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**2025 Biennial Groundwater Monitoring
Report – New Dundee Well Field**

The Region of Waterloo



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2025 Biennial Groundwater Monitoring Report – New Dundee Well Field

The Region of Waterloo

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R.J. Burnside & Associates Limited

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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 5581-B84PGT) for the New Dundee Well Field (ND4, ND5), requires submission of a well field specific biennial report to the Ministry of Environment, Conservation and Parks (MECP) which documents production well pumping volumes and water levels in specific monitoring wells during 2024 and 2025. This report has been prepared to meet the reporting conditions of the PTTW for 2024 and 2025. A copy of the PTTW is included in Appendix A.

The location of the New Dundee Well Field is shown on Figure 1. The production wells in the Township of Wilmot are shown on Figure 2 with the monitoring network for ND4 and ND5 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 PTTW and to confirm that water taking is sustainable in the long term. The monitoring wells are concentrated near the production wells and in known aquifer recharge areas. 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 the New Dundee Well Field in accordance with PTTW 5581-B84PGT which consists of the following activities:

- Measuring the daily volume pumped from the ND4 and ND5 production wells (Condition 4.1 of the PTTW);
- Measuring the water levels in monitoring wells WT-AC-AC1-03-AB, WT-ND-OW1-03-A and WT-ND-OW2-03-AB (Condition 4.2 of the PTTW);
- 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 4.3 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 New Dundee Well Field is located southwest of Kitchener, near the eastern edge of the Township of Wilmot. Wells ND4 and ND5 are located near the northern edge of New Dundee. The closest surface water feature to the ND4 and ND5 site is Alder Lake, located approximately 200 m west of ND5 (Figure 3).

2.1.1 Pumping Wells

Well records for the production wells are found in Appendix B. ND4 was constructed in 1989 with a 203 mm diameter stainless steel well screen from 14.0 to 17.1 metres below ground level (mbgl). Well ND5 was constructed in 2003 with a 191 mm diameter stainless steel well screen between 13.7 and 15.2 mbgl. Both ND4 and ND5 are screened in AFB1 / AFB2 (AquaResource Inc., 2012). Further production well details are included in Table 1.

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

Table 1: Production Well Construction Details

Production Well ID	Year Built	Screen Diameter (mm)	Screened Interval (mbgs)	Aquifer
ND4	1989	203	14.0 – 17.1	AFB1/ AFB2
ND5	2003	191	13.7 – 15.2	AFB1/ AFB2

The water taking volumes for the New Dundee 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 Details	2024			2025		
		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)
ND4	983.52	117	255	42,735	128	213	46,876
ND5	983.52	73	127	26,482	75	126	27,221

Well	PTTW Details	2024			2025		
		Both Wells	983.52	190	382	69,217	203

Condition 3.3 of the PTTW specifies that the combined daily water taking from ND4 and ND5 must not exceed a maximum of 982.52 m³/day from any well or both wells. 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 4.1 of the PTTW.

ND4 and ND5 are pumped together, with ND4 providing 55 to 80% of the total volume. In 2024 and 2025, ND4 and ND5 provided about 62% and 48% of the total volume, respectively.

Pumping volumes from the well field ranged from 4,974 m³/month to 6,625 m³/month in 2024, and from 4,996 m³/month to 7,928 m³/month in 2025. In total, 69,217 m³ was produced at this well field in 2024 and 74,097 m³ was produced in 2025. These volumes are lower than the previous four years and below the permitted volume of 358,985 m³ per year (Table C-1).

2.1.2 Monitoring Wells

Observation wells WT-ND-AC1-03-A, WT-ND-AC1-03-B, WT-ND-ND-OW2-03-A and WT-ND-OW2-03-B are located 100 northeast of ND4 and WT-ND-NDOW1-03 is located adjacent to ND5 (Figure 3). Construction and monitoring details of WT-ND-AC1-03-A, WT-ND-AC1-03-B, WT-ND-OW1-03-A, WT-ND-OW2-03-A and WT-ND-OW2-03-B are described in the table below. Well records for the monitoring wells are provided in Appendix B.

Table 3: Monitoring Well Construction Details

Monitoring Well ID	Year Constructed	Screened Depth (mbgs)	Screened Formation	Distance to ND4 (m)	Distance to ND5 (m)
WT-ND-AC1-03-A	2003	20.1 – 23.1	AFB1	100	200
WT-ND-AC1-03-B	2003	11.9 – 14.9	AFB1	100	200
WT-ND-OW1-03-A	2003	13.7 – 16.8	AFB1	50	Beside
WT-ND-OW2-03-A	2003	9.1 – 12.2	AFB1	100	300
WT-ND-OW2-03-B	2003	3.0 – 6.1	AFB1	100	300

2.2 Regional Geology and Hydrostratigraphy

The following sections provide a brief overview of the regional geology and hydrogeology of the New Dundee Well Field. The surficial geology at the site based on regional OGS mapping is provided in Figure 4. Representative cross-sections showing the stratigraphy in the vicinity of the New Dundee Well Field (ND4, ND5) are included as Figures 6 and 7 to visualize the stratigraphy described in this section. 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 New Dundee 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.

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 New Dundee 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 Alder Creek. In addition, the deposition of the Waterloo Moraine in this area resulted in fine- to coarse-grained sand and gravel deposits at surface (AFB1). The thickness of the overburden deposits generally ranged from 50 to 70 m in this area and is thickest outside the Alder Creek valley.

The Quaternary units typically present in the New Dundee area are briefly described below, in order from youngest to oldest.

Aquitard ATB1 – Port Stanley Till

The Port Stanley Till is a sandy silt to silty sand till, with occasional stony texture, that is predominantly found along the flanks of the Waterloo Moraine. The Port Stanley Till was deposited by ice advancing from the Erie-Ontario ice lobe. In other parts of the Region, Bajc and Shirota (2007) have also used unit ATB1 to represent Tavistock, Mornington and Upper Maryhill Tills. ATB1 is approximately 10 m thick in the area of New Dundee. This unit is considered an aquitard and, where present, acts to restrict recharge to the lower aquifers.

Aquifer AFB1 / AFB2 – Upper Waterloo Moraine Stratified Sediments and Equivalent

Aquifer AFB1 / AFB2 represents the main water supply aquifer in the core areas of the Waterloo Moraine, including the New Dundee production wells. 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. 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. This unit is approximately 10 m thick in the New Dundee Well Field area.

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. This unit is approximately 5 m thick in the New Dundee Well Field area.

Aquifer AFB3 – Lower Waterloo Moraine Stratified Sediments

The Lower Waterloo Moraine Stratified Sediments is present below the Lower Maryhill Till, mainly along the eastern flank of the Moraine. This unit consists of stratified gravels, sands, or silts and is of very limited extent. It is approximately 5 to 15 m thick in the New Dundee Well Field area.

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. It is approximately 20 m thick in the New Dundee Well Field area.

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 Till and represents the main supply aquifer in several production wells in the Cities of Kitchener and Waterloo. This unit is spatially discontinuous throughout much of the core areas of the Waterloo Moraine and pinches out beneath Alder Creek.

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 underlying bedrock at the New Dundee Well Field is characterized as the Salina Formation, and consists of interbedded grey and brown dolostone, green to red shale units, and gypsum. Groundwater extracted from this unit tends to be of poor quality due to the presence of sulphates (Johnston et al., 1992). In the New Dundee Well Field area, bedrock is found at depths of approximately 50 metres below ground surface (mbgs).

2.3 Local Geology

The following description of local geology is based on drilling investigations for the installation of the production well ND5 (CH2M Hill, 2003). Borehole logs of the New Dundee Well Field are included in Appendix B.

Port Stanley Till (ATB1) – This unit was identified in ND4 as silt with clay / sand from 0.6 m to 8.5 mbgs and at ND5 as silt from 0.6 m to 7.3 mbgs.

Upper Waterloo Moraine (AFB1/AFB2) – This unit was identified in the well record for ND4 as gravel with sand/cobbles from 8.5 m to 17 mbgs and at ND5 as gravel with sand and cobbles from 7.3 to 15.5 mgs, gravel with silt / clay from 15.5 to 16.8 mbgs and clay from 16.8 to 18.3 mbgs. Production wells ND4 and ND5 are both completed in this aquifer.

Lower Maryhill Till (ATB3) – This unit was identified below AFB1 / AFB2 in well records for ND4 at a depth of 17 m, at WT-ND-AC1-03-A at 14.6 m and at WT-ND-OW1-03-A at a depth of 15.5 m.

3.0 2024 / 2025 Results

The following sections summarize groundwater levels at the monitoring in relation to precipitation and water taking from the aquifer (in accordance with condition 4.3 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 GRCA and Environment Canada station located closest to the production wells are used. The closest weather station to the well field is the Environment Canada Roseville station located about 4.7 km east from the well field. The second closest weather station is the University of Waterloo weather station located 13.4 km north from the well field. The locations of the meteorological stations are shown on Figure 1. Annual precipitation data from the past ten years for all stations are compared with long-term averages in Table D.1, Appendix D. Monthly precipitation data for the past ten years at the Roseville station are shown on Figure D.1, Appendix D. At the University of Waterloo (U of W) 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 closest weather stations to the New Dundee well field are presented in Table 4 below. In 2024 Roseville was missing five 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)
Roseville Station ⁽¹⁾	856	-63	919 ^(A)	786	-133
University of Waterloo ⁽²⁾	763	-108	871 ^(B)	943	+72

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

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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 the U of W station was 763 mm, which is 108 mm below the long-term average, indicating 2024 was a drier-than-average year at the well field. A similar lower than long-term average trend is noted at the Roseville station. The March 1, 2024 GRCA snow survey indicated a snowpack across the Region that was low compared to normal. In 2025, the total precipitation at the U of W station was 943 mm, which is 72 mm above the long-term average. Alternately, the total precipitation at the Roseville station was 133 mm below the long-term average, indicating 2025 was a drier-than-average year. However, Roseville was missing 25 days of data in 2024 / 2025 and as a result, precipitation totals may be under reported. The snow survey conducted by the GRCA on March 15, 2025, showed that the stations in the Region had a high to very high measured snow water equivalent.

3.2 Monitoring Results

In accordance with condition 4.2 of the PTTW, water levels were measured and recorded once a month in all listed monitoring wells. Hydrographs showing the results of manual monthly water level monitoring at each monitoring well 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-ND-AC1-03-A and WT-AC-AC1-03-B

Monitoring well WT-ND-AC1-03-AB is located 100 m northeast of ND4 and has been monitored since April 2004. The well monitors water levels at two depths:

- Screen A is located from 20.1 to 23.1 m below grade and monitors the overburden aquifer AFB1 slightly below the production wells from 303.0 to 300.0 masl (metres above sea level); and
- Screen B is located from 11.9 to 14.9 m below grade monitors the shallow overburden aquifer AFB1 at the same depth as the production wells from 311.3 masl to 308.2 masl.

2024 / 2025 water levels are consistent with historical levels. Water levels in both screens have been within a consistent range for the past 10 years and show no impacts from pumping. Since 2016 water levels in the A screen have varied within a 0.9 m range from 315.4 masl to 316.3 masl and showed typical seasonal trends with peak water levels in the spring / early summer. The water levels in the B screen follow a very similar trend to the A screen although they are consistently about 0.5 m lower from 314.9 masl to 315.9 masl.

WT-ND-OW1-03-A

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Monitoring well WT-ND-OW1-03-A is located beside ND5 and is screened in the production aquifer AFB1 from 13.7 to 16.8 m below grade. 2024 / 2025 water levels are consistent with historical levels. Water levels at WT-ND-OW1-03-A vary within a 1 m range between 313.9 and 314.9 masl with a stable trend and show no impacts from pumping. In 2024 and 2025, the seasonal water level trends are similar to those at WT-ND-AC1-03-AB.

WT-ND-OW2-03-A and WT-ND-OW2-03-B

Monitoring well WT-ND-OW2-03-AB is located 100 m northeast of ND4. The well monitors water levels at two depths:

- Screen A is located from 9.1 to 12.2 m below grade and monitors the overburden aquifer AFB1 above the production wells from 308.1 masl to 311.2 masl; and
- Screen B is located from 3.0 to 6.1 m below grade and monitors the shallow overburden aquifer AFB1 above the production wells from 314.2 masl to 317. masl.

2024 / 2025 water levels are consistent with historical levels and show typical seasonal water level trends with a spike in water levels in July 2024 due to higher than normal precipitation. WT-ND-OW2-03-A has a similar water level trend to WT-ND-AC1-03-AB and WT-ND OW1-03-A, with water levels showing seasonal fluctuations between 315.3 masl and 316.2 masl. Water levels in WT-ND-OW2-03-B vary by about 3.6 m with highest levels typically observed during the spring season (March / April). The water level trend is similar to that seen in the A screen, except variations are greater. Water levels vary between 315.6 masl and 318.7 masl.

4.0 Impact Assessment

4.1 Well Interference

Condition 5.1 of the PTTW 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."

There are properties which are not municipally serviced for water supply within 500 m of the New Dundee wells. In the event that 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 have been no well interference complaints related to pumping at the New Dundee Well Field in 2024 and 2025.

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PTTW Condition 5.2 states: "For Groundwater Takings - If the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide to those affected temporary water supplies adequate to meet their normal requirements or shall compensate such persons for their reasonable costs of doing so. If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected."

There are no water takings registered in the MECP PTTW database within 2 km of the wellfield (Figure 3).

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 commencing June 30, 2020, that presents the results of the well field water level monitoring for the two preceding calendar years, assesses changes in water levels in the supply aquifer(s) in relation to precipitation and water taking from the aquifer(s)".

All the monitoring wells are screened in the production overburden aquifer AFB1 and are primarily influenced through seasonal fluctuations. Municipal pumping has minimal impact on water levels in the area. This is consistent with previous testing of ND5 (CH2MHILL, 2004) that indicated no water level response in WT-ND-AC2-03 and WT-ND-AC1-03-A and only 0.6 m of drawdown in WT-ND-OW1-03-A.

All the monitoring wells show similar seasonal fluctuations with the highest and lowest levels observed in the spring and late summer / fall, respectively. However, 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, ground cover conditions and the time between water level measurements (monthly).

5.0 Conclusions

Impacts from pumping the municipal wells at the New Dundee Well Field were evaluated through implementation of the Groundwater Monitoring Program. Based on the information contained in the report, Burnside offers the following conclusions:

- The information presented in this report satisfies condition 4.3 of PTTW 5581-B84PGT;

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- There were no reported well interference complaints arising from water taking at the New Dundee well field;
- The monitoring wells are screened in the production aquifer AFB1, however water levels reflect seasonal climatic conditions with no obvious response to municipal pumping; and
- Water levels in monitoring wells are stable, indicating that current pumping rates have not resulted in any adverse impacts to water levels in the monitoring wells.

6.0 References

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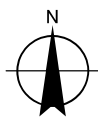
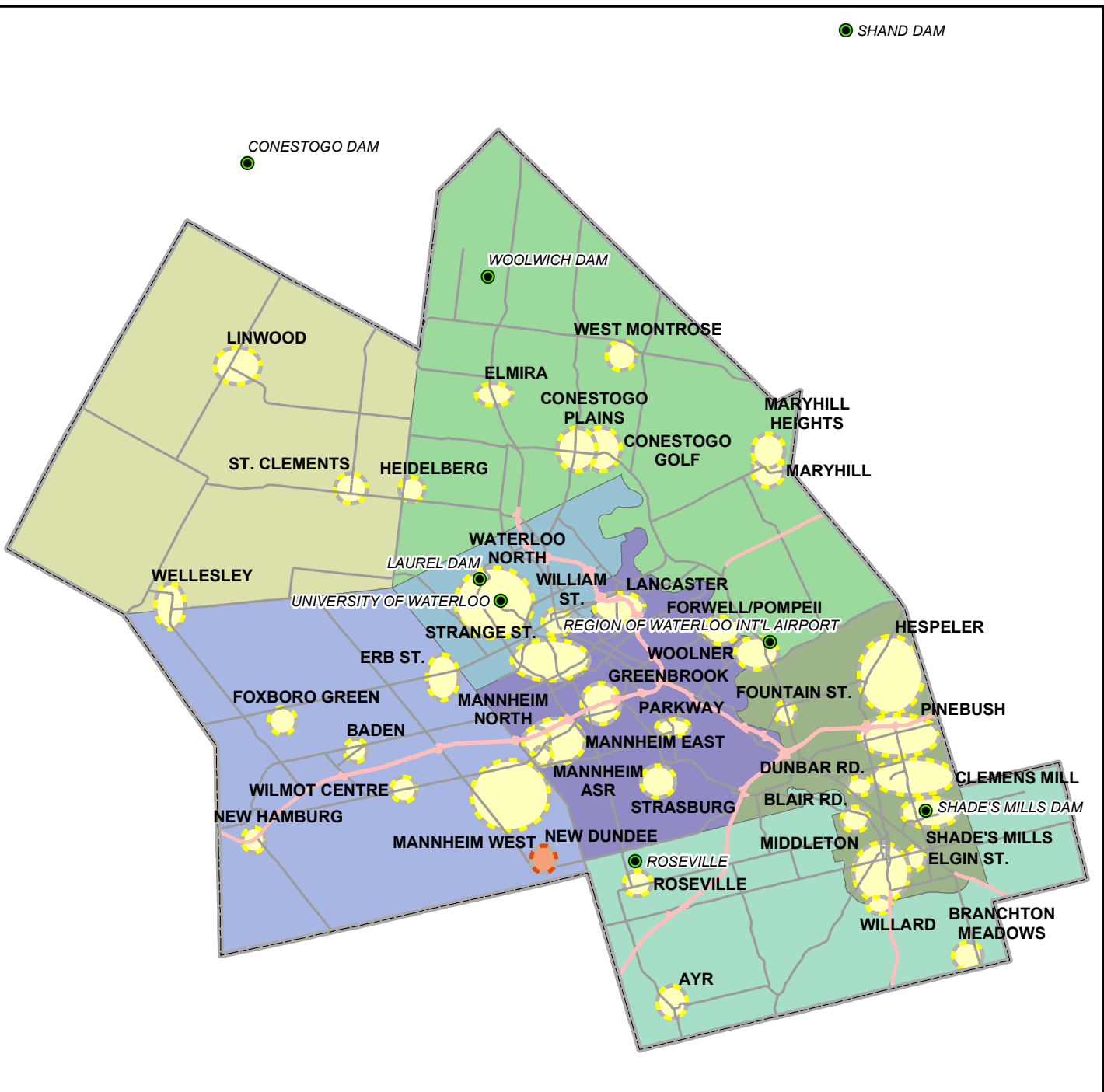


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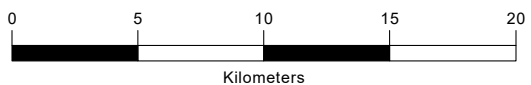
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Figures



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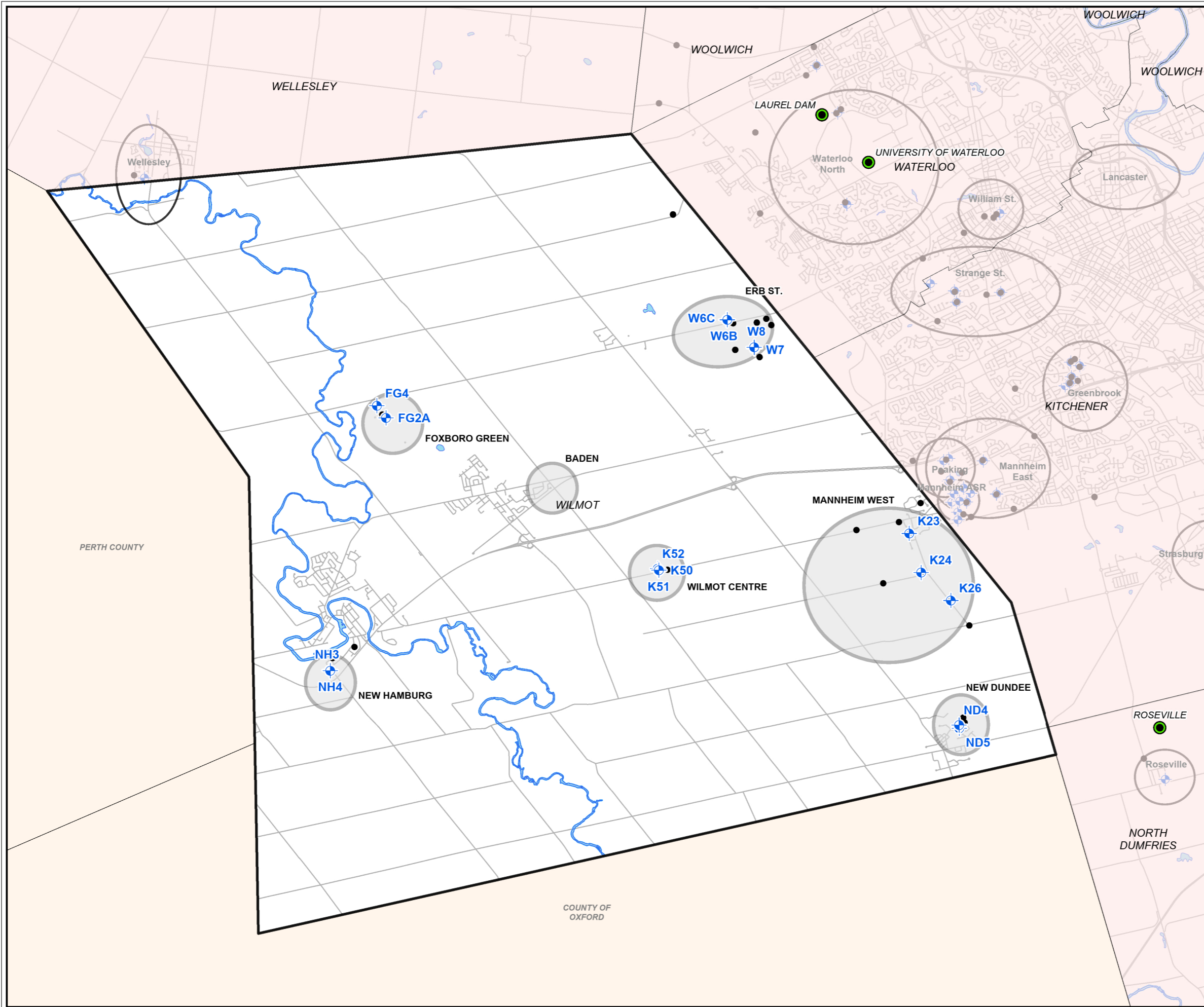
- Well Field Location
- Well Fields
- Regional Municipal Boundaries
- City of Cambridge
- City of Kitchener
- City of Waterloo
- Township of North Dumfries
- Township of Wellesley
- Township of Wilmot
- Township of Woolwich
- Meteorological Monitoring Locations



Map Title
**2025 GROUNDWATER MONITORING REPORT -
NEW DUNDEE WELL FIELD**
WELL FIELD LOCATION MAP

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Drawn	Checked	Date	Figure No. 1
HN	SQ	February 2026	
Scale		Project No.	
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LEGEND

- Production Well Location
- Monitoring Well Location
- Wilmot 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

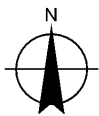
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 Coord. System: NAD 1983 CSRS UTM Zone 17N

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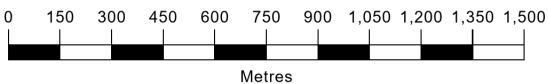
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Figure Title
2025 GROUNDWATER MONITORING REPORT - NEW DUNDEE WELL FIELD
WILMOT WELL FIELDS AND MONITORING NETWORK

Drawn	Checked	Date	Figure No. 2
HN	SQ	February 2026	
Scale	Project No.		
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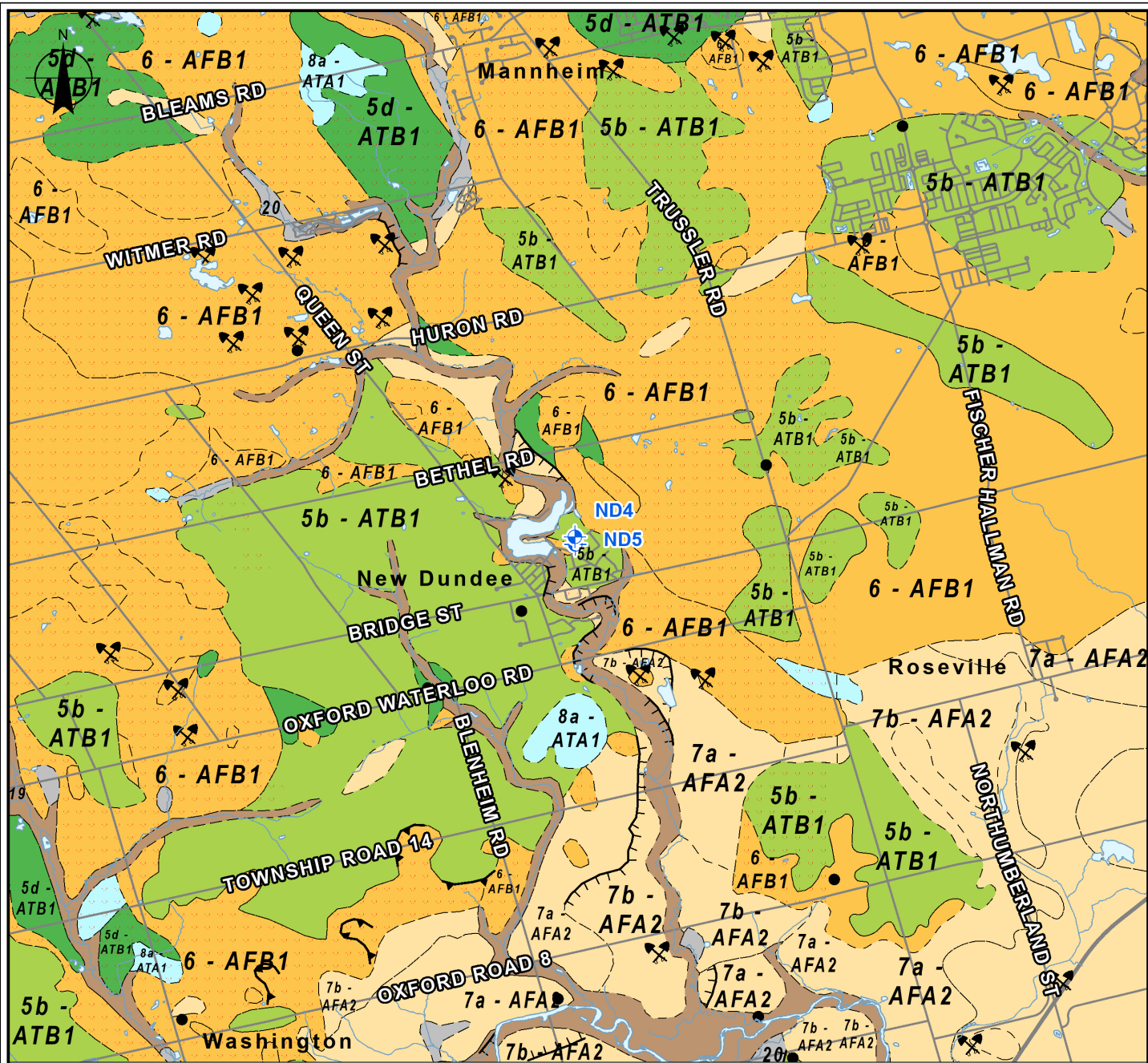
- PTTW Monitoring Well Location
- Production Well Location
- Nearby Monitoring Well Location
- Decommissioned Production Well
- Additional MECP PTTW Locations
- Groundwater
- Cross Section Orientation
- Intermittent Creek
- Creek
- Provincially Significant Wetland (MNR)



Map Title
**2025 GROUNDWATER MONITORING
 REPORT - NEW DUNDEE WELL FIELD**
 WELL LOCATION MAP

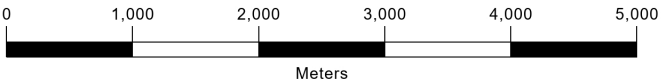
Client
REGION OF WATERLOO

Drawn	Checked	Date	Figure No. 3
HN	SQ	February 2026	
Scale		Project No. HA0464020	



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

- 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



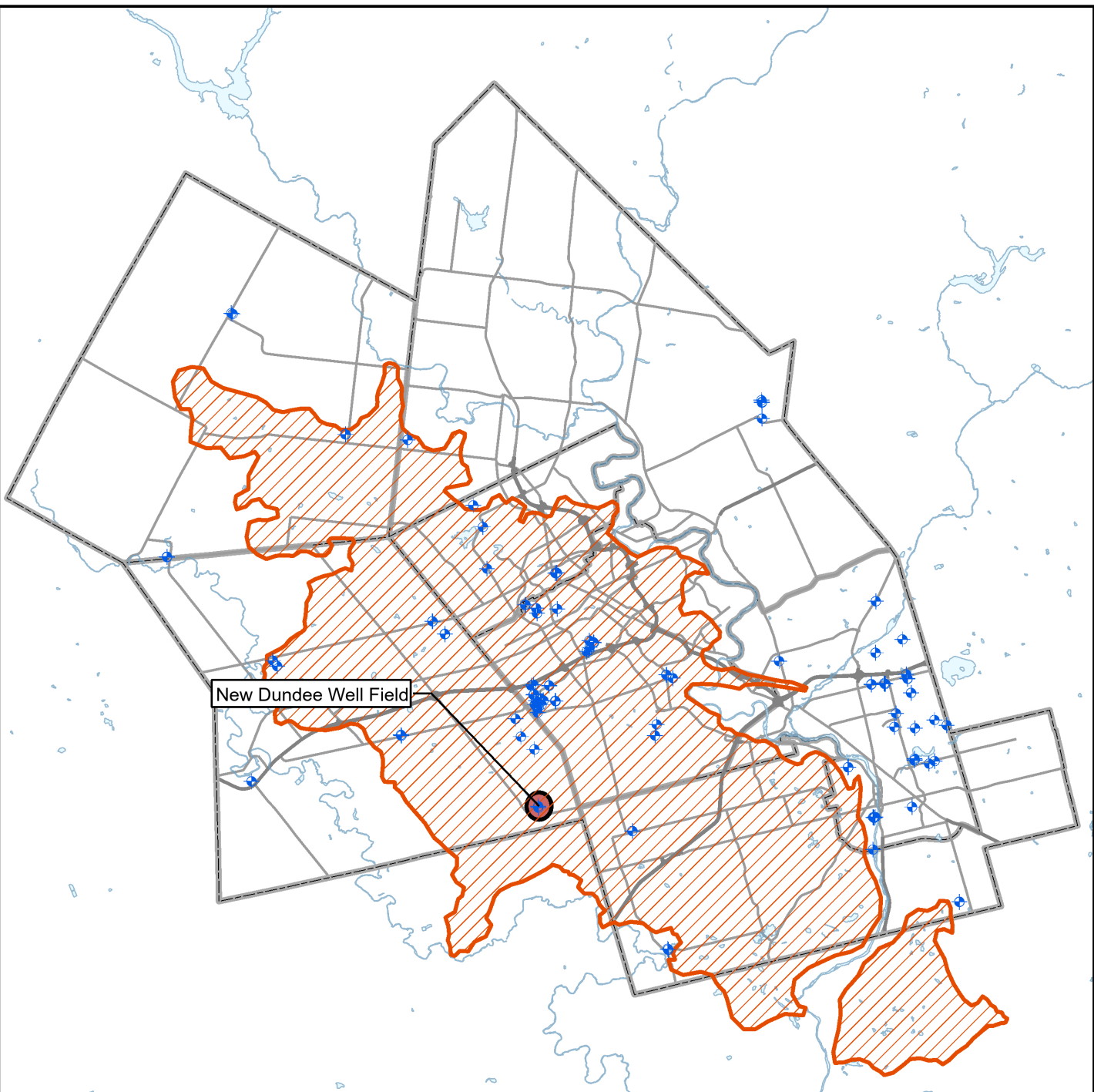
- 20: Organic deposits
- Sand and Gravel Pit
- Ice-Contact Slope
- Terrace
- Sample Location
- Hummocky
- Topography
- Unit Contact
- Boundary



Map Title
2025 GROUNDWATER MONITORING REPORT - NEW DUNDEE WELL FIELD
 SURFICIAL GEOLOGY

Client
REGION OF WATERLOO

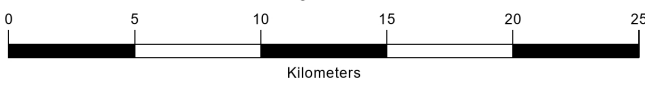
Drawn	Checked	Date	Figure No.
HN	SQ	February 2026	
Scale	Project No.		4
1:60,000	HA0464020		



New Dundee Well Field



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.



- RMOV Supply Well
- Waterloo Moraine (2014)
- New Dundee Well Field
- Waterbody
- Regional Municipal Boundaries



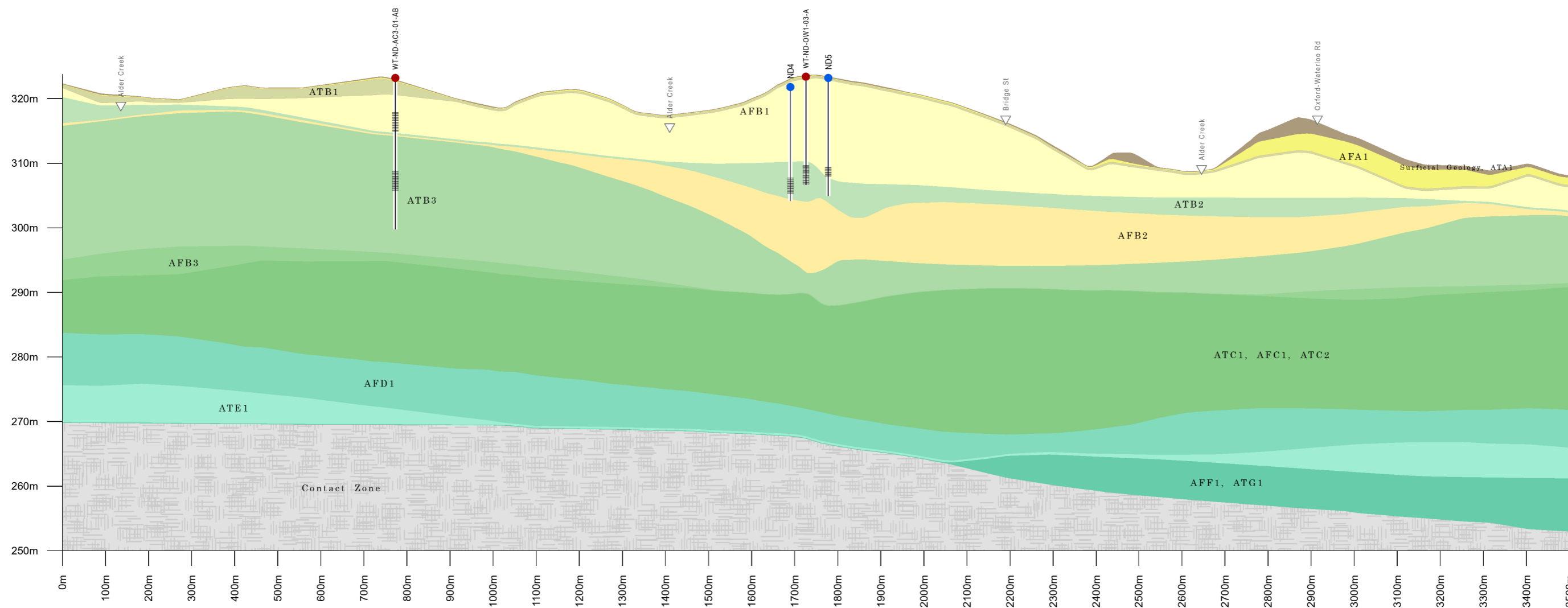
Map Title
**2025 GROUNDWATER MONITORING REPORT -
 NEW DUNDEE WELL FIELD**
 LOCATION OF THE WATERLOO MORaine

Client
REGION OF WATERLOO

Drawn	Checked	Date	Figure No. 5
HN	SQ	February 2026	
Scale	Project No.		
1:300,000		HA0464020	

A

A'

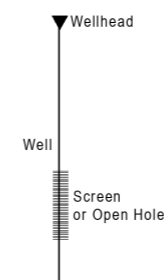


Wells

- Production Well (Active)
- Monitoring Well

Moraine Model 2026

Surficial Geology, Whittlesey Clay (ATA1)	Upper Waterloo Moraine Stratified Sediments & Equivalents (AFB1)	Lower Maryhill Till & Stratified Equivalents (ATB3)	Pre-Catfish Creek Coarse-Grained Glaciofluvial/Lacustrine Deposits (AFD1)	Weathered Bedrock
Whittlesey Sand (AFA1)	Middle Maryhill Till & Equivalents (ATB2)	Lower Waterloo Moraine Stratified Sediments or Catfish Creek Till Outwash (AFB3)	Canning Drift, Till & Fine Textured Glaciolacustrine Deposits (ATE1)	
Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)	Middle Waterloo Moraine Stratified Sediments & Equivalents (AFB2)	Upper/Main Catfish Creek Till (ATC1), Middle Catfish Creek Stratified Deposits (AFC1), Lower Catfish Creek Till (ATC2)	Pre-Canning Coarse Textured Glaciofluvial / Glaciolacustrine Deposits (AFF1), Pre-Canning Coarse Textured Till (ATG1)	



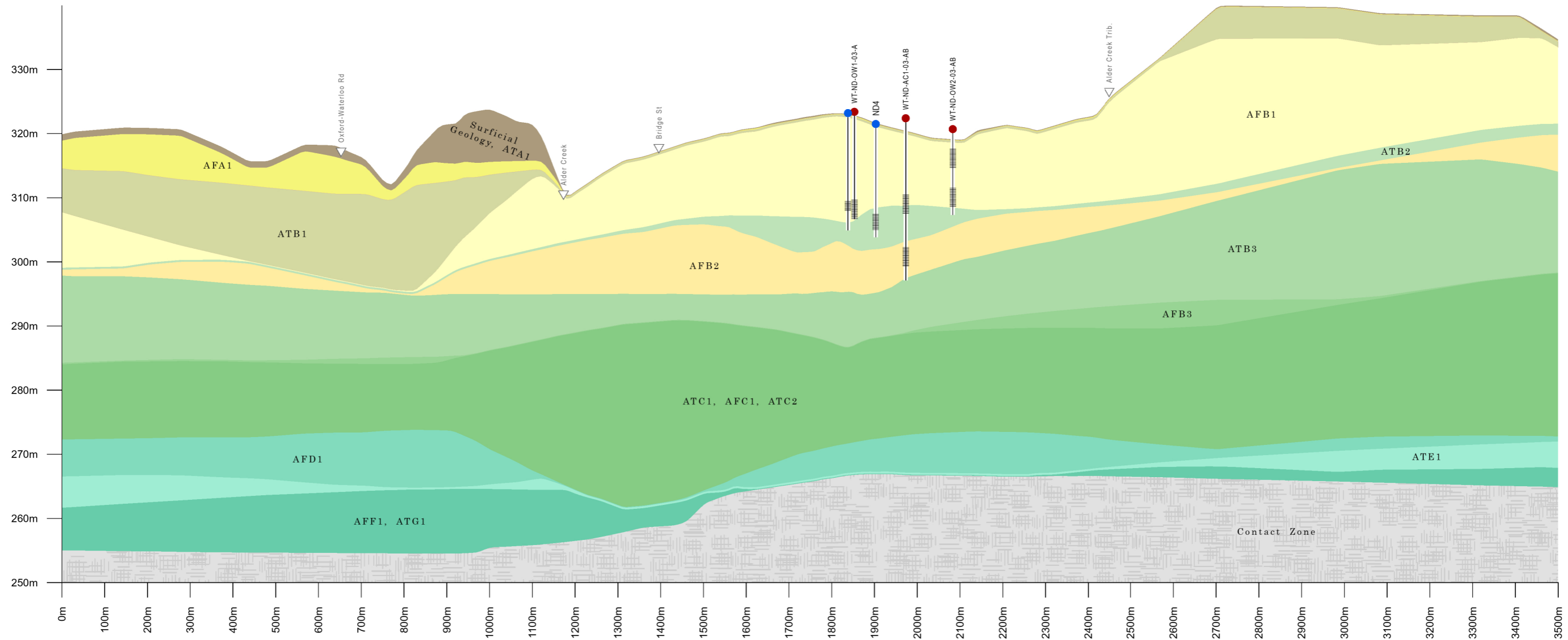
BURNSIDE

Client
REGION OF WATERLOO

Figure Title GEOLOGIC CROSS SECTION REGION OF WATERLOO New Dundee Cross Section A - A'			
Drawn PS	Checked DH	Date 2026/05/26	Figure No. 6
Horizontal Scale 1:10,000		Project No. HA046402	
Vertical Ex.:15x			

B

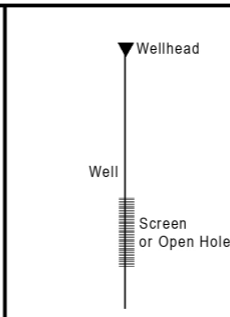
B'



Wells
● Production Well (Active) ● Monitoring Well

Moraine Model 2026

Surficial Geology, Whittlesey Clay (ATA1)	Upper Waterloo Moraine Stratified Sediments & Equivalents (AFB1)	Lower Maryhill Till & Stratified Equivalents (ATB3)	Pre-Catfish Creek Coarse-Grained Glaciofluvial/Lacustrine Deposits (AFD1)	Weathered Bedrock
Whittlesey Sand (AFA1)	Middle Maryhill Till & Equivalents (ATB2)	Lower Waterloo Moraine Stratified Sediments or Catfish Creek Till Outwash (AFB3)	Canning Drift, Till & Fine Textured Glaciolacustrine Deposits (ATE1)	
Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)	Middle Waterloo Moraine Stratified Sediments & Equivalents (AFB2)	Upper/Main Catfish Creek Till (ATC1), Middle Catfish Creek Stratified Deposits (AFC1), Lower Catfish Creek Till (ATC2)	Pre-Canning Coarse Textured Glaciofluvial / Glaciolacustrine Deposits (AFF1), Pre-Canning Coarse Textured Till (ATG1)	



BURNSIDE

Client
REGION OF WATERLOO

Figure Title GEOLOGIC CROSS SECTION REGION OF WATERLOO New Dundee Cross Section B - B'			
Drawn PS	Checked DH	Date 2026/05/26	Figure No. 7
Horizontal Scale 1:10,000		Project No. HA046402	
Vertical Ex.:15x			



BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

Appendix A

Permit To Take Water

Appendix A

PERMIT TO TAKE WATER
Ground Water
NUMBER 5581-B84PGT

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: Two Wells (ND4 & ND5)

Located at: Lot 5, Concession 3, Block A, Geographic Township of Wilmot
Wilmot, 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. 5581-B84PGT including its Schedules, if any, issued in accordance with Section 34.1 of the OWRA.
- (f) "Permit Holder" means The Regional Municipality of Waterloo.
- (g) "OWRA " means the *Ontario Water Resources Act*, R.S.O. 1990, c. O. 40, as amended.

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

TERMS AND CONDITIONS

1. Compliance with Permit

- 1.1 Except where modified by this Permit, the water taking shall be in accordance with the application for this Permit To Take Water, dated December 6, 2018 and signed by Richard Wootton, and all Schedules included in this Permit.
- 1.2 The Permit Holder shall ensure that any person authorized by the Permit Holder to take water under this Permit is provided with a copy of this Permit and shall take all reasonable measures to ensure that any such person complies with the conditions of this Permit.
- 1.3 Any person authorized by the Permit Holder to take water under this Permit shall comply with the conditions of this Permit.
- 1.4 This Permit is not transferable to another person.
- 1.5 This Permit provides the Permit Holder with permission to take water in accordance with the conditions of this Permit, up to the date of the expiry of this Permit. This Permit does not constitute a legal right, vested or otherwise, to a water allocation, and the issuance of this Permit does not guarantee that, upon its expiry, it will be renewed.
- 1.6 The Permit Holder shall keep this Permit available at all times at or near the site of the taking, and shall produce this Permit immediately for inspection by a Provincial Officer upon his or her request.
- 1.7 The Permit Holder shall report any changes of address to the Director within thirty days of any such change. The Permit Holder shall report any change of ownership of the property for which this Permit is issued within thirty days of any such change. A change in ownership in the property shall cause this Permit to be cancelled.

2. General Conditions and Interpretation

- 2.1 Inspections
The Permit Holder must forthwith, upon presentation of credentials, permit a Provincial Officer to carry out any and all inspections authorized by the OWRA, the *Environmental Protection Act*, R.S.O. 1990, the *Pesticides Act*, R.S.O. 1990, or the *Safe Drinking Water Act*, S. O. 2002.
- 2.2 Other Approvals
The issuance of, and compliance with this Permit, does not:
 - (a) relieve the Permit Holder or any other person from any obligation to comply with any other applicable legal requirements, including the provisions of the *Ontario Water Resources Act*, and the *Environmental Protection Act*, and any regulations made thereunder; or
 - (b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3 Information

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

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

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

2.4 Rights of Action

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

2.5 Severability

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

2.6 Conflicts

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

3. **Water Takings Authorized by This Permit**

3.1 **Expiry**

This Permit expires on **January 28, 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	ND4 (WWR# 6506733)	Well Drilled	Municipal	Water Supply	683	24	983,520	365	17 537938 4800208
2	ND5 (WWR# 6509565)	Well Drilled	Municipal	Water Supply	683	24	983,520	365	17 537939 4800210
							Total Taking:	983,520	

3.3 Notwithstanding Table A, the Permit Holder shall not exceed the maximum rate and amount of taking of 683 L/minute and 982,520 L/day from any well or both wells.

4. Monitoring

4.1 Under section 9 of O. Reg. 387/04, and as authorized by subsection 34(6) of the *Ontario Water Resources Act*, the Permit Holder shall, on each day water is taken under the authorization of this Permit, record the date, the volume of water taken on that date and the rate at which it was taken. The daily volume of water taken shall be measured by a flow meter or calculated in accordance with the method described in the application for this Permit, or as otherwise accepted by the Director. 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.

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

- WT-ND-AC1-03-A
- WT-ND-AC1-03-B
- WT-ND-OW1-03-A
- WT-ND-OW2-03-A
- WT-ND-OW2-03-B

4.3 The Permit Holder shall prepare and submit an electronic copy of a report every two years by June 30 commencing June 30, 2020, that presents the results of the well field water level monitoring for the two preceding calendar years, assesses changes in water levels in the supply aquifer(s) in relation to precipitation and water taking from the aquifer(s), and provides a summary for all interference complaints received by the Permit Holder related to this permit and reported in the District Office in accordance with Condition 5.1 and

the manner in which the Permit Holder has dealt with the complaint. Any application for an amendment or renewal shall be accompanied by the most recent biennial report.

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
(416) 212-6349
Toll Free 1(866) 448-2248

by Fax at
(416) 326-5370
Toll Free 1(844) 213-3474

by e-mail at
www.ert.gov.on.ca

This Permit cancels and replaces Permit Number 6562-837S4S, issued on 2010/03/31.

Dated at Hamilton this 28th day of January, 2019.



Cynthia Doughty
Director, Section 34.1
Ontario Water Resources Act , R.S.O. 1990

Schedule A

This Schedule "A" forms part of Permit To Take Water 5581-B84PGT, dated January 28, 2019.

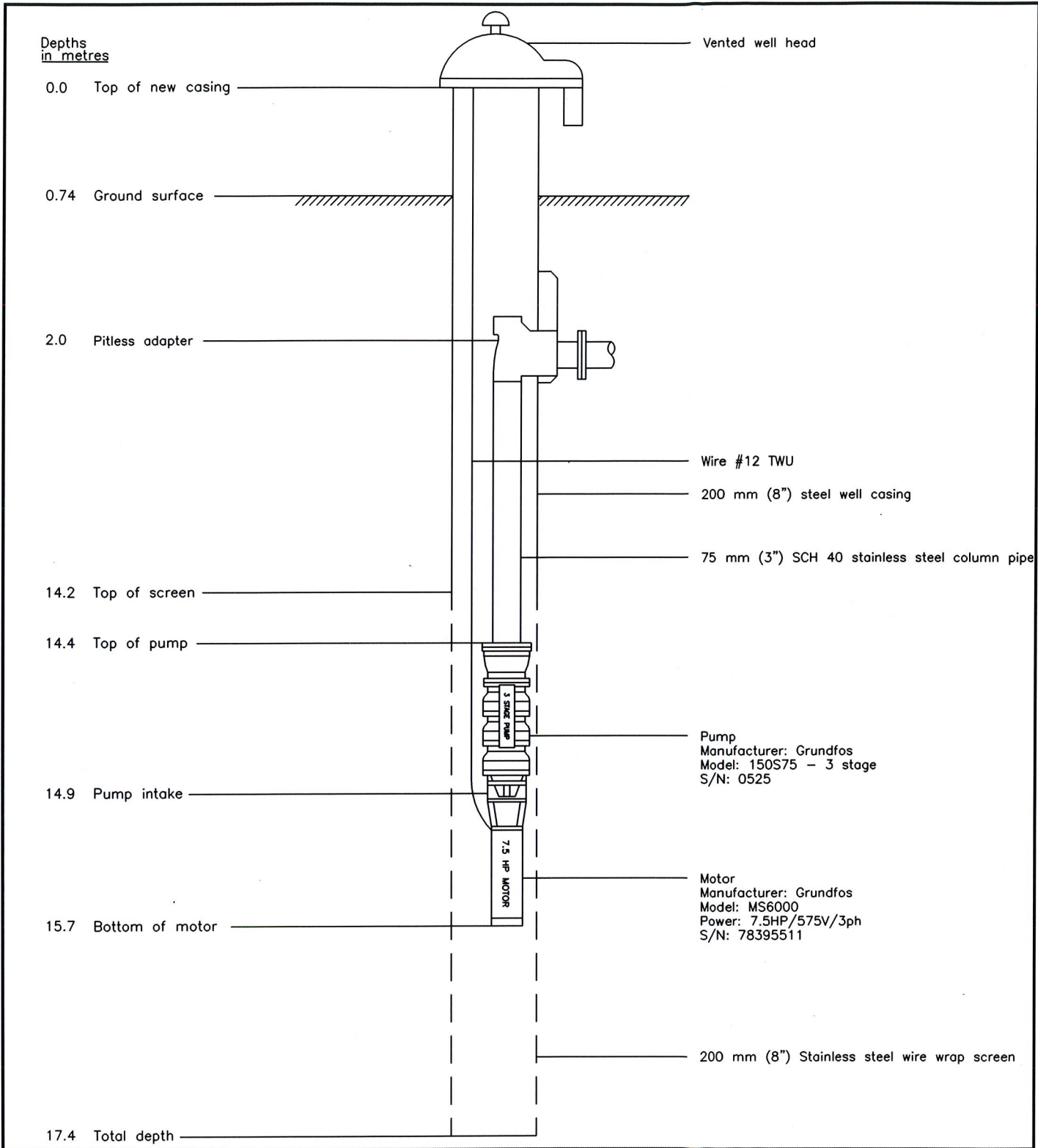


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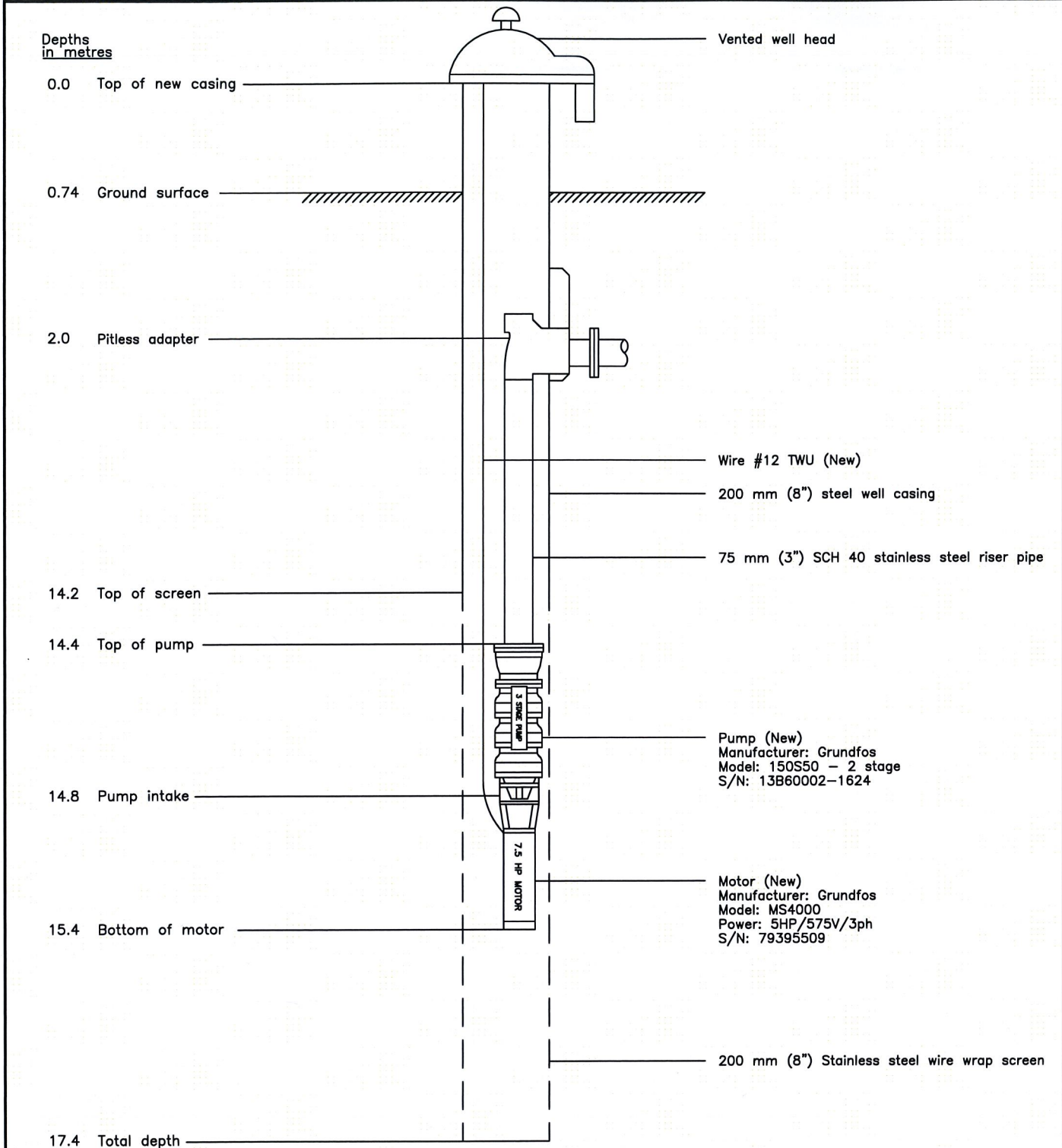
[THE DIFFERENCE IS OUR PEOPLE]

Appendix B

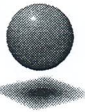
Well Records



			CLIENT Regional Municipality of Waterloo	
			TITLE Well Name ND4 Pump Installation Drawing	
PROJECT No. 006-224		G:\Lotowater Projects\006 Region of Waterloo\224 New Dundee Well 4 Service\Pump Installation.dwg		
DESIGN		REVISION No. 2012-10-15	SCALE N.T.S.	FIGURE 4
DRAWN	EH 2012/10/15			
CHECKED				



		CLIENT	Regional Municipality of Waterloo	
		TITLE	Well ND4 Pump Installation Drawing	
PROJECT No. 006-371		...\\006 Region of Waterloo\371 New Dundee Well 4 Service\Pump Installation.dwg		
DESIGN		REVISION No. 2016-06-09	SCALE N.T.S.	FIGURE 2
DRAWN	EH 2012/10/15			
CHECKED				



Location Coordinates:

Northing: 4800206 m

Easting: 537930 m

LOCATION: New Dundee, Ontario

DATE DRILLED: November 3, 2003

LOGGED BY: B.Neck

DRILLER: Boart Longyear & Davidson

PROJECT NUMBER: 122505.T1.02

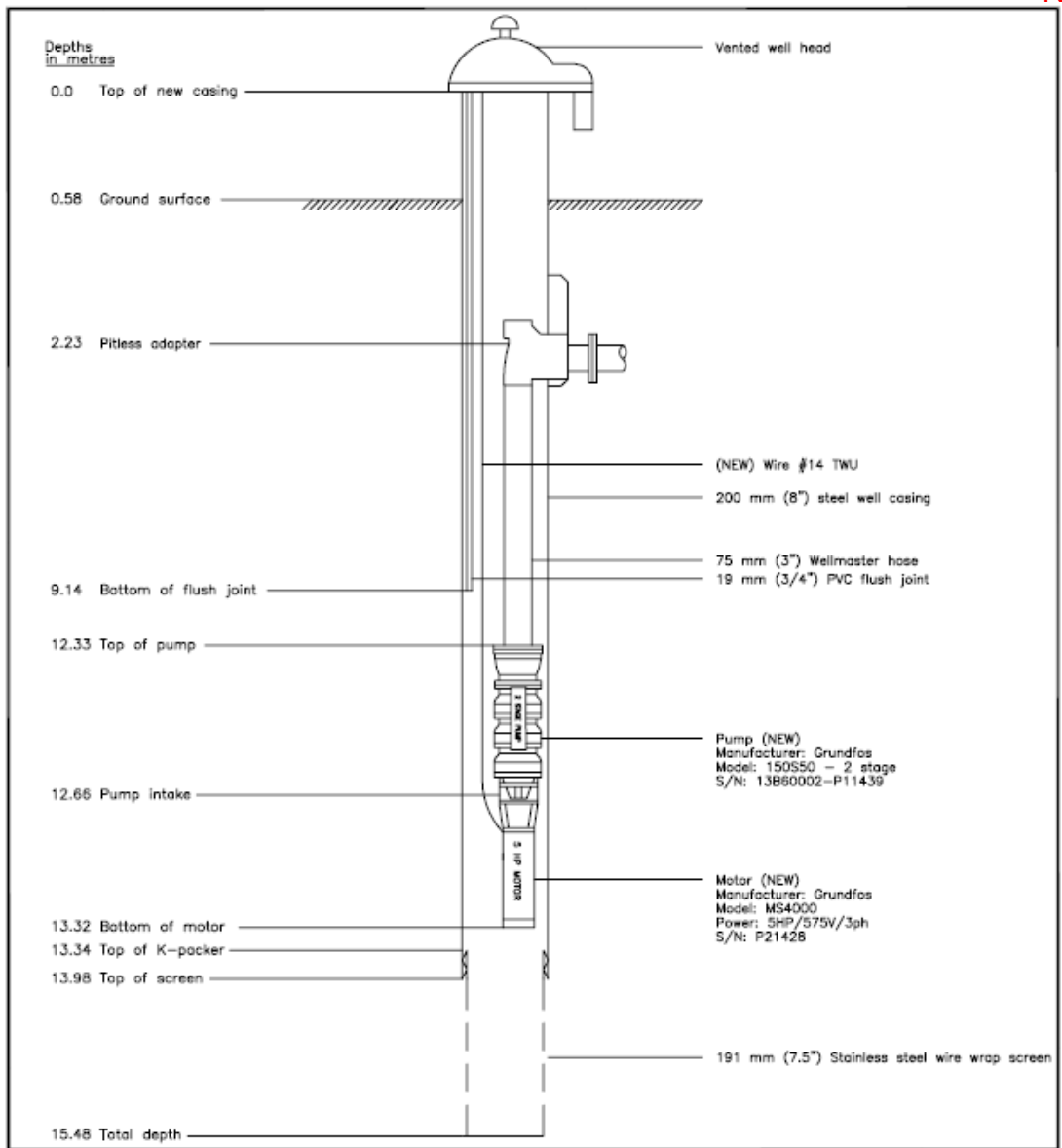
DRILLING METHOD: Roto-Sonic and Mud Rotary

MOE WELL TAG #: A000876

GROUND ELEVATION: masl

DEPTH (mbgs)	SAMPLES		SOIL DESCRIPTION	STRATA PLOT	(masl) ELEV. DEPTH (mbgs)	DETAILS	⊕ ORGANIC VAPOUR READINGS PID (ppm)			
	RECOV. (m)	TYPE					Blows/0.15m	25	50	75
1	1.05 CORE		Silty Sand Silty sand, trace clay, brown, trace subrounded gravel.			Lockable steel stickup casing.				
			Asphalt layer black, asphalt-like material.		0.70					
			Sand Fine grained, brown, damp, trace fines (silt)		0.95	Bentonite chip seal. Concrete grout.				
2										
3	2.5 CORE		Sand and silt Very fine sand and silt, moist, brown, rapid dilatancy		2.80					
			Sand Fine grained, brown, damp, trace fines (silt), rapid dilatancy		3.05					
4										
5										
6	2.95 CORE		Silty Sand Fine silty sand, moist, brown, rapid dilatancy		5.10	Installation of 0.203 m nominal diameter steel casing with concrete grout to 13.61 mbgs.				
7			Sand Fine grained, brown, trace gravel, moist		6.70					
			Silty Sand Silty fine sand, increasing gravel content with depth, moist becoming wetter with depth, brown		7.00					
8			Water level at 7.04 mbgs as measured on November 20, 2003.		7.04					
			Sand and Gravel Brown, moist to wet, trace silt		8.10	0.35 m-diameter borehole				
9	2.6 CORE									
			Gravel Gravel, cobbles, trace sand and silt, dark brown, moist to wet		9.20					
10			Sand and Gravel Orange oxidation staining, gravel <3"-diameter (<7.5 cm), loose, wet, trace silt		9.50					
			Sand and Gravel Light brown/greyish brown sand and gravel, trace silt, wet		10.20					
11			Sand and Gravel Brown sand and gravel, trace silt, wet		10.70					
12										
13			Sand Light brown sand trace silt, wet		12.80					
			-approximate positioning of 0.2 m-dia. steel blank section (0.51 m long)		13.23	- K-Packer				
14	3.7 CORE		Sand Clean sand, light brown/brown, wet		14.00	-0.2 m-diameter stainless steel wire wrap telescoping Johnson Screen (60-slot) with natural sandpack from 13.74 to 15.27 mbgs.				
			Sand Light brown sand trace silt, wet		14.50					
15										
			Gravel Coarse gravel and cobbles, trace silt, wet		15.15					
16			-Sump (0.19 m long) with welded steel plate bottom		15.27	-0.2 m-diameter reamed borehole. -Natural caved material.				
17			Sand and Silt Sand and silt grading into brown silt, trace sand, moist to wet		16.45					
			Clayey Silt Grey silt trace sand grading into a grey clayey silt, damp, drier than plastic limit, firm		16.80					
18	1.5 CORE					Holeplug				
			End of borehole at 18.3 mbgs		18.30					
19										

ANDYMW2 ND5.GPJ CG&S.GDT 12/16/03



CLIENT

Regional Municipality of Waterloo

TITLE

New Dundee Well ND5
Pump Installation Drawing

PROJECT No. 006-319\319 New Dundee ND5 Scheduled Maintenance\Pump Installation.dwg

DESIGN

DRAWN

CHECKED

RS 2014/09/22

REVISION No. N/A

SCALE N.T.S.

FIGURE

2



CH2MHILL

RECORD OF MONITORING WELL: AC1A-03

Location Coordinates: **WT-ND-AC1-03-A**

Northing: 4800298 m Easting: 538331 m

LOCATION: Alderview Drive, New Dundee
 DATE DRILLED: May 15, 2003
 LOGGED BY: Bob Neck

DRILLER: All Terrain Drilling Inc. DATUM:
 PROJECT NUMBER: 122267.T1.02 GROUND ELEVATION: masl
 DRILLING METHOD: 7 1/4" ID Hollow Stem Auger with 5' Core Barrel

DEPTH (m bgs)	SAMPLES		SOIL DESCRIPTION	STRATA PLOT	ELEV. (masl) DEPTH (m bgs)	MONITORING WELL DETAILS			
	RECOVERY (m)	TYPE				ORGANIC VAPOUR READINGS PID (ppm)			
		SPT (or blows/6")				100	200	300	400
			Top Soil Dark brown, moist, no odour, contained vegetative matter (rootlets)						
			Fine Sand with silt : Brown, moist, compact, no odour		0.28				
1	1.35	CB1	Fine Sand Light brown, damp to moist, soft, no odour, trace amounts of gravel and silt		0.70				
2	1.40	CB2	Clay Clay layer (2 cm). Sandy Silt : Brown, moist, non-plastic, no odour		2.32 2.34				
			Fine Sand : Brown, moist, thin silty clay layers, no odour		2.62				
3									
4	1.45	CB3	1 inch seam of black granular rock , no odour Fine Sand : Brown, moist, thin silty clay layers, no odour		4.27 4.30				
			Silt : Light brown, moist to wet, 2 cm seam of fine sand interbedded, light brown, no odour		4.57				
5			Coarse Sand with gravel with cobbles : Light brown, moist, sub-rounded gravel and cobbles to 13-cm maximum, no odour, very thin interbedded silty clay layers throughout		4.77				

122267.T1.02
 C&S
 1251003



Location Coordinates:

Northing: 4800298 m

Easting: 538331 m

LOCATION: Alderview Drive, New Dundee

DRILLER: All Terrain Drilling Inc.

DATUM:

DATE DRILLED: May 15, 2003

PROJECT NUMBER: 122267.T1.02

GROUND ELEVATION: mast

LOGGED BY: Bob Neck

DRILLING METHOD: 7 1/4" ID Hollow Stem Auger with 5' Core Barrel

DEPTH (mbgs)	SAMPLES			SOIL DESCRIPTION	STRATA PLOT	ELEV. DEPTH (mbgs)	MONITORING WELL DETAILS			
	RECOVERY (m)	TYPE	SPT (or blows/ft)				ORGANIC VAPOUR READINGS PID (ppm)			
							100	200	300	400
6	0.96	CB4		<p>Sand with gravel: Coarse brown sand with grey sand pockets, moist to wet, gravel ranges in size from 0.6 to 1.2-cm with maximum size of 3.8-cm, no odour</p>		6.10				
7	0.95	CB5								
8										
9										
10	1.4	CB7		<p>Coarse Gravelly Sand: As above, brown with some grey, wet to saturated, very soft, with thin interbedded silty clay layers, no odour</p>						

ANDY MW2 122267.GPJ CG&S.GDT 6/25/03



CH2MHILL

RECORD OF MONITORING WELL: AC1A-03

Location Coordinates:

Northing: 4800298 m

Easting: 538331 m

LOCATION: Alderview Drive, New Dundee

DRILLER: All Terrain Drilling Inc.

DATUM:

DATE DRILLED: May 15, 2003

PROJECT NUMBER: 122267.T1.02

GROUND ELEVATION: masl

LOGGED BY: Bob Neck

DRILLING METHOD: 7 1/4" ID Hollow Stem Auger with 5' Core Barrel

DEPTH (mbs)	SAMPLES			SOIL DESCRIPTION	STRATA PLOT	(masl) ELEV. DEPTH (mbs)	MONITORING WELL DETAILS			
	RECOVERY (m)	TYPE	SPT (or blows/6")				⊕ ORGANIC VAPOUR READINGS PID (ppm)			
							100	200	300	400
11	0	CB8		No Recovery - expected to be very loose, no stones or pebbles, likely a clean sand and gravel- using a sand trap however, sample still passed through		10.67				
12				Coarse Sand: Grey in colour, saturated, clean sand with trace gravel and small pebbles, rounded to sub-rounded gravel and cobbles to 11.4-cm maximum, no odour		12.19				
13	0.65	CB9				13.63				
14	0.7	CB10				14.63				
15				Silty clay: Grey/brown, moist, very dense, with trace gravel, clasts, no odour						

Sandpack No. 1 Silica Sand (sandpack for nested well AC1B-03)

Bentonite Holeplug

ANL 122267.T1.02/25/03



Location Coordinates:

Northing: 4800298 m

Easting: 538331 m

LOCATION: Alderview Drive, New Dundee

DRILLER: All Terrain Drilling Inc.

DATUM:

DATE DRILLED: May 15, 2003

PROJECT NUMBER: 122267.T1.02

GROUND ELEVATION: mast

LOGGED BY: Bob Neck

DRILLING METHOD: 7 1/4" ID Hollow Stem Auger with 5' Core Barrel

DEPTH (mbgs)	SAMPLES		SOIL DESCRIPTION	STRATA PLOT	MONITORING WELL DETAILS		⊕ ORGANIC VAPOUR READINGS PID (ppm)											
	RECOVERY (m)	TYPE			ELEV. DEPTH (mbgs)		100	200	300	400								
16	AUGER																	
17			Clay with Silt: Brown, damp, trace sand and occasional gravel/cobbles to 10.2-cm, no odour															
18	1.45	CB11																
19	1.45	CB12	Clayey Silt: Till-like material, trace fine sand, brown, damp, very hard/dense, small clasts, no odour		18.29													
20			Fine Sandy Silt Till: Brown, moist, small clasts, no odour		19.81													
			Sand: Fine sand seam, moist to wet		20.10													
			Fine Sandy Silt Till: Brown, moist, small clasts, no odour		20.15													
			Silty Clay: Seam, brown, moist, firm, trace fine sand, no odour		20.42													
			Fine Sandy Silt Till: Brown, moist, small clasts, no odour		20.52													
			Silty clay: Brown, damp, layered trace sand, no odour		20.63													
			Clayey Silt: Brown, damp, trace sand, no odour															
	1.37	CB13																

Bentonite Holeplug

Sandpack No. 1 Silica Sand

0.05-m diameter Schedule 40 PVC Slot 20 Screen

ANDY/MW2_122267.GPJ_CG&S.GDT_6/25/03



CH2MHILL

RECORD OF MONITORING WELL: AC1A-03

Location Coordinates:

Northing: 4800298 m

Easting: 538331 m

LOCATION: Alderview Drive, New Dundee

DRILLER: All Terrain Drilling Inc.

DATUM:

DATE DRILLED: May 15, 2003

PROJECT NUMBER: 122267.T1.02

GROUND ELEVATION: masl

LOGGED BY: Bob Neck

DRILLING METHOD: 7 1/4" ID Hollow Stem Auger with 5' Core Barrel

DEP TH (mbgs)	SAMPLES		SOIL DESCRIPTION	STRATA PLOT	(masl) ELEV. DEPTH (mbgs)	MONITORING WELL DETAILS			
	RECOVERY (m)	TYPE				⊕ ORGANIC VAPOUR READINGS PID (ppm)			
		SPT (or blows/6")				100	200	300	400
21			<u>Fine Sandy Silt</u> : Fine sand, brown, moist, trace round gravel.		20.72				
					21.34				
22	1.45	CB14	<u>Sand</u> : Medium grained sand seam, moist. <u>Silt with Sand</u> : Silt with interbedded fine sand		22.05				
			<u>Sand and Silt</u> : Brown, moist		22.07				
					22.30				
			<u>Sand</u> : Sand seam, moist. <u>Sand and Silt</u> : Brown, moist		22.56				
					22.63				
23			<u>Fine Sandy Silt</u> : Brown, moist, no odour		22.86				
			<u>Medium Sand with Silt</u> : Brown, moist to wet, trace gravel, no odour. <u>Silt</u> : Brown, moist, trace clay trace fine sand, thin medium sand layer imbedded in silt at 25.3 m, dense		23.36				
	1.25	CB15			23.46				
24									
25	0.9	CB16							
			Borehole terminated at 25.3 mbgs.		25.30				

20-slot Schedule 40 PVC Well Screen

Sandpack No. 1 Silica Sand

Hofoe Plug

AN 122267.T1.02 CG&S



Location Coordinates:

Northing: 4800298 m

Easting: 538331 m

LOCATION: Alderview Drive, New Dundee

DRILLER: All Terrain Drilling Inc.

DATUM:

DATEDRILLED: May 13, 2003

PROJECTNUMBER: 122267.T1.02

GROUND ELEVATION: masl

LOGGEDBY: Bob Neck

DRILLING METHOD: 7 1/4" ID Hollow Stem Auger with 5' Core Barrel

DEPTH (mbgs)	SAMPLES			SOIL DESCRIPTION	STRATA PLOT	ELEV. (masl) DEPTH (mbgs)	MONITORING WELL DETAILS					
	RECOVERY (m)	TYPE	SPT (or blows/6")				⊕ ORGANIC VAPOUR READINGS PID (ppm)					
							100	200	300	400		
1	1.35	CB1		Top Soil: Dark brown, moist, no odour, contained vegetative matter (rootlets)								
				Fine Sand with silt: Brown, moist, compact, no odour		0.28						
				Fine Sand: Light brown, damp to moist, soft, no odour, trace amounts of gravel and silt		0.70						
2	1.40	CB2		Clay Clay layer (2 cm)		2.32						
				Sandy Silt: Brown, moist, non-plastic, no odour		2.34						
				Fine Sand: Brown, moist, thin silty clay layers, no odour		2.62						
3	1.45	CB3										
4	1.45	CB3										
5	1.45	CB3		1 inch seam of black granular rock, no odour		4.27						
				Fine Sand: Brown, moist, thin silty clay layers, no odour		4.30						
				Silt: Light brown, moist to wet, 2 cm thick seam of fine sand interbedded, light brown, no odour		4.57						
				Coarse Sand with gravel with cobbles: Light brown, moist, sub-rounded gravel and cobbles to 13-cm maximum, no odour, very thin interbedded silty clay layers throughout		4.77						

ANUJ.MWZ.122267.GPJ.CG&S.GDT.6/25/03



Location Coordinates:

Northing: 4800298 m

Easting: 538331 m

LOCATION: Alderview Drive, New Dundee

DRILLER: All Terrain Drilling Inc.

DATUM:

DATE DRILLED: May 13, 2003

PROJECT NUMBER: 122267.T1.02

GROUND ELEVATION: masl

LOGGED BY: Bob Neck

DRILLING METHOD: 7 1/4" ID Hollow Stem Auger with 5' Core Barrel

DEPTH (mbgs)	SAMPLES		SOIL DESCRIPTION	STRATA PLOT	ELEV. DEPTH (mbgs)	MONITORING WELL DETAILS			
	RECOVERY (m)	TYPE				⊕ ORGANIC VAPOUR READINGS PID (ppm)			
						100	200	300	400
6	0.96	CB4							
			Sand with gravel: Coarse brown sand with grey sand pockets, moist to wet, gravel ranges in size from 0.6 to 1.2-cm with maximum size of 3.8-cm, no odour		6.10				
7	0.95	CB5							
			Medium Sand: Orange oxidation zone of moist to wet sand, no odour		7.62				
			Water level at 7.79 mbgs (June 24, 2003)		7.79				
8			Coarse Gravelly Sand: Brown/light brown with increasing grey with depth, wet to saturated, rounded gravel to 8.9-cm maximum, no odour, trace silt		7.92				
	1.2	CB6							
9			Coarse Gravelly Sand: As above, brown with some grey, wet to saturated, very soft, with thin interbedded silty clay layers, no odour						
10	1.4	CB7							

Benseal Grout

Silica Sandpack No. 1

CG&I 122267.T1.02



Location Coordinates:

Northing: 4800298 m Easting: 538331 m

LOCATION: Alderview Drive, New Dundee

DRILLER: All Terrain Drilling Inc.

DATUM:

DATE DRILLED: May 13, 2003

PROJECT NUMBER: 122267.T1.02

GROUND ELEVATION: masl

LOGGED BY: Bob Neck

DRILLING METHOD: 7 1/4" ID Hollow Stem Auger with 5' Core Barrel

DEPTH (mbgs)	SAMPLES		SOIL DESCRIPTION	STRATA PLOT	ELEV. DEPTH (mbgs)	MONITORING WELL DETAILS			
	RECOVERY (m)	TYPE SPT (or blows/6")				⊕ ORGANIC VAPOUR READINGS PID (ppm)			
						100	200	300	400
11	0	CB8	No Recovery - expected to be very loose, no stones or pebbles, likely a clean sand and gravel- using a sand trap however, sample still passed through		10.67				
12			Coarse Sand: Grey in colour, saturated, clean sand with trace gravel and small pebbles, rounded to sub-rounded gravel and cobbles to 11.4-cm maximum, no odour		12.19				
13	0.65	CB9							
14	0.7	CB10							
15			Silty clay: Grey/brown, moist, very dense, with trace gravel, clasts, no odour		14.63				
			Borehole terminated at 15.24 mbgs.		15.24				

Silica Sandpack No. 1

0.05-m diameter
Schedule 40 PVC
Slot 20 Screen

Hole Plug

ANDY\MW2_122267.GPJ CG&S.GDT 6/25/03

9201304



CH2MHILL

RECORD OF MONITORING WELL: NDOW1-03

Location Coordinates:

WT-ND-OW1-03-A

Northing: 4800213 m

Easting: 537923 m

LOCATION: New Dundee, Ontario

DRILLER: Boart Longyear Inc.

MOE WELL TAG #:

DATE DRILLED: November 4, 2003

PROJECT NUMBER: 122505.T1.02

GROUND ELEVATION: mast

LOGGED BY: B. Neck

DRILLING METHOD: Roto-Sonic

DEPTH (mbgs)	SAMPLES		SOIL DESCRIPTION	STRATA PLOT	ELEV. (masl) DEPTH (mbgs)	MONITORING WELL DETAILS			
	RECOV. (m)	TYPE				ORGANIC VAPOUR READINGS PID (ppm)			
		Blows/0.15m				25	50	75	100
1	0.75	CORE	Silty Sand Fill Fill material (placed on ground as a drilling pad), trace clay, brown, trace subrounded gravel, moist.						
2			Sand Fine grained, light brown to brown, damp, trace fines (silt) increasing with depth		1.02				
3	3.05	CORE							
4									
5			Silty Sand Fine silty sand, moist, brown, trace gravel		4.57				
6									
7			Water level at 6.71 mbgs as measured on November 18, 2003.		6.71				
8	5.1	CORE	Sand Coarse sand with silt layer, brown, damp		6.90				
9			Silty Sand Fine silty sand, moist, brown, trace gravel		7.08				
10			Sand and Gravel Coarse sand and gravel, trace silt, moist to wet		8.21				
11			Sand and Gravel Orange iron oxidation staining, coarser gravel, trace silt, moist to wet		9.29				
12			Sand and Gravel Light brown/greyish brown sand and gravel, trace silt, wet, round to subrounded		10.13				
13			Sand Coarse sand, with gravel, brown, wet, trace silt with depth		10.67				
14	4.7	CORE							
15			Sand Well graded light brown medium grained sand, clean, wet		14.82				
16			Gravel Coarse gravel, cobbles, trace silt, wet		15.53				
17			Clayey Silt Brown grading to grey clayey silt, firm, moist, trace fine sand decreasing with depth		15.79				
18			End of borehole at 16.76 mbgs		16.76				
19									

2. NDS. G.S.C. 14/03



CH2MHILL

RECORD OF MONITORING WELL: NDOW2A-03

Location Coordinates:

WT-ND-OW2-03-A

Northing: 4800456 m

Easting: 538029 m

LOCATION: New Dundee, Ontario

DRILLER: Atcost Soil Drilling Inc.

MOE WELL TAG #: A005173

DATE DRILLED: November 17, 2003

PROJECT NUMBER: 122505.T1.02

GROUND ELEVATION: mast

LOGGED BY: B.Neck

DRILLING METHOD: Track-mount rig with 0.11 m-dia. I.D. Hollow Stem Augers

DEPTH (mbgs)	SAMPLES		SOIL DESCRIPTION	STRATA PLOT	ELEV. (m) DEPTH (mbgs)	MONITORING WELL DETAILS			
	RECOV. (m)	TYPE				Blows/0.15m	⊕ ORGANIC VAPOUR READINGS PID (ppm)		
						25	50	75	100
1			Topsoil Dark brown silt with sand, organics, moist, trace clay, soft.						
			Sandy Silt Fine sandy silt, light brown, moist, soft/loose		0.90				
2			Silty Sand Fine silty sand, moist, brown, loose		1.52				
3			Sand Fine wet sand trace silt, brown, loose		3.05				
	0.42	SS 1	Water level at 3.39 mbgs as measured on November 24, 2003.		3.39				
4									
5			Sand Dark brown sand with pebbles and gravel, saturated, flowing sands condition		4.57				
	0.42	SS 2	Sand Fine sand (grains are black, tan, opaque white, grey in colour) trace silt, interbedded 6-mm thick seams of medium sand, wet, brown, compact, trace pebbles		4.83				
6									
	0.61	SS 3			6.58				
7			Sand and Gravel Brown sand and gravel (<25-mm diameter), trace silt, wet, subround to subangular.		6.71				
			Silty Sand Silty sand, moist, brown.		6.76				
			Sand Well graded light brown medium grained sand, clean, wet, compact		7.87				
8			Clayey Silt Brown clayey silt, firm, moist, trace fine sand		8.05				
	0.61	SS 5	Sand Well graded light brown medium grained sand, trace silt, wet, compact		8.23				
			Sand Sand with 5-mm thick interbedded silt layers, wet, trace clay, brown.		8.53				
9			Sand Fine to medium grained sand, trace silt and pebbles, brown, compact, wet		9.68				
	0.61	SS 6	Coarse Sand Coarse sand, trace silt, wet		9.70				
10			Silty Sand Silty sand, compact, wet, brown, interbedded silt layers.						
11			Gravel layer encountered during augering.						
12			Medium sand with silt grading into coarse sand with silt, wet, trace fine gravel, flowing sands condition						
	0.61	SS 7			13.41				
13			Gravel very predominant during augering. Flowing sands continuing. End of borehole at 13.41 mbgs						
14									
15									
16									

ANDY:W2 ND5.GPJ CG&S.GDT 12/14/03



LOCATION: New Dundee, Ontario

DRILLER: Atcost Soil Drilling Inc.

MOE WELL TAG #: A005173

DATEDRILLED: November 17, 2003

PROJECTNUMBER: 122505.T1.02

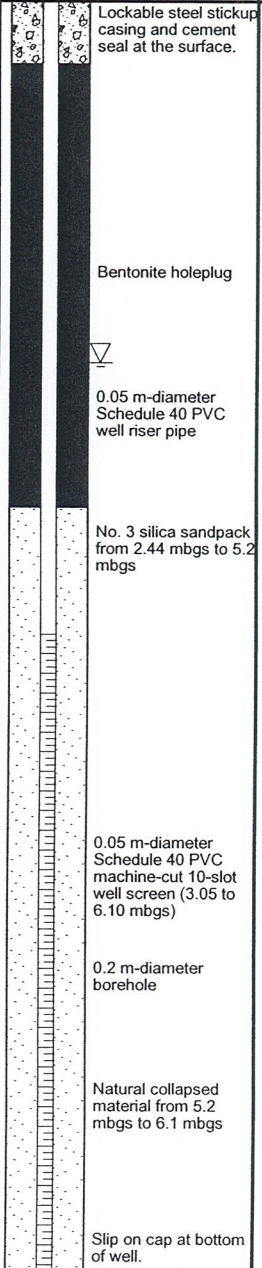
GROUND ELEVATION: masl

LOGGEDBY: B.Neck

DRILLING METHOD: Track-mount rig with 0.11 m-dia. I.D. Hollow Stem Augers

DEPTH (mbgs)	SAMPLES		SOIL DESCRIPTION	STRATA PLOT	ELEV. (masl) DEPTH (mbgs)	MONITORING WELL DETAILS				
	RECOV. (m)	TYPE				Blows/0.15m	⊕ ORGANIC VAPOUR READINGS PID (ppm)			
							25	50	75	100
1			<u>Topsoil</u> Dark brown silt with sand, organics, moist, trace clay, soft.							
			<u>Sandy Silt</u> Fine sandy silt, light brown, moist, soft/loose		0.90					
			<u>Silty Sand</u> Fine silty sand, moist, brown, loose		1.52					
2			Water level at 1.74 mbgs as measured on November 24, 2003.		1.74					
3			<u>Sand</u> Fine wet sand trace silt, brown, loose		3.05					
4										
5			<u>Sand</u> Dark brown sand with pebbles and gravel, saturated, flowing sands condition		4.57					
			<u>Sand</u> Fine sand (grains are black, tan, opaque white, grey in colour) trace silt, interbedded 6-mm thick seams of medium sand, wet, brown, compact, trace pebbles		4.83					
6			End of borehole at 6.1 mbgs		6.10					

AUGER



WT-ND-OW2-03-B, November 17, 2003, CG&S, 12/14/03



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Appendix C

Monitoring Data (Pumped Volumes and Hydrographs)



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



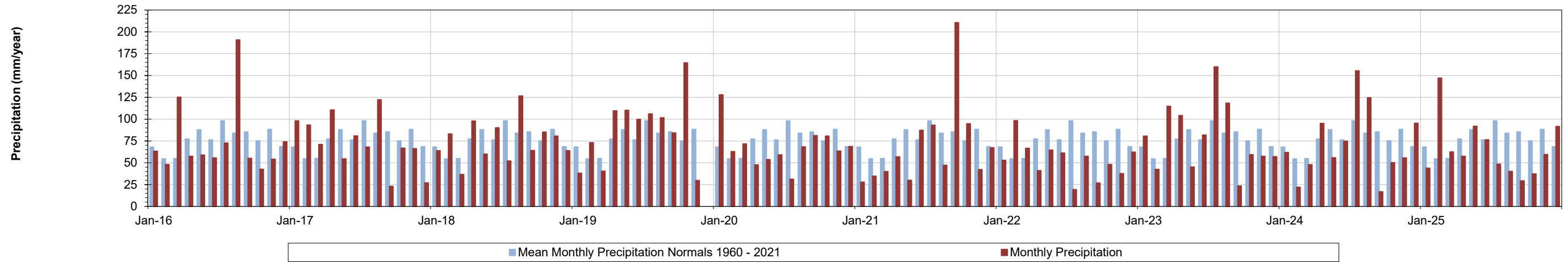
Well Field	Major or Minor Supply	Production Well Name	Permit to Take Water Details			2021 Production Summary			2022 Production Summary			2023 Production Summary			2024 Production Summary			2025 Production Summary		
			MOE Permit Number	Permitted Capacity (total m ³ /year)*	Permitted Rate (L/s)*	Total Production Well Volume (total m ³ /year)	Average Daily Rate (m ³ /day)	Average Rate (L/s)	Total Production Well Volume (total m ³ /year)	Average Daily Rate (m ³ /day)	Average Rate (L/s)	Total Production Well Volume (total m ³ /year)	Average Daily Rate (m ³ /day)	Average Rate (L/s)	Total Production Well Volume (total m ³ /year)	Average Daily Rate (m ³ /day)	Average Rate (L/s)	Total Production Well Volume (total m ³ /year)	Average Daily Rate (m ³ /day)	Average Rate (L/s)
New Dundee	Minor	ND4 ND5	5581-B84PGT	Combined rate for PTTW 5581-B84PGT 358,985	5581-B84PGT	53,044	145	1.7	56,645	155	1.8	57,438	157	1.8	42,735	117	1.4	46,876	128	1.5
			5581-B84PGT		32,534	89	1.0	37,018	101	1.2	35,257	97	1.1	26,482	73	0.8	27,221	75	0.9	
			Well Field Total			85,578	234	2.7	93,663	257	3.0	92,695	254	2.9	69,217	190	2.2	74,097	203	2.3
			*Maximum rate and amount of taking shall not exceed 683L/min and 983,520 L/day respectively, for the wellfield																	

Notes:

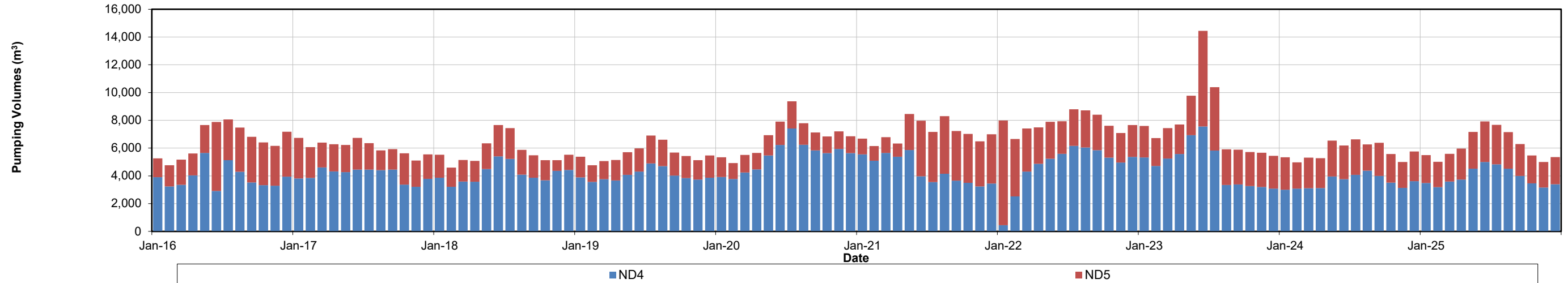
- = no applicable data
- n/a = data not available
- * = rates and volumes based on permitted L/day

REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
NEW DUNDEE

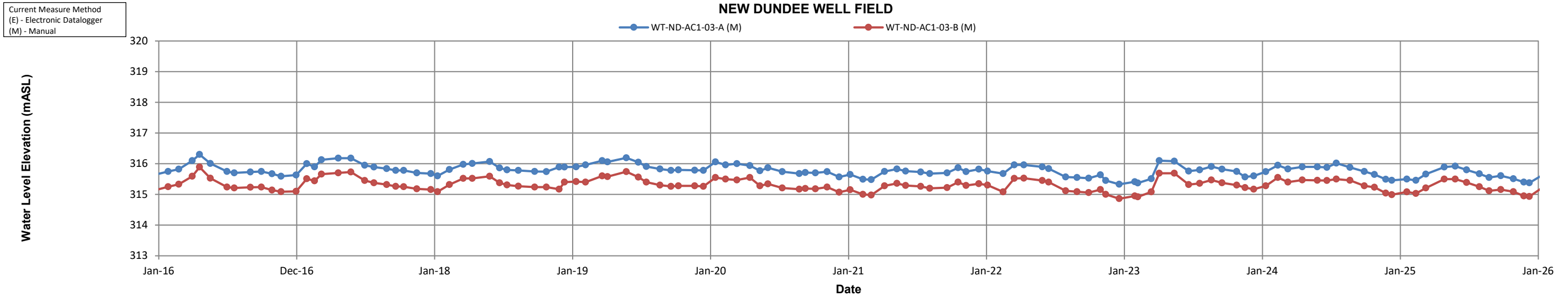
Actual versus Mean Monthly Precipitation
Weather Station - Roseville Weather Station



Monthly Total Pumped Volumes
NEW DUNDEE WELL FIELD

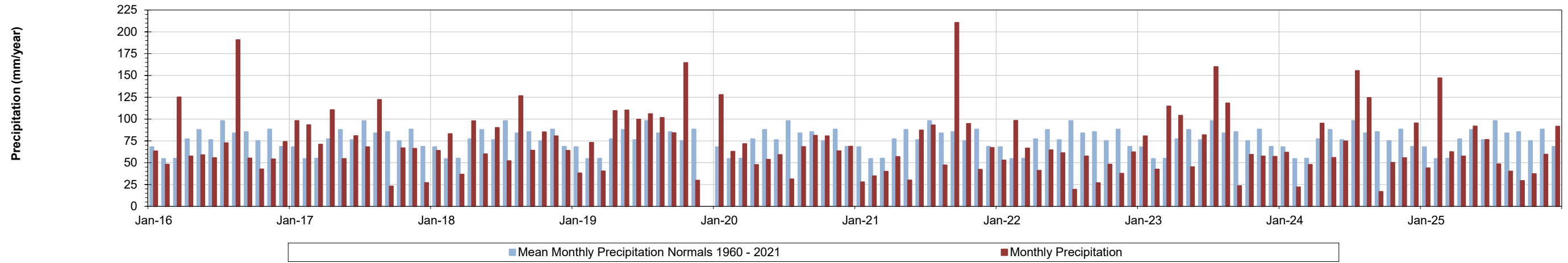


NEW DUNDEE WELL FIELD

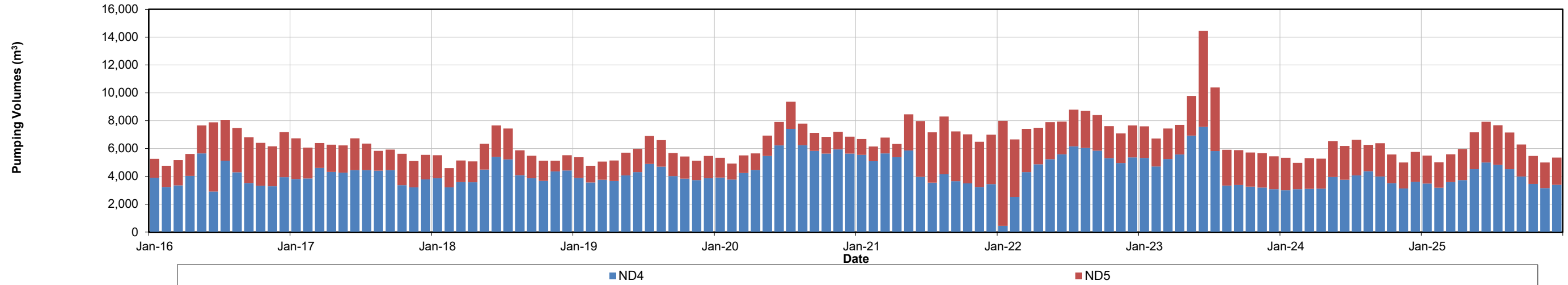


REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
NEW DUNDEE

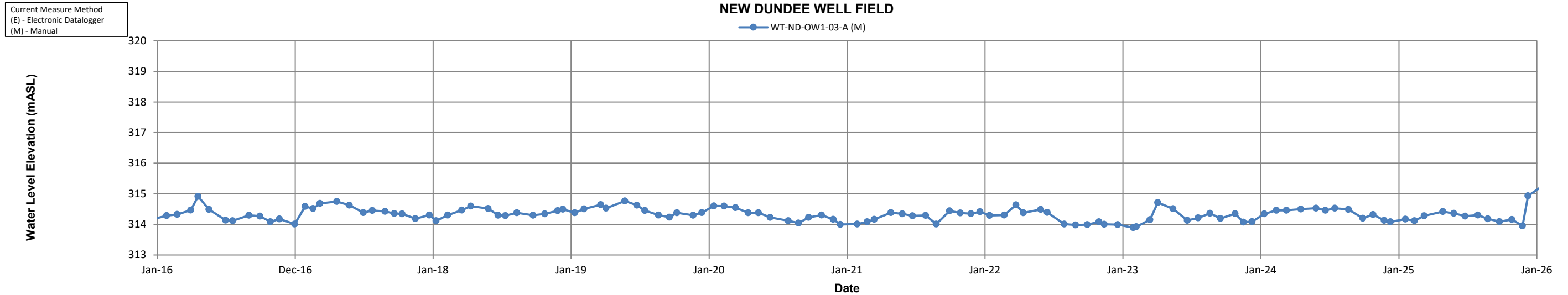
Actual versus Mean Monthly Precipitation
Weather Station - Roseville Weather Station



Monthly Total Pumped Volumes
NEW DUNDEE WELL FIELD

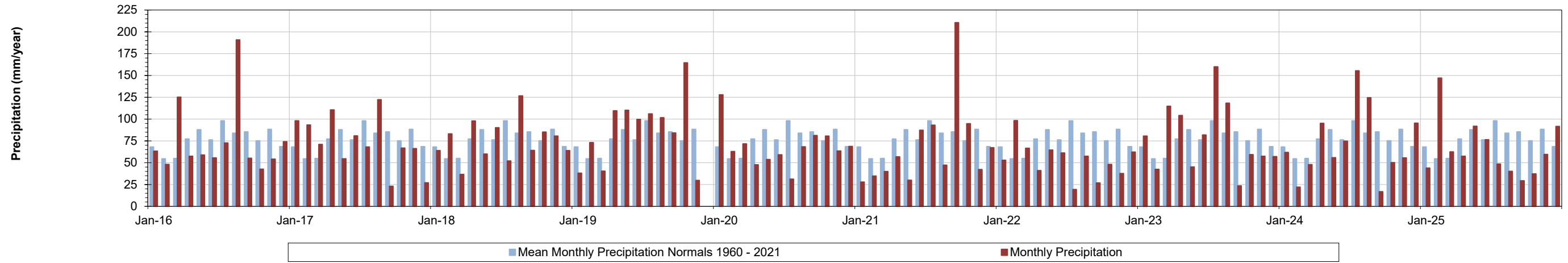


NEW DUNDEE WELL FIELD

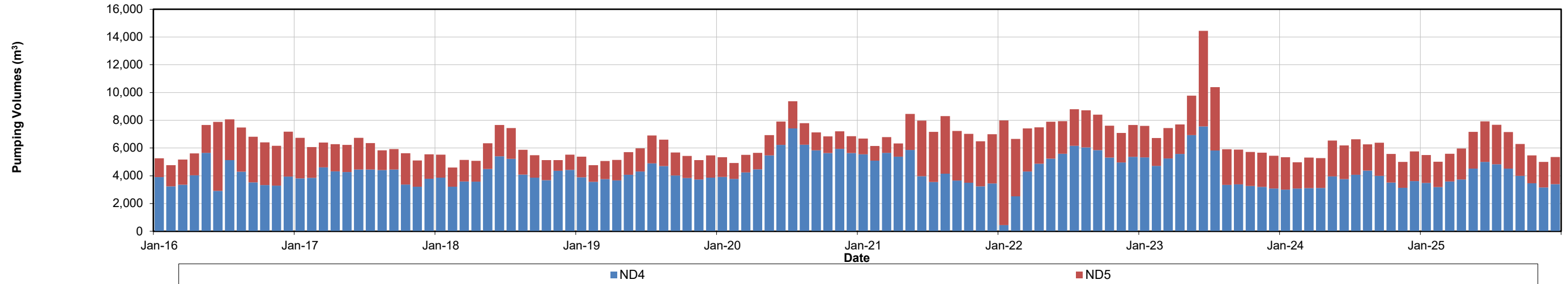


REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
NEW DUNDEE

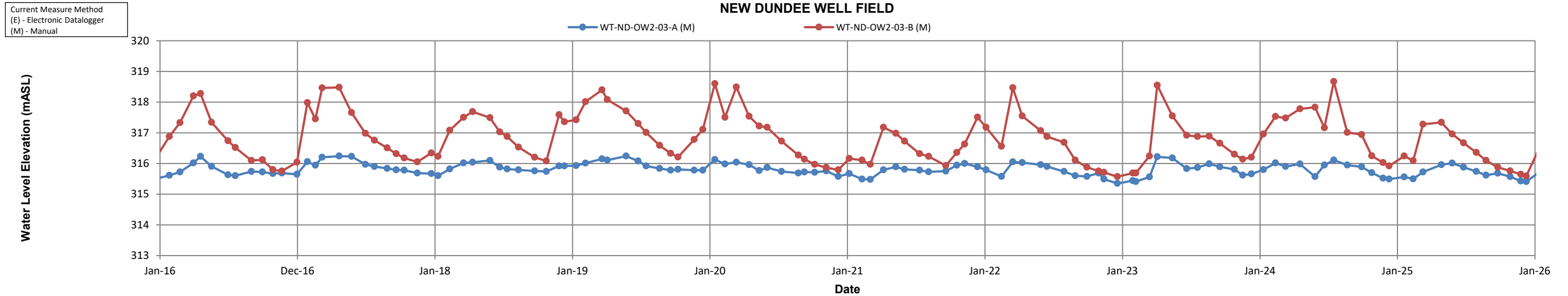
Actual versus Mean Monthly Precipitation
Weather Station - Roseville Weather Station



Monthly Total Pumped Volumes
NEW DUNDEE WELL FIELD



NEW DUNDEE WELL FIELD





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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
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
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
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
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
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
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
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

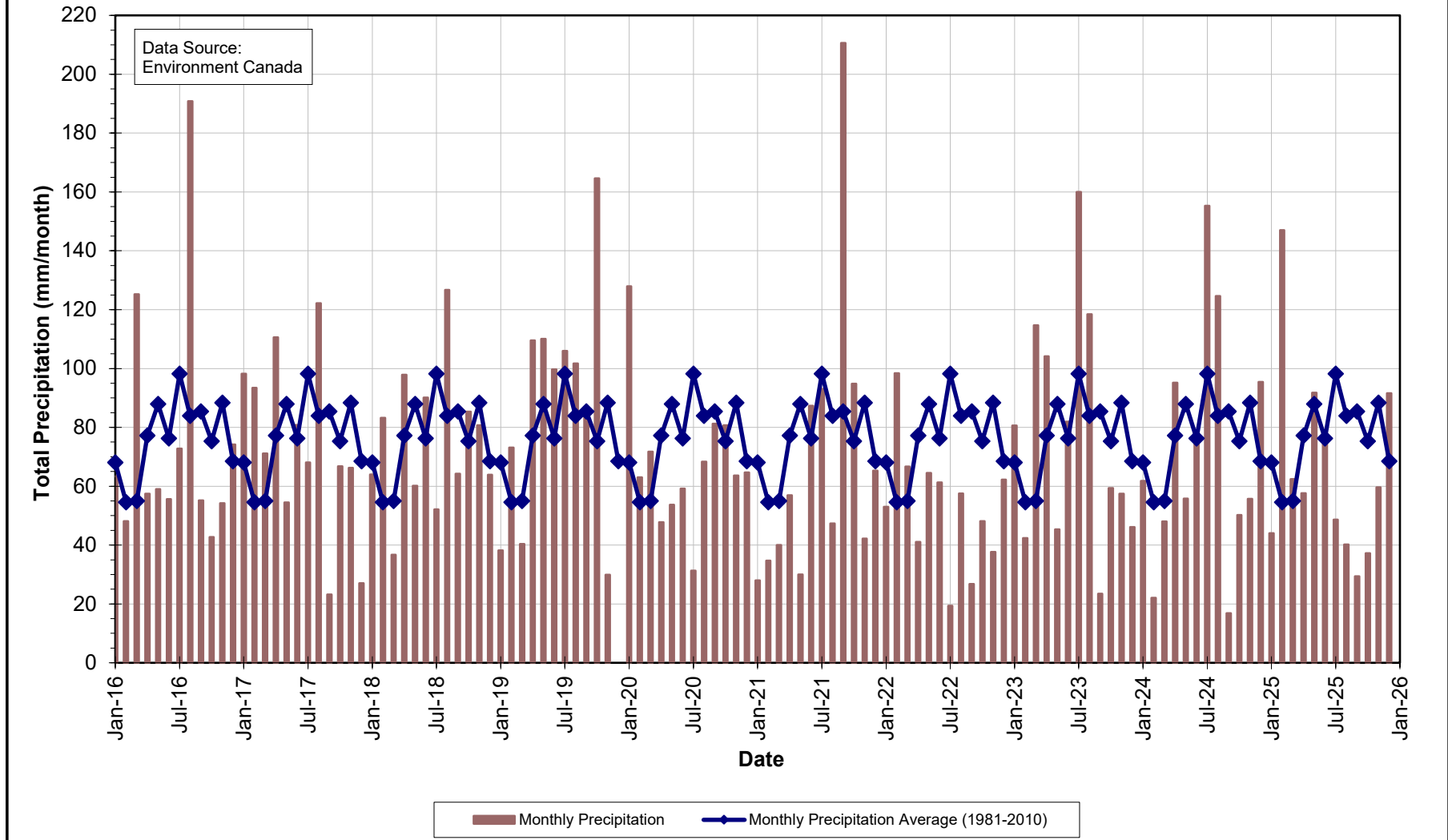
Year	Roseville Weather Station Established 1972		
	Annual Precipitation (mm)	30-yr NORMAL Precipitation 1981-2010 (mm)	Difference (mm)
	2016	899	919
2017	882	919	-37
2018	905	919	-14
2019	957	919	38
2020	817	919	-102
2021	832	919	-87
2022	637	919	-282
2023	945	919	26
2024	856	919	-63
2025	786	919	-133

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.

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Figure D.1
Roseville Weather Station
Monthly Precipitation





BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

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*® Levelloggers®. 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*® Levelloggers®

- 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.

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- 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.

