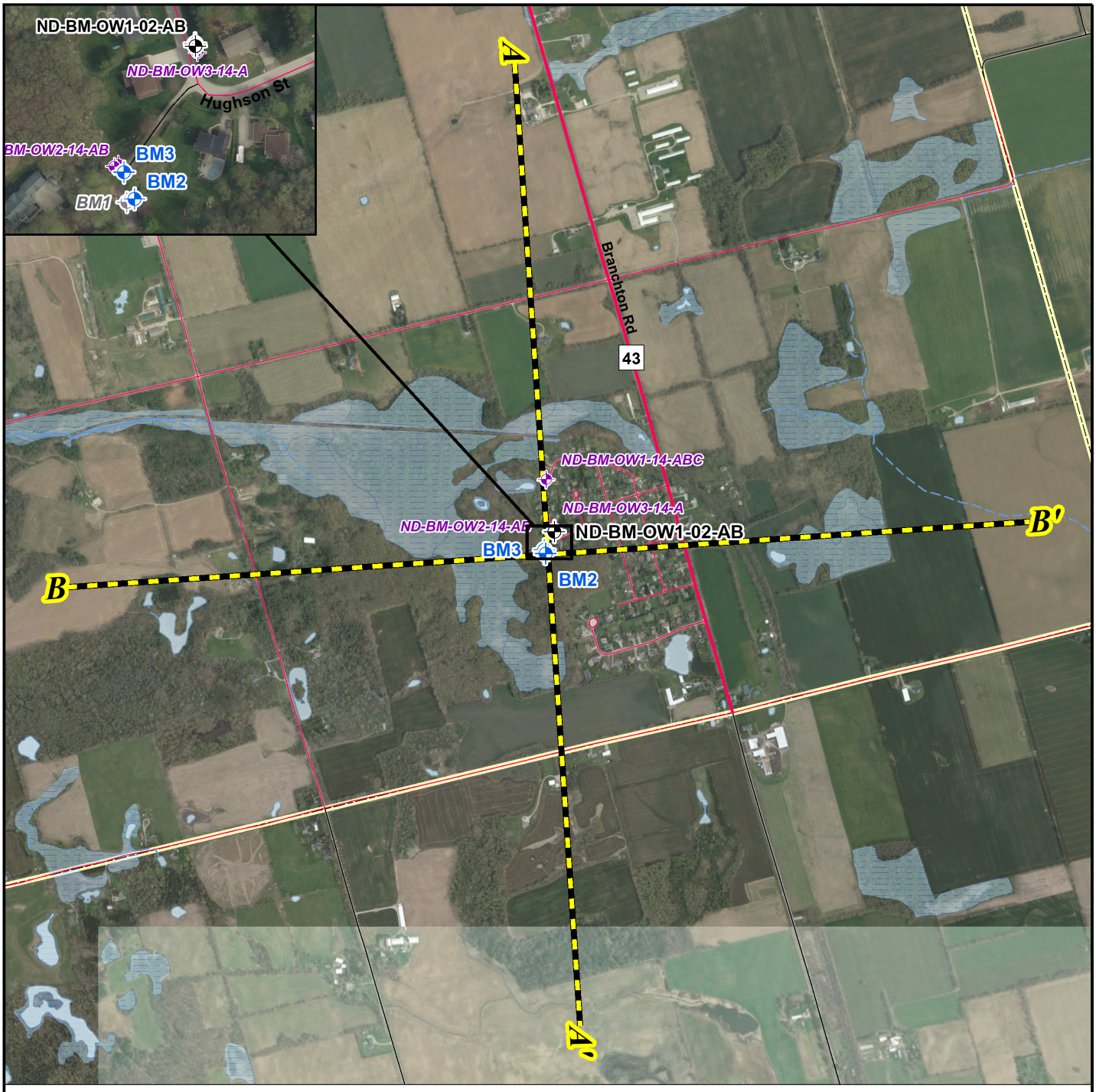


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Data Source:
Region of Waterloo GIS Data; Background 2020 Air Photo: ArcGIS Image Service Region of Waterloo; Ministry of Natural Resources, © Queen's Printer for Ontario; Natural Resources Canada © Her Majesty the Queen in Right of Canada.

0 150 300 450 600 750 900 1,050 1,200 1,350
Metres

- PTTW Monitoring Well Location
- Production Well Location
- Nearby Monitoring Well Location
- Decommissioned Production Well Location
- Cross Section Orientation
- Intermittent Creek
- Creek
- Provincially Significant Wetland (MNR)
- Regional Road
- Local Road
- Private / Other Road
- Region of Waterloo Boundary

BURNSIDE

Map Title

**2025 GROUNDWATER MONITORING REPORT - BRANCHTON MEADOWS WELL FIELD**

WELL LOCATION MAP

Client

**REGION OF WATERLOO**

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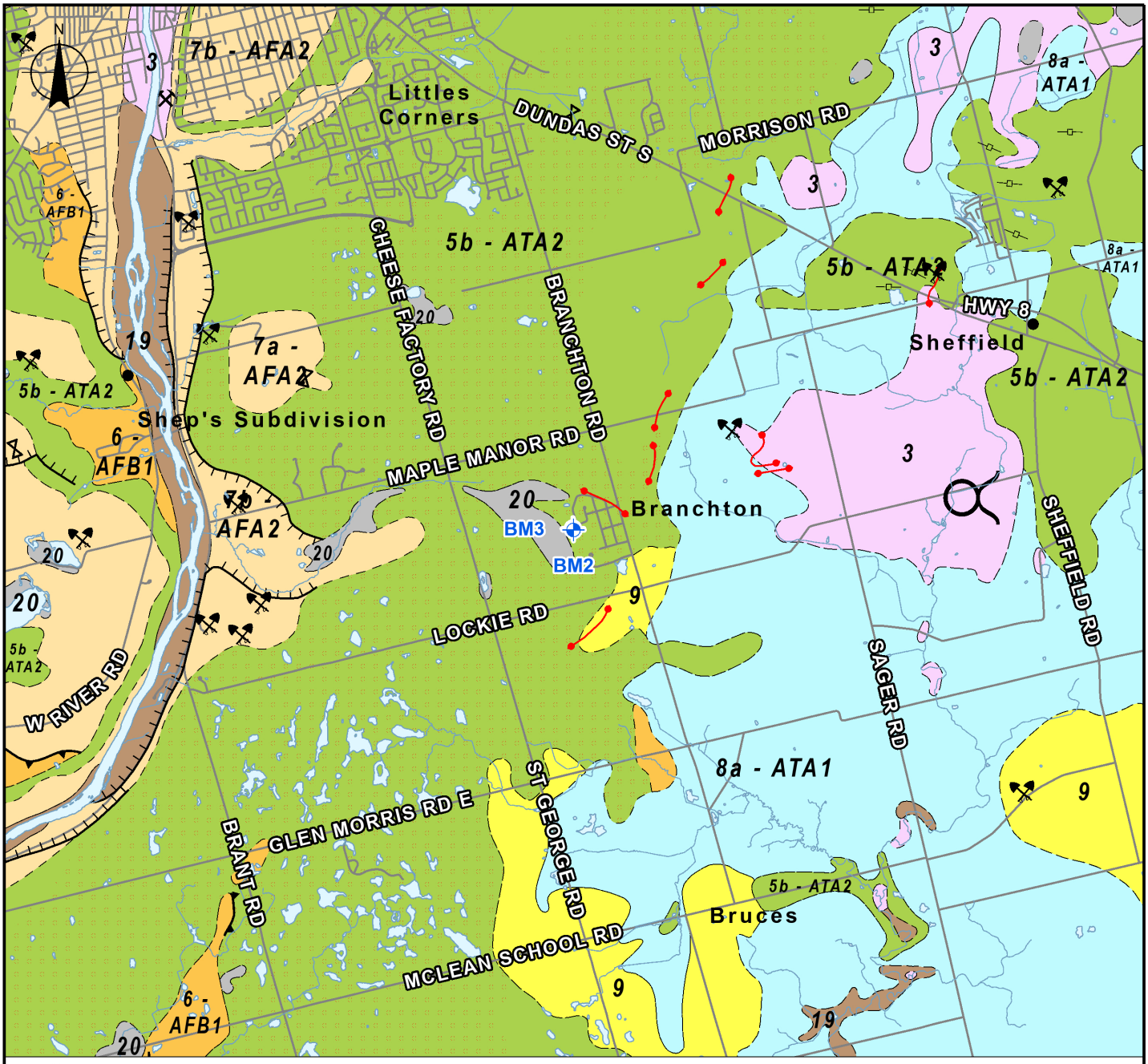


Data Source:
1. Ontario Geological Survey 2003. Surficial Geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128.
2. Region of Waterloo GIS

0 1,000 2,000 3,000 4,000 5,000
Meters

RMOW Supply Well
Watercourse
Waterbody

**Surficial Geology**

3: Paleozoic bedrock
5b: Stone-poor, carbonate-derived silty to sandy till (ATA2/ATB1 - Aquitard)
6: Ice-contact stratified deposits (AFB1 - Aquifer)
7a: Glaciofluvial deposits: Sandy deposits (AFA2 - Aquifer)
7b: Glaciofluvial deposits: Gravelly deposits (AFA2 - Aquifer)
8a: Fine-textured glaciolacustrine deposits: Massive-well laminated (ATA1)
9: Coarse-textured glaciolacustrine deposits
19: Modern alluvial deposits
20: Organic deposits

Quarry (Point)
Sand and Gravel Pit
Beach
Ice-Contact Slope
Terrace
Delta, glaciolacustrine
Drumlin or drumlinoid ridges (point)
Sample Location
Glacial striae; direction of ice movement known
Hummocky Topography
Unit Contact Boundary

BURNSIDE

Map Title
**2025 GROUNDWATER MONITORING REPORT - BRANCHTON MEADOWS WELL FIELD**

SURFICIAL GEOLOGY

Client
**REGION OF WATERLOO**

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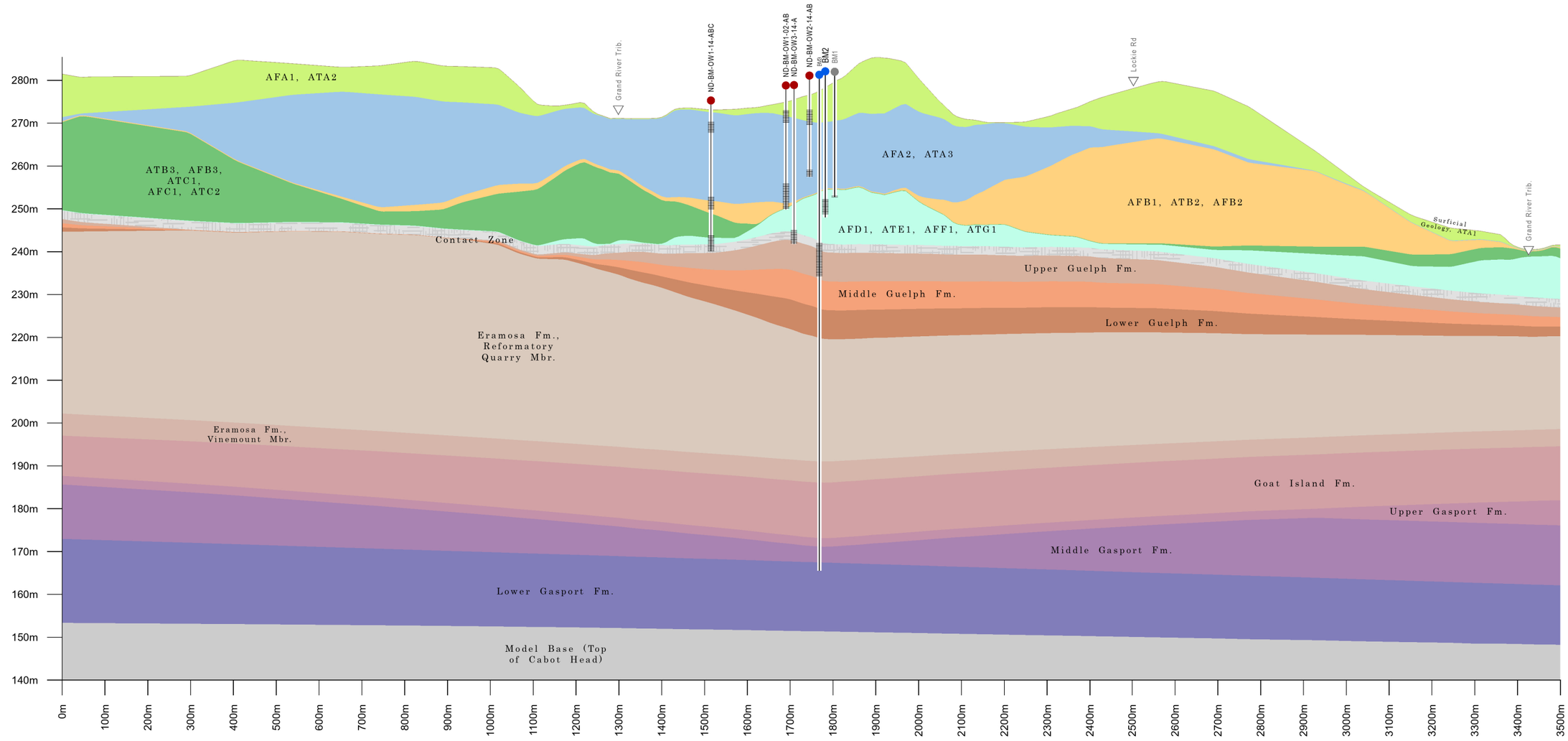


Wells

- Production Well (Active)
- Production Well (Decommissioned)
- Monitoring Well

*Cambridge Model 2026*

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1), Wenthworth Till (ATA2)
- Grand River Valley Outwash Deposits (AFA2), Fine Grain Deposits in the Grand River Valley (ATA3)
- Upper Waterloo Moraine Stratified Sediments & Equivalents (AFB1), Middle Maryhill Till & Equivalents (ATB2), Middle Waterloo Moraine Stratified Sediments & Equivalents (AFB2)
- Lower Maryhill Till & stratified Equivalents (ATB3), Lower Waterloo Moraine Stratified Sediments or Catfish Creek Till Outwash (AFB3), Upper / Main Catfish Creek Till (ATC1), Middle Catfish Creek Stratified Deposits (AFC1), Lower Catfish Creek Till (ATC2)
- Pre-Catfish Creek Coarse-Grained Glaciofluvial/ Lacustrine Deposits (AFD1), Canning Drift: Till & Fine Textured Glaciolacustrine Deposits (ATE1), Pre-Canning Coarse-Textured Glaciofluvial/ Glaciolacustrine Deposits (AFF1), Pre-Canning Coarse-Textured Till (ATG1)
- Weathered Bedrock
- Bedrock: Upper Guelph Fm.
- Bedrock: Middle Guelph Fm.
- Bedrock: Lower Guelph Fm.
- Bedrock: Eramosa Fm., Reformatory Quarry Mbr.
- Bedrock: Eramosa Fm., Vinemount Mbr.
- Bedrock: Goat Island Fm.
- Bedrock: Lower Gasport Fm.
- Bedrock: Upper Gasport Fm.
- Bedrock: Middle Gasport Fm.
- Model Base (Top of Cabot Head)

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

**REGION OF WATERLOO**

Figure Title

**GEOLOGIC CROSS SECTION REGION OF WATERLOO**

Branchton

Cross Section A - A'

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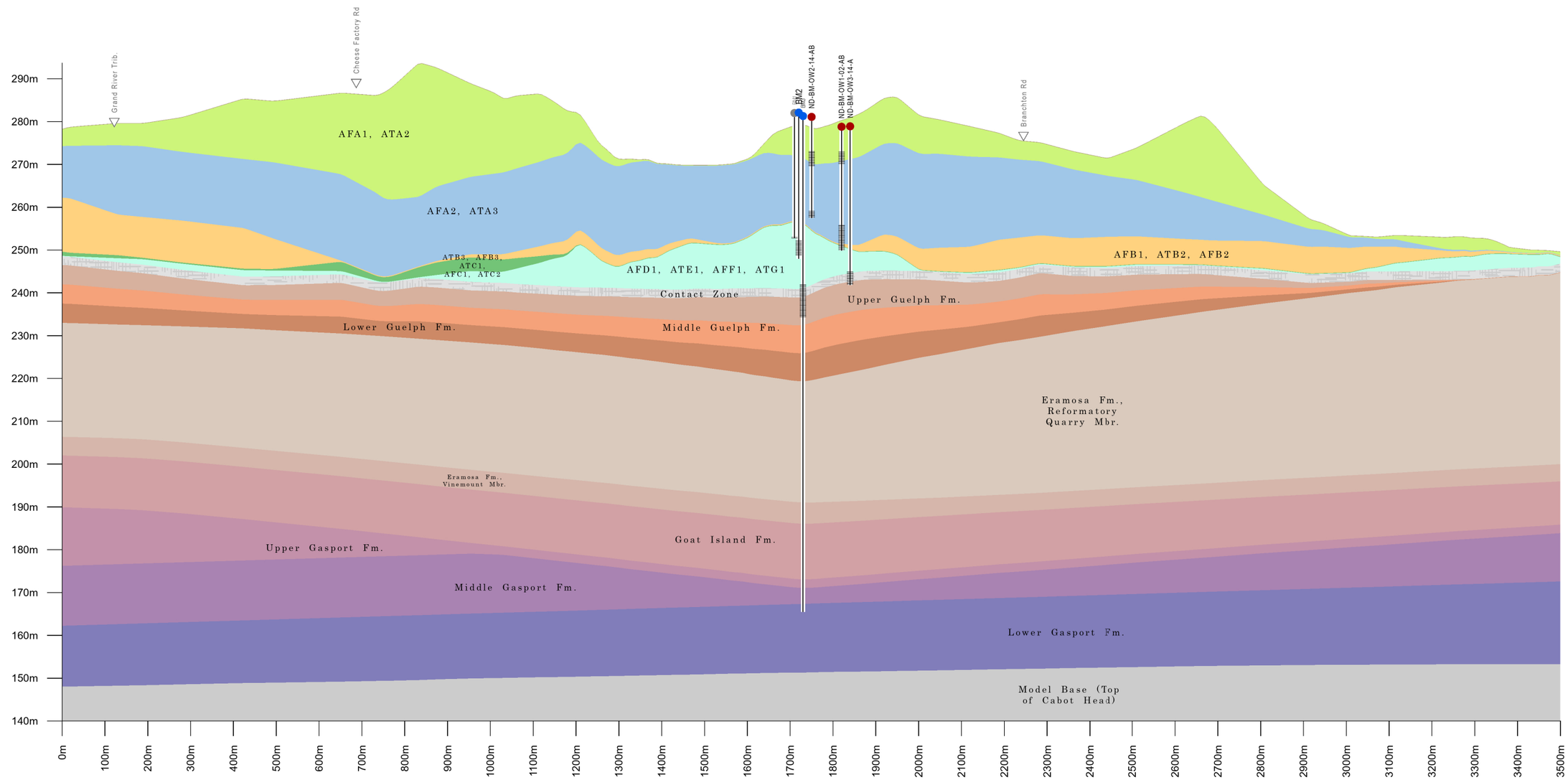


Wells

- Production Well (Active)
- Production Well (Decommissioned)
- Monitoring Well

*Cambridge Model 2026*

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1), Wenthworth Till (ATA2)
- Grand River Valley Outwash Deposits (AFA2), Fine Grain Deposits in the Grand River Valley (ATA3)
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- Lower Maryhill Till & stratified Equivalents (ATB3), Lower Waterloo Moraine Stratified Sediments or Catfish Creek Till Outwash (AFB3), Upper / Main Catfish Creek Till (ATC1), Middle Catfish Creek Stratified Deposits (AFC1), Lower Catfish Creek Till (ATC2)
- Pre-Catfish Creek Coarse-Grained Glaciofluvial/ Lacustrine Deposits (AFD1), Canning Drift: Till & Fine Textured Glaciolacustrine Deposits (ATE1), Pre-Canning Coarse-Textured Glaciofluvial/ Glaciolacustrine Deposits (AFF1), Pre-Canning Coarse-Textured Till (ATG1)
- Weathered Bedrock
- Bedrock: Upper Guelph Fm.
- Bedrock: Middle Guelph Fm.
- Bedrock: Lower Guelph Fm.
- Bedrock: Eramosa Fm., Reformatory Quarry Mbr.
- Bedrock: Eramosa Fm., Vinemount Mbr.
- Bedrock: Goat Island Fm.
- Bedrock: Lower Gasport Fm.
- Bedrock: Upper Gasport Fm.
- Bedrock: Middle Gasport Fm.
- Model Base (Top of Cabot Head)

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

**REGION OF WATERLOO**

Figure Title

**GEOLOGIC CROSS SECTION**
**REGION OF WATERLOO**
Branchton
Cross Section B - B'

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# Appendix A

# Permit To Take Water

**PERMIT TO TAKE WATER**
Ground Water
NUMBER 2481-DJKHVA

*Pursuant to Section 34.1 of the Ontario Water Resources Act, R.S.O. 1990 this Permit To Take Water is hereby issued to:*

The Regional Municipality of Waterloo
Floor 7 - 150 Frederick St
Kitchener, Ontario, N2G 4J3
Canada

*For the water taking from:* BM2, BM3

*Located at:* Lot 4, 5, Concession 7, Geographic Township of Dumfries
North Dumfries, Regional Municipality of Waterloo

*For the purposes of this Permit, and the terms and conditions specified below, the following definitions apply:*

**DEFINITIONS**

(a) "Director" means any person appointed in writing as a Director pursuant to section 5 of the OWRA for the purposes of section 34.1, OWRA.

(b) "Provincial Officer" means any person designated in writing by the Minister as a Provincial Officer pursuant to section 5 of the OWRA.

(c) "Ministry" means Ontario Ministry of the Environment, Conservation and Parks.

(d) "District Office" means the Guelph District Office.

(e) "Permit" means this Permit to Take Water No. 2481-DJKHVA including its Schedules, if any, issued in accordance with Section 34.1 of the OWRA.

(f) "Permit Holder" means The Regional Municipality of Waterloo.

(g) "OWRA " means the *Ontario Water Resources Act,* R.S.O. 1990, c. O. 40, as amended.

*You are hereby notified that this Permit is issued subject to the terms and conditions outlined below:*

## TERMS AND CONDITIONS

### 1. Compliance with Permit

1.1 Except where modified by this Permit, the water taking shall be in accordance with the application for this Permit To Take Water, dated February 26, 2025 and signed by Karl Belan, and all Schedules included in this Permit.

1.2 The Permit Holder shall ensure that any person authorized by the Permit Holder to take water under this Permit is provided with a copy of this Permit and shall take all reasonable measures to ensure that any such person complies with the conditions of this Permit.

1.3 Any person authorized by the Permit Holder to take water under this Permit shall comply with the conditions of this Permit.

1.4 This Permit is not transferable to another person without the Director's written consent.

1.5 This Permit provides the Permit Holder with permission to take water in accordance with the conditions of this Permit, up to the date of the expiry of this Permit. This Permit does not constitute a legal right, vested or otherwise, to a water allocation, and the issuance of this Permit does not guarantee that, upon its expiry, it will be renewed.

1.6 The Permit Holder shall keep this Permit available at all times at or near the site of the taking, and shall produce this Permit immediately for inspection by a Provincial Officer upon his or her request.

1.7 The Permit Holder shall report any changes of address to the Director within thirty days of any such change. The Permit Holder shall report any change of ownership of the property for which this Permit is issued within thirty days of any such change.

### 2. General Conditions and Interpretation

2.1 Inspections
The Permit Holder must forthwith, upon presentation of credentials, permit a Provincial Officer to carry out any and all inspections authorized by the OWRA, the *Environmental Protection Act*, R.S.O. 1990, the *Pesticides Act*, R.S.O. 1990, or the *Safe Drinking Water Act,* S. O. 2002.

2.2 Other Approvals
The issuance of, and compliance with this Permit, does not:

(a) relieve the Permit Holder or any other person from any obligation to comply with any other applicable legal requirements, including the provisions of the *Ontario Water Resources Act*, and the *Environmental Protection Act*, and any regulations made thereunder; or

(b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3 Information

The receipt of any information by the Ministry, the failure of the Ministry to take any action or require any person to take any action in relation to the information, or the failure of a Provincial Officer to prosecute any person in relation to the information, shall not be construed as:

(a) an approval, waiver or justification by the Ministry of any act or omission of any person that contravenes this Permit or other legal requirement; or

(b) acceptance by the Ministry of the information's completeness or accuracy.

2.4 Rights of Action

The issuance of, and compliance with this Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

2.5 Severability

The requirements of this Permit are severable. If any requirements of this Permit, or the application of any requirements of this Permit to any circumstance, is held invalid or unenforceable, the application of such requirements to other circumstances and the remainder of this Permit shall not be affected thereby.

2.6 Conflicts

Where there is a conflict between a provision of any submitted document referred to in this Permit, including its Schedules, and the conditions of this Permit, the conditions in this Permit shall take precedence.

## 3. Water Takings Authorized by This Permit

3.1 **Expiry**

This Permit expires on **May 31, 2035**. No water shall be taken under authority of this Permit after the expiry date.

3.2 Amounts of Taking Permitted

The Permit Holder shall only take water from the source, during the periods and at the rates and amounts of taking specified in Table A. Water takings are authorized only for the purposes specified in Table A.

**Table A**

| | Source Name / Description: | Source: Type: | Taking Specific Purpose: | Taking Major Category: | Max. Taken per Minute (litres): | Max. Num. of Hrs Taken per Day: | Max. Taken per Day (litres): | Max. Num. of Days Taken per Year: | Zone/ Easting/ Northing: |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BM2 | Well<br><br>Drilled | Municipal | Water Supply | 180 | 24 | 130,000 | 365 | 17<br>559622<br>4795353 |
| 2 | BM3 | Well<br><br>Drilled | Municipal | Water Supply | 180 | 24 | 130,000 | 365 | 17<br>559618<br>4795367 |
| | | | | | | Total Taking: | 130,000 | | |

3.3 Notwithstanding Table A, the combined volume of water taking from all sources listed in Table A shall not exceed **130,000 litres per day**.

## 4. Monitoring

4.1 The Permit Holder shall maintain a record of all water takings. The daily volume of water taken shall be measured by a flow meter or calculated in accordance with the method described in the application for this Permit, or as otherwise accepted by the Director. This record shall include the dates and times of water takings, the rates of pumping, and the total measured amounts of water pumped per day for each day that water is taken under the authorization of this Permit. A separate record shall be maintained for each source. The Permit Holder shall keep all required records up to date and available at or near the site of the taking and shall produce the records immediately for inspection by a Provincial Officer upon his or her request. The Permit Holder shall submit, on or before March 31st in every year, the daily water taking data collected and recorded for the previous year to the Ministry's Water Taking Reporting System.

4.2 The Permit Holder shall measure and record water levels once a month in the following monitoring wells:

- ND-BM-OW1-02-A

- ND-BM-OW1-02-B

4.3 The Permit Holder shall prepare and submit a report to the Director and the Guelph District Office every two years by **June 30**, commencing **June 30, 2026** that presents the results of the well field water level monitoring for the two preceding calendar years, assesses changes in water levels in the supply aquifer(s) in relation to precipitation and water taking from the aquifer(s), and provides a summary for all interference complaints received by the Permit Holder related to this Permit and reported in the District Office in accordance with Condition 5.1, including the manner in which the Permit Holder has dealt with the complaint.

## 5. Impacts of the Water Taking

5.1 Notification
The Permit Holder shall immediately notify the local District Office of any complaint arising

from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060.

5.2 For Groundwater Takings

If the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of doing so.

If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected.

**6. Director May Amend Permit**

The Director may amend this Permit by letter requiring the Permit Holder to suspend or reduce the taking to an amount or threshold specified by the Director in the letter. The suspension or reduction in taking shall be effective immediately and may be revoked at any time upon notification by the Director. This condition does not affect your right to appeal the suspension or reduction in taking to the Environmental Review Tribunal under the *Ontario Water Resources Act* , Section 100 (4).

*The reasons for the imposition of these terms and conditions are as follows:*

1. Condition 1 is included to ensure that the conditions in this Permit are complied with and can be enforced.

2. Condition 2 is included to clarify the legal interpretation of aspects of this Permit.

3. Conditions 3 through 6 are included to protect the quality of the natural environment so as to safeguard the ecosystem and human health and foster efficient use and conservation of waters. These conditions allow for the beneficial use of waters while ensuring the fair sharing, conservation and sustainable use of the waters of Ontario. The conditions also specify the water takings that are authorized by this Permit and the scope of this Permit.

*In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, you may by written Notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, as amended, provides that the Notice requiring the hearing shall state:*

1. The portions of the Permit or each term or condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

*In addition to these legal requirements, the Notice should also include:*

a. The name of the appellant;
b. The address of the appellant;
c. The Permit to Take Water number;
d. The date of the Permit to Take Water;
e. The name of the Director;
f. The municipality within which the works are located;

*This notice must be served upon:*

*The Secretary*
*Environmental Review Tribunal*
*Registrar*
*Ontario Land Tribunal*
*655 Bay Street, Suite 1500*
*Toronto, Ontario*
*M5G 1E5*
*OLT.Registrar@ontario.ca*

*AND*

*The Director, Section 34.1,*
*Ministry of the Environment, Conservation and Parks*
*Floor 1, 135 St Clair Ave W*
*Toronto, ON*
*M4V 1P5*

***Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal:***

| by Telephone at | by Fax at | by e-mail at |
|---|---|---|
| (416) 212-6349 | (416) 326-5370 | www.ert.gov.on.ca |
| Toll Free 1(866) 448-2248 | Toll Free 1(844) 213-3474 | |

This Permit cancels and replaces Permit Number 2577-9TPMWL, issued on 2015/03/02.

Dated at Toronto this 16th day of July, 2025.

Matthew Corriveau
Director, Section 34.1
*Ontario Water Resources Act* , R.S.O. 1990

## Schedule A

This Schedule "A" forms part of Permit To Take Water 2481-DJKHVA, dated July 16, 2025.

1. Memorandum entitled "Category 1 Application for Renewal of Permit to Take Water No. 2577-9TPMWL for Regional Municipality of Waterloo Groundwater Supply Wells BM2 and BM3 of the Branchton Meadows Well Field (North Dumfries, Ontario)," prepared by The Regional Municipality of Waterloo, signed by Karl Belan, M.A.Sc., P.Geo., and dated February 2025.

2. R.J. Burnside & Associates Limited. 2024. 2023 Biennial Groundwater Monitoring Report – Branchton Meadows Well Field (BM1, BM2, BM3), prepared for the Region of Waterloo, signed by Sean Quinlan, B.E.S., C.Tech and Dave Hopkins, P.Geo., dated May 23, 2024.

3. Email entitled "RE: Letter of Acknowledgement (Ref. #4520-DEGJAP) – deadline extended to May 2, 2025," from Karl Belan of the Region of Waterloo to Ricki Allum, Ajay Persaud, and Neil Taylor of the MECP, dated April 25, 2025.

Ontario

**Ministry of the Environment and Climate Change**
**Ministère de l'Environnement et de l'Action en matière de changement climatique**

**PERMIT TO TAKE WATER**
Ground Water
NUMBER 2577-9TPMWL

*Pursuant to Section 34.1 of the Ontario Water Resources Act, R.S.O. 1990 this Permit To Take Water is hereby issued to:*

The Regional Municipality of Waterloo
Post Office Box 9051
Kitchener, Ontario N2G 4J3

*For the water taking from:* Wells BM1, BM2, BM3

*Located at:* Lot 45, Concession 7, Geographic Township of Dumfries
North Dumfries, Regional Municipality of Waterloo

*For the purposes of this Permit, and the terms and conditions specified below, the following definitions apply:*

**DEFINITIONS**

(a) "Director" means any person appointed in writing as a Director pursuant to section 5 of the OWRA for the purposes of section 34.1, OWRA.

(b) "Provincial Officer" means any person designated in writing by the Minister as a Provincial Officer pursuant to section 5 of the OWRA.

(c) "Ministry" means Ontario Ministry of the Environment and Climate Change.

(d) "District Office" means the Guelph District Office.

(e) "Permit" means this Permit to Take Water No. 2577-9TPMWL including its Schedules, if any, issued in accordance with Section 34.1 of the OWRA.

(f) "Permit Holder" means The Regional Municipality of Waterloo.

(g) "OWRA " means the *Ontario Water Resources Act,* R.S.O. 1990, c. O. 40, as amended.

*You are hereby notified that this Permit is issued subject to the terms and conditions outlined below:*

**TERMS AND CONDITIONS**

**1. Compliance with Permit**

1.1 Except where modified by this Permit, the water taking shall be in accordance with the application for this Permit To Take Water, dated December 10, 2014 and signed by Richard Wootton, and all Schedules included in this Permit.

1.2 The Permit Holder shall ensure that any person authorized by the Permit Holder to take water under this Permit is provided with a copy of this Permit and shall take all reasonable measures to ensure that any such person complies with the conditions of this Permit.

1.3 Any person authorized by the Permit Holder to take water under this Permit shall comply with the conditions of this Permit.

1.4 This Permit is not transferable to another person.

1.5 This Permit provides the Permit Holder with permission to take water in accordance with the conditions of this Permit, up to the date of the expiry of this Permit. This Permit does not constitute a legal right, vested or otherwise, to a water allocation, and the issuance of this Permit does not guarantee that, upon its expiry, it will be renewed.

1.6 The Permit Holder shall keep this Permit available at all times at or near the site of the taking, and shall produce this Permit immediately for inspection by a Provincial Officer upon his or her request.

1.7 The Permit Holder shall report any changes of address to the Director within thirty days of any such change. The Permit Holder shall report any change of ownership of the property for which this Permit is issued within thirty days of any such change. A change in ownership in the property shall cause this Permit to be cancelled.

**2. General Conditions and Interpretation**

2.1 Inspections
The Permit Holder must forthwith, upon presentation of credentials, permit a Provincial Officer to carry out any and all inspections authorized by the OWRA, the *Environmental Protection Act*, R.S.O. 1990, the *Pesticides Act*, R.S.O. 1990, or the *Safe Drinking Water Act*, S. O. 2002.

2.2 Other Approvals
The issuance of, and compliance with this Permit, does not:

(a) relieve the Permit Holder or any other person from any obligation to comply with any other applicable legal requirements, including the provisions of the *Ontario Water Resources Act*, and

the *Environmental Protection Act* , and any regulations made thereunder; or

(b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3 Information

The receipt of any information by the Ministry, the failure of the Ministry to take any action or require any person to take any action in relation to the information, or the failure of a Provincial Officer to prosecute any person in relation to the information, shall not be construed as:

(a) an approval, waiver or justification by the Ministry of any act or omission of any person that contravenes this Permit or other legal requirement; or

(b) acceptance by the Ministry of the information's completeness or accuracy.

2.4 Rights of Action

The issuance of, and compliance with this Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

2.5 Severability

The requirements of this Permit are severable. If any requirements of this Permit, or the application of any requirements of this Permit to any circumstance, is held invalid or unenforceable, the application of such requirements to other circumstances and the remainder of this Permit shall not be affected thereby.

2.6 Conflicts

Where there is a conflict between a provision of any submitted document referred to in this Permit, including its Schedules, and the conditions of this Permit, the conditions in this Permit shall take precedence.

## 3. Water Takings Authorized by This Permit

### 3.1 Expiry

This Permit expires on **May 31, 2025**. No water shall be taken under authority of this Permit after the expiry date.

3.2 Amounts of Taking Permitted

The Permit Holder shall only take water from the source, during the periods and at the rates and amounts of taking specified in Table A. Water takings are authorized only for the purposes specified in Table A.

**Table A**

| | Source Name / Description: | Source: Type: | Taking Specific Purpose: | Taking Major Category: | Max. Taken per Minute (litres): | Max. Num. of Hrs Taken per Day: | Max. Taken per Day (litres): | Max. Num. of Days Taken per Year: | Zone/ Easting/ Northing: |
|---|---|---|---|---|---|---|---|---|---|
| **1** | BM1 | Well Drilled | Municipal | Water Supply | 90 | 24 | 130,000 | 365 | 17 559618 4795353 |
| **2** | BM2 | Well Drilled | Municipal | Water Supply | 90 | 24 | 130,000 | 365 | 17 559622 4795353 |
| **3** | BM3 | Well Drilled | Municipal | Water Supply | 90 | 24 | 130,000 | 365 | 17 559618 4795367 |
| | | | | | | **Total Taking:** | 130,000 | | |

3.3 Notwithstanding Table A, Permit Holder shall not exceed the pumping rate of 90 L/min and volume of 130,000 L/ day from any or combination of wells BM1, BM2 and BM3.

## 4. Monitoring

4.1 Under section 9 of O. Reg. 387/04, and as authorized by subsection 34(6) of the *Ontario Water Resources Act* , the Permit Holder shall, on each day water is taken under the authorization of this Permit, record the date, the volume of water taken on that date and the rate at which it was taken. The daily volume of water taken shall be measured by a flow meter or calculated in accordance with the method described in the application for this Permit, or as otherwise accepted by the Director. The Permit Holder shall keep all records required by this condition current and available at or near the site of the taking and shall produce the records for inspection by a Provincial Officer upon his or her request. The Permit Holder, unless otherwise required by the Director, shall submit, on or before March 31st in every year, the records required by this condition to the ministry's Water Taking Reporting System.

4.2 The Permit Holder shall measure and record water levels once a month in the following monitoring wells:

ND-BM-OW1A-02
ND-BM-OW1B-02

4.3 The Permit Holder shall prepare and submit a report every two years by June 30 commencing June 30, 2016, that presents the results of the well field water level monitoring for the two preceding calendar years, assesses changes in water levels in the supply aquifer(s) in relation to precipitation and water taking from the aquifer(s), and provides a summary for all interference complaints received by the Permit Holder related to this permit and reported in the District Office in accordance with Condition 5.1 and the manner in which the Permit Holder has dealt with the complaint.

## 5. Impacts of the Water Taking

5.1 Notification

The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060.

5.2 For Groundwater Takings

If the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of doing so.

If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected.

## 6. Director May Amend Permit

The Director may amend this Permit by letter requiring the Permit Holder to suspend or reduce the taking to an amount or threshold specified by the Director in the letter. The suspension or reduction in taking shall be effective immediately and may be revoked at any time upon notification by the Director. This condition does not affect your right to appeal the suspension or reduction in taking to the Environmental Review Tribunal under the *Ontario Water Resources Act* , Section 100 (4).

*The reasons for the imposition of these terms and conditions are as follows:*

1. Condition 1 is included to ensure that the conditions in this Permit are complied with and can be enforced.

2. Condition 2 is included to clarify the legal interpretation of aspects of this Permit.

3. Conditions 3 through 6 are included to protect the quality of the natural environment so as to safeguard the ecosystem and human health and foster efficient use and conservation of waters. These conditions allow for the beneficial use of waters while ensuring the fair sharing, conservation and sustainable use of the waters of Ontario. The conditions also specify the water takings that are authorized by this Permit and the scope of this Permit.

*In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, you may by written Notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, as amended, provides that the Notice requiring the hearing shall state:*

1. The portions of the Permit or each term or condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

*In addition to these legal requirements, the Notice should also include:*

3. The name of the appellant;
4. The address of the appellant;
5. The Permit to Take Water number;
6. The date of the Permit to Take Water;
7. The name of the Director;
8. The municipality within which the works are located;

*This notice must be served upon:*

*The Secretary*
*Environmental Review Tribunal*
*655 Bay Street, 15th Floor*
*Toronto ON*
*M5G 1E5*
*Fax: (416) 314-4506*
*Email: ERTTribunalsecretary@ontario.ca*

*AND*

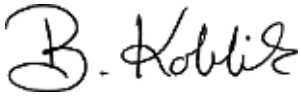
*The Director, Section 34.1, Ministry of the Environment and Climate Change*
*12th Floor*
*119 King St W*
*Hamilton ON L8P 4Y7*
*Fax: (905) 521-7820*

***Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal:***

***by telephone at (416) 314-4600*** ***by fax at (416) 314-4506*** ***by e-mail at www.ert.gov.on.ca***

This Permit cancels and replaces Permit Number 3011-839NE7, issued on 2010/03/31.

Dated at Hamilton this 2nd day of March, 2015.



Belinda Koblik
Director, Section 34.1
*Ontario Water Resources Act* , R.S.O. 1990

## Schedule A

This Schedule “A” forms part of Permit To Take Water 2577-9TPMWL, dated March 2, 2015.

BURNSIDE

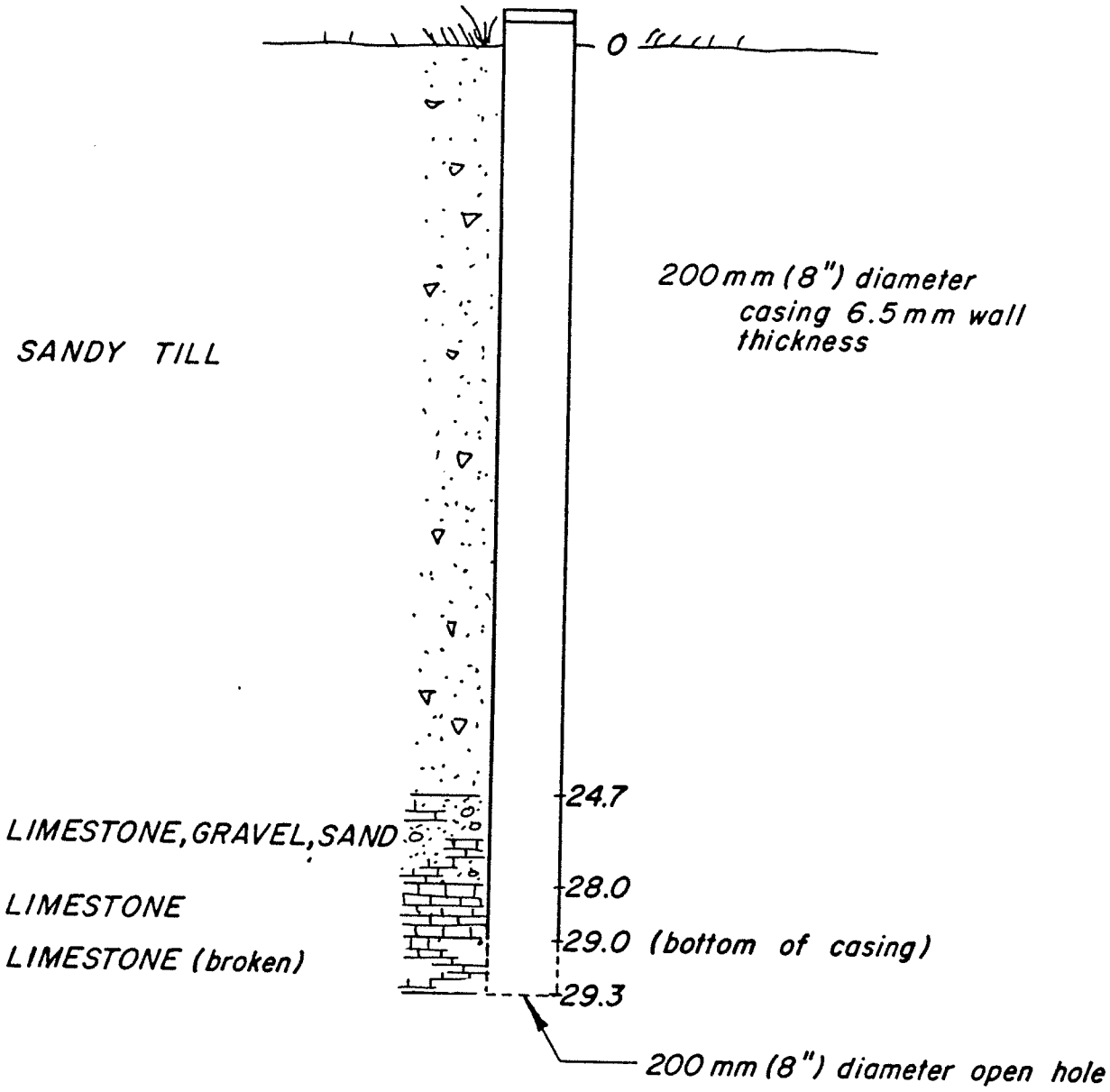
[THE DIFFERENCE IS OUR PEOPLE]

# Appendix B

# Well Records

BM1

# TW 1



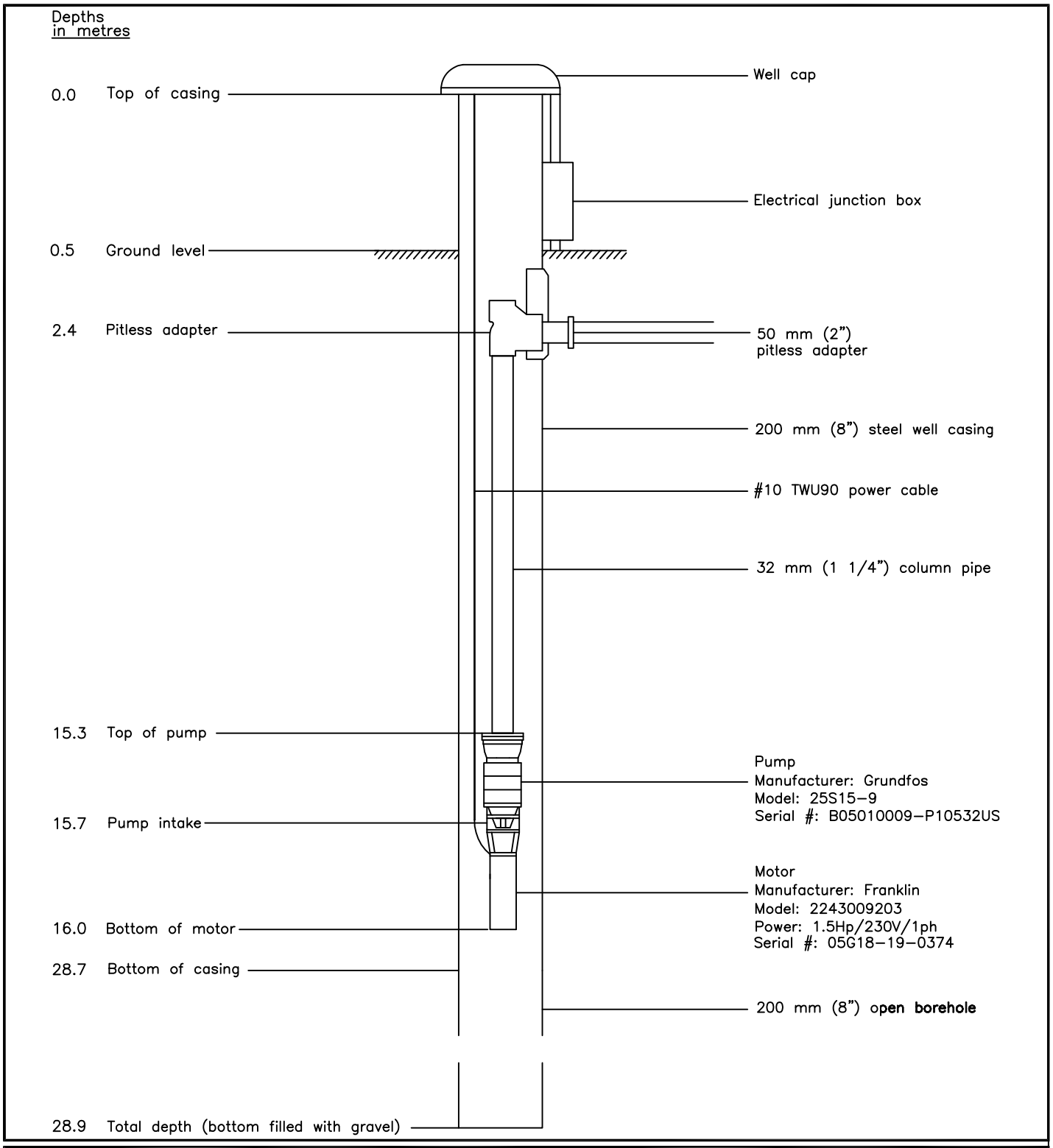

N.T.S.

WELL CONSTRUCTION DETAIL
PROJECT NO. 364-831

morrison beatty limited
consulting engineers and hydrogeologists

3-2

BM1



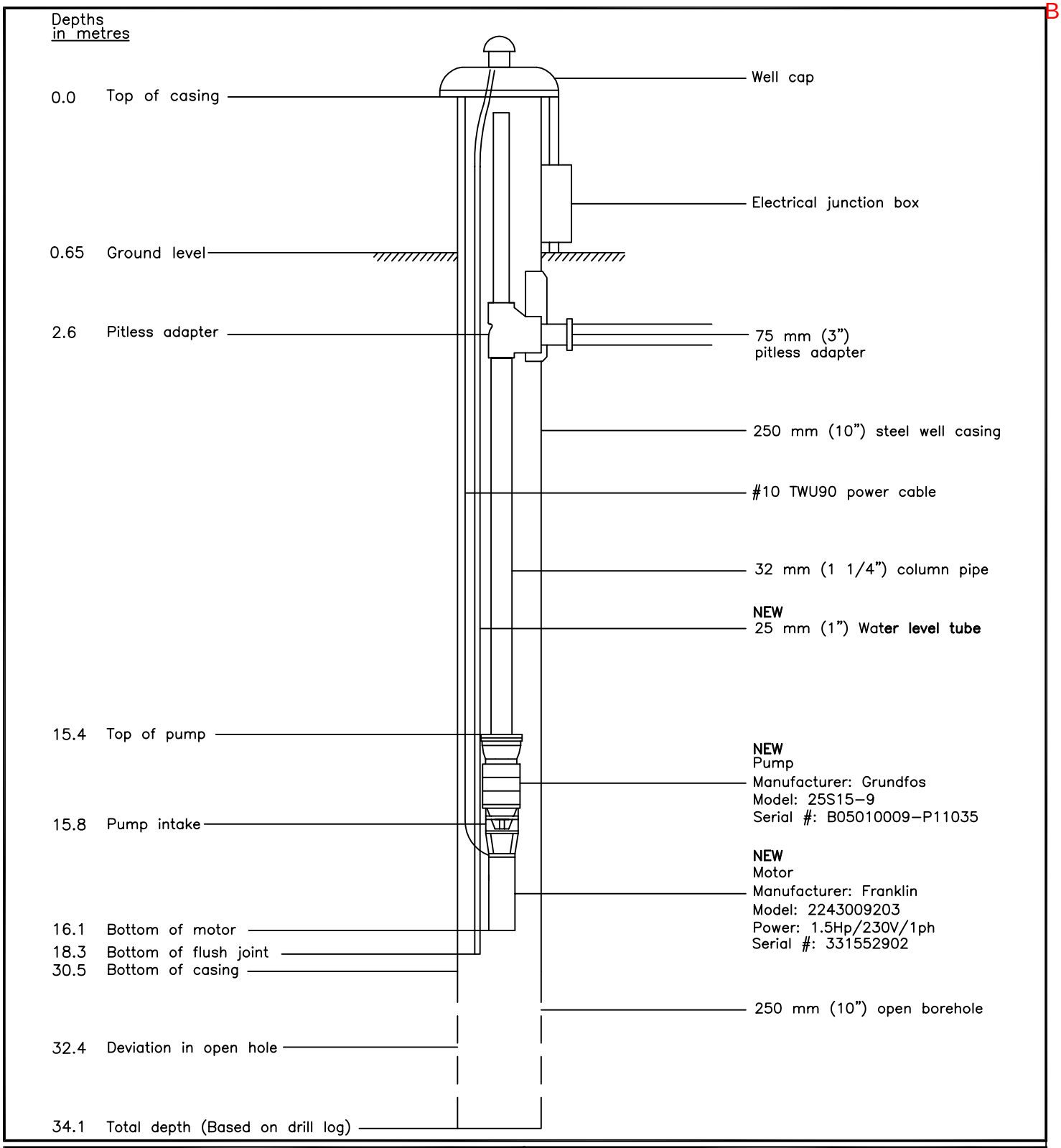

Lotowater
TECHNICAL SERVICES INC.

CLIENT
**Regional Municipality of Waterloo**

TITLE
**Branchton Meadows BM1**
**Pump Installation Drawing**

| | | | | | |
|---|---|---|---|---|---|
| PROJECT No. | 006-171 | | G:\Lotowater Projects\006 Region of Waterloo\171 Branchton Meadows #1\Pump Installation.dwg | | FIGURE |
| DESIGN | | | | | |
| DRAWN | EH | 2010/06/03 | REVISION No. 2010/07/21 | SCALE N.T.S. | 3 |
| CHECKED | | | | | |

BM2




G:\Miscellaneous\Alfredo\Lototech.JPG

CLIENT
**Regional Municipality of Waterloo**

TITLE
**Branchton Meadows Well 2**
**Pump Installation Drawing**

| | | | | |
|---|---|---|---|---|
| PROJECT No. | 006-194 | G:\Lotowater Projects\006 Region of Waterloo\171 Branchton Meadows Well 2\Pump Installation.dwg | | FIGURE |
| DESIGN | | | | |
| DRAWN | EH | 2011/02/04 | REVISION No. 2011/02/04 | SCALE N.T.S. | 4 |
| CHECKED | | | | |

# Test Production Well: ND-BM-TW1-11.

BM3

**Project:** 2012 Construction and Testing of Municipal Wells
**Client:** Regional Municipality of Waterloo
**Location:** Region of Waterloo
**Number:** 160900679

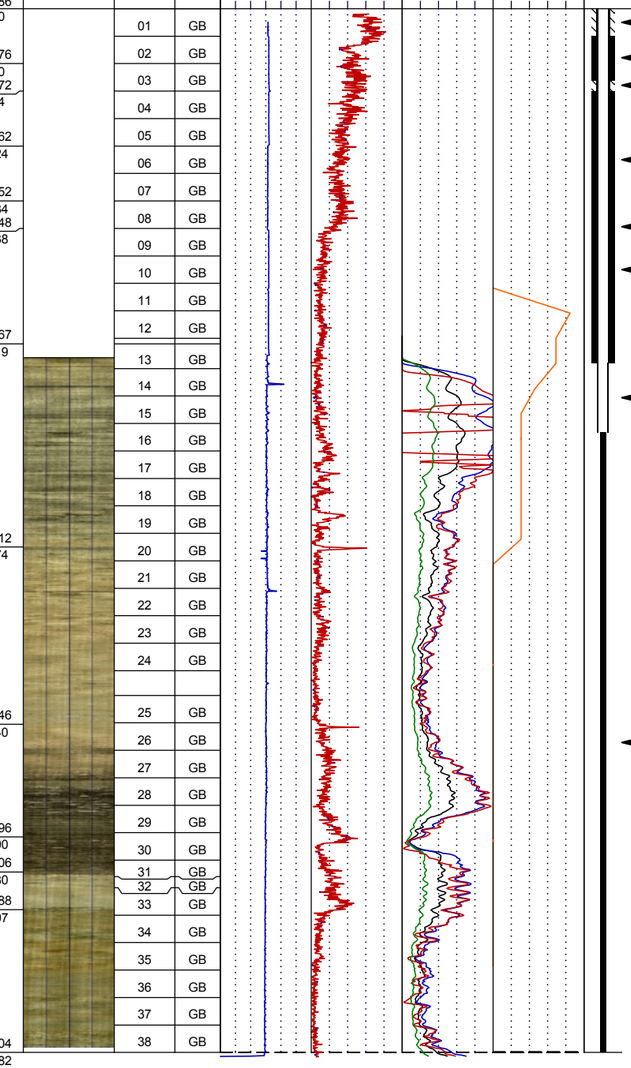
**Field Investigator:** E. Hayman
**Contractor:** Gerrits Well Drilling Inc.
**Drilling method:** DR24, truckmount, air rotary
**Date started/completed:** 29-Nov-2012 / 04-Jan-2012

**Ground surface elevation:** 278.94 m AMSL
**Top of casing elevation:** 279.49 m AMSL
**Easting:** 559612
**Northing:** 4795356

SUBSURFACE PROFILE | SAMPLE DETAILS | GEOPHYSIC DETAILS | WELL DETAILS

| Depth (m BGS) | Lithologic Description | Elevation (m AMSL) Depth (m BGS) |
|---|---|---|
| | Ground Surface | 278.86 |
| 0.00 – 272.76 | SILTY SAND<br>trace gravel, fine grained sand, brown | 0.00 |
| 272.76 – 269.72 | SILT<br>some sand, very fine grained, brownish red | 6.10 |
| 269.72 – 263.62 | SAND<br>trace clay, some silt, trace gravel, brownish red | 9.14 |
| 263.62 – 257.52 | SAND<br>some silt grading to trace silt, fine grained, brown<br>grey at 18.2 m BGS | 15.24 |
| 257.52 – 254.48 | SANDY SILT<br>trace gravel, fine grained, grey | 21.34 |
| 254.48 – 241.67 | SAND AND GRAVEL<br>well graded gravel, medium to coarse grained sand, subrounded to rounded sedimentary and igneous gravel, cemented | 24.38 |
| 241.67 – 219.12 | GUELPH FORMATION<br>dark blue grey dolostone (reef mound)<br>fracture at 38.8 m BGS<br>large fracture at 40.9 m BGS<br>becoming more porous and fractured with depth<br>becoming light grey blue | 37.19 |
| 219.12 – 199.46 | GUELPH FORMATION<br>tan dolostone, some secondary minerals (white, possibly gypsum)<br>large fracture at 63.7 m BGS<br>small gypsum nodule at 67.3 m BGS<br>small gypsum nodule at 72.0 m BGS<br>small gypsum nodule at 74.9 m BGS<br>large gypsum nodule at 78.0 m BGS | 59.74 |
| 199.46 – 186.96 | ERAMOSA FORMATION - REFORMATORY QUARRY MEMBER<br>brown dolostone with shale partings, large and abundent gypsum nodules<br>less gypsum nodules from 89.3 m BGS to base of unit | 79.40 |
| 186.96 – 183.06 | ERAMOSA FORMATION - POSSIBLE VINEMOUNT MEMBER<br>brown to black dolostone with shale partings, some small gypsum nodules | 91.90 |
| 183.06 – 178.88 | GOAT ISLAND FORMATION<br>light to dark grey, no visible fractures | 95.80 |
| 178.88 – 163.04 | GASPORT FORMATION<br>light grey to light blue grey porous dolostone (coquina) with sections of dark blue grey dolostone (reef mound) | 99.97 |
| 163.04 – 115.82 | End of Borehole | |

Optical Televiewer




| Sample Number | Sample Type |
|---|---|
| 01 | GB |
| 02 | GB |
| 03 | GB |
| 04 | GB |
| 05 | GB |
| 06 | GB |
| 07 | GB |
| 08 | GB |
| 09 | GB |
| 10 | GB |
| 11 | GB |
| 12 | GB |
| 13 | GB |
| 14 | GB |
| 15 | GB |
| 16 | GB |
| 17 | GB |
| 18 | GB |
| 19 | GB |
| 20 | GB |
| 21 | GB |
| 22 | GB |
| 23 | GB |
| 24 | GB |
| 25 | GB |
| 26 | GB |
| 27 | GB |
| 28 | GB |
| 29 | GB |
| 30 | GB |
| 31 | GB |
| 32 | GB |
| 33 | GB |
| 34 | GB |
| 35 | GB |
| 36 | GB |
| 37 | GB |
| 38 | GB |

WELL DETAILS:
- Bentonite chips 0 to 3.0 m
- Neat cement 3.0 to 7.9 m
- Bentonite chips 7.9 to 9.1 m
- 304 mm diameter borehole 0 to 39.3 m
- Neat cement 9.1 to 39.3 m
- 219 mm OD Schedule 40 306 Stainless Steel Casing 0 to 39.3 m
- 203 mm diameter open borehole 39.3 to 47.0 m
- 152 mm diameter borehole sealed with a combination of cement and grout 47.0 to 115.8 m

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
GB - grab sample

n/a - not available/applicable

Ground surface elevation based on level survey referenced to BM1/BM2
Spatial coordinates obtained using handheld GPS
Flow profile pumping rate was 4.5 L/s

Drawn By/Checked By: EH / MF

Stantec



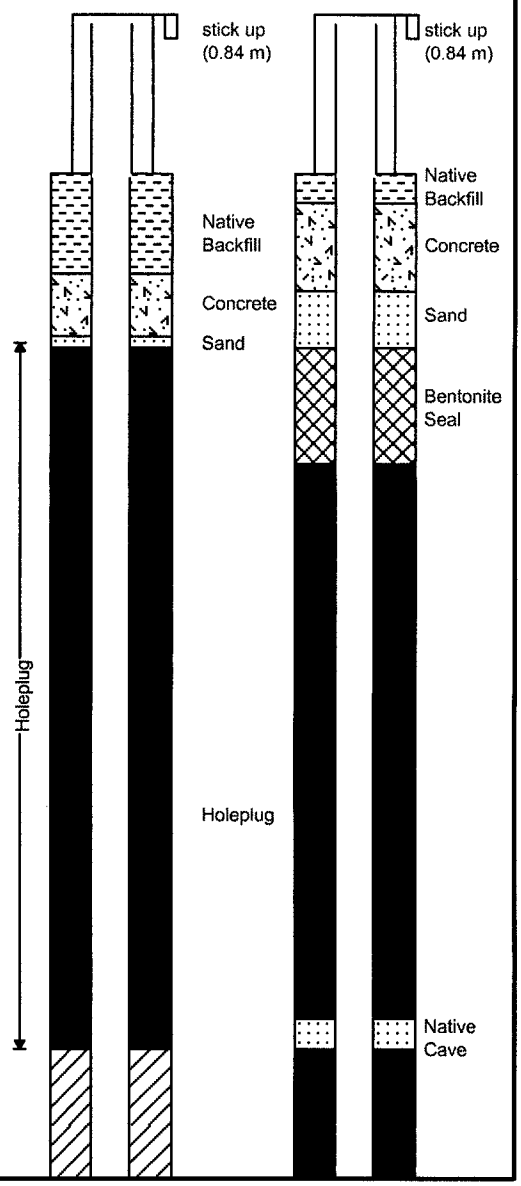
STANTEC BOREHOLE AND WELL - MASTER 17X11 160900679_LOGS.GPJ STANTEC - DATA TEMPLATE.GDT 7/4/13 MJFRASER

# Borehole No.: BM1-02(D & S)

**Project:** RMOW GUDI Study
**Project No:** 609-00116
**Location:** Branchton Meadows Well Field along Hughson Street
**Contractor:** All-Terrain Drilling Limited
**Drilling Method:** PQ Coring

**Date:** 28 June 2002
**Supervisor:** J.D.Campbell
**Ground Surface:** 274.84 m AMSL
**Top of Casing:** 275.69 m AMSL

| SUBSURFACE PROFILE | | | | SAMPLE DETAILS | | | | WELL DETAILS |
|---|---|---|---|---|---|---|---|---|
| Depth (ft / m) | Lithologic Symbol | Lithologic Description | Elevation/Depth (m BGS) | Number | Type | Recovery | N-Value | Well |
| | | Ground Surface | 274.84 | | | | | |
| | | SANDY SILT (TILL) reddish-brown, with trace clay and gravel, soft, slight moist to moist | 0.00 | 1 | GB | n/a | | |
| | | STONY SILT (TILL) reddish-brown, loose, well graded, moist to wet | 273.93 0.91 | 2 | CC | 50 % | | |
| | | cobbles, moist, hard to loose | | 3 | CC | 40 % | | |
| | | some gravel and cobbles | | 4 | CC | 66 % | | |
| | | | | 5 | CC | 66 % | | |
| | | | | 6 | CC | 100 % | | |
| | | washed gravel and cobbles, no matrix left | | 7 | CC | 100 % | | |




Screen interval (shallow): 5.8 m to 8.8 m BGS
Screen interval (deep): 22.9 m to 29 m BGS
Sand pack interval (shallow): 5.3 m to 8.8 m BGS
Sand pack interval (deep): 22.6 m to 29 m BGS
Well seal interval (shallow): 1.5 m to 5.3 m BGS
Well seal interval (deep): 0.9 m to 22.6 m BGS

Drawn By/Checked By: OR/JDC

Notes:
mAMSL - metres above mean sea level
mBGS - metres below ground surface
n/v - no value
CC - Continous Core Sample

Stantec

Stantec Consulting Ltd.
49 Frederick Street
Kitchener, ON
N2H 6M7

# Borehole No.: BM1-02(D & S)

**Project:** RMOW GUDI Study
**Project No:** 609-00116
**Location:** Branchton Meadows Well Field along Hughson Street
**Contractor:** All-Terrain Drilling Limited
**Drilling Method:** PQ Coring

**Date:** 28 June 2002
**Supervisor:** J.D.Campbell
**Ground Surface:** 274.84 m AMSL
**Top of Casing:** 275.69 m AMSL

| SUBSURFACE PROFILE | | | | SAMPLE DETAILS | | | | WELL DETAILS |
|---|---|---|---|---|---|---|---|---|
| Depth | Lithologic Symbol | Lithologic Description | Elevation/Depth (m BGS) | Number | Type | Recovery | N-Value | Well |
| 19 | | grey, soft to firm, some to trace clay, moist | | 8 | CC | 60 % | | Bentonite Grout; Top of Screen (5.8 m BGS) |
| 21 | | dark grey | | | | | | |
| | | very well laminated | 268.13 | | | | | |
| 23 | 7 | SAND<br>very fine, some silt, trace clay, brown<br>faintly laminated, moist | 6.71 | 9 | CC | 25 % | | No.10 Slot PVC Screen 50 mm diameter |
| 25 | | | | | | | | |
| 27 | | trace clay, trace gravel, moist to wet, firm | | 10 | CC | 100 % | | No.1 Silica Sand |
| 29 | 9 | dolostone boulders | | | | | | Native Cave |
| 31 | | clayey lessening with depth, trace gravel/cobbles, moist to slight moist, firm to soft | | | | | | Bottom of well (9.1 m BGS) |
| 33 | | | | | | | | |
| 35 | | | | 11 | CC | 92 % | | Bentonite Grout |
| | 11 | | | | | | | |
| 37 | | | | | | | | |

Screen interval (shallow): 5.8 m to 8.8 m BGS
Screen interval (deep): 22.9 m to 29 m BGS
Sand pack interval (shallow): 5.3 m to 8.8 m BGS
Sand pack interval (deep): 22.6 m to 29 m BGS
Well seal interval (shallow): 1.5 m to 5.3 m BGS
Well seal interval (deep): 0.9 m to 22.6 m BGS

Drawn By/Checked By: OR/JDC

Notes:
mAMSL - metres above mean sea level
mBGS - metres below ground surface
n/v - no value
CC - Continous Core Sample

Stantec

Stantec Consulting Ltd.
49 Frederick Street
Kitchener, ON
N2H 6M7

# Borehole No.: BM1-02(D & S)

**Project:** RMOW GUDI Study
**Project No:** 609-00116
**Location:** Branchton Meadows Well Field along Hughson Street
**Contractor:** All-Terrain Drilling Limited
**Drilling Method:** PQ Coring

**Date:** 28 June 2002
**Supervisor:** J.D.Campbell
**Ground Surface:** 274.84 m AMSL
**Top of Casing:** 275.69 m AMSL

| SUBSURFACE PROFILE | | | | SAMPLE DETAILS | | | | WELL DETAILS |
|---|---|---|---|---|---|---|---|---|
| Depth | Lithologic Symbol | Lithologic Description | Elevation/Depth (m BGS) | Number | Type | Recovery | N-Value | Well |
| 39 | | silt and clay, light brown | | 12 | CC | 92 % | | |
| 41 | | silty clay to clayey silt grading to silty very fine sand | | | | | | |
| 43 (13) | | | | 13 | CC | 100 % | | |
| 45 | | | | | | | | |
| 47 | | | | | | | | |
| 49 (15) | | | | 14 | CC | 100 % | | |
| 51 | | occasional gravel | | | | | | |
| 53 | | | | 15 | CC | 100 % | | |
| 55 (17) | | | | | | | | |
| 57 | | | | | | | | |

Screen interval (shallow): 5.8 m to 8.8 m BGS
Screen interval (deep): 22.9 m to 29 m BGS
Sand pack interval (shallow): 5.3 m to 8.8 m BGS
Sand pack interval (deep): 22.6 m to 29 m BGS
Well seal interval (shallow): 1.5 m to 5.3 m BGS
Well seal interval (deep): 0.9 m to 22.6 m BGS

Drawn By/Checked By: OR/JDC

Notes:
mAMSL - metres above mean sea level
mBGS - metres below ground surface
n/v - no value
CC - Continous Core Sample

Stantec

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49 Frederick Street
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N2H 6M7

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**Top of Casing:** 275.69 m AMSL

| SUBSURFACE PROFILE | | | | SAMPLE DETAILS | | | | WELL DETAILS |
|---|---|---|---|---|---|---|---|---|
| Depth | Lithologic Symbol | Lithologic Description | Elevation/Depth (m BGS) | Number | Type | Recovery | N-Value | Well |
| | | | | 16 | CC | 66 % | | |
| | | | | 17 | CC | 33 % | | |
| 59 | | occasional clay layer | | | | | | |
| | | | | 18 | CC | 89 % | | |
| 61 | | | | | | | | |
| | 19 | | | | | | | |
| 63 | | well sorted | | | | | | |
| | | | | 19 | CC | 97 % | | |
| 65 | | | | | | | | |
| 67 | | | | | | | | Bentonite Grout |
| | | | | 20 | CC | 100 % | | |
| | | some gravel, well laminated | | | | | | |
| 69 | 21 | | | | | | | |
| | | | | 21 | CC | 100 % | | |
| 71 | | | | | | | | |
| | | DOLOSTONE<br>highly fractured, some sand and silt infilling, grey, wet | 252.89<br>21.95 | | | | | Holeplug |
| 73 | | | | 22 | CC | 66 % | | |
| | | Competent bedrock was not encountered | | | | | | |
| 75 | | | | | | | | Top of Screen |
| | 23 | | | 23 | CC | 20 % | | (22.9 m BGS) |
| 77 | | | | | | | | |

Screen interval (shallow): 5.8 m to 8.8 m BGS
Screen interval (deep): 22.9 m to 29 m BGS
Sand pack interval (shallow): 5.3 m to 8.8 m BGS
Sand pack interval (deep): 22.6 m to 29 m BGS
Well seal interval (shallow): 1.5 m to 5.3 m BGS
Well seal interval (deep): 0.9 m to 22.6 m BGS

Drawn By/Checked By: OR/JDC

Notes:
mAMSL - metres above mean sea level
mBGS - metres below ground surface
n/v - no value
CC - Continous Core Sample

Stantec

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49 Frederick Street
Kitchener, ON
N2H 6M7

# Borehole No.: BM1-02(D & S)

**Project:** RMOW GUDI Study
**Project No:** 609-00116
**Location:** Branchton Meadows Well Field along Hughson Street
**Contractor:** All-Terrain Drilling Limited
**Drilling Method:** PQ Coring

**Date:** 28 June 2002
**Supervisor:** J.D.Campbell
**Ground Surface:** 274.84 m AMSL
**Top of Casing:** 275.69 m AMSL

| SUBSURFACE PROFILE | | | | SAMPLE DETAILS | | | | WELL DETAILS |
|---|---|---|---|---|---|---|---|---|
| Depth | Lithologic Symbol | Lithologic Description | Elevation/Depth (m BGS) | Number | Type | Recovery | N-Value | Well |
| 79 | | | | 24 | CC | 60 % | | No.1 Silica Sand |
| 81 | | | | | | | | |
| 25 | | | | | | | | |
| 83 | | | | 25 | CC | 37 % | | No.10 Slot PVC Screen<br>50 mm diameter |
| 85 | | | | | | | | Sand Pack |
| 87 | | | | | | | | |
| 27 | | | | | | | | |
| 89 | | Dark grey dolomitic carbonate, possibly bedrock, although still highly fractured with silt and sand infilling | 247.71<br>27.13 | 26 | CC | 40 % | | |
| 91 | | | | | | | | |
| 93 | | | | 27 | CC | 66 % | | |
| 95 | | | 245.88<br>28.96 | 28 | CC | 100 % | | |
| 29 | | End of Borehole | | | | | | Bottom of well<br>(29 m BGS) |
| 97 | | | | | | | | |

Screen interval (shallow): 5.8 m to 8.8 m BGS
Screen interval (deep): 22.9 m to 29 m BGS
Sand pack interval (shallow): 5.3 m to 8.8 m BGS
Sand pack interval (deep): 22.6 m to 29 m BGS
Well seal interval (shallow): 1.5 m to 5.3 m BGS
Well seal interval (deep): 0.9 m to 22.6 m BGS

Drawn By/Checked By: OR/JDC

Notes:
mAMSL - metres above mean sea level
mBGS - metres below ground surface
n/v - no value
CC - Continous Core Sample

Stantec

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Kitchener, ON
N2H 6M7

# Monitoring Well: ND-BM-OW1-14

**Project:** Branchton Meadows Salt Assessment
**Client:** Region of Waterloo
**Location:** Region of Waterloo; Branchton Meadows Well Field
**Number:** 160900765

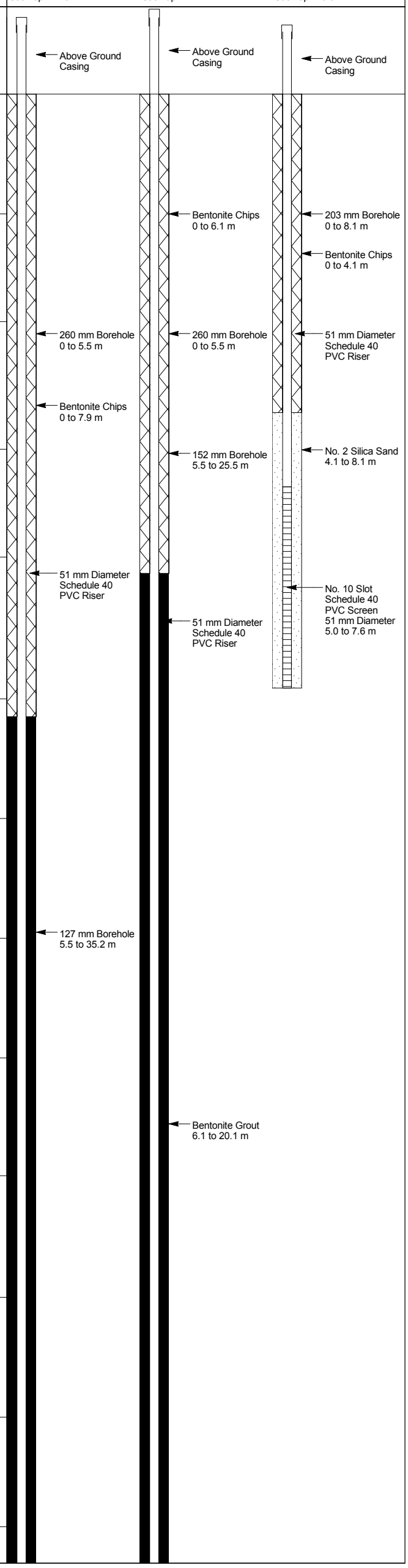
**Field investigator:** A. Ducharme/ N.Spina
**Contractor:** Aardvark Drilling Inc.
**Drilling method:** Track Mount CME75, HSA / PQ / HQ
**Date started/completed:** 04-Apr-2014 / 16-Apr-2014

| Depth (ft) | Depth (m) | Graphic Log | Lithologic Description | Elevation (m AMSL) Depth (m BGS) | Hydro Stratigraphic Unit | Description |
|---|---|---|---|---|---|---|
| | | | | 273.33 | | |
| | | | Ground Surface | 272.32 | | |
| 0 | 0 | | TOPSOIL, CLAYEY SILT<br>soft to firm, medium brown, some organics, trace fine grained sand, trace fine grained gravel, moist, no odour | 0.00<br>272.02 | | |
| | | | SANDY GRAVELLY CLAYEY SILT<br>loose, medium brown, poorly sorted, fine to coarse sand, subangular to subrounded gravel, trace to some cobbles | 0.30<br>270.80 | | |
| 5 | | | SILTY SAND and GRAVEL<br>very loose, greyish brown, coarse sand, some fine to medium grained sand, some subangluar to subrounded gravel, some cobbles, wet | 1.52<br>269.43 | | |
| 10 | | | SAND<br>loose, medium brown, medium to coarse grained sand, some fine grained sand, trace silt, wet | 2.90<br>268.97 | | |
| | | | SANDY SILT to CLAYEY SILT<br>soft to firm, greyish brown, trace gravel, trace to little sand, wet | 3.35 | | |
| 15 | | | | | | |
| 20 | | | | | | |
| 25 | | | | | ATA2 | Wentworth Till |
| 30 | | | | | | |
| 35 | | | | | | |
| 40 | | | | | | |
| 45 | | | | | | |
| 50 | | | | 257.01 | | |
| | | | SILTY SAND<br>loose to dense, greyish brown, fine to medium grained sand, trace gravel, wet | 15.32 | | |
| 55 | | | | | ATB1 | Outwash Deposits |
| | | | | 254.09 | | |
| 60 | | | SAND and GRAVEL to SAND<br>compact to dense, grey, well graded sand and gravel with cobbles | 18.24 | | |

| Sample Number | Sample Type | Recovery | SCR | RQD | Fractures per 1.52m |
|---|---|---|---|---|---|
| 1 | CC | 19" 32% | n/a | n/a | n/a |
| 2 | CC | 16" 30% | n/a | n/a | n/a |
| 3 | CC | 21" 33% | n/a | n/a | n/a |
| 4 | CC | 52" 96% | n/a | n/a | n/a |
| 5 | CC | 57" 80% | n/a | n/a | n/a |
| 6 | CC | 55" 92% | n/a | n/a | n/a |
| 7 | CC | 52" 87% | n/a | n/a | n/a |
| 8 | CC | 59" 98% | n/a | n/a | n/a |
| 9 | CC | 54" 91% | n/a | n/a | n/a |
| 10 | CC | 59" 97% | n/a | n/a | n/a |
| 11 | CC | 60" 100% | n/a | n/a | n/a |
| 12 | CC | 40" 73% | n/a | n/a | n/a |

WELL DETAILS

| | ND-BM-OW1A-14 | ND-BM-OW1B-14 | ND-BM-OW1C-14 |
|---|---|---|---|
| Name: | ND-BM-OW1A-14 | ND-BM-OW1B-14 | ND-BM-OW1C-14 |
| Location: | 9207075 | 9207076 | 9207077 |
| GS Elev: | 272.32 m AMSL | 272.11 m AMSL | 272.45 m AMSL |
| TOC Elev: | 273.33 m AMSL | 273.22 m AMSL | 273.36 m AMSL |
| Easting: | 559624.8 | 559625.5 | 559624.3 |
| Northing: | 4795620.7 | 4795622.6 | 4795619.3 |
| Stick-up: | 1.01 m | 1.11 m | 0.91 m |




Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available

ND-BM-OW1A-14 WRAS No. 9207075
ND-BM-OW1B-14 WRAS No. 9207076
ND-BM-OW1C-14 WRAS No. 9207077

Stantec

Drawn By/Checked By: MD, JC/ LV



STANTEC BOREHOLE AND WELL - CLUST 11X17 160900765.GPJ STANTEC - DATA TEMPLATE.GDT 1/19/15 NSPINA

# Monitoring Well: ND-BM-OW1-14

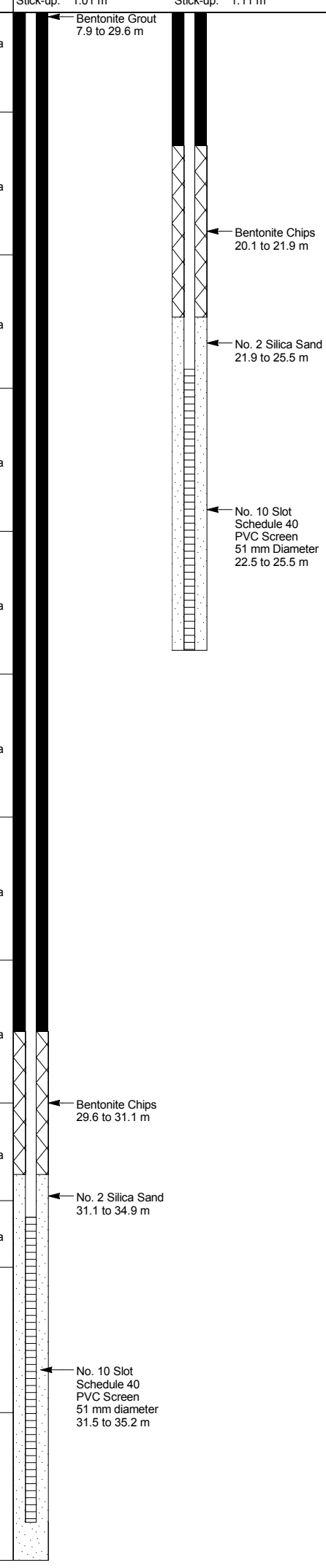
**Project:** Branchton Meadows Salt Assessment
**Client:** Region of Waterloo
**Location:** Region of Waterloo; Branchton Meadows Well Field
**Number:** 160900765

**Field investigator:** A. Ducharme/ N.Spina
**Contractor:** Aardvark Drilling Inc.
**Drilling method:** Track Mount CME75, HSA / PQ / HQ
**Date started/completed:** 04-Apr-2014 / 16-Apr-2014

| SUBSURFACE PROFILE | | | | HYDROGEOLOGY | | SAMPLE DETAILS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (ft) | Depth (m) | Graphic Log | Lithologic Description | Elevation (m AMSL) Depth (m BGS) | Hydro Stratigraphic Unit | Description | Sample Number | Sample Type | Recovery | SCR | RQD | Fractures per 1.52m |
| | | | SAND and GRAVEL to SAND<br>compact to dense, grey, well graded sand and gravel with cobbles | | | | 13 | CC | 58"<br>97% | n/a | n/a | n/a |
| 65 | 20 | | | | | | 14 | CC | 59"<br>98% | n/a | n/a | n/a |
| 70 | 22 | | | | | | 15 | CC | 55"<br>98% | n/a | n/a | n/a |
| 75 | 24 | | | | | | 16 | CC | 37"<br>62% | n/a | n/a | n/a |
| 80 | | | | | ATC1 | Catfish Creek Till | 17 | CC | 0"<br>0% | n/a | n/a | n/a |
| 85 | 26 | | | | | | 18 | CC | 24"<br>40% | n/a | n/a | n/a |
| 90 | 28 | | | | | | 19 | CC | 30"<br>50% | n/a | n/a | n/a |
| 95 | | | | | | | 20 | CC | 48"<br>80% | n/a | n/a | n/a |
| 100 | 30 | | | 241.23 | | | 21 | CC | n/a | n/a | n/a | n/a |
| 105 | 32 | | DOLOSTONE<br>dark blue grey dolostone (reef mound), fine crystalline, occasionally vuggy with secondary crystallization | 31.09 | | | 22 | RC | n/a | n/a | n/a | n/a |
| 110 | | | | | Bedrock | Guelph Formation | 23 | RC | 60"<br>98% | 57"<br>94% | 58"<br>95% | 4 |
| 115 | 34 | | | 237.12 | | | 24 | RC | 62"<br>100% | 59.5"<br>96% | 60"<br>97% | 3 |
| | | | End of Borehole | 35.20 | | | | | | | | |
| 120 | 36 | | | | | | | | | | | |
| 125 | 38 | | | | | | | | | | | |

**WELL DETAILS**

| Name: | ND-BM-OW1A-14 | Name: | ND-BM-OW1B-14 | Name: | ND-BM-OW1C-14 |
|---|---|---|---|---|---|
| Location: | 9207075 | Location: | 9207076 | Location: | 9207077 |
| GS Elev: | 272.32 m AMSL | GS Elev: | 272.11 m AMSL | GS Elev: | 272.45 m AMSL |
| TOC Elev: | 273.33 m AMSL | TOC Elev: | 273.22 m AMSL | TOC Elev: | 273.36 m AMSL |
| Easting: | 559624.8 | Easting: | 559625.5 | Easting: | 559624.3 |
| Northing: | 4795620.7 | Northing: | 4795622.6 | Northing: | 4795619.3 |
| Stick-up: | 1.01 m | Stick-up: | 1.11 m | Stick-up: | 0.91 m |




Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available

ND-BM-OW1A-14 WRAS No. 9207075
ND-BM-OW1B-14 WRAS No. 9207076
ND-BM-OW1C-14 WRAS No. 9207077

Stantec

Drawn By/Checked By: MD, JC/ LV



STANTEC BOREHOLE AND WELL - CLUST 11X17 160900765.GPJ STANTEC - DATA TEMPLATE.GDT 1/19/15 NSPINA

# Monitoring Well: ND-BM-OW2-14

**Project:** Branchton Meadows Salt Assessment
**Client:** Region of Waterloo
**Location:** Region of Waterloo; Branchton Meadows Well Field
**Number:** 160900765

**Field investigator:** N. Spina
**Contractor:** Aardvark Drilling Inc.
**Drilling method:** Track Mount, HSA / PQ
**Date started/completed:** 10-Apr-2014 / 15-Apr-2014

## SUBSURFACE PROFILE

| Lithologic Description | Elevation (m AMSL) Depth (m BGS) |
|---|---|
| | 279.02 |
| Ground Surface | 278.10 |
| TOPSOIL, SANDY CLAYEY SILT<br>very loose, dark brown, fine grained sand, trace coarse sand, trace fine gravel, trace organics, moist, no odour | 0.00<br>277.80 |
| SAND<br>loose to compact, brown, trace to some silt, moist<br>0.23 m seam of sandy clayey silt at 2.82 m BGS<br>silty sand from 4.57 to 5.15 m BGS | 0.30<br>273.13 |
| CLAYEY SILT<br>stiff to very stiff, brown, trace gravel, moist<br>wet at 5.72 m BGS | 4.98<br>270.38 |
| SILT to SILTY SAND<br>stiff to very stiff, laminations of greyish brown clay, trace gravel, wet | 7.72<br>269.49 |
| SAND<br>very loose, brown, trace to some gravel, trace to little silt, wet | 8.61<br>261.19 |
| SANDY CLAYEY SILT<br>loose to compact, grey, fine grained sand, wet, no odour | 16.92<br>260.88 |
| SILTY SAND<br>loose, grey, trace gravel, trave cobbles, wet | 17.22 |

## HYDROGEOLOGY

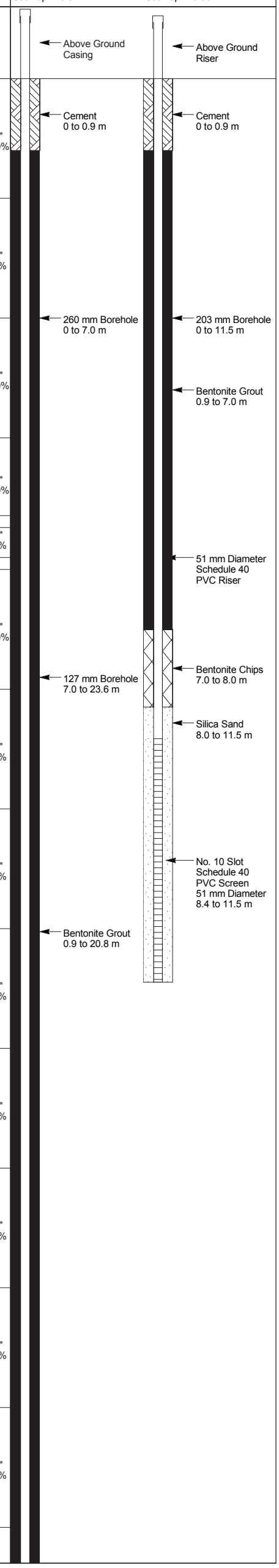
| Hydro Stratigraphic Unit | Description |
|---|---|
| ATB1 | Wentworth Till |
| AFA2 | Outwash Deposits |

## SAMPLE DETAILS

| Sample Number | Sample Type | Recovery |
|---|---|---|
| 1 | CC | 60" 100% |
| 2 | CC | 59" 98% |
| 3 | CC | 60" 100% |
| 4 | CC | 45" 100% |
| 5 | CC | 19" 90% |
| 6 | CC | 60" 100% |
| 7 | CC | 34" 57% |
| 8 | CC | 42" 70% |
| 9 | CC | 59" 98% |
| 10 | CC | 50" 83% |
| 11 | CC | 52" 87% |
| 12 | CC | 24" 40% |
| 13 | CC | 59" 98% |

## WELL DETAILS

| | ND-BM-OW2A-14 | ND-BM-OW2B-14 |
|---|---|---|
| Location: | 9207078 | 9207079 |
| GS Elev: | 278.10 m AMSL | 277.91 m AMSL |
| TOC Elev: | 279.01 m AMSL | 278.74 m AMSL |
| Easting: | 559613.4 | 559615.2 |
| Northing: | 4795369.8 | 4795370.8 |
| Stick-up: | 0.91 m | 0.83 m |




Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available

ND-BM-OW2A-14 WRAS No. 9207078
ND-BM-OW2B-14 WRAS No. 9207079

Stantec

Drawn By/Checked By: MD, JC/ LV



STANTEC BOREHOLE AND WELL - CLUST 11X17 160900765.GPJ STANTEC - DATA TEMPLATE.GDT 1/22/15 NSPINA

# Monitoring Well: ND-BM-OW2-14

**Project:** Branchton Meadows Salt Assessment
**Client:** Region of Waterloo
**Location:** Region of Waterloo; Branchton Meadows Well Field
**Number:** 160900765

**Field investigator:** N. Spina
**Contractor:** Aardvark Drilling Inc.
**Drilling method:** Track Mount, HSA / PQ
**Date started/completed:** 10-Apr-2014 / 15-Apr-2014

| SUBSURFACE PROFILE | | | | HYDROGEOLOGY | | SAMPLE DETAILS | | | WELL DETAILS |
|---|---|---|---|---|---|---|---|---|---|
| Depth (ft) | Depth (m) | Graphic Log | Lithologic Description | Elevation (m AMSL) Depth (m BGS) | Hydro Stratigraphic Unit | Description | Sample Number | Sample Type | Recovery | Name: ND-BM-OW2A-14<br>Location: 9207078<br>GS Elev: 278.10 m AMSL<br>TOC Elev: 279.01 m AMSL<br>Easting: 559613.4<br>Northing: 4795369.8<br>Stick-up: 0.91 m<br><br>Name: ND-BM-OW2B-14<br>Location: 9207079<br>GS Elev: 277.91 m AMSL<br>TOC Elev: 278.74 m AMSL<br>Easting: 559615.2<br>Northing: 4795370.8<br>Stick-up: 0.83 m |
| 65 | 20 | | SILTY SAND<br>loose, grey, trace gravel, trave cobbles, wet | 257.55 | | | 14 | CC | 59"<br>100% | |
| 70 | 22 | | SAND and GRAVEL<br>compact, grey, well graded, with cobbles | 20.55<br>254.48 | - | - | 15<br>16<br>17 | CC<br>CC<br>CC | 36"<br>60%<br>50"<br>83%<br>20"<br>83% | Bentonite Chips<br>20.8 to 21.4 m<br>Silica Sand<br>21.4 to 23.5 m<br>No. 10 Slot<br>Schedule 40<br>PVC Screen<br>51 mm Diameter<br>22.0 to 23.5 m<br>Natural Cave<br>23.5 to 23.6 m |
| 75 | | | End of Borehole | 23.62 | | | | | | |
| 80 | 24 | | | | | | | | | |
| 85 | 26 | | | | | | | | | |
| 90 | 28 | | | | | | | | | |
| 95 | 30 | | | | | | | | | |
| 100 | | | | | | | | | | |
| 105 | 32 | | | | | | | | | |
| 110 | 34 | | | | | | | | | |
| 115 | 36 | | | | | | | | | |
| 120 | | | | | | | | | | |
| 125 | 38 | | | | | | | | | |

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available

ND-BM-OW2A-14 WRAS No. 9207078
ND-BM-OW2B-14 WRAS No. 9207079

Stantec

Drawn By/Checked By: MD, JC/ LV



STANTEC BOREHOLE AND WELL - CLUST 11X17 160900765.GPJ STANTEC - DATA TEMPLATE.GDT 1/22/15 NSPINA

# Monitoring Well: ND-BM-OW3-14

**Project:** Branchton Meadows Salt Assessment
**Client:** Region of Waterloo
**Location:** Region of Waterloo; Branchton Meadows Well Field
**Number:** 160900765

**Field investigator:** n/a
**Contractor:** Aardvark Drilling Inc.
**Drilling method:** Track Mount CME75, HSA / PQ / HQ
**Date started/completed:** 22-Apr-2014

| SUBSURFACE PROFILE | | | | HYDROGEOLOGY | | WELL DETAILS |
|---|---|---|---|---|---|---|
| Depth (ft) (m) | Graphic Log | Lithologic Description | Elevation (m AMSL) Depth (m BGS) | Hydro Stratigraphic Unit | Description | Name: ND-BM-OW3-14<br>Location: 9207080<br>GS Elev: 274.91 m AMSL<br>TOC Elev: 275.77 m AMSL<br>Easting: 559655.8<br>Northing: 4795428.8<br>Stick-up: 0.86 m |
| | | | 276.13 | | | Above Ground Casing |
| 0 (0) | | Ground Surface | 274.91 | | | |
| | | SANDY SILT<br>soft, reddish-brown, trace clay, trace gravel, slightly moist to moist | 0.00 | | | Cement 0 to 0.9 m |
| | | | 274.00 | | | |
| | | STONY SILT<br>loose, reddish-brown, well graded, moist to wet | 0.91 | | | |
| 5 (2) | | | | | | |
| 10 | | | | ATA2 | Wentworth Till | 254 mm Borehole 0 to 7.3 m |
| (4) | | | | | | |
| 15 | | | | | | |
| 20 (6) | | | 268.20 | | | |
| | | SAND<br>brown, very fine, some silt, trace clay, faintly laminated, moist | 6.71 | | | |
| 25 (8) | | | | | | |
| 30 | | | | | | |
| (10) | | | | | | |
| 35 | | | | | | |
| 40 (12) | | | | | | |
| 45 (14) | | | | AFA2 | Outwash Deposits | |
| 50 | | | | | | |
| (16) | | | | | | Bentonite Grout 0.9 to 32.3 m |
| 55 | | | | | | |
| (18) | | | | | | 152 mm Borehole 7.3 to 34.4 m |
| 60 | | | | | | |

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
n/a - not available

WRAS No. 9207080
Overburden details obtained from adjacent well BM1DS-02
(WRAS No. 9201544)

Screen Interval: 33.76 - 37.11 m BGS
Sand Pack Interval: 33.53 - 37.11 m BGS
Well Seal Interval: 0.30 - 33.53 m BGS

Stantec

Drawn By/Checked By: MD, JC/ LV



STANTEC BOREHOLE AND WELL - CL.LIST 11X17 160900765.GPJ STANTEC - DATA TEMPLATE.GDT 1/19/15 NSPNA

# Monitoring Well: ND-BM-OW3-14

**Project:** Branchton Meadows Salt Assessment
**Client:** Region of Waterloo
**Location:** Region of Waterloo; Branchton Meadows Well Field
**Number:** 160900765

**Field investigator:** n/a
**Contractor:** Aardvark Drilling Inc.
**Drilling method:** Track Mount CME75, HSA / PQ / HQ
**Date started/completed:** 22-Apr-2014

| SUBSURFACE PROFILE | | | | HYDROGEOLOGY | |
|---|---|---|---|---|---|
| Depth (ft) | Depth (m) | Graphic Log | Lithologic Description | Elevation (m AMSL) Depth (m BGS) | Hydro Stratigraphic Unit | Description |
| | | | SAND<br>brown, very fine, some silt, trace clay, faintly laminated, moist | 252.96 | | |
| | | | SAND and GRAVEL and COBBLES<br>very dense, some silt | 21.95 | ATC1 | Catfish Creek Till |
| | | | DOLOSTONE<br>grey dolostone, highly fractured, some sand & silt infilling, wet | 240.47<br>34.44 | Bedrock | Guelph Formation |
| | | | End of Borehole | 237.80<br>37.11 | | |

Depth (ft): 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125
Depth (m): 20, 22, 24, 26, 28, 30, 32, 34, 36, 38

**WELL DETILS**

Name: ND-BM-OW3-14
Location: 9207080
GS Elev: 274.91 m AMSL
TOC Elev: 275.77 m AMSL
Easting: 559655.8
Northing: 4795428.8
Stick-up: 0.86 m

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
n/a - not available

WRAS No. 9207080
Overburden details obtained from adjacent monitoring well BM1DS-02 (WRAS No. 9201544)

Screen Interval: 33.76 - 37.11 m BGS
Sand Pack Interval: 33.53 - 37.11 m BGS
Well Seal Interval: 0.30 - 33.53 m BGS

Stantec

Drawn By/Checked By: MD, JC/ LV



STANTEC BOREHOLE AND WELL - CL.LIST 11X17 160900765.GPJ STANTEC - DATA TEMPLATE.GDT 1/19/15 NSPNA

# Borehole: ND-BM-BH1-14

| | | | |
|---|---|---|---|
| **Project:** | Branchton Meadows Salt Assessment | **Drilling method:** | Track Mount Geoprobe 7822DT / 50.8 mm |
| **Client:** | Region of Waterloo | **Date started/completed:** | 24-Apr-2014 |
| **Location:** | Region of Waterloo | **Ground surface elevation:** | n/a |
| **Number:** | 160900765 | **Top of casing elevation:** | n/a |
| **Field investigator:** | N. Spina | **Easting:** | 559624 |
| **Contractor:** | Aardvark Drilling Inc. | **Northing:** | 4795619 |

| SUBSURFACE PROFILE | | | | SAMPLE DETAILS | | | INSTALLATION DETAILS | |
|---|---|---|---|---|---|---|---|---|
| Depth (ft) (m) | Graphic Log | Lithologic Description | Depth (m BGS) | Sample Number | Sample Type | Recovery | Diagram | Description |
| | | Ground Surface | | | | | | |
| | | TOPSOIL (SILTY SAND)<br>loose, brown, fine grained sand, some coarse grained sane, trace fine grained gravel, trace organics, wet, organic odour | 0.00 | | | | | |
| | | SAND<br>loose, brown and grey, fine to coarse grained sand, some fine to coarse grained gravel, some silt, moist, no odour | 0.25 | 1 | DP | 24"<br>50% | | 51 mm diameter borehole |
| | | SILTY SAND<br>compact, brown, fine grained sand, trace coarse grained sand, wet, no odour | 1.22 | 2 | DP | 38"<br>79% | | Bentonite Chips 0 to 2.4 m |
| | | End of Borehole | 2.44 | | | | | |

Depth scale: 2, 4, 6, 8, 10, 12, 14 (ft); 1, 2, 3, 4 (m)

Screen Interval: n/a
Sand Pack Interval: n/a
Well Seal Interval: n/a

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
DP - direct push sample
n/a - not available

WRAS No. 9207093

Stantec

Drawn By/Checked By: NS/ LV



STANTEC BOREHOLE AND WELL V2 160900765.GPJ STANTEC - DATA TEMPLATE.GDT 2/17/15 NSPINA

# Borehole: ND-BM-BH2-14

| | | | |
|---|---|---|---|
| **Project:** | Branchton Meadows Salt Assessment | **Drilling method:** | Track Mount Geoprobe 7822DT / 50.8 mm |
| **Client:** | Region of Waterloo | **Date started/completed:** | 24-Apr-2014 |
| **Location:** | Region of Waterloo | **Ground surface elevation:** | n/a |
| **Number:** | 160900765 | **Top of casing elevation:** | n/a |
| **Field investigator:** | N. Spina | **Easting:** | 559615 |
| **Contractor:** | Aardvark Drilling Inc. | **Northing:** | 4795371 |

| SUBSURFACE PROFILE | | | | SAMPLE DETAILS | | | INSTALLATION DETAILS | |
|---|---|---|---|---|---|---|---|---|
| Depth (ft) | Depth (m) | Graphic Log | Lithologic Description | Depth (m BGS) | Sample Number | Sample Type | Recovery | Diagram | Description |
| | | | Ground Surface | | | | | | |
| | | | TOPSOIL (SANDY CLAYEY SILT)<br>loose, brown, fine grained sand, trace to little coarse grained sand, trace fine grained gravel, trace organics, no odour | 0.00 | | | | | |
| | | | SAND<br>loose to compact, brown, fine grained sand, some silt, trace coarse grained sand, trace fine grained gravel, moist, no odour<br><br>becoming silty from 0.5 m to 0.8 m BGS | 0.27 | 1 | DP | 42.8"<br>89% | | 51 mm diameter borehole |
| 2 | 1 | | | | | | | | |
| 4 | | | SILTY SAND<br>loose to compact, brown, fine grained sand, moist, no odour | 1.22 | 2 | DP | 42"<br>88% | | Bentonite Chips 0 to 3.7 m |
| 6 | 2 | | | | | | | | |
| | | | SAND<br>loose to compact, brown, fine grained sand, trace coarse graned sand, some silt, moist, no odour | 2.02 | | | | | |
| 8 | | | | | | | | | |
| 10 | 3 | | SANDY SILT<br>compact, brown, fine grained sand, trace coarse grained sand, trace fine grained gravel, moist, no odour | 2.98 | 3 | DP | 40"<br>83% | | |
| 12 | | | End of Borehole | 3.66 | | | | | |
| | 4 | | | | | | | | |
| 14 | | | | | | | | | |

Screen Interval: n/a
Sand Pack Interval: n/a
Well Seal Interval: n/a

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
DP - direct push sample
n/a - not available

WRAS No. 9207094

Stantec

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Sheet 1 of 1

STANTEC BOREHOLE AND WELL V2 160900765.GPJ STANTEC - DATA TEMPLATE.GDT 2/17/15 NSPINA

# Borehole: ND-BM-BH3-14

| | | | |
|---|---|---|---|
| **Project:** | Branchton Meadows Salt Assessment | **Drilling method:** | Track Mount Geoprobe 7822DT / 50.8 mm |
| **Client:** | Region of Waterloo | **Date started/completed:** | 24-Apr-2014 |
| **Location:** | Region of Waterloo | **Ground surface elevation:** | n/a |
| **Number:** | 160900765 | **Top of casing elevation:** | n/a |
| **Field investigator:** | N. Spina | **Easting:** | 559656 |
| **Contractor:** | Aardvark Drilling Inc. | **Northing:** | 4795429 |

| SUBSURFACE PROFILE | | | | SAMPLE DETAILS | | | INSTALLATION DETAILS | |
|---|---|---|---|---|---|---|---|---|
| Depth (ft) | Depth (m) | Graphic Log | Lithologic Description | Depth (m BGS) | Sample Number | Sample Type | Recovery | Diagram | Description |
| | | | Ground Surface | | | | | | |
| | | | TOPSOIL (SANDY CLAYEY SILT)<br>loose, dark brown to brown, fine grained sand, trace organics, trace fine and coarse grained sand, trace fine grained gravel, moist, no odour | 0.00 | | | | | |
| 2 | 1 | | SAND and GRAVEL<br>loose to compact, brown, well graded sand, some silt, trace cobbles, moist, no odour | 0.50 | 1 | DP | 38"<br>79% | | 51 mm diameter borehole |
| 4 | | | | | | | | | |
| 6 | 2 | | | | 2 | DP | 33.5"<br>70% | | Bentonite Chips 0 to 3.7 m |
| 8 | | | | | | | | | |
| 10 | 3 | | | | 3 | DP | 35.5"<br>74% | | |
| 12 | | | End of Borehole | 3.66 | | | | | |
| 14 | 4 | | | | | | | | |

Screen Interval: n/a
Sand Pack Interval: n/a
Well Seal Interval: n/a

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
DP - direct push sample
n/a - not available

WRAS No. 9207095

Stantec

Drawn By/Checked By: NS/ LV

Sheet 1 of 1

STANTEC BOREHOLE AND WELL V2 160900765.GPJ STANTEC - DATA TEMPLATE.GDT 2/17/15 NSPINA

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# Appendix C

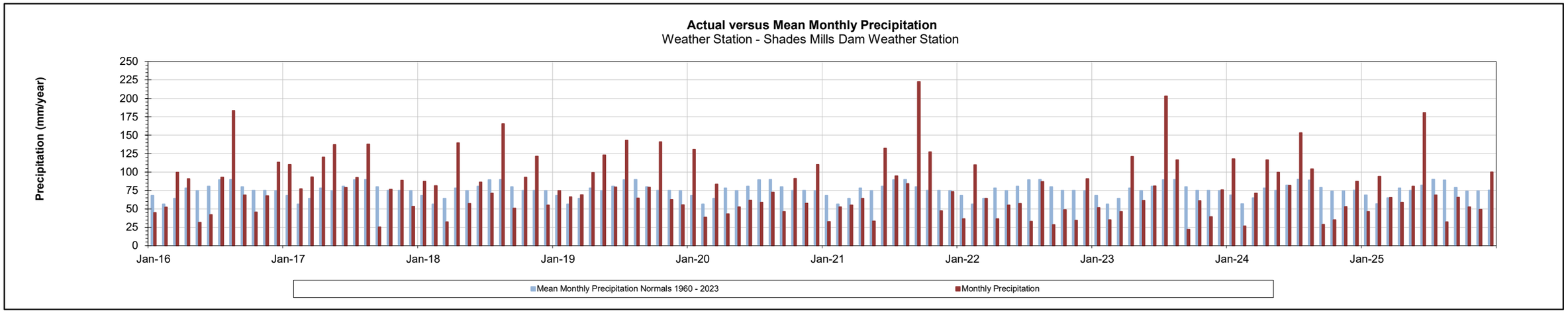
# Monitoring Data
# (Pumped Volumes and Hydrographs)

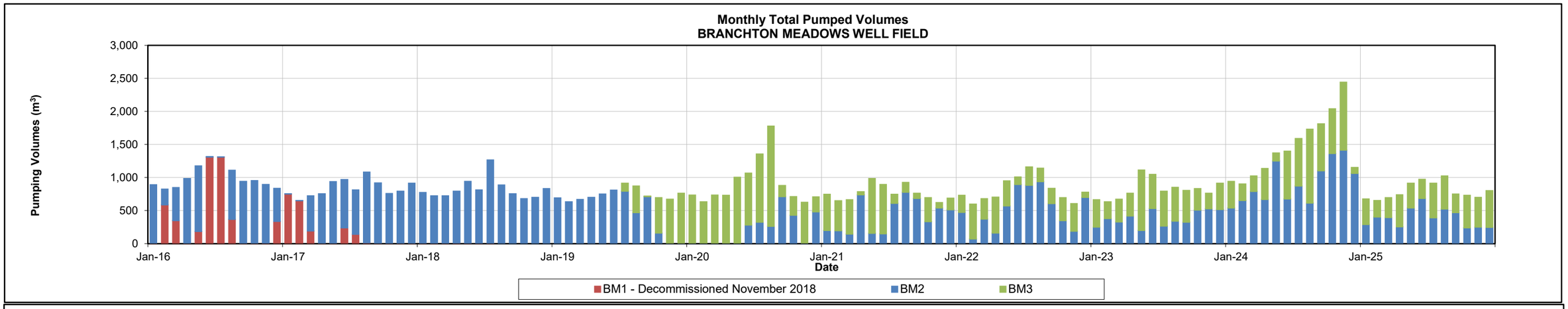
**TABLE C-1**
**WELL FIELD WATER PRODUCTION SUMMARY**
**REGION OF WATERLOO - 2025 GROUNDWATER MONITORING REPORT**

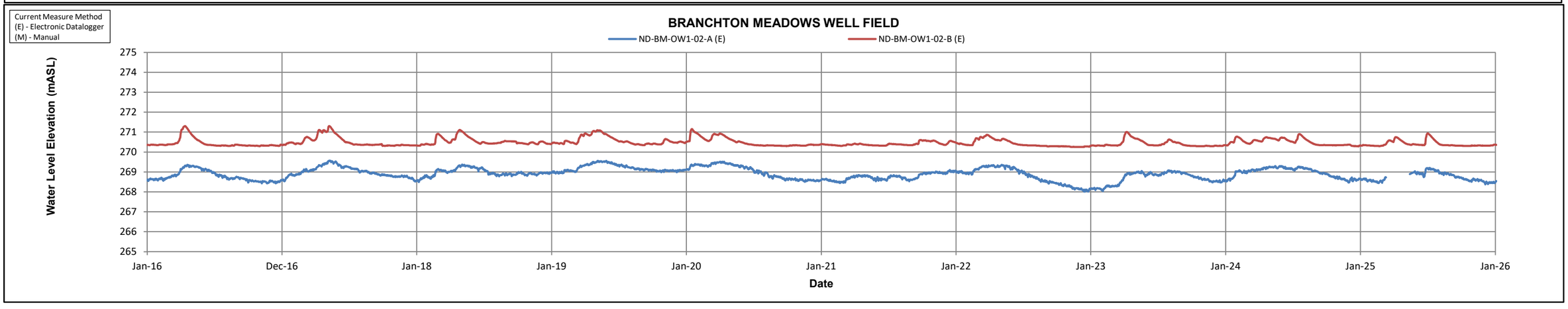
| Well Field | Major or Minor Supply | Production Well Name | Permit to Take Water Details | | | 2021 Production Summary | | | 2022 Production Summary | | | 2023 Production Summary | | | 2024 Production Summary | | | 2025 Production Summary | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | MOE Permit Number[1] | Permitted Capacity (total $m^3$/year)* | Permitted Rate (L/s)* | Total Production Well Volume (total $m^3$/year) | Average Daily Rate ($m^3$/day) | Average Rate (L/s) | Total Production Well Volume (total $m^3$/year) | Average Daily Rate ($m^3$/day) | Average Rate (L/s) | Total Production Well Volume (total $m^3$/year) | Average Daily Rate ($m^3$/day) | Average Rate (L/s) | Total Production Well Volume (total $m^3$/year) | Average Daily Rate ($m^3$/day) | Average Rate (L/s) | Total Production Well Volume (total $m^3$/year) | Average Daily Rate ($m^3$/day) | Average Rate (L/s) |
| Branchton Meadows | Minor | BM2 | Combined rate for PTTW 2481-DJKHVA<br>2481-DJKHVA | 47,450 | 1.5 | 5,048 | 14 | 0.2 | 6,212 | 17 | 0.2 | 4,600 | 13 | 0.1 | 11,019 | 30 | 0.3 | 4,697 | 13 | 0.1 |
| | | BM3 | 2481-DJKHVA | | | 4,128 | 11 | 0.1 | 3,679 | 10 | 0.1 | 5,261 | 14 | 0.2 | 6,536 | 18 | 0.2 | 4,883 | 13 | 0.2 |
| | | | ***Well Field Total*** | ***47,450*** | ***1.5*** | ***9,176*** | ***25*** | ***0.3*** | ***9,891*** | ***27*** | ***0.3*** | ***9,861*** | ***27*** | ***0.3*** | ***17,555*** | ***48*** | ***0.6*** | ***9,580*** | ***26*** | ***0.3*** |
| | | | *Maximum rate and amount shall not exceed 1.5 L/s and 47,450 $m^3$/yr, respectively for all wells | | | | | | | | | | | | | | | | | |

**Notes:**
**- = no applicable data**
**n/a = data not available**
*** = rates and volumes based on permitted L/day**
**[1] = Current Permit**

REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
BRANCHTON MEADOWS



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# Appendix D

# Precipitation Data

# Table D-1
## Precipitation Variation from Average
## Region of Waterloo - 2025 Groundwater Monitoring Report

| Year | Kitchener/Waterloo Weather Station Established 1966 | | |
|---|---|---|---|
| | Annual Precipitation (mm) | 30-yr NORMAL Precipitation 1981-2010 (mm) | Difference (mm) |
| **2016** | 748 | 851 | **-103** |
| **2017** | 818 | 851 | **-33** |
| **2018** | 749 | 851 | **-102** |
| **2019** | 695 | 851 | **-156** |
| **2020** | 689 | 851 | **-162** |
| **2021** | 772 | 851 | **-79** |
| **2022** | 438 | 851 | **-413** |
| **2023** | 813 | 851 | **-38** |
| **2024** | 874 | 851 | **23** |
| **2025** | 723 | 851 | **-128** |

| Year | University of Waterloo Station Established 1988 | | |
|---|---|---|---|
| | Annual Precipitation (mm) | Average Precipitation 1998-2024 (mm) | Difference (mm) |
| **2016** | 891 | 871 | **20** |
| **2017** | 989 | 871 | **118** |
| **2018** | 950 | 871 | **79** |
| **2019** | 923 | 871 | **52** |
| **2020** | 953 | 871 | **82** |
| **2021** | 1022 | 871 | **151** |
| **2022** | 578 | 871 | **-293** |
| **2023** | 959 | 871 | **88** |
| **2024** | 763 | 871 | **-108** |
| **2025** | 943 | 871 | **72** |

| Year | Shand Dam Established 1939 | | |
|---|---|---|---|
| | Annual Precipitation (mm) | Average Precipitation 1940-2025 (mm) | Difference (mm) |
| **2016** | 976 | 926 | **50** |
| **2017** | 1093 | 926 | **167** |
| **2018** | 849 | 926 | **-77** |
| **2019** | 1081 | 926 | **155** |
| **2020** | 1017 | 926 | **91** |
| **2021** | 876 | 926 | **-50** |
| **2022** | 798 | 926 | **-128** |
| **2023** | 1015 | 926 | **89** |
| **2024** | 994 | 926 | **68** |
| **2025** | 995 | 926 | **69** |

| Year | Conestogo Dam Established 1961 | | |
|---|---|---|---|
| | Annual Precipitation (mm) | Average Precipitation 1961-2025 (mm) | Difference (mm) |
| **2016** | 983 | 990 | **-7** |
| **2017** | 1210 | 990 | **220** |
| **2018** | 962 | 990 | **-28** |
| **2019** | 992 | 990 | **2** |
| **2020** | 1021 | 990 | **31** |
| **2021** | 975 | 990 | **-15** |
| **2022** | 907 | 990 | **-83** |
| **2023** | 1053 | 990 | **63** |
| **2024** | 972 | 990 | **-18** |
| **2025** | 1025 | 990 | **35** |

| Year | Woolwich Dam Established 1960 | | |
|---|---|---|---|
| | Annual Precipitation (mm) | Average Precipitation 1960-2025 (mm) | Difference (mm) |
| **2016** | 844 | 835 | **9** |
| **2017** | 986 | 835 | **151** |
| **2018** | 869 | 835 | **34** |
| **2019** | 824 | 835 | **-11** |
| **2020** | 862 | 835 | **27** |
| **2021** | 649 | 835 | **-186** |
| **2022** | 668 | 835 | **-167** |
| **2023** | 859 | 835 | **24** |
| **2024** | 793 | 835 | **-42** |
| **2025** | 732 | 835 | **-103** |

| Year | Shade's Mills Dam Established 1960 | | |
|---|---|---|---|
| | Annual Precipitation (mm) | Average Precipitation 1960-2025 (mm) | Difference (mm) |
| **2016** | 934 | 909 | **24** |
| **2017** | 1092 | 909 | **183** |
| **2018** | 1042 | 909 | **133** |
| **2019** | 1059 | 909 | **150** |
| **2020** | 848 | 909 | **-62** |
| **2021** | 1020 | 909 | **111** |
| **2022** | 682 | 909 | **-227** |
| **2023** | 982 | 909 | **73** |
| **2024** | 976 | 909 | **67** |
| **2025** | 895 | 909 | **-14** |

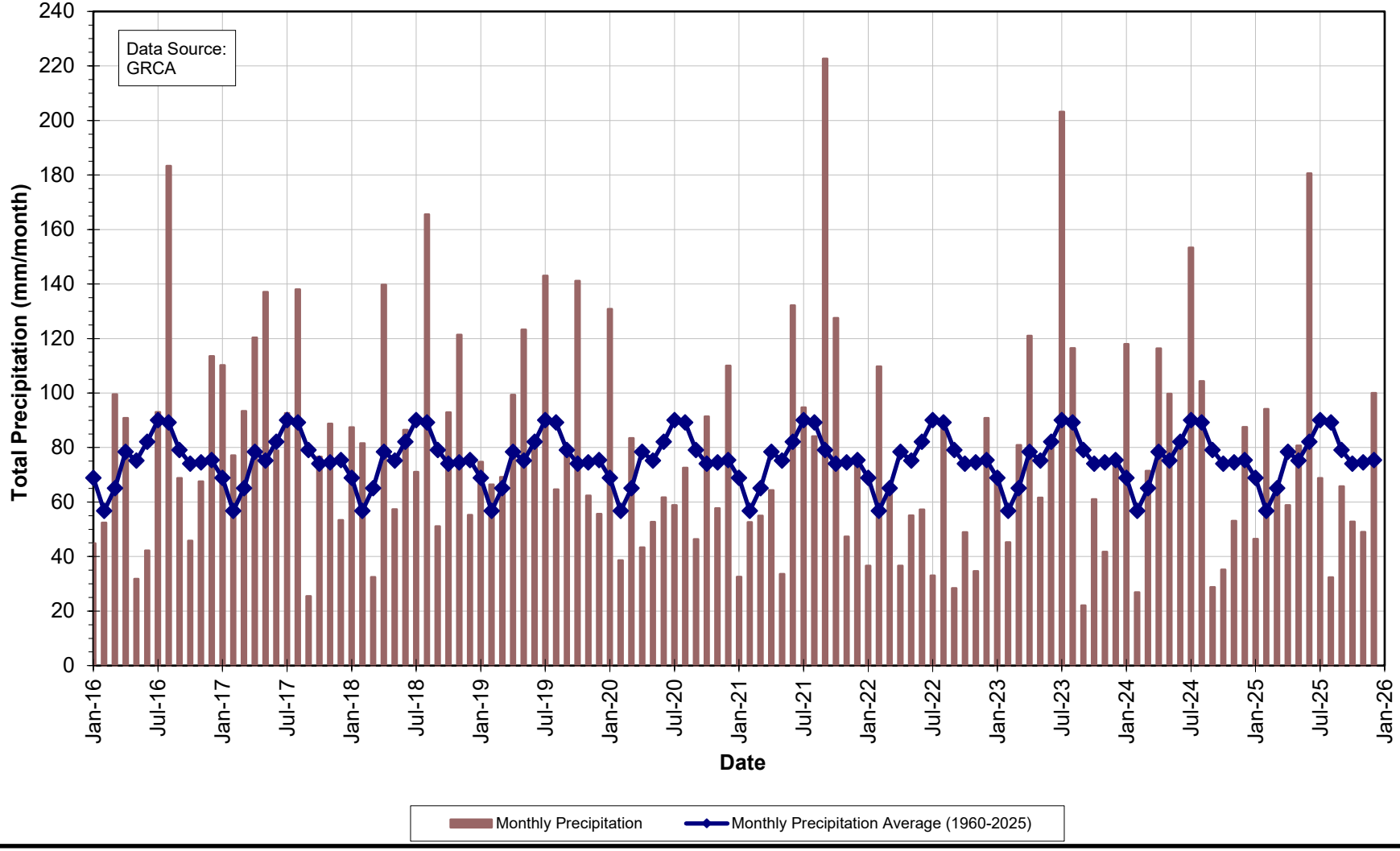
| Year | Laurel Dam Established 1960 | | |
|---|---|---|---|
| | Annual Precipitation (mm) | Average Precipitation 1960-2025 (mm) | Difference (mm) |
| **2016** | 985 | 938 | **47** |
| **2017** | 1062 | 938 | **124** |
| **2018** | 1071 | 938 | **133** |
| **2019** | 940 | 938 | **2** |
| **2020** | 938 | 938 | **0** |
| **2021** | 1027 | 938 | **89** |
| **2022** | 689 | 938 | **-249** |
| **2023** | 921 | 938 | **-17** |
| **2024** | 907 | 938 | **-31** |
| **2025** | 894 | 938 | **-44** |

| Year | Roseville Weather Station Established 1972 | | |
|---|---|---|---|
| | Annual Precipitation (mm) | 30-yr NORMAL Precipitation 1981-2010 (mm) | Difference (mm) |
| **2016** | 899 | 919 | **-20** |
| **2017** | 882 | 919 | **-37** |
| **2018** | 905 | 919 | **-14** |
| **2019** | 957 | 919 | **38** |
| **2020** | 817 | 919 | **-102** |
| **2021** | 832 | 919 | **-87** |
| **2022** | 637 | 919 | **-282** |
| **2023** | 945 | 919 | **26** |
| **2024** | 856 | 919 | **-63** |
| **2025** | 786 | 919 | **-133** |

**NOTES:**

WIA station data is not subject to review by the National Climate Archives, therefore, undergoes very limited quality checking.
GRCA Dam stations data is not reviewed extensively and undergoes limited quality checking.

**Figure D.1**
**Shade's Mills Dam**
***Monthly Precipitation***

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Prepared By: S.Q.
Printed On: 2/13/2026
File: Appendix D Precipitation Data/Monthly Shades Mills

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# Appendix E

# Monitoring Program Overview

# GROUNDWATER LEVEL MONITORING PROGRAM PROCEDURES

## E.1 Overview

The Region of Waterloo (Region) collects water level measurements at specific monitoring wells to ensure sustainable long-term water supply and to meet monitoring and reporting requirements for the Region's water-taking permits. The goal of the program is to manage and protect the Region's groundwater supply and to assess the potential impact of municipal pumping on the groundwater and surface water resources in the Region. The ongoing collection and assessment of groundwater level data is integral to assess any changes to the water resources that may occur due to pumping.

### E.1.1 Production Well Pumping and Water Levels

In 2023 the Region managed approximately 132 production wells with status defined as:

- Commissioned – Active wells
- New Not-Commissioned – Well are inactive or locked out until future demand or repairs/maintenance of other wells requires activating them

The well fields are referred to as Urban (Kitchener, Waterloo, and Cambridge) and Rural (North Dumfries, Woolwich, Wilmot, and Wellesley). Well fields in Kitchener, Waterloo, and Cambridge are referred to as the Integrated Urban System (IUS).

The Region's active production wells are monitored through the Region's SCADA (Supervisory Control and Data Acquisition) system, which reads and records the volume pumped on a daily basis. A few wells do not have their own meter but are combined with other nearby well(s) in the well field and the combined flow is divided into a record for each source. Water level measurements are obtained from the production wells where required. All manual measurements are obtained using either an air line or a water level tape.

### E.1.2 Monitoring Wells and Surface Water levels

Water levels are measured at monitoring wells and at some surface water features. The objective of this monitoring is to collect data to ensure that the Region's water taking has minimal impact on the environment and on private water takers.

Water levels in the Region's monitoring wells are measured either electronically or manually. Most of the wells that are monitored electronically use datalogger equipment manufactured by *In-Situ Inc.*® LevelTROLLs® and RuggedTROLLs®; as well as, by *Van Essen Instruments (formerly Schlumberger Water Services)* Mini-Divers®, Micro-Divers®, and TD-Divers®; or by *Solinst*® Leveloggers®. The datalogger pressure sensor models used may be either vented (gauged) or non-vented (absolute) for *In-Situ Inc.*®; whereas, for *Van Essen Instruments* and for *Solinst,*® non-vented (absolute) models are used. Barometric dataloggers by each manufacturer suspended in select well locations are also used with the non-vented (absolute) models to provide the required barometric pressure compensation necessary in producing the water level data. Manual monitoring is done using a *Solinst*® and/or *Heron Instruments Inc.* electronic water level meter with both visual and audio indicators.

The electronically monitored wells are typically measured every hour, with increased frequency as required. At the hourly frequency, the following trends can be distinguished in an individual monitoring well:

- Seasonal climate trends;
- Water level changes in the aquifer that is being pumped;
- Water level changes in aquifers connected to the pumped aquifer; and
- Individual precipitation events in unconfined aquifers.

The manually monitored wells are measured once per month. At this frequency only the first three responses listed above can be distinguished.

### E.1.3 Climatological Data

To evaluate the reaction of water levels to changes in climatic conditions, precipitation data are monitored at various locations throughout the Region. Within the Region of Waterloo, climate data is collected by Environment Canada at the Region of Waterloo International Airport (WIA) and the Roseville weather station, by the Grand River Conservation Authority (GRCA) at various Dam locations and by the University of Waterloo at a weather station located on the north campus.

## E.2 Groundwater Level Collection Protocols

### E.2.1 Groundwater Level Monitoring Network Summary Well Checklist

A well checklist and data entry spreadsheet are prepared of all the measuring points where water levels will be collected on a monthly basis. The checklist and spreadsheet are organized by well field so wells in close proximity are grouped together and indicates whether locations are measured with electronic dataloggers or manual measurements only. Once a well is visited, data is entered in the spreadsheet and the well is checked off the list; thus, the checklist and spreadsheet provides an obvious indication that work is unfinished if a location is unchecked and has no data.

### E.2.2 Well Inspection

Upon visiting a well for the first time, the well/casing/equipment details are noted, photos taken, and GPS coordinates are recorded in a field book and/or in the monthly data entry spreadsheet. Well/casing/equipment details includes: location, access, condition, materials, diameters, casing security, surface seal condition, requiring repair or not, well/casing stickup measurements from ground level, well total depth, and the type of datalogger and/or sampling equipment installed. Any notable deficiencies, concerns, problems, or changes in the well condition are recorded in a field book and/or in the monthly data entry spreadsheet, as well as, photos are taken. Also, any observed activities taking place around or near the well that are worth noting are recorded in a field book and/or in the monthly data entry spreadsheet.

### E.2.3 Monitoring Well Manual Water Level Measurement Procedure

- Unlock well casing and open well casing lid.
- Remove well cap (if present).
- Use an Electronic Water Level meter and lower the probe down the well until the meter beeps to indicate the probe has encountered water.
- The probe is raised up until the beep of the meter stops, indicating the probe is now above the water.
- Then the probe is slowly lowered down until the probe just contacts the water level surface causing the meter to beep.
- At this point the depth (in meters) is read off the water level meter tape from the measuring point of the well (in most cases is the top of the casing or pipe) and this provides the water level depth below the measuring point.
- The date, time, and water level depth measured is recorded in a field book and/or in the monthly data entry spreadsheet.
- This procedure is repeated for each of the well screens inside the well casing.

- Replace well caps.
- Close well casing lid and lock well casing.

### E.2.4 Downloading of Water Levels from Electronic Dataloggers Procedure

**For Non-Vented (Absolute) Datalogger Models:**
*In-Situ Inc.*® LevelTROLLs® and RuggedTROLLs®, *Van Essen Instruments* Divers®, and *Solinst*® Leveloggers®

- Prior to downloading data from the datalogger, a manual water level is measured in each well screen containing a datalogger.
- The datalogger is pulled out of the well, unthreaded from the cap that is attached to a wire cable and connected to (or placed in) the corresponding datalogger communication device. The communication device is connected to a laptop/tablet PC or a RuggedReader® Handheld PC and the associated datalogger software is started.
- Water level data stored in the datalogger is subsequently downloaded and viewed using the datalogger software and saved on the hard drive/memory.
- Note: downloading data from the datalogger does not automatically stop the datalogger from recording.
- The status of the datalogger is viewed and checked for correct operation and to confirm that the datalogger is hanging in the well water within its operating range.
- Select datalogger details such as the battery level and free/used memory are recorded in a field book and/or in the monthly data entry spreadsheet.
- If the datalogger does not require restarting to free up memory or to change the sample rate, then the datalogger is removed from the communication device and is threaded back onto its cap and lowered back down the well on the wire cable.
- If the datalogger does require restarting to free up memory or to change the sample rate, then the datalogger is stopped, reprogrammed, and restarted using the datalogger software and, as a result, erases the previous data stored in memory on the datalogger.
- This procedure is repeated for each datalogger within each of the well screens inside the well casing.
- After all the non-vented (absolute) dataloggers have been downloaded then the Barometric dataloggers are downloaded following the same procedure as above.

**For Vented (Gauged) Datalogger Models:**
*In-Situ Inc.*® LevelTROLLs®

- Prior to downloading data from the datalogger, a manual water level is measured in each well screen containing a datalogger.
- The desiccant tube is unconnected from the datalogger cable.
- The datalogger cable is connected to a communication cable device that is connected to a laptop/tablet PC or a RuggedReader® Handheld PC and the datalogger software is started.
- Water level data stored in the datalogger is subsequently downloaded and viewed using the datalogger software and saved on the hard drive/memory.
- Note: downloading data from the datalogger does not automatically stop the datalogger from recording.
- The status of the datalogger is viewed and checked for correct operation and to confirm that the datalogger is hanging in the well water within its operating range.
- Select datalogger details such as the battery level, free/used memory, and desiccant condition (colour) are recorded in a field book and/or in the monthly data entry spreadsheet.
- The desiccant tube condition is checked and replaced if necessary.
- If the datalogger does not require restarting to free up memory or to change the sample rate, then the communication cable device is disconnected from the datalogger cable and the desiccant tube is reconnected.
- If the datalogger does require restarting to free up memory or to change the sample rate, then the datalogger is stopped, reprogrammed, and restarted using the datalogger software and, as a result, erases the previous data stored in memory on the datalogger.
- This procedure is repeated for each datalogger within each of the well screens inside the well casing.

### E.2.5 Data Entry and Processing into the Burnside MS ACCESS/SQL® Database

- All field data collected (i.e. date, time, manual water level depth measured, comments) and recorded for each well screen and datalogger in a field book is entered into the monthly data entry spreadsheet, unless already entered in the field using a laptop/tablet PC.
- The monthly data entry spreadsheet is checked and reviewed prior to importing the data into a database table using Burnside Water Level Data Tools software. Manual water level depth values are converted into water level elevation values using the software during this import process.
- Any associated well notes, comments, and datalogger details are entered into a database table under the appropriate well and screen.

- Water level data from the dataloggers downloaded to a laptop/tablet PC or a RuggedReader® Handheld PC are transferred to Burnside file folder network upon returning to the office.
- These datalogger water level data files are subsequently read and the data is imported into a database table using Burnside Water Level Data Tools software.
- Using Burnside Water Level Data Tools software, the datalogger water level data are reviewed and processed (as described below) resulting in corrected water level depth values and corrected water level elevation values that are stored in a database table.
- *For Non-Vented (Absolute) Datalogger Models:*
  Datalogger water level data is first barometric pressure compensated using selected Barometric datalogger data, then a manual water level depth value measured at the time of the most recent download is applied and used to convert the barometric compensated water level data into corrected water level depth values, which are converted into water level elevation values that are appended to a database table.
- *For Vented (Gauged) Datalogger Models:*
  A manual water level depth value measured at the time of the most recent download is applied to the datalogger water level data to convert the water level data into corrected water level depth values, which are converted into water level elevation values that are appended to a database table.
- Temperature data recorded by the dataloggers are also imported into a database table.
- Hydrographs are subsequently created for each well and screen from the water level elevation data in the database for review and presentation. If there are some data points that are erroneous, then these data points are marked as non-reportable (invalid) within the database and/or are removed resulting in them not being plotted on the hydrographs.
- An updated data file is provided to the Region on a quarterly basis for upload into their eWRAS EQuIS database.

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