Wellfield Capacity Assessment Report

Fergus and Elora Municipal Wells

Township of Centre Wellington

60692210

December 2023

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Township of Centre Wellington
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December 8, 2023

Project #
60692210

Subject: Wellfield Capacity Assessment Report – Fergus and Elora Municipal Wells

Dear Mr. Maiden:

AECOM Canada Ltd. (AECOM) is pleased to submit the enclosed *Wellfield Capacity Assessment Report* to the Township of Centre Wellington, which presents the findings of our Wellfield Capacity Assessment, completed to fulfill the requirements of Permit to Take Water (PTTW) No. 4856-9KBH5A Condition 4.2, which required the Township to undertake a Wellfield Capacity Assessment and prepare a Wellfield Capacity Report prior to December 31, 2023.

This report provides a summary, interpretation, and discussion of the wellfield capacity assessment results and recommendations for long-term, sustainable capacity.

We trust that the documentation provided herein meets with your satisfaction. Should you have any questions or comments, please do not hesitate to contact the undersigned.

Sincerely,
AECOM Canada Ltd.

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Encl.

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("AECOM") for the benefit of the Client ("Client") in accordance with the agreement between AECOM and Client, including the scope of work detailed therein (the "Agreement").

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- must be read as a whole and sections thereof should not be read out of such context;
- was prepared for the specific purposes described in the Report and the Agreement; and
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AECOM: 2015-04-13

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Revision History

Rev #	Revision Date	Revised By:	Revision Description
0	2023-11-16	PM	Draft Report
1	2023-12-08	PM	Final Report

Distribution List

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	✓	Township of Centre Wellington
	✓	AECOM Canada Ltd.

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Executive Summary

The Township of Centre Wellington (the 'Township') retained AECOM Canada Ltd. (AECOM) to provide engineering services for the completion of a Wellfield Capacity Assessment (WFCA). The Township initiated this Project as a requirement of Permit To Take Water (PTTW) No. 4856-9KBH5A Condition 4.2, which requires that the Township undertake a WFCA and prepare a Wellfield Capacity Report, prior to December 31st, 2023. In advance of the Wellfield Capacity Report being approved by the Ontario Ministry of Environment, Conservation and Parks (MECP) Director, pumping of the Township's municipal wells will continue to be restricted to 60% of the PTTW combined maximum volume of 15,031,080 L/day. The WFCA was completed according to the WFCA Work Plan, as prepared by AECOM on behalf of the Township in June 2020, and subsequently reviewed and accepted by MECP on March 11th, 2021 (**Appendix I**).

The WFCA includes seven (7) established Township production wells (F1, F4, F6, F7, E1, E3 and E4), and two (2) replacement wells (F2-R and F5-R) that have recently been constructed. The longer-term testing was organized by "well clusters", with Cluster #1 (F1, F2-R and F5-R) and Cluster #3 (F4, F6 and F7) pertaining to the Fergus municipal wells, and with Cluster #2 (E1, E3 and E4) pertaining to the Elora municipal wells.

The purpose of the WFCA is to meet the requirements of the PTTW program, which is, "*…to ensure the conservation, protection and wise use and management of the waters of the province. Permits are controlled, and not issued if the taking of more water in a given area would adversely affect existing users or the environment"*. Stated slightly differently, the purpose of the WFCA is to establish the sustainable capacity of the wellfield, such that the Township's wells can be reliably operated over the long-term without causing adverse impacts to other groundwater users and/or the natural environment.

A background review was completed, including a review of previous technical reports, memoranda, and letters pertaining to the Centre Wellington Municipal Wellfield to aid development of the WFCA scope of work and reporting requirements.

Following the background review, a private well monitoring program was established to capture groundwater levels within private wells surrounding each production well cluster during testing. This program included targeted communication with known private well owners in the vicinity of each municipal production well, with an invitation to participate in water level monitoring during the WFCA. The overall monitoring network for the longer-term cluster tests was developed to include groundwater level data collected at the pumping wells, in addition to established monitoring locations within the Township's monitoring network, which included private wells where property owners agreed to participate in the monitoring program and at Township monitoring wells, and drive-point piezometers at select surface water monitoring locations.

The WFCA was initiated by conducting short-term testing to confirm the current function of each well included in the WFCA and to establish the rate that each well was to be pumped during the longer-term testing (where required). Short-term testing was not completed at wells where ample recent testing data was available (F1, F2-R and F5-R). AECOM reviewed approximately one (1) year of production well data and determined that short-term testing was required at all of the Cluster #2 (E1, E3 and E4) and Cluster #3 (F4, F6 and F7) wells. Longer-term testing was completed for each of the three (3) clusters following the short-term testing to assess sustainability of the water-takings.

Based on drawdown interference observed in nearby private water supply wells during longer-term testing completed within Cluster #2, additional testing was performed; including step testing of each Elora municipal well, as well as longer-term testing of the Elora well cluster. The intent of this additional testing was to determine a maximum appropriate pumping rate for each Elora municipal well while mitigating potential private well interference.

The sustainability of pumping the municipal production wells at the test rates for a period of 20-years was evaluated using graphical analysis, representing a "worst-case" scenario of aquifer stress over the period. Analysis included drawdown within municipal pumping wells and nearby private wells which showed responses to the pumping tests.

A numerical modelling assessment was also completed for the project by Matrix Solutions Inc. (Matrix). This assessment involved forward modelling tasks (using the FEFLOW Tier Three Groundwater Model), which included average well pumping rates, maximum pumping rates, as well as an assessment of impacts to municipal wells, private wells, and surface water features. The results of the modelling included identification of the average annual pumping rates and maximum daily pumping rates which could be supported by the Township's municipal well system.

Based on all completed testing and analysis, conclusions were developed regarding recommended pumping rates for the Township production wells within Fergus and Elora, as well as total estimated wellfield production capacity. It is recommended that the Township submit this WFCA report to the MECP Director on or before December 31st, 2023, as required by Condition 4.2 of PTTW 4856-9KBH5A. As per Condition 3.3 of PTTW 4856-9KBH5A, following the approval of the WFCA report by MECP, the 60% restriction of yearly average Total Taking as specified within Table A of Condition 3.2 will be removed.

Upon approval of the WFCA report by MECP, and completion of any additional requirements (i.e., Environmental Assessment planned for the F2-R site), it is recommended that the Township apply for a PTTW amendment that adds F2-R and F5-R as new sources to the wellfield PTTW (and removes existing F2 and F5). This application should incorporate the well pumping rates listed in Section 7, using the average rates as 'typical volume per day' and the maximum rates as the 'maximum volume per year'.

The maximum pumping levels for wells F1 and F2-R have been established to mitigate the movement of TCE impacted groundwater within the aquifer. Maintaining the pumping water level within F1 below the pumping level in F2-R will maintain a hydraulic gradient between the sites and a barrier to the movement of impacted water against the gradient. As such, the F1 and F2-R sites should be operated in tandem and in the event of a prolonged shut down of the F1 well, the F2-R well should also be rested.

There are a significant number of private wells operating within Fergus and Elora, generally concentrated east of F2-R and F7, north of E1 and surrounding E3. A subset of the existing private wells were monitored for the WFCA and therefore there is uncertainty in terms of how each individual well will respond to operation of the production wells at the tested rates. It is recommended that the Township continue the established quarterly groundwater level monitoring program. The deepest port in the multi-level well located in proximity to E1 (MW2-11) did not provide reliable data during the WFCA. It is further recommended that this well be repaired/rehabilitated or that a replacement well be drilled to the depth of the deep port on the same site as MW2-11.

As per the recommendation in the Municipal Well F2 & F5 Well Replacement Program – Results of Well Installation and Testing technical memorandum, it is recommended that the Township consider obtaining an access agreement with the owner of Well 36 (590 St. Andrew St. East), or an equivalent nearby well, for the purpose of establishing a groundwater level monitoring point. The ongoing collection of data in this area will provide an understanding of how operation of the Fergus production wells may affect local groundwater levels. In the absence of a willing participant, the Township should establish a monitoring well at multiple levels within the bedrock aquifer to supplement the existing monitoring network.

A similar monitoring location should be established between E3 and E4, near the intersection of 1st Line and Wellington Road 7. The WFCA determined that the private wells in this area are sensitive to low water level conditions and operation of E3. The long-term pumping rates presented in this report have been selected to promote sustainable groundwater use; however, there are many known private wells that could not be monitored for the project. Establishing a long-term multi-level monitoring well in this area will allow for the ongoing measurement of groundwater levels under variable operating and seasonal conditions, further supporting the Township's objective of avoiding adverse impacts to private water supply use.

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1. Introduction

The Township of Centre Wellington (the 'Township') retained AECOM Canada Ltd. (AECOM) to provide engineering services for the completion of a Wellfield Capacity Assessment (WFCA). The Township initiated this Project as a requirement of Permit To Take Water (PTTW) No. 4856-9KBH5A Condition 4.2, which requires that the Township undertake a WFCA and prepare a Wellfield Capacity Report, prior to December 31st, 2023. In advance of the Wellfield Capacity Report being approved by the Ontario Ministry of Environment, Conservation and Parks (MECP) Director, pumping of the Township's municipal wells will continue to be restricted to 60% of the PTTW combined maximum volume of 15,031,080 L/day. The WFCA was completed according to the WFCA Work Plan, as prepared by AECOM on behalf of the Township in June 2020, and subsequently reviewed and accepted by MECP on March 11th, 2021 (**Appendix I**).

The WFCA includes seven (7) established Township production wells (F1, F4, F6, F7, E1, E3 and E4), and two (2) replacement wells (F2-R and F5-R) that have recently been constructed. The locations of the production wells are shown in **Figure 1**.

The purpose of the WFCA is to meet the requirements of the PTTW program, which is, "*…to ensure the conservation, protection and wise use and management of the waters of the province. Permits are controlled, and not issued if the taking of more water in a given area would adversely affect existing users or the environment"*. Stated slightly differently, the purpose of the WFCA is to establish the sustainable capacity of the wellfield, such that the Township's wells can be reliably operated over the long-term without causing adverse impacts to other groundwater users and/or the natural environment.

This purpose of this report is to present an overview of the testing completed as part of the WFCA, document the results and associated analysis, and to recommend a sustainable water-taking capacity for the wellfield.

1.1 Background Information

Below is a summary of the previous technical reports, memoranda, and letters pertaining to the Centre Wellington Municipal Wellfield that were available to AECOM in the development of the WFCA scope of work and reporting:

- Township of Centre Wellington Well Field Capacity Assessment, Township of Centre Wellington. September 2013. Golder Associates Ltd. (Golder)
- Scope of Work. Wellfield Capacity Assessment to Address Condition 4.3 of Permit to Take Water 2823-7QEH3C. January 27, 2010. Golder
- Memorandum. Municipal Well F2 & F5 Well Replacement Program – Results of Well Installation and Testing. May 2023. AECOM
- Technical Memorandum – Proposed Well Field Capacity Assessment Work Plan to Address Condition 4.2 of Permit to Take Water No. 4856-9KBH5A. June 22, 2020. AECOM
- Township of Centre Wellington Wellfield Capacity Work Plan Comments. March 5, 2021. AECOM
- Letter to Amend Permit Number 4856-9KBH5A. March 11, 2021. Ministry of Environment, Conservation and Parks
- Permit to Take Water 4856-9KBH5A. June 23, 2014. Ministry of Environment
- Centre Wellington Scoped Tier Three Water Budget Assessment Physical Characterization Report. December 2017. Matrix Solutions Inc. (Matrix)

1.2 Scope of Work

The WFCA program included short-term hydraulic testing to determine applicable maximum pumping rates for each well (where required), followed by longer-term testing to assess sustainability of the takings. The longer-term testing was organized by "well clusters", as outlined in **Table 1**. The Elora well cluster (E1/E3/E4) was operated independently of the two (2) Fergus well clusters. All tests were completed using existing installed pumping equipment and operated by Township Operations Staff, with the exception of F2-R and F5-R, where Lotowater Technical Services (LTS) completed the testing under the supervision of AECOM field staff.

During each longer-term Cluster test, groundwater level data was collected at the pumping wells, in addition to other established monitoring locations within the Township's monitoring network, including monitoring wells and drive-point piezometers as well as at selected private supply wells where access permissions were received.

Table 1: Well Cluster Overview

Test/Cluster Number	Production Well	Operator
#1 – Fergus	F1	Township
	F2-R	LTS
	F5-R	LTS
#2 – Elora	E1	Township
	E3	Township
	E4	Township
#3 – Fergus	F4	Township
	F6	Township
	F7	Township

Data collected during the WFCA was analyzed to determine the sustainable capacity of the Township's wellfield. This included an assessment of available historical data, drawdown curves observed during the capacity assessment (both pumping and monitored locations), anticipated steady-state pumping elevations, potential long-term drawdown over extended pumping periods, and typical drawdown under average municipal pumping conditions. Using these data, an impact assessment was completed to evaluate the Zone of Influence (horizontal), vertical propagation of drawdown within the various key hydrostratigraphic layers, magnitude of interference drawdown that occurred between pumping wells, observed/potential for municipal supply wells to interfere with private supply wells, and potential impacts on local surface water features.

The Matrix Solutions Inc. (Matrix) modelling team updated the existing Centre Wellington FEFLOW numerical groundwater flow model using new hydrogeological and well completion data collected during the F2 & F5 Well Replacement Project. The updated model was run to simulate pumping tests completed as part of the WFCA to ensure adequate model calibration. Matrix then completed two (2) additional separate simulations using average daily demands and maximum daily demands, respectively, to evaluate the capacity of the Township water supply network.

1.3 Township Production Well Pumping Rates

The current permitted production well pumping rates and the previous WFCA rates are shown in **Table 2**. The Typical Operating Rate is based on historical average pumping information for each production well from August 2021 to September 2022, as provided to AECOM by the Township.

Table 2: Historical and Test Pumping Rate Overview

Test/Cluster Number	Production Well	2013 WFCA Rate[a] (L/s)	Existing PTTW Rate[b] (L/s)	Typical Operating Rate (L/s)
#1 – Fergus	F1	18.8, 18.9 & 19.0	21.2	19.5
	F2-R	12.0[c]	-	-
	F5-R	10.6 & 10.7[c]	-	-
#2 – Elora	E1	17.2 & 19.8	20.2	19.0
	E3	18.2, 19.7 & 20.4	22.7	19.5
	E4	18.0, 18.9 & 20.4	22.7	19.0
#3 – Fergus	F4	17.9 , 19.6 & 20.1	22.7	19.5
	F6	17.2, 18.0 & 19.1	22.7	17.0
	F7	18.1, 18.6 & 19.5	22.7	19.0

Notes:
a. *Based on Tests 1 to 3 conducted as part of the 2013 Township of Centre Wellington Wellfield Capacity Assessment. Tests 1 and 2 of the 2013 WCA comprised staggered and simultaneous starts for both Fergus and Elora wellfield capacity testing. Test 3 comprised long-term testing on individual wells.*
b. *Permit to Take Water No. 4856-9KBH5A.*
c. *F2-R and F5-R rates provided for 2013 WFCA are for original wells (i.e., F2 and F5), not the replacement wells. The current permitted rates for F2 are 4.7 L/s over 24 hours (19 L/s instantaneous) and F5 22.7 L/s over 24 hours (30 L/s instantaneous).*

Two (2) of the wells within Cluster #1 (F2-R and F5-R) were constructed as replacement wells in 2021 and 2022 and are planned to be connected to the municipal drinking water system in the near future. F2 was decommissioned in 2021. F5 has not been decommissioned at this time but it was not included within this WFCA. The current PTTW specifies existing rates for F2 and F5 of 4.7 and 22.7 litres per second, respectively. The Township currently operates F5 on an as-needed basis to satisfy demand in the system. Additionally, the Township is currently undertaking a Class Environmental Assessment (EA) for the F2-R well site in order to increase pumping rates above the permitted rate for the decommissioned F2 well.

2. Physiographic, Geologic and Hydrogeological Setting

2.1 Desktop Review

2.1.1 Physiography

According to the Physiography of Southern Ontario (Chapman and Putnam, 1984) and "Map 2226-Physiography of the South Central Portion of Southern Ontario" (Ontario Department of Mines and Northern Affairs, 1972), Fergus and Elora are located within the Guelph Drumlin Field physiographic region, with landforms that include (**Figure 2**):

- Drumlinized till plains: present in large pockets on both the north and south side of the Grand River;
- Drumlins: present in small pockets to the southeast of Elora; and,
- Spillways: located along the Grand River.

2.1.2 Surficial Geology

According to Surficial Geology of Southern Ontario mapping from the Ontario Geological Survey (2003), the following surficial geology deposits are located within Fergus and Elora (**Figure 3**):

- Paleozoic bedrock (3)
  - Present along the Grand River
- Glaciofluvial Deposits: river deposits and delta topset facies (gravelly)
  - Adjacent to the exposed Paleozoic bedrock following the Grand River
- Till: Stone-poor, sandy silt to silty sand-textured till on Paleozoic terrain
  - Present in large areas on both the north and south sides of the Grand River
- Ice-Contact Stratified Deposits: sand and gravel, minor silt, clay and till
  - Present in isolated pockets on both the north and south sides of the Grand River, mainly adjacent to exposed Paleozoic bedrock
- Modern Alluvial Deposits: clay, silt, sand, gravel, may contain organic deposits
  - Present in a minor capacity along Grand River tributaries

2.1.3 Bedrock Geology

According to the "Paleozoic Geology of Southern Ontario," (Ontario Geological Survey, Map 2544), underlying the overburden deposits within the Study Area is the Guelph Formation bedrock, composed of sandstone, shale, dolostone and siltstone (**Figure 4**).

2.2 Site Geology

The Centre Wellington Tier Three Water Budget (Matrix, 2020) describes the bedrock geology within Fergus and Elora as consisting primarily of dolostone of the Guelph Formation, followed by the Goat Island Formation, and further underlain by the Gasport Formation. The spatial extent and continuity of the bedrock formations within the Tier Three Water Budget Study Area was developed by Matrix with assistance from Frank Brunton at the OGS.

Borehole logs for municipal replacement wells F2-R and F5-R, and multilevel monitoring wells MW7-21 and MW8-22, which were drilled in 2021 and 2022 as part of the Municipal Well F2 & F5 Well Replacement Program, are included within the F2 & F5 Well Replacement Memorandum provided in **Appendix A**. Geophysics testing by LTS was performed on each of the four (4) wells, including the following analyses: flow-profiling, gamma, caliper, temperature, conductivity, optical/acoustic televiewer and downhole camera. The geologic cross-sections developed by Matrix as part of the Centre Wellington Tier Three Water Budget Assessment Physical Characterization Report (2017) are in agreement with the formations identified locally in the borehole logs. The regional geologic cross-sections developed by Matrix are provided in **Appendix B**.

2.3 Local Groundwater Use

2.3.1 Private Wells

A number of active private, domestic water supply wells are located both within and surrounding the communities of Fergus and Elora. Based on Township records, the number of private wells within 500 m of each municipal supply well is summarized in **Table 3**, with the approximate locations of the wells shown in **Figure 5**. Private water well use was also assessed through review of Ministry of the Environment, Conservation and Parks (MECP) water well records (WWR), which indicated the presence of numerous private wells both within and surrounding the communities of Fergus and Elora.

Table 3: Summary of Private Wells within 500 m of Each Municipal Production Well

Test/Cluster Number	Production Well	Private Wells within 500 m
#1 – Fergus	F1	0
	F2-R	48
	F5-R	6
#2 – Elora	E1	105
	E3	24
	E4	8
#3 – Fergus	F4	3
	F6	4
	F7	33

2.3.2 Municipal Water Supply

As stated in **Section 1**, the Township currently operates a total of eight (8) municipal wells within Fergus and Elora (**Figure 1**). Two (2) of the wells within Cluster #1 (F2-R and F5-R) were drilled as replacement wells in 2021 and 2022 and are planned to be connected to the municipal drinking water system in the near future. F2 was decommissioned in 2021. F5 has not been decommissioned at this time but it was not included within this WFCA. Hydraulic testing conducted as part of the F2 & F5 well replacement program indicated that F5 and F5-R are hydraulically connected by a deep-water bearing zone within the bedrock. Additionally, F5 intercepts a shallow water bearing zone within the bedrock which is not intercepted in F5-R. Prior to WFCA testing, an inflatable packer was installed within F5 by LTS to isolate the upper water bearing zone from the deeper water bearing zone connecting F5 and F5-R, for the intent of removing potential influence from the shallow water bearing zone during testing.

Each of the eight (8) existing operational and two (2) replacement municipal well supplies is completed as an open corehole within bedrock. With the exception of F2-R and F5-R, all of the municipal wells are identified within their respective borehole logs as being completed within the Amabel formation (Golder, 2013). Revisions to Early Silurian stratigraphic sequencing by the Ontario Geologic Survey has since revised the Amabel Formation within the Guelph-Cambridge region (including Fergus), to the Goat Island, Gasport, and Irondequoit Formations

(Brunton, 2009). Replacement supply wells F2-R and F5-R derive their groundwater source from flow zones mainly within the Gasport Formation. A summary of the completion details for each of the Township's municipal wells is provided in **Table 4**.

Table 4: Township of Centre Wellington Municipal Supply Well Summary

Production Well	Date of Construction	Depth of Well (mBGS)	Depth of Casing (mBGS)	Completion Formation(s)	Status
F1	1940	79.6	19.9	Gasport	In regular use
F2-R	2022	116.3	44.0	Guelph Goat Island Gasport Irondequoit Rockway Merritton	Not connected to water supply network
F4	1972	129.5	81.6	Gasport	In regular use
F5-R	2021	144.9	55.6	Guelph Goat Island Gasport Irondequoit Rockway Merritton Cabot Head	Not connected to water supply network
F6	1989	122.5	33.4	Gasport	In regular use
F7	1999	138.7	47.2	Gasport	In regular use
E1	1949	129.8	20.4	Gasport	In regular use
E3	1991	121.9	28.7	Gasport	In regular use
E4	2002	128.0	25.0[a]	Gasport	In regular use

Notes: *a. A liner was installed at E4 following the Cluster #3 Longer-Term Test, and prior to the Additional Elora Testing. The depth of the liner is 26.3 mBGS.*

3. Overview of Testing

3.1 Short-Term Testing

The purpose of the short-term testing was to confirm the current function of each well included in the WFCA and to establish the rate that each well was to be tested during the longer-term testing stage (where required). Detailed testing recently completed at the F2-R and F5-R sites as part of the F2 & F5 Well Replacement Program (**Appendix A**) was utilized to establish target rates for those wells and negated the requirement for additional short-term testing. Short-term testing was also deemed unnecessary at F1, due to ample recent historical testing data informing the target testing rate at that location. AECOM reviewed approximately one (1) year of production well data and determined that short-term testing was required at all of the Cluster #2 (E1, E3 and E4) and Cluster #3 (F4, F6 and F7) wells.

The following provides details of the proposed short-term testing rationale:

- **Cluster #2 (E1, E3 & E4):** Groundwater levels within the three (3) Elora wells are generally affected by mutual interference between the wells, and the Township has received historical complaints of interference with local private wells due to their operation. Consequently, daily pumping of well E4 is limited to 15 hours in the current wellfield PTTW (this condition has been relaxed for the purposes of wellfield testing). Conducting short-term tests on these wells simultaneously provides information regarding pumping rates that can be achieved during longer-term testing while balancing the maximum capacity of the Elora wellfield against the potential for private well interference.
- **Cluster #3 (F4, F6 & F7):** Although the Fergus wells have been reported to experience little to no mutual interference, well F4 has shown minor response to the operation/shut down of other Township production wells. Conducting the short-term tests for wells within Cluster #2 simultaneously allowed for the monitoring of any interference between the wells and to establish sustainable rates for longer-term testing.

Discharge rates were adjusted during the short-term tests based on aquifer response and pump performance. SCADA system data collected during each short-term pumping test above, including flow rate, frequent water level measurements (i.e., every thirty [30] minutes) and well level drawdown, were transferred from the Township to AECOM.

Results of the short-term testing are discussed in **Section 4.1**.

3.2 Longer-Term Testing

In advance of each longer-term test, the Township production wells within each well cluster were shut down for a period of two (2) to three (3) days to allow for the wells to rest and for aquifer water levels to recover from pumping conditions. During each shut down period, water storage was drawn down to provide capacity for water pumped during the longer-term tests. The Township provided AECOM with water level and pumping rate data for each production well (SCADA output) on a daily basis during the longer-term testing period.

Upon conclusion of each cluster test, a recovery period occurred to allow for the monitoring of well/aquifer recovery (water level rebound). Similar to the shut down period, the duration of each recovery period was on the order of three (3) days following testing completion. The recovery target was 75 to 90% of the pre-test groundwater level.

Details of each cluster test are discussed in **Section 4.2**. **Table 5** provides a general summary of the operation of each cluster during the three (3) longer-term tests.

Table 5: Longer-Term Testing Overview

Test/Cluster Number	Production Well	Status of Cluster #1	Status of Cluster #2	Status of Cluster #3
#1 – Fergus	F1	Operating at Max. Capacity following shut-down period	Operating to meet demand	Operating at Max. Capacity following shut-down period
	F2-R			
	F5-R			
#2 – Elora	E1	Operating to meet demand	Operating at Max. Capacity following shut-down period	Operating to meet demand
	E3			
	E4			
#3 – Fergus	F4	Operating at Max. Capacity following shut-down period	Operating to meet demand	Operating at Max. Capacity following shut-down period
	F6			
	F7			

3.3 Well Rehabilitation

3.3.1 Well Cluster #2

Based on the results of the longer-term testing, several well performance issues were identified, including:

- Corroded casing in E4 allowing shallow water to cascade into the well;
- Underperformance of E1 and E4 as compares to the results of prior wellfield capacity testing in 2013; and,
- Underperformance of F4 as compared to the results of prior wellfield capacity testing in 2013.

To remedy the corroded casing issue at E4, LTS installed a new liner (nominal 200 mm diameter) in February 2023, extending the base of the casing from 25.0 to 26.3 mBGS. The well was also acid rehabilitated to improve well performance. Initial well performance testing by LTS following the liner installation and acid rehabilitation indicated a well capacity for E4 in excess of its “as-constructed” performance.

LTS conducted acid rehabilitation at E1 in March 2023. Initial well performance testing of E1 following the acid rehabilitation indicated that the well was performing at similar levels to its “as-constructed” performance.

LTS conducted acid rehabilitation at F4 in June 2023. Initial well performance testing of F4 following the acid rehabilitation indicated that the well was performing above its “as-constructed” performance.

3.4 Additional Elora Testing

On November 8th, 2022, the Township provided notification to MECP of additional testing planned for the three (3) Elora wells within Cluster #2 (E1, E3 and E4) based on interference observed in nearby private water supply wells during longer-term testing completed between October 23rd and 29th, 2022 (as discussed further in **Section 4.2.2**). The Township subsequently provided details to the MECP of the plan for the additional testing on April 18th, 2023, which was in turn accepted on April 27th, 2023.

The additional testing included step testing of each Elora municipal well, as well as longer-term constant rate testing of the Elora well cluster. The intent of this additional testing was to determine a maximum appropriate pumping rate for each Elora municipal well while mitigating private well interference. The constant rate testing was similar to the longer-term testing performed at the Cluster #2 wells in fall 2022, in that all Elora wells were simultaneously pumped for an extended duration (24 to 72 hours), using updated pumping rates designed to mitigate the adverse interference drawdown previously experienced. Fergus well Clusters #1 and #3 were operated normally during the additional Elora testing.

3.4.1 Step Testing

Step testing was performed at each of the Cluster #2 wells was completed initially to determine a maximum appropriate pumping rate for each well for the additional longer-term test. To minimize interference drawdown, step-testing of each of the three (3) Cluster #2 wells was performed on separate days, with minimum pumping at the remaining two (2) wells during each respective test. In advance of each step test, shut down of pumping at the tested well occurred for a minimum of 24-hours.

Upon conclusion of each step test, a recovery period occurred to allow for monitoring of well/aquifer recovery (water level rebound). Similar to the shut down period, the duration of each recovery period was on the order of one (1) day following testing completion. The recovery target was 75 to 90% of the pre-test groundwater level.

3.4.2 Longer-Term Testing

In advance of the additional longer-term test, Township production wells within Cluster #2 were shut down for minimum period of one (1) day, to allow for the wells to rest and for aquifer water levels to recover from pumping conditions. The duration of this recovery period was considered appropriate based on well response observed during step testing of the Cluster #2 wells and subsequent recovery (as discussed in **Section 4.3**). During each shut down period, the Township's water storage was drawn down to provide capacity for water pumped during the longer-term test. The Township provided AECOM with water level and pumping rate data for each production well (SCADA output) on a daily basis during the longer-term testing period.

Upon conclusion of the longer-term rate test, a recovery period occurred to allow for monitoring of well/aquifer recovery (water level rebound). Similar to the shut down period, the duration of each recovery period was on the order of one (1) day following testing completion. The recovery target was 75 to 90% of the pre-test groundwater level.

3.5 Private Well Monitoring Program

A monitoring program was established to adequately capture groundwater level response (drawdown) within private wells surrounding each production well during pump testing (i.e., both short and longer-term). This included targeted communication with known private well owners in the vicinity of each production well, with an invitation to participate in water level monitoring during completion of the WFCA. The following sections outline efforts made to include private well monitoring locations within the program. The locations of private well owners that were invited to participate in the WFCA monitoring program are shown in **Figure 5**. The incorporation of private wells into the WFCA monitoring program is summarized in **Section 3.7**.

3.5.1 Ongoing Private Well Monitoring by the Township

3.5.1.1 Groundwater Science Corp.

One (1) private well is presently monitored by Groundwater Science Corp., on behalf of the Township. Groundwater Science Corp. agreed to share monitoring data recorded at this private well with AECOM for a period extending from prior to through to conclusion of the WFCA. A summary of the private well is included in **Table 6**.

Table 6: Private Wells with Ongoing Township Monitoring

Associated Production Well	Centre Wellington Well ID	Address
E4	Well 19	GRCA Elora Gorge Park

3.5.1.2 F2 & F5 Well Replacement Program

As part of the F2 & F5 Well Replacement project, a water well survey (WWS) was completed for all properties not connected to the municipal water supply and located within approximate 500 m of the Well F2 and Well F5 Sites. The WWS form comprised a two (2) page survey pertaining to the construction, operation and condition of the owner's private water well supply. As part of the survey questionnaire, property owners also were requested to indicate their approval to participate in a Monitoring Program that was planned to be administered by the Township prior to and during Project implementation; including groundwater level monitoring and water quality sampling.

A total of fifty-four (54) WWS packages were hand delivered within the identified Study Area; including forty-five (45) in the vicinity of the Well F2 site and nine (9) in the vicinity of Well F5 site. Details of the WWS are included in the AECOM memorandum entitled *Municipal Supply Wells F2 & F5 Replacement Program – Private Water Well Survey Results* (WWS Memo), dated January 12, 2021 (**Appendix A**). Based on this survey, a total of five (5) private well owners agreed to participate in the Private Well Monitoring Program as part of the F2 & F5 Well Replacement Program (**Table 7**). Those five (5) well owners also agreed to participate in water level monitoring during the WFCA. It is noted that one (1) of the five (5) well owners (535 Orangeville Road) agreed to be included as part of a Private Well Monitoring Program subsequent to January 12, 2021, and therefore was not identified as part of the monitoring program within the WWS Memo. Notification letters provided to the property owners listed in **Table 7** are provided in **Appendix C-1**.

Table 7: Private Well Monitoring Program Participants Retained from the F2 & F5 Well Replacement Project

Associated Production Well	Centre Wellington Private Well ID	Address
F2	Well 37	535 Orangeville Rd
	Well 38	565 Orangeville Rd.
	Well 36	590 St. Andrew St. East
	Well 33	640 St. Andrew St. East
F5	Well 28	935 Scotland St.

3.5.2 Additional Private Well Monitoring

The Township extended an invitation to participate in the monitoring program to seven (7) property owners who had previously participated in the 2013 WFCA, and to fifteen (15) residents with private wells in key areas with identified data gaps.

Invitations to the water level monitoring program were delivered in-person by AECOM or were communicated in person by the Township during door-to-door surveys. This communication sought to obtain access permission to undertake groundwater level monitoring for the duration of the wellfield testing program. AECOM prepared a package that included the access permission request letter, a water well survey designed to obtain information on well details, use, type, etc., and a pre-stamped return envelope. AECOM managed the received responses by setting up appointments to visit each well, perform a well assessment to determine suitability for equipment installation, followed by monitoring equipment installation, where applicable. A sample of the invitation letter to the monitoring program is provided in **Appendix C-2**. A summary of the invitations to the WFCA monitoring program are provided in **Table 8**, with those locations shown in **Figure 5**.

Table 8: Summary of Invitations to WFCA Monitoring Program

Associated Production Well	Centre Wellington Private Well ID	Address	Agreed to Participate in Water Level Monitoring Program (Y/N)
F4, F6	Well 1	950 Gartshore St	N
E3	N/A	27 First Line	Y[a]

Associated Production Well	Centre Wellington Private Well ID	Address	Agreed to Participate in Water Level Monitoring Program (Y/N)
E3	Well 14	63 First Line	Y
Background	Well 20	6715 Wellington Road 7	N
E1	N/A	31 Emily Street	N
E1	Well 21	303 Erb Street	Y
F2, F5	Well 29	620 Belsyde Avenue	N
F6	Well 30	8063 Sideroad 10	N
F4, F6, F7	Well 31	19 Burnett Court	Y
F4, F6, F7	N/A	59 Victoria Crescent	N
F4, F6, F7	N/A	63 Victoria Crescent	N
F4, F6, F7	N/A	67 Victoria Crescent	N
F7	Well 32	6587 Beatty Line	N
E1	Well 34	7461 Wellington Road 18	Y
E3, E4	N/A	19 Hill Street	N
E3, E4	N/A	21 Hill Street	Y[b]
E3, E4	N/A	23 Hill Street	N
E1	Well 39	7444 Wellington Road 18	Y[c]
E3, E4	Well 40	148 Wellington Road 7	Y
E3, E4	N/A	152 Wellington Road 7	N
E1	N/A	354 Geddes Street	N
E1, E4	DDH5-09	7372 Middlebrook Road	N[d]

Notes: *a. 27 First Line could not be included in the monitoring program since the well was obstructed above the water table.*
b. 21 Hill Street could not be included in the monitoring program since the well was inaccessible (buried).
c. 7444 Wellington Road 18 is a monitoring well located at a Ready Mix plant. The plant operator agreed to share groundwater monitoring data collected by another consultant as part of the gravel pit operations.
d. 7372 Middlebrook Road is a multi-level monitoring well previously monitored by the Ontario Geological Survey (OGS).

3.5.3 Additional Elora (Cluster #2) Testing Private Well Monitoring

Prior to the additional well testing within Cluster #2, the Township obtained access permission for one (1) additional private well monitoring location in the Hill Street/Wellington Rd 7 area and one (1) additional private well monitoring location in proximity to E1. Monitoring equipment installations for these locations was completed by LTS. These additional two (2) monitoring locations are as follows:

Table 9: Additional Private Well Monitoring Program Participants

Associated Production Well	Centre Wellington Private Well ID	Address
E1	Well 43	308 Erb St
E3	Well 40	148 Wellington Rd 7

3.5.4 General Notification Letter to Private Well Owners

A notification letter was distributed to all private well owners identified by the Township within a radial distance of 500 m from each municipal pumping well. The purpose of the letter was to advise of the WFCA testing, to provide contact information for any inquiries related to the program and/or to report a potential well interference impact during the testing. Copies of the general WFCA notification letters are provided in **Appendix C-3**.

3.6 Surface Water Monitors

In accordance with the WFCA Work Plan (AECOM, 2020), the Township installed a series of drive-point piezometers within Swan and Irvine Creeks to allow for the monitoring of potential impacts to surface water levels

during WFCA testing. The piezometers were constructed of stainless-steel risers and screens that were hand-driven into the stream beds by the Township. Drive-point piezometers were installed at three (3) locations in Swan Creek (identified as Swan 1 to 3), and at four (4) locations within Irvine Creek (identified as Irvine 1 to 4) (**Figure 6**).

3.7 Monitoring Network

During each longer-term cluster test, groundwater level data was collected at the pumping wells, in addition to established monitoring locations within the Township's monitoring network, which included private wells where property owners agreed to participate in the monitoring program, Township monitoring wells, and drive-point piezometers (**Figure 6**). A tabular summary of the groundwater monitoring network is provided in **Appendix D**; including identification of which party was responsible for monitoring of the respective monitoring wells/piezometers. Groundwater level monitoring at each existing operational production well was performed directly by the Township via the existing SCADA system and monitoring at the replacement wells was completed by LTS.

Groundwater level information was collected at each monitoring location using an in situ datalogger configured to obtain readings at an hourly interval, supplemented by periodic manual measurements using an electronic water level indicator. A total of two (2) barometric dataloggers were installed for the project, one (1) in Fergus and one (1) in Elora and were configured to the same measurement frequency as that of the water level dataloggers to allow for the correction of data for fluctuations in atmospheric pressure.

Data collection commenced a minimum of 48-hours prior to the outset of each longer-term pumping test to establish a groundwater level baseline at each monitoring location and extended throughout the duration of testing; including the subsequent recovery period.

3.8 Discharge During Pump Testing

Off-site discharge during pump testing was only required for F2-R and F5-R within Cluster #1, and E4 in Cluster #2 (as needed). Water pumped from all of the other wells was treated and transferred directly to distribution. During discharge to the Township's storm sewer network at the F2-R site, AECOM monitored the discharge water quality and collected Total Suspended Solids (TSS) measurements, as necessary, to confirm compliance with the Township's sewer use by-law. Water pumped from F5-R was discharged to an existing dry swale located along the northern edge of the property. E4 was typically pumped to distribution; however, the Township utilized the established on-site storm sewer discharge infrastructure as needed. A summary of the discharge plan for each municipal well location is provided in **Table 10**.

Table 10: Discharge Plan

Test/Cluster Number	Production Well	Discharge Plan
#1 – Fergus	F1	N/A (distribution)
	F2-R	Storm Sewer
	F5-R	Waste/Storm Sewer
#2 – Elora	E1	N/A (distribution)
	E3	N/A (distribution)
	E4	Distribution, waste (as needed)
#3 – Fergus	F4	N/A (distribution)
	F6	N/A (distribution)
	F7	N/A (distribution)

3.9 Mitigation Strategy

The communities of Fergus and Elora both have a relatively high density of operating private wells within their urban envelope, and in some cases, there are private wells located in close proximity to the municipal supply wells (**Table 3**). Where/if a private well interference complaint was received during the completion of testing associated with the WFCA, AECOM offered the complainant a short-term supply of drinking water (bottled water) and initiated an assessment as to whether the received complaint was related to the testing.

Should the result of AECOM's assessment determine that WFCA testing caused the reported interference and that the private well could not provide the required supply in terms of quality or quantity, the test would be stopped. If, within 24 hours of the complaint being received, the interference assessment was inconclusive, the test would be stopped. Finally, if the assessment determined that the private well could continue to operate as required, or that the testing did not cause interference to the supply, the test was continued according to the planned schedule and duration. AECOM supported the Township with the required MECP notification of any complaints received during WFCA testing, the proposed action to assess and mitigate the complaint, and the complaint resolution. A summary of complaints received during each stage of the WFCA is summarized in **Section 4** and includes an overview of mitigation efforts conducted by AECOM.

4. Wellfield Capacity Assessment Results

4.1 Short-Term Testing

Short-term testing included four (4) hours of pumping at each of Cluster #2 and Cluster #3 on October 13th, 2022. Results of the short-term testing are summarized in **Table 11**; including recommended pumping rates for longer-term testing. Hydrographs displaying the groundwater elevation and pumping rate for each of the Cluster #2 and Cluster #3 wells during short-term testing are presented in **Figures E-1.01** and **E-1.02**, respectively. As stated in **Section 3.1**, short-term testing was not performed on the Cluster #1 wells due to the availability of background well performance information for F1, and the pumping rates for F2-R and F5-R were established during testing completed as part of the F2 & F5 Well Replacement Program.

Table 11: Short-Term Test Summary

Test/Cluster Number	Production Well	Date of Short-Term Testing (YYYY-MM-DD)	Short-Term Testing Time (HH:mm)	Target Short-Term Testing Rate (L/s)[a]	Stabilized Short-Term Testing Rate (L/s)
#2 – Elora	E1	2022-10-13	14:00 – 18:00	20.2	19.9
	E3	2022-10-13	14:00 – 18:00	20.0	20.0
	E4	2022-10-13	14:00 – 18:00	22.7	22.0
#3 – Fergus	F4	2022-10-13	08:00 – 12:00	22.7	21.0
	F6	2022-10-13	08:00 – 12:00	22.7	18.3
	F7	2022-10-13	08:00 – 12:00	22.7	20.0

Notes: a. The target rates are based on the MECP approved WFCA Work Plan and the system PTTW.

During short-term testing of Cluster #2, it was determined that E3 could sustain the target rate of 20.0 L/s (**Figure E-1.01**). For the long-term test, it was proposed that the rate for E3 be increased slightly due to the high performance observed during short-term testing. Target short-term test pumping rates for E1 and E4 could not be maintained due to lagging of the secondary, high-lift pump (used for distribution), and therefore the wells stabilized at slightly lower rates of 19.9 and 22.0 L/s, respectively, as shown on **Figure E-1.01**.

During the short-term testing of Cluster #3, it was determined that none of the three (3) wells could achieve the target short-term rate for the duration of the testing, based on limitations of the installed pumping equipment. Based on well performance during the short-term test, the proposed rates for the longer-term test for F4, F6 and F7 were decreased slightly to 21, 18 and 20 L/s, respectively.

4.1.1 Well Complaints

No well complaints were received during the short-term testing of Cluster #2 and Cluster #3.

4.2 Longer-Term Testing

4.2.1 Cluster #1 – Fergus

In advance of the Cluster #1 longer-term test, shut down of pumping activities at well F1 occurred between October 14th and 16th, 2022, with the test occurring between October 17th and 19th, 2022. During the test, the wells in Cluster #3 (F4, F6 and F7) operated at their existing capacity without a pre-test shut down period. Pumping of the Cluster #1 wells on October 17th, 2022 began with a staggered start in order to identify potential well interference between the municipal wells. Production wells within Cluster #1 were shut-off from October 20th to 22nd, 2022 to allow for

recovery monitoring following conclusion of the longer-term pumping test. A summary of the Cluster #1 longer-term test scheduling and pumping rates is provided in **Table 12**.

Table 12: Cluster #1 – Longer-Term Test Summary

Cluster Number	Production Well	Well Shut-Off Period Prior to Cluster #1 Test		Test Pumping Period			Well Recovery Period Following Cluster #1 Test	
		From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Pumping Rate (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)
#1 – Fergus	F1	2022-10-14 08:00	2022-10-17 08:00	2022-10-17 08:00	2022-10-20 16:00	19.5	2022-10-20 16:00	2022-10-23 08:00
	F2-R	N/A[a]		2022-10-17 12:00	2022-10-20 16:00	18.3 – 18.8	N/A[b]	
	F5-R	N/A[a]		2022-10-17 16:00	2022-10-20 16:00	18.5 – 20.0	N/A[b]	
#3 – Fergus	F4	N/A[c]		2022-10-17 08:00	2022-10-20 16:00	19.0	N/A[d]	
	F6	N/A[c]		2022-10-17 08:00	2022-10-20 16:00	17.2 – 18.1	N/A[d]	
	F7	N/A[c]		2022-10-17 08:00	2022-10-20 16:00	19.2 – 19.5	N/A[d]	

Notes: a. F2-R and F5-R were not active prior to the test and therefore did not require a shut-off period prior to the Cluster #1 – Fergus Longer-Term Test Pumping Period.
b. F2-R and F5-R remained shut-off following the pumping period until the Cluster #3 Longer-Term Test Pumping Period.
c. Cluster #3 Wells were in normal operation prior to the Cluster #1 – Fergus Longer-Term Test Pumping Period.
d. Cluster #3 Wells were returned to normal operation following the Cluster #1 – Fergus Longer-Term Test Pumping Period.

During the Cluster #1 test, AECOM staff collected manual groundwater level measurements from a subset of monitoring locations within the larger network around the two (2) Fergus well clusters. Monitoring locations associated with production wells F1, F2-R, F5-R, F4, F6 and F7 during longer-term testing of Cluster #1 are identified in **Section 3.7**. SCADA system data collected for each Fergus municipal well (including Clusters #1 and #3) were compiled and reviewed by AECOM's Project Hydrogeologist on a daily basis to evaluate the testing progress. Disturbance to private well owners in the vicinity of each pumping well was minimized by conducting monitoring of private wells exclusively with installed pressure transducers, except in instances where a well interference complaint was received, as outlined in **Section 3.9**. Following completion of the Cluster #1 longer-term test, aquifer recovery was monitored through the collection of manual groundwater level measurements from a subset of monitoring locations within the larger network around the two (2) Fergus clusters. The data were reviewed by AECOM's Project Hydrogeologist to evaluate the recovery progress and provide regular updates to the Township.

4.2.1.1 Water Level Monitoring Results

Results of the groundwater level monitoring completed during the Cluster #1 longer-term test are provided as hydrographs in **Appendix E** (**Figures E-2.01** to **E-2.27**) and **Appendix F**. Maximum observed drawdown results for each monitoring location included in the Cluster #1 longer-term test, with the exception of the drive-point piezometers, are presented in **Figure 7**. As stated in **Section 4.2.1.1.3**, drawdown responses were not detected in any drive-point piezometer during the Cluster #1 longer-term test.

4.2.1.1.1 Municipal Well Response

Groundwater levels and pumping rates associated with the Cluster #1 municipal wells during the longer-term test are presented as hydrographs in **Figure E-2.01**.

During the shut-down period prior to the Cluster #1 longer-term test, the groundwater level within F1 recovered to 372.5 mASL. The pumping rate in F1 was consistently maintained at 19.5 L/s throughout the test. At the conclusion of pumping period, the water level within F1 was approaching a stabilized drawdown of 15.5 m (357.0 mASL).

F2-R was not in operation prior to the Cluster #1 longer-term test, and therefore the water level had completely recovered to an elevation of 391.5 mASL prior to the start of pumping on October 17, 2022. The F2-R pumping rate began at 18.3 L/s on October 17, 2022 and continued until October 19, 2022 at 8:00 a.m., 48-hours into the test, when LTS identified the lower than anticipated rate and increased it to 18.8 L/s. A slight decrease in the drawdown trend was observed following the increase in the pumping rate. At the conclusion of the pumping period, the water level within F2-R was approaching a stabilized drawdown of 35.8 m (355.8 mASL).

F5-R was also not in operation prior to the Cluster #1 longer-term test, and therefore the water level was completely recovered prior to pumping on October 17, 2022, at an elevation of 403.9 mASL. The initial F5-R pumping rate was 18.5 L/s starting on October 17, 2022, and was increased to 19.2 L/s on October 19, 2022 at 8:00 a.m., 48 hours into the test. Additionally, on October 20, 2022 at 10:30 a.m. (approximately 74.5 hours elapsed time), the pumping rate was increased to 20.0 L/s, the original target rate of the test. At the conclusion of the pumping period, the water level within F5-R was approaching a stabilized drawdown of 26.3 m (377.6 mASL).

Mutual interference drawdown due to municipal pumping was not observed at F1, F2-R or F5-R during the Cluster #1 longer-term test. The staggered start of F1, followed by F2-R and F5-R, did not cause any drawdown within F2-R or F5-R prior to the start of pumping at those locations.

As stated previously, the Cluster #3 municipal wells were operated at estimated peak capacity during the Cluster #1 longer-term test. The Cluster #3 municipal well responses during the Cluster #1 longer-term test are shown as hydrographs on **Figure E-2.02**. No mutual interference due to the pumping of Cluster #1 longer-term test was observed in the Cluster #3 hydrographs.

4.2.1.1.2 Private Wells and Monitoring Wells Response

Private well and monitoring well response during the Cluster #1 longer-term test are shown as hydrographs in **Figures E-2.03** to **E-2.20**, as well as **Appendix F**.

Township multi-level monitoring wells MW1-12 (A, B and C), MW2-11 (A, B and C), MW3-11 (A, B and C), MW4-12 (A, B and C), MW5-11 (A and B), MW5-18(C) and MW6-12 (A, B and C) were monitored by Groundwater Science Corp. during the Cluster #1 longer-term test and are presented in hydrographs in **Appendix F**[1]. MW1-12 and MW2-11 did not show a response to the Cluster #1 longer-term test, as those wells are located in Elora and are associated with the Elora municipal wells (i.e., Cluster #2). MW3A-11 and MW3B-11, located at a distance of less than 1 km from F5-R, showed identical, strong groundwater level response (3.5 m drawdown) to municipal pumping during the Cluster #1 longer-term test. The shallow overburden well MW3C-11 showed a slight drawdown response (<1.0 m drawdown) to the Cluster #1 test. MW4A-12 and MW4B-12, located less than 1 km from F7, showed strong groundwater level response, with maximum observed drawdowns during the test of 7.5 and 4.0 m, respectively. The shallow overburden well MW4C-12 did not show an appreciable response to the Cluster #1 test. MW5A-11, located less than 1 km from F6, showed slight drawdown response to the Cluster #1 test (~1.0 m). Data was not available for the intermediate well at the MW5-11 location (MW5B-11). The shallow overburden well MW5C-18 did not show a drawdown response to the test. MW6A-12 and MW6B-12, also located less than 1 km from F6, showed moderate drawdown response to the Cluster #1 test, with maximum observed drawdown of approximately 3 and 2 m, respectively. The shallow overburden well MW6C-12 did not show a response to the test.

1. *The Township multi-level wells use the letter A to designate the deepest screen interval, B for the intermediate interval, and C for the shallow interval. The conventions MW1B-12 and MW1-12B are both used by the Township to name/refer to the wells.*

The hydrographs for multi-level monitoring well MW7-21 during the Cluster #1 longer-term test are provided in **Figures E-2.03, 2.04** and **2.05**. The deep monitoring well (MW7-21D) showed a strong response to municipal pumping, with a maximum drawdown of 13.9 m. The intermediate monitoring well (MW7-21I), showed a moderate drawdown response, with a maximum drawdown of 7.6 m. The shallow monitoring well (MW7-21S) did not show a response to municipal pumping. It is noted that all three (3) of the MW7-21 wells are screened in bedrock, as bedrock surface is nearly at ground level at this location.

During the Cluster #1 longer-term test, MW8-21 was an open corehole from 2.4 to 79.0 mBGS, with a temporary packer placed at 16.3 mBGS, separating the shallow fractured bedrock from the deeper bedrock aquifer providing groundwater supply to F1. Groundwater levels were measured above and below the packer during the Cluster #1 longer-term test and results are presented in **Figures 2.06** and **2.07**, respectively. Only the water level monitored below the packer showed a response during the testing, with a maximum observed drawdown of 9.0 m that followed a pattern very similar to the drawdown observed in F1.

Private well groundwater level monitoring results during the Cluster #1 longer-term tests are provided as hydrographs in **Figures E-2.08** to **E-2.13**. The six (6) private wells monitored during the Cluster #1 longer-term test and their responses to the test are summarized in **Table 13**. The maximum observed drawdown within a private well during the Cluster #1 longer-term test was 4.8 m at Well 36 (590 St. Andrew Street E), which is located approximately 425 m east of F2-R.

Table 13: Summary of Private Well Response During Cluster #1 Longer-Term Test

Well Name	Associated Production Well	Completion Formation	Maximum Drawdown Observed During Test (m)
Well 28	F5-R	Unknown	1.3
Well 31	F4, F6, F7	Unknown	3.7
Well 33	F2-R	Unknown	0.2
Well 36	F2-R	Bedrock	4.8
Well 37	F2-R	Bedrock	0.2
Well 38	F2-R	Bedrock	0.4

Two (2) bedrock monitoring wells (MW1-22 and MW3-22) that were installed by the Township as part of a water supply project to the north of Fergus/Elora were monitored during the Cluster #1 longer-term test, with the results being presented as hydrographs in **Figures E-2.14** and **2.15**. MW1-22 showed a delayed drawdown response of approximately 1.1 m during the test, likely due to the operation of F7. Based on the delayed drawdown response observed during the Cluster #1 longer term test, it is interpreted that MW3-22 may only slightly be influenced by pumping at the Fergus municipal wells.

Five (5) bedrock monitoring wells (MS24A-94S, MS46A-00S, MS46A-00I, MS47A-01S and MS47A-01I) located at the A.O. Smith site in Fergus were monitored during the Cluster #1 longer-term test, with the results being presented as hydrographs in **Figures E-2.16** to **E-2.20**. The five (5) monitoring wells did not show any response to the Cluster #1 test.

4.2.1.1.3 Surface Water Features

Water level monitoring results for the drive-point piezometers during the Cluster #1 longer-term test are shown as hydrographs on **Figures E-2.21** to **E-2.27**.

The drive-point piezometers installed in Swan Creek (Swan 1, 2 and 3) and Irvine Creek (Irvine 2, 3 and 4) did not show any drawdown responses to the Cluster #1 longer-term pumping test. It is noted that the drive-point piezometer at Irvine 1 was damaged and the datalogger could not be recovered. As a result, only manual readings are available for this monitoring location. The minimal manual readings recorded at Irvine 1 during the Cluster #1 longer-term pumping test are insufficient to confirm whether drawdown occurred in the shallow groundwater at this

location; however, based on the lack of response in the other three (3) Irvine drive-point piezometers, it is considered unlikely that the drawdown occurred at Irvine 1 during the test.

4.2.1.2 Well Complaints

No well complaints were received by the Township during the Cluster #1 longer-term test.

4.2.2 Cluster #2 – Elora

This WFCA program was staged to utilize the distance between the Fergus and Elora wellfields to permit sequential testing of Cluster #1 followed by Cluster #2 (Elora). Following this strategy, when the Elora wells were shut down, both of the Fergus well clusters were operating, thereby facilitating the transfer of water from Fergus to address water demand in Elora, as necessary. Shut down of the Elora production wells occurred from October 23rd to 24th, 2022, in advance of the Cluster #2 longer-term test. Active pumping for the Cluster #2 longer-term test occurred from October 25th to 27th, 2022. Pumping of the Cluster #2 wells on October 25th, 2022 began with a staggered start in order to identify potential well interference between the municipal wells. Following the test, the Cluster #2 wells were shut-off from October 28th to 29th, 2022 to allow for groundwater level recovery monitoring, following conclusion of the longer-term test. During this shut-down period, all of the Fergus wells were available to operate as needed to meet community water demands. A summary of the Cluster #2 longer-term test scheduling and pumping rates is provided in **Table 14**.

Table 14: Cluster #2 – Longer-Term Test Summary

Cluster Number	Production Well	Well Shut-Off Period Prior to Cluster #2 Test		Test Pumping Period			Well Recovery Period Following Cluster #2 Test	
		From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Pumping Rate (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)
#2 – Elora	E1	2022-10-23 08:00	2022-10-25 08:00	2022-10-25 08:00	2022-10-28 16:00	17.5 - 19.4	2022-10-28 16:00	2022-10-30 11:30
	E3	2022-10-23 08:00	2022-10-25 12:00	2022-10-25 12:00	2022-10-28 16:00	21.0 - 21.2	2022-10-28 16:00	2022-10-30 08:30
	E4	2022-10-23 08:00	2022-10-25 16:00	2022-10-25 16:00	2022-10-28 16:00	20.0 – 22.0	2022-10-28 16:00	2022-10-30 12:00

During the Cluster #2 test, AECOM staff collected manual groundwater level measurements from a subset of monitoring locations within the larger network around the Elora well cluster. Monitoring locations associated with production wells E1, E3 and E4 during longer-term testing of Cluster #2 are identified in **Section 3.7**. SCADA system data collected for each municipal well (including Clusters #1 and #3) were compiled on a daily basis and reviewed by AECOM's Project Hydrogeologist to evaluate the testing progress. Disturbance to private well owners in the vicinity of each pumping well was minimized by conducting monitoring of private wells exclusively with installed pressure transducers, except in instances where a well interference complaint was received, as outlined in **Section 3.9**. Following the completion of the Cluster #2 longer-term test, AECOM staff monitored aquifer recovery through the collection of manual groundwater level measurements from a subset of monitoring locations within the larger network. The data were reviewed by AECOM's Project Hydrogeologist to evaluate the recovery progress and provide regular updates to the Township.

4.2.2.1 Water Level Monitoring Results

Results of groundwater level monitoring completed during the Cluster #2 longer-term test are provided as hydrographs in **Figures E-3.01** to **E-3.20**.

4.2.2.1.1 Municipal Well Response

Municipal well responses and pumping rates of the Cluster #2 wells during the longer-term test are shown as hydrographs on **Figure E-3.01**.

At the conclusion of the shut-down period prior to the test, E1 recovered to 375.8 mASL. With an initial E1 pumping rate of 19.4 L/s, the pumping rate during the test was subsequently lowered on two (2) occasions, to 18.4 and 17.5 L/s at 35 and 56 hours elapsed test time, respectively, due to the water level within E1 approaching the maximum drawdown pumping level. At the conclusion of the pumping period, the water level within E1 was approaching a stabilized drawdown of 31.9 m (343.9 mASL).

At the conclusion of the shut-down period prior to the test, E3 recovered to 374.4 mASL. The E3 pumping rate was generally maintained during the test, as shown in **Table 14**. At the conclusion of the pumping period, the water level within E3 was approaching a stabilized drawdown of 21.9 m (354.0 mASL).

At the conclusion of the shut-down period prior to the test, E4 recovered to 375.8 mASL. With an initial E4 pumping rate of 22 L/s, the pumping rate during the test was subsequently lowered on two (2) occasions. First, at 29.5 hours elapsed test time, the water level approached the maximum drawdown pumping level, and the pump subsequently shut-off for a period of three (3) hours as a result of the SCADA programming for the well. When pumping resumed, it was at a rate of 21.0 L/s. The second rate adjustment occurred at approximately 65 hours elapsed test time, where the water level once again approached the maximum drawdown pumping level. At that time, the pumping rate was adjusted to 20.0 L/s. At the conclusion of the pumping period, the water level within E4 was approaching a stabilized drawdown of 45.2 m (330.5 mASL).

Well interference due to municipal pumping was observed in wells E3 and E4. The staggered start of E1, followed by E3 and E4, caused <1 m of drawdown within E3 (due to E1 pumping) and E4 (due to E1/E3 pumping) prior to the start of pumping at those locations, respectively. This is shown in the E3 and E4 hydrographs at the conclusion of the recovery period prior to initiating the longer-term pumping at those locations, where there is a slight dip in the respective water levels.

4.2.2.1.2 Private Wells and Monitoring Wells Response

Private well and monitoring well response during the Cluster #2 longer-term test are shown as hydrographs in **Figures E-3.02** to **E-3.13**, as well as **Appendix F**.

Township multi-level monitoring wells MW1-12 (A, B and C), MW2-11 (A, B and C), MW3-11 (A, B and C), MW4-12 (A, B and C), MW5-11 (A and B), MW5-18(C) and MW6-12 (A, B and C) were monitored by Groundwater Science Corp. during the Cluster #2 longer-term test and are presented in hydrographs in **Appendix F**. MW3-11, MW4-12, MW5-11 and MW6-12 did not show a response to the Cluster #2 longer-term test, as those wells are located in Fergus and are associated with the Fergus municipal wells (i.e., Clusters #1 and #3). The deep bedrock well MW1A-12 showed a distinct drawdown response (8.0 m) during the test, while the intermediate bedrock well MW1B-12 showed moderate drawdown response (1.5 m). The shallow overburden well MW1C-12 showed a very slight drawdown response (<0.5 m) during the test. The intermediate bedrock well MW2B-11 showed a strong drawdown response during the test (3.0 m). Data was not available for the deep well MW2A-11 due to well malfunction. The shallow overburden well MW2C-11 did not show a drawdown response during the test.

Private well groundwater level monitoring results during the Cluster #2 longer-term test are provided as hydrographs in **Figures E-3.02** to **E-3.07**. The six (6) private wells monitored during the Cluster #2 longer-term test and their responses to municipal pumping are summarized in **Table 15**. The maximum observed drawdown at a private well during the Cluster #2 longer-term test was 3.0 m at Well 19, which is located approximately 950 m north of E4.

Table 15: Summary of Private Well Response During Cluster #2 Longer-Term Test

Well Name	Associated Production Well	Completion Formation	Maximum Drawdown Observed During Test (m)
Well 14	E3	Unknown	1.4
Well 15	E3, E4	Unknown	1.4
Well 19	E4	Unknown	3.0
Well 21	E1	Unknown	2.3
Well 34	E1	Multiple[a]	N/A[b]
Well 39	E1, E4	Unknown	N/A[b]

Notes: a. Open hole bedrock well likely open to Goat Island/Gasport FMs based on depth and Bedrock Materials described on well record.
b. Water level fluctuations in hydrograph likely due to local, private well pumping.

Two (2) bedrock monitoring wells (MW2-22 and MW3-22) installed the Township as part of a water supply project to the north of Elora were monitored during the Cluster #2 longer-term test, with the results being presented as hydrographs in **Figures E-3.08** and **3.09**. Neither of the two (2) monitoring wells showed any appreciable drawdown response during the test.

Four (4) research bedrock monitoring wells (ELR1-R1, ELR1-R2, ELR2-R1 and ELR2-R2) were monitored by the University of Guelph during the Cluster #2 longer-term test, with the results being presented as hydrographs in **Figures E-3.10** to **E-3.13**. ELR1-R1 and ELR1-R2 showed a strong hydraulic response to the test, with observed drawdowns of greater than 4.7 and 3.0 m, respectively. It is noted that a large proportion of the hydrographs for those wells are cut-off due to the water levels within the wells dropping below the installation depth of the dataloggers during the tests. ELR2-R1 and ELR2-R2 may have shown a minor delayed drawdown response (<1 m) to the municipal pumping during the test.

4.2.2.1.3 Surface Water Features

Groundwater level monitoring results for the drive-point piezometers during the Cluster #2 longer-term test are shown as hydrographs in **Figures E-3.14** to **E-3.19**.

The drive-point piezometers installed in Swan Creek (Swan 1, 2 and 3) and Irvine Creek (Irvine 2, 3 and 4) did not show any drawdown responses to the Cluster #2 longer-term pumping test. It is noted that the drive-point piezometer at Irvine 1 was damaged and the datalogger could not be recovered. As a result, only manual readings are available for this monitoring location. The minimal manual readings recorded at Irvine 1 during the Cluster #1 longer-term pumping test are insufficient to confirm whether drawdown occurred in the shallow groundwater at this location; however, based on the lack of response in the other three (3) Irvine drive-point piezometers, it is considered unlikely that the drawdown occurred at Irvine 1 during the test.

4.2.2.2 Well Complaints

Three well complaints were received by the Township during the Cluster #2 longer-term testing related to interruption to the normal use of private wells. Specific complaint locations included:

- 5 Hill Street (E3 and E4)
- 148 Wellington Road 7 (E3 and E4)
- 354 Geddes (E1)

The Township responded to each well complaint that was received and worked with the residents to ensure that regular supply well use was re-established, as required. This process was documented directly between the Township and MECP.

4.2.3 Cluster #3 – Fergus

In advance of the Cluster #3 longer-term test, the wells were shut down from October 30th to 31st, 2022 to permit groundwater level recovery. During that time, the Elora wells and Fergus well F1 were available to operate as needed to meet community demand. Active pumping during the Cluster #3 longer-term test occurred from November 1st to 3rd, 2022. Following the test, the Cluster #3 production wells were shut-off from November 4th to November 6th, 2022 to allow for recovery monitoring. During that time, the Elora wells and Fergus well F1 were available to operate as needed to meet community water demands. A summary of the Cluster #3 longer-term test scheduling and pumping rates is provided in **Table 16**.

Table 16: Cluster #3 – Longer-Term Test Summary

Cluster Number	Production Well	Well Shut-Off Period Prior to Longer-Term Test		Test Pumping Period			Well Recovery Period Following Cluster #3 Test	
		From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rate (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)
#1 – Fergus	F1	N/A[a]		2022-11-01 08:00	2022-11-04 16:00	19.2 - 19.5	N/A[c]	
	F2-R	N/A[b]		2022-11-01 08:00	2022-11-04 16:00	18.9 - 19.0	N/A[d]	
	F5-R	N/A[b]		2022-11-01 08:00	2022-11-04 16:00	18.6 - 18.8[e]	N/A[d]	
#3 – Fergus	F4	2022-10-30 08:00	2022-11-01 08:00	2022-11-01 08:00	2022-11-04 16:00	19.0 - 19.5	2022-11-04 16:00	2022-11-06 08:00
	F6	2022-10-30 08:00	2022-11-01 12:00	2022-11-01 12:00	2022-11-04 16:00	17.4 - 17.5	2022-11-04 16:00	2022-11-06 08:00
	F7	2022-10-30 08:00	2022-11-01 16:00	2022-11-01 16:00	2022-11-04 16:00	19.5	2022-11-04 16:00	2022-11-06 08:00

Notes:
a. *Prior to the Cluster #3 – Longer-Term Testing pumping period, F1 was operated normally and did not include a shut off period.*
b. *F2-R and F5-R were not in normal operation and therefore did not require a shut-off period prior to the Cluster #3 – Fergus Longer-Term Test Pumping Period.*
c. *Following the Cluster #3 – Longer-Term Testing pumping period, F1 was operated normally and did not include a shut off period.*
d. *F2-R and F5-R were shut off following the Cluster #3 – Fergus Longer-Term Test Pumping Period, since they were not in normal operation.*
e. *The F5-R pumping rate was briefly set at 19.7 L/s (approximately 1-hour duration).*

During the Cluster #3 test, AECOM staff collected manual groundwater level measurements from a subset of monitoring locations within the larger network around the two (2) Fergus well clusters. Monitoring locations associated with production wells F1, F2-R, F5-R, F4, F6 and F7 during longer-term testing of Cluster #3 are identified in **Section 3.7**. SCADA system data collected for each Fergus municipal well (including Clusters #1 and #3) were compiled on a daily basis and reviewed by AECOM's Project Hydrogeologist to evaluate the testing progress. Disturbance to private well owners in the vicinity of each pumping well was minimized by conducting monitoring of private wells exclusively with installed pressure transducers, except in instances where a well interference complaint was received, as outlined in **Section 3.9**. Following the completion of the Cluster #3 longer-term test, AECOM staff monitored aquifer recovery via manual measurements from a subset of monitoring locations within the larger network around the two (2) Fergus clusters. The data were reviewed by AECOM's Project Hydrogeologist to evaluate the recovery progress and provide regular updates to the Township.

4.2.3.1 Water Level Monitoring Results

Results of groundwater level monitoring during the Cluster #3 longer-term test are provided as hydrographs in **Figures E-4.01** to **E-4.28**. Maximum observed drawdown results for each monitoring location included in the Cluster #3 longer-term test, with the exception of the drive-point piezometers, are presented in **Figure 9**. As stated in **Section 4.2.3.1.3**, drawdown responses were not detected in any drive-point piezometer during the Cluster #3 longer-term test.

4.2.3.1.1 Municipal Well Response

Cluster #3 municipal well responses and pumping rates during the longer-term test are shown as hydrographs in **Figure E-4.01**.

During the shut-down period prior to the test, F4 recovered to 390.3 mASL. With an initial F4 pumping rate of 19.5 L/s, the pumping rate during the test was subsequently lowered on one (1) occasion, to 19.0 L/s at 55 hours elapsed test time, as the water level within F4 approached the maximum drawdown pumping level. At the conclusion of the pumping period, the water level within F4 was approaching a stabilized drawdown of 34.2 m (356.1 mASL).

During the shut-down period prior to the test, F6 recovered to 375.9 mASL. The pumping rate in F6 was maintained between 17.4 and 17.5 L/s throughout the duration of the longer-term test. At the conclusion of the pumping period, the water level within F6 was approaching a stabilized drawdown of 17.6 m (358.3 mASL).

During the shut-down period prior to the test, F7 recovered to 398.6 mASL. The pumping rate in F7 was maintained at 19.5 L/s throughout the duration of the longer-term test. At the conclusion of the pumping period, the water level within F7 was approaching a stabilized drawdown of 25.3 m (373.3 mASL).

Mutual interference drawdown due to municipal pumping was not observed at F4, F6 or F7 during the Cluster #3 longer-term test. The staggered start of F4, followed by F6 and F7, did not cause any drawdown within F6 or F7 prior to the start of pumping at those locations.

As stated previously, the Cluster #1 municipal wells were operated at estimated peak capacity during the Cluster #3 longer-term test. The Cluster #1 municipal well responses during the Cluster #3 longer-term test are shown as hydrographs in **Figure E-4.02**. No mutual interference due to the pumping of Cluster #3 longer-term test was observed in the Cluster #1 hydrographs.

4.2.3.1.2 Private Wells and Monitoring Wells Response

Private well and monitoring well responses during the Cluster #3 longer-term test are shown as hydrographs in **Figures E-4.03** to **E-4.21** as well as **Appendix F**.

Township multi-level monitoring wells MW1-12 (A, B and C), MW2-11 (A, B and C), MW3-11 (A, B and C), MW4-12 (A, B and C), MW5-11 (A and B), MW5-18(C) and MW6-12 (A, B and C) were monitored by Groundwater Science Corp. during the Cluster #3 longer-term test and are presented in hydrographs in **Appendix F**. MW1-12 and MW2-11 did not show a response to the Cluster #3 longer-term test, as these wells are located in Elora and are associated with the Elora municipal wells (i.e., Cluster #2). Drawdown and recovery of the water levels within MW1A-12 and MW2-11A during the Cluster #3 longer-term test were likely associated with localized pumping in Elora, as the pumping and recovery trends does not coincide with the Cluster #3 longer-term test pumping and recovery periods. MW3A-11 and MW3B-11 showed identical, strong groundwater level drawdown responses (3.5 m) due to municipal pumping during the Cluster #3 longer-term test. The shallow overburden well MW3C-11 showed a slight drawdown response (<1.0 m) during the test. MW4A-12 and MW4B-12 showed a strong groundwater level drawdown response, with maximum observed drawdowns of 9.0 and 4.5 m, respectively. The shallow overburden well MW4C-12 did not show a significant drawdown response to municipal pumping (<1 m). MW5A-11 showed a moderate drawdown response during the test (3.0 m). Data was not available from the Township's monitoring consultant for the intermediate well at the MW5-11 location (MW5B-11). The shallow overburden well MW5C-18 did not show a drawdown response during the test. MW6A-12 and MW6B-12 showed a moderate response to the test, with maximum observed drawdown of approximately 4.5 and 2.0 m, respectively. The shallow overburden well MW6C-12 did not show a drawdown response to the test.

The hydrographs for multi-level monitoring MW7-21 during the Cluster #3 longer-term test are provided in **Figures E-4.03, 4.04** and **4.05**. The deep monitoring well (MW7-21D) showed a strong drawdown response to municipal pumping, with a maximum drawdown of 13.9 m. The intermediate monitoring well (MW7-21I), showed a moderate drawdown response, with a maximum drawdown of 6.9 m. It is noted that MW7-21I shows cyclical recovery in response to the operation of F1. The shallow monitoring well (MW7-21S) did not show a drawdown response to municipal pumping. As noted previously, all three (3) MW7-21 wells are screened in bedrock.

During the Cluster #3 longer-term test, MW8-21 was an open corehole from 2.4 to 79.0 mBGS, with a packer installed at 16.3 mBGS, separating the shallow fractured bedrock from the deeper bedrock aquifer supplying F1. Groundwater levels were measured above and below the packer and results are presented in **Figures 4.06** and **4.07**, respectively. Only the water level monitored below the packer showed a drawdown response to testing, with a maximum observed drawdown of 9.2 m. Drawdown in MW8-21 (below packer) continued following the Cluster #3 longer-term test pumping period, due to continued pumping at F1, which is within Cluster #1 and located adjacent to MW8-21.

Private well groundwater level monitoring results during the Cluster #3 longer-term test is provided as hydrographs in **Figures E-4.08** to **E-4.14**. The seven (7) private wells monitored during the Cluster #3 longer-term test and their respective responses are summarized in **Table 17**. The maximum observed drawdown observed within a private well was 4.8 m at Well 31 (19 Burnett Court), which is located approximately 500 m east of F7.

Table 17: Summary of Private Well Response During Cluster #3 Longer-Term Test

Well Name	Associated Production Well	Completion Formation	Maximum Drawdown Observed During Test (m)
Well 28	F5-R	Unknown	0.7
Well 29	F2-R, F5-R	Unknown	0.4[a]
Well 31	F4, F6, F7	Unknown	5.6
Well 33	F2-R	Unknown	0.2
Well 36	F2-R	Bedrock	4.8
Well 37	F2-R	Bedrock	0.2
Well 38	F2-R	Bedrock	0.1

Notes: *a. Datalogger could not be installed in Well 29 due to an obstruction within the well above the static water level. Minimal manual water level measurements were recorded during the Cluster #3 longer-term test; maximum drawdown during the test was likely >0.4 m.*

Two (2) bedrock monitoring wells (MW1-22 and MW3-22) installed the Township as part of a water supply project to the north of Fergus/Elora were monitored during the Cluster #3 longer-term test, with the results being presented as hydrographs in **Figures E-4.15** and **4.16**. MW1-22 showed a delayed drawdown response of approximately 1.1 m during the test. Based on the lack of water level response in MW1-22 during the Cluster #1 longer-term test, and the delayed drawdown response observed during the Cluster #3 longer term test, it is interpreted that MW3-22 may only slightly be influenced by pumping at the Fergus municipal wells. MW3-22 did not respond to the municipal pumping during the test.

Five (5) bedrock monitoring wells (MS24A-94S, MS46A-00S, MS46A-00I, MS47A-01S and MS47A-01I) at the A.O. Smith site in Fergus were monitored during the Cluster #1 longer-term test, with the results being presented as hydrographs in **Figures E-4.17** to **E-4.21**. The five (5) monitoring wells did not show any drawdown response to municipal pumping during the test.

4.2.3.1.3 Surface Water Features

Groundwater level monitoring results for the drive-point piezometers during the Cluster #3 longer-term test are shown as hydrographs in **Figures E-4.22** to **E-4.28**.

The drive-point piezometers installed in Swan Creek (Swan 1, 2 and 3) and Irvine Creek (Irvine 2, 3 and 4) did not show any drawdown responses to the Cluster #3 longer-term pumping test. It is noted that the drive-point piezometer at Irvine 1 was damaged and the datalogger could not be recovered. As a result, only manual readings are available for this monitoring location. The minimal manual readings recorded at Irvine 1 during the Cluster #3 longer-term pumping test are insufficient to confirm whether drawdown occurred in the shallow groundwater at this location; however, based on the lack of response in the other three (3) Irvine drive-point piezometers, it is considered unlikely that drawdown occurred at Irvine 1 during the test.

4.2.3.2 Well Complaints

No well complaints were received by the Township during the Cluster #3 longer-term test.

4.3 Additional Elora Testing

4.3.1 E1 Step Test

In advance of the E1 step test, shut down of pumping activities at E1 and E3 occurred from April 24th to 25th, 2023 (a duration of >24 hours). E3 remained offline for the duration of the E1 step test (except for the E1 post step-testing recovery period which overlapped with the E3 step test pumping period) to minimize the effects of mutual well interference. E4 was operated normally during the E1 step test to meet water demands in Elora. During step testing, water level data was collected at the Cluster #2 private wells in addition to each of the three (3) Cluster #2 production wells. Based on a review of local aquifer response to historical pumping as well as the results from the short-term testing and longer term testing previously conducted for Cluster #2 (**Sections 4.1** and **4.2.2**), testing of E1 included three (3) progressively increasing rate steps, extending four (4) hours each in duration (no recovery between rate steps). The selected rates targeted a potential sustainable maximum pumping rate, while minimizing interference drawdown in nearby private wells, which was identified as an issue in Elora during the fall 2022 Cluster #2 testing.

Upon conclusion of the final rate step, a 24-hour recovery period occurred to allow for monitoring of well/aquifer recovery. At the end of the 24-hour recovery period, all measured private well interference drawdown had recovered by >90%.

Detailed scheduling information for the step testing of E1 is provided in **Table 18**.

Table 18: E1 - Step Test Summary

Clust.	Well	Well Shut-Off Period Prior to Step Test		Step #1 Pumping Period			Step #2 Pumping Period			Step #3 Pumping Period			Well Shut-Off Period Following Step Test[a]	
		From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rate (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rate (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rate (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)
#2 - Elora	E1	2023-04-24 00:10	2023-04-25 08:00	2023-04-25 08:00	2023-04-25 12:00	12.0	2023-04-25 12:00	2023-04-25 16:00	16.0	2023-04-25 16:00	2023-04-25 20:00	20.0	2023-04-25 20:00	2023-04-26 20:00
	E3	2023-04-24 01:55	2023-04-25 08:00	2023-04-25 08:00	2023-04-25 12:00	0.0	2023-04-25 12:00	2023-04-25 16:00	0.0	2023-04-25 16:00	2023-04-25 20:00	0.0	2023-04-25 20:00	2023-04-26 08:00
	E4	NA[a]												

Notes: a. E4 was operated normally during the E1 step test.

In order to maintain the proposed schedule, SCADA system data collected during the E1 step test, including flow rates, water level measurements (i.e., every 5 minutes), and well level drawdown, were transferred from the Township to AECOM on the day following the conclusion of the test (i.e., April 26th, 2023).

During the E1 step test, AECOM staff collected frequent manual groundwater level measurements at each monitored private well location, and the readings were provided to AECOM's Project Hydrogeologist as they were obtained. Following the completion of the step-test, AECOM staff monitored aquifer recovery via manual measurements from a subset of monitoring locations within the larger network around the Elora cluster. The data were reviewed by AECOM's Project Hydrogeologist to evaluate the recovery progress and provide regular updates to the Township.

Following completion of the E1 step test, AECOM reviewed data collected at each of the monitored private wells to identify estimated rates at which the wellfield can be operated while not causing adverse interference drawdown during the additional, longer-term test.

4.3.1.1 Water Level Monitoring Results

Groundwater level monitoring results during the E1 step test are provided as hydrographs in **Figures E-5.01** to **E-5.20**.

4.3.1.1.1 Municipal Well Response

Municipal well responses and pumping rates during the E1 step test are shown as hydrographs in **Figure E-5.01**.

At the conclusion of the shut-down period prior to the step test, E1 recovered to 376.1 mASL. The E1 pumping rate steps were set at 12.0, 16.0 and 20.0 L/s, with corresponding increased drawdown during each step, and a maximum drawdown pumping level of 21.4 m (354.7 mASL). The municipal well response indicated that E1 was capable of pumping at a rate greater than 20 L/s for the longer-term pumping test. As mentioned previously, the limiting factor for the target pumping rate of the Elora longer-term testing is the extent of interference drawdown experienced between municipal wells and by nearby private wells, as discussed in **Section 4.3.1.1.2**.

Well interference due to step testing at E1 was observed in E3, with a temporary reversal of the recovery trend in E3 over the E1 step testing period. E4 was in operation during the E1 step test, with no indication of interference occurring between the two wells.

4.3.1.1.2 Private Wells and Monitoring Wells Response

Private well and monitoring well response during the E1 step test are shown as hydrographs in **Figures E-5.02** to **E-5.17**.

Township multi-level monitoring wells MW1-12 (A, B and C) and MW2-11 (A, B and C) were monitored during the E1 step test and are presented in hydrographs in **Figures E-5.02** to **E-5.07**. The deep bedrock well MW1A-12 showed a recovery trend coinciding with the shut-off period of E1 and E3 prior to the step test, as well as a temporary reversal of the recovery trend coinciding with the pumping period during the E1 step test. MW1B-12 and MW1C-12 did not show a drawdown response to the E1 step test.

The intermediate bedrock well MW2-11B showed a recovery trend coinciding with the shut-off period of E1 and E3 prior to the step test, as well as a temporary reversal of the recovery trend coinciding with the pumping period during the E1 step test. MW2-11C did not show a drawdown response to the E1 step test. MW2A-11 was monitored during the test but was not functioning properly and the resulting water levels have not been used to provide interpretation or draw conclusions about the local aquifer response to municipal pumping.

Private well groundwater level monitoring results during the E1 step test are provided as hydrographs in **Figures E-5.08** to **E-5.13**. The six (6) private wells monitored during the E1 step test and their responses to municipal pumping are summarized in **Table 19**. The maximum drawdown at a private well during the E3 step test was 0.3 m, as observed at both Well 40 (148 Wellington Road 7) and Well 43 (308 Erb Street), located approximately 2 km to the south of E1 and 240 m to the west of E1, respectively.

Table 19: Summary of Private Well Response During the E1 Step Test

Well Name	Associated Production Well	Completion Formation	Maximum Drawdown Observed During Test (m)
Well 14	E3	Unknown	0
Well 15	E3, E4	Unknown	0
Well 19	E4	Unknown	0[a]
Well 34	E1	Multiple[b]	N/A[c]
Well 40	E3, E4	Bedrock	0.3[d]
Well 43	E1	Unknown	0.3[d]

Notes: *a. Drawdown observed during the E1 step test is likely attributable to pumping at E4.*
b. Open hole bedrock well likely open to Goat Island/Gasport FMs based on depth and Bedrock Materials described on well record.
c. Water level fluctuations in hydrograph likely due to local, private well pumping. Note that recovery in Well 34 occurs prior to the end of the pumping period of the E1 step test.
d. Small fluctuations in the water levels within Well 40 and Well 43 during the E1 step test indicate response to localized pumping in addition to the interference drawdown likely caused by the E1 step test. Maximum drawdown estimations exclude the large, intermittent water level decreases attributed to localized pumping.
Well 21 was not included in the Additional Elora Testing at the request of the well owner.
Well 39 was not included in the Additional Elora Testing due to data not being provided by the well owner. The well is currently monitored by another consultant as part of a long-term monitoring program.

Two (2) bedrock monitoring wells (MW2-22 and MW3-22) installed the Township as part of a water supply project to the north of Elora were monitored during the E1 step test, with the results being presented as hydrographs in **Figures E-5.14** and **5.15**. Neither of the two (2) monitoring wells showed any drawdown response to municipal pumping during the test.

Two (2) research bedrock monitoring wells (ELR1-R2 and ELR2-R2) were monitored by the University of Guelph during the E1 step test, with the results being presented as hydrographs in **Figures E-5.16** and **E-5.17**. Neither ELR1-R2 or ELR2-R2 showed any drawdown response to municipal pumping during the test.

4.3.1.1.3 Surface Water Features

Groundwater level monitoring results for the drive-point piezometers during the E1 step test are shown as hydrographs in **Figures E-5.18** to **E-5.21**.

The drive-point piezometers installed in Swan Creek (Swan 1, 2 and 3) and Irvine Creek (Irvine 3) did not show any drawdown responses to the E1 step test. It is noted that the drive-point piezometer at Swan 3 was tampered with during/following the testing, and the transducer equipped with datalogger could not be recovered. As a result, only one (1) manual reading was recorded at this location during the E1 step test. However, based on the lack of response at Swan 3 during the fall 2022 Cluster #2 testing, it is considered unlikely that the E1 step test caused a drawdown response in surface water levels at Swan 3.

4.3.1.2 Well Complaints

No well complaints were received by the Township during the E1 step test.

4.3.1.3 Recommendations for Longer-term Test

Following completion of the E1 step test, AECOM reviewed data collected at each of the monitored private wells to identify the estimated rate at which E1 can be sustainably operated without causing adverse interference with local private wells.

Based on E1 having a sustainable pumping rate of at least 20.0 L/s and the minimal private well interference drawdown response observed during the E1 step test, this rate was identified as being appropriate for the longer-term test.

Based on the recovery response in E1 prior to the step test, it was recommended that 24 hours be allotted as the recovery period for E1 prior to the longer-term test.

4.3.2 E3 Step Test

In advance the E3 step test, the well was shut down from April 24th to 26th, 2023 (a duration of >48 hours). This shutoff period overlaps with both the pre-test, step testing and post-test period for the E1 step test. E1 was shut off following the E1 step test and remained off until the conclusion of the E3 step test. E4 was operated normally during the E3 step test to supply system demand. During step testing, data was collected at the Cluster #2 private wells and monitoring wells, in addition to each of the three (3) Cluster #2 production wells. Based on a review of local aquifer response to historical pumping as well as the results from the short-term testing and longer term testing previously conducted for Cluster #2 (**Sections 4.1** and **4.2.2**), testing of E3 included three (3) progressively increasing rate steps, extending four (4) hours each in duration (no recovery between rate steps).

Upon conclusion of the final step, a 48-hour recovery period occurred to allow for monitoring of well/aquifer recovery. At the end of the 48-hour recovery period, all measured private well interference drawdown had recovered by >90%.

Detailed scheduling information for the E3 step test is provided in **Table 20**.

Table 20: E3 - Step Test Summary

Clust.	Well	Well Shut-Off Period Prior to Step Test		Step #1 Pumping Period			Step #2 Pumping Period			Step #3 Pumping Period			Well Shut-Off Period Following Step Test	
		From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rat. (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rat. (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rat. (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)
#2 - Elora	E1	2023-04-25 20:00	2023-04-26 08:00	2023-04-26 08:00	2023-04-26 12:00	0.0	2023-04-26 12:00	2023-04-26 16:00	0.0	2023-04-26 16:00	2023-04-26 20:00	0.0	N/A[a]	
	E3	2023-04-24 02:00	2023-04-26 08:00	2023-04-26 08:00	2023-04-26 12:00	12.5	2023-04-26 12:00	2023-04-26 16:00	16.0	2023-04-26 16:00	2023-04-26 20:00	21.0	2023-04-26 20:00	2023-04-28 20:00
	E4	N/A[b]												

Notes: *a. E1 was operated normally following the third step.*
b. E4 was operated normally during the E3 step test.

In order to maintain the proposed schedule, SCADA system data collected during the E3 step test, including flow rates, water level measurements (i.e., every 5 minutes), and well level drawdown, were transferred from the Township to AECOM on the day following the conclusion of the test (i.e., April 29th, 2023).

During the E3 step test, AECOM staff collected frequent manual groundwater level measurements at each monitored private well location, and the readings were provided to AECOM's Project Hydrogeologist as they were obtained. Following the completion of the step-test, AECOM staff monitored aquifer recovery via manual measurements from a subset of monitoring locations within the larger network around the Elora cluster. The data were reviewed by AECOM's Project Hydrogeologist to evaluate the recovery progress and provide regular updates to the Township.

Following completion of the E3 step test, AECOM reviewed data collected at each of the monitored private wells to identify estimated rates at which the wellfield can be operated while not causing adverse interference drawdown during the additional, longer-term test.

4.3.2.1 Water Level Monitoring Results

Groundwater level monitoring results during the E3 step test are provided as hydrographs in **Figures E-5.01** to **E-5.21**.

4.3.2.1.1 Municipal Well Response

Municipal well responses and pumping rates during the E3 step test are shown as hydrographs in **Figure E-5.01**.

At the conclusion of the shut-down period prior to the step test, E3 recovered to 374.3 mASL. The E3 pumping rate steps were set at 12.5, 16.0 and 21.0 L/s, with corresponding increased drawdown during each step, and a maximum drawdown pumping level of 7.7 m (366.6 mASL). The municipal well response indicated that E3 was capable of sustainably pumping at a rate greater than 21.0 L/s for the longer-term pumping test. As mentioned previously, the limiting factor for the target pumping rate of the Elora longer-term testing is the extent of interference drawdown experienced by nearby to private wells (**Section 4.3.1.1.2**).

Well drawdown interference due to step testing at E3 was observed in E1, with a temporary reversal of the recovery trend in E1 over the E3 step testing period.

4.3.2.1.2 Private Wells and Monitoring Wells Response

Private well and monitoring well response during the E3 step test are shown as hydrographs in **Figures E-5.02** to **E-5.17**.

Township multi-level monitoring wells MW1-12 (A, B and C) and MW2-11 (A, B and C) were monitored during the E3 step test and are presented in hydrographs in **Figures E-5.02** to **E-5.07**. The deep bedrock well MW1A-12 showed interference drawdown of 0.5 m during the E3 step test. MW1B-12 and MW1C-12 did not show a response to the test. MW2-11B and MW2-11C did not respond to the test.

Private well groundwater level monitoring results during the E3 step test are provided as hydrographs in **Figures E-5.08** to **E-5.13**. The six (6) private wells monitored during the test and their responses to municipal pumping are summarized in **Table 21**. The maximum observed drawdown at a private well during the test was 1.5 m, as observed at Well 40 (148 Wellington Road 7), located approximately 610 m west of E3.

Table 21: Summary of Private Well Response During the E3 Step Test

Well Name	Associated Production Well	Completion Formation	Maximum Drawdown Observed During Test (m)
Well 14	E3	Unknown	0.3
Well 15	E3, E4	Unknown	0
Well 19	E4	Unknown	N/A[a]
Well 34	E1	Multiple[b]	N/A[c]
Well 40	E3, E4	Bedrock	1.5[d]
Well 43	E1	Unknown	0

Notes:
a. Drawdown observed during the E3 step test is likely attributable to pumping at E4.
b. Open hole bedrock well likely open to Goat Island/Gasport FMs based on depth and Bedrock Materials described on well record.
c. Water level fluctuations in hydrograph likely due to local, private well pumping. Note that the minor drawdown/recovery trend in Well 34 does not coincide with E3 operation.
d. Small fluctuations in the water levels within Well 40 and Well 43 during the E3 step test indicate response to localized pumping in addition to the interference drawdown likely caused by the E3 step test. Maximum drawdown estimations exclude the large, intermittent water level decreases attributed to localized pumping.
Well 21 was not included in the Additional Elora Testing at the request of the well owner.
Well 39 was not included in the Additional Elora Testing due to data not being provided by the well owner. The well is currently monitored by another consultant as part of a long-term monitoring program.

Two (2) bedrock monitoring wells (MW2-22 and MW3-22) were monitored during the E3 step test, with the results being presented as hydrographs in **Figures E-5.14** and **5.15**. Neither of the two (2) monitoring wells showed any drawdown response to the test.

Two (2) research bedrock monitoring wells (ELR1-R2 and ELR2-R2) were monitored by the University of Guelph during the E3 step test, with the results being presented as hydrographs in **Figures E-5.16** and **E-5.17**. Neither ELR1-R2 or ELR2-R2 showed any drawdown response to the test.

4.3.2.1.3 Surface Water Features

Groundwater level monitoring results for the drive-point piezometers during the E3 step test are shown as hydrographs in **Figures E-5.18** to **E-5.21**.

The drive-point piezometers installed in Swan Creek (Swan 1 and 2) and Irvine Creek (Irvine 3) did not show any drawdown responses to the E3 step test. It is noted that the drive-point piezometer at Swan 3 was tampered with during/following the testing, and the transducer equipped with datalogger could not be recovered. As a result, only one (1) manual reading was recorded at this location during the E3 step test. However, based on the lack of response at Swan 3 during the fall 2022 Cluster #2 testing, it is considered unlikely that the E3 step test caused a drawdown response in surface water levels at Swan 3.

4.3.2.2 Well Complaints

No well complaints were received by the Township during the E3 step testing.

4.3.2.3 Recommendations for Longer-term Test

Following completion of the E3 step test, AECOM reviewed data collected at each of the monitored private wells to identify the estimated rate at which the E3 can be operated while not causing adverse interference drawdown during the longer-term test.

E3 was determined to have a sustainable pumping rate of 21.0 L/s during step testing. However, non-stabilized well interference drawdown observed in the Hill Street area (i.e., Well 40) of approximately 1.5 m at the end of the step test indicated that the pumping rate should be reduced during the longer-term test. A target pumping rate of 15.5 L/s was chosen for E3 for the longer-term test to reduce the interference drawdown locally within the aquifer.

Based on the recovery response in E3 prior to the step test, it was recommended that 48 hours be allotted as the recovery period for E3 prior to the longer-term test.

4.3.3 E4 Step Test

In advance of the E4 step test, shut down of pumping activities at E3 and E4 wells occurred from April 19th to 20th, 2023 (a duration of >24 hours). E3 remained offline for the duration of the E4 step test to minimize the effects of well interference; and E1 was operated normally during the E4 step test to service system demand. During the step test, water level data was collected at the Cluster #2 private wells in addition to each of the three (3) Cluster #2 production wells. Based on a review of local aquifer response to historical pumping as well as the results from the short-term testing and longer-term testing previously conducted for Cluster #2 (**Sections 4.1** and **4.2.2**), step testing of E4 comprised of three (3) progressively increasing rate steps, extending four (4) hours each in duration (no recovery between rate steps).

Upon conclusion of the final step, a recovery period of greater than 1-day was provided to allow for monitoring of well/aquifer recovery. At the end of the recovery period, all measured private well interference drawdown had recovered by >90%.

Detailed scheduling information for the E4 step test is provided in **Table 22**.

Table 22: E4 – Step Test Summary

Clust.	Well	Well Shut-Off Period Prior to Step Test		Step #1 Pumping Period			Step #2 Pumping Period			Step #3 Pumping Period			Well Shut-Off Period Following Step Test[a]	
		From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rate (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rate (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rate (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)
#2 – Elora	E1	N/A[a]												
	E3	2023-04-19 08:00	2023-04-20 08:00	2023-04-20 08:00	2023-04-20 12:00	0.0	2023-04-20 12:00	2023-04-20 16:00	0.0	2023-04-20 16:00	2023-04-20 20:00	0.0	2023-04-20 20:00	2023-04-21 20:20
	E4	2023-04-19 00:00	2023-04-20 08:00	2023-04-20 08:00	2023-04-20 12:00	12.0	2023-04-20 12:00	2023-04-20 16:00	17.0	2023-04-20 16:00	2023-04-20 20:00	22.0	2023-04-20 20:00	2023-04-24 13:15

Notes: *a. E1 was operated normally during the E4 step test.*

In order to maintain the proposed schedule, SCADA system data collected during the E4 step test, including flow rates, water level measurements (i.e., every 5 minutes), and well level drawdown, were transferred from the Township to AECOM on the day following the conclusion of the test (i.e., April 25th, 2023).

During the E4 step test, AECOM staff collected frequent manual groundwater level measurements at each monitored private well location, and the readings were provided to AECOM's Project Hydrogeologist as they were obtained. Following the completion of the step-test, AECOM staff monitored aquifer recovery via manual measurements from a subset of monitoring locations within the larger network around the Elora cluster. The data were reviewed by AECOM's Project Hydrogeologist to evaluate the recovery progress and provide regular updates to the Township.

Following completion of the E4 step test, AECOM reviewed data collected at each of the monitored private wells to identify estimated rates at which the wellfield can be operated while not causing adverse interference drawdown during the additional, longer-term test.

4.3.3.1 Water Level Monitoring Results

Groundwater level monitoring results during the E4 step test are provided as hydrographs in **Figures E-5.01** to **E-5.21**.

4.3.3.1.1 Municipal Well Response

Municipal well responses and pumping rates during the E4 step test are shown as hydrographs in **Figure E-5.01**.

Based on manual groundwater level measurement, E4 recovered to 375.65 mASL on April 19th, 2023 at 3:00 p.m., approximately 15 hours after E4 was shut off, and 17 hours prior to the start of the E4 step test (April 20th at 8:00 a.m.). SCADA measurements of the groundwater level in E4 were not available leading up to the step test due to a malfunction in the datalogger. The E4 pumping rate steps were set at 12, 17, and 22 L/s, with corresponding increased drawdown during each step, and a maximum drawdown pumping level of 359.37 mASL (>16.3 m based on the non-static water level recorded on April 19th, 2023). The municipal well response indicated that E4 was capable of sustainably operating at a rate greater than 22 L/s for the proposed longer-term pumping test. As mentioned previously, the limiting factor for the target rate of the Elora longer-term testing is the extent of interference drawdown experienced by nearby to private wells (**Section 4.3.1.1.2**).

Well interference due to the E4 step test was not observed in E3. E1 was operating during the test but did not show a drawdown response to the E4 step test.

4.3.3.1.2 Private Wells and Monitoring Wells Response

Private well and monitoring well responses during the E4 step test are shown as hydrographs in **Figures E-5.02** to **E-5.17**.

Township multi-level monitoring wells MW1-12 (A, B and C) and MW2-11 (A, B and C) were monitored during the E4 step test and are presented as hydrographs in **Figures E-5.02** to **E-5.07**. Multi-level monitoring wells MW1-12 (A, B and C) and MW2-11 (B and C) did not show a significant drawdown response to the E4 step test.

The private well groundwater level monitoring results during the E4 step test are provided as hydrographs in **Figures E-5.08** to **E-5.12**. The five (5) private wells monitored during the E4 step test and their drawdown responses to municipal pumping are summarized in **Table 23**. Some decrease in the groundwater recovery trend at Well 40 during the E4 step test can likely be attributed to the pumping at E4. As noted in **Section 4.3.2.1.2**, Well 40 is highly influenced by the pumping at E3, which was inactive over this period.

Table 23: Summary of Private Well Response During the E4 Step Test

Well Name	Associated Production Well	Completion Formation	Maximum Drawdown Observed During Test (m)
Well 14	E3	Unknown	0
Well 15	E3, E4	Unknown	0
Well 19	E4	Unknown	0
Well 34	E1	Multiple[a]	N/A[b]
Well 40	E3, E4	Bedrock	0

Notes: *a. Open hole bedrock well likely open to Goat Island/Gasport FMs based on depth and Bedrock Materials described on well record.*

b. Water level fluctuations in hydrograph likely due to local, private well pumping. Note that recovery in Well 34 occurs prior to the end of the pumping period of the E4 step test.

Well 39 was not included in the Additional Elora Testing due to data not being provided by the well owner. The well is currently monitored by another consultant as part of gravel pit operations.

Well 43 was not included in the E4 step test monitoring since permission to monitor this private well was granted following the E4 step test, and prior to the E1 and E3 step tests.

Two (2) bedrock monitoring wells (MW2-22 and MW3-22) were monitored during the E4 step test, with the results being presented as hydrographs in **Figures E-5.14** and **5.15**. Neither of the two (2) monitoring wells showed any drawdown response to municipal pumping during the test.

Two (2) research bedrock monitoring wells (ELR1-R2 and ELR2-R2) were monitored by the University of Guelph during the E4 step test, with the results being presented as hydrographs in **Figures E-5.16** and **E-5.17**. ELR1-R2 showed strong drawdown response to the E4 step test pumping (1.5 m). ELR2-R2 did not show any drawdown response to municipal pumping during the test.

4.3.3.1.3 Surface Water Features

Groundwater level monitoring results for the drive-point piezometers during the E4 step test are shown as hydrographs in **Figures E-5.18** to **E-5.21**.

The drive-point piezometers installed in Swan Creek (Swan 1 and 2) and Irvine Creek (Irvine 3) did not show any drawdown responses to the E4 step test. It is noted that the drive-point piezometer at Swan 3 was tampered with during/following the testing, and the transducer equipped with datalogger could not be recovered. As a result, only one (1) manual reading was recorded at this location during the E4 step test. However, based on the lack of response at Swan 3 during the fall 2022 Cluster #2 testing, it is considered unlikely that the E4 step test caused a drawdown response in surface water levels at Swan 3.

4.3.3.2 Well Complaints

No well complaints were received by the Township during the E4 step testing.

4.3.3.3 Recommendations for Longer-term Test

Following completion of the E4 step test, AECOM reviewed data collected at each of the monitored private wells to identify the estimated rate at which the E4 can be operated while not causing adverse interference drawdown during the longer-term test.

Based on E4 having a sustainable pumping rate of 22 L/s and the minimal private well interference drawdown observed during the step test, the recommended target pumping rate for E4 during the longer-term test was 22 L/s.

4.3.4 Longer-Term Testing

Longer-term constant rate testing was performed on Cluster #2 wells E1, E3 and E4 from May 3rd to May 6th, 2023 to evaluate the maximum capacity of the Elora wellfield without adversely impacting local private wells. In advance of the longer-term test, shut down of pumping activities at wells E1 and E4 occurred from May 2nd to 3rd, 2023, and at well E3 from May 1st to 3rd, 2023. Pumping rates recommended for E1, E3 and E4 were based on the results from the short-term testing and longer term testing previously conducted for Cluster #2 (**Sections 4.1** and **4.2.2**), in addition to the results of the step testing (**Sections 4.3.1**, **4.3.2**, and **4.3.3**).

On May 3rd, 2023, pumping of the Elora wells commenced simultaneously, as outlined below. The pumping duration ranged from 24-hours (E1) to 72-hours (E3 and E4). During the longer-term test, AECOM staff collected manual groundwater level measurements from a subset of monitoring locations within the larger network around the Elora well cluster, including the private well locations identified in **Section 3.5.3**. SCADA system data collected for each Elora municipal well were compiled on a daily basis and reviewed by AECOM's Project Hydrogeologist to evaluate the testing progress.

Production well E1 was shut-off during the longer-term pumping test on April 4th, 2023 in order to observe the local aquifer response to simultaneously pumping E3 and E4, independent of E1. Production wells E3 and E4 were shut-off from April 6th to 8th, 2023 to allow for recovery monitoring following conclusion of the longer-term pumping test.

Detailed scheduling information for the longer-term test is provided below in **Table 24**.

Table 24: Additional Elora Testing (Cluster #2) – Longer-term Testing Summary

Cluster Number	Production Well	Well Shut-Off Period Prior to Cluster #2 Longer-Term Test		Cluster #2 Longer-Term Test Pumping Period			Well Shut-Off Period Following Cluster #1 Longer-Term Test	
		From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)	Rate (L/s)	From (YYYY-MM-DD; HH:mm)	To (YYYY-MM-DD; HH:mm)
#2 – Elora	E1	2023-05-01 21:15	2023-05-03 08:00	2023-05-03 08:00	2023-05-04 08:00	20.0	2023-05-04 08:00	2023-05-06 08:00
	E3	2023-05-01 02:20	2023-05-03 08:00	2023-05-03 08:00	2023-05-06 08:00	15.5	2023-05-06 08:00	2023-05-08 07:00
	E4	2023-05-02 03:50	2023-05-03 08:10	2023-05-03 08:10	2023-05-06 08:00	22.0	2023-05-06 08:00	2023-05-08 07:00

Following the completion of the Additional Elora longer-term test, AECOM staff monitored aquifer recovery via manual measurements from a subset of monitoring locations within the larger network around Cluster #2. The data were reviewed by AECOM's Project Hydrogeologist to evaluate the recovery progress and provide regular updates to the Township.

4.3.4.1 Water Level Monitoring Results

Groundwater level monitoring results during the Cluster #2 longer-term test are provided as hydrographs in **Figures E-6.01** to **E-6.20**. Maximum observed drawdown results for each monitoring location included in the Cluster #2 longer-term test, with the exception of the drive-point piezometers, are presented in **Figure 8**. As stated in **Section 4.3.1.1.3**, drawdown responses were not detected in any drive-point piezometer during the Cluster #2 longer-term test.

4.3.4.1.1 Municipal Well Response

Municipal well responses and pumping rates during the Cluster #2 longer-term test are shown as hydrographs in **Figure E-6.01**.

At the conclusion of the shut-down period prior to the test, E1 recovered to 377.8 mASL. Following a pumping duration of 24 hours at a rate of 20.0 L/s, the water level within E1 was approaching a stabilized drawdown of 27.1 m (350.6 mASL). Mutual interference between E1 and E3 was evident in the pumping/drawdown data from April 6th to 8th, when E3 and E4 were shut down. During this period, drawdown in E1 stabilized at approximately 350 mASL.

At the conclusion of the shut-down period prior to the test, E3 recovered to 375.8 mASL. Following a pumping duration of 48 hours at a rate of 15.5 L/s, the water level within E3 stabilized at a drawdown of 11.4 m (364.4 mASL). Stabilization of the E3 water level coincides with the shutdown of E1, further demonstrating the hydraulic connection between E1 and E3.

At the conclusion of the shut-down period prior to the test, E4 recovered to 376.5 mASL. Following a pumping duration of 48 hours at a rate of 22.0 L/s, the water level within E4 stabilized at a drawdown of 24.2 m (352.3 mASL). E4 did not respond to the shutdown of E1 at 24 hours elapsed time.

4.3.4.1.2 Private Wells and Monitoring Wells Response

Private well and monitoring well response during the longer-term test are shown as hydrographs in **Figures E-6.02** to **E-6.19**.

Township multi-level monitoring wells MW1-12 (A, B and C) and MW2-11 (A, B and C) were monitored during the test and are presented as hydrographs in **Figures E-6.02** to **E-6.07**. The deep bedrock well MW1A-12 showed a drawdown response of 3.9 m during the longer-term test, that included an inflection related to the shut-down of E1. MW1B-12 and MW1C-12 did not show an apparent response to the longer-term test. The intermediate bedrock well MW2-11B showed a drawdown response of 0.9 m at the conclusion of the E1 component of the longer-term test; MW2-11B subsequently showed recovery following the E1 shutoff at 24 hours elapsed time. MW2-11C did not show a drawdown response to the E1 step test. As with the step test portion of the additional Elora testing, MW2A-11 was monitored during the longer-term test but was not functioning properly and the resulting water levels have not been used to provide interpretation or draw conclusions about the local aquifer response to municipal pumping.

Private well groundwater level monitoring results during the longer-term test are provided as hydrographs in **Figures E-6.08** to **E-6.13**. The six (6) private wells monitored during the longer-term test and their responses to municipal pumping are summarized in **Table 25**. The maximum observed drawdown at a private well during the longer-term test was 8.1 m, as observed at Well 40 (148 Wellington Road 7), located approximately 610 m west of E3. Well 40 presented a noticeable decrease in the rate of drawdown following shutoff of E1 at 24-hour elapsed time. The observed drawdown in Well 40 at the conclusion of the test had not stabilized and would likely have continued to develop should the test duration had been longer. Well 43 showed water level recovery following the shutoff of E1 at 24-hour elapsed time and does not appear to be affected by the pumping of E3 or E4.

Table 25: Summary of Private Well Response During the Longer-term Test

Well Name	Associated Production Well	Completion Formation	Maximum Drawdown Observed During Test (m)
Well 14	E3	Unknown	1.1
Well 15	E3, E4	Unknown	1.0
Well 19	E4	Unknown	2.4
Well 34	E1	Multiple[a]	0[b]
Well 40	E3, E4	Bedrock	8.1[c]
Well 43	E1	Unknown	0.7[c]

Notes: *a. Open hole bedrock well likely open to Goat Island/Gasport FMs based on depth and Bedrock Materials described on well record.*
b. Water level fluctuations in hydrograph likely due to local, private well pumping.
c. Small fluctuations in the water levels within Well 14, Well 40 and Well 43 during the longer-term test indicate response to localized pumping in addition to the observed interference drawdown. Maximum drawdown estimations exclude the large, intermittent water level decreases attributed to localized pumping.
Well 21 was not included in the Additional Elora Testing at the request of the well owner.
Well 39 was not included in the Additional Elora Testing due to data not being provided by the well owner. The well is currently monitored by another consultant as part of gravel pit operations.

Two (2) bedrock monitoring wells (MW2-22 and MW3-22) were monitored during the longer-term test, with the results being presented as hydrographs in **Figures E-6.14** and **6.15**. Neither of the two (2) monitoring wells indicated a drawdown response during the test.

Two (2) research bedrock monitoring wells (ELR1-R2 and ELR2-R2) were monitored by the University of Guelph during the longer-term test, with the results being presented as hydrographs in **Figures E-6.16** and **E-6.17**. ELR1-R2 showed strong drawdown response to the longer-term test (5.9 m). ELR2-R2 did not show any drawdown response to municipal pumping during the test.

4.3.4.1.3 Surface Water Features

Groundwater level monitoring results for the drive-point piezometers during the longer-term test are shown as hydrographs in **Figures E-6.18** to **E-6.20**.

The drive-point piezometers installed in Swan Creek (Swan 1 and 2) and Irvine Creek (Irvine 3) did not show any drawdown responses to the longer-term test. It is noted that the drive-point piezometer at Swan 3 was tampered with during/following the testing, and the transducer equipped with datalogger could not be recovered. As a result, no manual readings were recorded at this location during the longer-term test. However, based on the lack of response at Swan 3 during the fall 2022 Cluster #2 testing, it is considered unlikely that the longer-term test caused a drawdown response in surface water levels at Swan 3.

4.3.4.2 Well Complaints

No well complaints were received by the Township during the Cluster #2 longer-term test.

5. Data Analysis

5.1 Maximum Pumping Water Levels

Maximum pumping water levels were assessed for each of the Township's municipal wells based on a review of available information regarding the current well configurations. A summary of the identified maximum pumping water levels is presented in **Table 26**, with comments for adjustments in comparison to levels included in the Township's Water Supply Master Plan (AECOM, 2019). Adjustments to the maximum pumping levels in **Table 26** were also considered in the numerical groundwater flow model analysis completed by Matrix.

Table 26: Summary of Revised Maximum Pumping Levels

Well Name	Water Supply Master Plan Maximum Pumping Water Level (mASL)	Maximum Pumping Water Level (mASL)	Comments
E1	338	338	No change, pump depth restricted by well diameter reduction.
E3	348	323	Revised set point based on maximum practical pump depth (76 mbgs) + 5 m.
E4	325	314	Revised set point based on maximum practical pump depth (76 mbgs) + 5 m.
F1	345	345	No change, well impacted by TCE. Inducing higher hydraulic gradient not recommended.
F2-R	370	350	Main water bearing fracture is at 341.8 mASL.
F4	352	344	Well has deep casing, set point is base of casing elevation.
F5-R	350	365	Base of casing is 365 mASL.
F6	378	353	Current pump setting + 5 m.
F7	355	355	No change, current pump setting + 5 m.

5.2 Long Term Drawdown Analysis

Sustainability of pumping the municipal production wells at the tested rates for a period of 20 years was evaluated using graphical analysis. Assessment of well Cluster #1 and Cluster #3 utilized data collected during the fall 2022 longer-term tests, while the assessment of Cluster #2 utilized data collected during longer-term testing completed both in fall 2022 and spring 2023.

The extrapolated 20-year drawdown curves represent a "worst-case" scenario of aquifer stress over the period, considering a constant pumping rate and duration, with no influence due to seasonal recharge effects or regular cycling of the municipal wells as which occurs on a daily basis during normal operations.

5.2.1 Cluster #1 – Fergus

Results of the analysis completed for Cluster #1 are presented as an elapsed time versus drawdown, semi-log plot in **Figure G-1**. Groundwater level monitoring data for private wells 31 and 36 were also plotted and extended for a 20-year pumping period to reflect potential drawdown in nearby private wells screened within the target aquifer. These data are presented in **Figure G-3**. As the magnitude of drawdown in the private wells was greater during the Cluster #3 test it therefore is considered to be a conservative assessment. Specific construction details are not available for many of the private wells included in the WFCA program. The assessment was therefore conducted by assuming that private wells which demonstrated a strong response to the test pumping were completed to at least midway through the Guelph Formation. The local midway depth of the formation was estimated from regional

geologic cross-sections (**Appendix B**). To estimate the available drawdown within each private well, the field measured static water level prior to the test was compared to the estimated well depth and a 5-metre buffer was included to allow for placement of the well pump and regular domestic operation.

The longer-term test at Cluster #1 was conducted with simultaneous pumping of Clusters #1 and #3 at maximum rates. Therefore, the 20-year extrapolations of drawdown due to continuous pumping include potential pumping influence from the pumping of all six (6) Fergus municipal wells. Results are summarized in **Table 27**.

Table 27: Cluster #1 Long Term Drawdown Extrapolation Summary

Well Name	Cluster #1 Test Pumping Rate (L/s)	Max. Pumping Level (mASL / mBGS)[b]	Static Water Level (mASL / mBGS)[b]	Available Drawdown (m)	Cluster #1 Longer-Term Test Drawdown (80-hour elapsed time)[a]			Extended Drawdown (20-year elapsed time)			Approx. Time to Consume Available Drawdown
					(m)	(mASL)	Consumed Available Drawdown	(m)	(mASL)	Consumed Available Drawdown	
F1	19.5	345.0	372.5	27.5	15.2	357.3	55%	39.1	333.4	142%	6 months
F2-R	18.75	350.0	391.5	41.5	35.8	355.7	86%	47.6	343.9	115%	4.5 months
F5-R	20.0	365.0	403.9	38.9	26.4	377.5	68%	36.5	367.4	94%	>20 years
Well 31	-	55.0	26.0	29.0	5.6	-	19%	28.7	-	99%	>20 years
Well 36	-	35.0	9.5	25.5	4.8	-	19%	17.3	-	68%	>20 years

Notes: a – Cluster #3 drawdown presented for private wells as a conservative measure.
b – Private well data are provided as metres below ground surface.

For 20-year constant pumping rates of 19.5 and 18.75 L/s, respectively, the water levels within F1 and F2-R are projected to drop below the maximum pumping levels, with consumed available drawdown of 142% and 115%, respectively. While pumping at a rate of 20.0 L/s for 20 years, the water level within F5-R is evaluated to remain above the maximum pumping level. The water levels for private wells 31 and 36 are evaluated to remain above the maximum pumping level for a period of greater than 20 years.

5.2.2 Cluster #2 – Elora

Results of the analysis completed for Cluster #2 are presented as an elapsed time versus drawdown, semi-log plot in **Figure G-2**. Groundwater level monitoring data for Well 40 were also plotted and extended for a 20-year pumping period to reflect potential drawdown in nearby private wells screened within the target aquifer. As stated in **Section 4.3.4.1.2**, Well 40 showed a strong connection to the target aquifer during the longer-term test. Specific construction details were available for this well and used in the assessment.

A summary of drawdown of the Cluster #2 wells and Well 40 at the conclusion of the longer-term test, as well as the estimated 20-year drawdown is presented in **Table 28**.

Table 28: Cluster #2 Long Term Drawdown Extrapolation Summary

Well Name	Cluster #2 Test Pumping Rate (L/s)	Max. Pumping Level (mASL / mBGS)[a]	Static Water Level (mASL / mBGS)[a]	Available Drawdown (m)	Cluster #2 Longer-Term Test Drawdown (48-hour elapsed time)			Extended Drawdown (20-year elapsed time)			Approx. Time to Consume Available Drawdown
					(m)	(mASL)	Consumed Available Drawdown	(m)	(mASL)	Consumed Available Drawdown	
E1	20.0	338.0	377.8	39.8	28.3	349.4	71%	58.2	319.6	146%	1.5 months
E3	15.5	323.0	375.8	52.8	14.0	361.8	27%	48.7	327.1	92%	>20 years
E4	22.0	314.0	376.5	62.5	23.3	353.3	37%	50.1	326.5	80%	>20 years
Well 40	-	45.7	15.5	30.2	8.6	-	29%	41.2	-	136%	16.5 months

Notes: a. Private well data are provided as metres below ground surface.

For a 20-year constant pumping rate of 20.0 L/s, the water level within E1 is projected to drop below the maximum pumping level with a drawdown of 58.2 m, at a consumed available drawdown of 146%. While pumping at rates of 15.5 and 22.0 L/s for 20 years, respectively, the water levels within E3 and E4 are projected to drawdown approximately 48.7 and 50.1 m, which are above the maximum pumping level for each well, at consumed available drawdowns of 92% and 80%, respectively. The water level within private bedrock well 40 is anticipated to drop approximately 41.2 m over the projected 20-year period due to constant municipal pumping, or 136% of the available drawdown.

5.2.3 Cluster #3 – Fergus

Results of the analysis completed for Cluster #3 are presented as an elapsed time versus drawdown, semi-log plot in **Figure G-3**. Groundwater level monitoring data for Wells 31 and 36 were also plotted and extended for a 20-year pumping period to reflect potential drawdown in nearby private wells screened within the target aquifer (using the methodology presented in **Section 5.2.1**).

The longer-term Cluster #3 test was conducted with simultaneous pumping of Clusters #1 and #3 at maximum rates; therefore, the 20-year extrapolations of drawdown due to continuous pumping include potential pumping influence of all six (6) Fergus municipal wells. Results are summarized in **Table 29**.

Table 29: Cluster #3 Long Term Drawdown Extrapolation Summary

Well Name	Cluster #1 Test Pumping Rate (L/s)	Max. Pumping Level (mASL / mBGS)[b]	Static Water Level (mASL / mBGS)[b]	Available Drawdown (m)	Cluster #1 Longer-Term Test Drawdown (80-hour elapsed time)[a]			Extended Drawdown (20-year elapsed time)			Approx. Time to Consume Available Drawdown
					(m)	(mASL)	Consumed Available Drawdown	(m)	(mASL)	Consumed Available Drawdown	
F4	19.5	344.0	390.4	46.4	34.7	355.7	75%	54.2	336.1	117%	11 months
F6	18.0	353.0	375.9	22.9	17.8	358.2	77%	21.0	355.0	91%	>20 years
F7	19.5	355.0	398.6	43.6	25.5	373.1	59%	42.8	355.8	98%	>20 years
Well 31	-	55.0	26.0	29.0	5.6	-	19%	28.7	-	99%	>20 years
Well 36	-	35.0	9.5	25.5	4.8	-	19%	17.3	-	68%	>20 years

Notes: a. Cluster #3 drawdown presented for private wells as a conservative measure.
b. Private well data are provided as metres below ground surface.

For a 20-year constant pumping rate of 19.5 L/s, the water level within F4 is projected to drop below the maximum pumping level with a drawdown of 54.2 m, at a consumed available drawdown of 117%. While pumping at rates of 18.0 and 19.5 L/s for 20 years, the water levels within F6 and F7 are projected to drawdown approximately 21.0 and 42.8 m, which are above the maximum pumping level for each well, at consumed available drawdowns of 91% and 98%, respectively. The water levels for private wells 31 and 36 are evaluated to remain above the maximum pumping level for a period of greater than 20 years.

6. Numerical Modelling Results

A numerical modelling assessment was completed for the project by Matrix (**Appendix H**). This assessment included the following forward modelling tasks:

- Analysis of average well pumping rates;
- Analysis of maximum well pumping rates;
- Analysis of potential impacts to surface water features (rivers and wetlands), and,
- Analysis of potential impacts to private wells.

This work provided the following conclusions:

- The system can support an average annual pumping rate of approximately 128.5 L/s in total, with 44.0 L/s in Elora and 84.5 L/s in Fergus (**Table 30**);
- The system can support a maximum daily pumping rate of approximately 179.0 L/s in total, with 53.5 L/s in Elora and 125.5 L/s in Fergus (**Table 30**); and,
- The analysis of potential impacts, evaluated for average annual pumping rates, were deemed to be acceptable (i.e., the evaluated pumping rates are sustainable) for both the evaluated surface water features and local private wells.

An important aspect of this analysis, as communicated by Matrix, is that the resulting pumping rates should be considered as totals, rather than on a per well basis. The Tier Three groundwater model is a regional model that is calibrated to represent conditions within the various hydrostratigraphic units at this scale. As a result, there is inherently some variability in the precision of results at the scale of each production well.

Table 30: Average and Maximum Pumping Rates Evaluated in the Modelling Assessment

Well Name	Analyzed Average Pumping Rate (L/s)	Available Head Above Set Point (m)	Analyzed Maximum Pumping Rate[a] (L/s)
E1	17.0	10.0	16.0
E3	10.0	3.0	15.5
E4	16.0	10.0	22.0
Subtotal	**44.0**		**53.5**
F1	15.0	24.0	25.5
F2-R	18.5	6.0	17.0
F4	15.0	15.0	18.0
F5-R	6.0	-0.5	23.0
F6	11.5	39.0	14.0
F7	18.5	34.0	28.0
Subtotal	**84.5**		**125.5**
Total	**128.5**		**179.0**

Notes: a. Available head above set point not shown for maximum pumping rate scenario as set points were set as boundary conditions in model (i.e., maximum rates were evaluated by the model with water levels forced to remain above set point).

7. Wellfield Production Capacity

All collected data were utilized to assess aquifer response; including potential pumping impacts on local groundwater users and groundwater-dependant natural features. Analysis of long-term drawdown trends were completed using both analytical and numerical modelling techniques. This section includes a review of all results and presents conclusions regarding the recommended pumping rates for all of the Township production wells within Fergus and Elora (both existing and replacement).

7.1 Elora Production Wells

Through the additional testing program completed within Cluster #2, wells E1, E3 and E4 demonstrated a combined pumping capacity of 57.5 L/s. It is noted that both wells E3 and E4 are capable of pumping in excess of the tested rates (15.5 and 22.0 L/s, respectively); however, as discussed in **Section 7.3**, there is a risk of private well interference occurring at higher pumping rates. The modelling study concluded that these wells could sustainably pump at combined rates of 44.0 and 53.5 L/s, on an average and maximum basis, respectively.

7.2 Fergus Production Wells

Through the Cluster #1 and Cluster #3 tests in Fergus, the production wells demonstrated a combined pumping capacity of 115.0 L/s. It is noted that both wells F6 and F7 are likely capable of pumping in excess of the tested rates of 18.0 and 19.5 L/s, respectively. The modelling study concluded that these wells could sustainably pump at combined rates of 84.5 and 125.5 L/s, on an average and maximum basis, respectively.

7.3 Private Well Interference

Multiple private well complaints were received during the initial (fall 2022) wellfield test within Cluster #2. During additional testing of the Cluster #2 production wells (spring 2023), no complaints were received. While pumping at a combined 57.5 L/s during the spring 2023 test, a maximum drawdown of 8.1 m was observed at Well 40 (148 Wellington Road 7), located approximately 610 m west of E3. Based on the MECP Water Well Record for this well, it is estimated that approximately 30 m of available drawdown remained within this well at that time. Through combined pumping of the Township production wells and regular use of the private well, it is estimated that the water level in this well would reach the pump set point within approximately 16.5 months of continuous pumping.

Private wells most significantly affected by the testing in Fergus were evaluated (Wells 31 and 36). The assessment concluded that these wells are not at significant risk of being adversely impacted by the municipal wells operating at the test rates.

7.4 Impacts to the Natural Environment

Drawdown response to pumping was not detected at any of the surface water monitoring locations. Further, the modelling assessment concluded that the evaluated pumping rates would not pose an impact to local surface water features.

7.5 Recommended Pumping Rates

Recommended pumping rates are presented for each of the production wells within Fergus *(Cluster #1 and Cluster #3) and Elora (Cluster #2) based on the testing data and analysis/interpretation presented within this WFCA

report. Where the long-term extrapolation of drawdown data indicates that a water level could drop to below the associated maximum pumping level at the WFCA test rate, the recommended average pumping rate for that well is below the test rate. The lower average rate was determined as the theoretical rate that would maintain the water level above the maximum pumping level under 20-year constant pumping scenario (e.g., F1, F2-R, F4). Where the test rate was estimated to be sustainable over a 20-year constant pumping scenario, but that one or more private wells experienced interference drawdown that could cause drawdown to below the assessed maximum pumping level, the theoretical rate that would maintain the water level above the maximum pumping level in the private well is recommended (e.g., E3). As previously stated in **Section 6**, the modelling results were considered at a regional scale to provide an indication of the overall wellfield rates that could be sustained. The maximum rates presented should be utilized to address annual maximum demand in the system, typically required to support peak week production during hot, dry summer conditions. These rates can be sustained up to a month (30-day period) annually.

The recommended rates equate to 13,100 and 15,000 m^3/d for the average and maximum rates, respectively. This is in comparison to the current permitted system rates (PTTW 4856-9KBH5A) of 9,019 m^3/d (with the 60% limitation, Condition 3.3) and maximum of 15,000 m^3/d (not permitted prior to completion of this Wellfield Capacity Assessment).

Table 31: Recommended Average and Maximum Pumping Rates

Well Name	Existing PTTW Rate[a] (L/s)	Recommended Average Pumping Rate (L/s)	Recommended Maximum Pumping Rate (L/s)
E1	20.2	14.0	20.0
E3	22.7	12.0	15.5
E4	22.7	22.0	22.0
Subtotal	**65.6**	**48.0**	**57.5**
F1	21.2	13.5	19.5
F2-R	-	16.5	19.0
F4	22.7	16.5	19.5
F5-R	-	20.0	20.0
F6	22.7	18.0	18.0
F7	22.7	19.5	19.5
Subtotal	**89.3**	**104.0**	**115.5**
Total	**104.4[b]**	**152.0**	**173**

Notes: *a. Permit to Take Water No. 4856-9KBH5A.*
b. As per Condition 3.3 of Permit to Take Water No. 4856-9KBH5A, the total taking is currently capped at 9,018,648 litres per day (104.4 litres per second) on a yearly average.

Table 32 presents the recommended maximum pumping rates in the typical PTTW format. The recommended total average pumping rate of 13,132,800 litres per day represents 88% of the total maximum pumping rate.

Table 32: Recommended Maximum Pumping Rates

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
F1	Well Drilled	Municipal	Water Supply	1,170	24	1,684,800	365	17 550406 4839507
F2-R	Well Drilled	Municipal	Water Supply	1,140	24	1,641,600	365	17 550597 4839939
F4	Well Drilled	Municipal	Water Supply	1,170	24	1,684,800	365	17 550021 4840805
F5-R	Well Drilled	Municipal	Water Supply	1,200	24	1,728,000	365	17 551839 4839072
F6	Well Drilled	Municipal	Water Supply	1,080	24	1,555,200	365	17 549225 4841523
F7	Well Drilled	Municipal	Water Supply	1,170	24	1,684,800	365	17 548181 4839697
E1	Well Drilled	Municipal	Water Supply	1,200	24	1,728,000	365	17 545850 4837407
E3	Well Drilled	Municipal	Water Supply	930	24	1,339,200	365	17 547138 4835868
E4	Well Drilled	Municipal	Water Supply	1,320	24	1,900,800	365	17 545447 4834896
					Total Taking	**14,947,200**		

8. Conclusions and Recommendations

The following conclusions are provided based on the testing data and associated analyses included in this report:

- A background review was completed, including a review of previous technical reports, memoranda, and letters pertaining to the Centre Wellington Municipal Wellfield to aid development of the WFCA scope of work and reporting requirements;
- A private well monitoring program was established that adequately captured groundwater levels within private wells surrounding each production well cluster during testing. This program included targeted communication with known private well owners in the vicinity of each municipal production well, with an invitation to participate in water level monitoring during the WFCA;
- The overall monitoring network for the longer-term cluster tests was developed to include groundwater level data were collected at the pumping wells, in addition to established monitoring locations within the Township's monitoring network, which included private wells where property owners agreed to participate in the monitoring program and at Township monitoring wells, and drive-point piezometers at select surface water monitoring locations;
- Short-term testing was performed to confirm the current function of each well included in the WFCA and to establish the rate that each well was to be pumped during the longer-term testing (where required). Short-term testing was not completed at wells where ample recent testing data was available (F1, F2-R and F5-R). AECOM reviewed approximately one (1) year of production well data and determined that short-term testing was required at all of the Cluster #2 (E1, E3 and E4) and Cluster #3 (F4, F6 and F7) wells;
- Longer-term testing was completed for each of the three (3) clusters following the short-term testing to assess sustainability of the water-takings;
- Based on drawdown interference observed in nearby private water supply wells during longer-term testing completed within Cluster #2, additional testing was performed; including step testing of each Elora municipal well, as well as longer-term testing of the Elora well cluster. The intent of this additional testing was to determine a maximum appropriate pumping rate for each Elora municipal well while mitigating potential private well interference;
- The sustainability of pumping the municipal production wells at the test rates for a period of 20-years was evaluated using graphical analysis, representing a "worst-case" scenario of aquifer stress over the period. Analysis included drawdown within municipal pumping wells and nearby private wells which showed responses to the pumping tests;
- A numerical modelling assessment was completed for the project by Matrix. This assessment involved forward modelling tasks which included average well pumping rates, maximum pumping rates, as well as impacts to municipal wells, private wells, and surface water features. The results of the modelling included identification of the average annual pumping rates and maximum daily pumping rates which could be supported by the Township's municipal well system; and,
- Conclusions were developed regarding recommended pumping rates for all of the Township production wells within Fergus and Elora., as well as total wellfield production capacity. All collected data were utilized to assess aquifer response; including potential pumping impacts on local groundwater users and groundwater-dependent natural features (i.e., surface water). Analysis of long-term drawdown trends were completed using both the results from both analytical and numerical modelling techniques.

The following recommendations are provided based on the testing data and associated analysis included in this report:

- It is recommended that the Township submit this WFCA report to the MECP Director on or before December 31st, 2023, as required by Condition 4.2 of PTTW 4856-9KBH5A;
- Upon approval of the WFCA report by MECP, and completion of any additional requirements (i.e., Environmental Assessment planned for the F2-R site), it is recommended that the Township apply for a PTTW amendment that adds F2-R and F5-R as new sources to the wellfield PTTW (and removes existing F2 and F5[2]). This application should incorporate the well pumping rates listed in **Section 7**, using the average rates as 'typical volume per day' and the maximum rates as the 'maximum volume per year';
- As per Condition 3.3 of PTTW 4856-9KBH5A, following the approval of the WFCA report by MECP, the 60% restriction of yearly average Total Taking as specified within Table A of Condition 3.2 will be removed;
- The maximum pumping levels for wells F1 and F2-R have been established to mitigate the movement of TCE impacted groundwater within the aquifer. Maintaining the pumping water level within F1 below the pumping level in F2-R will maintain a hydraulic gradient between the sites and a barrier to the movement of impacted water against the gradient. As such, the F1 and F2-R sites should be operated in tandem and in the event of a prolonged shut down of the F1 well, the F2-R well should also be rested;
- There are a significant number of private well operating within Fergus and Elora, generally concentrated east of F2-R and F7, north of E1 and surrounding E3. A subset of the existing private wells were monitored for the WFCA and therefore there is uncertainty in terms of how each individual well will respond to operation of the production wells at the tested rates. It is recommended that the Township continue the established quarterly monitoring program. The deepest port in the multi-level well located in proximity to E1 (MW2-11) did not provide reliable data during the WFCA. It is further recommended that this well be repaired/rehabilitated or that a replacement well be drilled to the depth of the deep port on the same site as MW2-11;
- As per the recommendation in the *Municipal Well F2 & F5 Well Replacement Program – Results of Well Installation and Testing* technical memorandum (**Appendix A**), it is recommended that the Township consider obtaining an access agreement with the owner of Well 36 (590 St. Andrew St. East), or an equivalent nearby well, for the purpose of establishing a groundwater level monitoring point. The ongoing collection of data in this area will provide an understanding of how operation of the Fergus production wells may affect local groundwater levels. In the absence of a willing participant, the Township should establish a monitoring well at multiple levels within the bedrock aquifer to supplement the existing monitoring network, and
- A similar monitoring location should be established between E3 and E4, near the intersection of 1st Line and Wellington Road 7. The WFCA determined that the private wells in this area are sensitive to low water level conditions and operation of E3. The long-term pumping rates presented in this report have been selected to promote sustainable groundwater use; however, there are many known private wells that could not be monitored for the project. Establishing a long-term multi-level monitoring well in this area will allow for the ongoing measurement of groundwater levels under variable operating and seasonal conditions, further supporting the Township's objective of avoiding adverse impacts to private water supply use.

2. *It is noted that the Township may elect to maintain F5 as a back-up well.*

9. References

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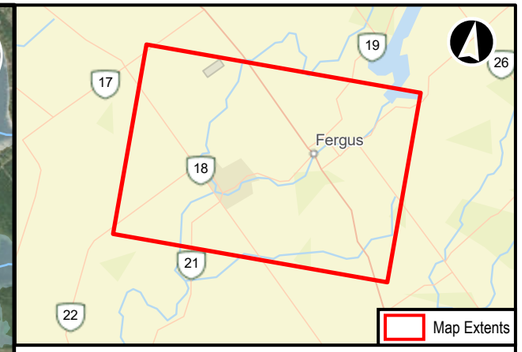
Figures



LEGEND

- Municipal Production Well
- Watercourse
- Waterbody

Wellfield Capacity Assessment Report
Fergus and Elora Municipal Wells

Study Area

0 500 1000 2000 M

NAD 1983 UTM Zone 17N

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P:60692210	Rev:00	
Figure 1		AECOM

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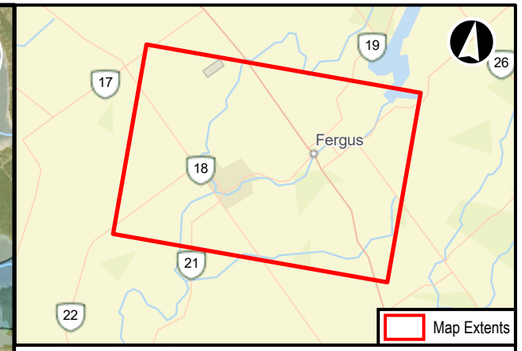

LEGEND

- Municipal Production Well
- Watercourse
- Waterbody

Physiography Description

- Drumlins
- Eskers
- Kame Moraines
- Spillways
- Till Plains (Drumlinized)
- Till Plains (Undrumlinized)

Wellfield Capacity Assessment Report
Fergus and Elora Municipal Wells

Physiography

0 500 1000 2000 M

NAD 1983 UTM Zone 17N

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Figure 2

AECOM

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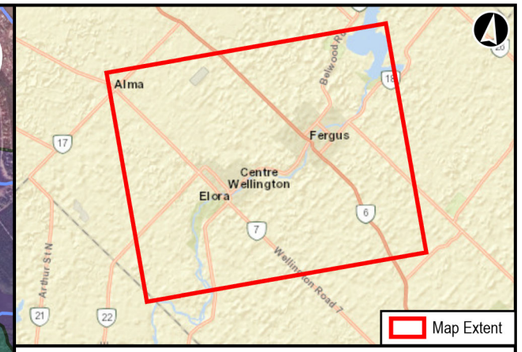


LEGEND

- Municipal Production Well
- Watercourse

Surficial Geology Material Description

- Brown clay till
- Buff or pink sandy till
- Clayey sand till
- Clayey silt till
- Dolomite
- Gravel
- Gravel and gravelly sand, frequently overlain by several feet of sand or silt
- Gravel, sand, silt
- Gravel, sand, silt and clay
- Mainly fine to very fine sand
- Peat, muck, marl
- Poorly to well sorted, fine gravel and/or sand to coarse gravel and/or sand textured
- Sand
- Sand and gravel
- Sand, minor gravel
- Sandy silt till
- Silt and clay
- Silt to clayey silt till; Georgian Bay lobe
- Unsubdivided silt, sand, gravel
- Well sorted, fine gravel and/or sand to medium gravel and/or gravel sand

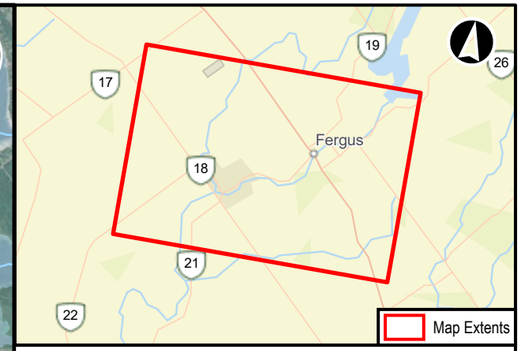
Wellfield Capacity Assessment Report
Fergus and Elora Municipal Wells

Surficial Geology

0 0.5 1 2 3 km

DATUM: NAD 1983 UTM Zone 17N

November, 2023	1:45,000	**Data Sources:** MNRF (2018), MMAH (2018), GRCA (2018), AECOM (2018)
P#:60692210	Rev:00	
AECOM		**Figure: 3**



LEGEND

- Municipal Production Well
- Watercourse
- Waterbody

Bedrock Geology

- **56a:** Guelph Formation

Wellfield Capacity Assessment Report
Fergus and Elora Municipal Wells

Bedrock Geology

0 500 1000 2000 M

NAD 1983 UTM Zone 17N

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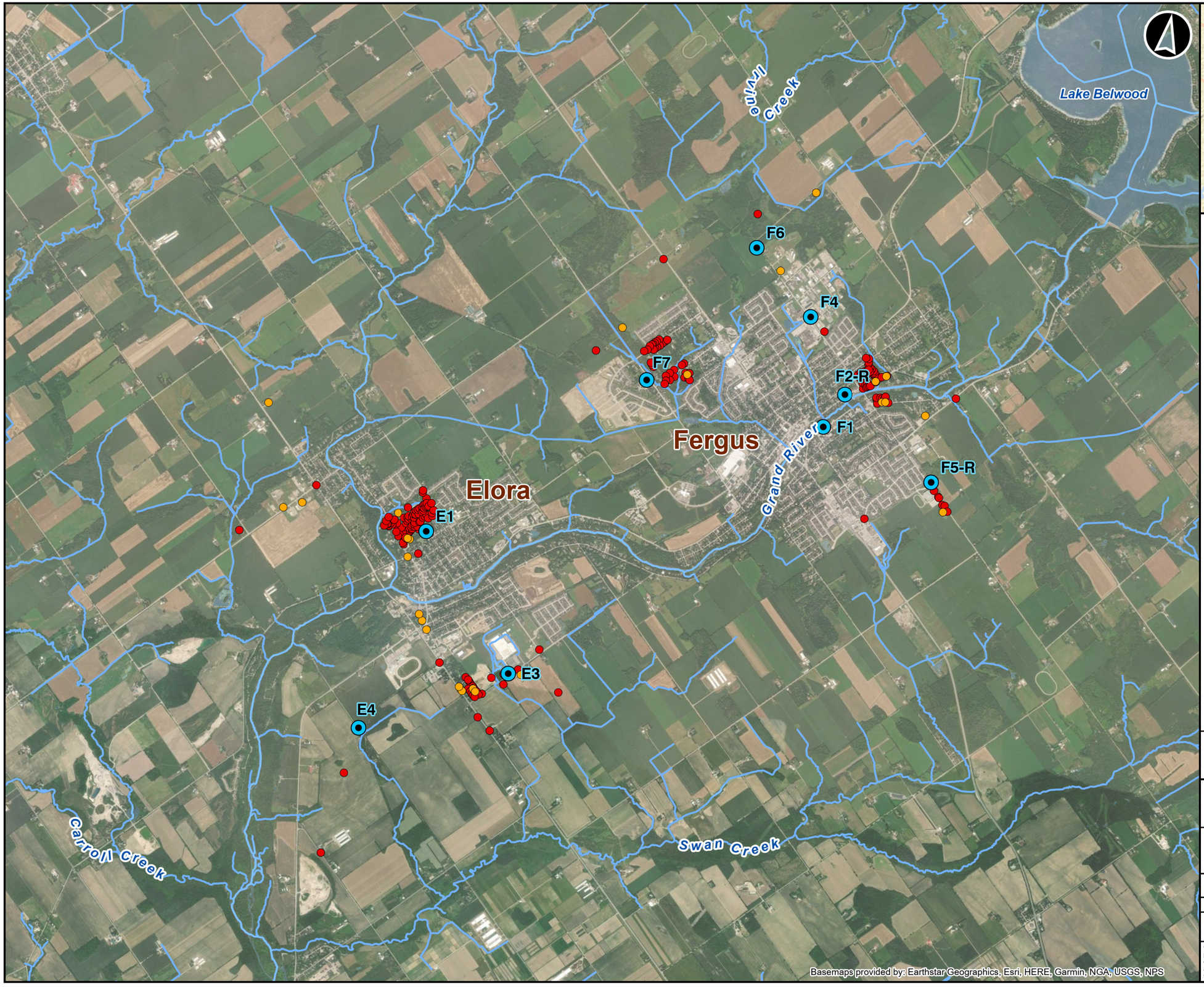
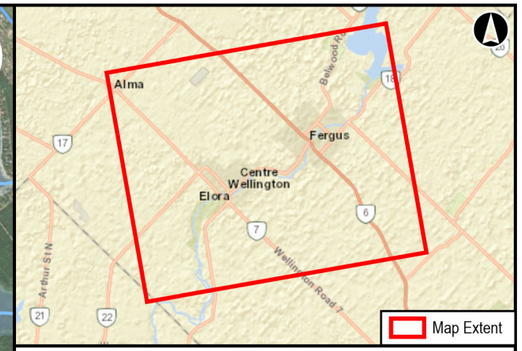
Figure 4		AECOM





LEGEND

- Municipal Production Well
- Well Owner Notified of Wellfield Capacity Assessment Testing
- Well Owner Invited to Participate in Monitoring Program
- Watercourse
- Waterbody

Wellfield Capacity Assessment Report
Fergus and Elora Municipal Wells

Private Wells in Township Database

0 0.5 1 2 km

DATUM: NAD 1983 UTM Zone 17N

November, 2023	1:45,000	**Data Sources:** MNRF (2018), MMAH (2018), GRCA (2018), AECOM (2018)
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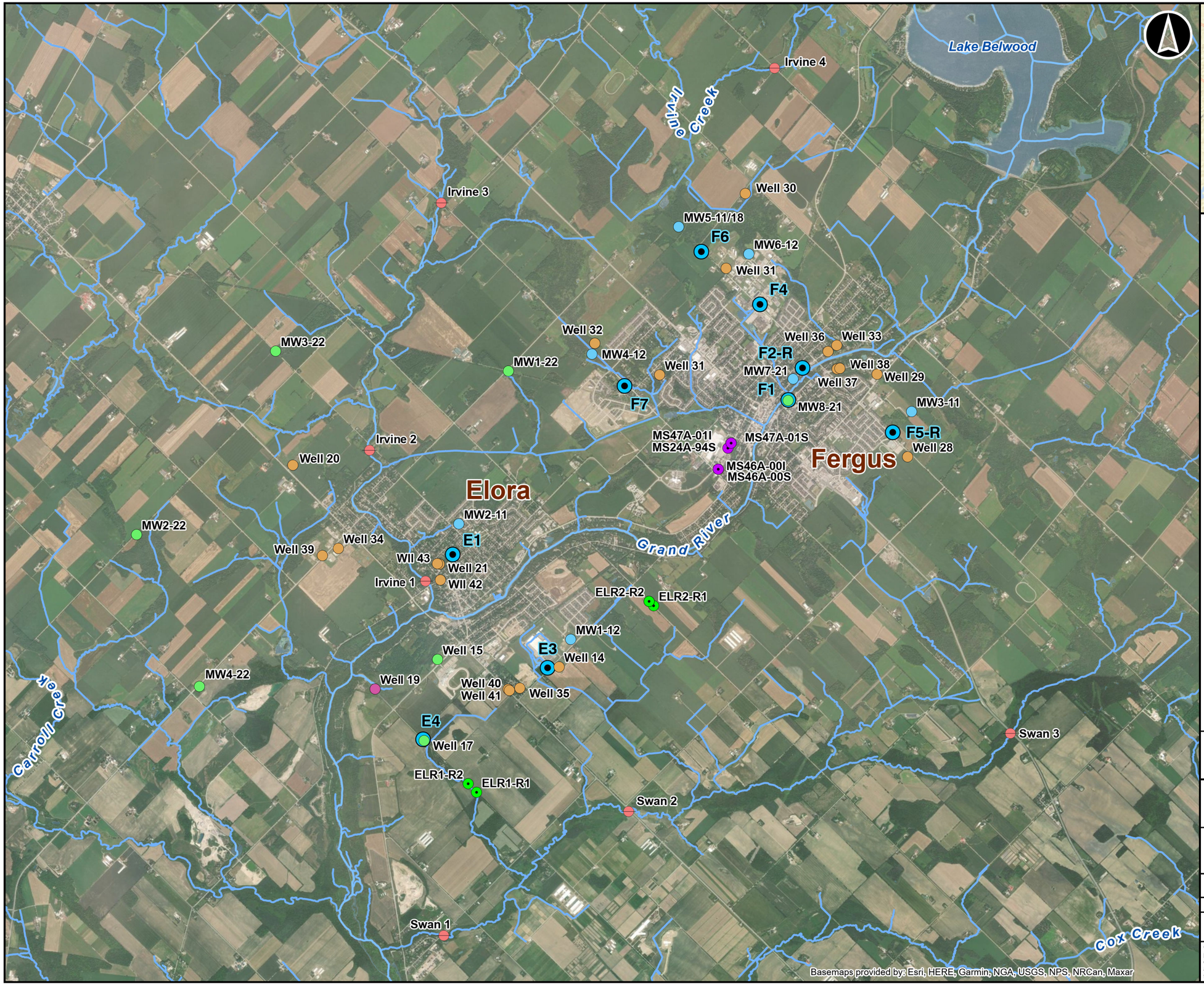
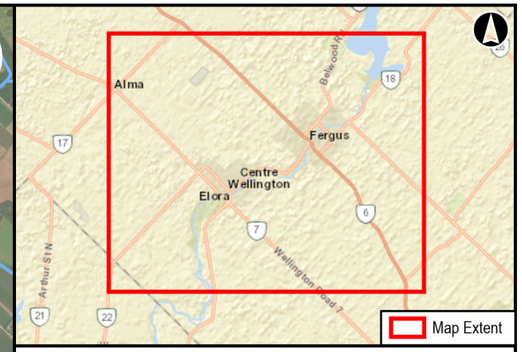
Figure: 5





Legend

- Municipal Production Well
- GRCA Supply Well
- Municipal Monitoring Well
- Municipal Multi-Level Monitoring Well
- Private Well
- Municipal Drive-Point Piezometer
- Research Monitoring Well
- A.O. Smith Monitoring Well
- Watercourse
- Waterbody

Wellfield Capacity Assessment Report
Fergus and Elora Municipal Wells

Monitoring Network

0 0.5 1 2 3 km

DATUM: NAD 1983 UTM Zone 17N

November, 2023	1:50,000	**Data Sources:** MNRF (2018), MMAH (2018), GRCA (2018), AECOM (2018)
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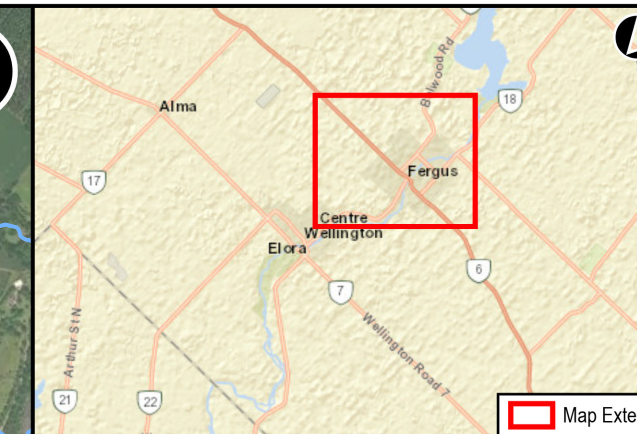
Figure: 6



Legend

- Watercourse
- Municipal Monitoring Well
- Municipal Multi-Level Monitoring Well
- Private Well
- Municipal Production Well
- A.O. Smith Monitoring Well
- MW (0.0m) Maximum Drawdown Observed During Test in metres

Wellfield Capacity Assessment Report
Fergus and Elora Municipal Wells

Cluster #1 Longer-Term Test - Maximum Observed Drawdown

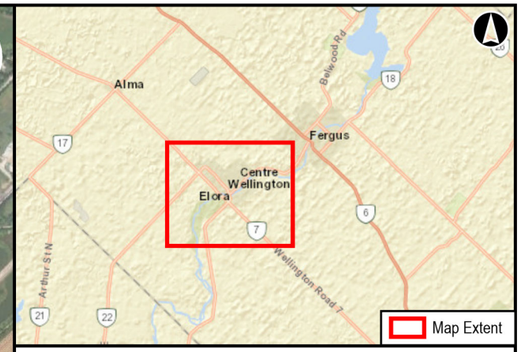
0 0.25 0.5 1 km

DATUM: NAD 1983 UTM Zone 17N

November, 2023	1:20,000	Data Sources: MNRF (2018), MMAH (2018), GRCA (2018), AECOM (2018)
P#:60692210	Rev:00	

AECOM

Figure: 7



Legend

- Watercourse
- Municipal Monitoring Well
- Municipal Multi-Level Monitoring Well
- Private Well
- GRCA Supply Well
- Municipal Production Well
- Research Monitoring Well

MW (0.0m) Maximum Drawdown Observed During Test in metres

Wellfield Capacity Assessment Report
Fergus and Elora Municipal Wells

Cluster #2 Longer-Term Test - Maximum Observed Drawdown (Additional Elora Testing)

0 0.25 0.5 1 km

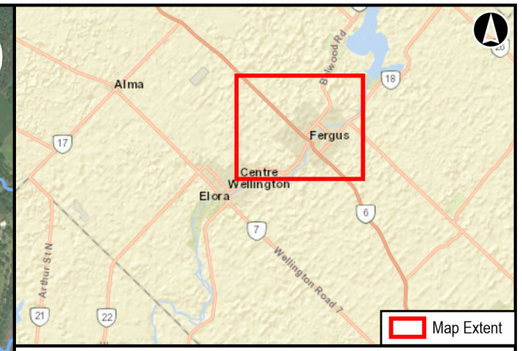
DATUM: NAD 1983 UTM Zone 17N

November, 2023	1:20,000	**Data Sources:** MNRF (2018), MMAH (2018), GRCA (2018), AECOM (2018)
P#:60692210	Rev:00	

AECOM

Figure: 8

MW5A-11 (3.0m)
MW5A-18 (0.0m)
F6(17.6m)
MW6A-12 (4.5m)
MW6B-12 (2.0m)
MW6C-12 (0.0m)
F4(34.2m)
Fergus
MW4A-12 (9.0m)
MW4B-12 (4.5m)
MW4C-12 (1.0m)
MW1-22 (1.1m)
Well 31 (5.6m)
F7(25.3m)
Well 33 (0.2m)
Well 36 (4.8m)
F2-R
Well 38 (0.1m)
Well 29 (0.4m)
MW7-21D (13.9m)
MW7-21I (6.9m)
MW7-21S (0.0m)
Well 37 (0.2m)
F1
MW8-21 (above packer) (0.0m)
MW8-21 (below packer) (9.2m)
MW3A-11 (3.5m)
MW3B-11 (3.5m)
MW3C-11 (1.0m)
F5-R
MS47A-01S (0.0m)
MS47A-01I (0.0m)
MS24A-94S (0.0m)
Well 28 (0.7m)
MS46A-00I (0.0m)
MS46A-00S (0.0m)
Grand River
Grand River
9m)
0m)
Basemaps provided by: Maxar, Esri, HERE, Garmin, NGA, USGS, NPS



Legend

- Watercourse
- Municipal Monitoring Well
- Municipal Multi-Level Monitoring Well
- Private Well
- Municipal Production Well
- A.O. Smith Monitoring Well

MW (0.0m) Maximum Drawdown Observed During Test in metres

Wellfield Capacity Assessment Report
Fergus and Elora Municipal Wells

Cluster #3 Longer-Term Test - Maximum Observed Drawdown

0 0.25 0.5 1 km

DATUM: NAD 1983 UTM Zone 17N

November, 2023	1:20,000	**Data Sources:** MNRF (2018), MMAH (2018), GRCA (2018), AECOM (2018)
P#:60692210	Rev:00	

AECOM

Figure: 9