Version 2.0
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Dave Belanger
CITY OF GUELPH
29 Waterworks Pl.
Guelph, ON N1H 3A1

Subject: Groundwater Modelling of the 10-Year Lafarge Wellington Quarry Footprint

Dear Dave Belanger:

1 INTRODUCTION AND OBJECTIVES

Lafarge Canada Inc. (Lafarge) has applied to amend their Permit to Take Water (PTTW) at their Wellington County Pit and Quarry (Wellington Quarry) located on the south side of Highway 124, in the Townships of Guelph-Eramosa and Puslinch, Ontario. The proposed permit amendment seeks approval for dewatering to an elevation of 285 m above sea level (asl); the approximate mapped top of the Vinemount Member of the Eramosa Formation that is generally considered to be an aquitard. An elevation of 280 m asl is the vertical quarry licence limit.

In January 2020, the City of Guelph (City) and Lafarge entered into an agreement to assess the effects of the proposed quarrying operations on local water resources through application of the City's groundwater flow model. Contracted by the City to perform the modelling, Matrix Solutions Inc., a Montrose Environmental Company, completed conceptual and numerical modelling in 2020 and 2021 for the City (Matrix 2021a, 2021b), to support an evaluation of the potential impacts to groundwater levels, surface water features and municipal and private well sustainability from excavation of the quarry to an elevation of 285 m asl and associated dewatering. The work plan for the modelling was developed in response to scopes of work proposed by Lafarge and Lafarge's consultant Golder Associates Ltd. (Golder). That work consisted of the development of a site-specific conceptual site model, refinement and calibration of the City's groundwater flow model to represent the site, and simulation of the proposed quarry and associated dewatering scenarios including quarrying of the full excavation area (Figure 1) to an elevation of 285 m asl.

The work described above was completed in 2021 under the initial agreement between the City and Lafarge. The City and Lafarge amended the agreement and the City again retained Matrix for the current project, to complete and document additional modelling simulations based on a new scope of work for additional quarry and dewatering scenarios based on Lafarge's proposed 10-year footprint (Lafarge 2022, Matrix 2021c). The 10-year footprint describes excavation to an area of 24 ha, 47% of the full 51 ha excavation area of the quarry (Figure 1). Matrix worked with the City, Lafarge, and Golder to develop a scope of work and work plan to complete the technical work, which included the simulation of scenarios that evaluate: 1) the potential impacts from quarry excavation and dewatering at the anticipated 10-year quarry footprint, and 2) the effectiveness of reinjecting water into the Gasport Formation to mitigate groundwater level and surface water feature changes from quarrying and dewatering.

In 2021 and 2022, following the initial evaluation of the Lafarge Wellington Quarry excavation/dewatering in 2021 (Matrix 2021a, 2021b), the City's groundwater flow model was updated (e.g., locally refined and recalibrated) as part of the City's Water Supply Master Plan Update (WSMP; AECOM 2022) and a groundwater supply feasibility assessment. Model updates included changes to hydraulic conductivity zones in the Middle Gasport Formation near the Lafarge site reflecting new data and analyses. Therefore, prior to applying the model for additional excavation/dewatering scenarios as part of this current scope of work, the updated baseline model and the model applied in 2021 (Matrix 2021a, 2021b) were compared, and model calibration was assessed in the area of the Wellington Quarry to confirm that the calibration is still reasonable for the purposes of this study.

This report summarizes the results of the numerical model simulations from the proposed excavation/dewatering and injection at the Wellington Quarry to 285 m asl at the 10-year quarry footprint. It is anticipated that the City and Lafarge will use the results of the numerical modelling to provide comments to the Ministry of the Environment, Conservation and Parks on the PTTW application.

2 MODEL UPDATES AND VERIFICATION

The Lafarge Wellington Quarry property is located within the Grand River watershed, in portions of Guelph/Eramosa and Puslinch Townships, approximately 1 km south of Guelph, along the south side of Wellington Road 124 (Figure 1). Detailed descriptions of the local and regional geologic and hydrologic settings are provided in Golder (Golder 2019) and Matrix (2017), respectively. Interpreted hydrogeologic units beneath Lafarge property are illustrated in a west-east cross-section through Lafarge property on Figure 2.

After completion of the evaluation of the Lafarge Wellington Quarry excavation/dewatering in 2021 (Matrix 2021a, 2021b), the City's groundwater flow model was updated, including changes to hydraulic conductivity zones in the Middle Gasport Formation near the Lafarge site based on new data analyses. To understand how the updates to the City's groundwater flow model effect the simulated conditions at the quarry, the previous baseline (full area of excavation) excavation scenario was simulated using the updated model and these results were compared to the previous quarry excavation and dewatering simulations (Matrix 2021b, 2021a).

The results of this analysis demonstrated that the City's current groundwater flow model produces a slight improvement in calibration performance with respect to near site (Figure 3) and regional simulated heads. Calibration performance is measured by the absolute mean residual, an aggregate measure of the agreement between simulated and observed heads. This statistic is calculated by averaging the absolute values of each residual, being the difference between simulated and observed head. Lower absolute mean residual values indicate better agreement between simulated and observed heads. Of 30 high-quality onsite water levels measured in 2016 or 2019 by Golder (Table 5; Matrix 2021a), the updated model produced an absolute mean residual of 0.96 m, as compared to 1.0 m using the 2021 version of the model. Of 418 regional observations sourced from the Tier Three Assessment, the updated model produces an absolute mean residual of 6.0 m as compared to 6.2 m previously. The current model also produces identical discharge to the Speed River as compared to the previous model (0.07 m^3/s local discharge, 0.52 m^3/s regional discharge) and similar drawdown magnitudes at municipal wells, with less than 6 cm of difference between drawdown simulated with the current and previous models. The simulated vertical gradient onsite is also consistent with the previous excavation and dewatering simulations, with all 11 nested well pairs onsite simulating the same direction as previously simulated, and seven nested well

pairs simulating gradients closer to the observed gradient. The updated model is thus deemed reasonable for the purposes of this study.

3 EXCAVATION SCENARIO EVALUATION

Four steady state quarry excavation and dewatering modelling scenarios were evaluated in consideration of long-term average climate conditions and distinct regimes of municipal pumping. Two additional scenarios were evaluated considering the potential additional impacts of transient drought conditions. These transient scenarios utilized the recharge dataset developed through the Tier Three Assessment project (Matrix 2017), which is based on the observed climate record and includes the significant drought of the 1960s. The six excavation scenarios are summarized in Table 1 and are described in detail in the sections below. Each scenario evaluated the potential impacts as a result of quarry excavation after 10 years to a depth of 285 m asl with a sump pump maintaining a groundwater elevation of 283 m asl, as provided by Lafarge/Golder. The extent of the 10-year footprint as compared to the previously simulated full excavation area is illustrated in Figure 1. The 10-year excavation footprint in the model was implemented following the methodology applied to the previous full quarry excavation simulations (Section 4; Matrix 2021a).

Table 1 Excavation Scenario Pumping Rates and Recharge Regimes

Scenario	Municipal Pumping	Recharge	Aggregate Pumping Rate (m^3/d)
1	'Existing' as per Matrix (2021a)	Long-term average conditions	43,708
2	WSMP current capacity		59,499
3	'future' rates as per Matrix (2021a)		66,550
4	WSMP future rates		75,180
T1	WSMP current drought capacity	Transient drought conditions	52,430
T2	WSMP future rates		75,180

3.1 Steady State Excavation Scenarios

Four steady state scenarios were simulated to evaluate potential impacts as a result of quarry excavation after 10 years to a depth of 285 m with a sump pump maintaining a groundwater elevation beneath the quarry floor at 283 m. The four scenarios are distinguished by the pumping rates applied at municipal pumping wells (Figure 4). A summary of the pumping regimes associated with each scenario is available in Table 2. Scenario 1 considered the 'existing' municipal pumping rates evaluated in Matrix (2021a), representing 2008 typical operating rates applied in Risk Assessment Scenario C of the *City of Guelph and Township of Guelph/Eramosa, Tier Three Water Budget and Local Area Risk Assessment* (Tier Three Assessment; Matrix 2017). Scenario 3 considered the 'future' municipal rates evaluated in Matrix (2021a), representing the future allocated municipal pumping rates from the Tier Three Assessment. These two scenarios provide a direct comparison of the potential impacts due to quarry excavation and dewatering at the 10-year footprint to the previously evaluated potential impacts associated with the full quarry excavation area footprint. Scenarios 2 and 4 provide insights into potential impacts using updated municipal pumping regimes. Scenario 2 considered refined 'existing' municipal pumping rates that were estimated recently as part of the City's WSMP and Scenario 4 considered refined future municipal pumping rates estimated as part of the City's WSMP. Scenarios 1-3 consider 22 municipal pumping wells, although not all wells are active in each scenario. Scenario 4 considers nine additional wells, with a total of 26 pumping municipal wells.

Table 2 Municipal Pumping Regimes

Well	Estimated Reduced Flow Capacity (AECOM 2022) ($m^3/d/m$)	Pumping Rate (m^3/d)				
		Scenario 1	Scenario 2	Scenario 3	Scenario 4, Transient 2	Transient 1
Arkell 1	550	730	2,000	1,400	2,000	2000
Arkell 14	350	0	3,100	3,300	1,500	0
Arkell 15	1490	0	7,000	3,300	7,000	7000
Arkell 6	860	3,774	1,495	4,900	1,495	2960
Arkell 7	730	3,689	8,000	4,900	8,000	8000
Arkell 8	260	3,694	0	4,900	0	0
Burke	340	5,385	5,200	6,000	5,000	3000
Calico	110	748	1,400	1,100	1,400	1400
Carter Wells	1200	3,400	6,100	4,000	5,500	4000
Dean Ave	110	1,215	539	1,500	0	400
Downey Road	240	3,940	5,237	5,100	2,250	5240
Emma	170	2,600	2,393	2,100	2,100	2360
Helmar	45	800	670	1,100	0	550
Membro	300	3,036	5,200	4,200	4,700	5200
Paisley	45	762	940	800	400	830
Park 1 and 2	250	6,400	6,675	6,400	6,300	6540
Queensdale	25	702	755	2,000	700	680
Sacco	23	0	0	1,150	0	0
Smallfield	26	0	0	1,400	980	0
University	200	1,648	845	2,500	0	470
Water Street	207	1,184	1,950	2,300	1,200	1800
Clythe	128	0	0	2,200	1,500	0
Edinburgh	177	0	0	0	980	0
Fleming	61	0	0	0	1,100	0
GSTW1-20	189	0	0	0	3,900	0
Guelph North	93	0	0	0	3,525	0
Guelph Southeast	134	0	0	0	4,000	0
Hauser	23	0	0	0	300	0
Ironwood	340	0	0	0	3,750	0
Logan	123	0	0	0	4,100	0
Steffler	134	0	0	0	1,500	0
	Total	43,708	59,499	66,550	78,150	52,430

Six types of model outputs are generated to support evaluation of the potential impacts of quarry excavation and dewatering in each steady state scenario:

1. Estimated reduced flow capacity at municipal pumping wells and identification of wells that exceed or are within 1 cm of the Low Water Threshold. A 1 cm threshold reflects the level of accuracy tenable given numerical model convergence criteria. Estimated specific capacity rates from AECOM (2021) are applied to evaluate changes in flow capacity.

2. Change in simulated groundwater discharge to the Speed River and wetlands

3. Estimated drawdown in 12 private wells evaluated previously in Matrix (2021b)

4. Change in quarry water balance pre- and post-excavation

5. Maps of additional drawdown greater than 10 cm in the Guelph and Gasport Formations.

3.1.1 Excavation Scenario 1: Tier Three 2008 Typical Operating Rates (43,708 m^3/d)

The 10-year quarry excavation induces a 104 m^3/d decrease in total flow when municipal pumping wells are simulated using the Tier Three 2008 pumping regime (Table 3). This is a near 50% reduction relative to the total reduction in flow capacity associated with the full quarry excavation area footprint simulated previously (209 m^3/d; Matrix 2021a), although specific capacity values used in this analysis (AECOM 2022) are updated from specific capacity values applied previously. No wells exceed the low water threshold in this scenario. Local discharge to the Speed River is reduced by 27% due to the excavation, while regional discharge is reduced by 6% (Table 4). Five of the seven wells exceeding available drawdown in the full quarry excavation simulation also exceed available drawdown in the 10-year footprint simulation (Table 5). Of the simulated 2,859 m^3/d extracted from the quarry sump, 93% is derived from inflow from the walls of the quarry and 7% is inflow from the floor of the quarry (Table 6). The simulated sump extraction associated with the 10-year footprint is 75% of the sump extraction associated with the full quarry excavation area (3,810 m^3/d). Simulated drawdown intervals greater than 10 cm are shown in Figure 5 for the Guelph Formation and Figure 6 for the Middle Gasport Formation. The drawdown extent is reduced relative to the additional drawdown induced by excavation to the full quarry excavation area simulated previously.

Results from Scenario 1 indicate that under previous 2008 typical operating rates, the 10-year footprint excavation would induce impacts at municipal wells, the Speed River, and private wells, although impacts are lessened relative to the full quarry excavation area footprint analysis and no municipal wells would draw down below the low water threshold due to the 10-year footprint excavation and dewatering.

3.1.2 Excavation Scenario 2: WSMP Current Capacity Rates (59,499 m^3/d)

The results and conclusions of Scenario 2 are similar to Scenario 1. Total flow at municipal pumping wells is reduced by 94 m^3/d due to the 10-year quarry excavation, and two wells exceed the low water threshold (Dean Ave. and Paisely wells; Table 3). Although the WSMP current capacity regime extracts more water in aggregate than the Tier 3 2008 regime applied in Scenario 1, the WSMP regime represents an updated and optimized distribution of pumping rates thus enabling a more efficient extraction of water than the Tier 3 2008 regime. As in Scenario 1, the 10-year excavation induces a 27% decrease in local discharge to the Speed River, though regional discharge is reduced by 4% and is thus less impacted (Table 4). Six of seven private wells exceeding available drawdown in the full quarry excavation simulation also exceed

available drawdown in this scenario (Table 5). The simulated sump extraction rate (2,835 m^3/d) and associated quarry water balance are nearly identical to Scenario 1 (Table 6). The extent of simulated drawdown intervals greater than 10 cm are also similar to Scenario 1 (Figures 7 and 8).

Results from Scenario 2 indicate that under WSMP current capacity rates, the 10-year footprint excavation would induce impacts at municipal wells, the Speed River, and private wells, and two municipal wells would draw down below the low water threshold due to the 10-year footprint excavation and dewatering.

3.1.3 Excavation Scenario 3: Tier Three Future Allocated Rates (66,550 m^3/d)

The 10-year quarry excavation induces a 91 m^3/d decrease in total flow when municipal pumping wells are simulated using the Tier Three future allocated rates pumping regime (Table 3). This is a near 70% reduction relative to the total reduction in flow capacity associated with the full quarry license limit simulated previously (286 m^3/d; Matrix 2021c). No wells exceed the low water threshold in this scenario. All wells with reduced flow capacity in Scenario 1 also show reduced capacity in Scenario 3, except for the Carter Wells, which exhibit just under 1 cm of drawdown in Scenario 3 and thus are associated with a no change in flow capacity result. Local discharge to the Speed River is reduced by 35% due to the excavation, while regional discharge is reduced by 6% as in Scenario 1 (Table 4). All seven wells exceeding available drawdown in the full quarry excavation simulation also exceed available drawdown in Scenario 3 (Table 5). The simulated sump extraction rate (2,783 m^3/d, Table 6) is 76% of the sump extraction associated with the full quarry license limit simulated previously (3,650 m^3/d). The extent of simulated drawdown intervals greater than 10 cm are also similar to Scenario 1 (Figures 9 and 10). The drawdown extent is reduced relative to the additional drawdown induced by excavation to the full quarry excavation area simulated previously.

Results from Scenario 3 indicate that under WSMP current capacity rates, the 10-year footprint excavation would induce impacts at municipal wells, the Speed River, and private wells, although impacts are lessened relative to the full quarry license limit footprint analysis and no municipal wells would draw down below the low water threshold due to the 10-year footprint excavation and dewatering.

3.1.4 Excavation Scenario 4: WSMP Future Capacity Rates (75,180 m^3/d)

The 10-year quarry excavation induces a 160 m^3/d decrease in total flow when municipal pumping wells are simulated using the WSMP future capacity rates pumping regime (Table 3) and one well (Downey Well) exceeds the low water threshold. All wells with reduced flow capacity in Scenario 2 also show reduced capacity in Scenario 4 except for the Dean and University Wells. Scenario 4 introduces nine additional wells, five of which show reduced flow capacity. Local discharge to the Speed River is reduced by 31% due to the excavation, while regional discharge is reduced by 4% as in Scenario 3 (Table 4). All seven wells exceeding available drawdown in the full quarry excavation simulation also exceed available drawdown in Scenario 4 (Table 5). The simulated sump extraction rate (2,756 m^3/d, Table 6) is similar to Scenario 3. The extent of simulated drawdown intervals greater than 10 cm are also similar to Scenario 3 (Figures 10 and 11).

Results from Scenario 4 indicate that under WSMP future capacity rates, the 10-year footprint excavation would induce impacts at municipal wells, the Speed River, and private wells, and one municipal well would draw down below the low water threshold due to the excavation and dewatering.

As Scenario 4 is most representative of future operational rates, includes additional wells that would be online to meet future demand, and is the scenario showing the most impacts to municipal well flow capacity, this scenario was selected to evaluate the efficacy of injection wells to offset/mitigate impacts of the 10-year quarry excavation and dewatering.

Table 3 Steady State Scenarios: Estimated Reduced Flow Capacity and Exceedance of Low Water Threshold

Well	Adjusted Simulated Low Water Threshold (m asl)	Pumping Rate (m^3/d)				Estimated Reduced Flow associated with Excavation (m^3/d)			
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Arkell 1	319.5	730	2,000	1,400	2,000	0	0	0	0
Arkell 14	310.9	0	3,100	3,300	1,500	0	0	0	0
Arkell 15	304.4	0	7,000	3,300	7,000	0	0	0	0
Arkell 6	305.7	3,774	1,495	4,900	1,495	0	0	0	0
Arkell 7	305.7	3,689	8,000	4,900	8,000	0	0	0	0
Arkell 8	311.1	3,694	0	4,900	0	0	0	0	0
Burke	323.4	5,385	5,200	6,000	5,000	0	0	0	0
Calico	294.2	748	1,400	1,100	1,400	-1.6	-1.5	-1.5	-1.7
Carter Wells	318.5	3,400	6,100	4,000	5,500	-31.2	0	0	0
Dean Ave	289.9	1,215	539	1,500	0	-3.4	-4.6	-4.3	0
Downey Road	286.4	3,940	5,237	5,100	2,250	-30.2	-34.9	-34	-34
Emma	278.2	2,600	2,393	2,100	2,100	0	-2.1	-1.9	-2.2
Helmar	321.4	800	670	1,100	0	0	0	0	0
Membro	282.1	3,036	5,200	4,200	4,700	-7.6	-9.2	-8.7	-9.1
Paisley	298.5	762	940	800	400	-2.4	-2.4	-2.5	-2.4
Park 1 and 2	281	6,400	6,675	6,400	6,300	0	-3	-2.7	-3.2
Queensdale	295.9	702	755	2,000	700	-3.2	-3.3	-3.4	-3.3
Sacco	321.2	0	0	1,150	0	0	0	0	0
Smallfield	284.3	0	0	1,400	980	0	0	-0.7	-0.7
University	290.4	1,648	845	2,500	0	-19.9	-25.4	-24.2	0
Water Street	289.2	1,184	1,950	2,300	1,200	-4.7	-7.3	-6.7	-7.2
Clythe Creek	309.3	0	0	2,200	1500	0	0	0	0
Edinburgh	288	0	0	0	980	0	0	0	-6.1

Well	Adjusted Simulated Low Water Threshold (m asl)	Pumping Rate (m^3/d)				Estimated Reduced Flow associated with Excavation (m^3/d)			
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Fleming	310.7	0	0	0	1100	0	0	0	0
GSTW1-20	288.2	0	0	0	3900	0	0	0	-28.1
Guelph North	298.1	0	0	0	3525	0	0	0	0
Guelph Southeast	276.7	0	0	0	4000	0	0	0	0
Hauser	317.7	0	0	0	300	0	0	0	-0.7
Ironwood	273.6	0	0	0	3750	0	0	0	-43.9
Logan	281.5	0	0	0	4100	0	0	0	0
Steffler	285.7	0	0	0	1500	0	0	0	-17.8
Totals		43,708	59,499	66,550	78,150	-104	-94	-91	-160
				Previous Totals		-209*		-286*	

Notes:
* Analysis uses updated specific capacity values from recent WSMP (distinct from previous quarry analysis).
Orange cells indicate wells that exceed the Low Water Threshold

Table 4 Steady State Scenarios: Change in Simulated Discharge to Speed River and Wetlands

Scale	Station	Estimated Gain in Baseflow (m^3/s)	% Change in Simulated Discharge due to Excavation				Change in Simulated Discharge as % of Total Estimated Baseflow			
			Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Local (Lafarge Site)	SW3 - upstream	0.04	-27%	-27%	-35%	-31%	0.4%[1]	0.4%	0.5%	0.4%
	SW1 - downstream									
Regional (Guelph to Cambridge)	02GA015 - Speed River Below Guelph	1.83	-6%	-4%	-6%	-4%	0.6%[2]	0.4%	0.6%	0.4%
	02GA047 - Speed River at Cambridge									

Notes:
1 Relative to estimated baseflow at SW1 station (4.30 m^3/s; *Lafarge Guelph Pit/Quarry, Quarry Dewatering and Water Use Investigation* [Golder 2019])
2 Relative to estimated baseflow at "Speed River at Cambridge" station (5.18 m^3/s; *Lafarge Guelph Pit/Quarry, Quarry Dewatering and Water Use Investigation* [Golder 2019])

Table 5 Steady State Scenarios: Estimated Drawdown in Private Wells

				Simulated Available Drawdown (m)				Total Estimated Drawdown (m) (from Private Well Use + Excavation Dewatering)			
Water Well Record ID	Distance from Proposed Dewatering Sump (m)	Simulated Aquifer Unit at Midpoint of Open Hole	Estimated Drawdown from Private Well Use Only (m)	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
6703318	1,384	Goat Island Fm.	5.5	5.5	5.2	4.4	4	6.2	6.2	6.2	6.2
6705230	1,283	Guelph Fm.	3.7	4.6	4.4	3.9	3.9	6	6	6.1	6.1
6706927	944	Reformatory Quarry Mbr.	24.7	23	22.9	22.7	22.6	29	29	29	29
6707288	1,351	Guelph Fm.	8.5	10.5	10.3	9.8	9.7	10.6	10.6	10.7	10.7
6707880	1,306	Guelph Fm.	1.7	4.5	4.3	3.8	3.8	4	4	4.1	4.1
6708796	734	Guelph Fm.	6.1	5.1	5.1	5	4.9	6.2	6.2	6.2	6.2
6710019	873	Goat Island Fm.	3.6	41.1	40.4	39.2	38.1	4.1	4.1	4.1	4.1
6711941	1,483	Guelph Fm.	2.9	6.6	6.4	5.9	5.8	4	4	4	4
6712349	1,381	Guelph Fm.	2.7	11.3	11.1	10.6	10.4	3.9	3.9	4	4
6712388	799	Guelph Fm.	7.3	16.8	16.7	16.5	16.5	13	13	13.1	13.1
7334558	692	Reformatroy Quarry Mbr.	17.7	27.7	27.7	27.5	27.4	24	24	24	24
6712571	1,011	Goat Island Fm.	7	7.6	7.1	6.2	5.3	7.5	7.5	7.5	7.5

Note:
Orange cells indicate wells that exceed available drawdown in current and previous analysis.
Beige cells indicate wells that exceed simulated drawdown in previous analysis only.

Table 6 Steady State Scenarios: Quarry Water Balance

	No Excavation				With Excavation			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Groundwater in from quarry wall	69%	68%	66%	65%	93%	93%	93%	93%
Groundwater in from quarry floor	1%	1%	0%	0.4%	7%	7%	7%	7%
Direct recharge	28%	29%	30%	31%	0%	0%	0%	0%
Recharge from Site Ponds	2%	2%	3%	4%	0%	0%	0%	0%
Groundwater out from quarry wall	74%	75%	78%	78%	1%	1%	1%	1%
Groundwater out from quarry floor	2%	2%	4%	5%	0%	0%	0%	0%
Surface water outflows (sump)	0%	0%	0%	0%	99%	99%	99%	99%
Discharge from Site Ponds	24%	22%	18%	17%	0%	0%	0%	0%
`Total					2,859	2,835	2,783	2,756
Previous Total					3,810		3,650	

Notes:
Blue cells indicate inflows.
Orange cells indicate outflows.

3.2 Transient Drought Scenarios

Two additional scenarios, considering WSMP current drought capacity and future municipal pumping regimes respectively, were evaluated under drought conditions. In these scenarios, each model was run transiently using a monthly recharge time series representative of significant drought-type conditions observed in the 1960s. Pumping rates were held constant over time. The largest drawdown at each municipal pumping well was recorded during the simulations to evaluate potential for low water threshold exceedances associated with drought conditions. To isolate the influence of drought conditions, additional drawdown was calculated as the difference between the steady state drawdown associated with the excavation and the largest recorded drawdown in the transient simulation. These additional drawdown results were then converted to an estimated reduced flow capacity. The results of these simulations are summarized in Table 7.

These results demonstrate that drought conditions induce a high number of low water threshold exceedances and significant decreases in total well capacity as compared to the equivalent steady state excavation scenario considering long-term average recharge conditions. In the WSMP current drought capacity scenario (Transient Scenario 1), two wells previously identified as having no available head (Burke and University; AECOM 2022) now exceed the low water threshold. In the WSMP future municipal pumping scenario (Transient Scenario 2), 15 wells exceed the low water threshold, although this scenario was not previously evaluated under drought conditions (AECOM 2022). Note that the simulated drawdown and reduction in flow capacity may represent drawdown below current pump elevation.

Table 7 Transient Scenarios: Estimated Reduced Flow Capacity

City of Guelph Municipal Well	Estimated Specific Capacity ($m^3/d/m$)	Adjusted Simulated Low Water Threshold (m asl)	Transient Scenario 1		Transient Scenario 2	
			Pumping Rate m^3/d	Estimated Reduced Flow associated with Drought m^3/d	Pumping Rate m^3/d	Estimated Reduced Flow associated with Drought m^3/d
Arkell 1	550	319.5	2000	-660	2000	-685
Arkell 14	350	310.9	0	0	1500	-558
Arkell 15	1490	304.4	7000	-200	7000	-2417
Arkell 6	860	305.7	2960	-211	1495	-1375
Arkell 8	260	311.1	0	0	0	0
Arkell 7	730	305.7	8000	-89	8000	-1184
Burke	340	323.4	3000	-108	5000	-1373
Calico	110	294.2	1400	-132	1400	-165
Carter Wells	1200	318.5	4000	0.00	5500	-7676
Dean Ave	110	289.9	400	-10	0	0
Downey Road	240	286.4	5240	-181	2250	-341
Emma	170	278.2	2360	0	2100	-277
Helmar	45	321.4	550	0	0	0
Membro	300	282.1	5200	-69	4700	-251
Paisley	45	298.5	830	0	400	-71
Park 1 and 2	250	281	6540	0	6300	-408
Queensdale	25	295.9	680	-10	700	-40
Sacco	23	321.2	0	0	0	0
Smallfield	26	284.3	0	0	980	-59
University	200	290.4	470	-62	0	0
Water Street	207	289.2	1800	-31	1200	-266
Clythe Creek	128	309.3	0	0	1500	-227
Edinburgh	177	288	0	0	980	-192
Fleming	61	310.7	0	0	1100	-114
GSTW1-20	189	288.2	0	0	3900	-516
Guelph North	93	298.1	0	0	3525	-126
Guelph Southeast	134	276.7	0	0	4000	-359
Hauser	23	317.7	0	0	300	-47
Ironwood	340	273.6	0	0	3750	-467
Logan	123	281.5	0	0	4100	-798
Steffler	134	285.7	0	0	1500	-182
		Total	**52,430**	**-1,763**	**75,180**	**-20,175**

Notes:
The simulated drawdown and equivalent lost pumping capacity is not constrained by current pump depth.
Orange highlighted cells indicate where drawdown exceeds low water threshold.

4 INJECTION SCENARIO EVALUATION

An additional scenario was simulated to evaluate the effectiveness of reinjecting a portion of the water from the excavation dewatering to below the Vinemount Member, to reduce impacts to municipal and private wells. Injection wells were added to the Scenario 4 (WSMP future capacity rates) steady state model considering the 10-year quarry excavation footprint and future municipal pumping. A single injection well was evaluated on Lafarge property at the southeast corner of the quarry footprint, as identified in discussions with the City and Lafarge/Golder (Figure 13). Multiple injection rates (300 m^3/d – 500 m^3/d) and screened intervals (Goat Island Fm., Upper Gasport Fm.) were evaluated. A single injection well screened in the Upper Gasport Fm (264.7-249.4 m asl) and injecting 500 m^3/d was found to satisfactorily offset the simulated impacts (reduction in flow capacity) at municipal wells.

The simulated injection well offsets the drawdown associated with the quarry excavation at all municipal wells and leads to rebounded water levels (compared to Scenario 4) at some wells within 5 km of the quarry. The simulated drawdown in each municipal well and the simulated recovery due to the injection well at each municipal well is summarized in Table 8. Baseline heads are the simulated water levels in the municipal pumping wells under the Excavation Scenario 4 pumping regime when no excavation is present. Excavation heads are the simulated water levels under the same regime but with the excavation is present. The difference in elevations between these two conditions characterizes the drawdown at municipal wells associated with the excavation.

In Table 8, negative values indicate drawdown and positive values indicate recovery relative to the baseline condition. Injection heads are the simulated water levels in the municipal pumping wells under the same pumping regime with the excavation present, but with injection simulated into the Gasport Fm at 500 m^3/d. Table 8 demonstrates that the injection well offsets the drawdown associated with the excavation at each well. The simulated areas of recovery of groundwater levels between the excavation and the Downey Well is presented in Figures 14 and 15. These results illustrate the recovery of groundwater heads within the Upper Gasport Formation due to the injection well. Maps of simulated drawdown and recovery within the Guelph and Middle Gasport Formations are available in Figures 16 and 17. Recovery is also simulated under injection conditions at ten of the 12 private wells near site (Table 9).

The quarry water balance is summarized in Table 10. The nearly identical sump extraction rate with (2,773 m^3/d) and without (2,756 m^3/d) the injection well reflects the efficacy of the simulated continuous Vinemont Member beneath the quarry to separate the head regime above and below the Vinemount: in this simulation, injection into the Upper Gasport focuses head recovery in the transmissive Gasport Formations below the Vinemount, with minor changes and head recovery above the Vinemount. The slight reduction in drawdown in the Guelph Formation as compared to the absence of drawdown in the Middle Gasport Formation (Figures 16 and 17) reinforce this conclusion. The nearly identical change in simulated discharge to the Speed River with and without the active injection well (Table 11) demonstrates marginal impacts in the shallow subsurface, and further supports the role of the simulated continuous Vinemount Member capacity to support head recovery in the deeper formations with minimal influence in shallower units.

Table 8 Injection Scenario: Simulated Recovery Due to Injection Well

Well	Distance from Sump (m)	Baseline Head[1] (masl)	Excavation Head[2] (masl)	Excavation Baseline[4] (m)	Injection Head[3] (masl)	Injection Baseline[4] (m)
Downey Road	2,548	286.5	286.4	-0.14	286.6	0.1
Queensdale	2,953	296.2	296.1	-0.14	296.2	0
Steffler	3,106	286.2	286.1	-0.13	286.3	0.09
GSTW1-20	3,467	287.0	286.8	-0.15	287.1	0.13
Ironwood	3,716	283.2	283.0	-0.13	283.2	0.09
University	4,046	288.0	287.9	-0.12	288.1	0.08
Membro	4,298	283.0	283.0	-0.03	283.0	0.02
Paisley	4,316	302.2	302.1	-0.06	302.2	0
Dean Ave	4,406	290.2	290.1	-0.04	290.2	0.02
Edinburgh	4,549	288.1	288.1	-0.03	288.1	0.02
Water Street	4,877	289.8	289.7	-0.04	289.8	0.02
Hauser	5,703	318.3	318.2	-0.03	318.3	0
Smallfield	6,020	313.7	313.7	-0.03	313.7	0
Burke	6,290	323.4	323.4	0	323.4	0
Calico	6,648	306.1	306.1	-0.02	306.1	0
Sacco	7,114	321.4	321.4	-0.02	321.4	0
Carter Wells	7,360	319.0	319.0	0	319.0	0
Park 1 and 2	7,666	281.2	281.1	-0.02	281.2	0.01
Emma	7,749	280.1	280.1	-0.02	280.1	0
Guelph Southeast	9,298	290.7	290.7	0	290.7	0
Clythe	9,391	309.3	309.3	-0.01	309.3	0
Guelph North	10,089	305.3	305.3	0	305.3	0
Helmar	10,193	322.2	322.2	-0.01	322.2	0
Arkell 15	10,641	308.6	308.6	-0.01	308.6	0
Arkell 1	10,723	321.5	321.5	0	321.5	0
Arkell 7	10,757	308.3	308.3	-0.01	308.3	0
Fleming	11,052	310.1	310.1	0	310.1	0
Arkell 6	11,130	310.0	310.0	0	310.0	0
Arkell 8	11,149	310.2	310.2	0	310.2	0
Arkell 14	11,284	310.2	310.2	-0.01	310.2	0
Logan	11,818	279.2	279.2	-0.01	279.2	0

Notes:
(1) Baseline head is the simulated water level in the municipal pumping wells under the Excavation Scenario 4 pumping regime when no excavation is present.
(2) Excavation heads are the simulated water levels under the Excavation Scenario 4 pumping regime with the excavation present.
(3) Injection heads are the simulated water levels under the Excavation Scenario 4 pumping regime with the excavation present, and with injection simulated into the Gasport Fm at 500 m^3/d.
(4) The difference between baseline and excavation indicates drawdown associated with excavation (negative values). The difference between baseline and injection indicates recovery associated with the injection well (positive values).
Highlighted cells indicate wells within 5 km where water levels recover above the baseline head in the injection scenario.

Table 9 Injection Scenario: Recovery at Private Wells

Water Well Record ID	Distance from Proposed Dewatering Sump (m)	Simulated Aquifer Unit at Midpoint of Open Hole	Estimated Drawdown from Private Well Use Only (m)	Simulated Available Drawdown (m)	Total Estimated Drawdown (m) (from Private Well Use + Excavation Dewatering)	
					Excavation	Excavation + Injection
6703318	1,384	Goat Island Fm.	5.5	4	6.2	6
6705230	1,283	Guelph Fm.	3.7	3.9	6.1	6
6706927	944	Reformatory Quarry Mbr.	24.7	22.6	29	29
6707288	1,351	Guelph Fm.	8.5	9.7	10.7	10.6
6707880	1,306	Guelph Fm.	1.7	3.8	4.1	4
6708796	734	Guelph Fm.	6.1	4.9	6.2	6.1
6710019	873	Goat Island Fm.	3.6	38.1	4.1	3.6
6711941	1,483	Guelph Fm.	2.9	5.8	4	3.9
6712349	1,381	Guelph Fm.	2.7	10.4	4	3.8
6712388	799	Guelph Fm.	7.3	16.5	13.1	13
7334558	692	Reformatroy Quarry Mbr.	17.7	27.4	24	24
6712571	1,011	Goat Island Fm.	7	5.3	7.5	7.1

Note:
Blue highlighted cells show wells that partially recover with reinjection.

Table 10 Injection Scenario: Quarry Water Balance

	No Excavation	Excavation	Excavation + Injection
Groundwater in from quarry wall	65%	93%	93%
Groundwater in from quarry floor	0.4%	7%	7%
Direct recharge	31%	0%	0%
Recharge from Site Ponds	4%	0%	0%
Groundwater out from quarry wall	78%	1%	1%
Groundwater out from quarry floor	5%	0%	0%
Surface water outflows (sump)	0%	99%	99%
Discharge from Site Ponds	17%	0%	0%
Sump Pumping Rate (m^3/d)		2,756	2,773

Notes:
Blue cells indicate inflows.
Orange cells indicate outflows.

Table 11 Injection Scenario: Change in Simulated Discharge to Speed River and Wetlands

Scale	Station	Estimated Gain in Baseflow (m^3/s)	Percent Change in Simulated Discharge		Change in Simulated Discharge as Percent of Total Estimated Baseflow	
			With Excavation	With Excavation + Injection	With Excavation	With Excavation + Injection
Local (Lafarge Site)	SW3 - upstream SW1 - downstream	0.04	-31%	-29%	0.4%	0.4%
Regional (Guelph to Cambridge)	02GA015 - Speed River Below Guelph 02GA047 - Speed River at Cambridge	1.83	-4%	-4%	0.4%	0.4%

5 SUMMARY AND CONSIDERATIONS

Numerical modelling was previously completed for the City and Lafarge to assess the potential impacts of excavation to the full quarry excavation area footprint and dewatering to 285 m asl on City municipal well capacity and on adjacent surface water features (Matrix 2021a, 2021b). Additional scenarios were simulated in the current work to evaluate the potential impacts of excavation to the 10-year excavation footprint and the potential for injection wells to offset/mitigate these potential impacts.

The 10-year footprint excavation and dewatering without reinjection mitigates the reduction in municipal well flow capacity by 50 to 70% compared to the full license footprint excavation and dewatering simulated previously (Matrix 2021a, 2021b). Impacts to private wells and reduction in discharge to Speed River is similar under the 10-year and full license footprints and dewatering.

Potential impacts of the 10-year quarry excavation: Four steady state excavation scenarios were simulated to evaluate the potential impacts of the quarry excavation under distinct pumping regimes at municipal wells. All four scenarios produce evidence of potential impacts due to quarry dewatering and support the potential connection between the quarry and municipal wells, the Speed River, and private wells near the Lafarge site. Scenario 4, representing future operational rates as defined in the WSMP, resulted in the largest aggregate reduction in flow capacity at municipal wells and was identified as the scenario best suited to evaluate the efficacy of an injection well on Lafarge property to mitigate potential impacts. The steady state excavation scenarios considered long-term average climate conditions. Two transient simulations evaluating drought conditions demonstrate that impacts at municipal wells may be enhanced by drought.

Potential mitigation due to injection well: A single simulated injection well injecting at a rate of 500 m^3/d, located at the southeast corner of the quarry on Lafarge property and open within the Upper Gasport Fm, was found to have the potential to offset impacts at municipal and private wells. The simulated injection well eliminated simulated drawdown at municipal pumping wells associated with the 10-year excavation and reduced simulated drawdown at all but private wells. However, groundwater levels were still

simulated exceed available drawdown in all private wells. Injection below the Vinemount Member was most effective within the Middle Gasport as compared to the Guelph Formation. Furthermore, there was minimal reduction in impacts to the Speed River with injection below the Vinemount Member.

The simulated results do not account for any potential discontinuities between the quarry and the municipal wells not currently represented by available data. The presence of additional discontinuities in the Vinemount aquitard could reduce the effectiveness of the reinjecting water. Additional wells or other approaches may be required to achieve mitigation. In addition, the model assumes an ideal injection well with no well-bore efficiency or fractured rock considerations and may overestimate the effectiveness of this well. Therefore, the model predictions should be refined and validated with additional field data and hydraulic testing as part of an overall feasibility study. Furthermore, since the deep aquifers are used as a source of drinking water, the water quality compatibility between shallow water being pumped from the sump and being reinjected into the deeper Goat Island and Gasport aquifers would need to be assessed in line with relevant regulations and policies.

The 10-year footprint excavation and injection scenario simulations thus support the hypothesis that the quarry excavation and dewatering may result in potential impacts at municipal wells which may be enhanced under drought conditions, and that these impacts may be mitigated by an injection well on Lafarge property. This hypothesis must be further tested by field programs for injection and response.

6 CLOSURE

We trust that this letter report suits your present requirements. If you have any questions or comments, please call either of the undersigned at 403.237.0606.

Yours truly,

MATRIX SOLUTIONS INC.
A Montrose Environmental Company

Mark Ranjram, Ph.D., E.I.T.
Hydrogeological EIT

Reviewed by

PROFESSIONAL GEOSCIENTISTS ONTARIO
DARON G. ABBEY
PRACTISING MEMBER
0697

February 9, 2024

Daron Abbey, M. Sc., P.Geo.
Practice Lead, Geosciences

MR/pg
Attachments

copy: Scott Cousins, City of Guelph, Guelph, Ontario

CONTRIBUTORS

Name	Job Title	Role
Mark Ranjram, Ph.D., E.I.T	Hydrogeological Engineer-in-Training	Primary Author
Daron Abbey, M.Sc., P.Geo.	Practice Lead, Geosciences	Geoscientist of Record
Jeff Melchin, M.Sc., P.Geo.	Hydrogeologist	Contributing Author

VERSION CONTROL

Version	Date	Issue Type	Filename	Description
V0.1	2023-11-09	Draft	195880-15072-528 Lafarge Dewatering LR 2023-11-09 draft V0.1.docx	Issued to client for review
V1.0	2023-12-12	Final	195880-15072-528 Lafarge Dewatering LR 2023-12-11 final V1.0.docx	Issued to client
V2.0	2024-02-09	Final Revised	195880-15072-528 Lafarge Dewatering LR 2024-02-09 final V2.0.docx	Edit to disclaimer, issued to client

REFERENCES

AECOM Canada Ltd. (AECOM). 2022. *Final Water Supply Master Plan Update*. Prepared for the City of Guelph. Kitchener, Ontario. July 2022.

Golder Associated Ltd. (Golder). 2019. *Lafarge Guelph Pit/Quarry, Quarry Dewatering and Water Use Investigation*. May 2019.

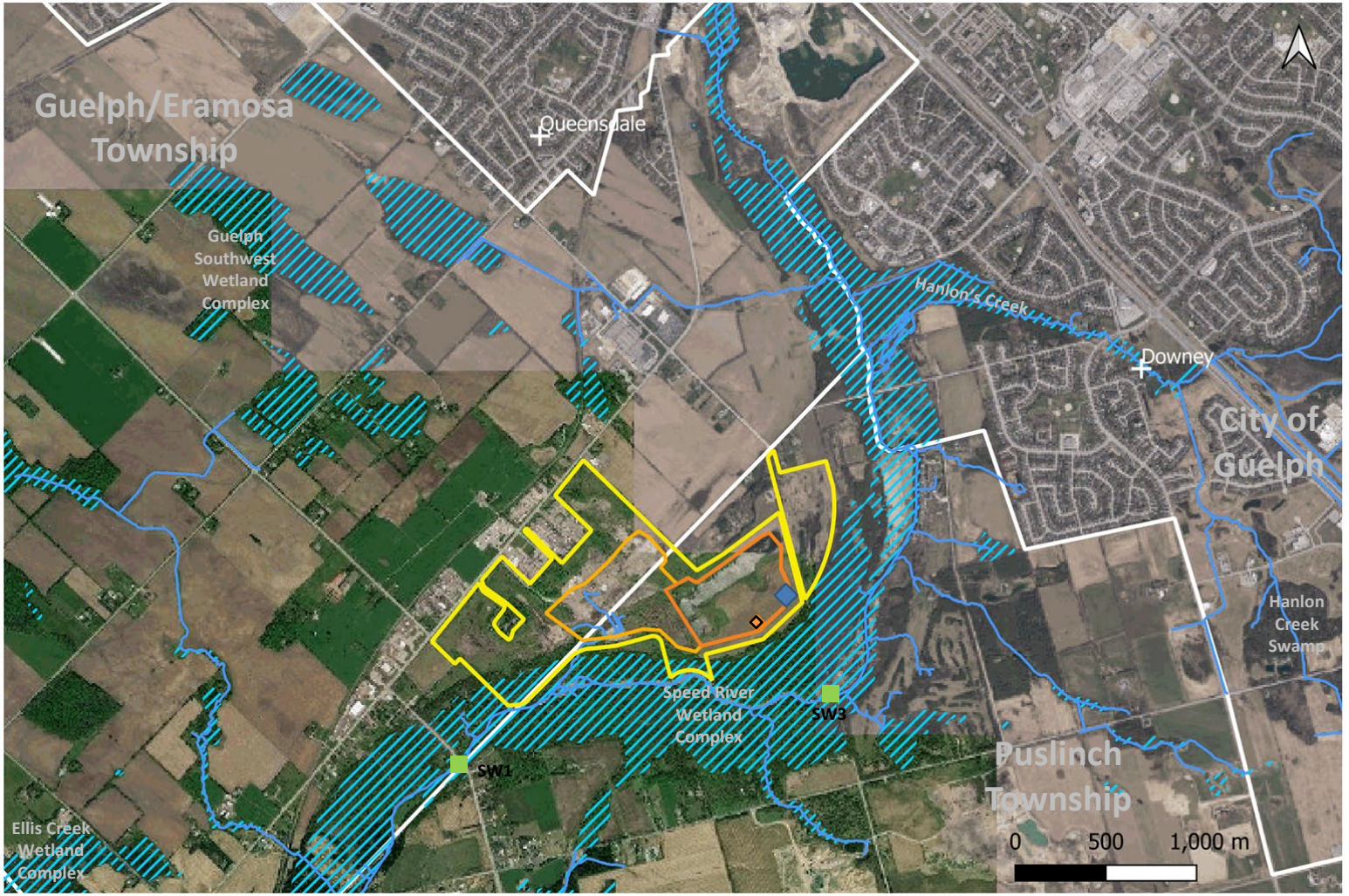
Lafarge Canada Inc. (Lafarge). 2022. *Terms of Reference for Groundwater Flow Modelling of the 10 Year Quarry Excavation Footprint of the Wellington Quarry*. September 2022.

Matrix Solutions Inc. (Matrix). 2021a. *Groundwater Modelling Report for Amendment of the Permit to Take Water for the Lafarge Canada Inc. Wellington County Quarry*. Version 1.0. Prepared for the City of Guelph and Lafarge Canada Inc. Guelph, Ontario. May 2021.

Matrix Solutions Inc. (Matrix). 2021b. *Private Water Well Impact Evaluation for Lafarge Canada Inc. Wellington County Quarry*. Version 1.0. Prepared for the City of Guelph. Guelph, Ontario. June 8, 2021.

Matrix Solutions Inc. (Matrix). 2021c. "Groundwater Modelling Report for Amendment of the Permit to Take Water for the Lafarge Canada Inc. Wellington County Quarry." Version 0.2. Draft prepared for City of Guelph and Lafarge Canada Inc. Guelph, Ontario. February 2021.

Matrix Solutions Inc. (Matrix). 2017. *City of Guelph and Township of Guelph/Eramosa, Tier Three Water Budget and Local Area Risk Assessment*. Prepared for Lake Erie Source Protection Region. Breslau, Ontario. March 2017.



Wetland

Watercourse

Municipal Well

Surface Water Station

Previous Sump Location

Lafarge Property Boundary

Lafarge excavation Area – Full License Limit

Lafarge excavation Area – 10-year Footprint

Sump Location

Matrix Solutions Inc.
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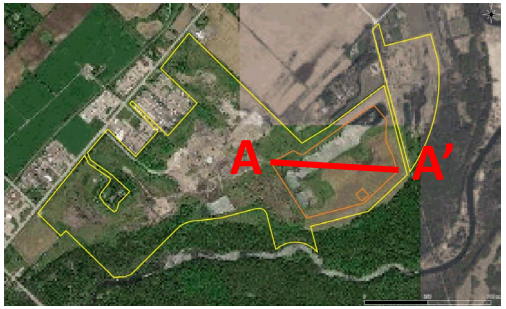
City of Guelph
Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Study Site

Date:	Project:	Technical:	Reviewer:
November 2023	15072	M. Ranjram	D. Abbey

Figure 1

Hydraulic Conductivity
[m/s]
- 0.1
- 0.01
- 0.001
- 0.0001
- 1e-05
- 1e-06
- 1e-07
- 1e-08
- 1e-09
- 1e-10



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City of Guelph

Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Stratigraphic Cross-section Through 10-year Quarry Excavation Area

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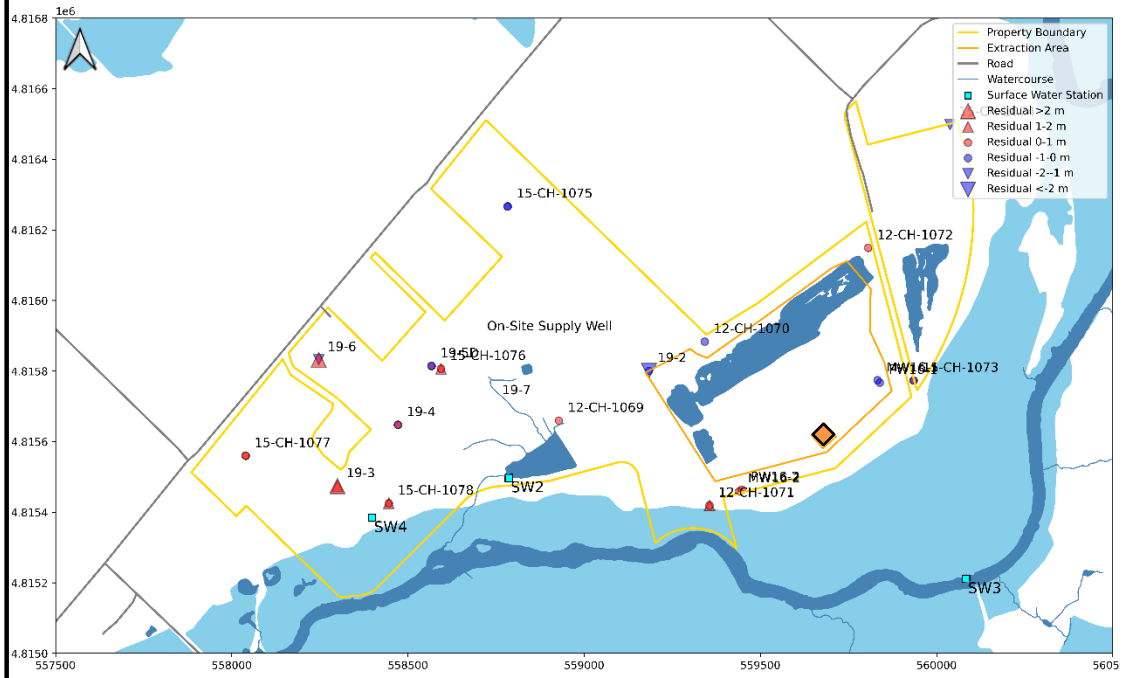
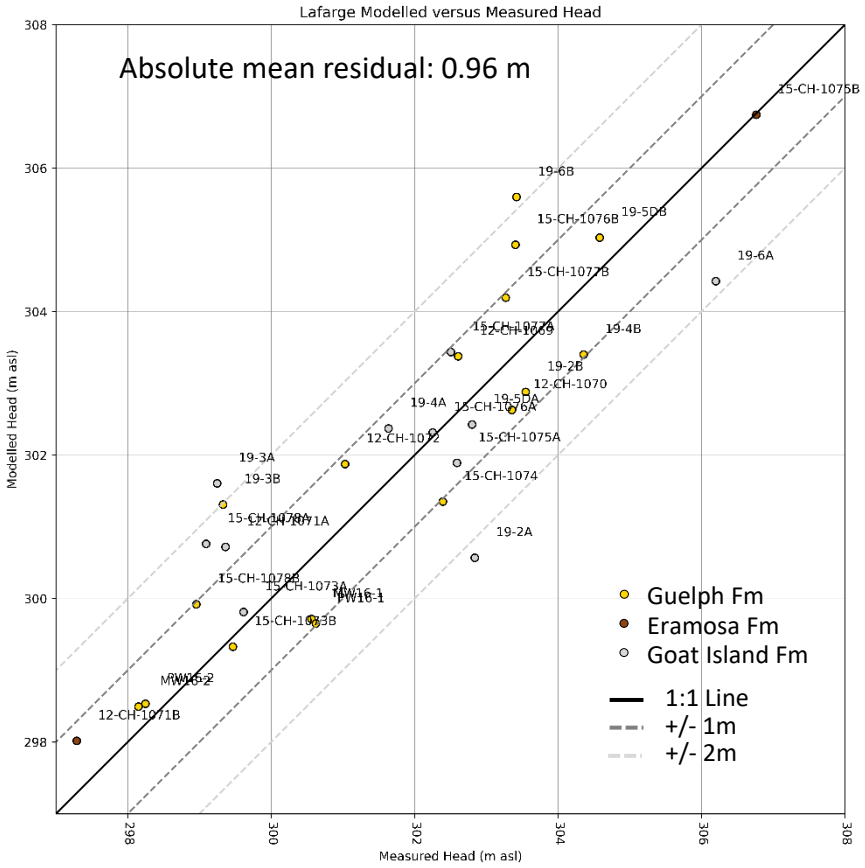
Figure 2





Lafarge Property Boundary
Lafarge Excavation Area - 10-year footprint
Road
Watercourse

Surface Water Station
Sump Location

Hydraulic Head Residual
[modelled – measured; m]

>2
1-2
0-1
-1-0
-2--1

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City of Guelph
Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Local Water Level Calibration Summary

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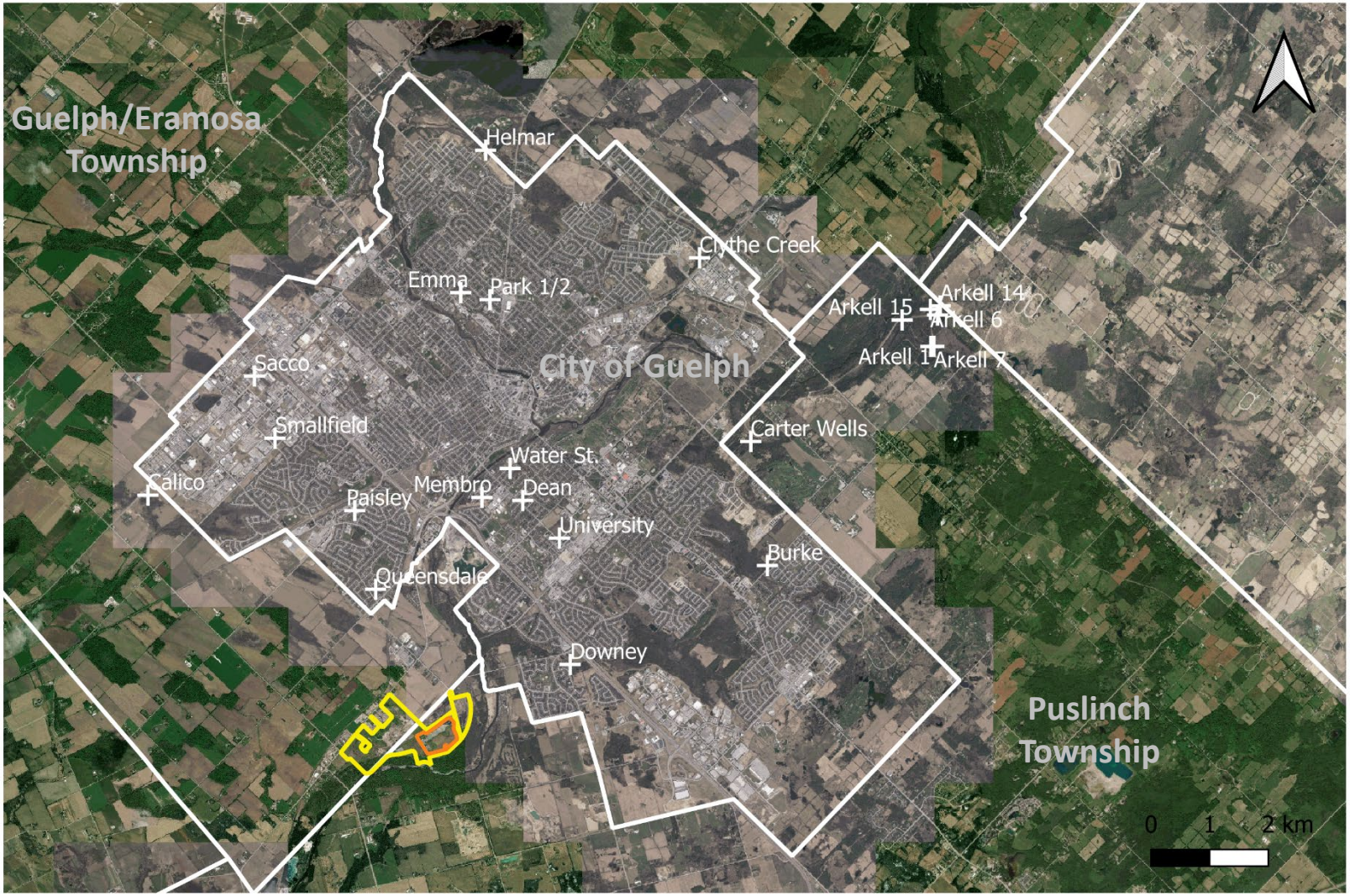
November 2023	15072	M. Ranjram	D. Abbey

Figure 3



Municipal Well

Lafarge Property Boundary

Lafarge Excavation Area – 10-year Footprint

Base of excavation at 285 m asl

Matrix Solutions Inc.
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City of Guelph

Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Municipal Well Locations

Date:	Project:	Technical:	Reviewer:
November 2023	15072	M. Ranjram	D. Abbey

Figure 4

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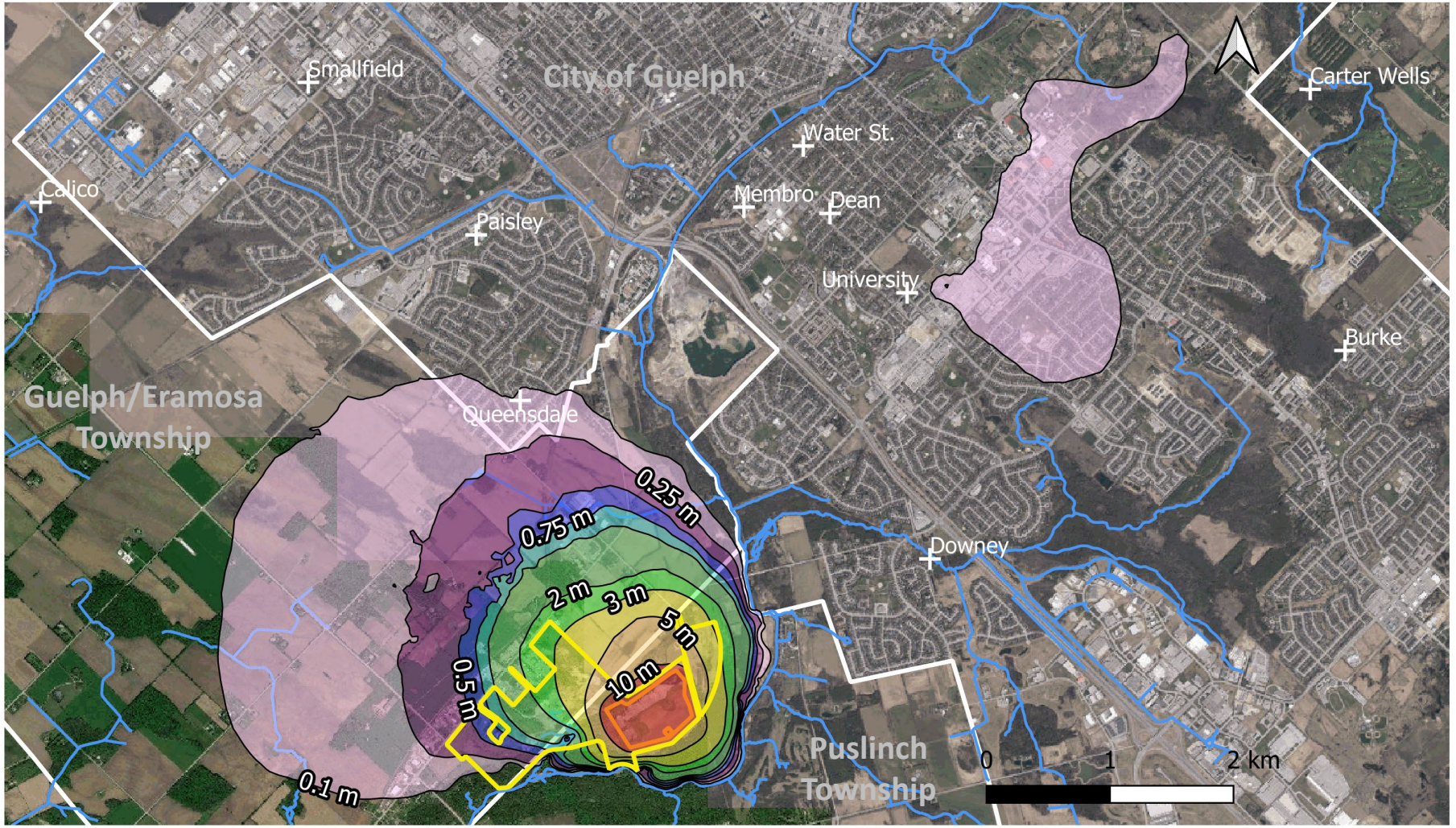

- Lafarge Property Boundary
- 10-Year Excavation Area
- Watercourse
- Municipal Well

Simulated Drawdown Interval

- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 0.75 m
- 0.75 - 1 m
- 1 - 2 m
- 2 - 3 m
- 3 - 5 m
- 5 - 10 m
- >10 m

Base of excavation at 285 m asl

Note: Drawdown contours were exported from model slice 5.

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City of Guelph

Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Excavation Scenario 1 (Tier Three 2008 Rates) - Additional Simulated Drawdown in Guelph Fm.

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November 2023	15072	M. Ranjram	D. Abbey

Figure 5

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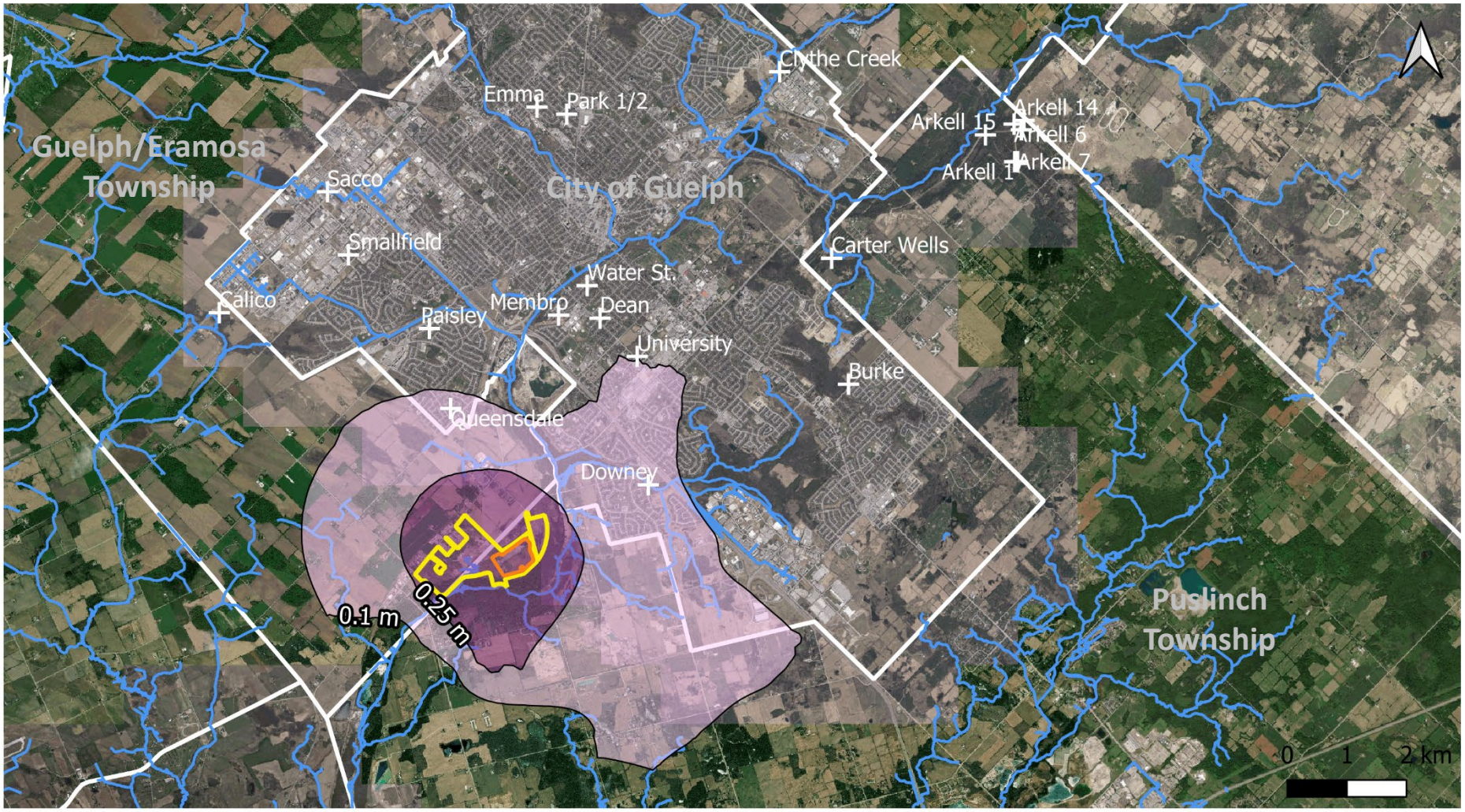

- Lafarge Property Boundary
- 10-Year Excavation Area
- Watercourse
- Municipal Well

Simulated Drawdown Interval

- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 0.75 m
- 0.75 - 1 m
- 1 - 2 m
- 2 - 3 m
- 3 - 5 m
- 5 - 10 m
- >10 m

Base of excavation at 285 m asl

Note: Drawdown contours were exported from model slice 14.

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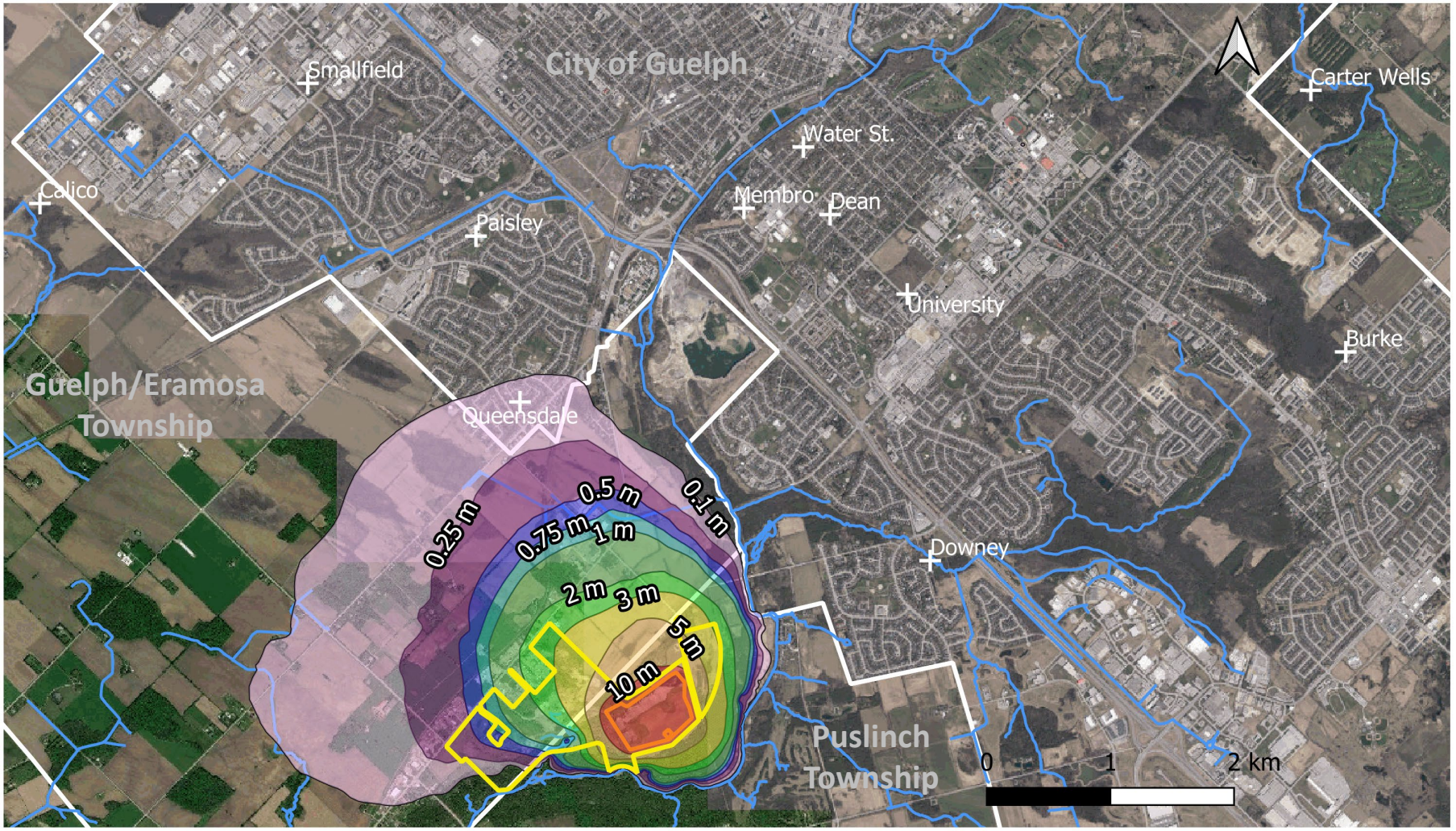
Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Excavation Scenario 1 (Tier Three 2008 Rates) - Additional Simulated Drawdown in Middle Gasport Fm.

Date:	Project:	Technical:	Reviewer:
November 2023	15072	M. Ranjram	D. Abbey

Figure 6



Lafarge Property Boundary
10-Year Excavation Area
Watercourse
Municipal Well

Simulated Drawdown Interval

- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 0.75 m
- 0.75 - 1 m
- 1 - 2 m
- 2 - 3 m
- 3 - 5 m
- 5 - 10 m
- >10 m

Base of excavation at 285 m asl
Note: Drawdown contours were exported from model slice 5.

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Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Excavation Scenario 2 (WSMP Current Capacity Rates) - Additional Simulated Drawdown in Guelph Fm.

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Figure 7

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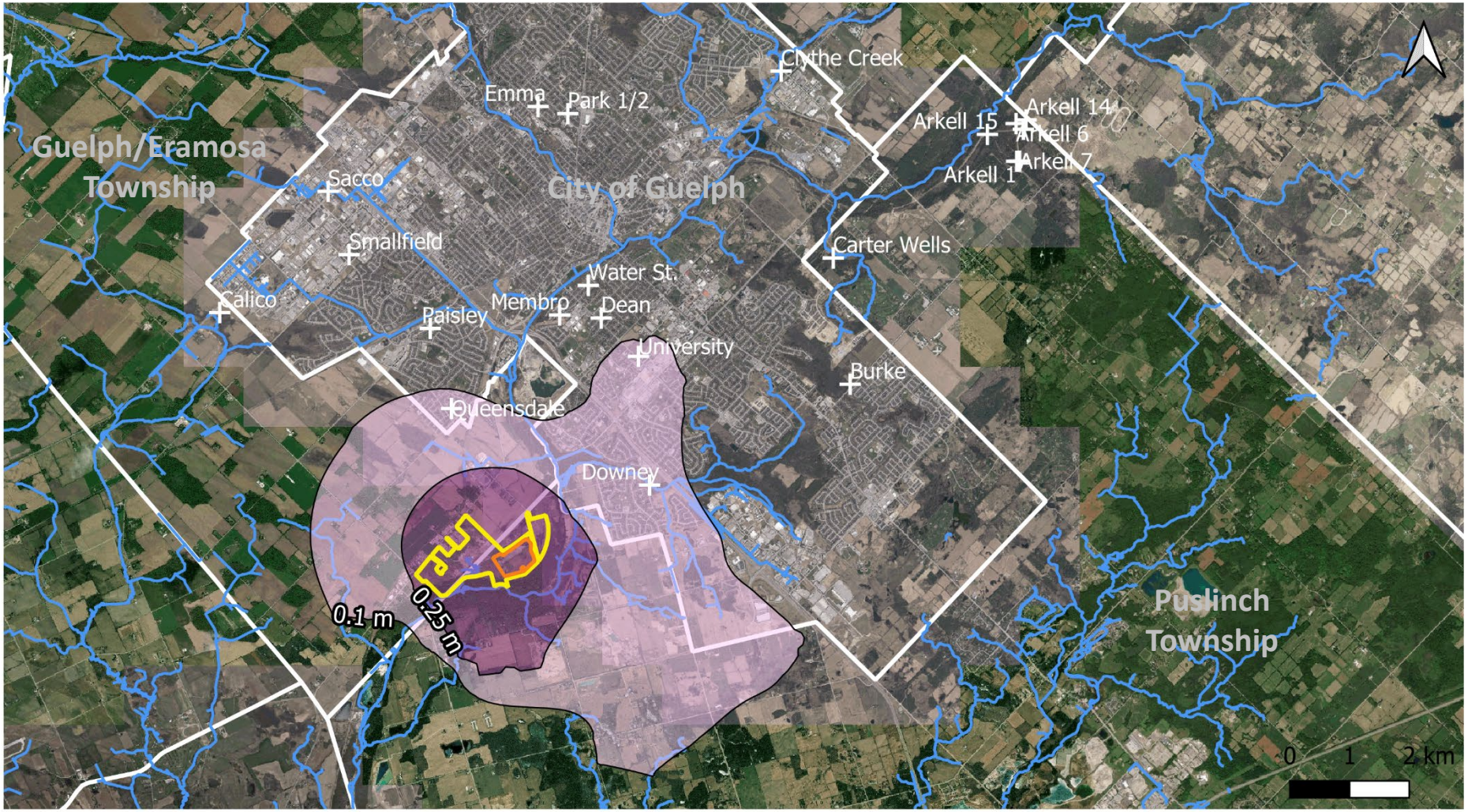

- Lafarge Property Boundary
- 10-Year Excavation Area
- Watercourse
- Municipal Well

Simulated Drawdown Interval

- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 0.75 m
- 0.75 - 1 m
- 1 - 2 m
- 2 - 3 m
- 3 - 5 m
- 5 - 10 m
- >10 m

Base of excavation at 285 m asl

Note: Drawdown contours were exported from model slice 14.

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Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Excavation Scenario 2 (WSMP Current Capacity Rates) - Additional Simulated Drawdown in Middle Gasport Fm.

Date:	Project:	Technical:	Reviewer:
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Figure 8

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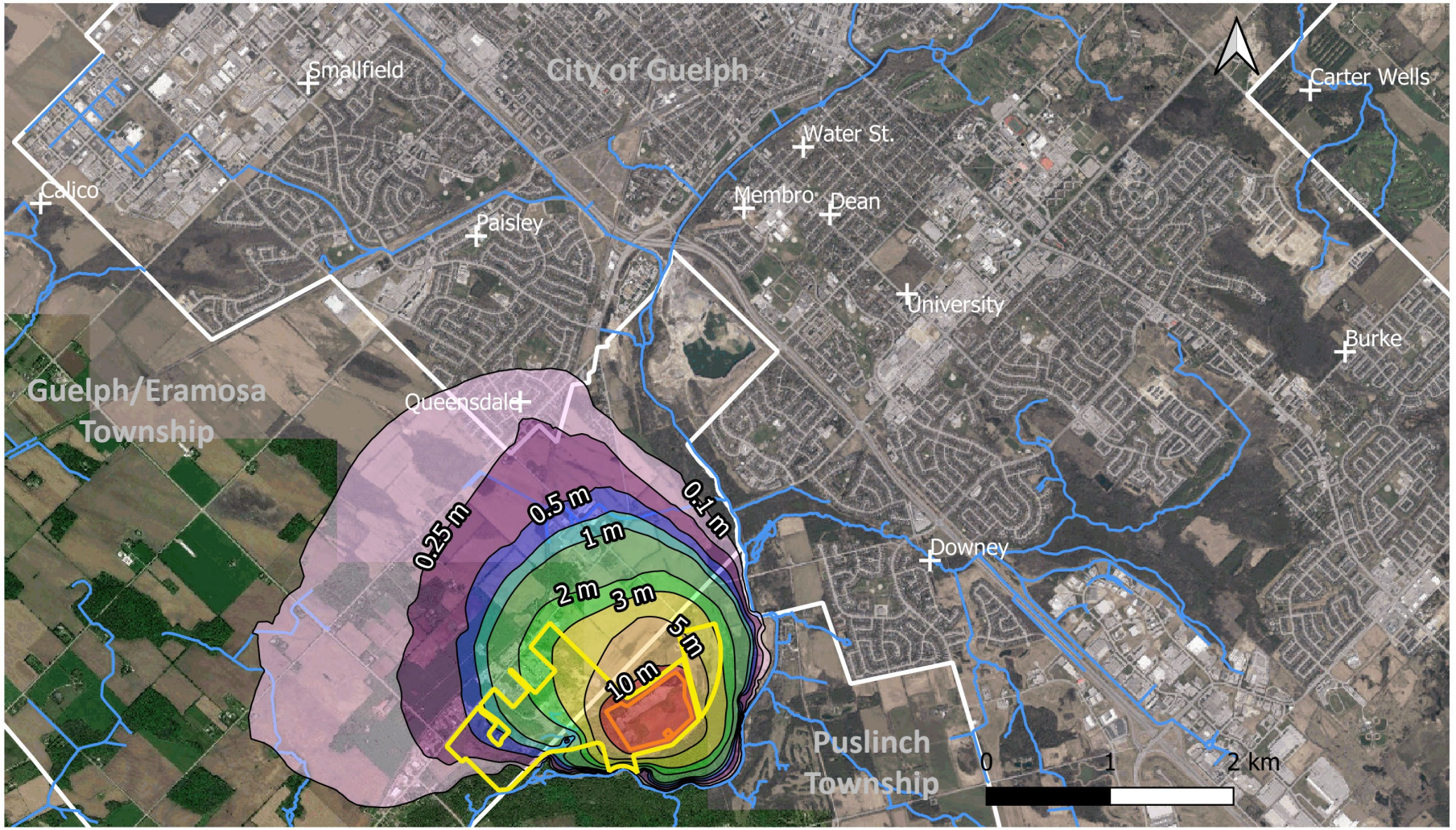

Lafarge Property Boundary
10-Year Excavation Area
Watercourse
Municipal Well

Simulated Drawdown Interval

- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 0.75 m
- 0.75 - 1 m
- 1 - 2 m
- 2 - 3 m
- 3 - 5 m
- 5 - 10 m
- >10 m

Base of excavation at 285 m asl
Note: Drawdown contours were exported from model slice 5.

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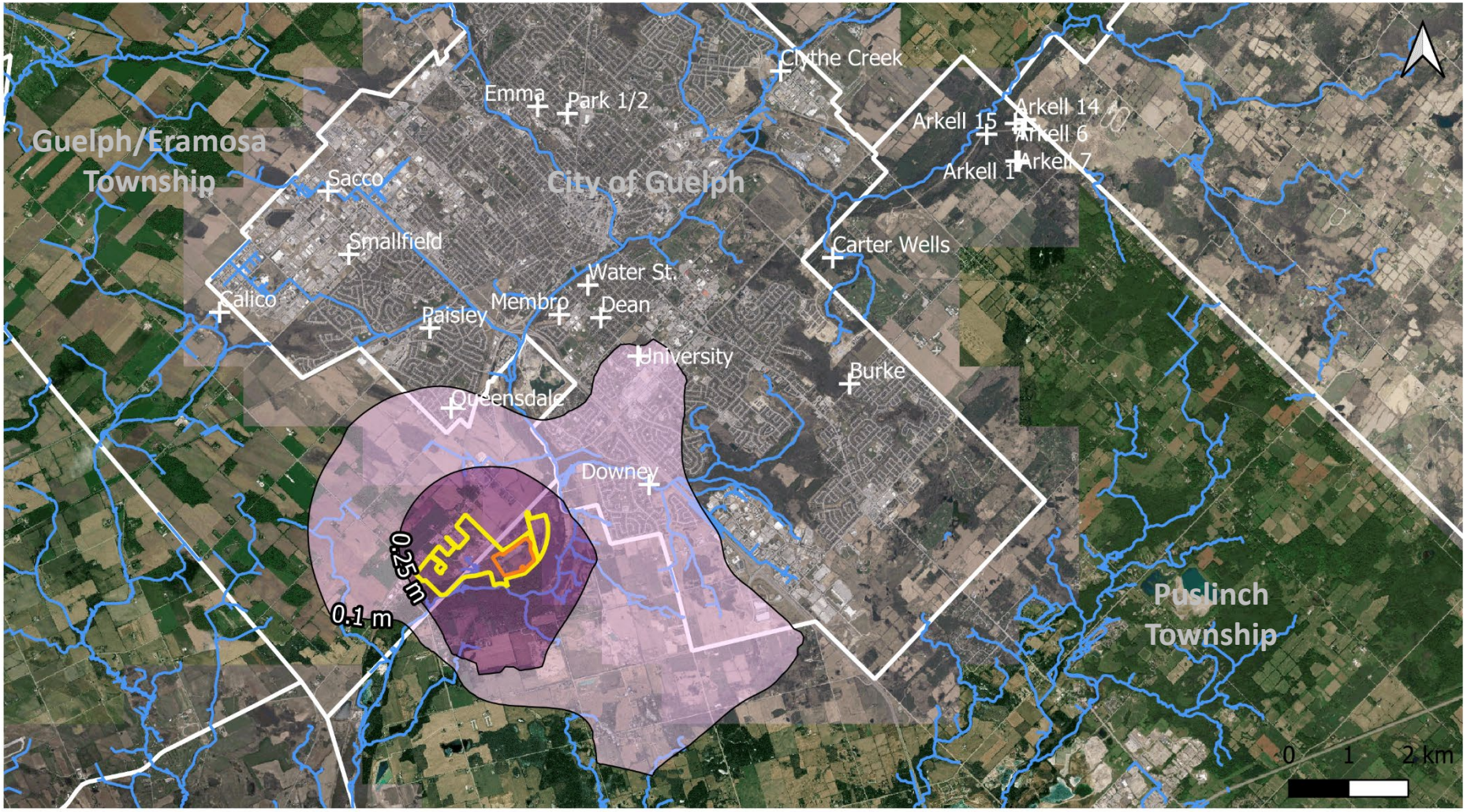
City of Guelph
Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Excavation Scenario 3 (Tier Three Future Allocated Rates) - Additional Simulated Drawdown in Guelph Fm.

Date:	Project:	Technical:	Reviewer:
November 2023	15072	M. Ranjram	D. Abbey

Figure 9



Lafarge Property Boundary
10-Year Excavation Area
Watercourse
Municipal Well

Simulated Drawdown Interval

- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 0.75 m
- 0.75 - 1 m
- 1 - 2 m
- 2 - 3 m
- 3 - 5 m
- 5 - 10 m
- >10 m

Base of excavation at 285 m asl
Note: Drawdown contours were exported from model slice 14.

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Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Excavation Scenario 3 (Tier Three Future Allocated Rates) - Additional Simulated Drawdown in Middle Gasport Fm.

Date:	Project:	Technical:	Reviewer:
November 2023	15072	M. Ranjram	D. Abbey

Figure 10

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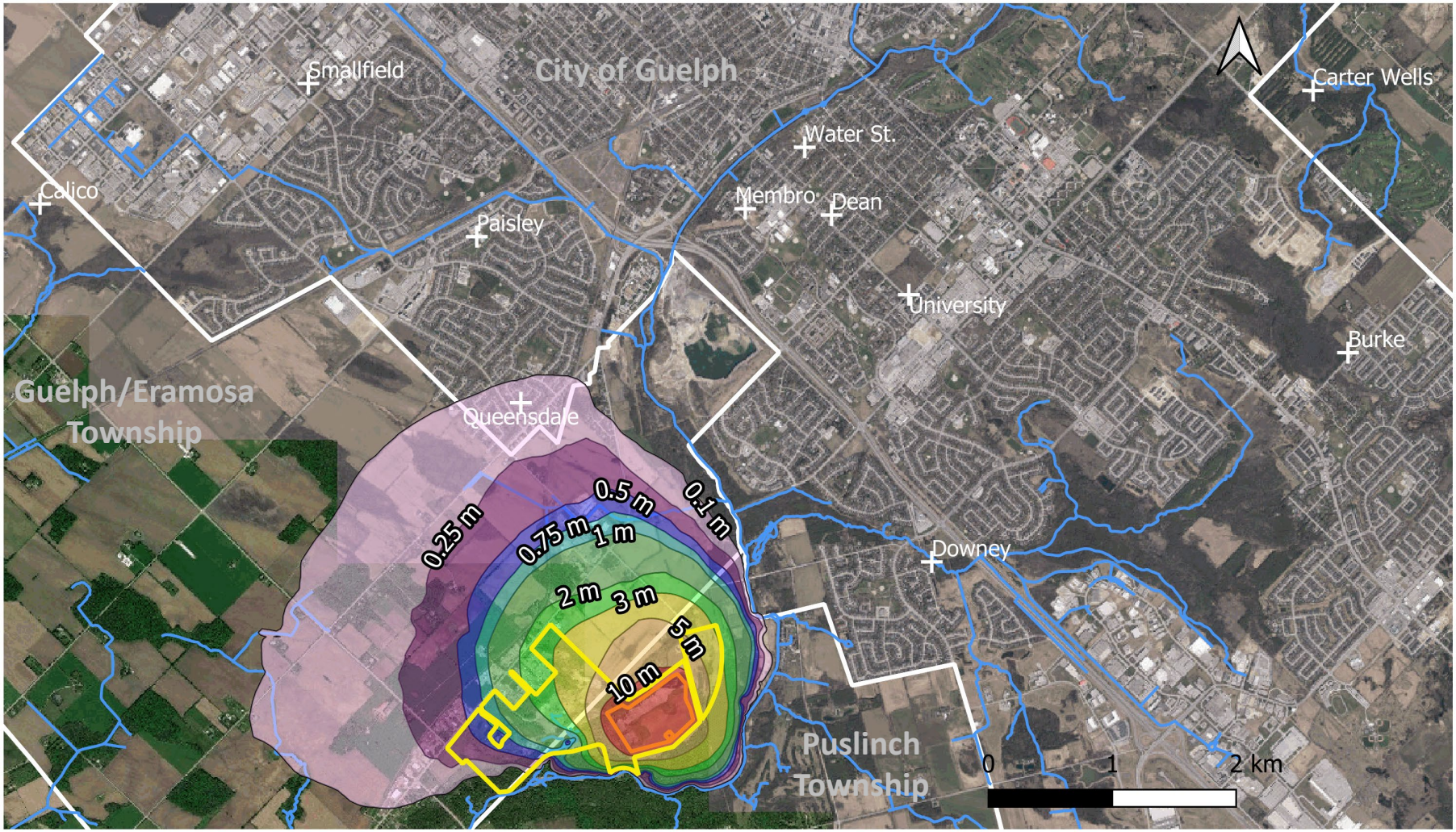

Lafarge Property Boundary
10-Year Excavation Area
Watercourse
Municipal Well

Simulated Drawdown Interval

- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 0.75 m
- 0.75 - 1 m
- 1 - 2 m
- 2 - 3 m
- 3 - 5 m
- 5 - 10 m
- >10 m

Base of excavation at 285 m asl
Note: Drawdown contours were exported from model slice 5.

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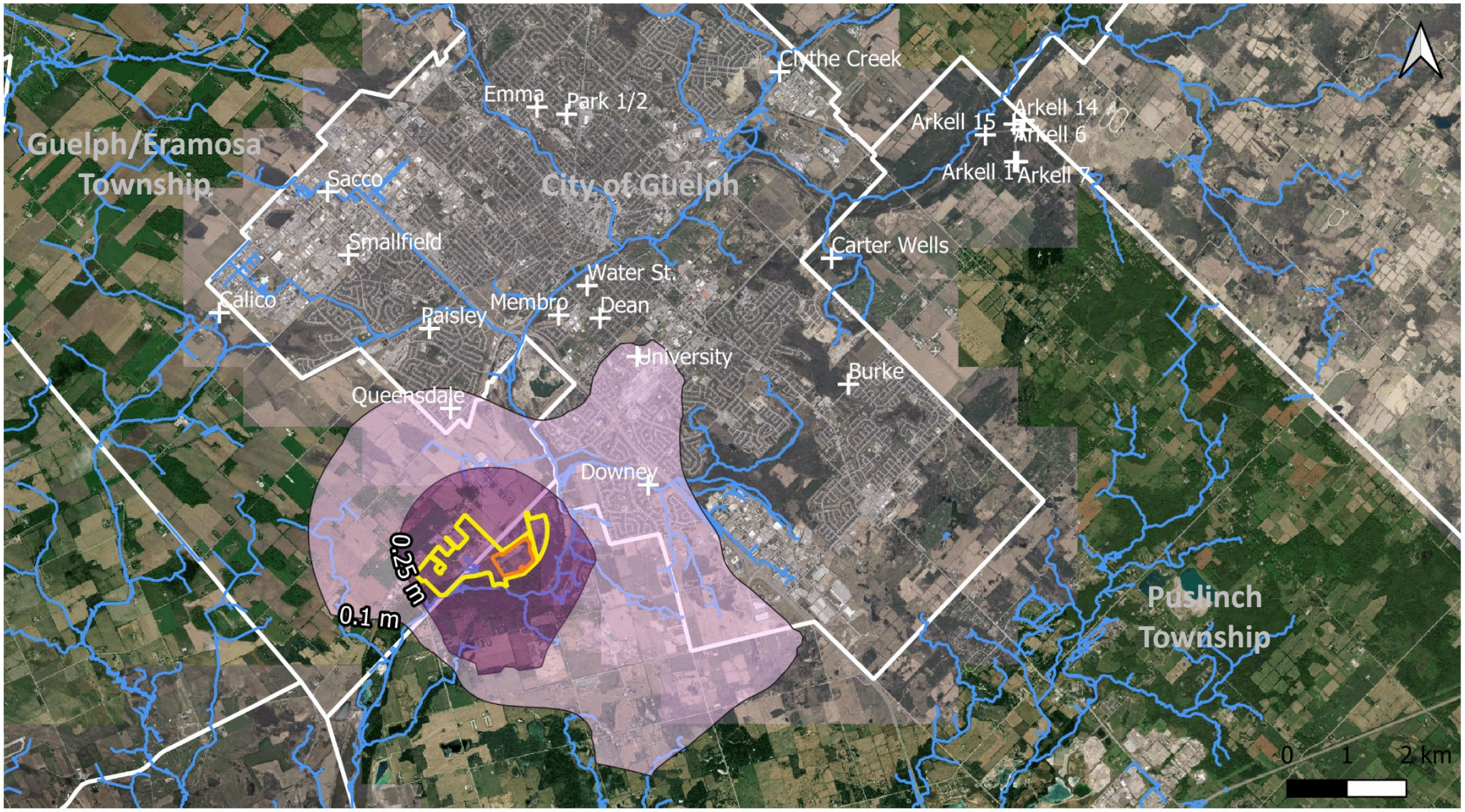
Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Excavation Scenario 4 (WSMP Future Capacity Rates) - Additional Simulated Drawdown in Guelph Fm.

Date:	Project:	Technical:	Reviewer:
November 2023	15072	M. Ranjram	D. Abbey

Figure 11



- Lafarge Property Boundary
- 10-Year Excavation Area
- Watercourse
- Municipal Well

Simulated Drawdown Interval

- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 0.75 m
- 0.75 - 1 m
- 1 - 2 m
- 2 - 3 m
- 3 - 5 m
- 5 - 10 m
- >10 m

Base of excavation at 285 m asl

Note: Drawdown contours were exported from model slice 14.

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Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Excavation Scenario 4 (WSMP Future Capacity Rates) - Additional Simulated Drawdown in Middle Gasport Fm.

Date:	Project:	Technical:	Reviewer:
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Figure 12

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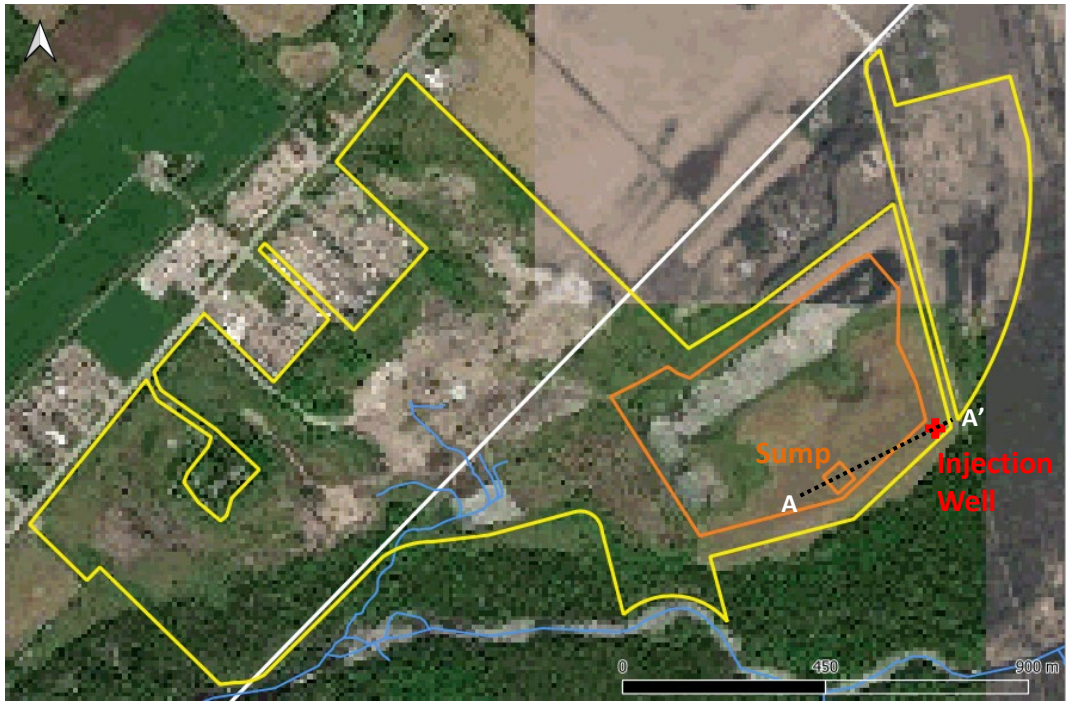

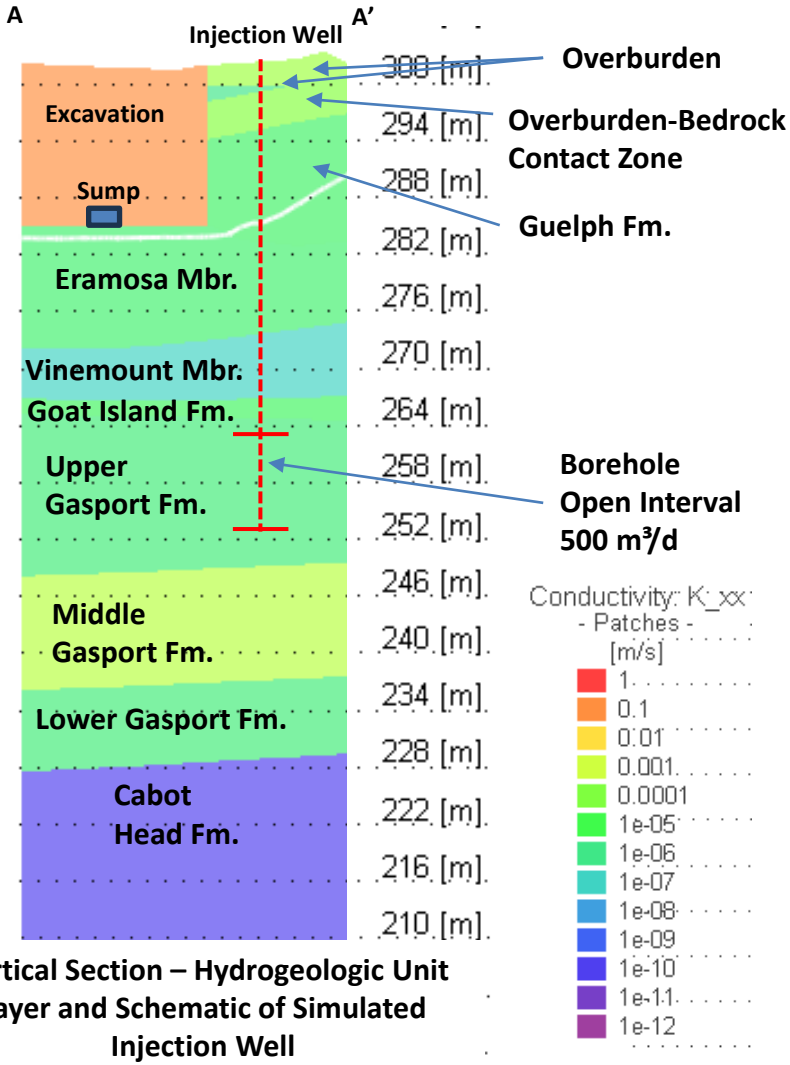

Vertical Section – Hydrogeologic Unit Layer and Schematic of Simulated Injection Well

Lafarge Property Boundary

Excavation Area – 10-year Footprint

Base of excavation at 285 m asl

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Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Injection Well Location and Location of Borehole Open Interval

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Figure 13

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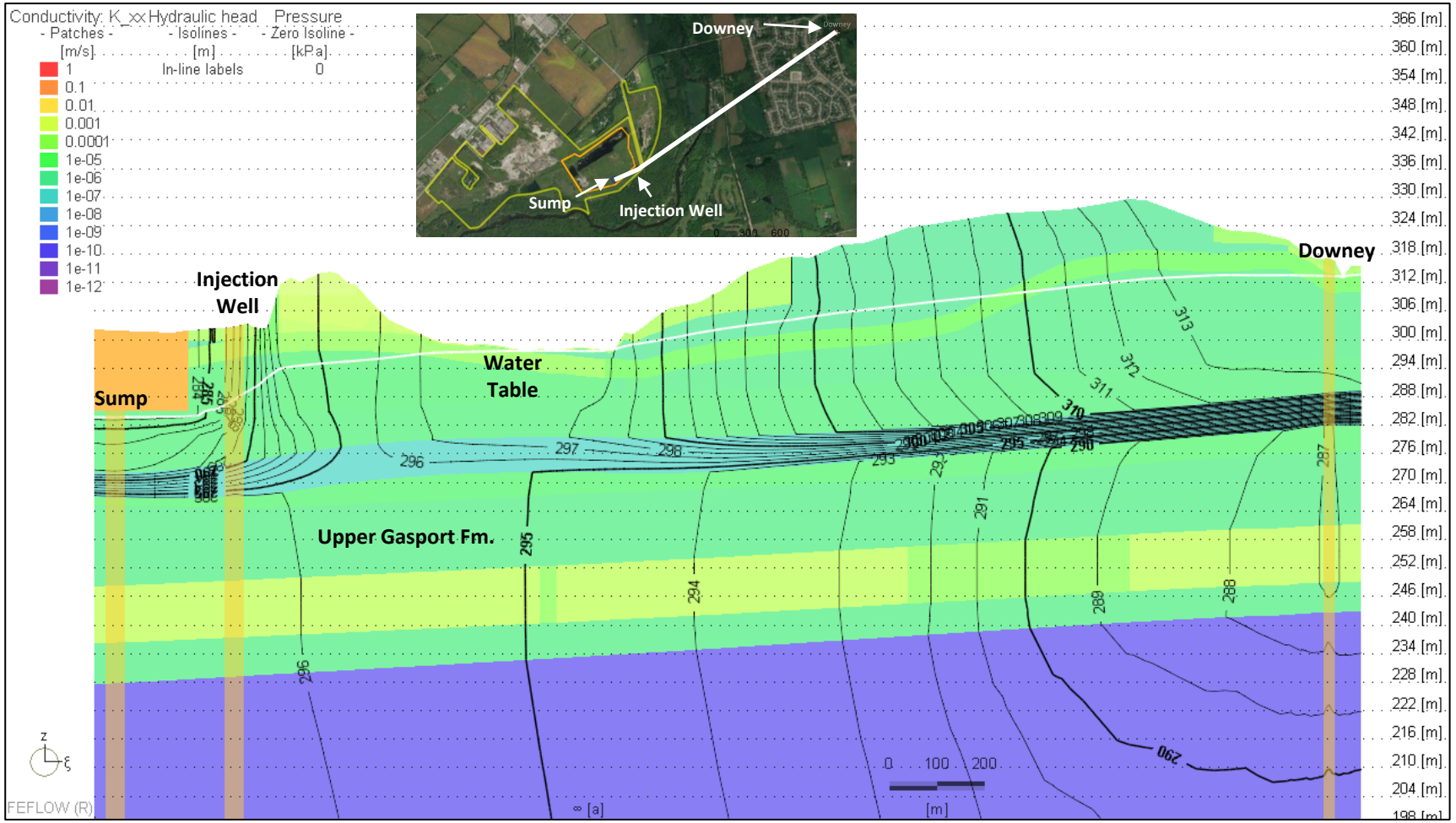

— Hydraulic Head (m asl)

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Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Injection Scenario – Simulated Drawdown Between Excavation and Downey Well

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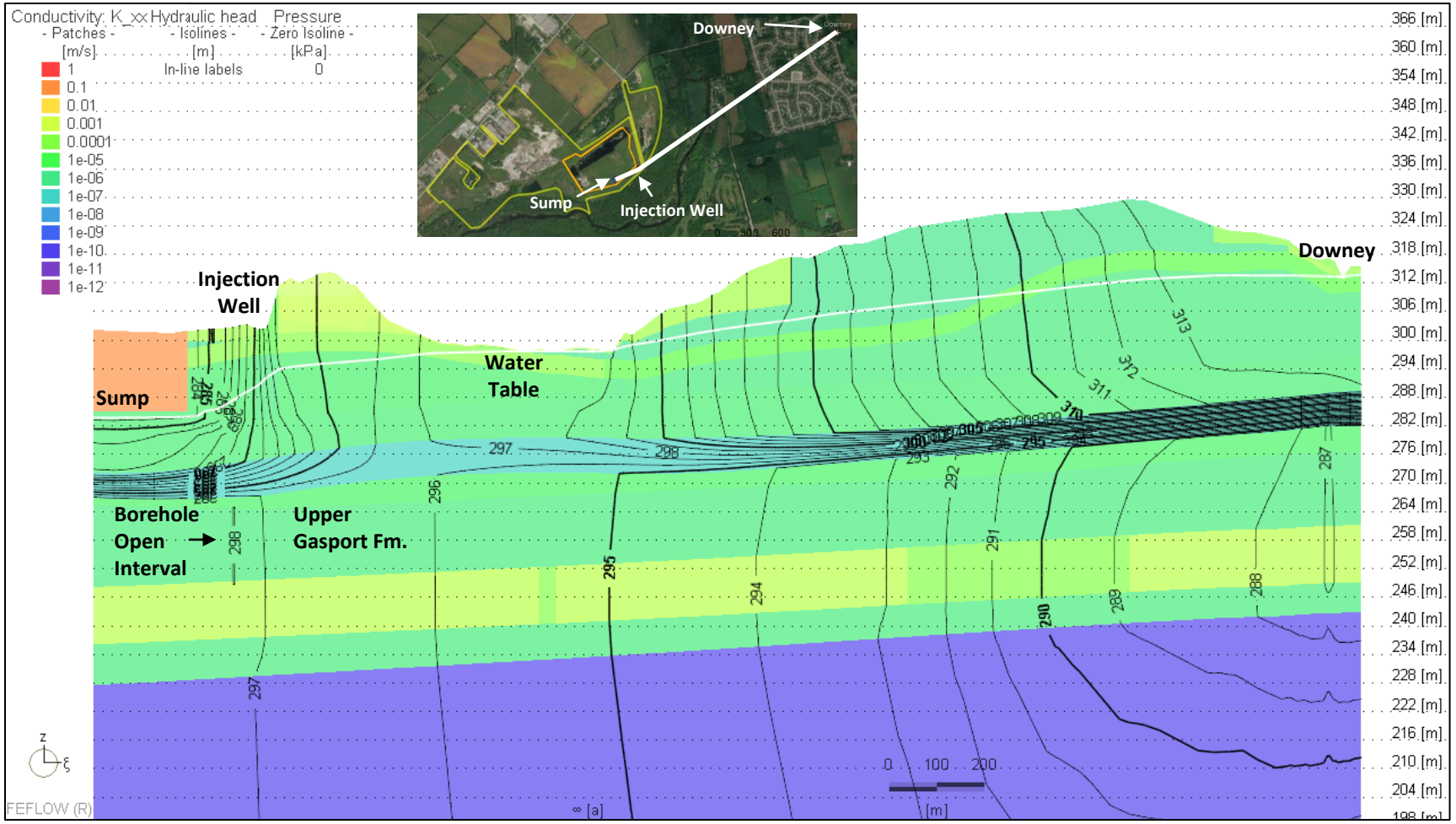
Figure 14



— Hydraulic Head (m asl)

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Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Injection Scenario – Simulated Recovery Between Excavation and Downey Well

Date:	Project:	Technical:	Reviewer:
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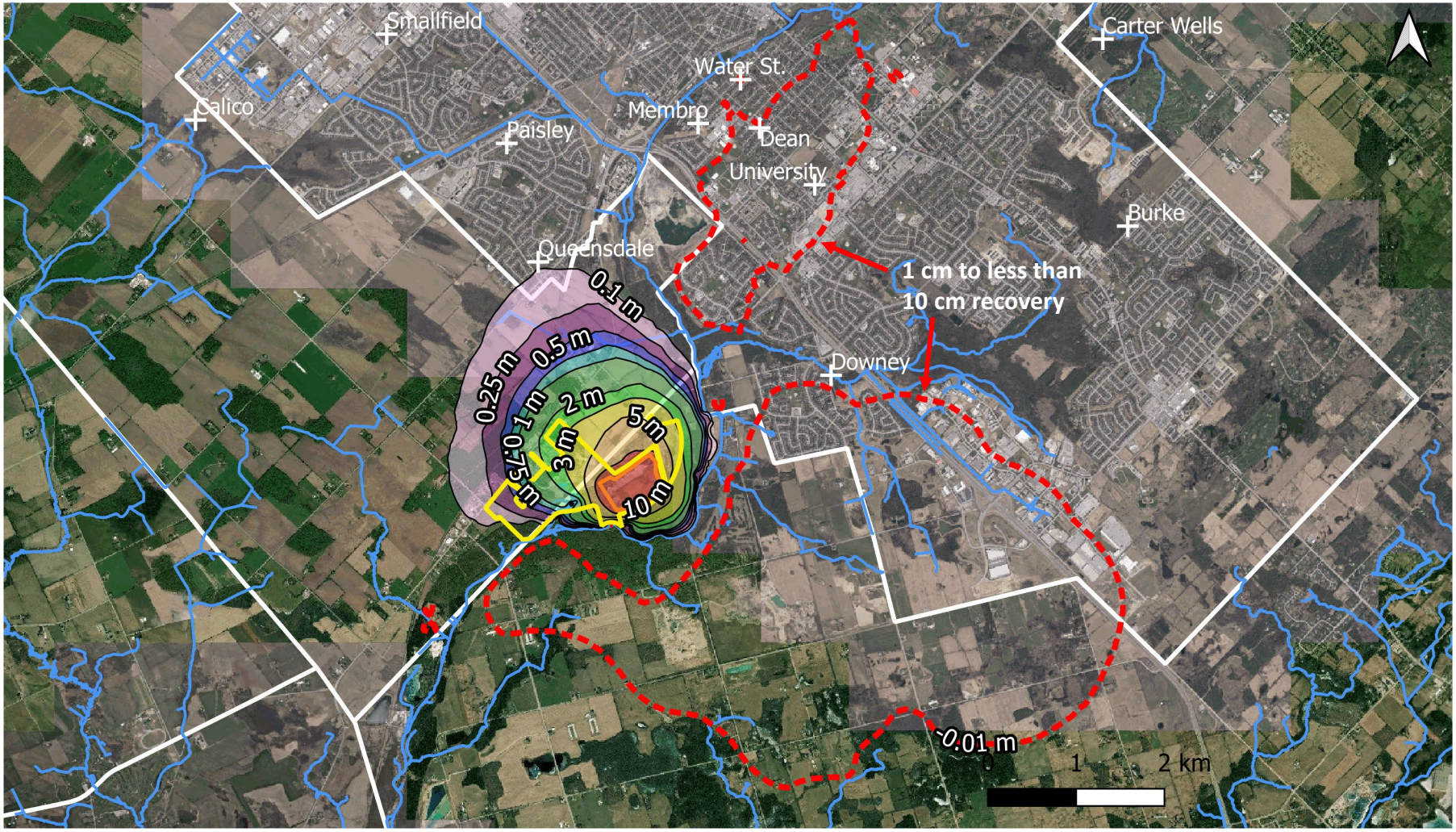
Figure 15



Lafarge Property Boundary
10-Year Excavation Area
Watercourse
Municipal Well
Simulated Recovery (m)

Base of excavation at 285 m asl
Note: Drawdown contours were exported from model slice 5.

Simulated Drawdown Interval

- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 0.75 m
- 0.75 - 1 m
- 1 - 2 m
- 2 - 3 m
- 3 - 5 m
- 5 - 10 m
- >10 m

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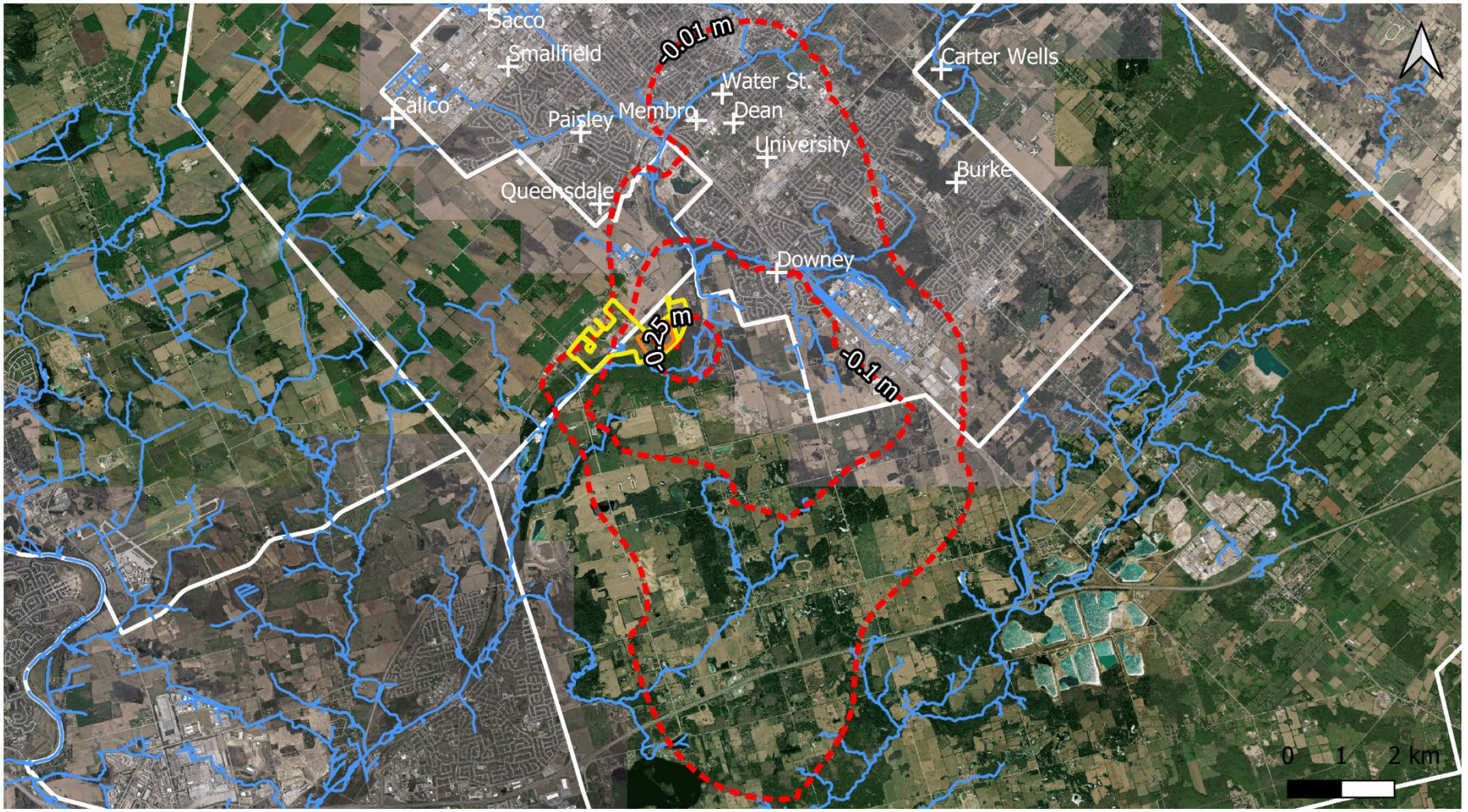
City of Guelph
Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Injection Scenario – Simulated Drawdown and Recovery in Guelph Fm.

Date:	Project:	Technical:	Reviewer:
November 2023	15072	M. Ranjram	D. Abbey

Figure 16



Lafarge Property Boundary
10-Year Excavation Area
Watercourse
Municipal Well
Simulated Recovery (m)

Base of excavation at 285 m asl
Note: Drawdown contours were exported from model slice 14.

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City of Guelph
Groundwater Modelling of the 10-year Lafarge Wellington Quarry Footprint

Injection Scenario – Simulated Recovery in Middle Gasport Fm.

Date:	Project:	Technical:	Reviewer:
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Figure 17

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