2025 Biennial Groundwater Monitoring Report - Waterloo North Well Field (W5A, W10, W25)

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.

The Permit to Take Water (PTTW; 0061-BLHQ45) for the Waterloo North Well Field issued on February 5, 2020 requires submission of a well field specific biennial report to the Ministry of Environment, Conservation and Parks (MECP) which documents production well (W5A, W10, W25) 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 Waterloo North Well Field is shown on Figure 1 and the production wells in Waterloo are shown on Figure 2 with the monitoring network for W5A, W10 and W25 shown on 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 the requirements of their Permits to Take Water (PTTW) and to confirm that water taking is sustainable in the long term. The monitoring wells are concentrated near the production wells' influence. 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 Waterloo North Well Field which consists of the following activities:

- Measuring the daily volume pumped from the W5A, W10 and W25 production wells (Condition 4.2 of PTTW);
- Groundwater and surface water monitoring requirements as described in the Monitoring Plan – Waterloo North Well Field PTTW Application (Golder, 2019) (Condition 4.1 of PTTW);
- Measuring the water levels in the following monitoring wells;

- WH-EM-CH93-91-AB
- WH-EM-CH94-91-AB
- WT-EB-LC9-91-AB
- W-WN-OW3-06-AB
- W-WN-TW1-06-A
- W-WN-OW2-91-ACD
- W-WN-MWWN1-02-A
- W-WN-MWWN1-06-B
- W-WN-OW4-82-A
- W-WM-WM05-93-AB
- W-WN-OW1-06-AB
- W-WN-OW1-09-ACD

- Review of precipitation data from the nearest GRCA / Environment Canada weather station; and
- Completion of a biennial report (every 2 years) that presents data in compliance with Condition 4.1 of the PTTW.

The monitoring data (pumped volumes and hydrographs) are found in Appendix C with 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 Waterloo North Well Field is located in a fully developed area near the western edge of the City of Waterloo. Well W10 is located on Fischer Hallman Road North just south of where Clair Creek flows under Fischer Hallman Road (Figure 3). W5A is located on Westmount Road North, 2.2 km north of W10 and W25 is located on Conservation Drive 1.2 km north of W5A.

The closest municipal well fields are William Street located 3 km to the east and Strange Street Well Field 3 km to the southeast (Figure 2). Surface water features in the area of the North Waterloo Well Field include Clair Creek located about 50 m from W10, Laurel Creek located 270 m southwest of W25, the Laurel Creek Reservoir located 400 m west of W5A and 800 m south of W25, Martin Creek located 700 m north of W25, and Forwell Creek located 700 m northeast of W25. (Figure 3).

2.1.1 Pumping Wells

The Waterloo North Well Field consists of three production wells, W5A, W10 and W25. Well records for the production wells are found in Appendix B. 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 / Screen Diameter (mm)	Screened Interval (mbgs)	Aquifer
W5A	2006	387 / 406	34.4 – 39	AFD1
W10	1972	400	12.5 – 17.6	AFB2
W25	2009	300	75 – 78.3	AFF1

The water taking volumes for the Waterloo North 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

Well	PTTW	2024			2025		
	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)
W25	5,184	3,545	4,829	1,293,983	3,770	4,744	1,375,915
W5A	3,629	0	0	0	0	0	0
W10	3,142	1,678	1,901	612,621	1,704	1,800	621,938
Total	11,955	5,224	6,730	1,906,604	5,474	6,434	1,997,853

Condition 3.3 of the PTTW specifies that the combined daily average water taking from the well field shall not exceed 7,050.24 m^3/day. As shown in Table 2, this requirement was met in both 2024 and 2025.

The Region of Waterloo's SCADA system records total daily water taking volumes including the dates and times of water takings, the rates of pumping, and calculations of the total amounts of water pumped per day for each supply well, which complies with condition 4.2 of the PTTW.

The pumping volumes are presented in Appendix C as total monthly volumes. W10 was was off-line from July 2004 to December 2018 except for being pumped to waste for brief periods for testing purposes, then was brought back online in 2019. W5A and W25 were added to the PTTW in 2020 and W25 came online in January 2024. W5A is not yet connected to the system. Pumping volumes from the well field ranged from

58,736 m^3/month to 196,372 m^3/month in 2024, and from 130,558 m^3/month to 193,1014 m^3/month in 2025. In 2024 / 2025, W25 accounted for 68% of the pumping volumes. In total, 1,906,604 m^3 was produced at this well field in 2024 and 1,997,8538 m^3 was produced in 2025. These volumes are higher than volumes in the past five years (Table C-1) due to the commissioning of W25 in 2024. The volumes are well below the permitted volume of 4,363,531 m^3 per year (Table C-1).

2.1.2 Monitoring Wells

There are 23 monitoring wells included in the monitoring program required by the PTTW which was outlined in the Waterloo North Well Field Monitoring Plan (Golder, 2019) submitted with the PTTW application. The construction and location details of these monitoring wells are summarized in the table below. Well records for the monitoring wells are provided in Appendix B and well locations are shown on Figure 3.

Table 3: Monitoring Well Construction Details

Monitoring Well ID	Screened Depth (mbgs)	Screened Formation	Distance to W5A	Distance to W10	Distance to W25
WH-EM-CH93-91-A	74.7 – 76.2	Salina	4.2 km	5.0 km	3.8 km
WH-EM-CH93-91-B	25.9 – 30.5	AFB1			
WH-EM-CH94-91-A	73.8 – 75.3	AFF1 / ATG1	4.1 km	5.5 km	3.3 km
WH-EM-CH94-91-B	49.4 – 52.5	ATC1 / AFC1 / ATC2			
WT-EB-LC9-91-A	73.5 – 76.5	AFD1	4.5 km	4.1 km	4.9 km
WT-EB-LC9-91-B	15.2 – 18.3	AFB2			
W-WN-MWWN1-02-A	11.9 – 14.0	AFB1	2.1 km	62 m	3.3 km
W-WN-MWWN1-06-B	1.4 – 4.4	AFB1	2.1 km	62 m	3.3 km
W-WN-OW4-82-A	35.0 – 39.6	AFD1	110 m	2.2 km	1.2 km

Monitoring Well ID	Screened Depth (mbgs)	Screened Formation	Distance to W5A	Distance to W10	Distance to W25
W-WM-WM05-93-A	38.0 – 41.0	ATC1/ AFC1/ ATC2	3.0 km	2.0 km	3.7 km
W-WM-WM05-93-B	28.9 – 32.0	ATB3			
W-WN-OW1-06-A	15.2 – 18.3	AFB3	37 m	2.2 km	1.2 km
W-WN-OW1-06-B	4.6 – 7.6	ATB1			
W-WN-OW3-06-A	53.3 – 55.8	ATE1	1.2 km	3.2 km	336 m
W-WN-OW3-06-B	32.6 – 35.7	AFB3			
W-WN-TW1-06-A	74.7 – 78.3	AFF1/ATG1	1.2 km	3.3 km	5 m
W-WN-OW2-91-A	68.0 – 71.9	Bedrock	2.0 km	2.7 km	2.1 km
W-WN-OW2-91-C	33.5 – 35.0	ATC1/ AFC1/ ATC2			
W-WN-OW2-91-D	9.0 – 10.5	AFB1			
W-WN-OW1-09-A	75.0 – 78.0	Salina	1.6 km	3.8 km	0.4 km
W-WN-OW1-09-B	64.0 – 67.1	Salina			
W-WN-OW1-09-C	45.7 – 48.8	AFD1			
W-WN-OW1-09-D	14.0 – 17.1	ATB3			

2.1.3 Surface Water Monitoring

The PTTW requires monitoring of surface flow at two surface water flow stations Erbsville and Martin Creek, and a shallow piezometer identified as W-WN-DP1-22, and a corresponding surface water level monitoring site designated as W-WN-SW1-22. The locations of these monitoring locations are shown on Figure 3.

2.2 Regional Geology and Hydrostratigraphy

The following sections provide a brief overview of the regional geology and hydrogeology of the Waterloo North Well Field. The surficial geology based on regional OGS mapping is provided in Figure 4. The Waterloo North Well Field is located near the northeast edge of the Waterloo Moraine (Figure 5). Representative cross-sections showing the stratigraphy in the vicinity of the Waterloo North Well Field are included as Figures 6, 7 and 8. The cross-section locations are provided in Figure 3.

Note that the cross-sections are provided as a visual aid and do not necessarily contain all wells in the monitoring program for the Waterloo North 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 and may not necessarily match layers identified through borehole log interpretation.

Refinements (Aqua Insight et al, 2023) along cross-sections B-B" and C-C' (Figures 7 & 8) include the following:

- Thicker ATE1 and thinner AFD1 at W25
- Thicker ATE1 west of wellfield and thinner AFF1/ATG1

2.2.1 Surficial Geology and Conceptual Hydrostratigraphy

The surficial geology of the Study Area has been mapped and described by the Ontario Geological Survey (2003) and updated in Bajc and Shirota (2007). The surficial geology of the Waterloo North Well Field is characterized primarily by silty to sandy till sediments and ice contact sand and gravel (Figure 4). Modern Alluvial and outwash deposits are present along Martin Creek, Laurel Creek, and Claire Creek.

The Quaternary units typically present in the Waterloo Moraine are briefly described below, in order from youngest to oldest.

Aquitard ATB1 – Port Stanley Till

Aquitard ATB1 consists of low permeability, spatially discontinuous, surficial till units found predominantly along the flanks of the Waterloo Moraine. Along the western flank of the Moraine, Aquitard 1 corresponds to the Mornington, Stratford and Tavistock Tills;

whereas along the eastern flank of the Moraine this unit corresponds to the Upper Maryhill and Port Stanley Tills (Bajc and Shirota, 2007). Along the western portion of the Moraine in the vicinity of the Waterloo North well field, Aquitard 1 generally corresponds to silty to clayey Port Stanley Till.

Aquifer AFB1 / ATB2 / AFB2 – Upper Waterloo Moraine Stratified Sediments and Equivalents

Aquifer AFB1 / AFB2 represents the main water supply aquifer in the core areas of the Waterloo Moraine, including the W10 production well of the Waterloo North Well Field. These units are generally comprised of layered silt and fine sand to coarse sand and gravel. Throughout the core areas of the Moraine (Figure 5), the unit typically exceeds 45 m in thickness, and ranges in thickness from 20 m to 33 m in the vicinity of the Waterloo North Well Field. In some areas, the Upper Waterloo Moraine is interpreted to be bisected by the middle Maryhill Till (ATB2), effectively separating the aquifer into two units, AFB1 and AFB2. This aquifer is the most prolific aquifer in the Waterloo Region due to its high hydraulic conductivity and transmissivity, lateral extent, and high recharge rate.

Aquitard ATB3 – Lower Maryhill Till

The Lower Maryhill Till is described as a clayey silt to silty clay till. This unit represents one of the primary regional aquitards due to its strong influence on the groundwater flow system within the Waterloo Moraine. This unit is extensive within the core area of the Waterloo Moraine, and along the eastern flank tends to be thin, discontinuous, or re-worked and re-deposited as glaciofluvial sediments. In the vicinity of the Waterloo North Well Field, ATB3 ranges in thickness from 6 to 23.5 m.

Aquifer AFB3 – Lower Waterloo Moraine Stratified Sediments and Equivalents

Aquifer AFB3 is mainly found along the eastern flank of the Waterloo Moraine below ATB3. The unit consists of stratified gravels, sands or silts. In the Waterloo North Well Field area this unit is approximately 4 m thick.

Aquitard ATC1 / ATC2 – 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. It is a dense, stony, sandy silt to silty sand till with little clay content. 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. The Catfish Creek Till is typically thickest in the core area of the Waterloo Moraine, and thin or absent along the eastern flank. Within the area of the Waterloo North Well Field this unit ranges in thickness from 4 to 10 m.

Aquifer AFD1 – Pre-Catfish Creek Sand and Gravel

Pre-Catfish Creek Till aquifer corresponds to sands and gravel re-worked from Catfish Creek and Pre-Catfish Creek Tills and represents the main supply aquifer in several production wells in the Cities of Kitchener and Waterloo, including W5A and W25 of the Waterloo North Well Field. This unit is spatially discontinuous throughout much of the core areas of the Waterloo Moraine but is laterally extensive in the area of the Waterloo North Well Field.

Aquitard ATE1 – Canning Drift

The Canning Drift is comprised of till and associated fine-textured lake deposits. It is typically found at depths of greater than 70 mbgs in the Waterloo Moraine area and is identified to be discontinuous and limited in lateral extent and thickness. Where it is absent, a hydraulic connection is present between the deep overburden aquifers and the underlying bedrock.

Aquifer AFF1 – Pre-Canning Till

The Pre-Canning aquifer is characterized by coarse-grained sand and gravel sediments and is typically found within bedrock depressions. This unit is discontinuous throughout the Region, and where present is hydraulically connected with the upper weathered portion of the bedrock aquifer.

2.2.2 Bedrock Geology

The Paleozoic bedrock in the area consists of the Salina and Guelph Formations.

2.3 Local Geology

Figure 3 displays the Waterloo North Well Field well plan and cross-section locations. Representative cross-sections are included as Figures 6, 7 and 8 to visualize the stratigraphy described in this section.

Port Stanley Till (ATB1) – The silty to clayey till (ATB1) is mapped at surface to the northeast and south of W10 (Figure 4) and is discontinuous at surface to the northwest of W10. At W10, Port Stanley till extends from surface to 7 mbgs. The unit was also encountered at W-WN-OW1-06 with a thickness of 15 meters, at TW1-06-A with a thickness of 16.7 m and at W-WN-OW2-91 with a thickness of 8 m.

Upper Waterloo Moraine (AFB1 / ATB2 / AFB2) – This unit is interpreted to be laterally extensive in the North Waterloo well field area. W10 is screened in this aquifer between 7 and 30 mbgs. At WT-EB-LC9-91 the unit is 26 m thick, at WH-EM-CH93-91 it is 20 m thick and at W-WM-WM05-93 the unit is 33 m thick.

Lower Maryhill Till (ATB3) – This unit is interpreted to be laterally continuous in the well field area (Blackport, 2011). The unit was identified at WT-EB-LC9-91 from 30.5 m to 36.6 mbgs and W-WN-OW2-91 from 9.5 to 33 mbgs as clayey silt till.

Lower Waterloo Moraine Stratified Sediments and Equivalents (AFB3) - this sand and gravel unit is encountered at WH-EM-CH94-91 (from 50 m to 53 mbgs) and W-WN-OW3-06 (from 31.7 to 35.6 mbgs).

Catfish Creek Till (ATC1 / ATC2) – This unit is interpreted to be laterally extensive in the well field area (Blackport, 2011). The unit is described as stony sandy silt till in monitoring well logs for W-WM-WM05-93 (33.5 m to 43.6 m) and W-WN-OW2-91(33.5 to 37.5 mbgs).

Deep Aquifer (AFD1 / AFF1) – In the Waterloo North area the absence of ATE1 makes it difficult to separate AFD1 and AFF1 (Blackstock, 2011). The deep aquifer is the production aquifer for production wells W5A and W25 with thicknesses of at least 6 m (bottom of aquifer not reached) and 7 m respectively. At W-WN-TW1-06-A, the unit was described as gravel with a thickness of 7 m and at WT-EB-LC9-91 the thickness of the AFD1 and AFF1 units is 29 m thick.

Bedrock - The Salina Formation underlies the overburden and consists of interbedded brown dolostone and grey to green shale. Monitoring well records indicate bedrock in area of was found at depths from 69 to 90 mbgs.

3.0 2024 / 2025 Results

The following sections summarize groundwater levels at monitoring wells in relation to precipitation and water taking from the aquifer (in accordance with condition 4.1 of the PTTW).

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 University of Waterloo and Environment Canada stations located closest to the production wells are used. The closest weather station relative to the Waterloo North well field is the University of Waterloo station located 1.1 km from W10. The closest Environment Canada station is the Roseville Climate Station located about 14 km west/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 the University of Waterlooo station are shown on Figure D.1, Appendix D. At the University of Waterloo station, the long-term average was calculated from 1998 until the end of 2025. The Roseville station has “Climate Normals” calculated by Environment Canada for 1981 to 2010.

Annual 2024 / 2025 precipitation data for the U of W and Environment Canada meteorological station closest to the Waterloo North well field are presented in Table 4 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 4: Summary of Precipitation Data

Station	2024 Precipitation (mm)	2024 Deviation (mm)	Long-Term Average (mm)	2025 Precipitation (mm)	2025 Deviation (mm)
University of Waterloo (2)	763	-108	871(B)	943	+72
Roseville Station (1)	856	-63	919(A)	786	-133

Sources: Environment Canada (1), University of Waterloo (2)
A 1981 to 2010 Normal B 1998-2025 data

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 University of Waterloo station was 763 mm, which is 108 mm below the long-term average, indicating 2024 was wetter-than-average at the well field. A similar below long-term average trend is noted at the Roseville station. The March 1 GRCA snow survey indicated a snowpack across the Region that was low compared to normal.

In 2025, the total precipitation at the University of Waterloo station was 943 mm, which is 72 mm above the long-term average. However, the total precipitation at the Roseville station was 133 mm below the long-term average, indicating 2025 was a drier-than-average year. It should be noted that the Roseville station 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.

WT-EB-LC9-91-AB

WT-EB-LC9-91-AB is located about 4.1 km west of W10 and 4.9 km from W25. The A screen monitors AFD1 and measurements are collected with an electronic water level meter (data logger). The B screen is completed in AFB2 and water levels are collected by monthly manual measurements.

Seasonal variations of 1 m are observed in both screens. There is no observed response from pumping at W10. The A screen has periodic short-term drawdowns in water levels that do not correlate to pumping at W10 from 2016 to 2024. This suggests that the A screen is impacted from another source. When W25 is commissioned in March 2024, water levels decreased by about 2 m.

Water levels in 2024 and 2025 in the B screen are within the historical range of water levels since 2016.

W-WM-WM05-93-AB

W-WM-WM05-93-AB is located 2 km west of W10 and both screens are equipped with data loggers. The A screen is located in ATC1 / AFC1 / ATC2 and the B screen is in ATB3. Seasonal variations are observed in both screens.

Water levels in the A screen show a decreasing trend from 2021 to the end of 2025 with water levels at the end of 2025, 1 m below historical levels observed from 2016 to 2021. Water levels in the B screen also show a deceasing trend beginning in 2021 with 2025 water levels about 0.5 m below historical levels. There is no observed response in the A and B screens from pumping at W10 or W25. The decreasing trends in the A and B screens may be a result of climatic influences.

W-WN-MWWN1-02-A

W-WN-MWWN1-02-A is located about 60 m away from W10 adjacent to Clair Creek and 3.3 km from W25. The well is screened in AFB1 and is monitored with a datalogger. A drawdown of up to 4 m is observed at MWWN1-02-A when W10 is pumping. Water levels have declined about 1 m since full time pumping of W10 began in May 2022.

W-WN-MWWN1-06-B

W-WN-MWWN1-06-B is located 62 m from W10 and 3.3 km from W25 and is monitored with monthly manual measurements. The well is screened across AFB1, 6 m above the screened interval of W10. The water levels show a similar trend to W-WN-MWWN1-02-A but with less drawdown. When W10 is pumping, a drawdown of 1 to 1.5 m is observed. When W10 is off-line, water levels vary seasonally by about 1 m. Water levels in 2024/2025 are lower than historical levels observed from 2016 to 2021. Water levels have declined about 0.7 m since full time pumping of W10 began in May 2022.

W-WN-OW4-82-A

W-WN-OW4-82-A is located 110 m from W5A and is screened in the same aquifer, AFD1. The well is located 1.2 km from W25 and 2.2 km from W10. The well is equipped with a data logger which began collecting data in December 2019. A seasonal variation of 1.2 m is observed at the well. There is no observed response from pumping at W10. Similar to W-WN-OW1-06-A, water levels respond to pumping at W25 by decreasing about 1.4 m when W25 goes online. Further monitoring is required to establish baseline levels of aquifer response to pumping at W25.

W-WN-OW1-06-AB

W-WN-OW1-06-AB is located 37 m from W5A and 1.2 km from W25. Water level data has been collected from both screens since December 2019 using a data logger. The B screen is within clayey silt till (ATB1), and the A screen is within the AFB3 aquifer. Water levels in the A screen are above the top of the well pipe with water levels controlled by a packer.

Season variations are observed in both screens. In the A screen, a drawdown of 4.6 m is observed when W25 went online in spring 2024 with a 2 m recovery when pumping was reduced in January / February 2025. Further monitoring is required to establish baseline levels of aquifer response in the A screen to pumping at W25.

There is no observed response to pumping at W10/ W25 in the B Screen with 2024 / 2025 water levels similar to historical water levels.

WH-EM-CH93-91-AB

WH-EM-CH93-91-AB is located about 3.8 km from W25 and 4.2 km west of W5A. The A screen is in the bedrock and the B screen is in AFB1. Monthly manual measurements have been collected since January 2020.

The A screen appears to respond to W25 with a decline of about 2.2 m from March 2025 to the end of 2025. 2024/2025 water levels are lower than historical levels. Further

monitoring is required to establish baseline levels of aquifer response in the A screen to pumping at W25.

Seasonal variations of up to 1 m are observed in the B screen. There is no observed response to pumping at W10/ W25 in the B Screen with 2024 / 2025 water levels similar to historical water levels.

W-WN-OW2-91-ACD

W-WN-OW2-91-ACD is located 2 km west of W5A and 2.1 km from W25. Screen A is equipped with a data logger which began collecting water level data in December 2019. Monthly manual water levels in the C and D screen began in January 2020. Dataloggers were installed in the C screen in July 2023 and in the D screen in Februrary 2023. The A screen is in the bedrock aquifer with water levels varying seasonally by about 1 m. The A screen responds to pumping of W25 with a 5 m drawdown observed in spring 2024 after W25 is commissioned, and 2 m recovery when pumping was reduced in January / February 2025.

The C screen is in ATC1 / AFC1 / ATC2 and shows a seasonal variation of 1.2 m. The D screen, located in AFB1 shows seasonal variations of approximately 1.5 m. The levels in the C and D screen do not respond to pumping at W10 or W25.

WH-EM-CH94-91-AB

WH-EM-CH94-91-AB is located about 3.3 km west of W25. The A screen is in the deep (W25) production aquifer (AFF1 / ATG1) and the B screen is in ATC1 / AFC1 / ATC2. Monthly manual water level measurements have been collected since January 2020. Seasonal variations of 1 m are observed in both screens.

Water levels in the A screen decline 1.7 m in March 2024 when W25 goes online and then vary in response to changes in pumping. 2024 / 2025 water levels in the B screen follow a similar pattern to those in the A screen, but the 2024 / 2025 response to pumping of W25 is more subdued. There is no observed water level response from pumping at W10. Further monitoring is required to establish baseline levels of aquifer response to pumping at W25.

W-WN-OW1-09-ABCD

W-WN-OW1-09-ABCD is located 45 m from W25. Water level collection began in Decemebr 2019. All well screens are equipped with dataloggers. Water levels in the A screen were collected manually until an electronic water level meter was installed in February 2023. The A and B screens are in the bedrock aquifer and the C screen is in AFD1. Seasonal variations are observed at each screen.

All screens responded to pumping at W25. Beginning in March 2024, water levels in the A, B and C screens declined by up to 13 m in response to W25 pumping. The D screen, located in ATB3 showed the least response (up to 2.6 m) to pumping of W25. There is no observed response to pumping at W10 in any of the screens. Further monitoring is required to establish baseline levels of aquifer response to pumping at W25.

W-WN-OW3-06-AB

W-WN-OW3-06-AB is located 30 m from W25. Water levels have been collected since December 2019 from both screens using data loggers. The A screen is in ATE1 and the B screen is in AFB3.

Both screens respond to pumping at W25 however the response in the B screen is less pronounced. The A screen responds to pumping of W25 with a 10 m drawdown and the B screen with a 5 m drawdown observed in spring 2024 after W25 is commissioned, There is no observed response from pumping at W10 and seasonal variations in both screens are less than 1 m. Further monitoring is required to establish baseline levels of aquifer response to pumping at W25.

W-WN-TW1-06-A

W-WN-TW1-06-A is located beside W25 and is screened in AFF1 / ATG1. The well is equipped with a datalogger which began collecting data in December 2019. A seasonal variation of 1.0 m is observed at the well. Water levels decline 15 m – 20 m in response to pumping at W25 in 2024. There is no observed impact from pumping at W10. Further monitoring is required to establish baseline levels of aquifer response in the A screen to pumping at W25.

3.1 Surface Water Monitoring

Golder (2019) recommended streamflow and streambank piezometer monitoring at the locations described below.

3.1.1 Erbsville Station

The Erbsville flow station, overseen by the Grand River Conservation Authority is situated near the intersection of Erbsville Road and Conservation Drive. Hourly surface water flow data is recorded electronically. Typically, a seasonal peak in flow rate occurs during the spring. Flow rates are directly impacted by precipitation events. The flow rates and distribution patterns observed in 2024 and 2025 remained within the historical range, aligning with the station’s long-term data trends. The flows do not appear to be influenced by groundwater pumping.

3.1.2 Martin Creek Station

The Martin Creek station is a surface water flow location near the intersection of Martin Creek Road and Martin Creek. The Golder (2019) PTTW monitoring plan recommended that six stream flow measurements should be taken annually at this location to develop a rating curve for Martin Creek.

Surface water flow data was manually recorded during 9 events from December 2022 to October 2023 and monthly between April and November in 2024 and 2025. Flow rates ranged between 0.7 L/sec and 534.9 L/sec and are directly impacted by precipitation events. A stage-storage curve has been developed using the available flow data and surface water levels at W-WN-DP1-22 (Appendix C). W25 started pumping in 2024, so there is insufficient data to assess if there are any impacts to stream flow from pumping. Surface water flow monitoring is recommended to continue for another 2 years to establish a more detailed rating curve.

W-WN-SW1-22

W-WN-SW1-22, located at Martin Creek Road and Martin Creek, is a surface water level monitoring location equipped with a data logger dating back to September 2022. Water levels show a seasonal trend and increase up to 1.3 m in response to precipitation events. There is insufficient data to assess if there are any impacts to surface water levels from pumping.

W-WN-DP1-22

W-WN-DP1-22 is a piezometer extending 1.5 m into the subsurface also located where Martin Creek Road crosses Martin Creek. The piezometer is equipped with a data logger which began collecting data in September 2022. Between September 2022 and December 2022, water levels were recovering after the piezometer installation, indicating that the sediments around the screen of the piezometer have a low hydraulic conductivity.

Water levels in W-WN-DP1-22 follow a similar overall pattern to surface water levels at W-SW1-22 with a seasonal trend but no response to precipitation events. Variations in water levels readings in the winter of 2023 and March 2024 are caused by freezing conditions changing the pressure readings. Water levels were not collected in the winter months of 2024 and 2025 during freezing conditions. The available data does not indicate that there are any impacts to water levels beneath the creek from pumping. A comparison of groundwater levels to surface water levels indicates that groundwater levels are slightly higher than surface water levels during baseflow conditions.

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."

The wells in the Waterloo North well field are located in municipally serviced areas. 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 W10 received in 2022 and 2023.

Other groundwater takings registered in the MECP PTTW database within 2 km of the well field are mapped on Figure 3 and summarized below in Table 5.

Groundwater takings registered in the MECP’s PTTW database in the vicinity of the well field were reviewed. There was only one permit for a groundwater taking associated with a heat pump well located in the vicinity of the Waterloo North municipal wells (Figure 3).

Table 5: PTTWs in Vicinity of Waterloo North Well Field

Permit Number	Permit Holder	Purpose	Source, Max Liters per Day	Distance from Closest Supply Well	Expiry Date
2211-ARJNHJ	2237467 Ontario Inc.	Heat Pumps	Supply Well, 910,000	1,800 m from W5A	10/31/2027

4.2 Aquifer Response to Pumping and Precipitation

PTTW Condition 4.3 states: "The Permit Holder shall prepare and submit an electronic copy of a report every two years by June 30. The report shall present 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)".

The water levels in the shallow aquifer AFB1 / AFB2 show a response to pumping at W10 as indicated by water level results at W-WN-MWWN1-02-A and W-WN-MWWN1-06-B.

Water levels in the deeper production aquifer (AFD1 / AFF1 / Bedrock) show a response to pumping at W25 as indicated by water level results at WH-EM-CH94-91-A, WT-EB-LC9-91-A, W-WN-OW4-82-A, W-WN-TW1-06-A, W-WN-OW2-91-A, W-WN-OW3-06-A and W-WN-OW1-09-ABC. The greatest response to water taking is observed in wells with screens in the deeper production aquifers.

Water levels in the AFB3 aquifer also show a response to pumping at W25 as observed at W-WN-OW3-06-B and W-WN-OW1-06-A.

There is no evidence that current pumping rates at W10 and W25 are causing adverse impacts to water levels. Aquifer response to pumping at W25 will continue to be evaluated as further monitoring data is collected.

Seasonal fluctuations in the aquifers are observed with the highest and lowest levels observed in spring and late summer / fall, respectively. The correlation of individual precipitation events with groundwater levels is difficult due to several reasons including but not limited to hydraulic conductivity, well depth, precipitation intensity and ground cover conditions.

5.0 Conclusions

Impacts from pumping the municipal wells at the Waterloo North Well Field (W5A, W10, W25) 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 4.1 of PTTW 0061-BLHQ45;
- 2024 and 2025 pumping volumes were within the permitted range; and
- There were no reported well interference complaints arising from water taking at the Waterloo North Well Field impacts on private wells in 2024 and 2025;
- There is no evidence of long-term adverse effects to groundwater levels from pumping at the Waterloo North Well Field; and
- Many of the monitoring wells respond to pumping of W10/W25, however there is no evidence of adverse impacts to water levels at the current pumping rates.

6.0 References

AECOM, 2011. Waterloo North Hydrogeological Report: Waterloo North Water Study Class EA Environmental Study Report, Region of Waterloo.

Aqua Insight Inc., 2026. Technical Memorandum Numerical Model Surface Transfer, March 2026.

Aqua Insight Inc.,et al. 2023. Hydrogeological Characterization and Conceptual Model Update Report, Region of Waterloo Tier Three Assessment Update Project, June 2023.

Aqua Insight Inc. 2023. Moraine Model Update and Recalibration Report. Region of Waterloo Tier Three Update Project. Final Report, June 2023.

AquaResource Inc., 2012. Region of Waterloo Tier Three Water Budget and Local Area Risk Assessment Rural Well Fields Characterization Report

Bajc, A.F. and Shirota J., 2007. Three-dimensional mapping of surficial deposits in the Regional Municipality of Waterloo, southwestern Ontario; report in Ontario Geological Survey, Groundwater Resources Study 3, p. 42.

Blackport Hydrogeology Inc., June 2011, revised January 2012. Tier 3 Water Budget and Local Area Risk Assessment, Waterloo North, William Street and Lancaster Well Fields Characterization Study, Final Report.

Golder Associates, 2011. Regional Municipality of Waterloo North Water Supply Class Environmental Assessment – Hydrogeological and Natural Environment Report, October 2011.

Golder Associates, 2019. Monitoring Plan - Waterloo North Well Field PTTW Application. September 30, 2019.

Karrow, P.F., 1993. Quaternary Geology of the Stratford-Conestogo Area, Southern Ontario. Ontario Geologic Survey Report 283.

Karrow, P.F. and Paloschi, G.V.R, 1996. The Waterloo kame moraine revisited: new light on the origin of some Great Lake regions interlobate moraines, Z. Geomorph. N.F., Volume 40, Number 3, p. 305-315. September 1996.

R.J. Burnside & Associates Limited, 2024. Region of Waterloo 2023 Biennial Groundwater Monitoring Report-Waterloo North Well Field (W5A, W10, W25).

Stantec Consulting Ltd., 2002, Groundwater Under the Direct Influence of Surface Water Assessment, Waterloo North Well Field, Production Well W10.

Waterloo Hydrogeologic Inc., 2000. Delineation of Well Field Capture Zones within the Waterloo Moraine, Regional Municipality of Waterloo Water Services Division Report, 77 pages.

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).

BURNSIDE

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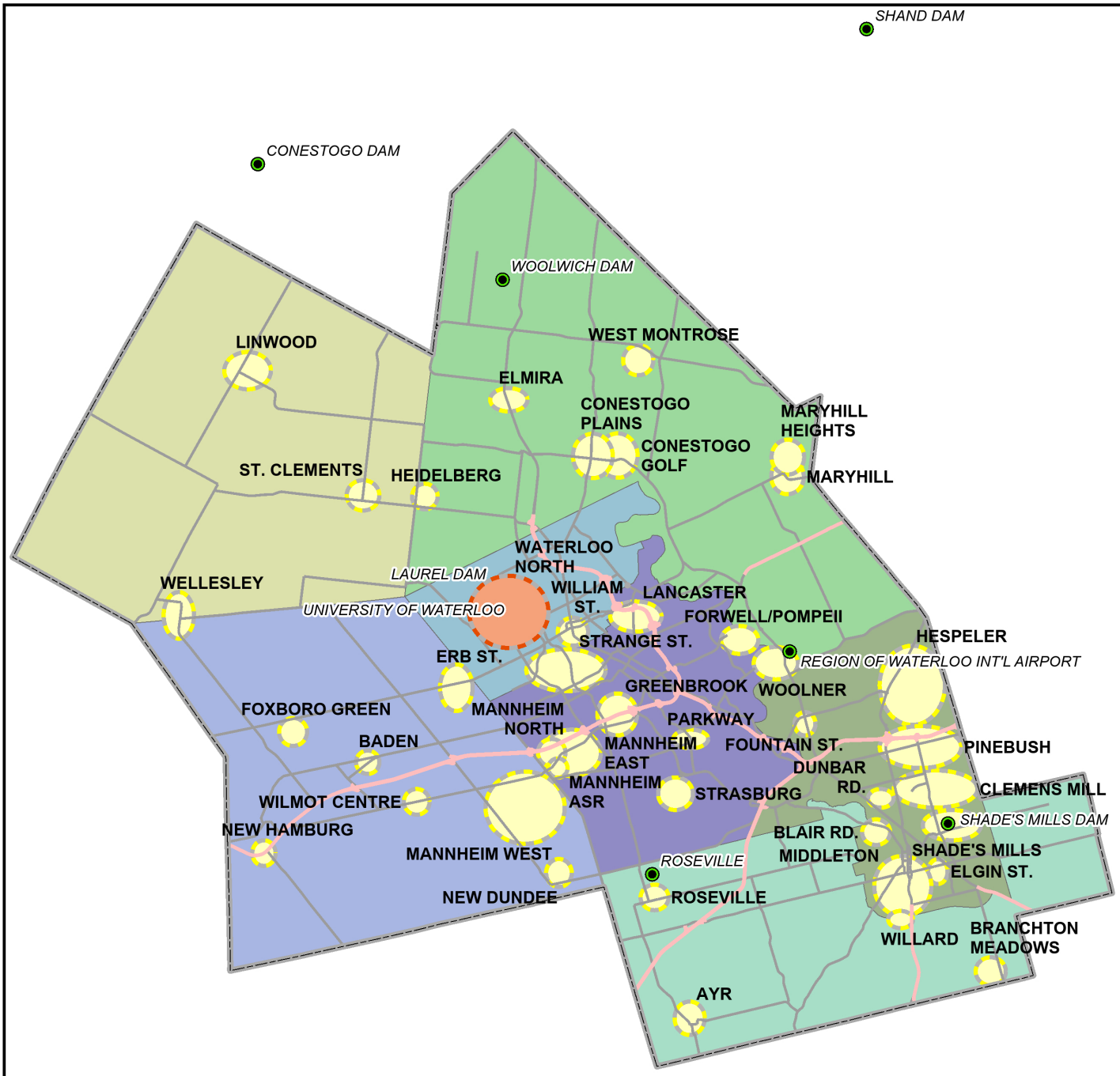
Figures



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Data Source:
Region of Waterloo; Includes material © 2012 of the Queen's Printer for Ontario. All rights reserved.

0 5 10 15 20
Kilometers

- Well Field Location
- Well Fields
- Regional Municipal Boundaries
- City of Cambridge
- City of Kitchener
- City of Waterloo
- Township of North Dumfries
- Township of Wellesley
- Township of Wilmot
- Township of Woolwich
- Meteorological Monitoring Locations

BURNSIDE

Map Title

2025 GROUNDWATER MONITORING REPORT - WATERLOO NORTH WELL FIELD

WELL FIELD LOCATION MAP

Client

REGION OF WATERLOO

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HN	SQ	February 2026	1
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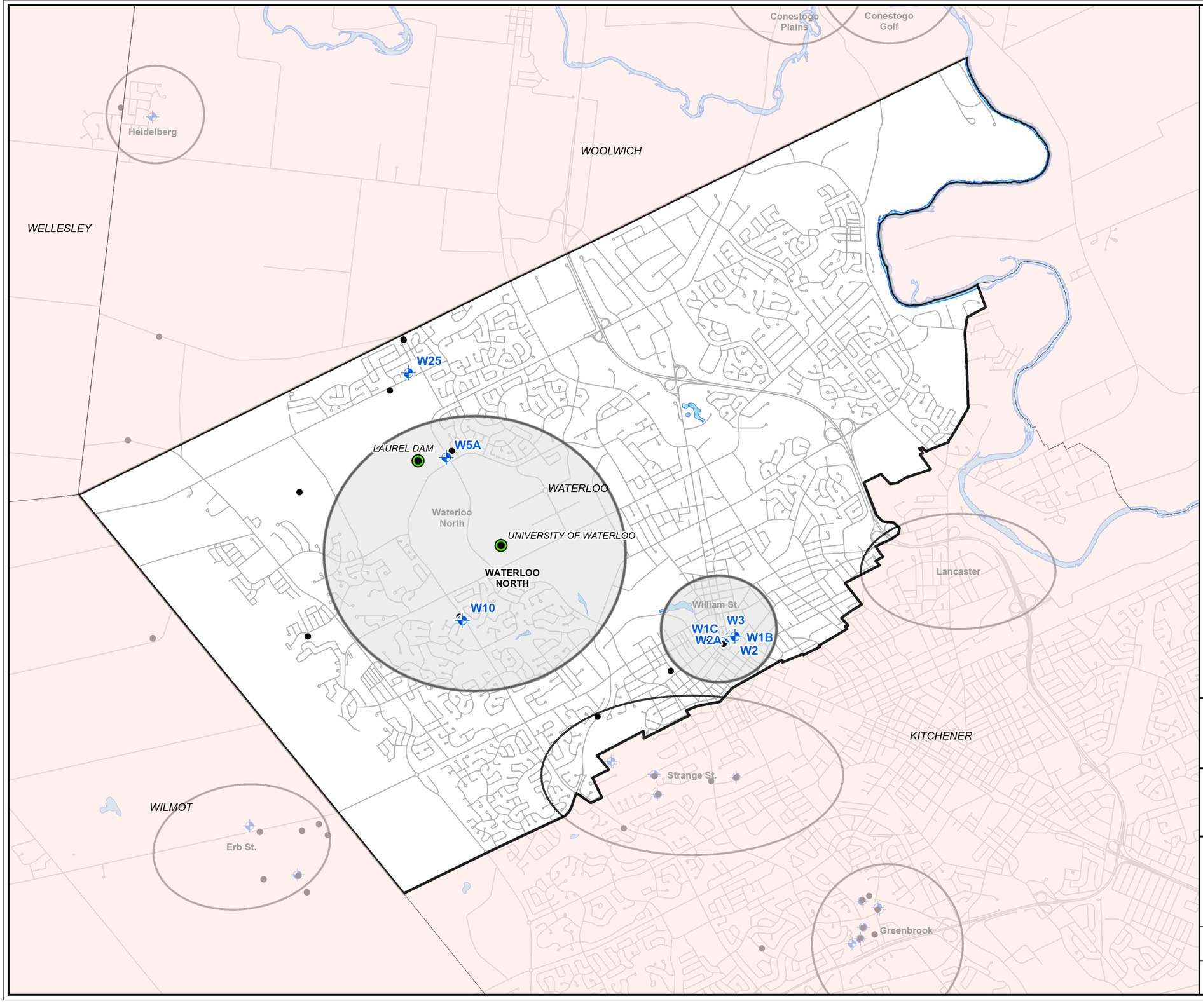

LEGEND

- Production Well Location
- Monitoring Well Location
- Waterloo 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.
3. Region of Waterloo

Datum: North American 1983 CSRS

Coord. System: NAD 1983 CSRS UTM Zone 17N

N

0 1 2 3 4

Kilometers

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Client

REGION OF WATERLOO

Figure Title

2025 GROUNDWATER MONITORING REPORT - WATERLOO NORTH WELL FIELD

WATERLOO WELL FIELDS AND MONITORING NETWORK

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HN	SQ	April 2026	2
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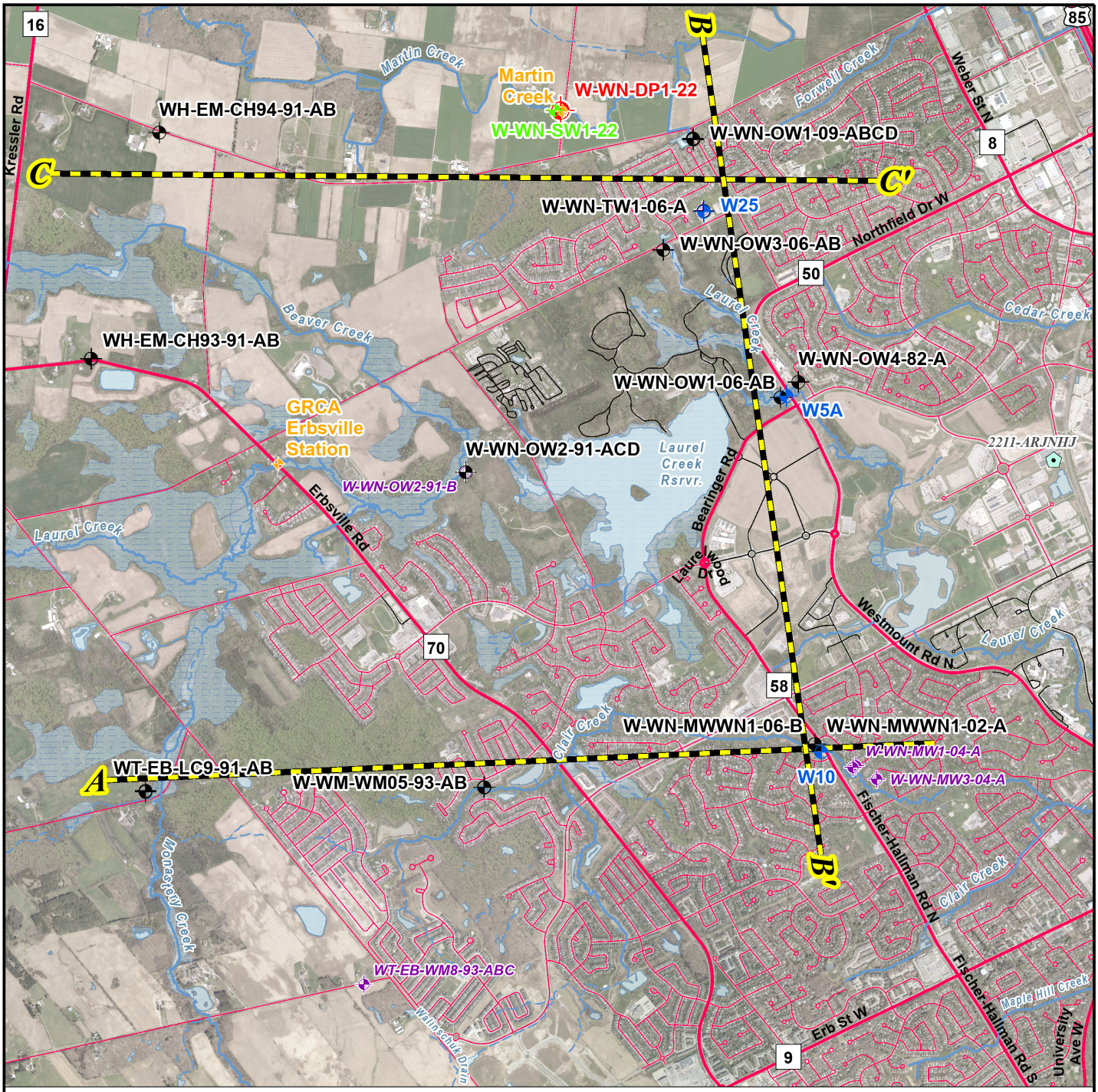

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Region of Waterloo GIS Data; Background 2020 Air Photo: ArcGIS Image Service Region of Waterloo; Ministry of Natural Resources, © Queen's Printer for Ontario; Natural Resources Canada © Her Majesty the Queen in Right of Canada.

0 400 800 1,200 1,600 2,000
Metres

- PTTW Monitoring Well Location
- Nearby Monitoring Well Location
- PTTW Piezometer Monitoring Location
- PTTW Stream Flow Monitoring Location
- PTTW Surface Water Monitoring Location

Additional MECP PTTW Locations
- Groundwater
- Cross Section Orientation
- Intermittent Creek
- Creek
- Provincially Significant Wetland (MNR)
- Provincial Highway
- Regional Road
- Local Road
- Private / Other Road

BURNSIDE

Map Title

2025 GROUNDWATER MONITORING REPORT - WATERLOO NORTH WELL FIELD

WELL LOCATION MAP

Client	Drawn	Checked	Date	Figure No.
REGION OF WATERLOO	HN	SQ	April 2026	3
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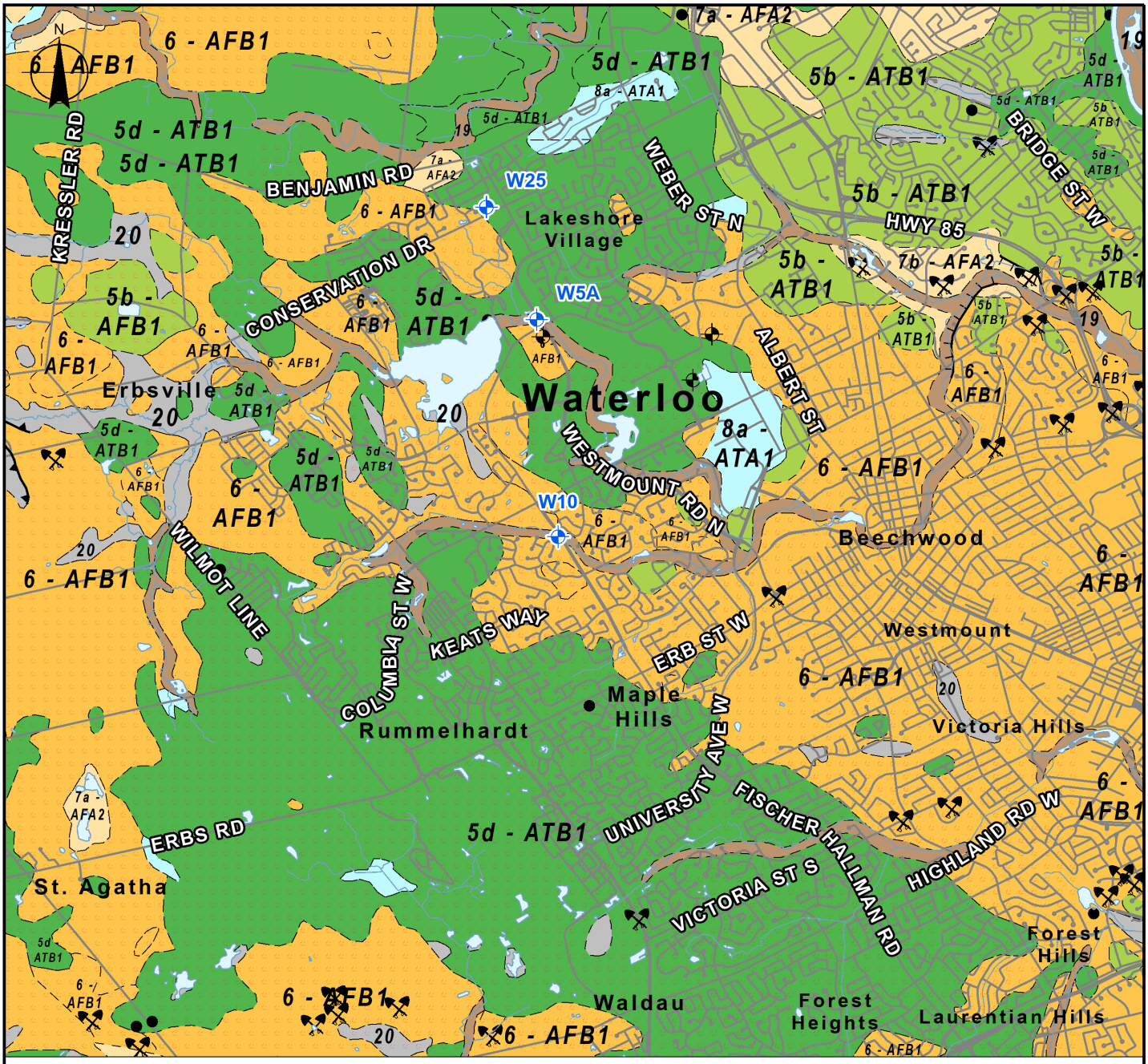

Data Source:
1. Ontario Geological Survey 2003. Surficial Geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128.
2. Region of Waterloo GIS

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

- RMOW Supply Well
- Watercourse
- Waterbody

Surficial Geology

- 5b: Stone-poor, carbonate-derived silty to sandy till (ATA2/ATB1 - Aquitard)
- 5d: Glaciolacustrine-derived silty to clayey till (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)
- 19: Modern alluvial deposits
- 20: Organic deposits
- Sand and Gravel Pit
- Ice-Contact Slope
- Terrace
- Drill Hole
- Sample Location
- Hummocky Topography
- Unit Contact
- Boundary

PTTW 2023 Report Wells Query
Well_Type
- RMOW Supply Well

BURNSIDE

Map Title
2025 GROUNDWATER MONITORING REPORT - WATERLOO NORTH WELL FIELD
SURFICIAL GEOLOGY

Client
REGION OF WATERLOO

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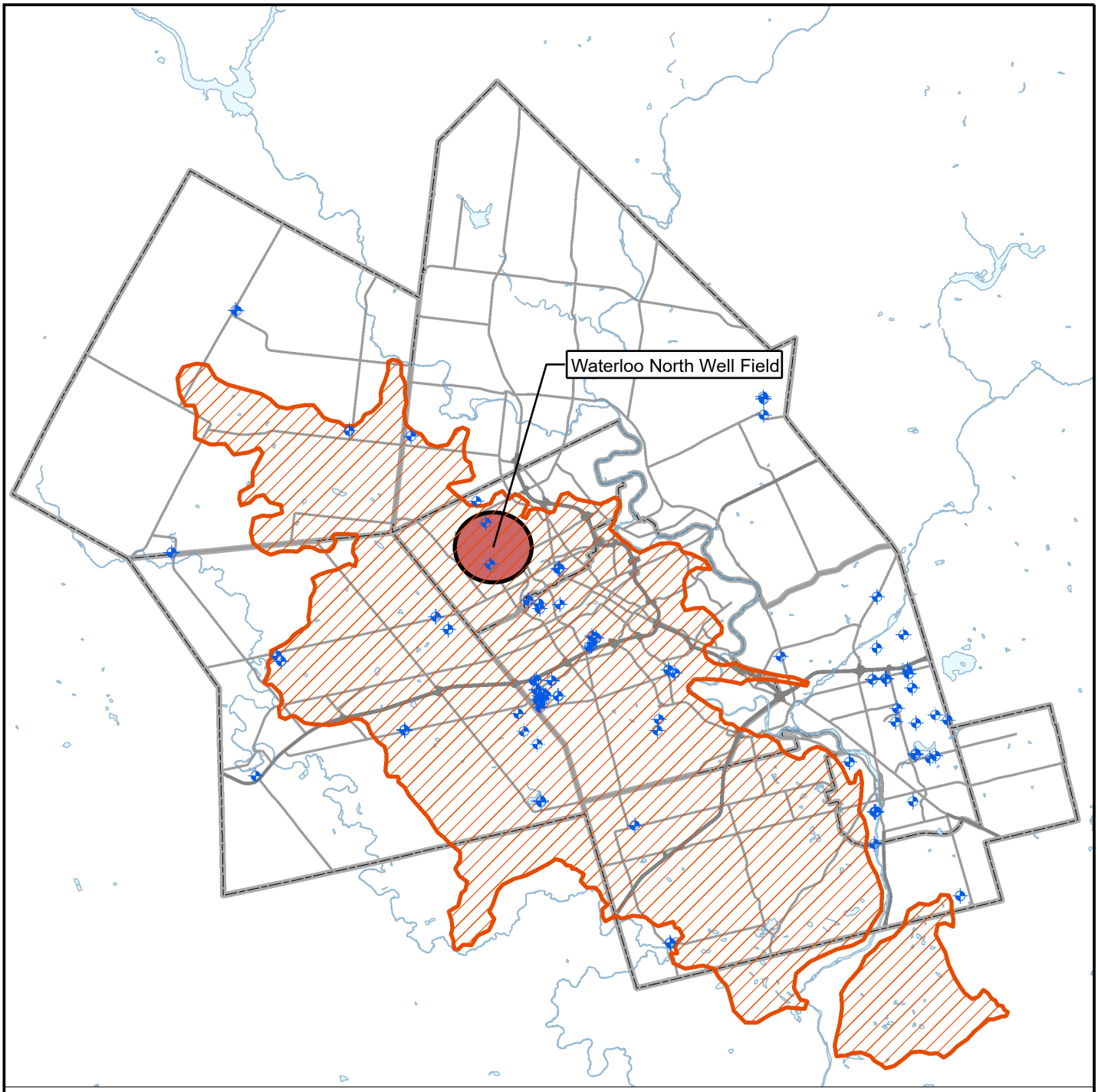

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Data Source:
1. Andy F. Bajc, Hazen A.J. Russell and David R. Sharpe (2014) A three-dimensional hydrostratigraphic model of the Waterloo Moraine area, Southern Ontario, Canada, Canadian Water Resources Journal / Revue canadienne des ressources hydriques, 39:2, 95-119
2. Region of Waterloo; Includes material © 2019 of the Queen's Printer for Ontario. All rights reserved.

0 5 10 15 20 25
Kilometers

RMOW Supply Well
Waterloo Moraine (2014)
Waterloo North Well Field
Waterbody
Regional Municipal Boundaries

BURNSIDE

Map Title

2025 GROUNDWATER MONITORING REPORT - WATERLOO NORTH WELL FIELD

LOCATION OF THE WATERLOO MORAINE

Client

REGION OF WATERLOO

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A

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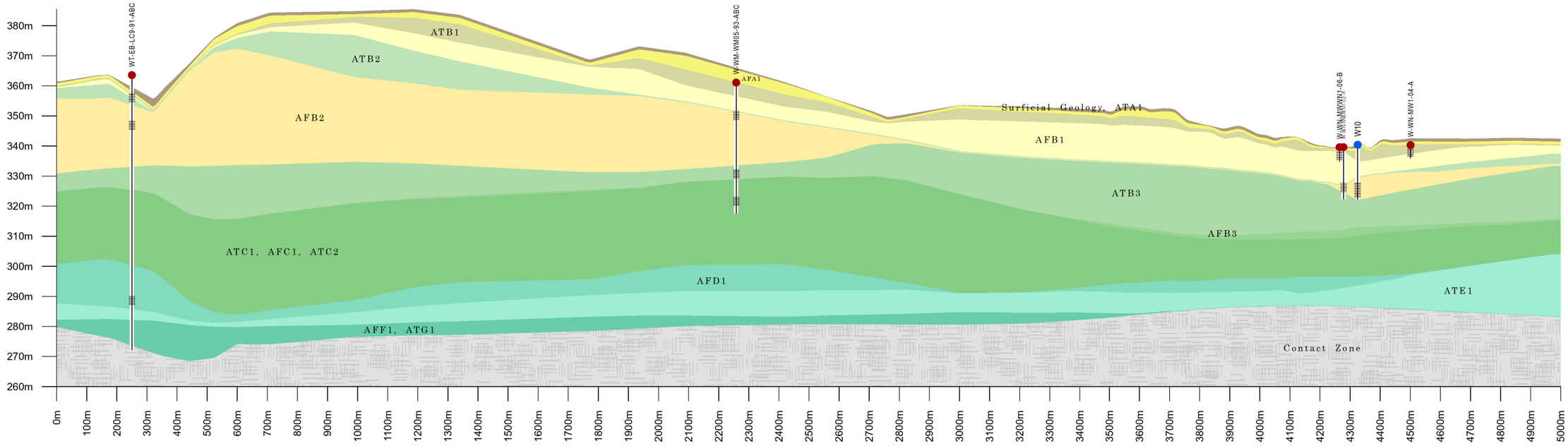

Wells

- Production Well (Active)
- Monitoring Well

Moraine Model 2026

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1)
- Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)
- 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

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION REGION OF WATERLOO

Waterloo North
Cross Section A - A'

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B

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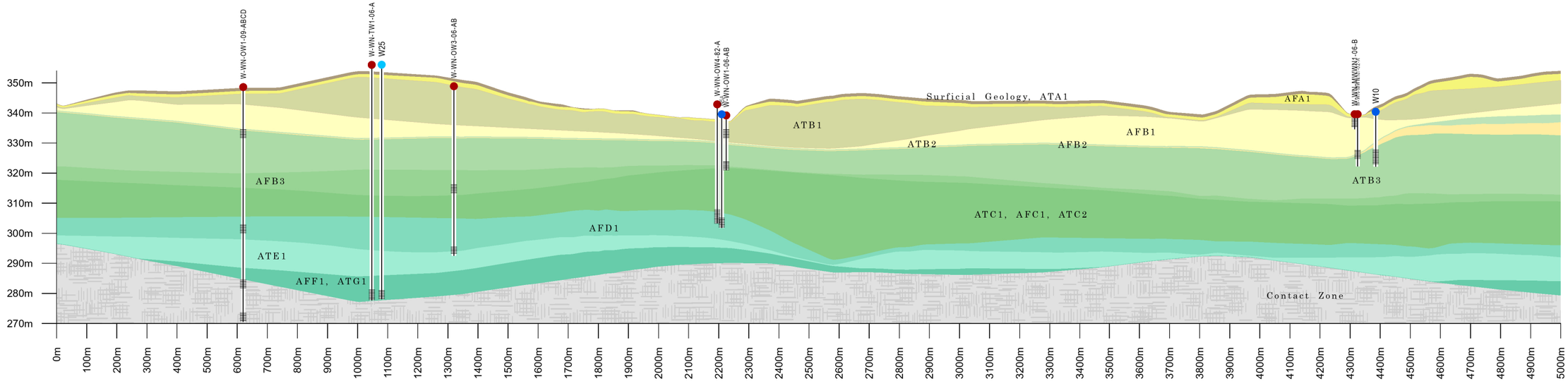

Wells

- Production Well (Active)
- Production Well (Inactive)
- Monitoring Well

Moraine Model 2026

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1)
- Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)
- 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

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION REGION OF WATERLOO

Waterloo North
Cross Section B - B'

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C

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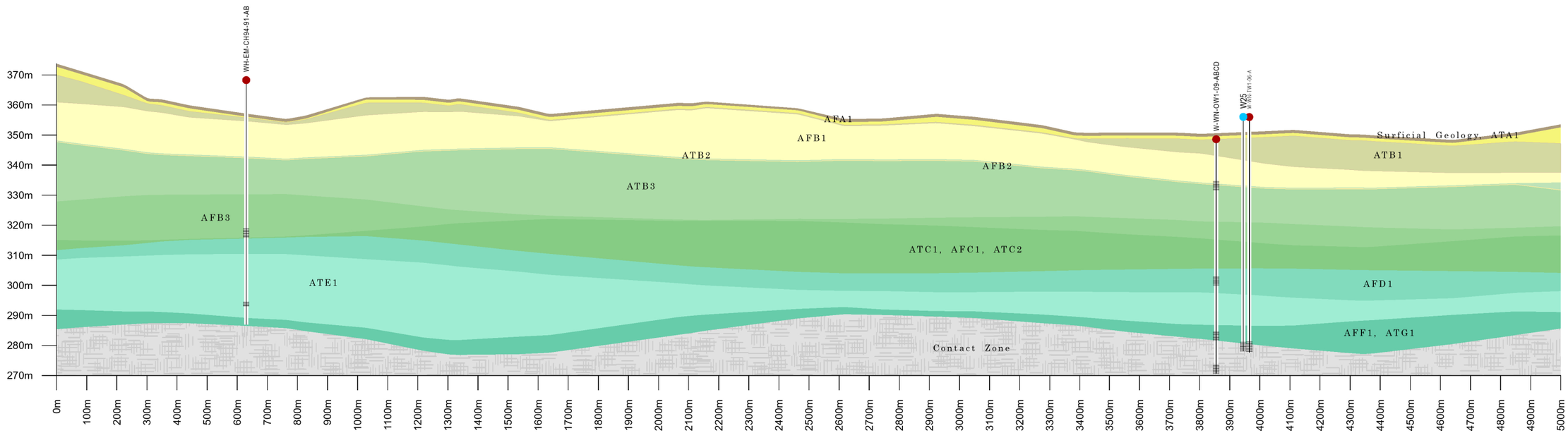
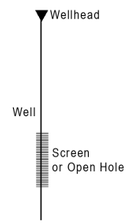


Wells

- Production Well (Inactive)
- Monitoring Well

Moraine Model 2026

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1)
- Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)
- 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



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Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION REGION OF WATERLOO

Waterloo North
Cross Section C - C'

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Appendix A

Permit To Take Water

AMENDED PERMIT TO TAKE WATER

Ground Water
NUMBER 0061-BLHQ45

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
150 Frederick St
Kitchener, Ontario
N2G 4J3

For the water taking from: Three Drilled Wells [W25 (7137876), W5A (6510932) and W10 (6503645)]

Located at: Lot 26, 27 & 31, Concession German Company Tract, Geographic Township of Waterloo
Waterloo, 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. 0061-BLHQ45 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 October 11, 2019 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.

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, 2029**. 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	W25 (7137876)	Well Drilled	Municipal	Water Supply	3,600	24	5,184,000	365	17 534593 4815768
2	W5A (6510932)	Well Drilled	Municipal	Water Supply	2,520	24	3,628,800	365	17 535071 4814444
3	W10 (6503645)	Well Drilled	Municipal	Water Supply	2,182	24	3,142,080	365	17 535304 4812506
						Total Taking:	11,954,880		

3.3 Notwithstanding the Maximum Taken Per Day specified in Table A of Condition 3.2, the combined daily average water taking from sources W25 and W5A listed in Table A shall not exceed 7,050,240 L/day.

4. Monitoring

4.1 The Permit Holder shall prepare and submit a report by June 30th every two years, commencing on June 30, 2022, that presents the results of the wellfield water level monitoring for the two preceding calendar years, assesses changes in water levels in the supply aquifer in relation to the precipitation and the water taking from the aquifer as well as surface water monitoring described in the Monitoring Plan - Waterloo North Well Field PTTW Application by Golder September 30, 2019. The Permit Holder shall also provide a summary of all interference complaints received related to this Permit including the manner in which each complaint has been dealt with and report them to the District Office in accordance with Condition 5.1.

4.2 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. A separate record shall be maintained for each source. 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.

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
655 Bay Street, 15th Floor
Toronto ON
M5G 1E5
Fax: (416) 326-5370
Email: ERTTribunalsecretary@ontario.ca

AND

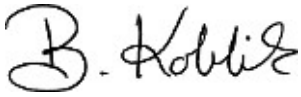
The Director, Section 34.1,
Ministry of the Environment, Conservation and Parks
12th Floor
119 King St W
Hamilton ON L8P 4Y7
Fax: (905) 521-7820

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

by Telephone at	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 3573-BJHR66, issued on 2020/01/09.

Dated at Hamilton this 5th day of February, 2020.



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 0061-BLHQ45, dated February 5, 2020.

September 30, 2019 Project No. 19119485

Karl Belan, M.A.Sc., P.Geo., Hydrogeologist
Regional Municipality of Waterloo
Water Services
150 Fredrick Street, 7th Floor
Kitchener, ON N2G 4J3

MONITORING PLAN – WATERLOO NORTH WELL FIELD PTTW APPLICATION

Dear Mr. Belan:

In support of the Region of Waterloo's consolidated Permit to Take Water (PTTW) application to the Ministry of the Environment, Conservation and Parks (MECP) for the Waterloo North well field, the following letter presents the monitoring plan to be completed by the Region in support of the consolidated PTTW. This letter follows the completion of a Waterloo North Class Environmental Assessment (EA) in December 2011 (AECOM, 2011) and an addendum to the Class EA in May 2017 (Stantec, 2017) which recommended the initial addition of water supply from the Tank Well (W25) and the delayed addition of W5A. This letter provides additional details on the recommended monitoring program provided in the EA documentation (Golder, 2011).

Background

The Region currently has a Waterloo North Permit for well W10 (PTTW No. 3436-9SGLDK, MECP ID 6503645) for 36.4 L/s. This permit was issued in January 2015 and expires on May 31, 2024. Following long-term testing of three test production wells in 2009 (Golder, 2011), the completion of an environmental assessment (EA) (AECOM, 2011), and an EA amendment (Stantec, 2017), the Region is applying for a PTTW for the Waterloo North well field which will include W10, W25 (previously referred to as WNTP1-09 or Tank Well) and W5A. As part of the Hydrogeological and Natural Environment Report, an assessment of the sustainability of the new takings was completed and a monitoring program was recommended (Golder, 2011); A copy of this report is included as Attachment A (electronic). W5A is the reconstructed inactive municipal production well W5. As W5 was originally drilled in 1953, prior to the Ontario Water Resources Act it did not require a PTTW. The Region would like to include W5A on the Waterloo North permit so that it is no longer grandfathered.

In 2009 long-term testing of the W25 (60 L/s) and W5A (20 L/s) was conducted to determine the individual and cumulative effect of pumping. The pumping test lasted for 42 days, with a staggered start. The W25 was pumped for 7 days prior to the start of pumping at W5A; both wells were shutdown simultaneously on the 42nd day of pumping. The drawdown in the deep aquifer is shown on Figure 24 in the Hydrogeological and Natural Environment Report (Golder, 2011; Attachment A). Approximately 15 m of drawdown was observed in the deep

aquifer in the vicinity of W25 and W5A with groundwater drawdown extending radially from the wells, skewed towards the upgradient area in the northwest with a total area of the zone of influence of approximately 113 km^2. There was drawdown observed at the shallow water table in a 1 to 2 km^2 area in the vicinity of the W25, with one shallow private well compromised by a drawdown of approximately 2 m and water had to be supplied to the well owner (Figure 31 in Attachment A). Seven other private wells were impacted by the pumping in the deep aquifer; however, the pumps in these wells were lowered to mitigate the impact and ensure their operation was no longer compromised.

It is noted that the 42-day pumping test also included the Erbsville Test Production Well (EBSVTP1-09), screened in the intermediate aquifer; the use of EBSVTP-09 was not selected as a preferred option in the EA due to potential impacts to the natural environment and privately-owned wells (AECOM, 2011). Monitoring wells and private wells that were impacted by pumping at EBSVTP1-09 but not impacted by W25 and W5A are not included in the recommended monitoring program below.

In the original Environmental Study Report (ESR) for the class EA, the following recommended solution for the Deep Aquifer was identified (AECOM, 2011):

- Deep Aquifer (W25 and W5A) – Alternative 4, pumping both the W25 and W5A (combined maximum of 80 L/s) at both sites. The preferred design included a centralized Water Treatment Plant (WTP) at the W25 site, with raw water being conveyed from W5A to the W25 site.

In 2015, the Region's Water Supply Master Plan (WSMP) was updated, recommending a staged approach to the addition of the two new wells to better match projected water demands in Waterloo North. The WSMP recommended that the W25 be developed initially as it requires less treatment, followed by the addition of W5A, with additional treatment requirements for sulphates at a later date (Stantec, 2015). Subsequently, the Waterloo North ESR recommended solution for the Deep Aquifer was modified to initially only include the W25 at 60 L/s, with a delayed implementation of W5A (Stantec, 2017).

In 2011 a butternut tree (*Juglans cinerea*), a species designated as endangered under the Ontario *Endangered Species Act* (ESA), was observed in the floodplain of Martin Creek approximately 1 km north of W25, within the zone of shallow impact of pumping (Golder, 2011). Golder completed a site visit to assess the health of this tree in August 2019 to assess the potential impact of shallow groundwater drawdown as any proposed works that could adversely impact butternut, and/or its habitat may require permitting under the ESA. This tree was confirmed to be no longer alive, so no additional measures are required.

Due to the elapsed time since completion of this initial natural heritage assessments and updates to relevant Species at Risk (SAR) legislation, an updated SAR assessment was conducted by Golder in August 2019 within the area of potential shallow drawdown. A memorandum documenting the updated SAR assessment (Golder, 2019) concluded that habitat for SAR designated threatened or endangered and Species of Conservation Concern (SOCC) under the Ontario Endangered Species Act (ESA) is restricted to anthropogenic features or upland terrestrial features and are not expected to be impacted by potential groundwater drawdown.

It was noted in the updated SAR assessment that the wetland portion of the Stamm woodlot does not contain permanent standing water that would be required to support snapping turtle habitat as was previously identified in the EA (Golder, 2011). Therefore, the shallow piezometer that was previously proposed to confirm the absence of groundwater drawdown in this wetland is no longer required.

There are two new private supply wells located in the area of potential shallow water table drawdown that were installed following the 2009 testing of W5A and W25. The locations of these wells are shown on Figure 1. The well construction details for these wells are provided in the table below. MECP Well ID 7265508 is screened in the shallow aquifer and Well ID 7172980. Based on well yield testing during drilling and the driller's recommended pump settings there is about 3.5 m of available drawdown in each of the wells based on maximum water levels while the wells are in operation. It would be recommended that the Region have a certified well contractor lower the pumps in each of these wells so that they are not impacted by pumping at W5A and W25.

Details of New Private Wells

MECP Well ID	Private Well Location	Easting	Northing	Top Screen (mbgs)	Bottom Screen (mbgs)	Formation Screened	Static Level (m)	Well Yield Testing Rate (L/min)	Maximum Water Level During Testing (m)	Pump Setting (m)	Available Drawdown (m)
7265508	445 Benjamin Road	530894	4814881	23.2	24.4	Shallow Aquifer	0.3	76	4.3	7.6	3.4
7172980	515 Benjamin Road	533605	4816033	41.8	43.3	Deep Aquifer	8.5	151	28.3	32.0	3.7

Note: The details from these wells are taken from the MECP water well records.

Recommended Monitoring

The following additional recommended monitoring is consistent with the recommendations included in the Waterloo North EA.

1) The operation of the shallow private well W (Figure 1) was compromised during the Waterloo North Pumping Test of the W25 and W5A. This well should be replaced with a deeper drilled well completed to mitigate potential effects of pumping from W25 and W5A.

2) Groundwater monitoring should be completed at the 23 wells (12 locations) in addition to two proposed shallow piezometers and one staff gauge listed in Table 1 and shown on Figure 1. Groundwater monitoring should be completed using dataloggers in wells in close proximity to W25 and W5A, set to record at 1-hour intervals. As per the protocol in the Region's Groundwater Monitoring Program (GMP), manual measurements will be completed to backup the dataloggers. Monitoring wells located at a greater distance from W25 and W5A can be monitored by monthly measurements, as indicated in Table 1.

3) Provided access is granted from the local landowner, a streambank piezometer and an in-stream staff gauge should be installed within Martin Creek (i.e., within the zone of predicted shallow impact). Provided that the landowner permits access to the lands, dataloggers should be installed in the piezometer and staff gauge and set to record at 1-hour intervals. Monthly measurements should also be completed.

4) Biennial reporting (once every two years) will provide a summary of the collected monitoring data. This reporting should include a discussion of any observed effects with respect to operation of the W5A and W25. Recommendations should be included within the biennial monitoring reports regarding changes to the program (if required) or the need for on-going monitoring.

5) Six stream flow measurements should be taken annually for two years and a rating curve should be developed for Martin Creek. Following two years of stream flow monitoring, the frequency of streamflow measurements should be re-evaluated. The frequency of monitoring can be revised upon approval from the District Manager.

6) Streamflow data at the GRCA Laurel Creek Erbsville gauging station (ID 8785042) (Figure 1) should be reviewed and reported on in the biennial reports.

7) The pumps in the two new wells along Benjamin Road (MECP Well IDs 7265508 and 7172980) should be lowered by a certified well contractor.

Closure

We trust that this information is suitable to support the PTTW application. Please do not hesitate to contact us if you have any questions or concerns.

Sincerely,

Golder Associates Ltd.

Jennifer Hancox, M.Sc., P.Geo.
Hydrogeologist

John Piersol, M.Sc., P.Geo.
Associate, Senior Hydrogeologist

JLH/JAP/ll

Attachments: Figure 1: Proposed Monitoring Locations – Waterloo North Well Field
Table 1: Proposed Waterloo North Monitoring Locations
Attachment A: Hydrogeological and Natural Environment Report – Regional Municipality of Waterloo, Waterloo North Water Supply Class Environmental Assessment

https://golderassociates.sharepoint.com/sites/105935/project files/6 deliverables/waterloo north pttw support/19119485_fnl wn pttw monitoring support_2019sept30.docx

References

AECOM Canada Ltd. (AECOM), 2011. Waterloo North Water Supply Class EA Environmental Study Report (Final). Dated December 5, 2011.

Golder Associates Ltd. (Golder), 2019. Species at Risk Screening and Natural Heritage Update for Waterloo North Permit to Take Water Monitoring Program. Technical Memorandum.

Golder Associates Ltd. (Golder), 2011. Regional Municipality of Waterloo North Water Supply Class Environmental Assessment – Hydrogeological and Natural Environment Report. Submitted to The Regional Municipality of Waterloo. Dated October 2011.

Stantec Consulting Ltd. (Stantec), 2017. Waterloo North Water Supply Class Environmental Assessment Addendum. Prepared for Region of Waterloo. Dated May 1, 2017.

Stantec Consulting Ltd. (Stantec), 2015. Water Supply Master Plan Update. Prepared for the Regional Municipality of Waterloo.

FIGURES

Figure 1: Proposed Monitoring Locations – Waterloo North Well Field

530000

540000

4820000

4810000

LOBSINGER LINE

KRESSLER ROAD

ARTHUR STREET SOUTH

MARTIN CREEK WETLAND COMPLEX

Martin Creek

Martin Creek

Martin Creek

Paradise Lake

CH94-91

W

7265508

WNOW1-09

BENJAMIN ROAD

Fonvell Creek

STAMM WOODLOT

W25

WNOW3-06

NORTHFIELD DRIVE WEST

KING STREET NORTH

HIGHWAY 85

NORTHFIELD DRIVE EAST

Critter Creek

Cuckoo Creek

Critter Creek

Cooper's Creek

Grand River

BRIDGE STREET WEST

LEXINGTON ROAD

Four Wells Lake

Cedar Creek

Laurel Creek

7265508

CH93-91

WEIMAR LINE

W5A

UWOW4-82

WNOW1-06

Laurel Creek Reservoir

BEARINGER ROAD

WN2-91

8785042

SUNFISH LAKE LAUREL CREEK WETLAND COMPLEX

Sunfish Lake

Columbia Lake

COLUMBIA STREET WEST

WEBER STREET NORTH

UNIVERSITY AVENUE EAST

BRIDGE STREET EAST

WEBER STREET SOUTH

WESTMOUNT ROAD NORTH

Laurel Lake

Silver Lake

KING STREET SOUTH

LC9-91

WM5-93

ERBSVILLE ROAD

Clair Creek

MWWN1-02

W10

Clair Lake

Clair Creek

FISCHER HALLMAN ROAD SOUTH

UNIVERSITY AVENUE WEST

WESTMOUNT ROAD SOUTH

WESTMOUNT ROAD WEST

KING STREET WEST

NOTRE DAME DRIVE

ERB STREET WEST

Maple Hills Creek

Schneider Creek

Victoria Park Lake

VICTORIA STREET SOUTH

ERBS ROAD

Henry Sturm Creek

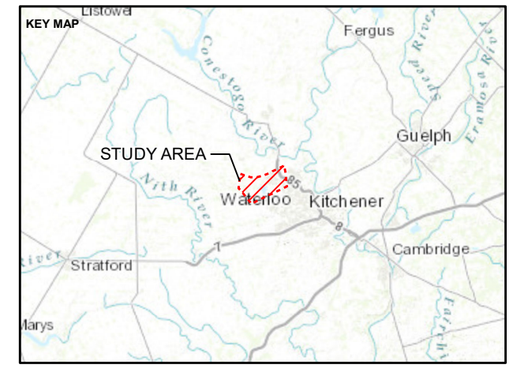
Sandrock Creek

Shoemaker Creek

LEGEND

- Municipal Production Well
- Municipal Monitoring Well
- Private Well
- Proposed Shallow Piezometer/Staff Guage
- GRCA Surface Water Monitoring Station
- Butternut Tree
- Road
- Railway
- Watercourse
- Waterloo North Study Area
- Waterbody
- Wooded Area
- Wetland Area
- Martin Creek Wetland Complex (Provincially Significant)
- Laurel Creek Wetland Complex (Provincially Significant)
- Area of Inferred Shallow Water Table Drawdown

KEY MAP



0 1,500 3,000

1:43,158 METRES

REFERENCE(S)

1. BASE DATA: LIO MNRF OBTAINED 2019
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N
3. BASE MAP: SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT

REGIONAL MUNICIPALITY OF WATERLOO

PROJECT

REGIONAL MUNICIPALITY OF WATERLOO, WATERLOO NORTH PTTW

TITLE

PROPOSED MONITORING LOCATIONS WATERLOO NORTH WELL FIELD

CONSULTANT

GOLDER

YYYY-MM-DD	2019-09-30
DESIGNED	ST
PREPARED	ST
REVIEWED	JLH
APPROVED	JAP

PROJECT NO.	CONTROL	REV.	FIGURE
19119485	-	-	1

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TABLES

Table 1: Proposed Waterloo North Monitoring Locations

SYS_LOC _CODE	REGION ID	MONITORING LOCATION	TYPE	EASTING	NORTHING	TOP SCRN (mbgs)	BOTTOM SCRN (mbgs)	FORMATION SCREENED	MONITORING FREQUENCY
6507089A	WH-EM-CH93-91-A	CH93A-91	Municipal Monitoring Well	530894	4814881	74.7	76.2	Deep Aquifer	Monthly Manual
6507090B	WH-EM-CH93-91-B	CH93B-91	Municipal Monitoring Well	530895	4814881	25.9	30.5	Shallow Overburden	Monthly Manual
6507088A	WH-EM-CH94-91-A	CH94A-91	Municipal Monitoring Well	531306	4816245	73.8	75.3	Deep Aquifer	Monthly Manual
6507088B	WH-EM-CH94-91-B	CH94B-91	Municipal Monitoring Well	531306	4816245	49.4	52.5	Shallow Overburden	Monthly Manual
9150022A	WT-EB-LC9-91-A	LC9A-91	Municipal Monitoring Well	531255	4812326	73.5	76.5	Deep Aquifer	Monthly Manual
9200984B	WT-EB-LC9-91-B	LC9B-91	Municipal Monitoring Well	531224	4812266	15.2	18.3	Shallow Overburden	Monthly Manual
9201414A	W-WN-MWWN1-02-A	MWWN1A-02	Municipal Monitoring Well	535262	4812555	11.9	14.0	Shallow Overburden	Monthly Manual
9203377B	W-WN-MWWN1-06-B	MWWN1B-06	Municipal Monitoring Well	535262	4812555	1.4	4.4	Shallow Overburden	Monthly Manual
9200420A	W-WN-OW4-82-A	UWOW4-82	Municipal Monitoring Well	535172	4814757	35.0	39.6	Deep Aquifer	Hourly Datalogger
9200502A	W-WM-WM05-93-A	WM5A-93	Municipal Monitoring Well	533279	4812287	38.0	41.0	Deep Aquifer	Hourly Datalogger
9200502B	W-WM-WM05-93-B	WM5B-93	Municipal Monitoring Well	533279	4812287	28.9	32.0	Shallow Overburden	Hourly Datalogger
9202655A	W-WN-OW1-06-A	WNOW1A-06	Municipal Monitoring Well	535056	4814647	15.2	18.3	Deep Aquifer	Hourly Datalogger
9202655B	W-WN-OW1-06-B	WNOW1B-06	Municipal Monitoring Well	535057	4814648	4.6	7.6	Shallow Overburden	Hourly Datalogger
9202659A	W-WN-OW3-06-A	WNOW3A-06	Municipal Monitoring Well	534348	4815537	53.3	55.8	Deep Aquifer	Hourly Datalogger
9202659B	W-WN-OW3-06-B	WNOW3B-06	Municipal Monitoring Well	534350	4815538	32.6	35.7	Deep Aquifer	Hourly Datalogger
9202657A	W-WN-TW1-06-A	WNTW1-06	Municipal Monitoring Well	534591	4815773	74.7	78.3	Deep Aquifer	Hourly Datalogger
9200427A	W-WN-OW2-91-A	WN2A-91	Municipal Monitoring Well	533148	4814197	68.0	71.9	Deep Aquifer	Hourly Datalogger
9200427C	W-WN-OW2-91-C	WN2C-91	Municipal Monitoring Well	533148	4814197	33.5	35.0	Deep Aquifer	Hourly Datalogger
9200427D	W-WN-OW2-91-D	WN2D-91	Municipal Monitoring Well	533148	4814197	9.0	10.5	Shallow Overburden	Hourly Datalogger
9205531A	W-WN-OW1-09-A	WNOW1A-09	Municipal Monitoring Well	534530	4816203	75.0	78.0	Deep Aquifer	Hourly Datalogger
9205532B	W-WN-OW1-09-B	WNOW1B-09	Municipal Monitoring Well	534529	4816205	64.0	67.1	Deep Aquifer	Hourly Datalogger
9205533C	W-WN-OW1-09-C	WNOW1C-09	Municipal Monitoring Well	534528	4816208	45.7	48.8	Deep Aquifer	Hourly Datalogger
9205534D	W-WN-OW1-09-D	WNOW1D-09	Municipal Monitoring Well	534527	4816210	14.0	17.1	Shallow Overburden	Hourly Datalogger
		Martin Creek	Shallow Piezometer	534058	4816424			Shallow Overburden	Hourly Datalogger under ice free conditions
			Staff Gauge	534058	4816424			Surface Water	Hourly Datalogger under ice free conditions; Stream Flows 6 times/year

ATTACHMENTS

Attachment A: Hydrogeological and Natural Environment Report – Regional Municipality of Waterloo, Waterloo North Water Supply Class Environmental Assessment

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6507090B	WH-EM-CH93-91-B	CH93B-91	Municipal Monitoring Well	530895	4814881	25.9	30.5	Shallow Overburden	Monthly Manual
6507088A	WH-EM-CH94-91-A	CH94A-91	Municipal Monitoring Well	531306	4816245	73.8	75.3	Deep Aquifer	Monthly Manual
6507088B	WH-EM-CH94-91-B	CH94B-91	Municipal Monitoring Well	531306	4816245	49.4	52.5	Shallow Overburden	Monthly Manual
9150022A	WT-EB-LC9-91-A	LC9A-91	Municipal Monitoring Well	531255	4812326	73.5	76.5	Deep Aquifer	Monthly Manual
9200984B	WT-EB-LC9-91-B	LC9B-91	Municipal Monitoring Well	531224	4812266	15.2	18.3	Shallow Overburden	Monthly Manual
9201414A	W-WN-MWWN1-02-A	MWWN1A-02	Municipal Monitoring Well	535262	4812555	11.9	14.0	Shallow Overburden	Monthly Manual
9203377B	W-WN-MWWN1-06-B	MWWN1B-06	Municipal Monitoring Well	535262	4812555	1.4	4.4	Shallow Overburden	Monthly Manual
9200420A	W-WN-OW4-82-A	UWOW4-82	Municipal Monitoring Well	535172	4814757	35.0	39.6	Deep Aquifer	Hourly Datalogger
9200502A	W-WM-WM05-93-A	WM5A-93	Municipal Monitoring Well	533279	4812287	38.0	41.0	Deep Aquifer	Hourly Datalogger
9200502B	W-WM-WM05-93-B	WM5B-93	Municipal Monitoring Well	533279	4812287	28.9	32.0	Shallow Overburden	Hourly Datalogger
9202655A	W-WN-OW1-06-A	WNOW1A-06	Municipal Monitoring Well	535056	4814647	15.2	18.3	Deep Aquifer	Hourly Datalogger
9202655B	W-WN-OW1-06-B	WNOW1B-06	Municipal Monitoring Well	535057	4814648	4.6	7.6	Shallow Overburden	Hourly Datalogger
9202659A	W-WN-OW3-06-A	WNOW3A-06	Municipal Monitoring Well	534348	4815537	53.3	55.8	Deep Aquifer	Hourly Datalogger
9202659B	W-WN-OW3-06-B	WNOW3B-06	Municipal Monitoring Well	534350	4815538	32.6	35.7	Deep Aquifer	Hourly Datalogger
9202657A	W-WN-TW1-06-A	WNTW1-06	Municipal Monitoring Well	534591	4815773	74.7	78.3	Deep Aquifer	Hourly Datalogger
9200427A	W-WN-OW2-91-A	WN2A-91	Municipal Monitoring Well	533148	4814197	68.0	71.9	Deep Aquifer	Hourly Datalogger
9200427C	W-WN-OW2-91-C	WN2C-91	Municipal Monitoring Well	533148	4814197	33.5	35.0	Deep Aquifer	Hourly Datalogger
9200427D	W-WN-OW2-91-D	WN2D-91	Municipal Monitoring Well	533148	4814197	9.0	10.5	Shallow Overburden	Hourly Datalogger
9205531A	W-WN-OW1-09-A	WNOW1A-09	Municipal Monitoring Well	534530	4816203	75.0	78.0	Deep Aquifer	Hourly Datalogger
9205532B	W-WN-OW1-09-B	WNOW1B-09	Municipal Monitoring Well	534529	4816205	64.0	67.1	Deep Aquifer	Hourly Datalogger
9205533C	W-WN-OW1-09-C	WNOW1C-09	Municipal Monitoring Well	534528	4816208	45.7	48.8	Deep Aquifer	Hourly Datalogger
9205534D	W-WN-OW1-09-D	WNOW1D-09	Municipal Monitoring Well	534527	4816210	14.0	17.1	Shallow Overburden	Hourly Datalogger
		Martin Creek	Shallow Piezometer	534058	4816424			Shallow Overburden	Hourly Datalogger under ice free conditions
			Staff Gauge	534058	4816424			Surface Water	Hourly Datalogger under ice free conditions; Stream Flows 6 times/year

BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

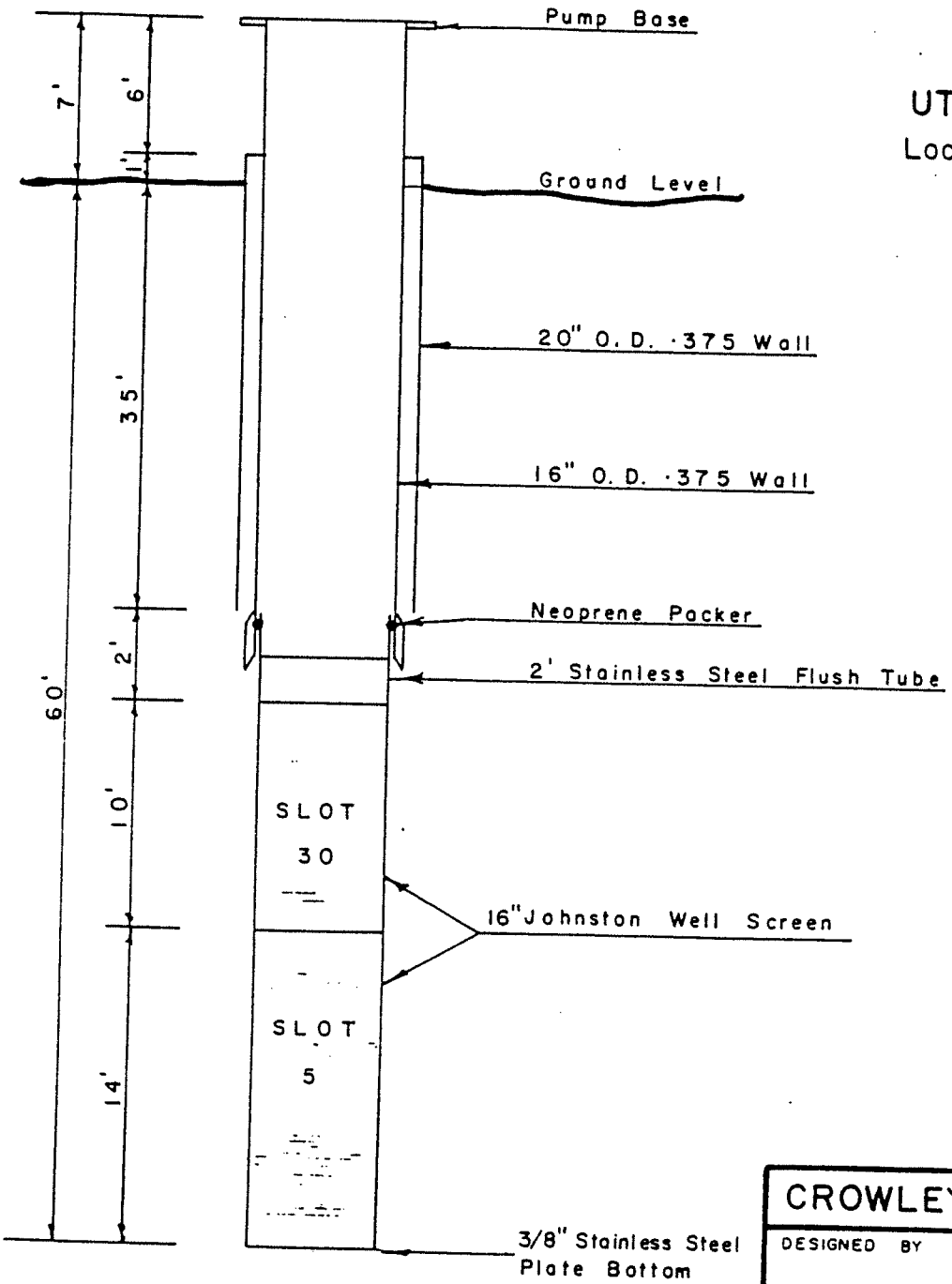
Appendix B

Well Records

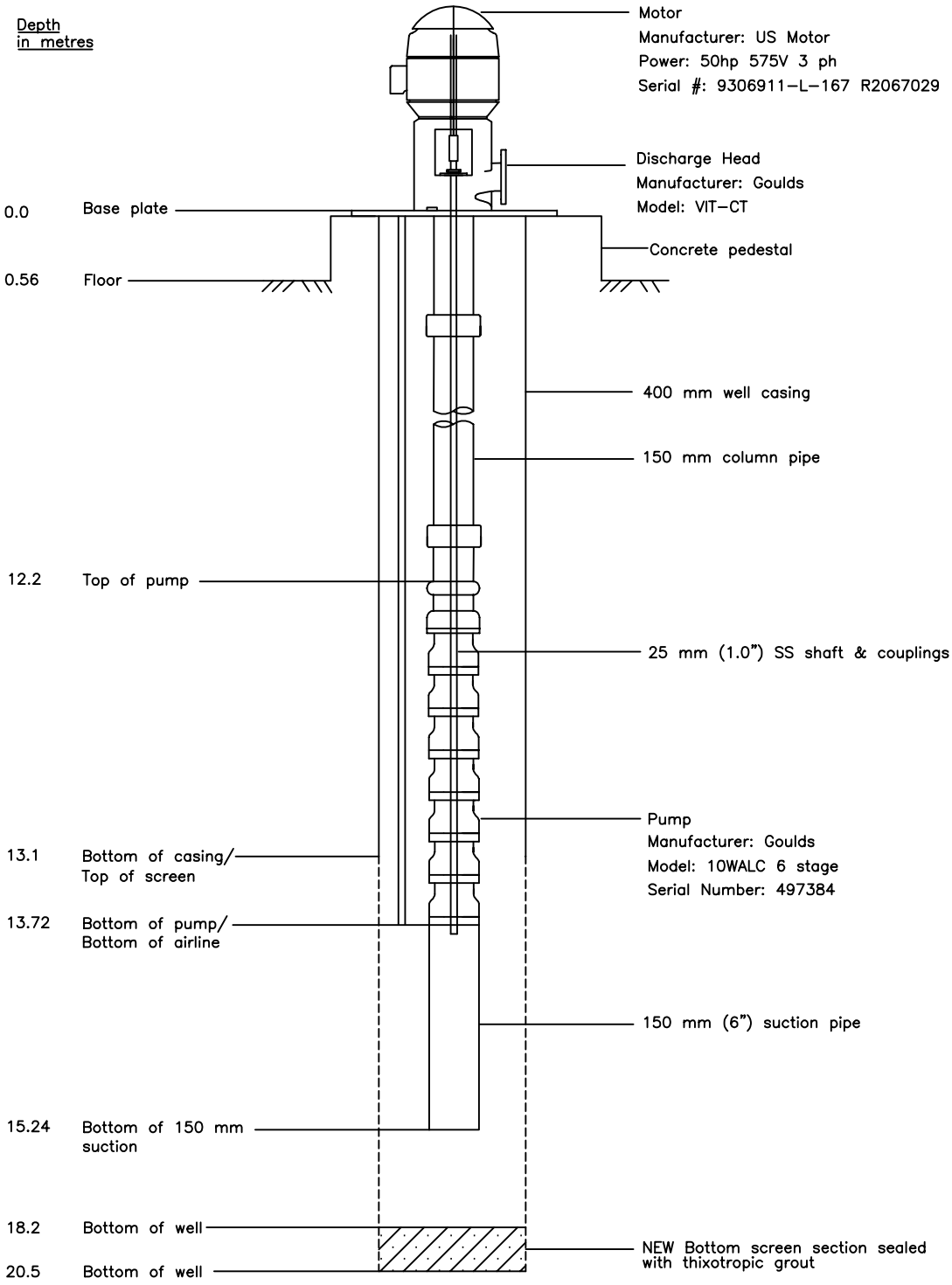
WELL Nº 10

WATERLOO PUBLIC UTILITIES COMMISSION

Location - Hallman Road North
G.C.T. 31



CROWLEY GROUNDWATER LTD.	
DESIGNED BY	REGISTERED PROFESSIONAL ENGINEER R. J. BURNSIDE PROVINCE OF ONTARIO
APPROVED CHAIRMAN:	
MANAGER:	
SCALE: NOT TO SCALE	
DATE: DECEMBER, 1972	



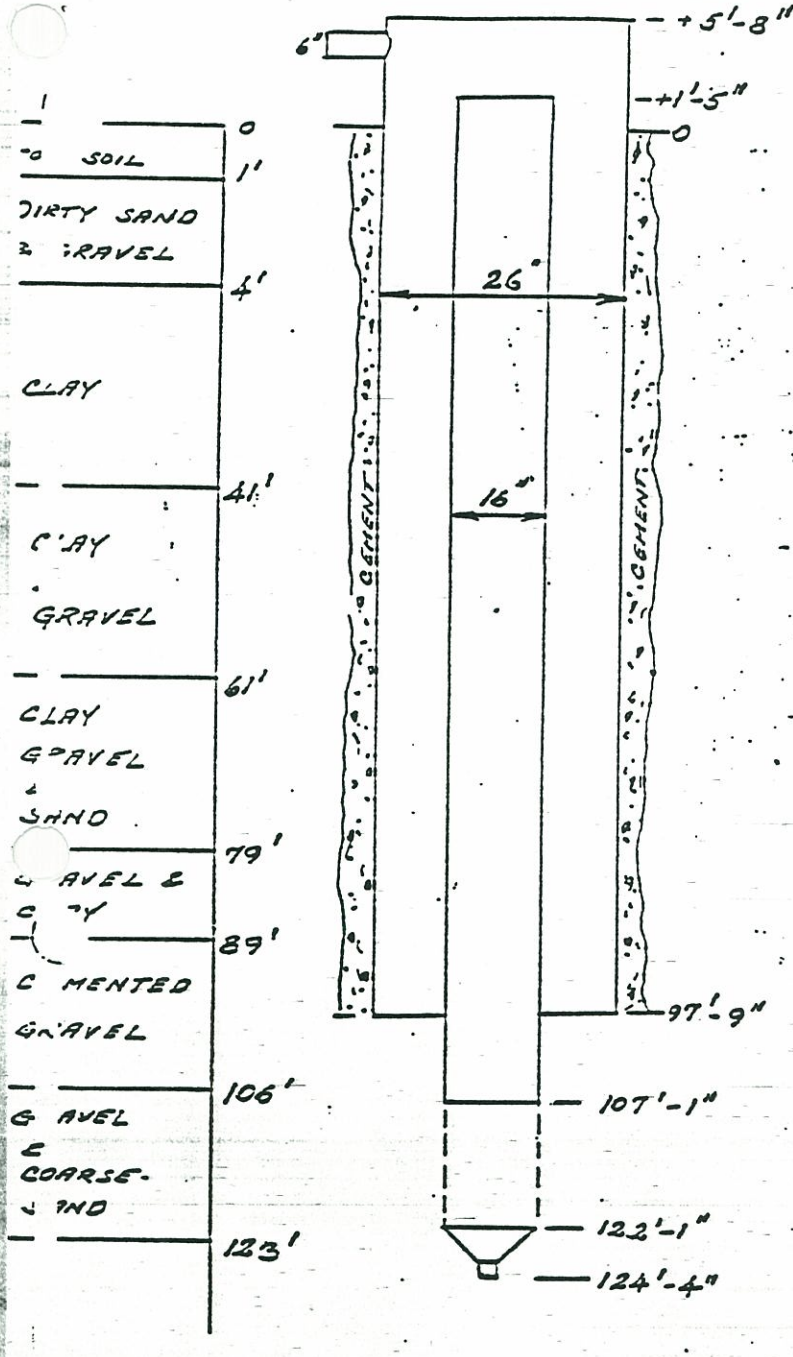
Lotowater
TECHNICAL SERVICES INC.

CLIENT
REGIONAL MUNICIPALITY OF WATERLOO

TITLE
Well W10
Pump installation details

PROJECT No. 006-276			G:\Lotowater Projects\006 Region of Waterloo\276...\Lineshaft installation drawing (W10).dwg		FIGURE 6
DESIGN			REVISION No. 2013/05/21	SCALE N.T.S.	
DRAWN	MO	08/06/23			
CHECKED					

WELL NO. 5



Well Material

W5

Outer Casing	26" ϕ x 103'-5'
Inner Casing	16" ϕ x 108'-6"
Screen	16" ϕ x 15' S.S. #6
Plug	BAKER WASHOUT
Gravel	19 Yds Capc MAX #3

Pump

No.	27258	Setting BP-MB	100'
No. Stages	5	Length Bowl	5'-11"
Bowl	12" RKLHC	Size & Lgth. Suction	8" x
Head	TF 818	Size Column	8" x 2½" x 1½

Materials or setting details other than standard
Pump design cap. 500 IGPM @ 327' & 1?
700 IGPM @ 269' & 1?

Motor

Make	US	Phase	3
Shaft	VHS	Cycles	60
H. P.	75	Volts	550
R. P. M.	1800	Amps.	
Type	CFU	Base	
Frame	445-6	Serial	975505

Special Equipment

Well

B. P. referred to original		Ground Level	+ 4
Started	APRIL 13, 1953	Clear Depth	127'-
Preliminary Test	June 22-26	Length Air Line	1/5
Final Test	NONE	Static Level	+ 17
Guarantee	500 IGPM	Pumping Level	83'-6
Pressure		Capacity	704 IGP

Driller: F. BARNHART 7/15/53

Installer: G Keyes 5/18/55

INTERNATIONAL WATER SUPPLY LTD.
LONDON, CANADA
WATER SUPPLY CONTRACTORS

WATERLOO PUC, ONT.,

W5

DRAWN BY CNL

APPROVED BY

W5A

Ontario Ministry of the Environment

Well Tag Number: A011225 / A011225

Well Record

Regulation 903 Ontario Water Resources Act

page 1 of 1

Instructions for Completing Form

- For use in the **Province of Ontario** only. This document is a permanent **legal** document. Please retain for future reference.
- All Sections **must** be completed in full to avoid delays in processing. Further instructions and explanations are available on the back of this form.
- Questions regarding completing this application can be directed to the Water Well Management Coordinator at 416-235-6203.
- **All metre measurements shall be reported to 1/10th of a metre.**
- Please print clearly in blue or black ink only.

Ministry Use Only

MUN | CON | LOT

Well Owner's Information and Location of Well Information

First Name	Last Name	Mailing Address (Street Number/Name, RR, Lot, Concession)
REGION OF	WATERLOO	150 FREDERICK ST.

County/District/Municipality	Township/City/Town/Village	Province	Postal Code	Telephone Number (include area code)
WATERLOO	KITCHENER	Ontario	N2G 4J3	519 575 4550

Address of Well Location (County/District/Municipality)	Township	Lot	Concession
WATERLOO		26	GCT

RR#/Street Number/Name	City/Town/Village	Site/Compartment/Block/Tract etc.
WESTMOUNT RD NORTH	WATERLOO	

GPS Reading: NAD 83 | Zone 17 | Easting 535071 | Northing 4814444 | Unit Make/Model MAGELLAN | Mode of Operation: [X] Undifferentiated [ ] Averaged [ ] Differentiated, specify

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	Depth From	Depth To (Metres)
	RE-BUILD WELL WS	REGION OF WATERLOO (ORIGINAL 1953)			
	INSTALL	NEW INNER	CASING, SCREEN & WELL GRAVEL		

Hole Diameter

Depth From (Metres)	Depth To (Metres)	Diameter (Centimetres)

Water Record

Water found at ___ Metres / Kind of Water

- ___ m: [ ] Fresh [ ] Sulphur [ ] Gas [ ] Salty [ ] Minerals [ ] Other:
- ___ m: [ ] Fresh [ ] Sulphur [ ] Gas [ ] Salty [ ] Minerals [ ] Other:
- ___ m: [ ] Fresh [ ] Sulphur [ ] Gas [ ] Salty [ ] Minerals [ ] Other:

After test of well yield, water was: [ ] Clear and sediment free [ ] Other, specify

Chlorinated [ ] Yes [ ] No

Construction Record

Inside diam centimetres	Material	Wall thickness centimetres	Depth From (Metres)	Depth To (Metres)
Casing				
641	[X] Steel [ ] Fibreglass [ ] Plastic [ ] Concrete [ ] Galvanized	1.0	+0.41	31.1
387	[X] Steel [ ] Fibreglass [ ] Plastic [ ] Concrete [ ] Galvanized	1.0	+0.41	34.4
	[ ] Steel [ ] Fibreglass [ ] Plastic [ ] Concrete [ ] Galvanized			
Screen				
Outside diam		Slot No.		
406	[X] Steel [ ] Fibreglass [ ] Plastic [ ] Concrete [ ] Galvanized	60	34.4	39.0
No Casing or Screen				
	[ ] Open hole			

Test of Well Yield

Pumping test method	Draw Down Time min	Draw Down Water Level Metres	Recovery Time min	Recovery Water Level Metres
Pump intake set at - (metres)	Static Level	FLOW		
Pumping rate - (litres/min) 25 23	1		1	15.40
Duration of pumping 72 hrs + 0 min	2	7.80	2	14.11
Final water level end of pumping 24.07 metres	3		3	13.77
Recommended pump type. [ ] Shallow [ ] Deep	4	7.84	4	13.26
Recommended pump depth. ___ metres	5	8.84	5	13.25
Recommended pump rate. (litres/min)	10	9.99	10	11.22
If flowing give rate - (litres/min)	15		15	
	20	11.71	20	9.40
	25	12.01	25	8.76
If pumping discontinued, give reason.	30	12.77	30	8.29
	40	13.71	40	7.44
	50	14.36	50	6.76
	60	14.89	60	6.24

Plugging and Sealing Record

[ ] Annular space [ ] Abandonment

Depth set at - Metres From	Depth set at - Metres To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)

Method of Construction

[X] Cable Tool [ ] Rotary (air) [ ] Diamond [ ] Digging
[ ] Rotary (conventional) [ ] Air percussion [ ] Jetting [ ] Other
[ ] Rotary (reverse) [ ] Boring [ ] Driving

Water Use

[ ] Domestic [ ] Industrial [ ] Public Supply [ ] Other
[ ] Stock [ ] Commercial [ ] Not used
[ ] Irrigation [X] Municipal [ ] Cooling & air conditioning

Final Status of Well

[X] Water Supply [ ] Recharge well [ ] Unfinished [ ] Abandoned, (Other)
[ ] Observation well [ ] Abandoned, insufficient supply [ ] Dewatering
[ ] Test Hole [ ] Abandoned, poor quality [ ] Replacement well

Well Contractor/Technician Information

Name of Well Contractor	Well Contractor's Licence No.
INTERNATIONAL WATER SUPPLY	2801

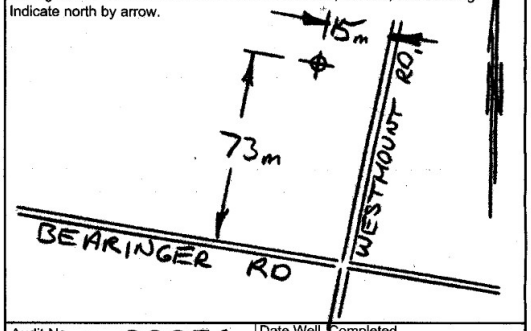
Business Address (street name, number, city etc.): PO BOX 310 BARRIE ON L4M4T5

Name of Well Technician (last name, first name)	Well Technician's Licence No.
WALTER NOBES	T0115

Signature of Technician/Contractor: X [signature] — Date Submitted: 2006 11 30

Location of Well

In diagram below show distances of well from road, lot line, and building. Indicate north by arrow.



Audit No. Z 33271 | Date Well Completed: 2006 11 17

Was the well owner's information package delivered? [ ] Yes [X] No | Date Delivered

Ministry Use Only

Data Source	Contractor: 2801
Date Received: DEC 15 2006	Date of Inspection
Remarks	Well Record Number

0506E (09/03) Contractor's Copy [ ] Ministry's Copy [X] Well Owner's Copy [ ]

Cette formule est disponible en français

PROJECT: 08-1112-0134

BOREHOLE LOG OF: WNTP1-09

SHEET 1 OF 2

LOCATION: N 4815767.6 ;E 534593.9

DRILLING DATE: April 3, 2009

DRILL RIG: Mud Rotary

DRILLING CONTRACTOR: Davidson Drilling Ltd.

DATUM: Geodetic

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD: GAMMA (cps) 40 80 120 160	GEOPHYSICAL RECORD: CONDUCTIVITY (mS/m) 20 40 60 80	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE		355.41			
	Light brown, silty SAND		0.00			
			350.51			
5	Light brown, silty SAND, some clay, trace gravel (TILL)		4.90			
10			341.41			
	Light brown to grey brown, silty SAND, some clay, trace gravel (TILL)		14.00			
15						
20						
25			329.21			Grout / Cement / Grout
	Light grey, SILTY CLAY		26.20			
			326.01			
30	Grey, sandy SILT, some clay, trace gravel (TILL)		29.40			
35						
40						
45			308.71			
	Light brown, silty SAND, some clay		46.70			
50			305.41			
	CONTINUED NEXT PAGE					

DEPTH SCALE

1 : 250

Golder Associates

LOGGED: BH

CHECKED: DN

MIS-HYD 003 08-1112-0134.GPJ GAL-MISS.GDT 10/6/11 RJ

PROJECT: 08-1112-0134

BOREHOLE LOG OF: WNTP1-09

SHEET 2 OF 2

LOCATION: N 4815767.6 ;E 534593.9

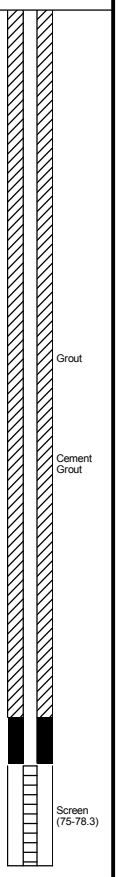
DRILLING DATE: April 3, 2009

DRILL RIG: Mud Rotary

DRILLING CONTRACTOR: Davidson Drilling Ltd.

DATUM: Geodetic

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD: GAMMA (cps) 40 80 120 160	GEOPHYSICAL RECORD: CONDUCTIVITY (mS/m) 20 40 60 80	PIEZOMETER OR STANDPIPE INSTALLATION
	--- CONTINUED FROM PREVIOUS PAGE ---					
50	Grey brown, SILTY CLAY with sand		50.00			
55			297.31			
	Grey/brown, silty SAND, trace clay, trace gravel		58.10			
60			294.45			
	Grey/brwon, medium to fine silty SAND, trace clay		60.96			
			292.93			
	Grey, medium silty SAND, some clay		62.48			
65			289.88			
	Grey/brown, medium silty SAND, some clay, trace gravel		65.53			
70			283.78			
	Brown/tan, medium to fine SAND, some clay and silt, trace gravel		71.63			
			282.31			
	Brown, fine SAND and SILT, trace medium sand		73.10			
			280.81			
75	Brown, medium SAND, some silt, trace gravel		74.60			
			279.21			
	Grey, medium to coarse SAND, some gravel		76.20			
	Some shale/dolostone fragments below 77.7 m depth		277.08			
	END OF BOREHOLE		78.33			
80						
85						
90						
95						
100						



DEPTH SCALE

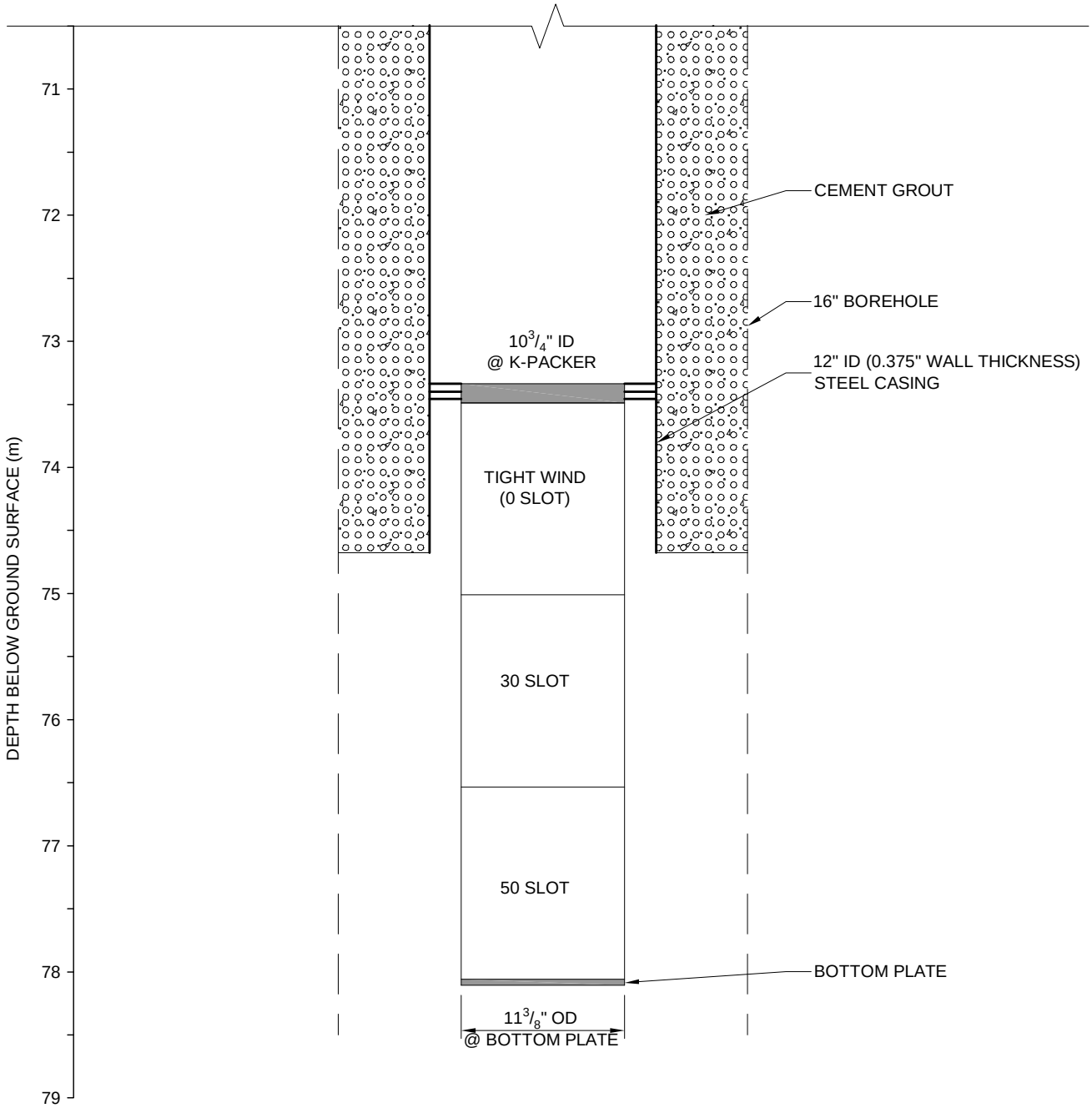
1 : 250

Golder Associates

LOGGED: BH

CHECKED: DN

MIS-HYD 003 08-1112-0134.GPJ GAL-MISS.GDT 10/6/11 RJ



Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	6-Oct-11
DESIGN	KD
CAD	KD/RJ
CHECK	DN
REVIEW	SMD

TITLE

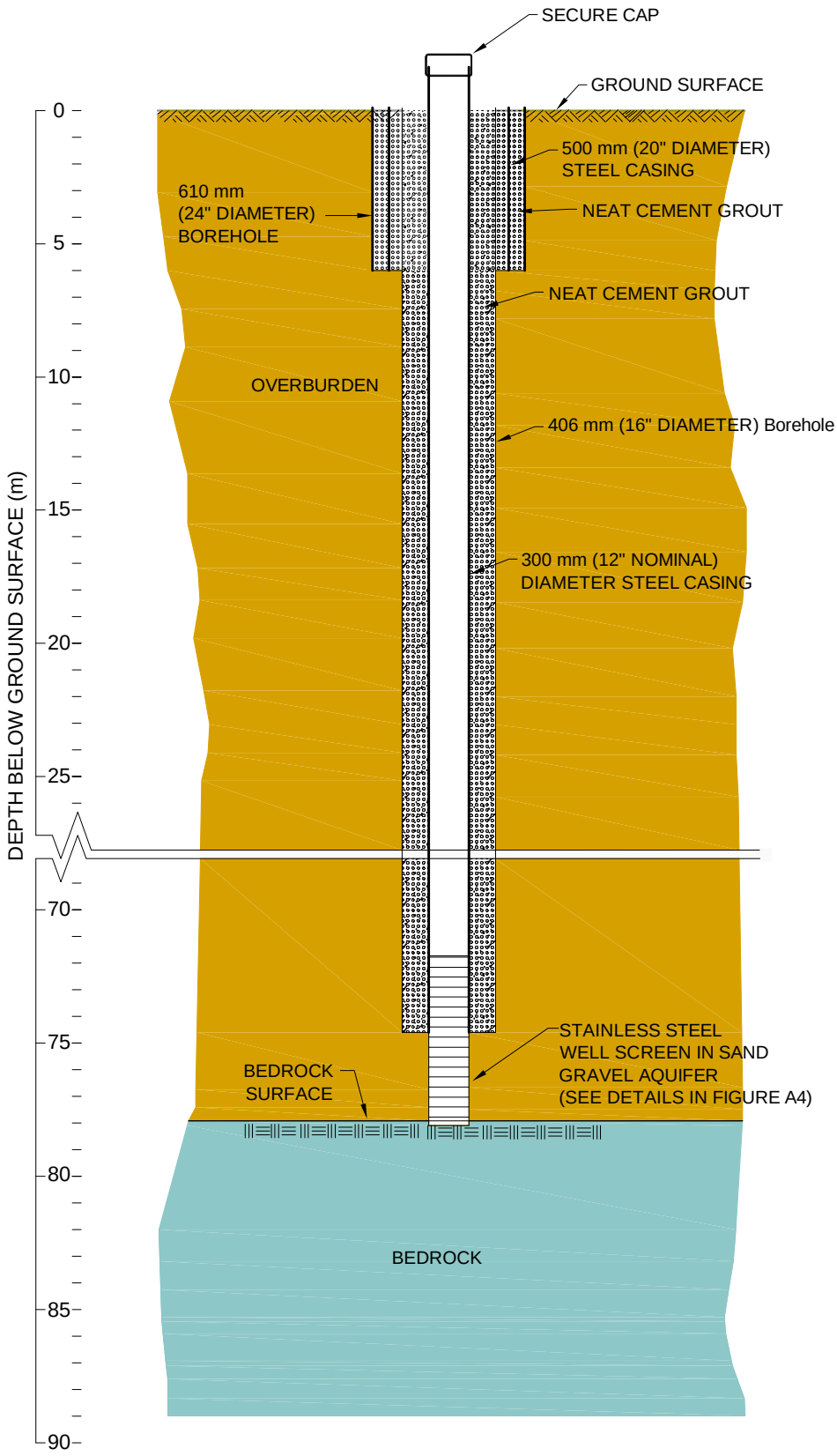
AS-CONSTRUCTED WELL SCREEN DETAIL OF WNTP1-09

FILE No. 0811120134GD0A4.dwg
PROJECT No. 08-1112-0134 REV. A

REGIONAL MUNICIPALITY OF WATERLOO
WATERLOO NORTH WATER SUPPLY CLASS EA

FIGURE **A4**

PLOT DATE: October 07, 2011
FILENAME: T:\Projects\2008\08-1112-0134 (Earth Tech, Waterloo)\-GD- Hydrogeology\0811120134GD0A4.dwg



Golder Associates
Mississauga, Ontario, Canada

FILE No.	0811120134GD0A5.dwg
PROJECT No.	08-1112-0134
REV.	A

SCALE	AS SHOWN
DATE	6-Oct-11
DESIGN	KD
CAD	KD/RJ
CHECK	DN
REVIEW	SMD

TITLE

AS-CONSTRUCTED DIAGRAM OF WNTP1-09

REGIONAL MUNICIPALITY OF WATERLOO
WATERLOO NORTH WATER SUPPLY CLASS EA

FIGURE **A5**

PLOT DATE: October 07, 2011
FILENAME: T:\Projects\2008\08-1112-0134 (Earth Tech, Waterloo)\-GD- Hydrogeology\0811120134GD0A5.dwg

WH-EM-CH94-91-(A-B)

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER	WELL NUMBER	
ONT 29307.KO	CH 94 A & B	PAGE 1 OF 4

MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St. Jacobs
CLIENT: Region of Waterloo
LOCATION: Henry B. Weber Farm, Twp. Rd # 40, Erbsville
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
DRILLING METHOD AND EQUIPMENT: Gardner Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DATE: 20/03/91
LOGGER: Peter Lamont
ELEVATION: -GROUND SURFACE:
-TOP OF RISER PIPE: A 368.264
B 368.314

DEPTH BELOW SURFACE (METRES)	SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION (CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL& GRADATION, GROUT INTERVAL, ETC.)
		CH 94 B CH 94 A protective casing
2	**CLAYEY SAND** (0 - 3.05 m) brown	**GROUT** (0 - 42.67 m)
4	**SANDY CLAY** (3.05 - 11.28 m) grey, soft	
6		
8		
10	10.06 m: sand layer	
12	**SAND & GRAVEL** (11.28 - 13.11 m) minor clay	
14	**STREAKY SAND & CLAY** (13.11 - 23.77 m)	
16	14.02 - 15.24 m: cobbles	
18	18.29 m: increasing clay content, hard drilling	
20		

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER	WELL NUMBER	
ONT 29307.KO	CH 94 A & B	PAGE 2 OF 4

MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St Jacobs
CLIENT: Region of Waterloo.
LOCATION: Henry B. Weber Farm, Twp. Rd # 40, Erbsville
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
DRILLING METHOD AND EQUIPMENT: Gardner-Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DATE: 20/03/91
LOGGER: Peter Lamont
ELEVATION: -GROUND SURFACE:
-TOP OF RISER PIPE:

DEPTH BELOW SURFACE (METRES)	SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION (CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL& GRADATION, GROUT INTERVAL, ETC.)
22	**STREAKY SAND & CLAY** (13.11 - 23.77 m) 22.56 - 22.86 m: sand layer	GROUT (0 - 42.67 m)
24	**SAND & GRAVEL** (23.77 - 28.04 m)	
26		
28	**CLAY** (28.04 - 33.53 m) very dense	
30		
32		
34	**COBBLE & CLAY** (33.53 - 47.24 m)	
36	sandy / silty 33.53 - 38.10 m: cobble	
38		
40		
42		

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER	WELL NUMBER	
ONT 29307.KO	CH 94 A & B	PAGE 3 OF 4

MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St. Jacobs
CLIENT: Region of Waterloo
LOCATION: Henry B. Weber Farm, Twp. Rd # 40, Erbsville
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
DRILLING METHOD AND EQUIPMENT: Gardner-Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DATE: 20/03/91
LOGGER: Peter Lamont
ELEVATION: -GROUND SURFACE:
-TOP OF RISER PIPE:

DEPTH BELOW SURFACE (METRES)	SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION (CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL& GRADATION, GROUT INTERVAL, ETC.)
44	**COBBLE & CLAY** (33.53 - 47.24 m)	FILTER PACK (42.67 - 54.86 m)
46	46.94 - 47.24 m: sand layer	natural material cave in
48	**STONEY CLAY** (47.24 - 49.99 m) sandy, streaky sand & gravel; 49.38 m: gravel streaks	
50	**SAND & GRAVEL** (49.99 - 53.34 m) 49.99 - 50.90 m: crse. sand & fn. gravel, mud loss; 50.90 - 53.34 m: gravel, med. - crse	SCREEN B (50.29 - 53.34 m)
52		
54	**CLAY** (53.34 - 62.48 m) soft, occasional cobble	BENTONITE SEAL (54.86 - 73.46 m)
56		
58		
60		
62		
64	**CLAY** (62.48 - 73.76 m) very hard, slow drilling	
66		

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER	WELL NUMBER	
ONT 29307.KO	CH 94 A & B	PAGE 4 OF 4

MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St. Jacobs
CLIENT: Region of Waterloo
LOCATION: Henry B. Weber Farm, Twp. Rd # 40, Erbsville
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
DRILLING METHOD AND EQUIPMENT: Gardner-Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DATE: 20/03/90
LOGGER: Peter Lamont
ELEVATION: -GROUND SURFACE:
-TOP OF RISER PIPE:

DEPTH BELOW SURFACE (METRES)	SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION (CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL & GRADATION, GROUT INTERVAL, ETC.)
68	**CLAY** (62.48 - 73.76 m) very hard, slow drilling	BENTONITE SEAL (54.86 - 73.46 m)
70		
72		
74	**COBBLE & CLAY** (73.76 - 75.59 m)	FILTER PACK (73.46 - 76.81 m)
76	**GRAVEL & COBBLE** (75.59 - 77.72 m)	SCREEN A (74.68 - 76.20 m)
78	**BEDROCK** (77.72 - 81.69 m) shale - blue / green	BENTONITE SEAL (76.81 - 81.69 m)
80	81.69 m: limestone	
82		
84		
86		
88		

WH-EM-CH93-91-A

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER	WELL NUMBER	
ONT 29307.KO	CH 93 A	PAGE 1 OF 4

MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St. Jacobs
CLIENT: Region of Waterloo
LOCATION: W. R. Martin Farm, Reg. Rd. # 16, Erbsville
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
DRILLING METHOD AND EQUIPMENT: Gardner Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DATE: 05/03/91
LOGGER: Peter Lamont
ELEVATION: -GROUND SURFACE:
-TOP OF RISER PIPE: 368.546

DEPTH BELOW SURFACE (METRES)	SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION (CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL & GRADATION, GROUT INTERVAL, ETC.)
		CH 93 A protective casing
2	**BROWN CLAY** (0 - 2.74 m)	GROUT (0 - 37.49 m)
4	**SAND & SILT** (2.74 - 5.18 m) minor brown clay, soft	
6	**GREY CLAY** (5.18 - 11.58 m) soft	
8		
10		
12	**BROWN CLAY** (11.58 - 17.37 m) brown clay & silt soft streaks	
14		
16		
18	**SILTY SAND** (17.37 - 22.25 m) grey	
20		

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER	WELL NUMBER	
ONT 29307.KO	CH 93 A	PAGE 2 OF 4

MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St Jacobs
CLIENT: Region of Waterloo.
LOCATION: W. R. Martin Farm, Reg. Rd. # 16, Erbsville
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
DRILLING METHOD AND EQUIPMENT: Gardner-Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DATE: 05/03/91
LOGGER: Peter Lamont
ELEVATION: -GROUND SURFACE:
-TOP OF RISER PIPE: **368.546**

DEPTH BELOW SURFACE (METRES)	SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION (CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL & GRADATION, GROUT INTERVAL, ETC.)
22	**SILTY SAND** (17.37 - 22.25 m) grey	
24	**SILTY SAND** (22.25 - 35.66 m) harder drilling than above 28.65 - 28.96 m: sand & gravel streak 28.96 - 35.66 m: streaky sand & gravel	
26		
28		GROUT (0 - 37.49 m)
30		
32		
34		
36	**GREY CLAY** (35.66 - 42.67 m) hard	
38	38.71 m: cobble	SAND & BENTONITE SEAL (37.49 - 68.58 m)
40	39.93 m: very hard drilling, dense	
42	42.67 m: less dense drilling increasing % cobble	

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER	WELL NUMBER	
ONT 29307.KO	CH 93 A	PAGE 3 OF 4

MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St. Jacobs
CLIENT: Region of Waterloo
LOCATION: W. R. Martin Farm, Reg. Rd. # 16, Erbsville
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
DRILLING METHOD AND EQUIPMENT: Gardner-Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DATE: 05/03/91
LOGGER: Peter Lamont
ELEVATION: -GROUND SURFACE:
-TOP OF RISER PIPE: 368.546

DEPTH BELOW SURFACE (METRES)	SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION (CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL& GRADATION, GROUT INTERVAL, ETC.)
44	**SANDY CLAY SILT TILL** (42.67 - 71.32 m)	
46	grey	
	44.50 m: cobble	
48	45.72 - 47.85 m: streaky - hard/soft drilling	SAND & BENTONITE SEAL (37.49 - 68.58 m)
50		
52		
54	54.86 m: streaky clay till & gravel	
56	55.47 - 57.30 m: sandy	
	57.30 - 71.32 m: very slow hard drilling	
58		
60		
62		
64		
66		

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER	WELL NUMBER	
ONT 29307.KO	CH 93 A	PAGE 4 OF 4

MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St. Jacobs
CLIENT: Region of Waterloo
LOCATION: W. R. Martin Farm, Reg. Rd. # 16, Erbsville
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
DRILLING METHOD AND EQUIPMENT: Gardner-Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DATE: 05/03/90
LOGGER: Peter Lamont
ELEVATION: -GROUND SURFACE:
-TOP OF RISER PIPE: 368.546

DEPTH BELOW SURFACE (METRES)	SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION (CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL & GRADATION, GROUT INTERVAL, ETC.)
68	**SANDY CLAY SILT TILL** (42.67 - 71.32 m) grey 57.30 - 71.32 m: very hard, slow drilling	BENTONITE SEAL (68.58 - 74.37 m)
70		
72	**SAND & GRAVEL** (71.32 - 72.24 m)	
	CLAY TILL (72.24 - 72.85 m) stoney	
74	**BEDROCK** (72.85 - 77.11 m) 72.85 - 73.76 m: limestone	FILTER PACK (74.37 - 76.50 m)
76	73.76 - 77.11 m: shale, blue & grey, minor limestone	SCREEN A (74.98 - 76.50 M)
78		
80		
82		
84		
86		
88		

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER	WELL NUMBER	
ONT 29307.KO	CH 93 B	PAGE 1 OF 2

MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St. Jacobs
CLIENT: Region of Waterloo
LOCATION: W. R. Martin Farm, Reg. Rd. # 16, Erbsville
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
DRILLING METHOD AND EQUIPMENT: Gardner Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DATE: 05/03/91
LOGGER: Peter Lamont
ELEVATION: -GROUND SURFACE:
-TOP OF RISER PIPE: 368.582

DEPTH BELOW SURFACE (METRES)	SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION (CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL & GRADATION, GROUT INTERVAL, ETC.)
		CH 93 B protective casing
2	**BROWN CLAY** (0 - 2.74 m)	BENTONITE SEAL (0 - 18.29 m)
4	**SAND & SILT** (2.74 - 5.18 m) minor brown clay, soft	
6	**GREY CLAY** (5.18 - 11.58 m) soft	
8		
10		
12	**BROWN CLAY** (11.58 - 17.37 m) brown clay & silt	
14	soft streaks	
16		
18	**SILTY SAND** (17.37 - 22.25 m) grey	FILTER PACK (18.29 - 33.53 m)
20		

CH2M HILL ENGINEERING LTD.

PROJECT NUMBER	WELL NUMBER	
ONT 29307.KO	CH 93 B	PAGE 2 OF 2

MONITORING WELL DRILLING & CONSTRUCTION LOG

PROJECT: Elmira / St Jacobs
CLIENT: Region of Waterloo.
LOCATION: W. R. Martin Farm, Reg. Rd. # 16, Erbsville
DRILLING CONTRACTOR: Davidson Well Drilling Ltd.
DRILLING METHOD AND EQUIPMENT: Gardner-Denver 15 mud rotary drill rig with 6- 5/8 " tricone bit and 4" drill pipe

DATE: 05/03/91
LOGGER: Peter Lamont
ELEVATION: -GROUND SURFACE:
-TOP OF RISER PIPE: 368.582

DEPTH BELOW SURFACE (METRES)	SAMPLE DESCRIPTION AND DRILLING OBSERVATIONS	WELL CONSTRUCTION (CASING, DIAMETER, SCREEN INTERVAL, SLOT SIZE, GRAVEL PACK INTERVAL & GRADATION, GROUT INTERVAL, ETC.)
22	**SILTY SAND** (17.37 - 22.25 m) grey	FILTER PACK (18.29 - 33.53 m)
24	**SILTY SAND** (22.25 - 35.66 m) harder drilling than above 28.65 - 28.96 m: sand & gravel streak 28.96 - 35.66 m: streaky sand & gravel	
26		SCREEN B (25.91 - 30.48 m)
28		
30		
32		
34		BENTONITE SEAL (33.53 - 35.05 m)
36	**GREY CLAY** (35.66 - 42.67 m) hard 38.71 m: cobble 39.93 m: very hard drilling, dense	
38		
40		
42	42.67 m: less dense drilling increasing % cobble	

WT-EB-LC9-91-A

Terraqua Investigations Ltd.

pg1

BOREHOLE NO.: **LC9 (Deep) (Monastery Well)**

PROJECT : Waterloo North Aquifer System Study / Laurel Creek Watershed Study

PROJECT NO.: TA91328 / TA90284

DATE: November 1–7, 1991

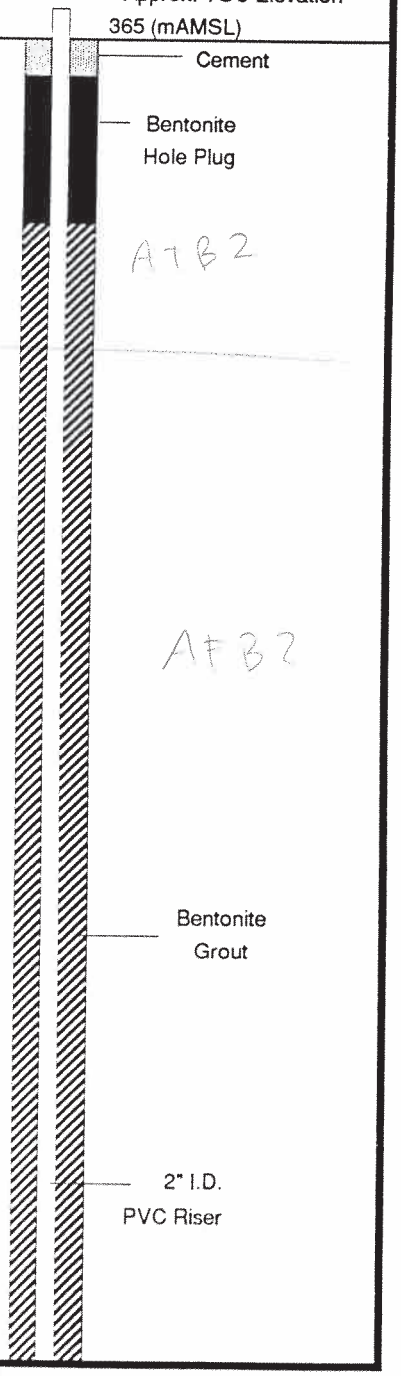
DRILLING METHOD: 5" Dia. Tricone Mud Rotary

TERRAQUA SUPERVISOR: S. Anderson, E. Sherlock

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	blow count	rec
	0	0	364.00				
SILT TILL: Dark brown, sandy, some stones and granules, dense dry.				1	SS	2–4–13	8"
		2		2	SS	3–16–21	10"
	10						
SILT: light brown, sandy, some clay, dry to moist.		4		3	SS	6–23–39	5"
				4	SS	3–28–24	6"
	20	6					
SAND: light brown, fine grained, clean, structureless, wet.				5	SS	4–21–30	10"
		8		6	SS	13–22–28	18"
	30						
		10		7	SS	6–19–29	18"
				8	SS	3–23–60	18"
	40	12					
SILT: dark brown grey, sandy, structureless primarily, some laminated zones, wet.				9	SS	8–30	12"
		14		10	SS	11–22–32	18"
	50						
		16		11	SS	12–22–37	18"
				12	SS	7–11–11	18"
		18					
	60			13	SS	9–8–13	18"
		20					
	70						
		22					
SAND: silty, grey, laminated some clay, wet							
		24		1	SS	32–77	10"
	80						

Samples 1–13 from Shallow Borehole (LC9–I)

GROUNDWATER MONITOR



Terraqua Investigations Ltd.

BOREHOLE NO.: **LC9 (Deep) (Monastery Well)**

PROJECT : Waterloo North Aquifer System Study / Laurel Creek Watershed Study

PROJECT NO.: TA91328 / TA90284 DATE: November 1–7, 1991

DRILLING METHOD: 5" Dia. Tricone Mud Rotary TERRAQUA SUPERVISOR: S. Anderson, E. Sherlock

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	blow count	rec	GROUNDWATER MONITOR
	80		339.62					
SAND: grey, fine to medium grained, structureless. little fines	90	26 28 30		2	SS	35–52	8"	AT82
	100		333.52					
CLAY TILL: dark brown, very dense, some silt and granules, trace stones (MARYHILL TILL)	110	32 34 36		3	SS	27–50(3")	9"	AT83
	120		327.4 36.6	4	SS	38–42	10"	
SILT TILL: stony, dark brown, some clay (CATFISH CREEK TILL ?)	130	38 40 42		5	SS	95	6"	Bentonite Grout AT81
	140		43.0 321.0					
SAND: coarse grained, grey, some fine grained sand and silt, structureless.	150	44 46	45.8 319.2	6	SS	50–47	8"	
SILT TILL: dark brown, very dense, some stones and granules (CATFISH CREEK TILL)	160	48		7	SS	69–50(3")	8"	AT81 2" I.D. PVC Riser

Terraqua Investigations Ltd.

BOREHOLE NO.: **LC9 (Deep) (Monastery Well)**

PROJECT : Waterloo North Aquifer System Study / Laurel Creek Watershed Study

PROJECT NO.: TA91328 / TA90284 DATE: November 1–7, 1991

DRILLING METHOD: 5" Dia. Tricone Mud Rotary TERRAQUA SUPERVISOR: S. Anderson, E. Sherlock

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	blow count	rec	GROUNDWATER MONITOR
	160		315.23					
SILT TILL: dark brown, very dense, some sand & stones. (CATFISH CREEK TILL)	170	50 / 52						2" I.D. PVC Riser
	180	54		8	SS	150(1")	0	
		56		9	SS	150(4")	3"	
	190	58						
		60		10	SS	180(5")	0	
	200		303.0					
CEMENTED SAND AND GRAVEL: dense, silty, grey sand is coarse graded, with incorporated till		62						Bentonite Grout
	210	64		11	SS	180(3")	2"	
		66						
	220	68		12	SS	125	5"	
	230	70						Graded Sand
		72		13	SS	175(5")	4"	
	240							

Terraqua Investigations Ltd.

BOREHOLE NO.: **LC9 (Deep) (Monastery Well)**

PROJECT : Waterloo North Aquifer System Study / Laurel Creek Watershed Study

PROJECT NO.: TA 91328 / TA90284 DATE: November 1–7, 1991

DRILLING METHOD: 5" Dia. Tricone Mud Rotary TERRAQUA SUPERVISOR: S. Anderson, E. Sherlock

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	blow count	rec	GROUNDWATER MONITOR
	240		290.85					
CEMENTED SAND AND GRAVEL: dense, silty, grey sand is coarse graded, with some incorporated till	250	74 76 78	286.0	14	SS	130	6"	2" PVC Well Screen No. 10 slot; Graded Sand; Bentonite Hole Plug
CLAY TILL: dark brown–red, some silt, (CANNING TILL)	260	80	282.6	15	SS	19–31–33	14"	Cave Material
SILT/SAND TILL & SAND AND GRAVELS: some silt and clay	270 280 290	82 84 86 88		16	SS	142	6"	2" PVC Riser Pipe; Bentonite Hole Plug and Cave Material
SHALE: green, weathered, fissile	300	90	274.1	17	SS	260(5")	5"	
End of Hole	310 320	92 94 9	272.6					

WT-EB-LC9-91-(B-C)

pick added.

Terraqua Investigations Ltd. | **BOREHOLE NO.: LC 9** (pg. 1 of 3)

PROJECT: LAUREL CREEK WATERSHED STUDY

PROJECT NO.: TA 90284 DATE: Sept 6, 1991

DRILLING METHOD: 4 1/4" I.D. Hollow-Stem Auger TERRAQUA SUPERVISOR: E. Sherlock

DEPTH Feet	DEPTH Metres	DESCRIPTION	ELEV. Metres (AMSL)	SAMPLES NO.	TYPE	INT.	REC	BLOW COUNT	GROUND WATER MONITOR
									B C
									gl gs
									TOC Elev. 365.75 365.75 mAMSL
0	0		365.00						
		TOPSOIL: dark brown, silty sand with granules, stones and organics.		1	SS		8"	2-4-13	Cement; 2" I.D. PVC Riser - flush threaded
	1								Bentonite Seal
5		SILT TILL: dark brown, sandy, with granules, stones and stringers of fine sand, laminations, dense, dry.		2	SS		10"	3-16-21	
	2								
10	3	SILT: light brown, sandy (fine grained), trace to some clayey silt in clasts, some laminations, dry to moist.		3	SS		5"	6-23-39	
	4								
15				4	SS		6"	3-28-24	
	5								359.5
20	6	SAND: light brown, clean, fine grained sand, with some medium grained sand, structureless, wet.		5	SS		10"	4-21-30	Graded Silica & Caved Material; 2" I.D. PVC Well Screen No. 10 slot
	7								
25									

SS: Split Spoon Sample

GB: Grab Sample

ATB2

Terraqua Investigations Ltd. | BOREHOLE NO.: LC 9 (pg. 2 of 3)

PROJECT: LAUREL CREEK WATERSHED STUDY

PROJECT NO.: TA 90284 DATE: Sept 6, 1991

DRILLING METHOD: 4 1/4" I.D. Hollow-Stem Auger TERRAQUA SUPERVISOR: E. Sherlock

DEPTH Feet	DEPTH Metres	DESCRIPTION	ELEV. Metres (AMSL)	SAMPLES NO.	TYPE	INT.	REC	BLOW COUNT	GROUND WATER MONITOR
									gi gs
25	0								
	8	SAND: light brown, fine grained, clean, structureless, some laminations, wet.		6	SS	▼	18"	13-22-28	2" I.D. PVC Well Screen No. 10 slot
	9								Cave Material
30				7	SS	▼	18"	6-19-29	
	10	- rust staining on grains at contact.							2" I.D. PVC Riser -flush threaded
35									Bentonite Seal
	11	SILT: dark brown grey, sandy (fine grained), structureless, trace laminated areas, wet.		8	SS	▼	18"	3-23-60	
	12								
40				9	SS	▼	12"	8-30	
	13								
45									
	14			10	SS	▼	18"	11-22-32	
	15								Graded Silica & Caved Material
50									

SS: Split Spoon Sample

GB: Grab Sample

Terraqua Investigations Ltd. | **BOREHOLE NO.: LC 9 (pg. 3 of 3)**

PROJECT: LAUREL CREEK WATERSHED STUDY

PROJECT NO.: TA 90284 DATE: Sept 6, 1991

DRILLING METHOD: 4 1/4" I.D. Hollow-Stem Auger TERRAQUA SUPERVISOR: E. Sherlock

DEPTH Feet	DEPTH Metres	DESCRIPTION	ELEV. Metres (AMSL)	SAMPLES NO.	SAMPLES TYPE	SAMPLES INT.	SAMPLES REC	SAMPLES BLOW COUNT	GROUND WATER MONITOR
50									
	16	SILT: dark brown grey, sandy (fine grained) structureless with some laminations. wet.		11	SS	▼	18"	12-22-37	2" I.D. PVC Well Screen No. 10 slot
55	17			12	SS	▼	18"	7-11-11	
	18	346.8							Graded Silica and Caved Material
60		E O H		13	SS	▼	18"		
	19								
65	20								
	21								
70									
	22								
75									

SS: Split Spoon Sample

GB: Grab Sample

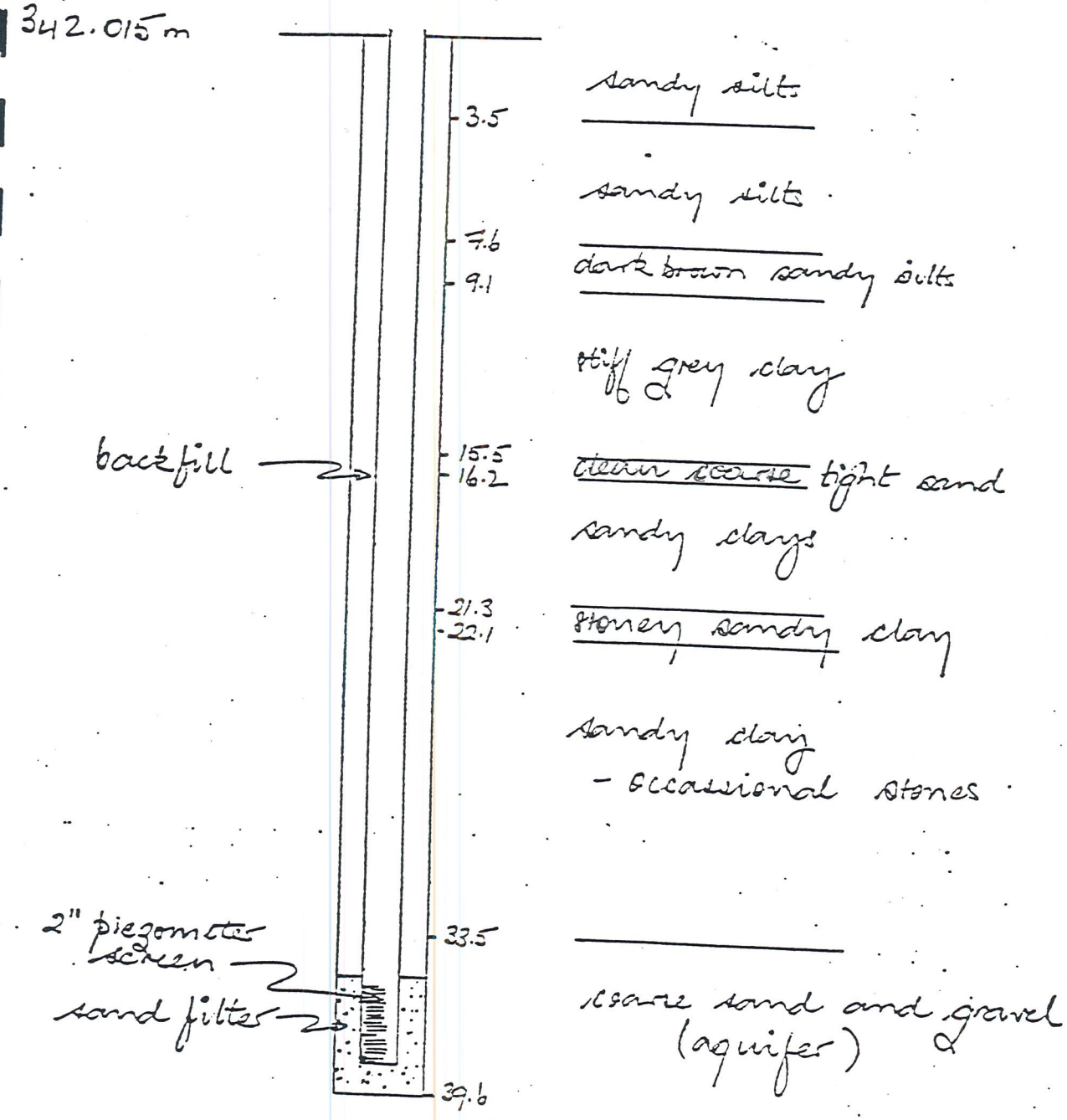
9200488

1982

fig 7

GEOLOGIC AND CONSTRUCTION LOG OW-4

W-WNW-OW4-82



Terraqua Investigations Ltd.

BOREHOLE NO. : WN2

PROJECT : Waterloo North Aquifer System Study

PROJECT NO.: TA 91328

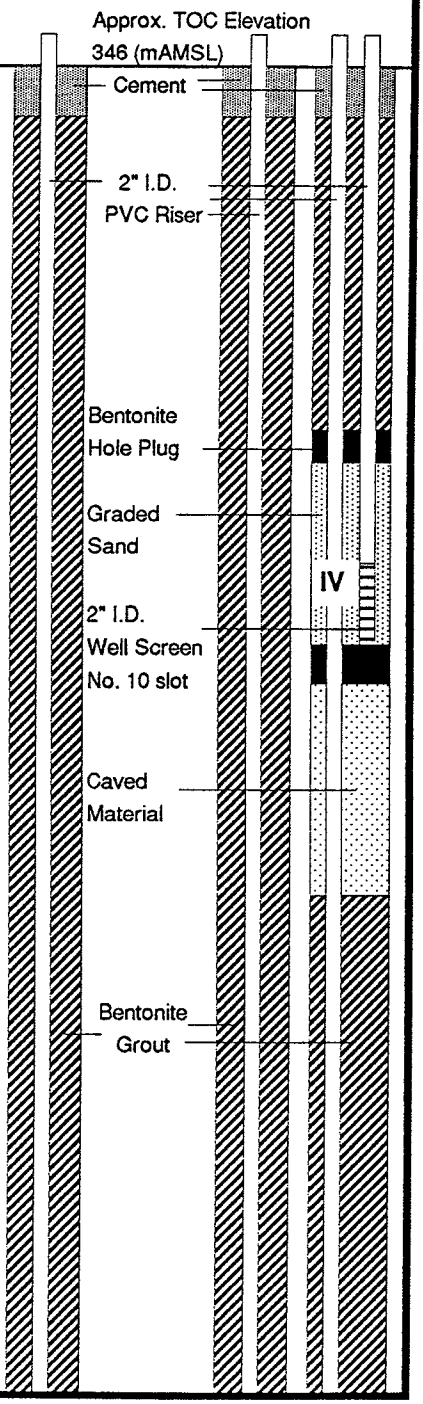
DRILLING METHOD: 4.25 Hollow Stem Auger,
94 mm Christensen Wireline Core Barrel Drill System

DATE: August 19 – August 29, 1991

TERRAQUA SUPERVISOR: S. Anderson
E. Sherlock

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	blow count	rec
	0	0	345				
SANDY CLAY / SILT TILL: reworked, weathered, soft, some stones, brown, moist		2		1	SS	4–4–6–7	16"
SILTY CLAY: with silt partings, grey, very soft, wet, occassional thin fine sand seam, some incorprated clayey silt till (increased occurence with depth)	10	4		2	CS		3.3'
				3	CS		5'
	20	6					
				4	CS		4.5'
FINE SAND & SILT: some clay in silt layers, wet, layered, dark grey–brown		8		5	CS		3'
	30						
		10	335.4	6	CS		4.5'
CLAYEY SILT TILL & SAND / SILT SEAMS: till predominates towards top, grey, dry, dense trace stones and sand, increased seams towards bottom (up to 6" thick) and containing clay balls (MARYHILL TILL)		12		7	CS		4.7'
	40						
				8	CS		0'
		14		9	CS		3'
	50						
		16		10	CS		5'
			327.9				
SILT: with very fine sand and some clayey zones, wet generally massive bedding, little–trace stones, grey–brown some incorporated till,		18		11	CS		1'
	60						
		20		12	CS		4'
				13	CS		4'
	70						
		22		15	CS		4'
– clay / silt varving at 75–76'							
		24		16	CS		4'
	80						

GROUNDWATER MONITOR
I (deep) II III, IV



Terraqua Investigations Ltd.

BOREHOLE NO. : WN2

PROJECT : Waterloo North Aquifer System Study

DATE: August 19 – August 29, 1991

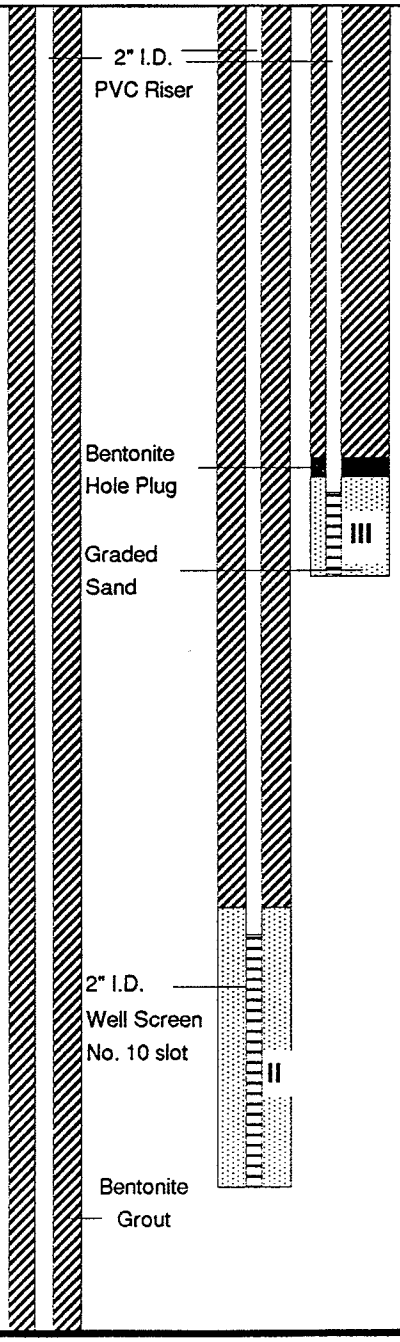
PROJECT NO.: TA 91328

TERRAQUA SUPERVISOR: S. Anderson, E. Sherlock

DRILLING METHOD: 4.25 Hollow Stem Auger, 94 mm Christensen Wireline Core Barrel Drill System

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	blow count	rec
	80		320.6				
SILT: with very fine sand and some clayey zones, wet generally massive bedding, little–trace stones, grey–brown some incorporated silt till (increased occurrance towards bottom		26		17	CS		4'
				18	CS		4'
	90	28					
				19	CS		4.5'
		30		20	CS		4.5'
	100						
		32		21	CS		4.5'
			312.8				
STONEY SILTY SAND TILL: fractured, wet				22	CS		2.5'
	110		311.6				
SAND & GRAVEL: with some silt , trace clay medium density, cemented in zones, wet, grey, with some cobbles		34		23	CS		0.7'
		36		24	CS		0'
	120						
		38	307.5	25	CS		0.2'
CLAYEY SAND / SILT TILL: with stones, very dense, grey (CATFISH CREEK TILL)				26	CS		0'
	130	40		27	SS	75	0.5"
				28	CS		0.9'
		42	303.5				
FINE–MEDIUM SAND: wet, dense, trace fines	140						
CLAY TILL: tr. silt and stones, dark brown		44		29	CS		3'
				30	CS		0.5'
FINE–MEDIUM SAND: wet, dense, trace fines 6" dense silt layer at 153'	150	46					
				31	CS		2'
		48	297.3	32	CS		2'
CLAY TILL (CANNING)	160						

GROUNDWATER MONITOR I (deep) II III



Terraqua Investigations Ltd.

BOREHOLE NO. : WN2

PROJECT : Waterloo North Aquifer System Study

DATE: August 19 – August 29, 1991

PROJECT NO.: TA 91328

TERRAQUA SUPERVISOR: S. Anderson, E. Sherlock

DRILLING METHOD: 4.25 Hollow Stem Auger, 94 mm Christensen Wireline Core Barrel Drill System

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	blow count	rec	GROUNDWATER MONITOR I (deep)
	160		296.2					
SILTY CLAY TILL: grey–brown with redish tinge, trace – little sand and stones (increasing with depth), irregular parting structure, straight cleavage in zones (CANNING TILL)		50		33	CS		5'	2" I.D. PVC Riser
				34	CS		5'	
	170	52						
				35	CS		5'	
		54		36	CS		5'	
	180		290.3					
SILT & FINE SAND: interlayered, grey, wet, trace stones and clay		56		37	CS		1.5'	
CLAYEY SAND & GRAVEL: cemented, bouldery, wet with incorporated silt/clay till (increased amount with depth) boulders/cobbles at 183', 186', 191', 206' & 217'	190	58						
				38	CS		0.2'	
		60		39	CS		1'	
	200							
		62		40	CS		0.5'	Bentonite Grout
			283.6					
	210	64						
		66						
	220							Bentonite Hole Plug
		68						Graded Sand
SAND/SILT TILL: with stones and clay			276	41	CS		1'	2" I.D. Well Screen No. 10 slot
SHALE: weathered, green fissile, sulphurous odour	230	70						
				42	CS		0.2'	
		72						
End of Hole	240		273.2					

W-WN-OW3-06-(A-B)

PROJECT: 05-1112-010(7000)

BOREHOLE LOG OF: WNOW3AB-06

SHEET 1 OF 2

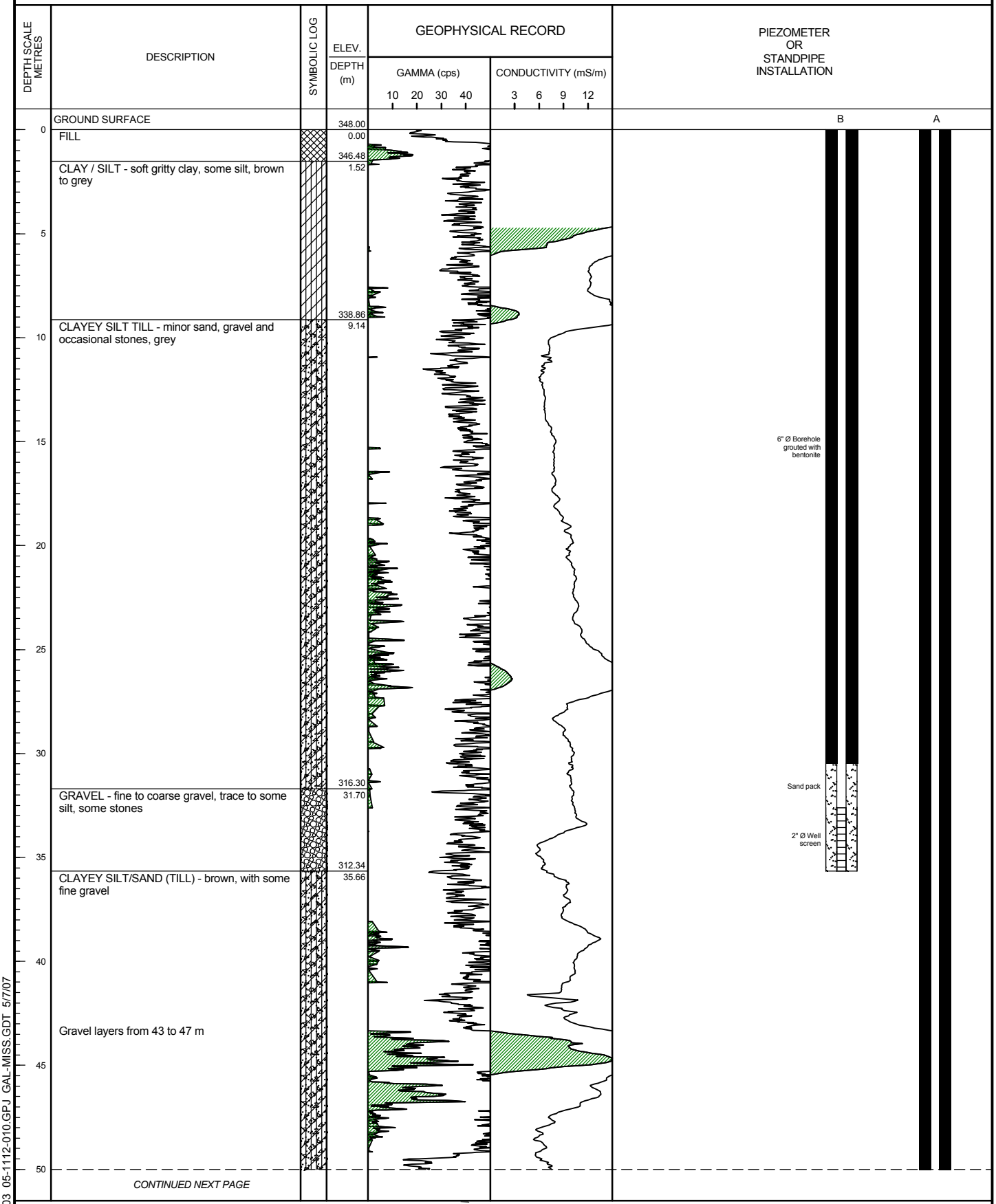
LOCATION: N 4815537.4 ;E 534348.2

DRILLING DATE: September 5-8, 2006

DRILL RIG: Mud Rotary

DRILLING CONTRACTOR: Davidson Well Drilling

DATUM: Geodetic



DEPTH SCALE

1 : 250

Golder Associates

LOGGED: AP

CHECKED: AP

MIS-HYD 003 05-1112-010.GPJ GAL-MISS.GDT 5/7/07

PROJECT: 05-1112-010(7000)

BOREHOLE LOG OF: WNOW3AB-06

SHEET 2 OF 2

LOCATION: N 4815537.4 ;E 534348.2

DRILLING DATE: September 5-8, 2006

DRILL RIG: Mud Rotary

DRILLING CONTRACTOR: Davidson Well Drilling

DATUM: Geodetic

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	GEOPHYSICAL RECORD: GAMMA (cps) 10 20 30 40	GEOPHYSICAL RECORD: CONDUCTIVITY (mS/m) 3 6 9 12	PIEZOMETER OR STANDPIPE INSTALLATION
	--- CONTINUED FROM PREVIOUS PAGE ---					B A
50	CLAYEY SILT/SAND (TILL) - brown, with some fine gravel					
55			291.60			
	END OF BOREHOLE		56.40			
60						
65						
70						
75						
80						
85						
90						
95						
100						

DEPTH SCALE

1 : 250

Golder Associates

LOGGED: AP

CHECKED: AP

MIS-HYD 003 05-1112-010.GPJ GAL-MISS.GDT 5/7/07

W-WM-WM05-93-(A-B) 9200502

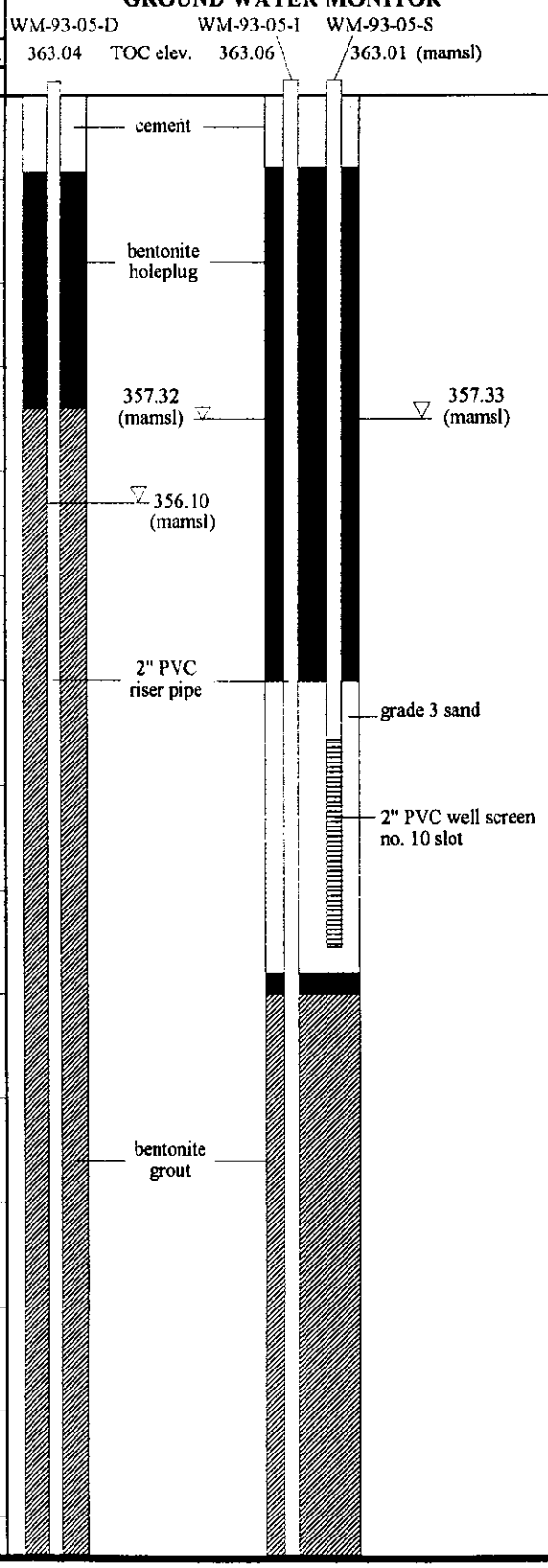
Terraqua Investigations Ltd.

BOREHOLE NO. : WM-93-05

PROJECT - CLIENT : Waterloo Moraine Study - Region of Waterloo
DATE : May 13 to May 19 1993
PROJECT NO. : TA92378
SUPERVISOR : V. Gerrie
CONTRACTOR : All Terrain Drilling Ltd.
METHOD : Christensen PQ (5.25" O.D.) Core Barrel Wireline System and 4.25" I.D. (8" O.D.) Hollow Stem Augers

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	rec ft	interval ft
	0	0	362				
Fine to Medium Sand:				1	AU	2.25	4
dark - organic rich silty sand with some stones from 0' to 2.5'	5	2		2	AU	3.5	5
light red-brown with horizontal laminations of fine to med. sand - 4' to 9'							
mostly clean and structureless, with occasional silty zones	10	4		3	PQ	3	4
	15			4	PQ	2.5	5
	20	6		5	PQ	3	5
	25	8		6	PQ	6	5
	30	10		7	PQ	0.25	5
Grain Size Analysis at 35': Fine Sand, some silt, trace clay 11.58	35			8	PQ	3	5
		12	350.42				
Medium to Coarse Sand:	40			9	PQ	4	5
clean, light brown near horizontal structuring (dark bands of sand inclined 0°to 10°)	45	14		10	PQ	2.5	5
no recovery from 48' to 53' - still drilled like sand	50	16			PQ	0	5
2" silty sand seam at 55'	55			11	PQ	5	5
1" very silty sand seam at 58.5'	60	18		12	PQ	3	5
clean coarse sand from 63' to 68'	65	20		13	PQ	3.25	5
noticed mud loss at 66'	70						

GROUND WATER MONITOR



Terraqua Investigations Ltd.

BOREHOLE NO. : WM-93-05

PROJECT - CLIENT : Waterloo Moraine Study - Region of Waterloo
DATE : May 13 to May 19 1993
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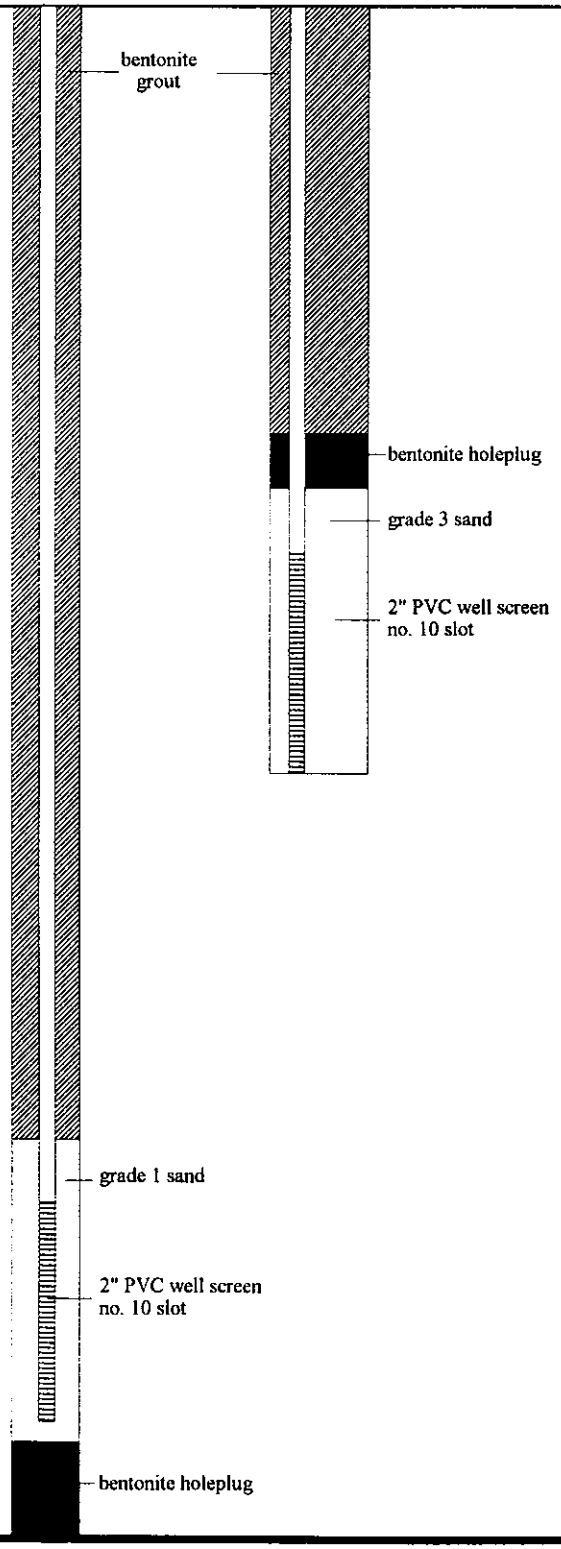
SUPERVISOR : V. Gerrie
CONTRACTOR : All Terrain Drilling Ltd.
METHOD : Christensen PQ (5.25" O.D.) Core Barrel Wireline System and 4.25" I.D. (8" O.D.) Hollow Stem Augers

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	rec ft	interval ft
	70						
		22		14	PQ	5	5
fine to med. sand from 73' to 75.75'	75			15	PQ	5	5
		24					
24.38	80		337.62	16	PQ	2.5	5
Gravelly Coarse Sand: one 0.5" stone with a glob of sandy, silty clay attached; 1" dia. glob of silty clay; rest of sample is very clean	85	26		17	PQ	5	5
Grain Size Analysis at 86': 26.87 Fine Sand, some medium sand, tr. silt			335.18				
Medium to Coarse Sand: clean (occasional trace silt); some pebbles in the coarse sands; 1.5" fine gravel seam at 93.5'; horizontal structuring (dark bands and layers of varying grain size)	90	28		18	PQ	5	5
	95			19	PQ	3	5
4" chunk of sandy stony silt till at 98.5'		30					
	100			20	PQ	4.5	5
	105	32		21	PQ	4.5	5
two 1" dia stones and a 5" cobble from 110' to 110.5'; bands of dark and light sand inclined at 10° to 15° from horizontal from 108' to 110.5' 33.53	110						
		34	328.32	22	PQ	4.5	5
Stony Sandy Silt Till: **(Catfish Creek)** dense, brown	115						
Grain Size Analysis at 111': 35.66 Matrix: Sandy Silt, some clay		36	326.34	23	PQ	4.5	5
Silty Clay: trace silt, some sand and pebbles; silt content increases in bottom 2' 36.88	120			24	PQ	4.5	5
			324.97				
Stony Sandy Silt Till: **(Catfish Creek)**	125	38		25	PQ	2.5	5
greenish brown; less silt and more gravel and silty sand from 123' to 128'; 8" clean med sand at 128'							
dense with some partially washed out sand seams from 129' to 143'	130	40		26	PQ	2.5	5
Grain Size Analysis at 129': Matrix: Silty Sand, some clay	135			27	PQ	4.5	5
		42					
	140						

GROUND WATER MONITOR



Terraqua Investigations Ltd.

BOREHOLE NO. : WM-93-05

PROJECT - CLIENT : Waterloo Moraine Study - Region of Waterloo
DATE : May 13 to May 19 1993
PROJECT NO. : TA92378
SUPERVISOR : V. Gerrie
CONTRACTOR : All Terrain Drilling Ltd.
METHOD : Christensen PQ (5.25" O.D.) Core Barrel Wireline System and 4.25" I.D. (8" O.D.) Hollow Stem Augers

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	rec ft	interval ft	GROUND WATER MONITOR WM-93-05-D
	140							
Grain Size Analysis at 141': Sandy Silt, some clay 43.59			318.41	28	PQ	3.5	5	
		44						
End of Borehole - 143'	145							
	150	46						
	155							
		48						
	160							
		50						
	165							
	170	52						
	175							
		54						
	180							
		56						
	185							
	190	58						
	195							
		60						
	200							
		62						
	205							
	210	64						

INSTALLATION SUMMARY *

Monitor	Sandpack top	Sandpack bottom	Screen top	Screen bottom	Static WL ▽	Static WL date
WM-93-05-S	353.5	349.2	352.6	349.6	357.33	05/94
WM-93-05-I	334.0	330.0	333.0	330.0	357.32	05/94
WM-93-05-D	324.9	320.7	324.0	320.9	356.10	05/94

* - All values are elevations (mAMSL)
- Water levels given are post development statics

ORJ 9201414 W-WN-MWWN1-02-A

Borehole No.: MWWN1S/D

W-WN-MWWN1-02

Project: RMOW GUDI Study

Project No: 609-00116

Location: 65 m Northwest of W10

Contractor: Geo-Environmental

Drilling Method: Hollow Steam Auger

Date: 27 June 2002

Supervisor: M.Free

Ground Surface: 340.81 mAMSL

Top of Casing: 341.68 (D), 341.66 (S) mAMSL

A B.

SUBSURFACE PROFILE				SAMPLE DETAILS				WELL DETAILS
Depth (ft / m)	Lithologic Symbol	Lithologic Description	Elevation/Depth (m BGS)	Number	Type	Recovery	N-Value	Well
0 / 0		Ground Surface	340.81 / 0.00					stick up (0.84 m)
0		SILTY SAND TO SAND brown, occasional silt, trace gravel, moist		1	CC	63 %		Cement
2				2	CC	71 %		Bentonite Grout
4		becoming wet at 1.5 m BGS		3	CC	25 %		Holeplug
6 / 2				4	CC	8 %		Top of Screen (1.5 m BGS)
8				5	CC	0		No.1 Silica Sand
10				6	CC	0		No.10 Slot PVC Screen 50 mm diameter
12 / 4		becoming grey at 3.8 m BGS		7	CC	0		Bottom of well (4.6 m BGS)
14								
16								

Screen interval (shallow): 1.5 to 4.6 m BGS
Screen interval (deep): 11.9 to 14 m BGS
Sand pack interval (shallow): 1.5 to 4.6 m BGS
Sand pack interval (deep): 11.3 to 15.2 m BGS
Well seal interval (shallow): 0 to 1.5 m BGS
Well seal interval (deep): 0 to 11.3 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
SS - Split Spoon Sample

Stantec Consulting Ltd.
871 Victoria St. North
Kitchener, ON
N2B 3S4

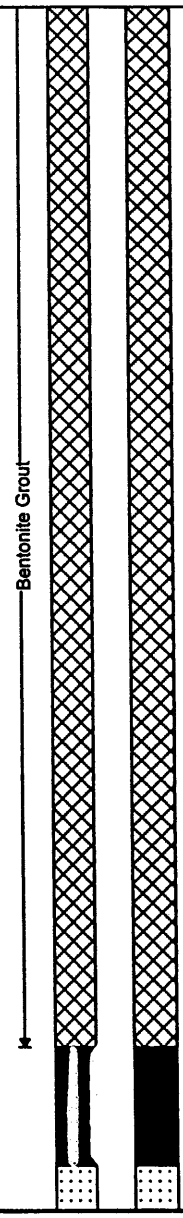
Stantec

Borehole No.: MWWN1S/D

Project: RMOW GUDI Study
Project No: 609-00116
Location: 65 m Northwest of W10
Contractor: Geo-Environmental
Drilling Method: Hollow Steam Auger

Date: 27 June 2002
Supervisor: M.Free
Ground Surface: 340.81 mAMSL
Top of Casing: 341.68 (D), 341.66 (S) mAMSL

SUBSURFACE PROFILE				SAMPLE DETAILS				WELL DETAILS
Depth	Lithologic Symbol	Lithologic Description	Elevation/Depth (m BGS)	Number	Type	Recovery	N-Value	Well
19				8	CC	79 %		
21				9	CC	100 %		
23 — 7				10	CC	0		
25								
27								
29				11	CC	17 %		
— 9								
31								
33								
35								
— 11								
37								



Screen interval (shallow): 1.5 to 4.6 m BGS
Screen interval (deep): 11.9 to 14 m BGS
Sand pack interval (shallow): 1.5 to 4.6 m BGS
Sand pack interval (deep): 11.3 to 15.2 m BGS
Well seal interval (shallow): 0 to 1.5 m BGS
Well seal interval (deep): 0 to 11.3 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
SS - Split Spoon Sample

Stantec Consulting Ltd.
871 Victoria St. North
Kitchener, ON
N2B 3S4

Stantec

Borehole No.: MWWN1S/D

Project: RMOW GUDI Study
Project No: 609-00116
Location: 65 m Northwest of W10
Contractor: Geo-Environmental
Drilling Method: Hollow Steam Auger

Date: 27 June 2002
Supervisor: M.Free
Ground Surface: 340.81 mAMSL
Top of Casing: 341.68 (D), 341.66 (S) mAMSL

SUBSURFACE PROFILE				SAMPLE DETAILS				WELL DETAILS
Depth	Lithologic Symbol	Lithologic Description	Elevation/Depth (m BGS)	Number	Type	Recovery	N-Value	Well
39								Top of Screen (11.9 m BGS)
41				13	CC	25 %		No.10 Slot PVC Screen 50 mm diameter
43	13	SAND AND GRAVEL grey, wet	327.80 13.01	14	CC	96 %		No.1 Silica Sand
45				15	SS	0		
47								
49	15			16	SS	0		Bottom of well (14.9 m BGS)
51								
53								
55		SILTY CLAY (TILL) grey, trace gravel, dense, moist to wet	324.05 16.76					
	17			17	SS	46 %		
57		End of Borehole	323.44 17.37					

Screen interval (shallow): 1.5 to 4.6 m BGS
Screen interval (deep): 11.9 to 14 m BGS
Sand pack interval (shallow): 1.5 to 4.6 m BGS
Sand pack interval (deep): 11.3 to 15.2 m BGS
Well seal interval (shallow): 0 to 1.5 m BGS
Well seal interval (deep): 0 to 11.3 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
SS - Split Spoon Sample

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871 Victoria St. North
Kitchener, ON
N2B 3S4

Stantec

W-WN-MWWN1-06-B

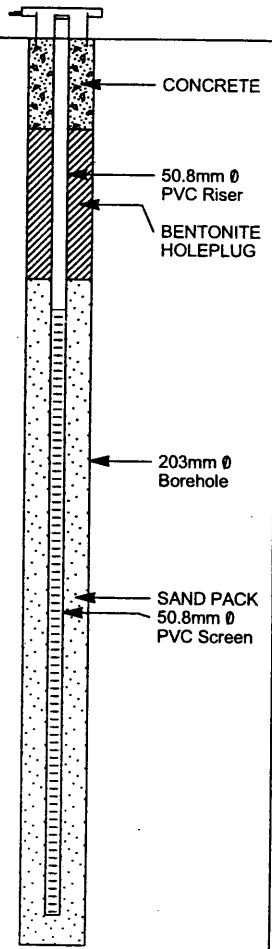
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: Spill Remediation
PROJECT NUMBER: T010085-10
CLIENT: Steed and Evans
LOCATION: Fischer-Hallman Road/Clair Creek

HOLE DESIGNATION: MW-WN1-06S
DATE COMPLETED: September 6, 2006
DRILLING METHOD: GEOPROBE/DIRECT PUSH
FIELD PERSONNEL: Brad Trytten

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m BGS
	TOP OF RISER	341.43
	GROUND SURFACE	340.56
	TOPSOIL	340.36
0.5	SM - SAND, silty, with clay, compact, slight plasticity, fine sand, poorly graded, dark brown, moist, blocky	340.10
	SM - SAND, with silt, with clay, compact, non-plastic, fine to medium sand, poorly graded, light grey-brown, wet, dark brown laminations	339.65
1.0	SM - SAND, with silt, trace clay, compact, fine to coarse sand, occasional rounded pebble, poorly graded, light grey-brown, wet	
1.5	- No Recovery at 1.07m BGS	
	SM - SAND, with silt, trace clay, compact, fine to coarse sand, occasional rounded pebble, poorly graded, light grey-brown, wet	339.04
2.0		
	SM/ML - SAND and SILT, interbedded, silty sand seams, fine sand, trace medium sand, medium brown, wet, with silty clay, laminated, medium brown	338.43
2.5	- No Recovery at 2.74m BGS	
3.0	SM - SAND, with silt, trace clay, loose, fine to medium sand, trace coarse sand, poorly graded, massive, medium grey-brown, wet	337.51
3.5		
	SM/ML - SAND and SILT, with clay, dense, fine sand, slight plasticity, moderately dilatent, poorly graded, medium grey-brown, moist to wet, with seams of clayey silt	336.90
4.0		
4.5	END OF BOREHOLE @ 4.57m BGS	335.99
5.0		
5.5		
6.0		
6.5		

Monitoring Well



WELL DETAILS
Screened interval:
339.19 to 336.14m BGS
1.37 to 4.42m BGS
Length: 3.05m
Diameter: 51mm
Slot Size: #10
Material: PVC
Seal:
340.10 to 339.34m BGS
0.46 to 1.22m BGS
Material: Bentonite Holeplug
Sand Pack:
339.34 to 336.14m BGS
1.22 to 4.42m BGS
Material: Silica Sand

SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	FID (ppm)
1	P/S	70	NA	0.0
2	P/S	80	NA	0.0
3	P/S	90	NA	0.0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

OVERBURDEN LOG T010085-10.GPJ CRA_CORP.GDT 9/13/06

W-WN-OW1-06-A

PROJECT: 05-1112-010(7000)

BOREHOLE LOG OF: WNOW1B-06

SHEET 1 OF 1

LOCATION: N 4814647.2 ;E 535055.6

DRILLING DATE: February 20, 2006

DRILL RIG:

DRILLING CONTRACTOR:

DATUM: Geodetic

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	GEOPHYSICAL RECORD: GAMMA (cps) 10 20 30 40	GEOPHYSICAL RECORD: CONDUCTIVITY (mS/m) 3 6 9 12	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE		338.30			
0	Soft, moist to wet, brown CLAYEY SILT, trace sand		0.00 / 336.78			
	Firm, moist, grey sandy SILT (TILL)		1.52			
	Moist to very moist, grey CLAYEY SILT (TILL)		2.13 / 332.20			
5	Dense, very moist to wet, grey silty fine SAND		6.30			
	Hard, moist, grey SILTY CLAY (TILL)		326.11			
10	Very hard, wet, grey CLAYEY SILT (TILL)		12.19 / 324.58			
	Very hard, moist, grey SILT, some gravel (TILL)		13.72 / 323.06			
15	Very hard, moist to wet, grey SAND (TILL)		15.24 / 320.01			
	END OF BOREHOLE		18.29			
20						
25						
30						
35						
40						
45						
50						

DEPTH SCALE

1 : 250

Golder Associates

LOGGED: KS

CHECKED:

MIS-HYD 003 05-1112-010.GPJ GAL-MISS.GDT 5/7/07

W-WN-OW1-06-B

PROJECT: 05-1112-010(7000)

BOREHOLE LOG OF: WNOW1A-06

SHEET 1 OF 1

LOCATION: N 4814647.2 ;E 535055.6

DRILLING DATE: February 21, 2006

DATUM: Geodetic

DRILL RIG:

DRILLING CONTRACTOR:

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	GEOPHYSICAL RECORD: GAMMA (cps) 10 20 30 40	GEOPHYSICAL RECORD: CONDUCTIVITY (mS/m) 3 6 9 12	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE		338.30			
	Soft, moist to wet, brown CLAYEY SILT (TILL)		0.00 / 336.78			
	Firm, moist, grey sandy SILT (TILL)		1.52			
	Hard, moist, grey CLAYEY SILT (TILL) to SILTY CLAY (TILL)		2.13 / 333.73			
5	Very stiff to hard, moist to wet, grey SILT, some fine sand, some clay		4.57 / 332.20			
	Dense, grey SAND		6.10 / 331.29			
	Very hard, moist, grey CLAYEY SILT (TILL)		7.01			
	END OF BOREHOLE		7.62			
10						
15						
20						
25						
30						
35						
40						
45						
50						

DEPTH SCALE

1 : 250

Golder Associates

LOGGED: KS

CHECKED:

MIS-HYD 003 05-1112-010.GPJ GAL-MISS.GDT 5/7/07

W-WN-TW1-06-A

PROJECT: 05-1112-010(7000)

BOREHOLE LOG OF: WNTW1-06

SHEET 1 OF 2

LOCATION: N 4815772.9 ;E 534591.3

DRILLING DATE: August 21-25, 2006

DRILL RIG: Mud Rotary

DRILLING CONTRACTOR: Davidson Well Drilling

DATUM: Geodetic

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)
0	GROUND SURFACE		355.50
	SILTY CLAY to CLAYEY SILT - gritty, with some fine sand and occasional fine gravel, dark brown to light brown		0.00
	SILTY SAND - silty fine to medium sand, some fine gravel, silt content increases with with depth, olive grey		338.74 / 16.76
	SILTY CLAY to CLAYEY SILT - with some sand and fine gravel, dark grey		331.12 / 24.38
	SILTY SAND - silty fine sand and fine gravel, minor clay, olive grey, possible silt/clay layers at depth		321.97 / 33.53
	CLAY to SILTY CLAY - clay with varying amounts of silt, very minor fine rounded gravel, brown to dark grey		311.00 / 44.50
50	*CONTINUED NEXT PAGE*		306.12 / 49.38

GEOPHYSICAL RECORD

GAMMA (cps): 10 20 30 40

CONDUCTIVITY (mS/m): 3 6 9 12

PIEZOMETER OR STANDPIPE INSTALLATION

6" Ø steel casing in a 10" Ø borehole Bentonite seal between borehole wall and casing from top to bottom

DEPTH SCALE

1 : 250

Golder Associates

LOGGED: KM, AP

CHECKED: AP

MIS-HYD 003 05-1112-010.GPJ GAL-MISS.GDT 5/7/07

PROJECT: 05-1112-010(7000)

BOREHOLE LOG OF: WNTW1-06

SHEET 2 OF 2

LOCATION: N 4815772.9 ;E 534591.3

DRILLING DATE: August 21-25, 2006

DRILL RIG: Mud Rotary

DRILLING CONTRACTOR: Davidson Well Drilling

DATUM: Geodetic

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	GEOPHYSICAL RECORD: GAMMA (cps) 10 20 30 40	GEOPHYSICAL RECORD: CONDUCTIVITY (mS/m) 3 6 9 12	PIEZOMETER OR STANDPIPE INSTALLATION
	--- CONTINUED FROM PREVIOUS PAGE ---					
50	SAND and GRAVEL - silty fine sand and fine gravel, grey		300.64			
55	GRAVEL - fine to medium gravel, minor silt (clean), grey		54.86 299.11			
	SAND and GRAVEL - fine to medium sand with fine to medium gravel, some silt, grey		56.39 295.45			
60	SAND - medium to coarse sand, some fine gravel, minor silt, grey		60.05 292.41			
	SAND - fine to medium sand, some silt, grey		63.09 287.83			
65	SILT / CLAY / SAND - silty clayey fine to medium sand (till-like), grey/brown		67.67 283.87			
70	GRAVEL - fine to medium gravel with coarse sand, minor silt, grey		71.63 276.97			
75	END OF BOREHOLE		78.53			
80						
85						
90						
95						
100						

PIEZOMETER INSTALLATION: 6" Ø steel casing in a 10" Ø borehole Bentonite seal between borehole wall and casing from top to bottom; 5.5" Ø Johnson well screen no sand pack

DEPTH SCALE

1 : 250

Golder Associates

LOGGED: KM, AP

CHECKED: AP

MIS-HYD 003 05-1112-010.GPJ GAL-MISS.GDT 5/7/07

W-WN-OW1-09-ABCD

PROJECT: 08-1112-0134

BOREHOLE LOG OF: WNOW1-09

SHEET 1 OF 2

LOCATION: N 4816205.3 ;E 534528.6

DRILLING DATE: March/April 2009

DATUM: Geodetic

DRILL RIG: Track-mounted Rotosonic/Mud Rotary

DRILLING CONTRACTOR: Boart Longyear/Davidson Drilling Ltd.

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)
0	GROUND SURFACE	347.80
	Dark brown to black, ORGANICS, some rootlets, trace sand and gravel	0.00
	Light to dark/grey, CLAY, trace sand and gravel, trace organics	0.81
5		339.88
	Light to dark grey/brown, CLAYEY SILT, trace sand	7.92
10		333.78
	Light to dark grey/brown, SILTY CLAY, trace sand	14.02
15	Light brown, fine SAND and SILT	14.53 331.37
	Brown, fine to medium SAND	16.43
	Light to dark grey/brown, SILTY CLAY TILL, trace sand and gravel	17.07
20		325.80
	Light brown, CLAY TILL with gravel, some silt, trace sand -Decreasing gravel content	22.00
25		321.59
	Light/brown, SILTY CLAY TILL, some gravel, trace sand	26.21 320.06
	Light to dark brown/grey, SILTY CLAY TILL, some gravel, trace sand	27.74
30		
35		312.44
	Light to dark grey/brown, SILTY CLAY TILL, trace sand and gravel	35.36
		308.48
	Light to dark grey, SAND, trace silt	39.32
40	Light to dark brown/grey, SILTY CLAY TILL, trace sand and gravel	40.13 304.70
	Light to dark grey, SAND, trace silt	43.36
	Light to dark brown/grey, SILTY CLAY TILL, trace sand and gravel	302.99
45	Light to dark brown, sandy GRAVEL, trace silt	44.81 301.78
	Light to dark brown, SAND,some gravel, trace silt	46.02
		299.08
	Light to dark green/grey, silty SAND TILL, trace clay, trace gravel	48.72
50	*CONTINUED NEXT PAGE*	

GEOPHYSICAL RECORD

GAMMA (cps) 40 80 120 160

CONDUCTIVITY (mS/m) 20 40 60 80

PIEZOMETER OR STANDPIPE INSTALLATION

WNOW1D-09 WNOW1C-09 WNOW1B-09 WNOW1A-09

Bentonite (0-13.1 m)

Sand (13.1-17 m)

Screen (14.0-17.1 m)

330.74

Bentonite (0-44.8 m)

Sand (44.8-48.8 m)

302.08

Screen (45.7-48.8 m)

299.03

Bentonite (0-63.1 m)

Bentonite (0-74.07m)

DEPTH SCALE

1 : 250

Golder Associates

LOGGED: SC/DN

CHECKED: DN

MIS-HYD 003 08-1112-0134.GPJ GAL-MISS.GDT 10/6/11 RJ

PROJECT: 08-1112-0134

BOREHOLE LOG OF: WNOW1-09

SHEET 2 OF 2

LOCATION: N 4816205.3 ;E 534528.6

DRILLING DATE: March/April 2009

DATUM: Geodetic

DRILL RIG: Track-mounted Rotosonic/Mud Rotary

DRILLING CONTRACTOR: Boart Longyear/Davidson Drilling Ltd.

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)
	--- CONTINUED FROM PREVIOUS PAGE ---		
50			297.20
	Light brown, SAND with some gravel and silt		50.60 / 295.68
	Brown to grey, sandy SILT, trace clay		52.12 / 291.10
55			
	Compact, motled grey/brown to red, SILTY CLAY TILL, trace gravel		56.70 / 284.80
60			
	Dark grey to blue grey, silty SAND and GRAVEL		63.00 / 282.26
65			
	Grey/blue, SAND and GRAVEL, trace silt		65.54 / 281.04
	Mottled grey/blue and brown, sandy CLAY TILL, some gravel, trace laminated limestone fragments		66.76 / 278.92
	Light brown/grey/wnite, CLAY, some shale and limestone fragments, trace sand, trace gravel		68.88 / 275.87
70			
	SALINA FORMATION Blue, SHALE with grey brown DOLOSTONE, thinly laminated platy		71.93 / 269.77
75			
	END OF BOREHOLE		78.03
80			
85			
90			
95			
100			

GEOPHYSICAL RECORD

GAMMA (cps) 40 80 120 160

CONDUCTIVITY (mS/m) 20 40 60 80

PIEZOMETER OR STANDPIPE INSTALLATION

WNOW1D-09 WNOW1C-09 WNOW1B-09 WNOW1A-09

Bentonite (0-74.07m)

Sand (63.1-67.1 m) 283.79

Screen (64.0-67.1 m)

280.74

Sand (74.07-78.03m 272.82

Screen (74.98-78.03m

269.77

DEPTH SCALE

1 : 250

Golder Associates

LOGGED: SC/DN

CHECKED: DN

MIS-HYD 003 08-1112-0134.GPJ GAL-MISS.GDT 10/6/11 RJ

BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

Appendix C

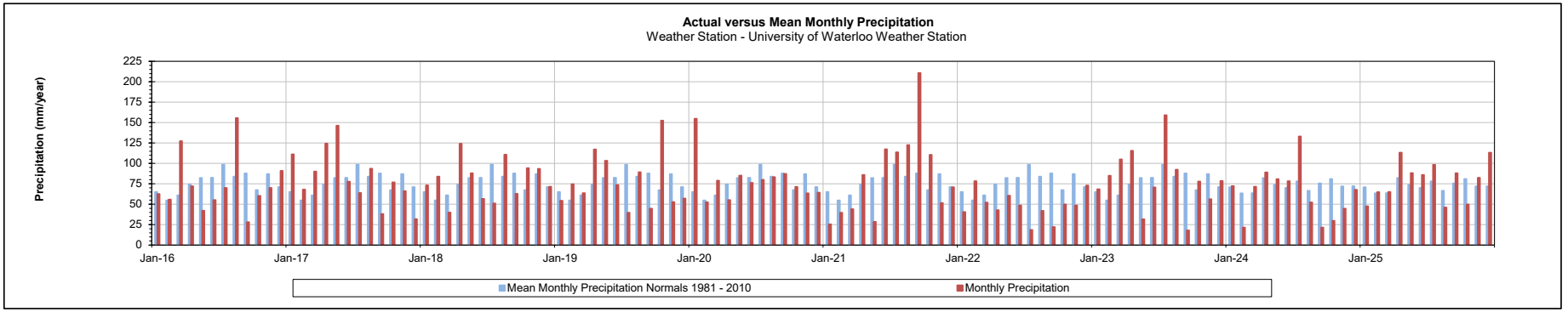
Monitoring Data
(Pumped Volumes and Hydrographs)

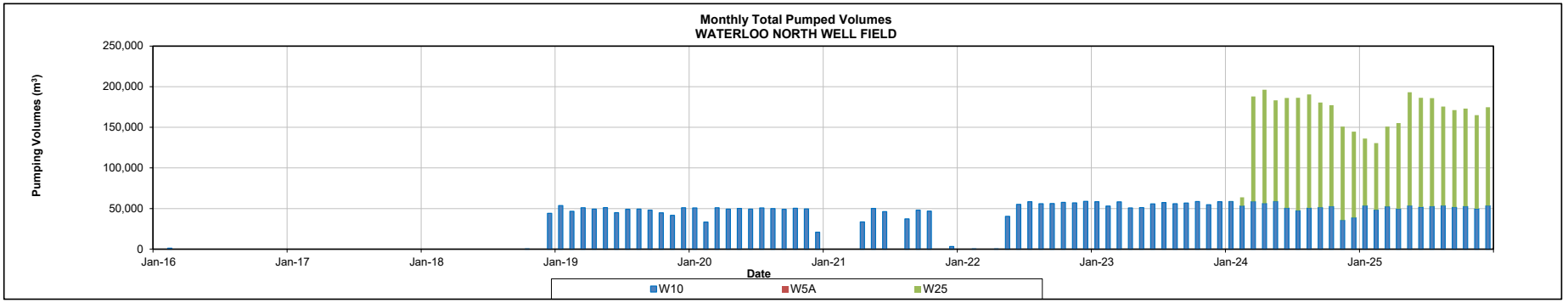
TABLE C-1
WELL FIELD WATER PRODUCTION SUMMARY
REGION OF WATERLOO - 2025 GROUNDWATER MONITORING REPORT

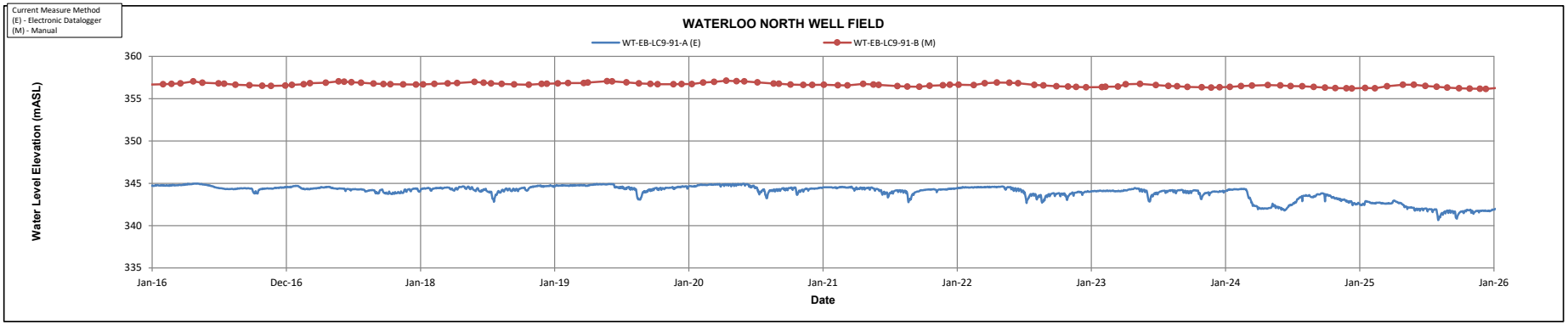
Well Field	*Major or Minor Supply*	*Production Well Name*	*Status*	*Permit to Take Water Details*			*2021 Production Summary*			*2022 Production Summary*			*2023 Production Summary*			*2024 Production Summary*			*2025 Production Summary*		
				MOE Permit Number	*Permitted Capacity (total m^3/year)**	*Permitted Rate (L/s)**	*Total Production Well Volume (total m3/year)*	*Average Daily Rate (m3/day)*	*Average Rate (L/s)*	*Total Production Well Volume (total m3/year)*	*Average Daily Rate (m3/day)*	*Average Rate (L/s)*	*Total Production Well Volume (total m3/year)*	*Average Daily Rate (m3/day)*	*Average Rate (L/s)*	*Total Production Well Volume (total m3/year)*	*Average Daily Rate (m3/day)*	*Average Rate (L/s)*	*Total Production Well Volume (total m3/year)*	*Average Daily Rate (m3/day)*	*Average Rate (L/s)*
Waterloo North	Major	W25	Supply		1,892,160	60.0	0	0	0	0	0	0	0	0	0	1,293,983	3,545	41	1,375,915	3,770	44
		W5A	Supply		1,324,512	42.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		W10	Supply	0061-BLHQ45	1,146,859	36.4	265,008	726	8.4	439,377	1,204	13.9	669,288	1,834	21.2	612,621	1,678	19.4	621,938	1,704	19.7
				Well Field Total	***4,363,531***		***265,008***	***726***	***8.4***	***439,377***	***1,204***	***13.9***	***669,288***	***1,834***	***21.2***	***1,906,604***	***5,224***	***60.5***	***1,997,853***	***5,474***	***63.4***

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

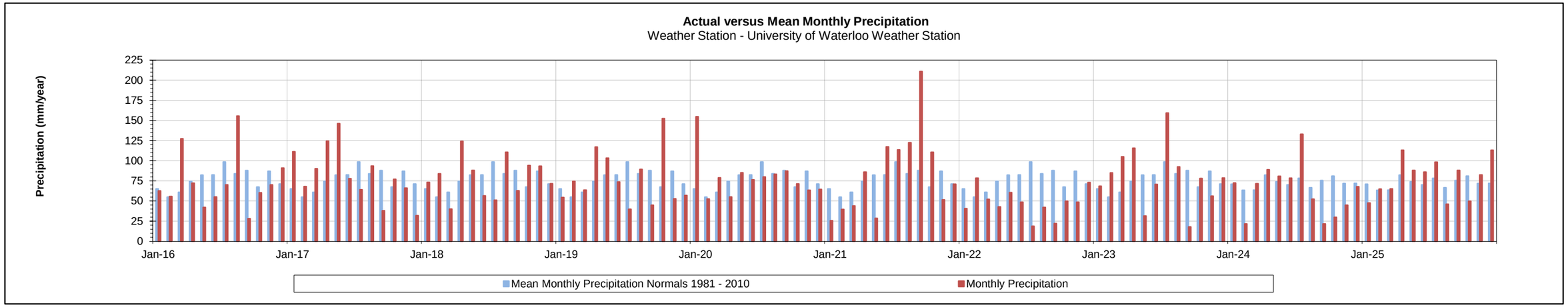
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

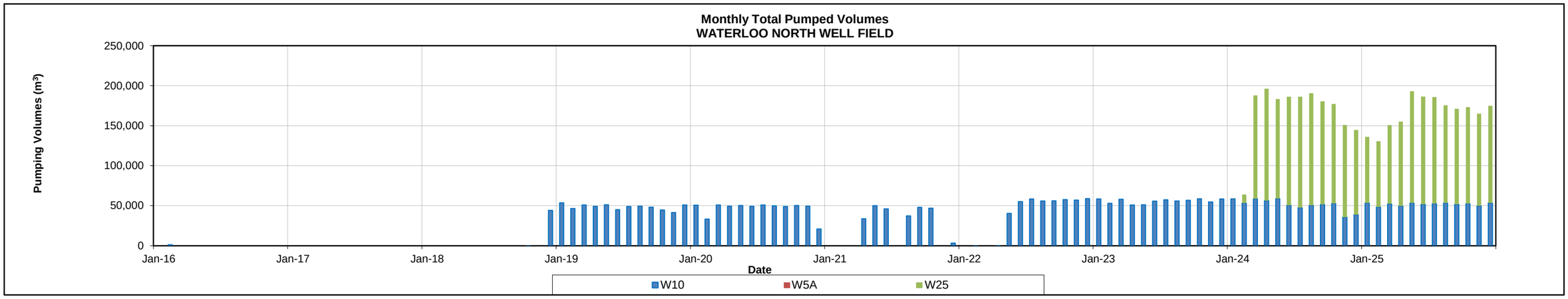


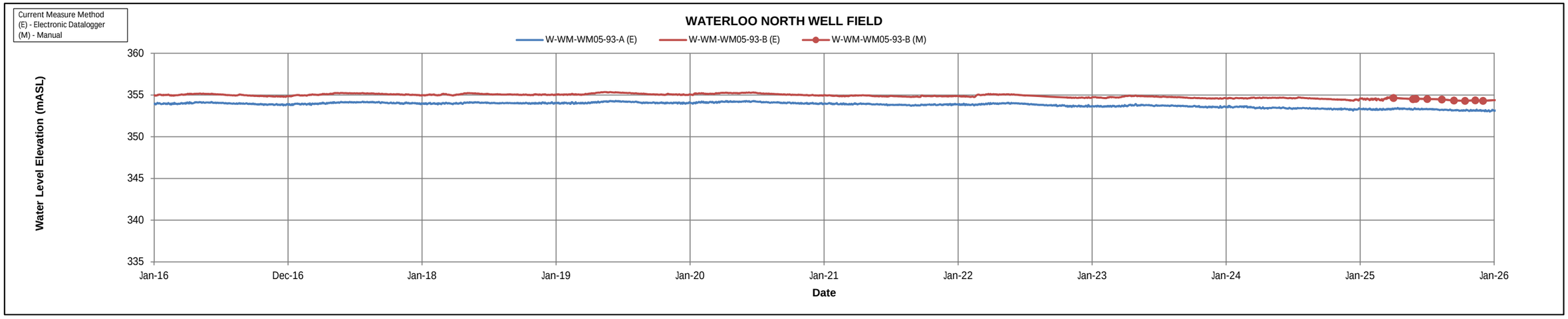




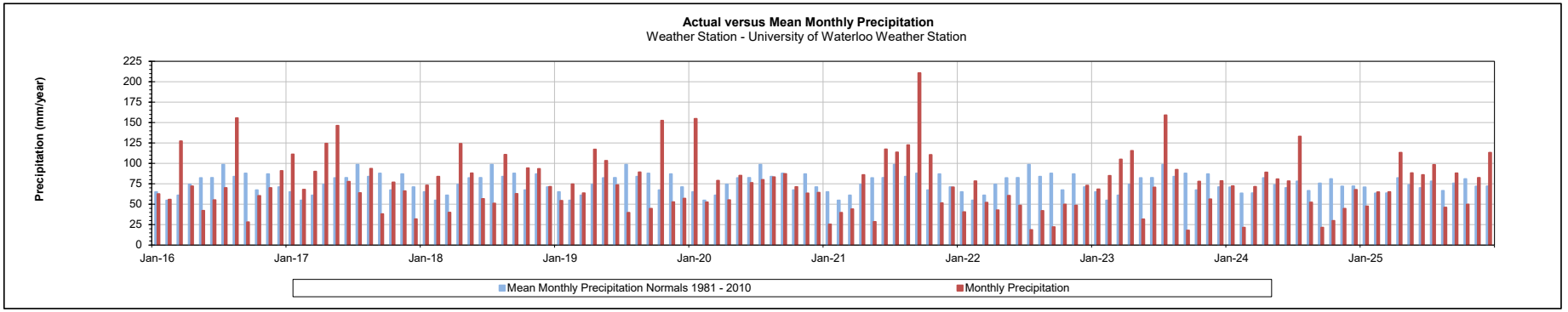
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

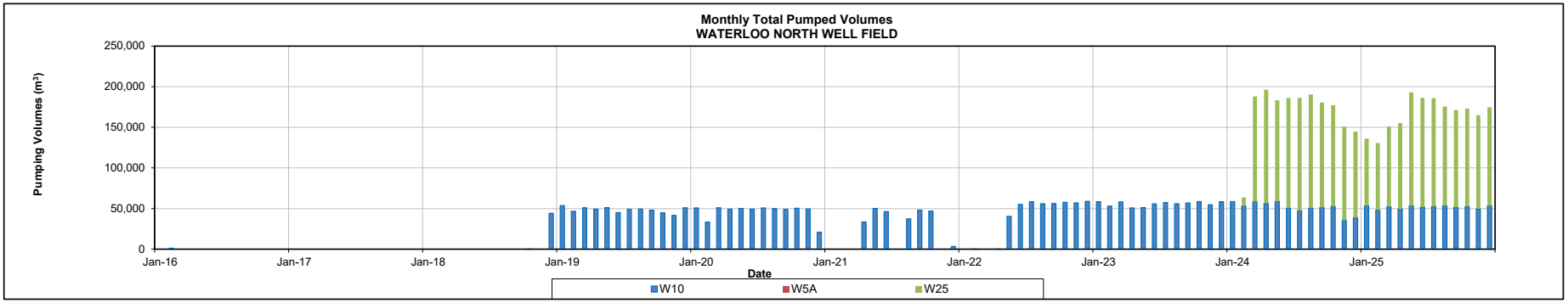


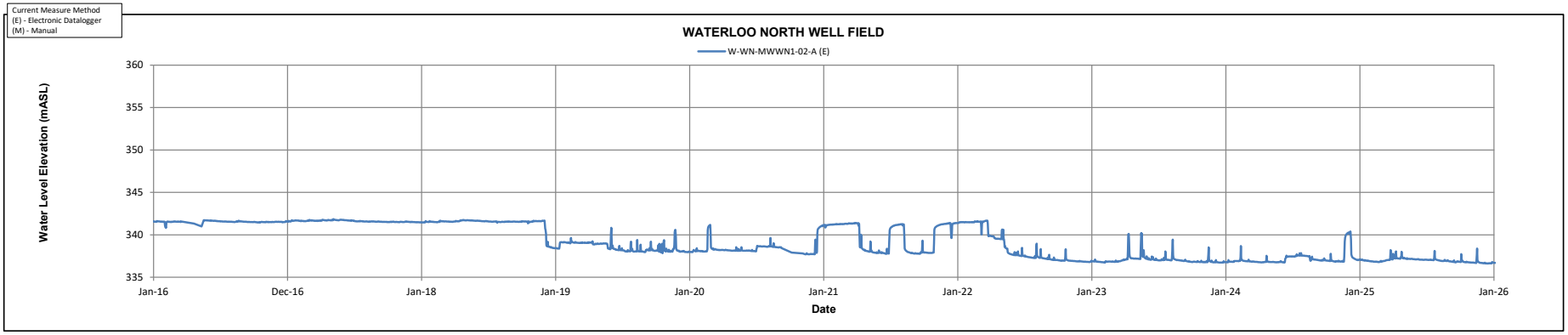


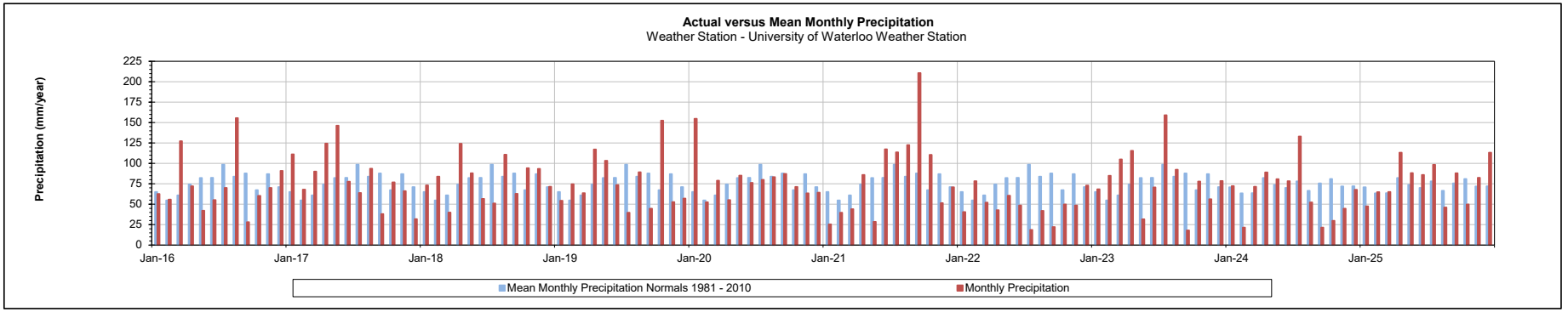


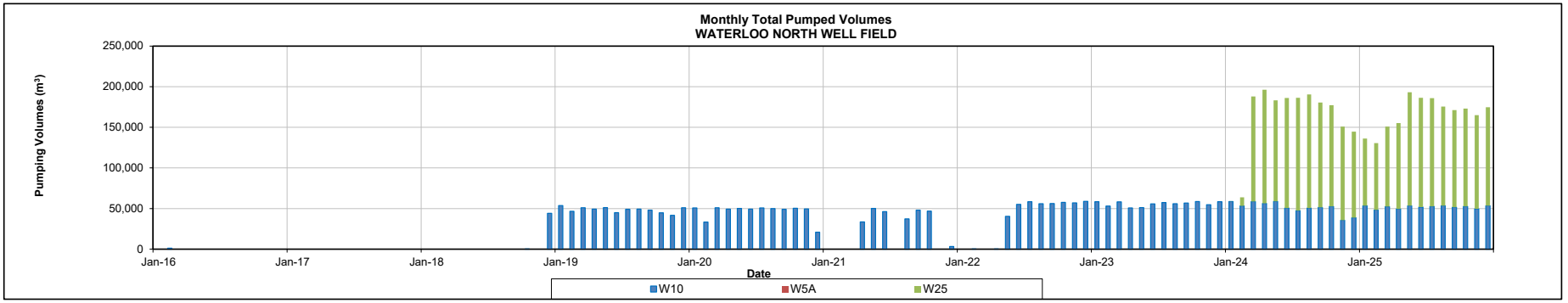
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

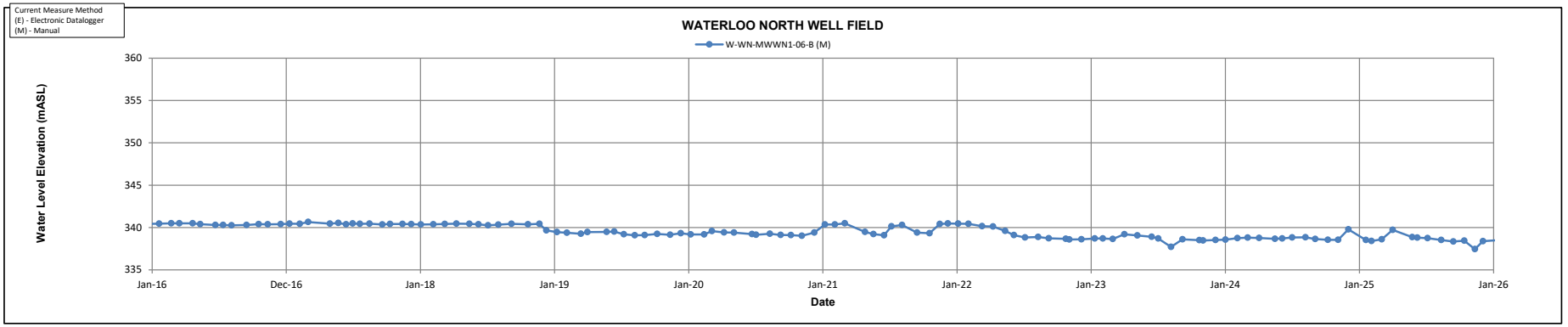




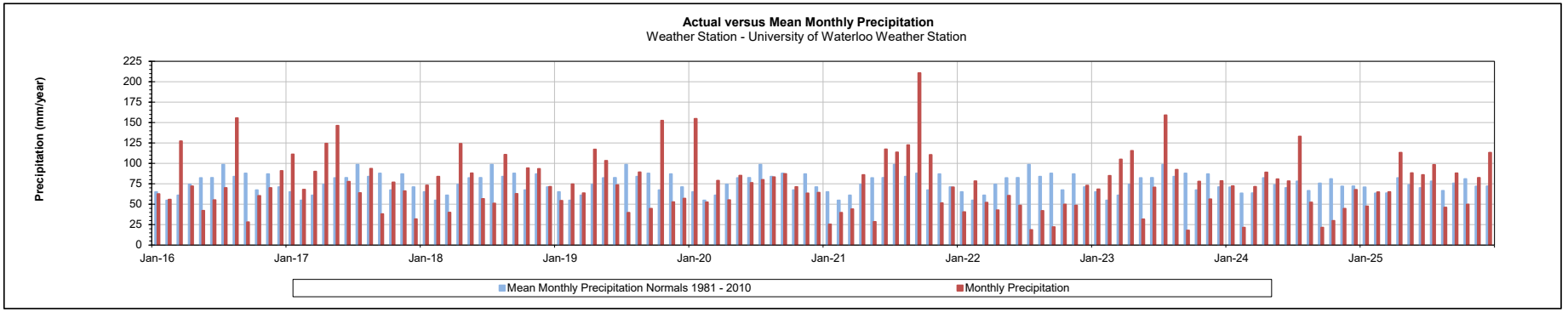


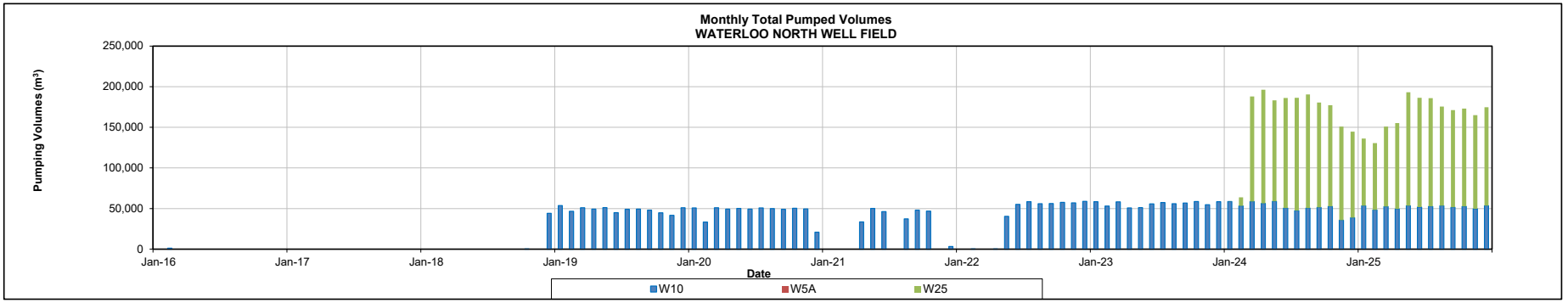

Actual versus Mean Monthly Precipitation
Weather Station - University of Waterloo Weather Station
Precipitation (mm/year)
225
200
175
150
125
100
75
50
25
0
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Mean Monthly Precipitation Normals 1981 - 2010
Monthly Precipitation

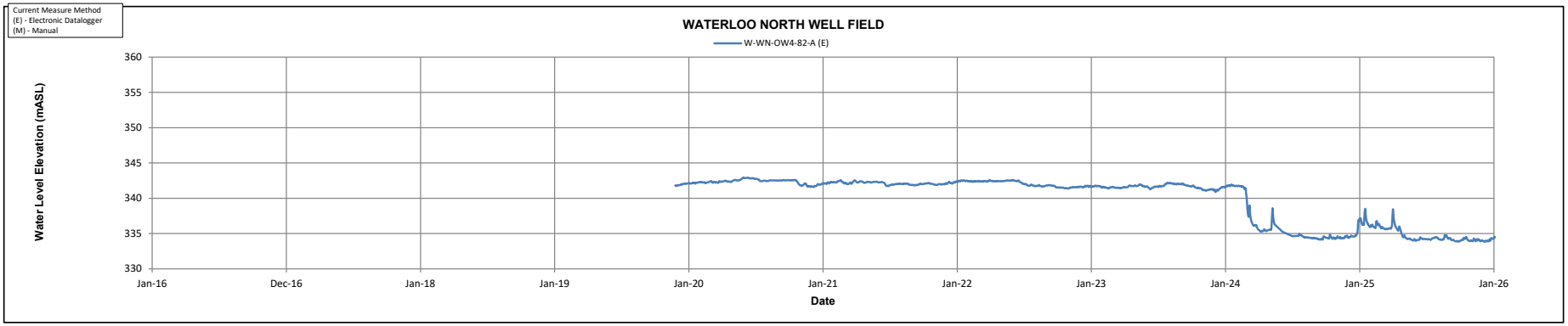

Monthly Total Pumped Volumes
WATERLOO NORTH WELL FIELD
Pumping Volumes (m³)
250,000
200,000
150,000
100,000
50,000
0
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Date
W10
W5A
W25


Current Measure Method
(E) - Electronic Datalogger
(M) - Manual
WATERLOO NORTH WELL FIELD
W-WN-MWWN1-06-B (M)
Water Level Elevation (mASL)
360
355
350
345
340
335
Jan-16
Dec-16
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Jan-26
Date

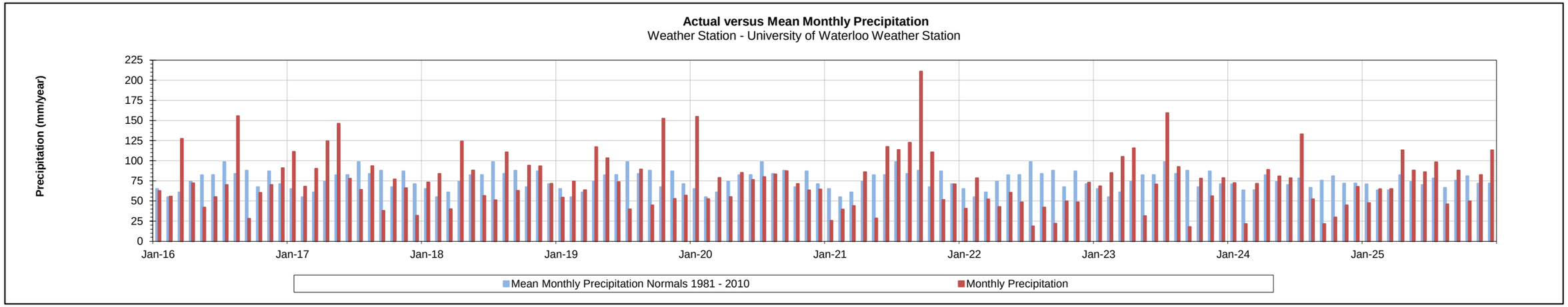
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

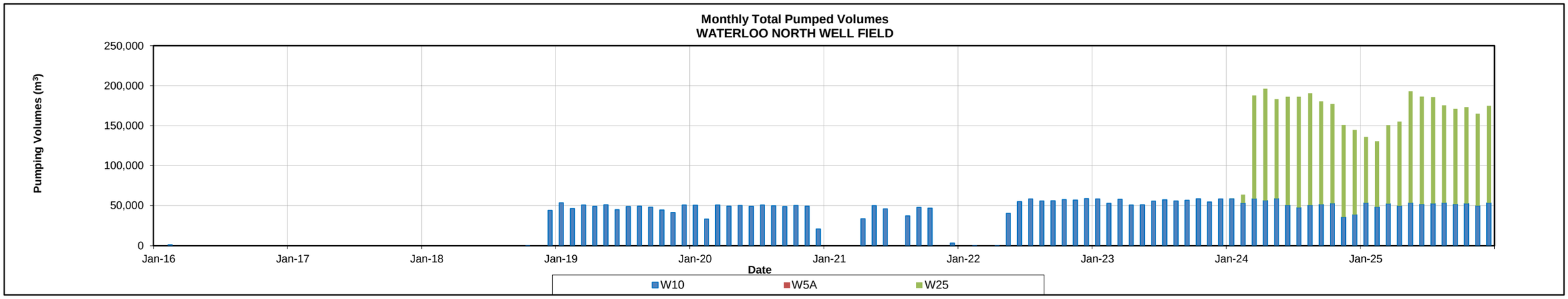


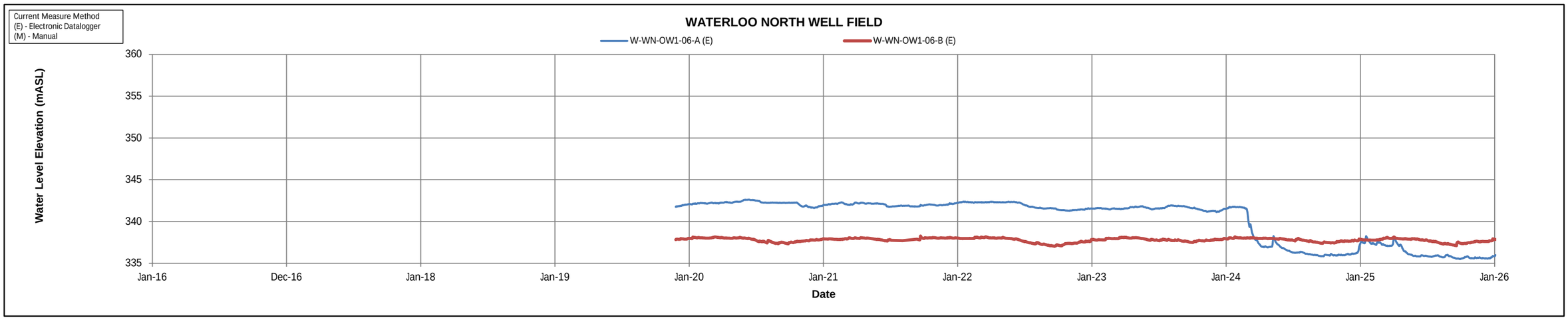




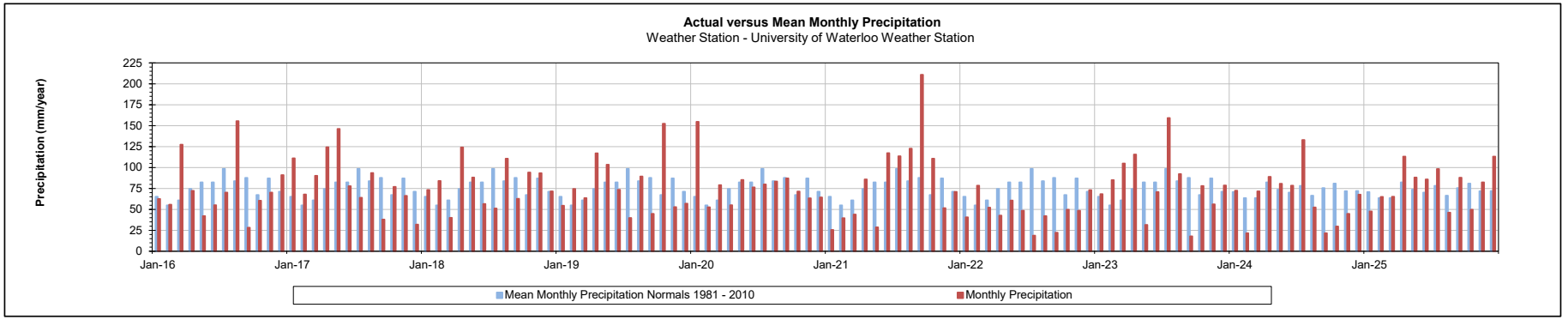
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

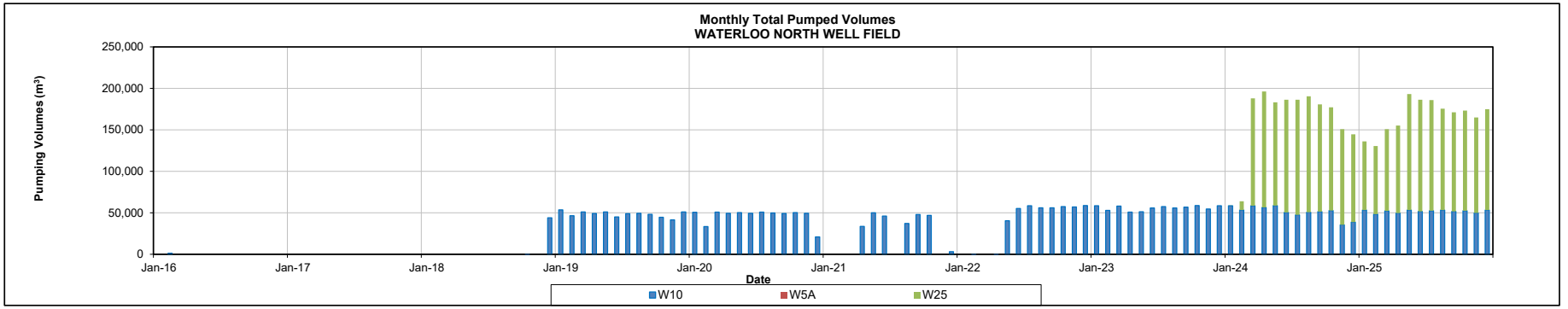


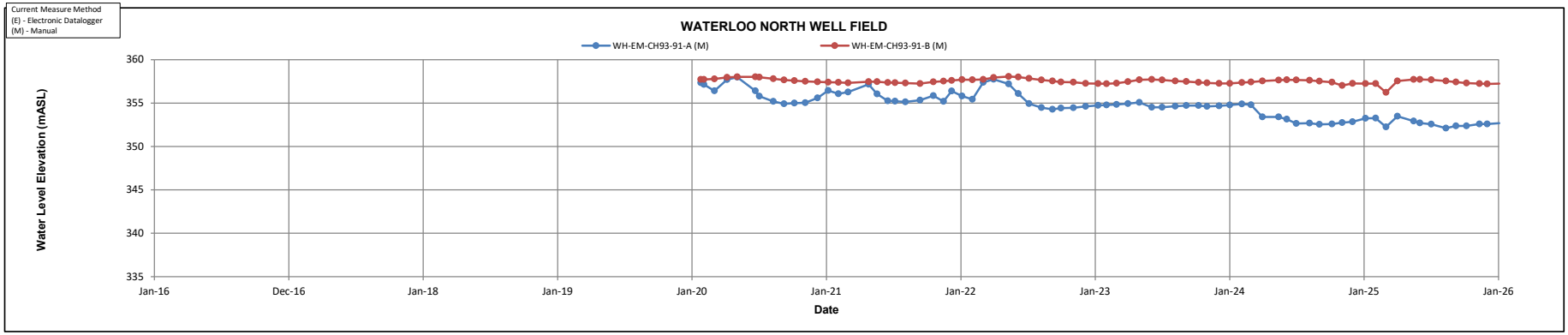


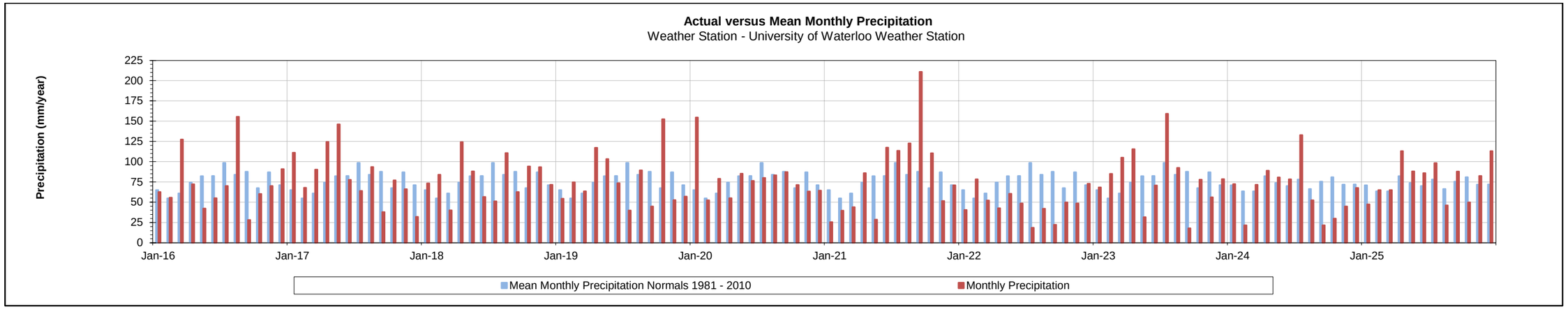


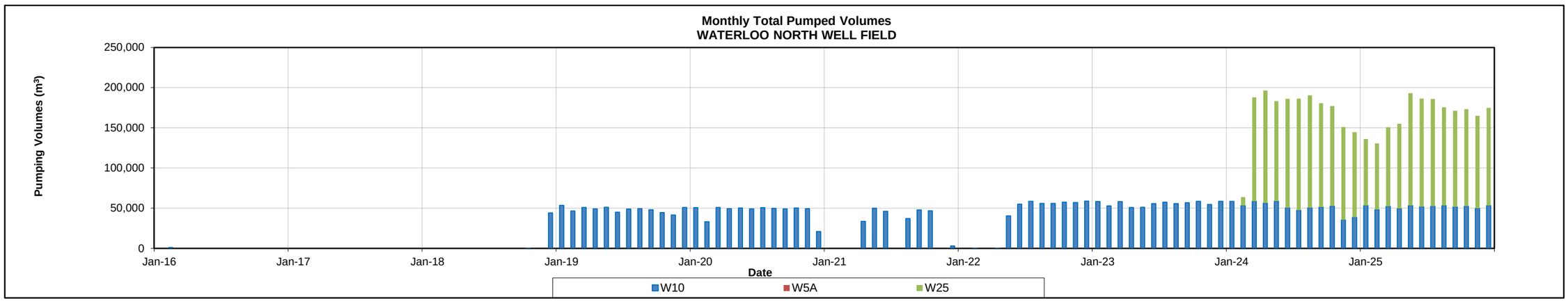
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

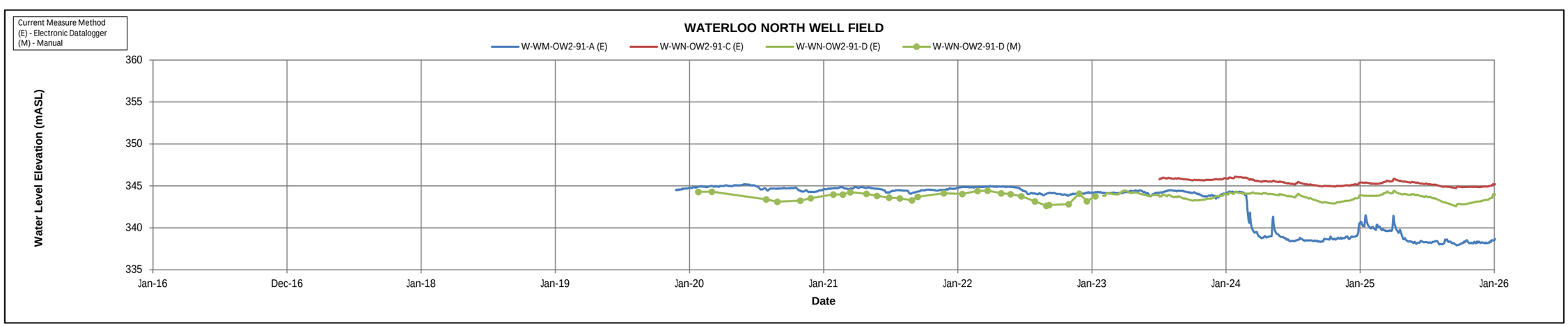




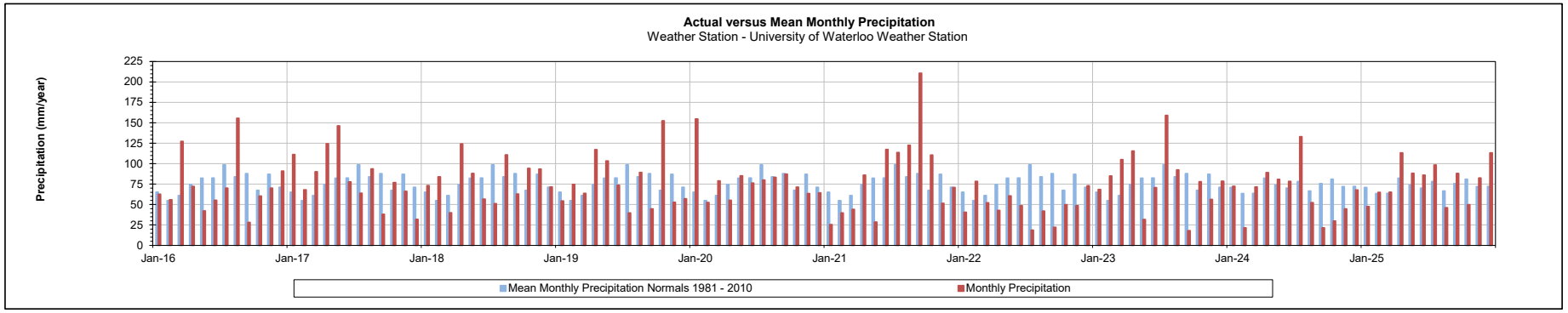


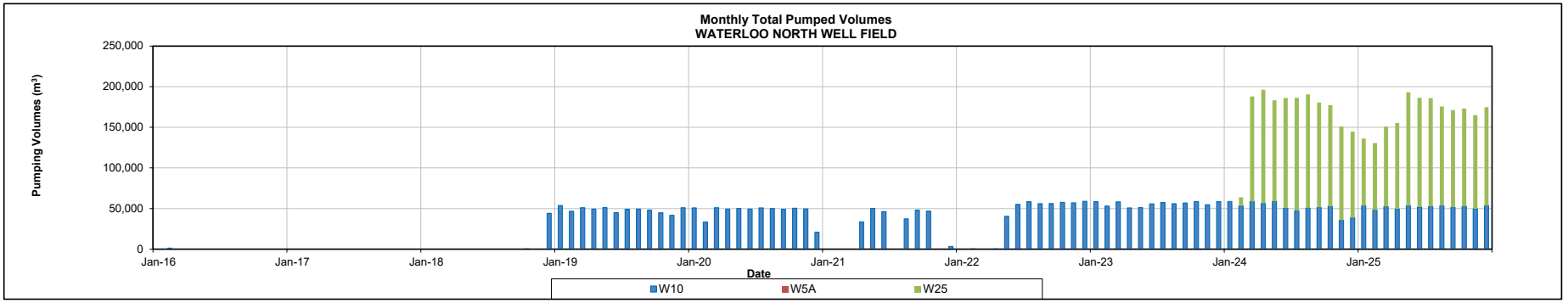

Actual versus Mean Monthly Precipitation
Weather Station - University of Waterloo Weather Station
Precipitation (mm/year)
225
200
175
150
125
100
75
50
25
0
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Mean Monthly Precipitation Normals 1981 - 2010
Monthly Precipitation

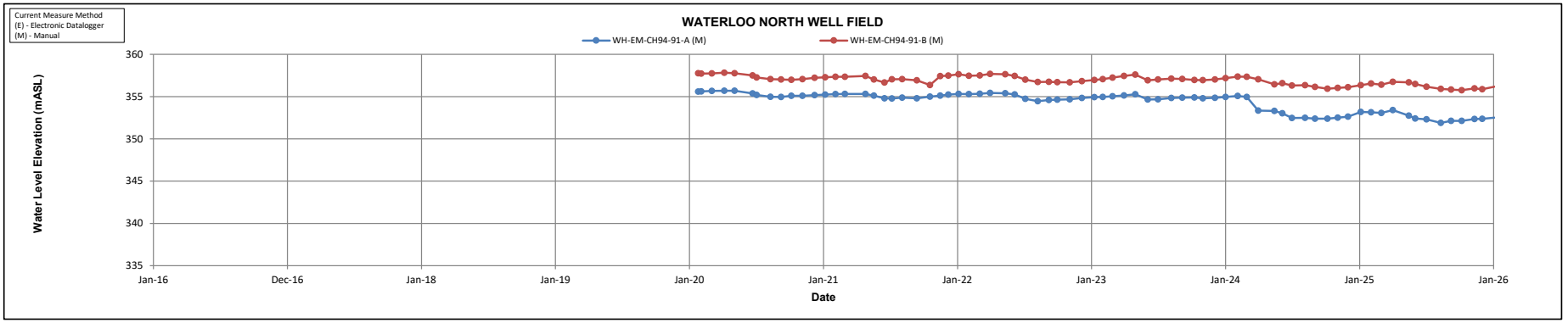

Monthly Total Pumped Volumes
WATERLOO NORTH WELL FIELD
Pumping Volumes (m³)
250,000
200,000
150,000
100,000
50,000
0
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Date
W10
W5A
W25


Current Measure Method
(E) - Electronic Datalogger
(M) - Manual
WATERLOO NORTH WELL FIELD
W-WM-OW2-91-A (E)
W-WN-OW2-91-C (E)
W-WN-OW2-91-D (E)
W-WN-OW2-91-D (M)
Water Level Elevation (mASL)
360
355
350
345
340
335
Jan-16
Dec-16
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Jan-26
Date

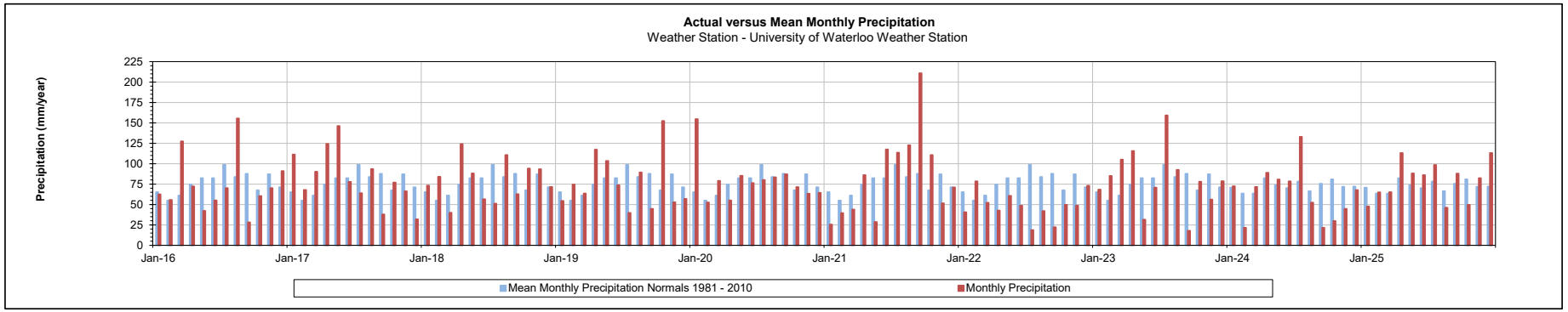
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

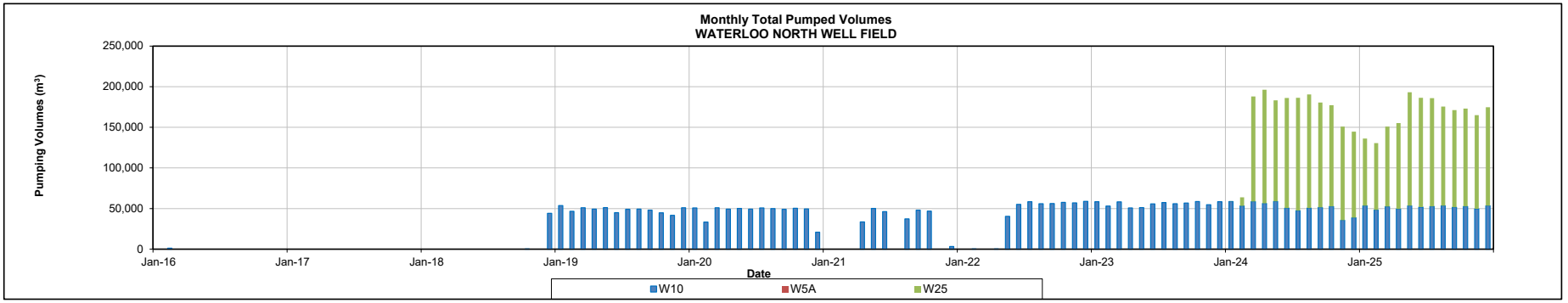


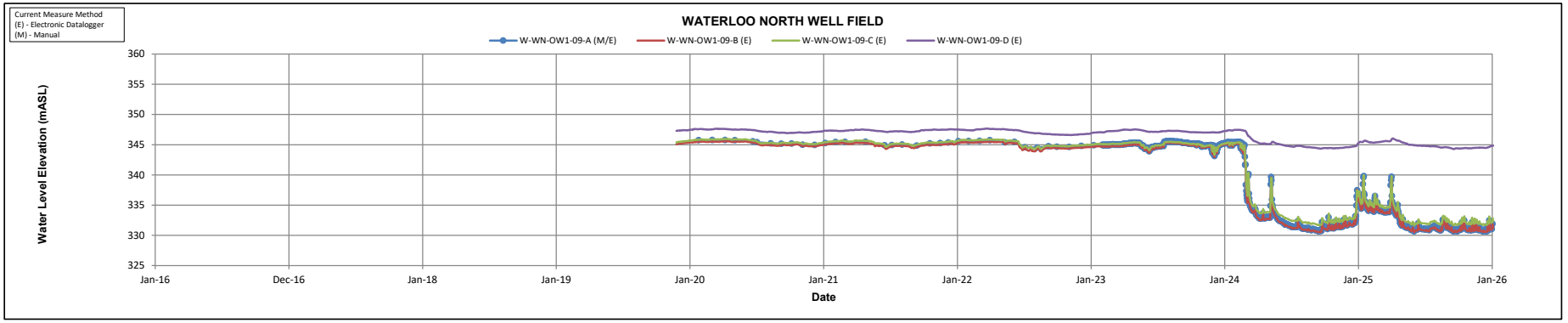




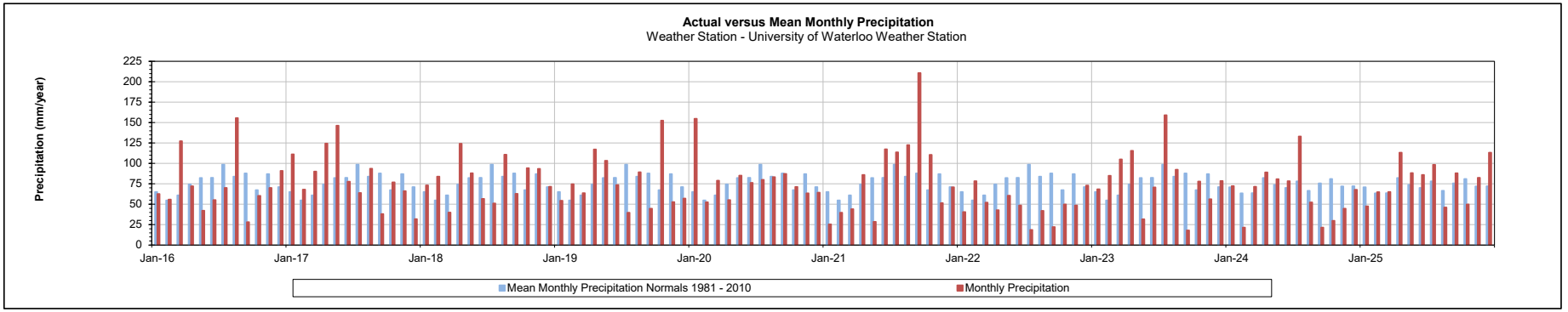
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

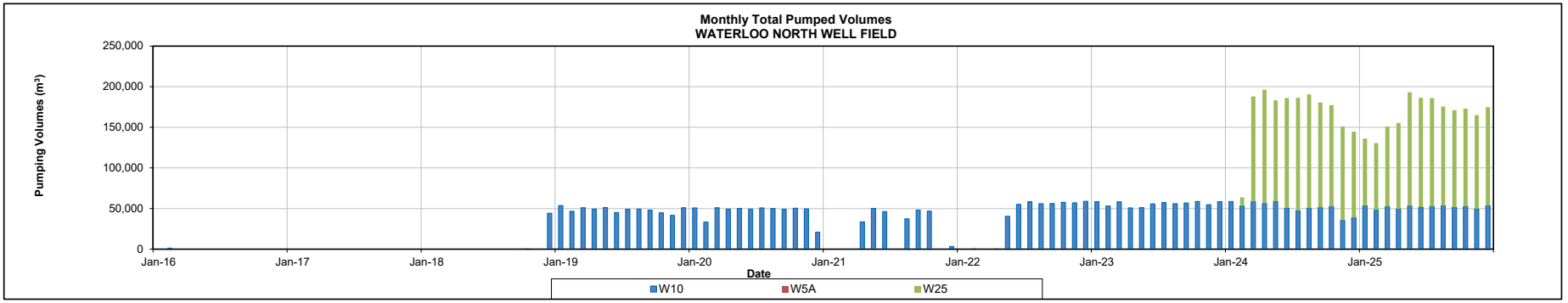


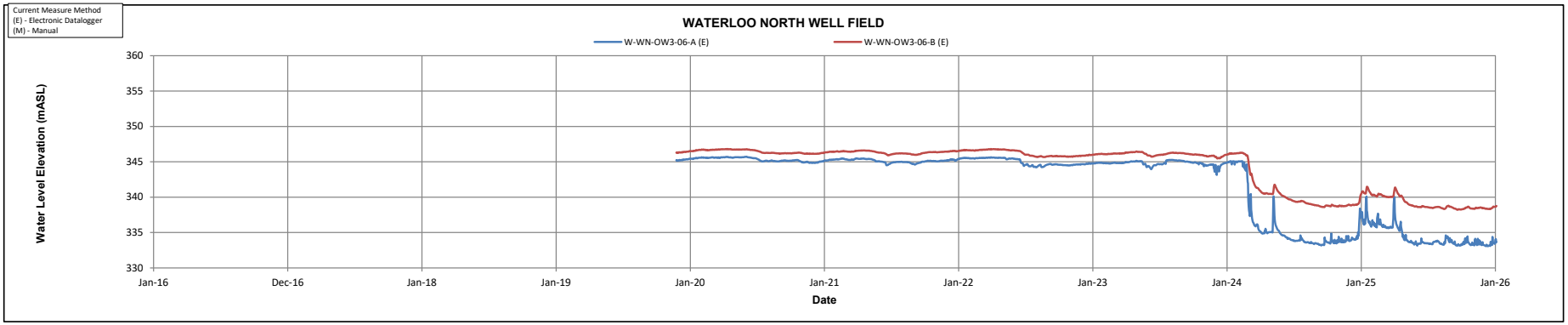




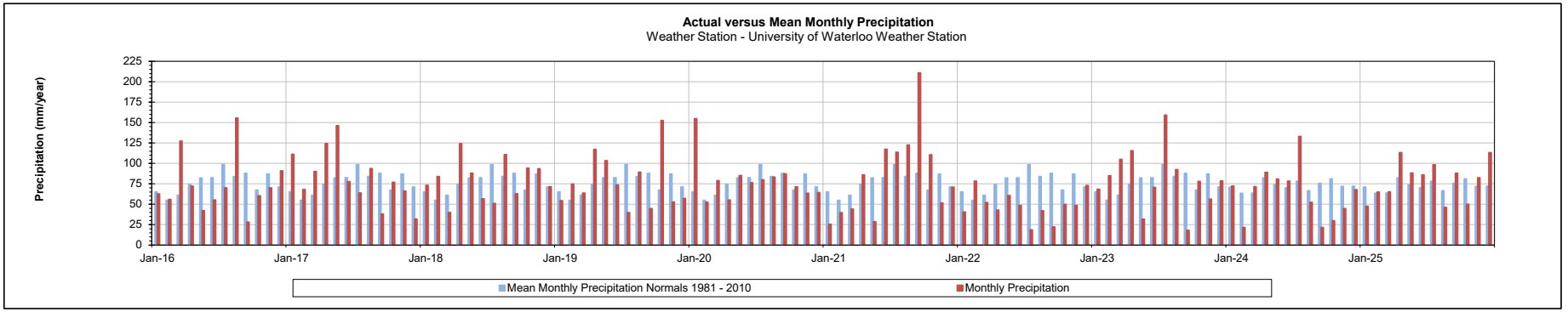
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

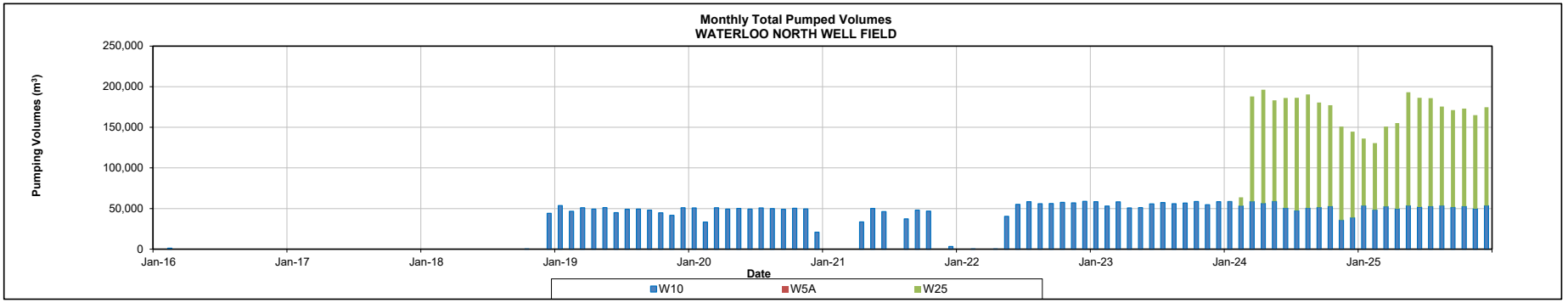


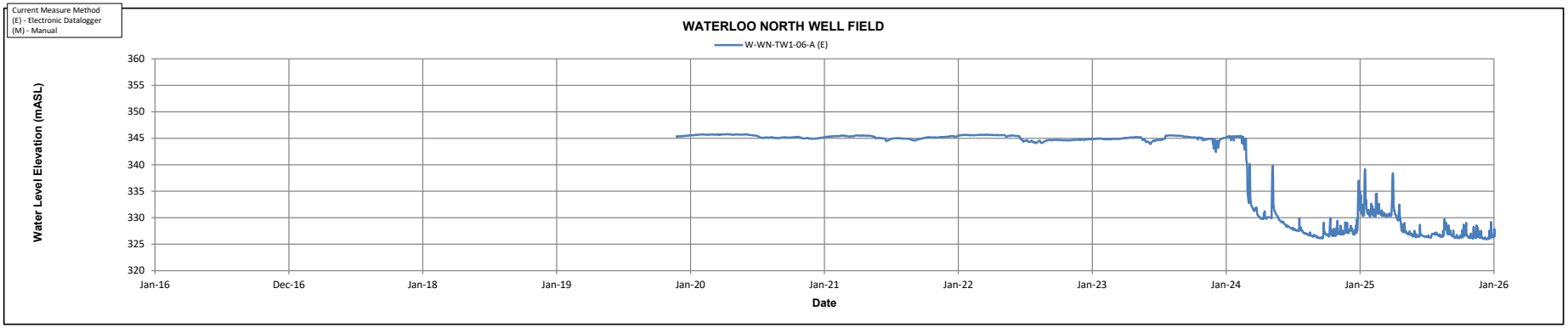




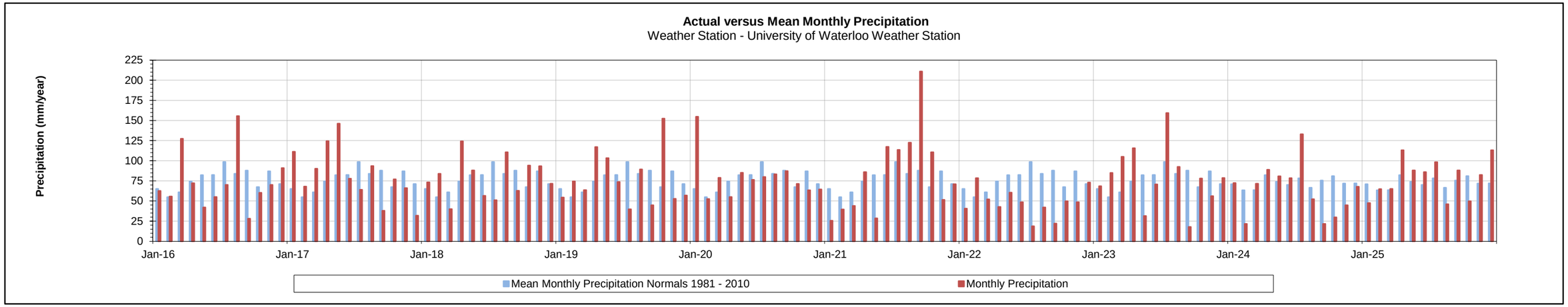
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

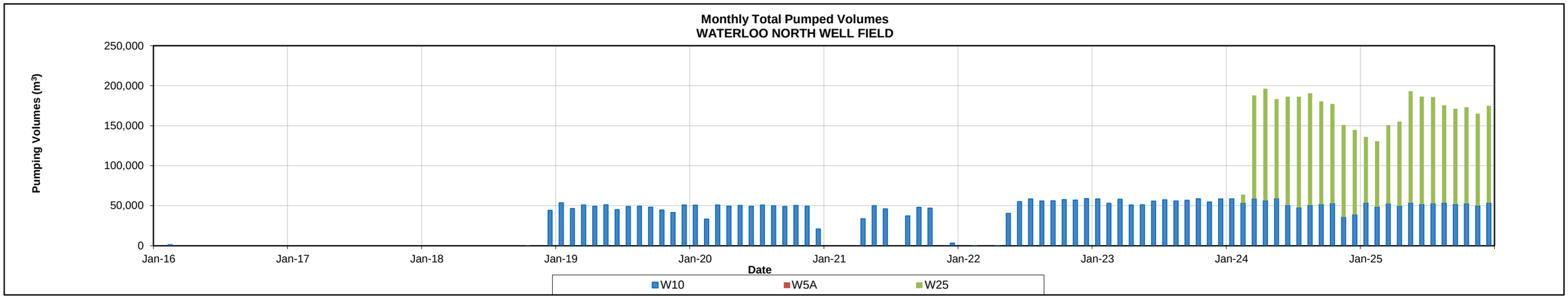


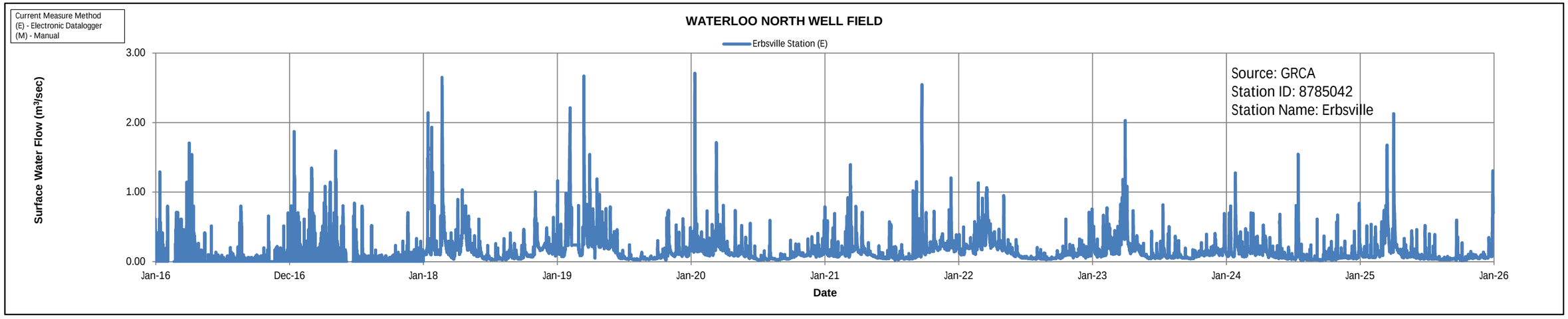




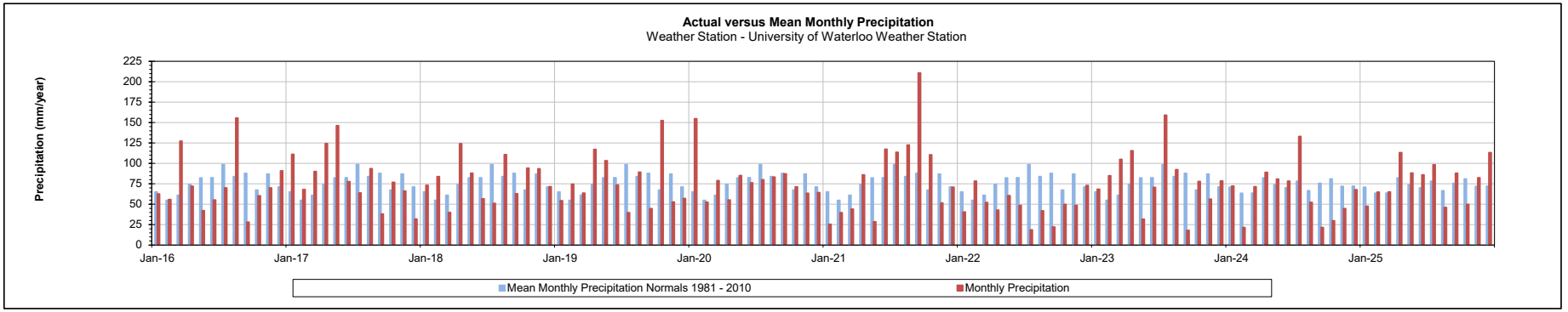
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

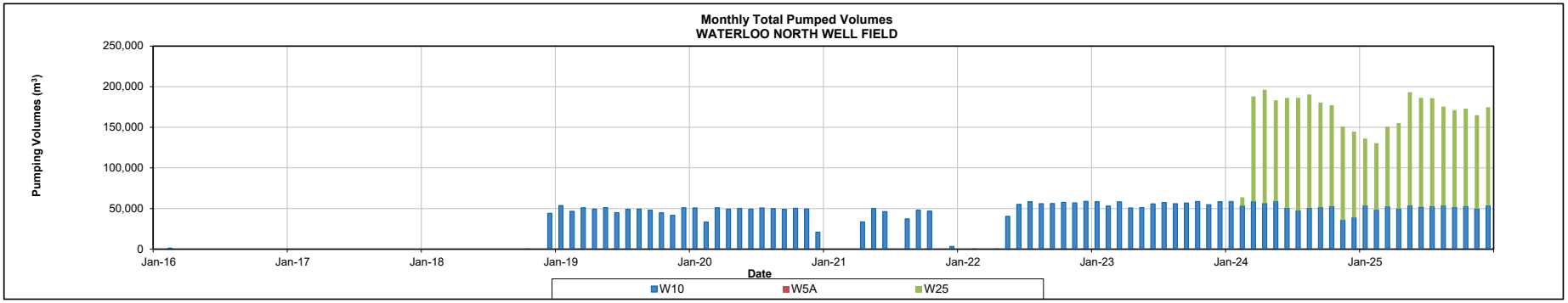


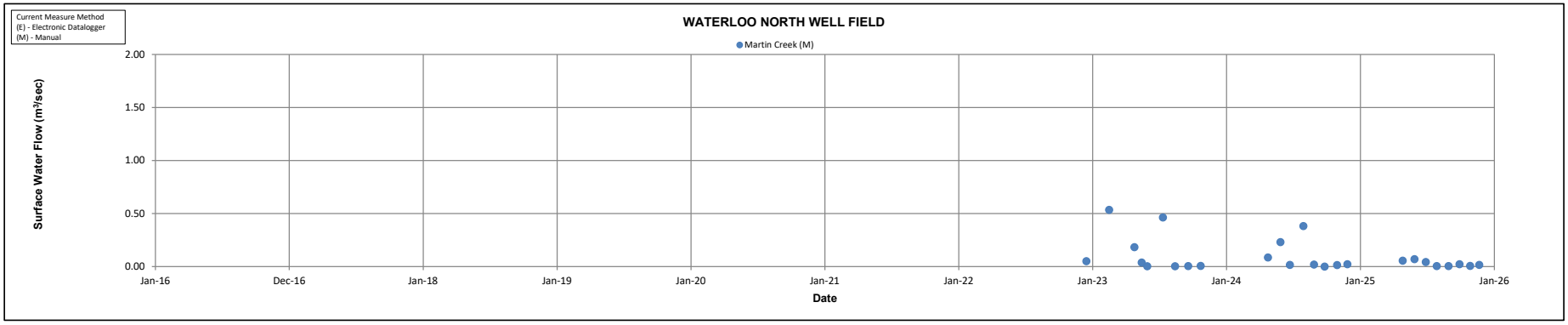




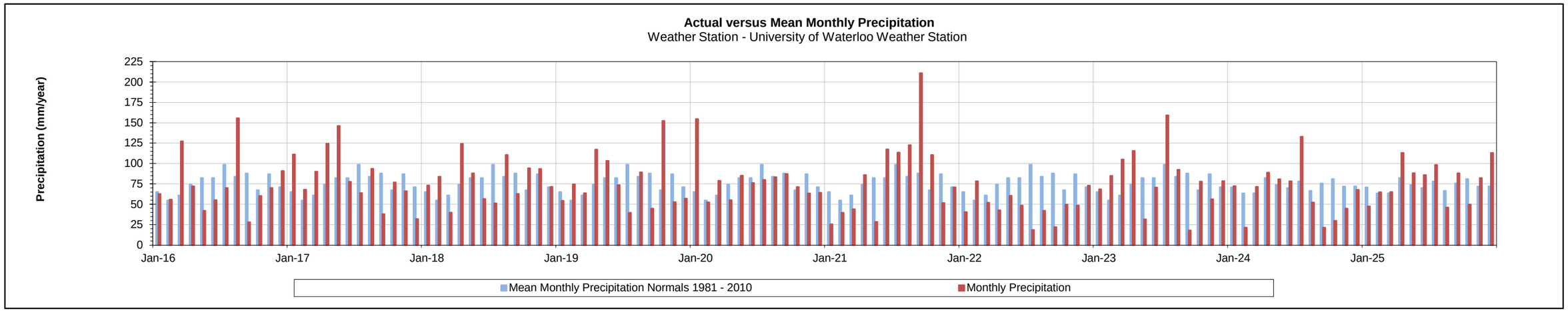
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH

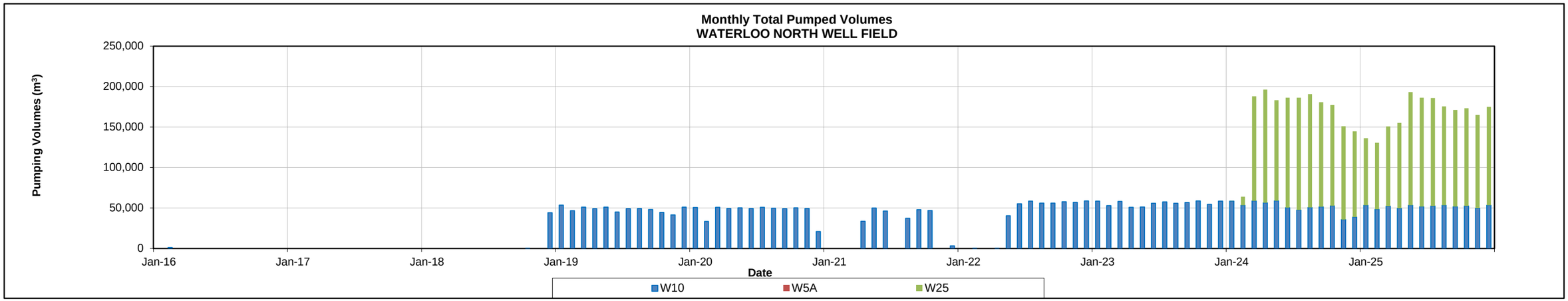


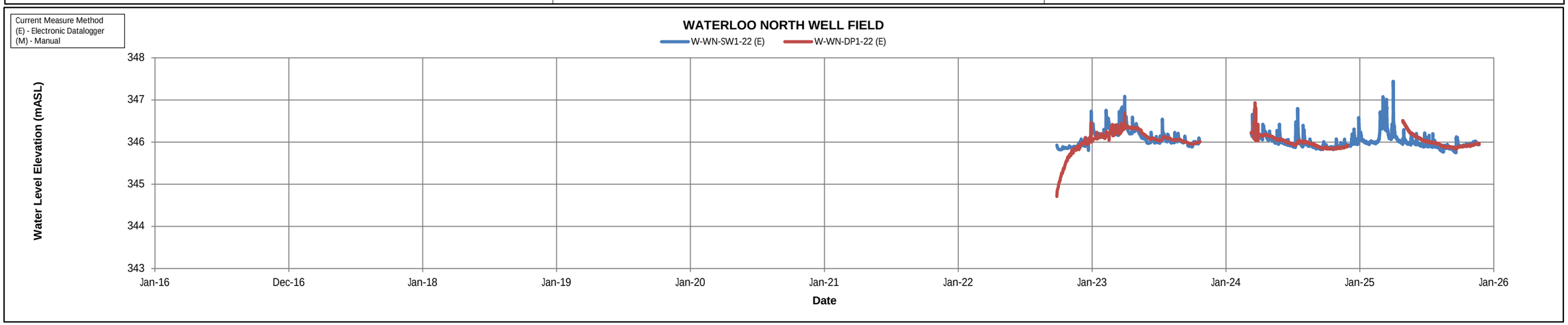


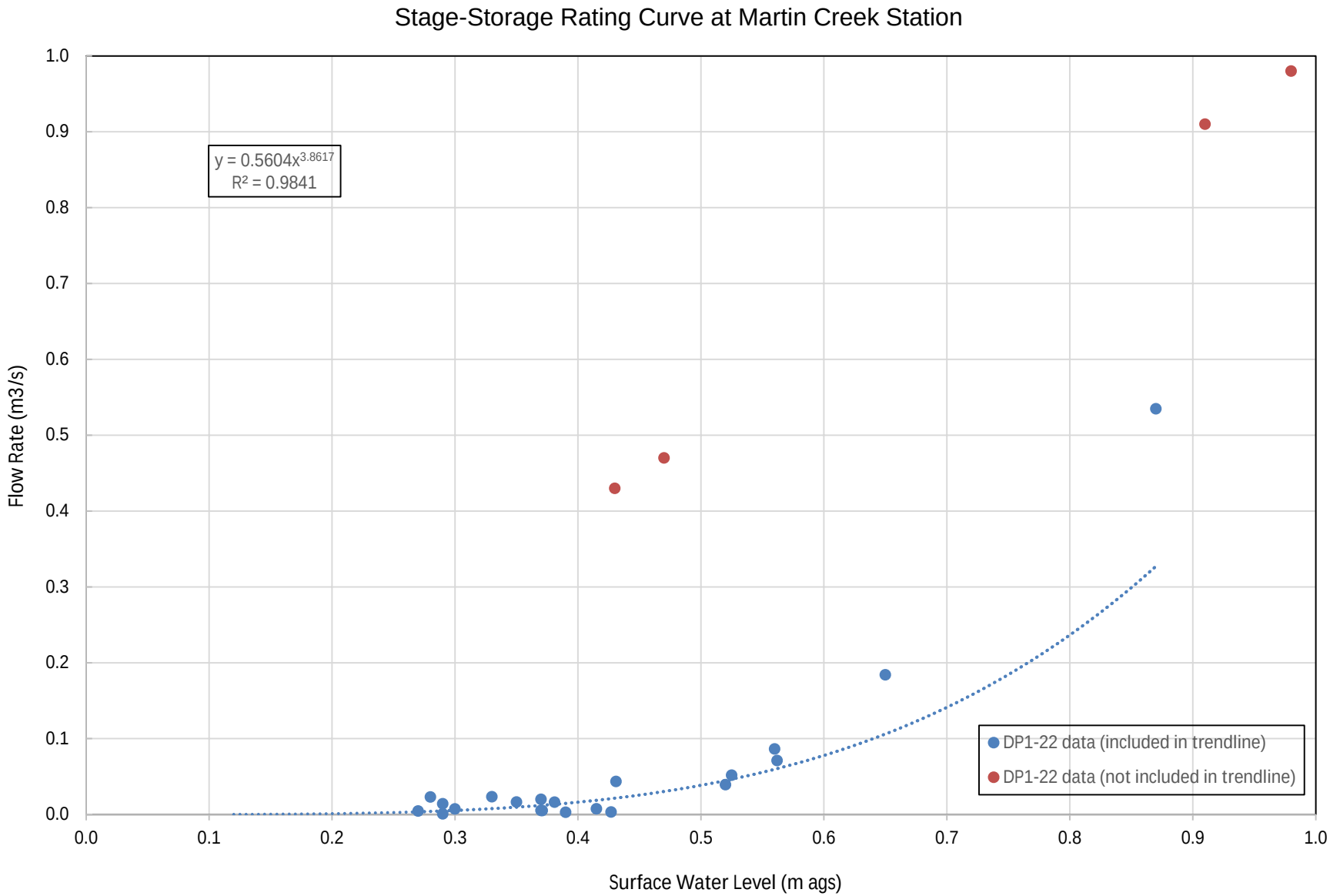


REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
WATERLOO NORTH








Stage-Storage Rating Curve at Martin Creek Station
y = 0.5604x^3.8617
R² = 0.9841
Flow Rate (m3/s)
Surface Water Level (m ags)
DP1-22 data (included in trendline)
DP1-22 data (not included in trendline)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

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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

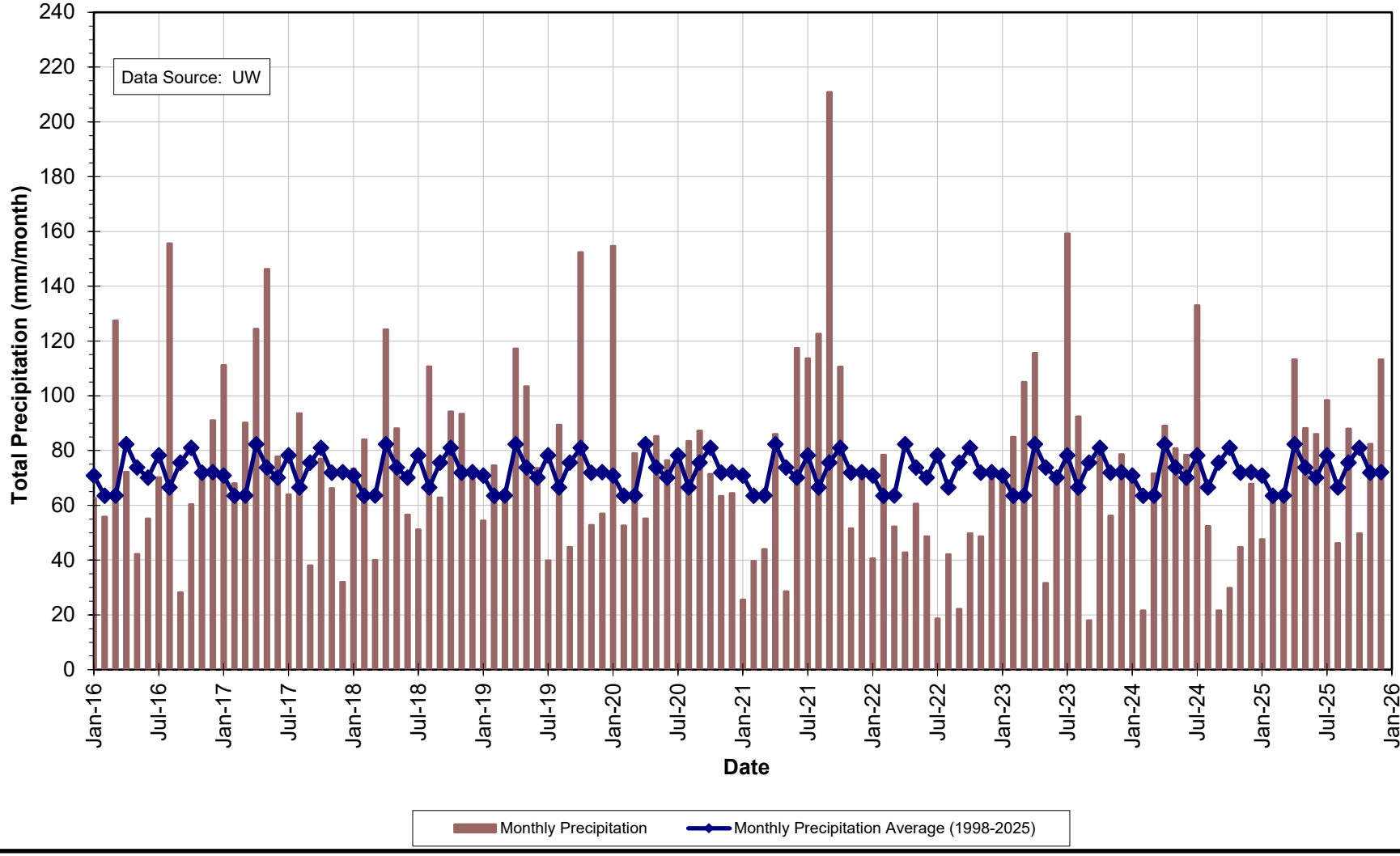
Year	Laurel Dam Established 1960		
	Annual Precipitation (mm)	Average Precipitation 1960-2025 (mm)	Difference (mm)
2016	985	938	47
2017	1062	938	124
2018	1071	938	133
2019	940	938	2
2020	938	938	0
2021	1027	938	89
2022	689	938	-249
2023	921	938	-17
2024	907	938	-31
2025	894	938	-44

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
University of Waterloo Weather Station
Monthly Precipitation



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Prepared By: C.D.
Printed On: 2/13/2026
File: Appendix D Precipitation Data/Monthly UW

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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.

R.J. Burnside & Associates Limited