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22.0 CENTRE WELLINGTON TIER 3 WATER BUDGET AND RISK ASSESSMENT

This section describes the Tier 3 Water Budget and Risk Assessment (Tier 3 Assessment) completed for the Township of Centre Wellington's municipal drinking water system, located in Wellington County. This study was completed to evaluate the current and future sustainability of the Township's municipal water supply wells and to identify potential water quantity threats to the drinking water supply.

22.1 Introduction

Tier 3 Assessments aim to determine if a municipality is able to meet their current and future water demands. The Assessments estimate the likelihood that a municipal drinking water supply or surface water feature (i.e., river or lake) can sustain pumping at their future pumping rates, while accounting for the needs of other water uses such as coldwater streams, or other permitted water takers in the area. They also consider current and future municipal water demand, future land development plans, drought conditions, and other water uses as part of the evaluation.

Specific tasks completed within the Tier 3 Assessment include:

1. The development of a detailed mathematical model to predict whether or not municipal drinking water supplies can meet current or future municipal water demands;

2. Evaluation of whether the municipal drinking water source could reliably pump at its future pumping rates, while maintaining the requirements of other water uses (e.g. ecological requirements and other water takings);

3. Maps of water quantity Wellhead Protection Areas (areas that contributes water to a municipal drinking water system) and assigned risk levels to those areas; and

4. The identification of water quantity threats that may influence a municipality's ability to meet their future rates.

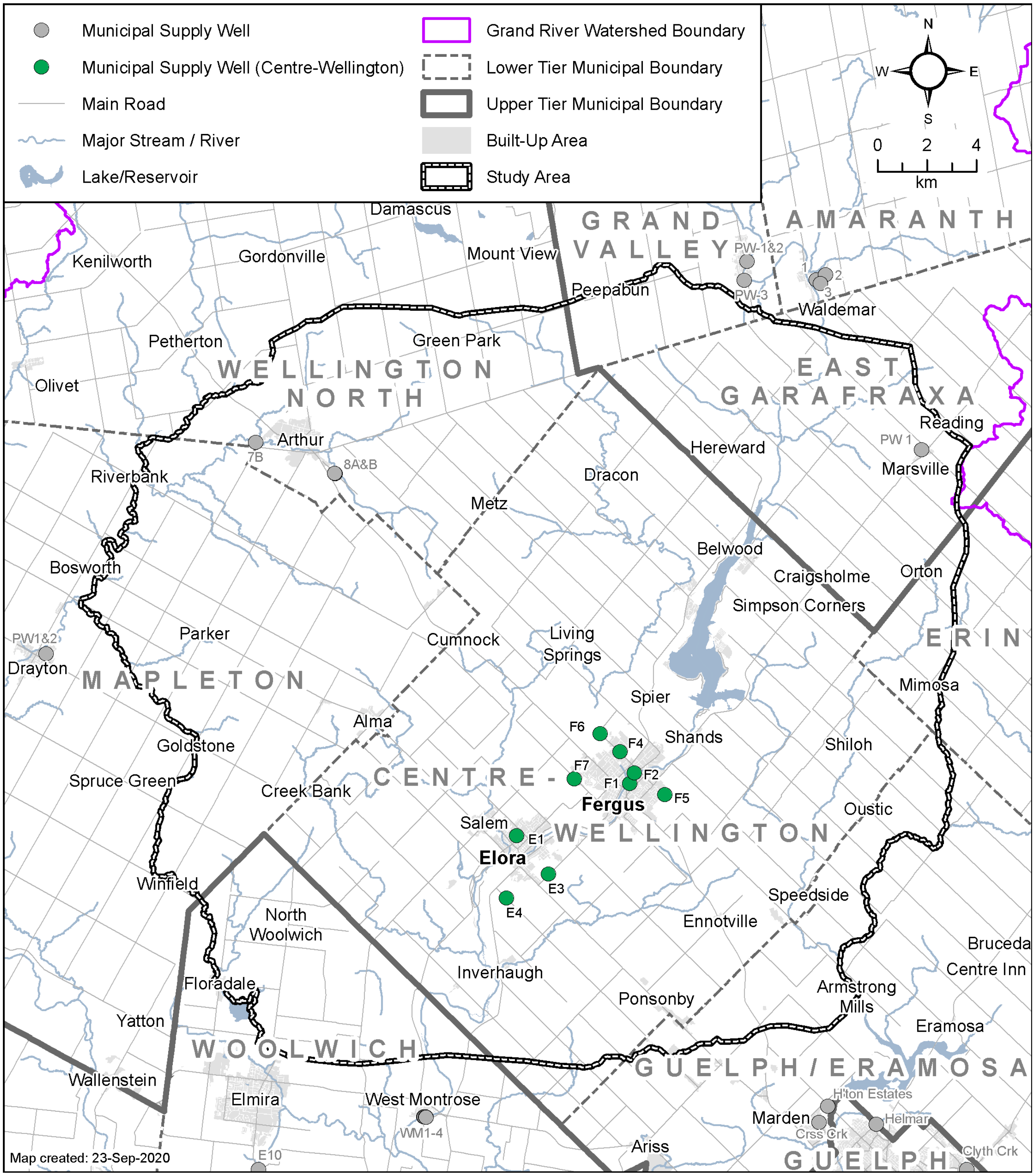
The Ministry of Environment, Conservation, and Parks (MECP) maintain a set of Technical Rules (MECP, 2017) that require Tier 3 Assessments be completed in subwatersheds that have a moderate or significant water quantity stress where there are municipal drinking water supplies. The Tier 2 Assessment for the Grand River Watershed (Section 18) identified that a Tier 3 Assessment was required for the Centre Wellington municipal system (AquaResource 2009).

The Study Area for the Tier 3 Assessment encompasses the Township of Centre Wellington and portions of neighbouring townships of Woolwich, East Garafraxa, Mapleton, Guelph/Eramosa, Wellington North and Towns of Grand Valley and Erin (**Map 22-1**).

The water supply system for the Township of Centre Wellington, which relies solely on groundwater to meet municipal demand, consists of 9 groundwater wells completed in bedrock aquifers.

The following sections outline the steps taken in the Tier 3 Assessment to characterize the groundwater system, develop and calibrate a numerical groundwater flow model, and complete a water quantity risk assessment for the Centre Wellington municipal water supply.

Map 22-1: Centre Wellington Tier 3 Study Area



22.2 Groundwater and Surface Water Characterization

The Centre Wellington Tier 3 Physical Characterization Report (Matrix, 2017) contains a detailed description of the Tier 3 Study Area, (**Map 22-1**). The following sections provide a brief overview of the physical setting of the Study Area.

22.2.1 Physical Setting

Across the Study Area, ground surface topography gently slopes from a high of approximately 500 m above sea level (asl) in the north and northeast to a low of 325 m asl along the Grand River valley, east of Elmira. Steep vertical cliff faces exist in the Elora Gorge where the Grand River eroded through the overburden and bedrock in the Elora area. The Grand River runs in a southwesterly direction through the centre of the Study Area, and its main tributaries include Irvine, Carroll and Swan Creek. The Conestogo and Speed rivers, and their respective tributaries are other notable watercourses in the Study Area.

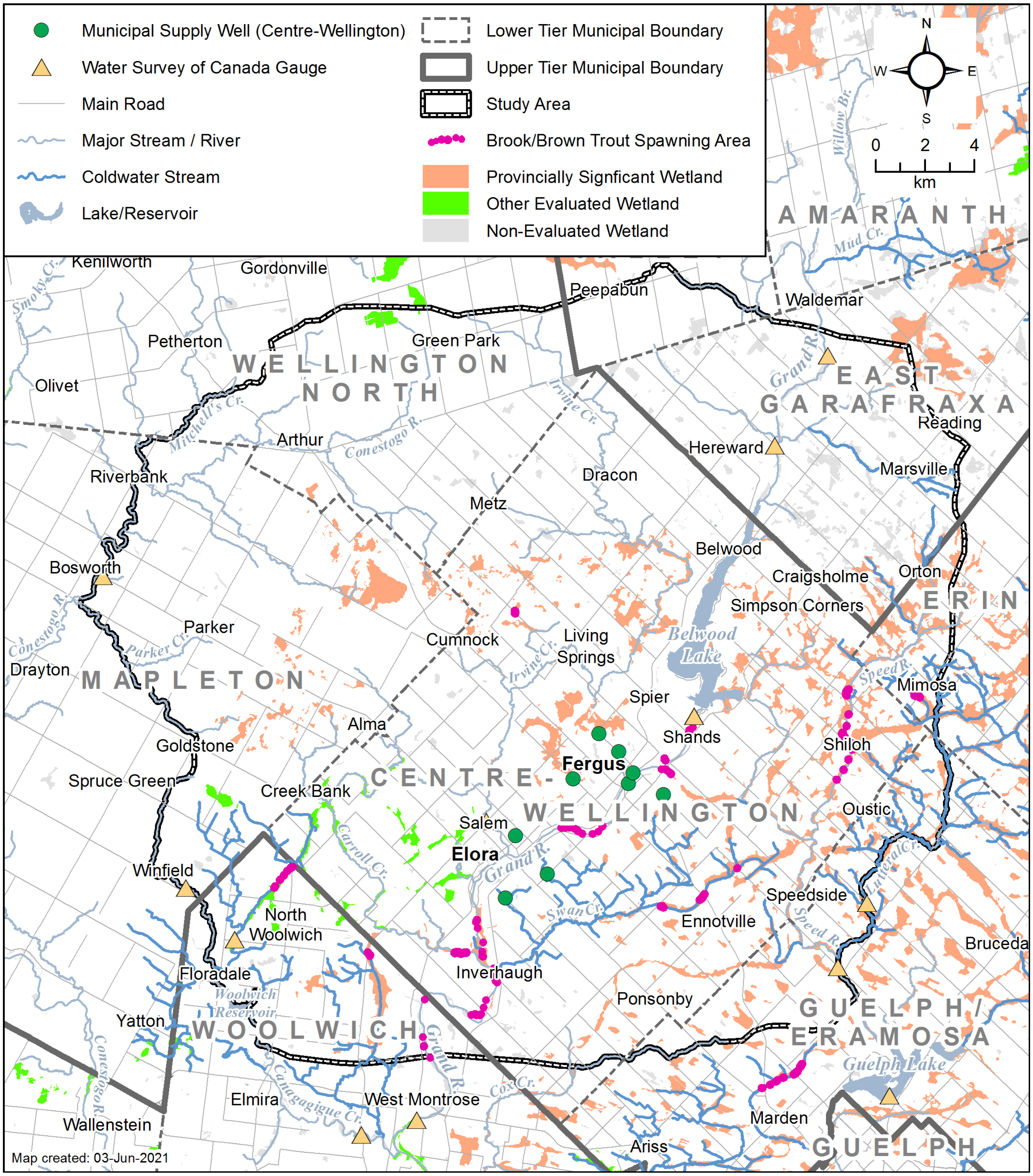
Coldwater streams in the Study Area include portions of the Grand River, and Swan, Lutteral and Canagagigue creeks and their tributaries. Reaches of streams that host coldwater fish species such as brook trout and brown trout are reliant on groundwater discharge, which is the flow of groundwater into a river or stream. The temperature of groundwater remains fairly constant (approximately 13^{O} C) and this flow of cool water moderates the stream temperature in hot summer months, and prevents the stream (and fish) from freezing in the winter.

Provincially Significant Wetlands (PSWs) of interest to this study include the Speed-Lutteral-Swan Creek Wetland Complex, Living Springs Wetland Complex, North Cumnock Wetland Complex, Ritch Tract Swamp, Alma Wetland Complex, Inverhaugh Valley Wetland Complex, and North Woolwich Swamp. **Map 22-2** shows the location of surface water and ecological features within the Study Area.

Overburden (soils that rest on top of bedrock) in the Study Area was laid down thousands of years ago as glaciers advanced and retreated through the Study Area. Most of the overburden in the area is fine-grained (i.e., silt and clay) with some sand-rich areas at surface in the south, and the northeast (associated with the Orangeville Moraine). The thickness of overburden in the Study Area overlying bedrock reaches a maximum of 100 m to the west and northwest of Alma, to zero thickness where bedrock lies at surface along the Elora Gorge and in other river valleys.

Bedrock geology beneath the Study Area consists primarily of dolostone. The bedrock surface in the Study Area slopes from north to south and in many areas, valleys were eroded into the top of the bedrock surface and subsequently infilled with overburden. One bedrock valley of interest runs from the northeast to southwest from the southern limits of Belwood Reservoir to the southern reaches of Elora. Some portions of the bedrock valley are infilled with sands, although the majority of the valley is interpreted to be infilled with finer-grained silts and clays. Other buried bedrock valleys include a valley that lies north of Fergus and Elora and trends along the same direction as the modern day Grand River, and another valley that trends in a north-south direction in the western portion of the Study Area, west of Arthur to west of Alma.

Map 22-2: Centre Wellington Surface Water and Ecological Features



22.2.2 Overburden Geology and Hydrogeology

The Ontario Geological Survey (OGS) compiled subsurface geologic data from numerous data sources to create a hydrostratigraphic model of the overburden deposits in the Orangeville-Fergus area (Burt and Dodge 2016).

The OGS overburden hydrostratigraphic model covers the central and eastern portion of the Study Area. Where the OGS's hydrostratigraphic units were present within the Centre Wellington Study Area, the units were applied in this project. **Table 22-1** below summarizes the lithologic units present in the Orangeville-Fergus area, and those interpreted to be present and carried forward into the Centre Wellington Study Area.

Table 22-1: Overburden Geologic and Hydrostratigraphic Units in the Study Area (Burt and Dodge 2016)

Hydrostrat. Unit Number	Hydrostrat. Unit	Geologic Unit	Lithology	Conceptual Hydrostratigraphic Unit
-	AFA1	Wentworth aquifer	Sand; silty sand; minor gravel	Not present in Study Area
	ATA2	Wentworth Till aquitard	Stony, sandy till to silty sandy till	
1	AFA2	Grand River Outwash Aquifer	Sand and gravel	AFA2
2	ATB1	Port Bruce Stade Aquitard – Tavistock and Port Stanley Tills	Sandy, silty to clayey till	ATB1
3	AFB1	Orangeville, Elmira, and Upper Waterloo Moraine Sands and Equivalents Aquifer	Sand; silt and sand rhythmites; localized gravel and cobbles	AFB1
4	ATB3	Maryhill Till and Associated Glaciolacustrine Sediments	Maryhill till, fine-textured glaciolacustrine sediments and equivalents	ATB3/ATC1/ATC2
-	AFB3	Lower Erie Phase aquifer	Sand; gravel; dirty sand and gravel;	Excluded; Not hydrogeologically

			Rockwood buried valley fill	significant in Study Area
4	ATC1	Catfish Creek Drift (Aquitard)	Stony, sandy silt till; rare gravel; rare silt and sand	ATB3/ATC1/ATC2
-	AFC1	Catfish Creek aquifer	Sand; sand and gravel	Excluded; Not hydrogeologically significant in Study Area
4	ATC2	Lower Catfish Creek Till aquitard	Stony, sandy silt till; rare silt and sand	ATB3/ATC1/ATC2
5	AFD1	Pre-Catfish Creek Outwash Aquifer	Gravel; sand; silt	AFD1
6	ATE1	Canning Drift Aquitard	Clayey silt till; silt till; silt and clay	ATE1
7	AFF1	Pre-Canning Aquifer	Sand; gravel	AFF1
8	ATG1	Pre-Canning Aquitard	Stony to very stony, sandy silt till	ATG1

Table 22-1 notes that several of the units that are present in the OGS's Orangeville study area are not present with any substantial thickness in the Study Area, and consequently the number of hydrostratigraphic layers was reduced from 14 to 8. Specifically, the Wentworth Till and associated coarse-grained sediments are only present southeast of the Study Area, the Lower Erie Phase aquifer (AFB3) and the Catfish Creek aquifer (AFC1) are rare and isolated pockets of aquifer material that were not considered hydrostratigraphically significant (see Plate 2 of Burt and Dodge 2016 for isopachs of units).

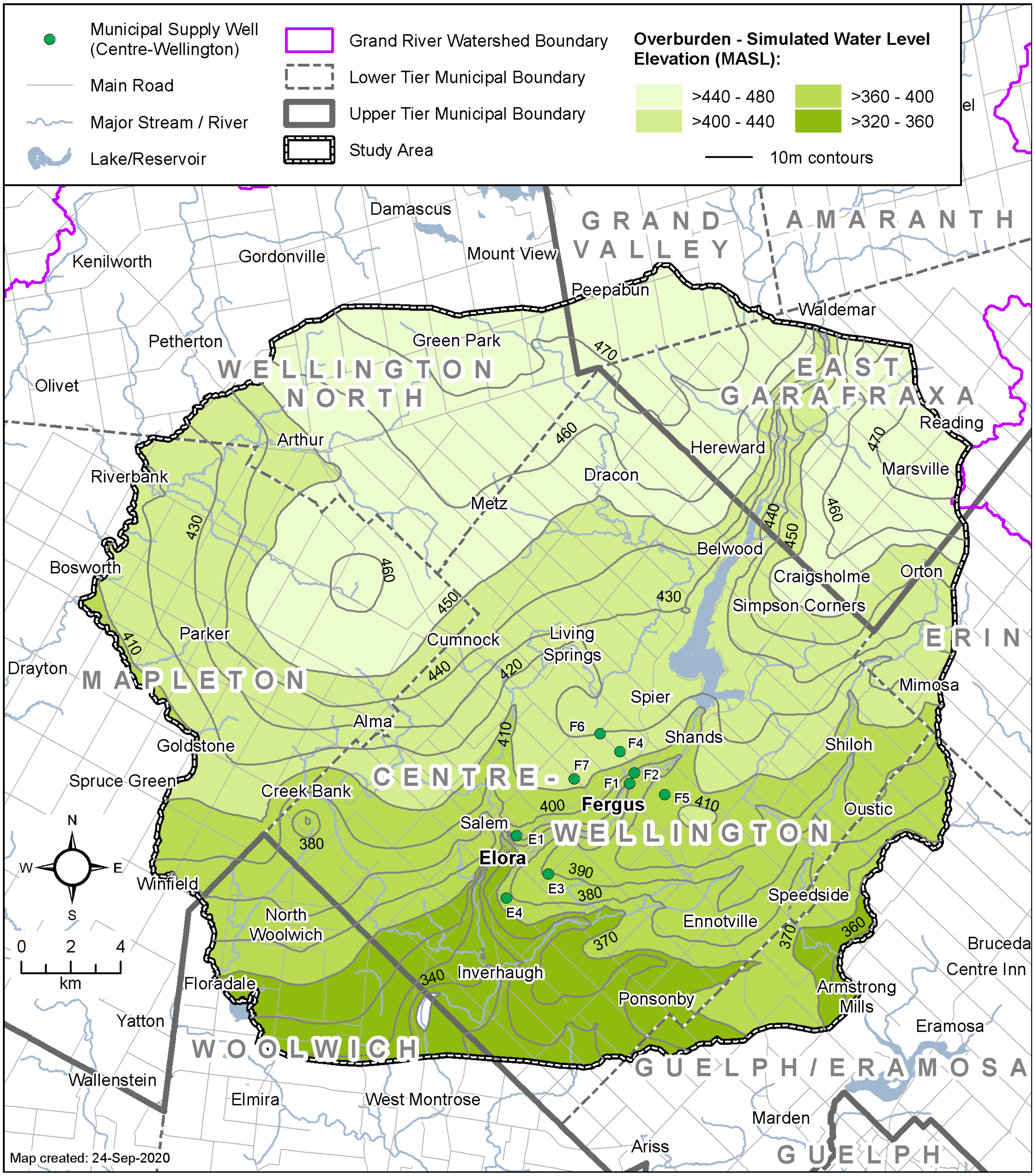
In contrast, the Maryhill Till (ATB3), the Catfish Creek Till (ATC1) and Lower Catfish Creek Till (ATC2) are present across much of the area, and as there is little to no intervening aquifer material, and as the three tills are assumed to have similar hydrostratigraphic properties, these three tills were merged together to form one hydrostratigraphic unit (**Table 22-1**).

Overburden deposits in the Fergus and Elora areas are comprised largely of fine-grained tills, with localized areas that contain sand and gravel aquifer material. Thick and continuous sand and gravel aquifers (AFB1; **Table 22-1**) exist in the southwestern portion of the Study Area associated with the Elmira Moraine (Bajc and Shirota 2007) and in the northeastern portion of the Study Area associated with the Orangeville Moraine (Burt and Dodge 2016). In both areas, the sands and gravel aquifers are present at or just below the surface and several domestic water wells are completed within these upper sands. Areas where the Orangeville and Elmira moraine aquifers lie at surface act as significant groundwater recharge areas as they consist of coarse-grained sediment and contain hummocky topography that reduces runoff and enhances recharge to underlying aquifers.

Within the Fergus and Elora area, localized sand and gravel deposits are mapped as discontinuous pockets of sand and gravel within the Elora Bedrock Valley that runs from Belwood Reservoir in the northwest to an area south of Elora in the southwest. These aquifers (AFB3 and AFC1) may be used for domestic water supply in some areas; however, as the sands are discontinuous along the 15 km length of the valley, the infill sediments are unlikely to be a suitable water supply aquifer for Centre Wellington.

The overburden water level surface is illustrated on **Map 22-3**. The overburden water level elevations follow ground surface topography and decline from a high of approximately 480 m asl in the north to a low of approximately 325 m asl in the south along the Grand River. On a local level, shallow groundwater flows toward and discharges into surface water features including portions of the Grand River, Swan Creek, and Belwood Reservoir. A muted groundwater flow divide exists in the west, south of Arthur where shallow groundwater flow is directed radially off the topographic high to the west toward Conestogo River and the southeast toward Fergus and Elora.

Map 22-3: Centre Wellington Simulated Overburden Water Level



22.2.3 Bedrock Geology and Hydrogeology

Hydrostratigraphic units are developed by lumping or splitting geological units based on their hydrogeologic properties. **Table 22-2** lists the hydrostratigraphic units identified within the Study Area. Aquifer units listed are defined solely on the basis of the estimated ability of the unit to yield water and do not consider water quality or vulnerability to surficial sources of contamination.

Table 22-2: Summary of Hydrostratigraphic Units in the Study Area (Matrix, 2017)

Layer Type	Hydrostratigraphic Unit Type	Interpreted Hydrostratigraphic Unit	Primary Materials
Overburden	Aquifer	Grand River Outwash Aquifer	Sand and gravel
	Aquitard	Port Bruce Stade Aquitard – Tavistock and Port Stanley Tills	Sandy, silty to clayey till
	Aquifer	Orangeville, Elmira, and Upper Waterloo Moraine Sands and Equivalents Aquifer	Fine to coarse sand and gravel
	Aquitard	Maryhill Till and Associated Glaciolacustrine Sediments Catfish Creek Drift (Aquitard)	Silty to clayey till, silt, clay; Stoney, silty to sandy till
	Aquifer	Pre-Catfish Creek Outwash Aquifer Sand and gravel Aquitard Canning Drift Aquitard	Silty to clayey till, silt, clay
	Aquifer	Pre-Canning Aquifer	Sand and gravel
	Aquitard	Pre-Canning Aquitard	Stony, silty to sandy till
Bedrock	Aquifer	Contact Zone	Fractured bedrock
	Aquifer/ Aquitard	Salina Group	Interbedded dolostone, mudstone and shale with lenses of evaporites

	Aquifer/ Aquitard	Guelph Formation Eramosa Formation – Stone Road Member	Carbonate wackestone to mudstone (upper) and crinoidal grainstones and wackestones and reefal complexes (lower)
	Aquifer	Eramosa Formation – Reformatory Quarry	Coarsely crystalline dolostone
	Aquitard	Eramosa Formation – Vinemount	Finely crystalline dolostone with shaley beds
	Aquifer	Goat Island Formation	Finely crystalline dolostone and cross-laminated crinoidal grainstone
	Aquifer	Gasport Formation	Crinoidal grainstone-packstone with reef mounds and coquina lithofacies
	Aquitard	Lions Head, Irondequoit, Rockway, Merritton	Fine-crystalline mud-rich dolostone
	Aquitard	Cabot Head Formation	Silty shale

The municipal water supply aquifers in the Study Area are sourced from fractured bedrock including the Guelph, Goat Island, and Gasport Formation aquifers. Aquitards in the Study Area include the Vinemount Member and in places the Reformatory Quarry Member of the Eramosa Formation, as well as the Cabot Head Formation.

Within the Study Area, the lowermost unit characterized is the Cabot Head Formation. This silty shale unit is present across the Study Area and is an aquitard that represents the base of the upper carbonate bedrock units across the Study Area. Overlying the Cabot Head are the Lions Head, Irondequoit, Rockway, Merritton formations which are often considered poor aquifers that have similar hydrogeologic properties (Brunton 2008). As such, these four formations were grouped together to create one hydrostratigraphic unit.

The Gasport Formation overlies the Lions Head, Irondequoit, Rockway, and Merritton formations, and represents a productive bedrock formation throughout the nearby Guelph area. Portions of the formation (i.e., coquina beds of the reef mounds) are interpreted to have zones of increased primary and secondary porosity (i.e., numerous vugs, cavities, and fractures) that in places can increase the transmissivity of the Gasport Formation.

The Goat Island Formation overlies the Gasport Formation and past studies (Brunton 2008) suggested that because the bedrock formation was finer-grained in nature, it was interpreted to have a lower hydraulic conductivity (or transmissivity) as compared to other formations (i.e., Gasport Formation). Recent studies that have built upon the previous work (Brunton et al 2012) suggest the formation exhibits a fining upward sequence whereby the lower member (Niagara Falls) is coarser grained than the upper (Ancaster).

The Eramosa Formation is largely absent throughout the Study Area. Where present, east of Belwood Reservoir, the mud-rich and microbial mat-bearing Vinemount Member is very thin. The Stone Road Member of the Eramosa Formation is also either absent or very thin (<5m) where present. In previous studies (Brunton, 2008), the Stone Road Member was noted to have similar hydrogeologic properties to the lower portion of the Guelph Formation. As such, the Guelph Formation and Stone Road Member were grouped together to form one hydrostratigraphic unit in Centre Wellington Tier 3 Study Area.

The Guelph Formation is the uppermost unit in the central and eastern portion of the Study Area. Similar to the Goat Island Formation, the Guelph Formation is interpreted to exhibit a fining upward sequence (Brunton et al 2012) whereby the upper portion is a mud-rich carbonate deposited in a lagoonal environment, while the lower portion is more reefal in nature. Therefore, from a qualitative perspective, one might expect the upper portion of the Guelph Formation to act as an aquitard (or weak aquifer), while the lower, reefal portion of the formation is likely to behave as a good aquifer. This trend is based on the grain-size and nature of the carbonate bedrock, and does not consider the degree of fracturing of the two members. OGS staff published a document outlining the trends in packer testing results from across the Guelph, Fergus and Elora areas (Priebe et al 2017; Priebe et al 2014) and results of the analysis suggest that there are wide ranges of hydraulic conductivity values within bedrock units.

The Salina Group is present in the western portions of the Study Area and it is composed of interbeds of dolostone and shale with evaporites (Armstrong and Carter 2010). The formation is considered an aquitard or poor aquifer.

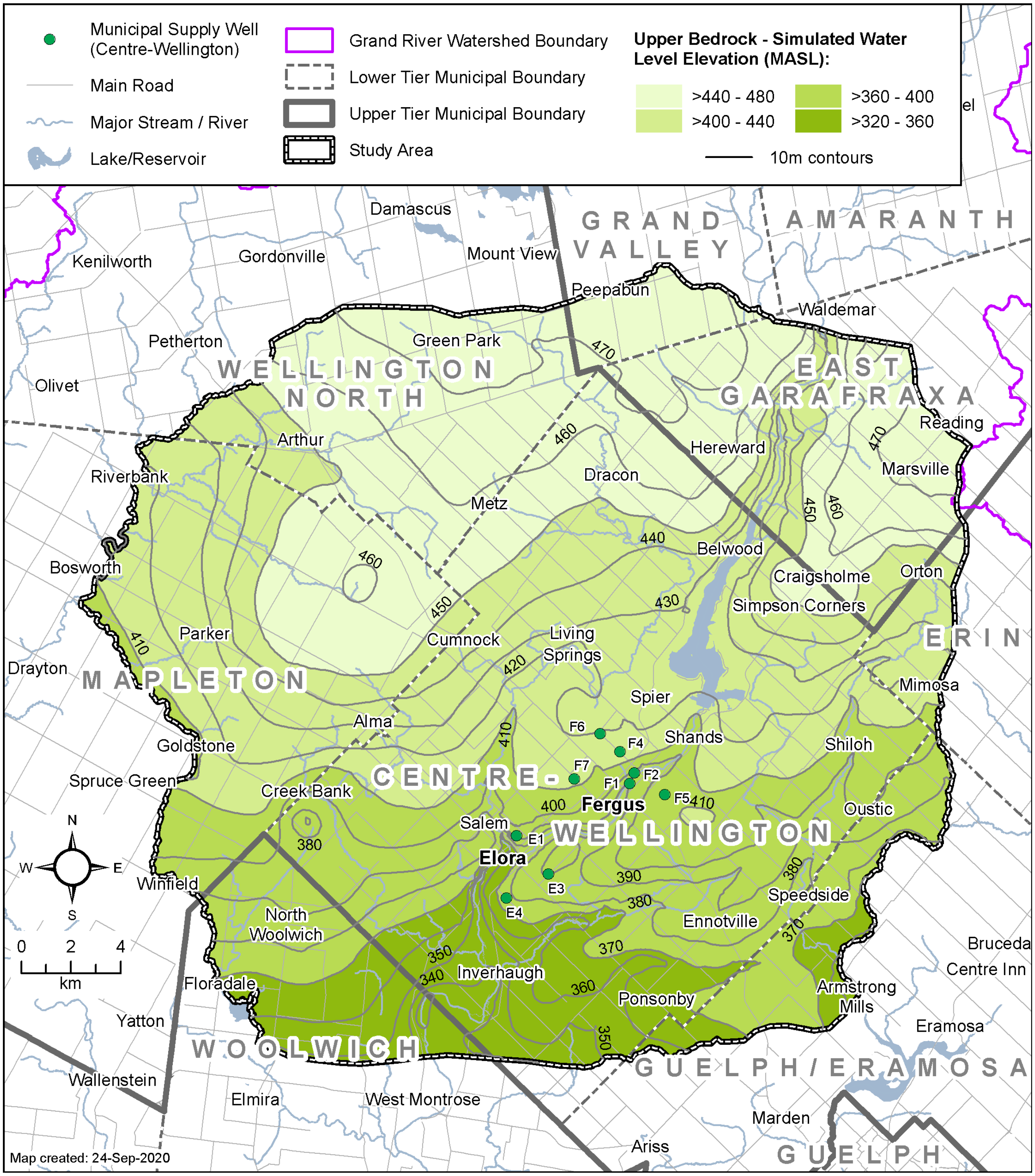
The water level elevation surface

Map 22-4 was created using model simulated water levels in the upper Guelph Formation bedrock units. The surface shown on

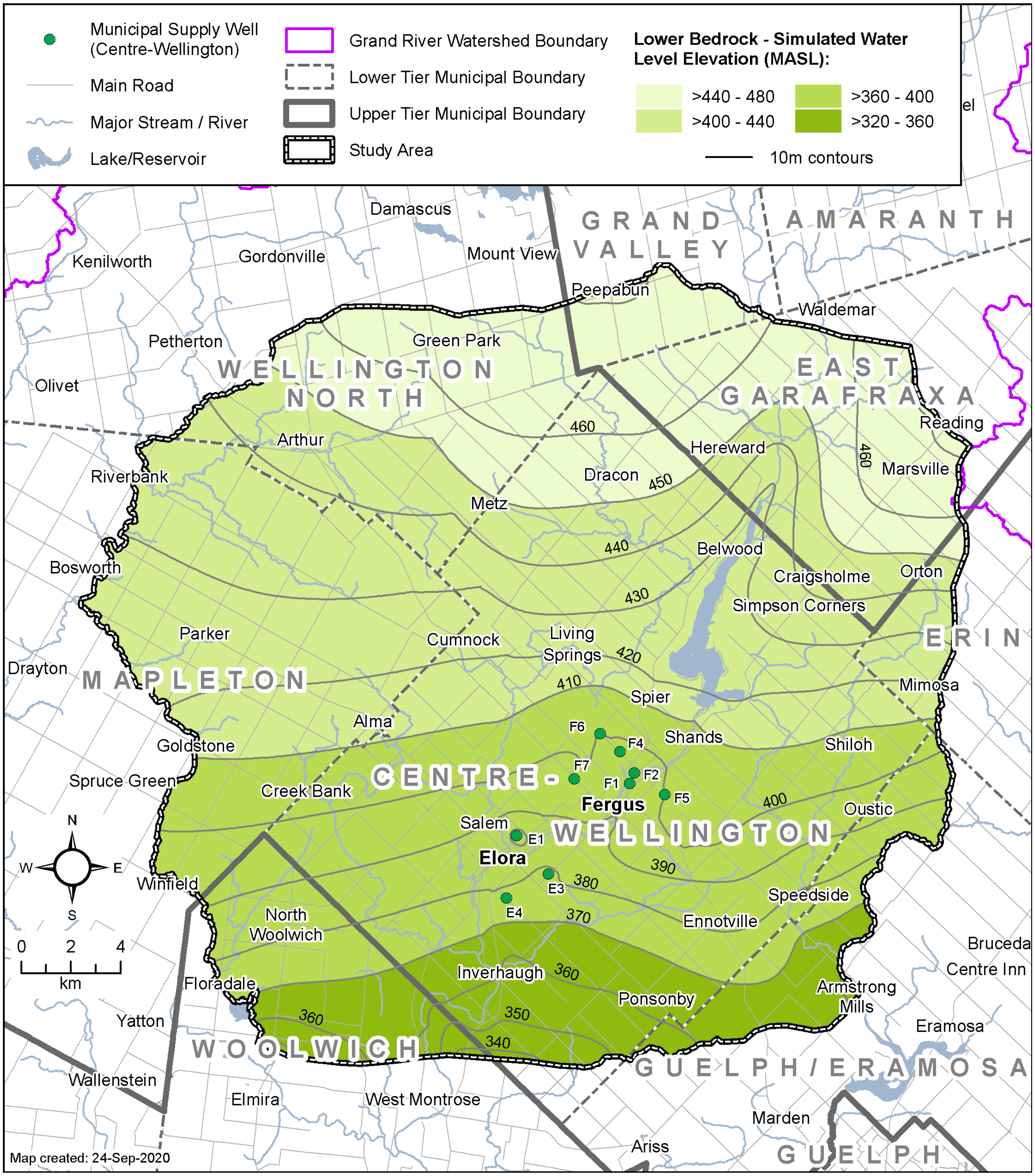
Map 22-4 illustrates highest water level elevations (480 m asl) in the north, and the lowest to the south along the Grand River (325 m asl). On a local level, water level elevations decline toward the Grand River and Belwood Reservoir. A groundwater divide exists in the west where deeper groundwater flow is interpreted to flow toward the Conestogo River in the west, and Fergus and Elora in the southeast.

The water level elevation surface shown on **Map 22-5** was created using model simulated water elevations within the lower bedrock Goat Island and Gasport formations. This surface shows that within the lower Goat Island and Gasport Formations a trend of high water level elevations (475 m asl) in the north, and low water level elevations in the south along the Grand River (310 m asl). Water level elevations decline locally in the vicinity of the municipal water supply wells in Fergus and Elora due to the influence of pumping. As evident in the overburden and upper bedrock flow systems, groundwater is interpreted to flow toward the Grand River and Belwood Reservoir.

Map 22-4: Centre Wellington Simulated Upper Bedrock Water Level


Municipal Supply Well (Centre-Wellington)
Main Road
Major Stream / River
Lake/Reservoir
Grand River Watershed Boundary
Lower Tier Municipal Boundary
Upper Tier Municipal Boundary
Study Area
Upper Bedrock - Simulated Water Level Elevation (MASL):
>440 - 480
>400 - 440
>360 - 400
>320 - 360
10m contours
WELLINGTON NORTH
GRAND VALLEY
AMARANTH
EAST GARAFRAXA
MAPLETON
CENTRE-WELLINGTON
ERIN
WOOLWICH
GUELPH/ERAMOSA
GUELPH
Damascus
Kenilworth
Gordonville
Mount View
Peepabun
Waldemar
Petherton
Green Park
Olivet
Arthur
Reading
Hereward
Marsville
Riverbank
Dracon
Metz
Belwood
Bosworth
Craigsholme
Orton
Simpson Corners
Parker
Cumnock
Living Springs
Drayton
Mimosa
Spier
Alma
Shands
Goldstone
Shiloh
Spruce Green
Creek Bank
Fergus
Oustic
Salem
Elora
Winfield
Speedside
North Woolwich
Ennotville
Floradale
Inverhaugh
Bruceda
Centre Inn
Armstrong Mills
Ponsonby
Yatton
Eramosa
Wallenstein
Elmira
West Montrose
Marden
Ariss
F1
F2
F4
F5
F6
F7
E1
E3
E4
470
460
450
440
430
420
410
400
390
380
370
360
350
340
N
S
E
W
0 2 4
km
Map created: 24-Sep-2020

Map 22-5: Centre Wellington Simulated Lower Bedrock Water Level



22.2.4 Karst Features within the Study Area

Karst is a distinctive type of topography or terrain, formed primarily by the dissolution (chemical erosion) of carbonate rocks such as limestone or dolostone due to the movement of acidic groundwater or surface water over thousands to millions of years (Brunton 2009).

Groundwater can enlarge the openings in subsurface fractures, especially along pre-existing faults or fractures and bedding planes, creating an extensive subsurface drainage system. Over time, the fractures increase in size and groundwater flow through these conduits increases.

Karst landscapes include a wide range of closed-surface depressions, well-developed underground drainage system and few streams or rivers.

Karstification of bedrock leads to large fracture apertures, groundwater pathways that are fairly continuous within the bedrock aquifers. The fractures dominate the groundwater flow, but the storage of water lies in the lower-permeability rock (matrix). Understanding karstification is important in areas where groundwater is the primary source of drinking water, because contaminants associated with agricultural activities (i.e., nitrates, bacteria from livestock waste, pesticides, etc.), can flow rapidly through karstic bedrock.

Karst tends to be most pronounced on the uppermost bedrock surface where bedrock is, or was exposed. Paleokarst refers to karst that forms on bedrock surfaces that were exposed in the past, but these surfaces were subsequently buried by sediments deposited on top, or by changes in groundwater flow conditions (Worthington 2011).

Within the Study Area, sinkholes and other surficial expressions of karstic terrain have not been mapped; however, small caverns and caves and well eroded joints or fractures are visible along the banks of the Grand River, and southeast of the Study Area along the Eramosa River valley where bedrock outcrops at surface (Kunert et al 1998; Kunert and Coniglio 2002). In these areas, water flowing over the dolostone bedrock slowly dissolves the carbonate rock enhancing existing fractures and the interconnected vuggy portions of the bedrock. The upper surface of the Guelph Formation is interpreted to be a paleokarst horizon and within the Study Area.

22.2.5 Water Demand and Other Water Uses

Municipal Water Supply System and Demand

The Fergus and Elora municipal water supply systems rely solely on groundwater for their potable water supplies. The Township of Centre Wellington owns and operates the municipal groundwater supply located in the urban areas of Elora/Salem and Fergus. A continued reliable supply of potable water is necessary for the social, economic, and environmental well-being of the Township. The separate water distribution systems of the two towns were combined into a single Centre Wellington distribution system in October 2005 via the Aboyne Booster Station. The distribution system also includes four water storage towers: two in Fergus and two in Elora. Water treatment occurs within the pump house for each active municipal well. The current water supply system provides drinking water to approximately 19,331 residents in Elora/Salem and Fergus (AECOM, 2019).

There are currently nine municipal bedrock wells in the towns of Fergus and Elora that have a Permit to Take Water (PTTW) **Map 22-1**. Six of those wells are in Fergus (Wells F1, F2, F4, F5, F6 and F7), and three are in Elora (Wells E1, E3, and E4). Wells F3 and E2 were previously decommissioned. Of the existing nine wells, only Fergus Well F2 is designated groundwater under direct influence of surface water (GUDI; Blackport 2002b), but it is currently inactive.

In addition to Fergus and Elora, the municipal groundwater supply systems of Arthur (Township of Wellington North) and Marsville (Township of East Garafraxa) are located in the Study Area (**Map 22-1**). Three groundwater wells are located in Arthur (Wells 7b, 8a, and 8b) and one is located in Marsville (Well 1).

The total permitted capacity of the Centre Wellington water supply system is 15,031 m^3/day under PTTW 4856-9KBH5A, which expires in June 2024. The total average pumping from all wells in 2016 was 5,422 m^3/day, representing 36% of the permitted amount. Each well has a permit that provides Centre Wellington the flexibility to pump a well at its permitted rate to sustain municipal demands during peak periods or while other municipal wells are shut down temporarily for maintenance. Golder (2013) suggested that all municipal wells in Centre Wellington would be unable to pump simultaneously at their permitted rates lowering the pump intake settings in three of the municipal wells.

In 2016, approximately 63% of the water demand was supplied by wells in Fergus, while 37% was supplied by the wells in Elora. Pumping at Wells F1 and E1 accounted for 42% of the total average 2016 demand (**Table 22-3**).

Table 22-3: Township of Centre Wellington Water Supply Wells (Matrix, 2017b)

Town	Well Name	Permit Number	Permitted Rate (m^3/day)	2016 Average Taking (m^3/day)
Fergus	F1	4856-9KBH5A (exp. Jun 30, 2024)	1,833	1,094
	F2		409	---
	F4		1,964	889
	F5		1,963	131
	F6		1,964	475
	F7		1,964	820
Elora	E1		1,741	1,195
	E3		1,964	570
	E4		1,228	249
		Total	**15,031**	**5,422**

The demands from the Arthur and Marsville wells were summarized in the 2016 annual reporting (DWCo. Ltd 2017; Township of Wellington North 2017). On average, Arthur and Marsville take 15% and 14% of their permitted rates, respectively (**Table 22-4**).

Table 22-4: Arthur and Marsville Water Supply Wells				
Town	**Well Name**	**Permit Number**	**Permitted Rate (m^3/day)**	**2016 Average Taking (m^3/day)**
Arthur	Well 7b	8202-9DNKD3 (expiry May 31, 2024)	1,965	335
	Well 8a		2,261	316
	Well 8b		2,261	317
Marsville	Well 1	0601-88MKJ7 (expiry May 31, 2030)	182	25
		Total	**6,669**	**993**

Non-Municipal Water Demand

Non-municipal consumptive water uses that are reliant on groundwater and/or surface were identified in the Tier 3 Assessment. Consumptive water demand is defined as the amount of water that is removed from a water source and not returned to the same water source within a reasonable amount of time.

Average consumptive demand was estimated for non-agricultural permitted water takers using data from the MECP's Permit To Take Water database and Water Taking Reporting System (accessed in 2017). Agricultural water use (ie livestock watering) was estimated by a GIS analysis of aerial photography.

Table 22-5 provides a summary of permitted water takings and consumptive non-municipal water demand within the Study Area.

Table 22-5: Permitted Rates and Consumptive Non-Municipal Demands in the Study Area (Matrix, 2017b)				
Specific Purpose (Groundwater Takings)	**No. of Wells or Intakes**	**Maximum Permitted Average Annual Rate (m^3/day)**	**Reported Demand (m^3/day)**	**Consumptive Rate (m^3/day)**
Aggregate Washing	**2**	**4,010**	**902**	**436**
Aquaculture	6	10,143	4,779	4,779
Campgrounds	5	1,024	50	50
Communal (Pine Meadows)	2	1,571	117	117
Golf Course Irrigation	6	2,261	61	52

Remediation	5	224	43	43
Agriculture/ Livestock Watering	3	-	-	280
Surface Water Takings				
Industrial (power generation)	1	588,888	-	0
Agriculture- Field/Pasture Crops	1	2,423	7	6
Wetlands/ Wildlife Conservation	6	222,494	-	0
Total	**36**	**19,233 (Groundwater)** **813,805 (Surface water)**		**5,756**

22.2.6 Land Use and Land Development

Land use within the Study Area is predominantly agricultural with urban areas and natural heritage features, such as wetlands and forests, scattered throughout. The largest urban areas are located within Fergus and Elora/Salem.

Land use development has the potential to reduce groundwater recharge by increasing areas of impervious cover such as parking lots and roads. The Tier 3 Assessment evaluated the impact of future changes in land use, as outlined in the Official Plan, on municipal water supplies. Recharge reductions were assumed to be equal to estimated percent impervious values for future land uses noted in the Official Plan; these land uses and impervious estimates are summarized below in **Table 22-6** for each land use. **Map 22-6** illustrates the areas of designated land use change.

Table 22-6: Land Use Impervious Estimates (Matrix and SSP&A 2014)

Land Use Type	Imperviousness (%)
Agriculture	0%
Open Space	0%
Institutional	32%
Low Density Residential	40%

Medium Density Residential	50%
High-Density Residential	80%
Low Density Commercial	60%
Medium Density Commercial	80%
Industrial	80%
Urban Commercial Core	90%

These imperviousness values represent the worst-case groundwater recharge reduction arising when a parcel of land is developed. For example, if an undeveloped plot of land has an estimated recharge rate of 100 mm/year, groundwater recharge will be reduced to 20 mm/year after the construction of a high-density residential subdivision (reduction of 80%). This groundwater recharge reduction is attributed to a decrease in recharge and an increase in runoff.

22.3 Risk Assessment

22.3.1 Water Budget Tools

To represent the complex hydrogeological conditions present in the Study Area, a regional-scale groundwater flow model (referred to as the Tier 3 model) was developed for the Tier 3 Assessment. A dedicated groundwater flow model provides an efficient method for the calibration of regional groundwater flow.

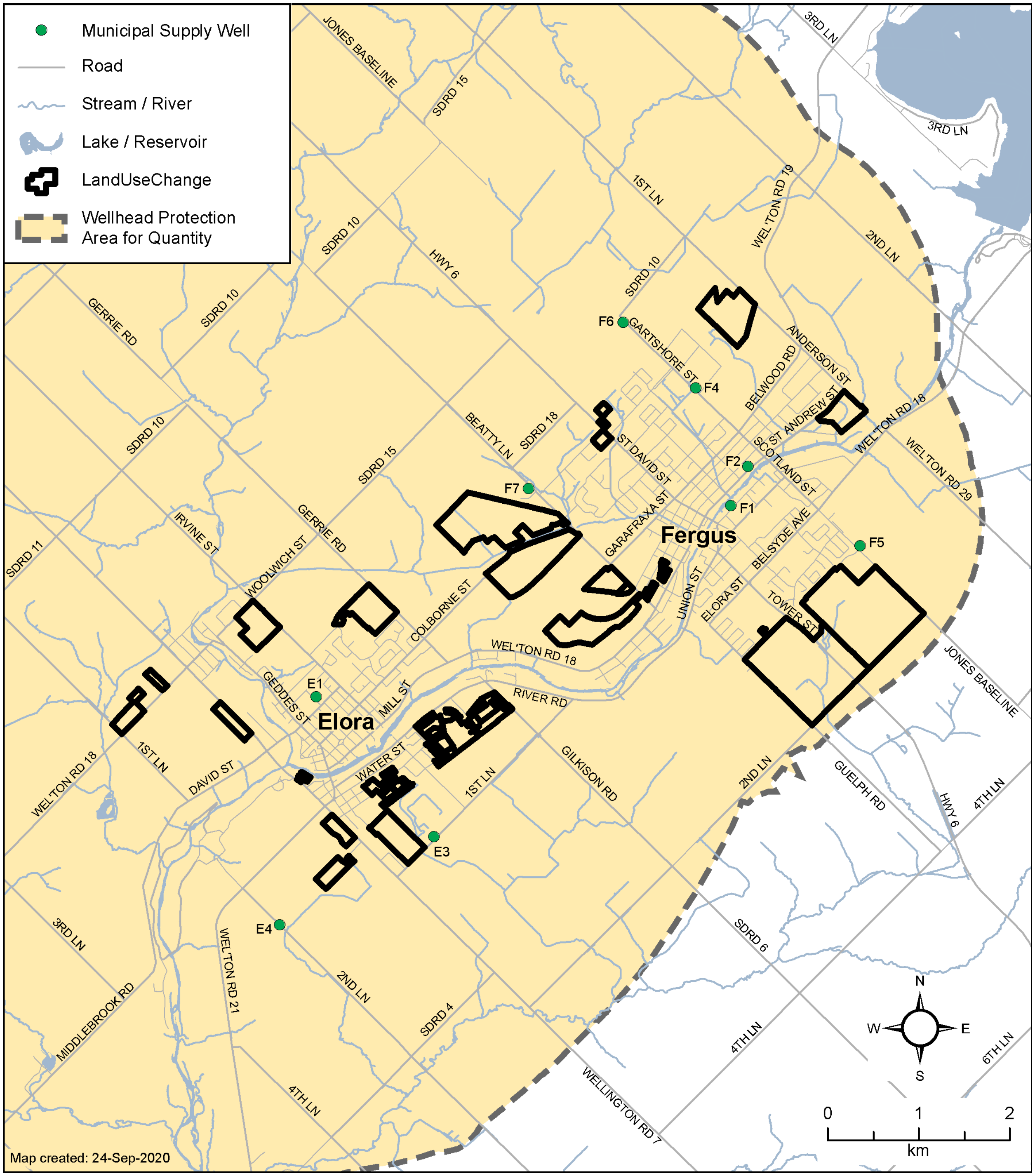
The groundwater flow model was calibrated to represent typical operating conditions under average and time-varying conditions. The groundwater flow model was developed using FEFLOW (Finite-Element Simulation System for Subsurface Flow and Transport Processes; v7.1, Diersch 2014)

Groundwater recharge in the groundwater flow model was assigned using output from the GAWSER (Guelph All-Weather Storm-Event Runoff) streamflow generation model (Schroeter & Associates 2004).

This GAWSER model was previously developed for the Grand River Watershed during the Tier 2 Assessment (AquaResource 2009a) and then updated as part of the Tier Three Assessments completed for the City of Guelph and Township of Guelph/Eramosa (Matrix 2017a) and Region of Waterloo (AquaResource and SSP&A 2014).

The groundwater flow model was used to simulate groundwater flow conditions across the Study Area and to complete the Tier 3 Risk Assessment scenarios.

Map 22-6: Centre Wellington Land Use Changes



22.3.2 Risk Assessment Results

Wellhead Protection Area for Quantity

Using the Tier 3 groundwater model, a Wellhead Protection Area for quantity (WHPA-Q) was delineated surrounding the municipal supply wells. This area was delineated based on a combination of the cone of influence of the municipal wells, and land areas where recharge has the potential to have a measurable impact on water levels at the municipal wells.

The WHPA-Q, as shown in **Map 22-7** encompasses the Centre Wellington municipal wells and many of the non-municipal takings simulated in the Study Area based on municipal pumping from 2018. The drawdown contours shown on Map 227 represent drawdown at the municipal wells when the municipal wells are pumped at their future (or allocated) rate and other permitted water takers in the study area are pumping at their current estimated rate compared to no municipal or non-municipal pumping. Data sources for the estimated rates for non-municipal water users are provided in Tier 3 Risk Assessment Report under Table 8. The WHPA-Q extends toward the west, encompassing non-municipal PTTWs in the west including a relatively larger aquaculture taking (PTTW 3347-84VQV5) (as shown on **Map 22-8**) that contributes to the extension of the area into parts of the Township of Mapleton and Township of Woolwich. The WHPA-Q does not extend into the vicinity of the communities of Arthur or Marsville or their municipal wells.

Risk Assessment Scenarios

The Tier 3 Risk Assessment Scenarios utilized the groundwater flow model to assess the municipality's ability to pump water under different stressors. The stressors - or different model scenarios - that were evaluated are prescribed by the Province. In general, the model is applied to evaluate how water levels will change under the following conditions:

a) When land is developed to the extent described in the municipality's Official Plan;

b) Municipal wells are pumped at their future pumping rates; and

c) Long term drought conditions.

Table 22-7 outlines the scenarios that were evaluated for the Tier 3 Assessment. The predicted water level elevations in each of the scenarios were compared to operational criteria to determine whether the municipal supply can meet future demands.

Tier 3 Assessments must also evaluate how municipal pumping at future rates impacts groundwater discharge into coldwater streams and Provincially Significant Wetlands (PSW). Potential reductions in the amount of groundwater that discharges into coldwater streams to support fish habitat, or into provincially significant wetlands to sustain ecological habitat were also estimated.

Table 22-7: Groundwater Risk Assessment Scenarios Applied to the Tier 3 Assessment

Scenario	Time Period	Land Cover	Municipal Water Demand	Other Permitted Demand	Model Simulation

C	Average of climate record (1961 to 2005)[1]	Existing	Existing	Existing	Steady-state, simulating water levels and flows using average annual recharge and pumping
D	45-year climate record (1961 to 2005[2]), including drought periods	Existing	Existing	Existing	Transient, using monthly recharge and average annual pumping
G(1)	Average of climate record (1961 to 2005)[1]	Planned	Future	Anticipated	Steady-state, simulating water levels and flows using average annual recharge and pumping
G(2)		Existing	Future	Existing	
G(3)		Planned	Existing	Anticipated	
G(4)		Existing	Future	Existing	
H(1)	45-year climate record (1961 to 2005[2]), including drought periods	Recharge reduction	Future	Anticipated	Transient, using monthly recharge and average annual pumping
H(2)		Existing	Future	Existing	
H(3)		Recharge reduction	Existing	Anticipated	

[1]The 1961 to 2005 average climate timeframe is based on GAWSER model recharge update work completed for the Region of Waterloo and City of Guelph (AquaResource 2009c; Matrix 2017) and represents the reported modelling period for that study.
[2]The 1961 to 2005 transient climate timeframe was carried forward to this project using transient recharge scaling factors that were applied as part of the City of Guelph and Township of Guelph/Eramosa (GGET) Water Quantity Policy Study (Matrix 2018a, b), which was based on recharge output generated from the GAWSER model developed for the GGET Tier Three Assessment (Matrix 2017).

For the Risk Assessment scenarios, existing and future (also referred to as Allocated in the Technical Rules) pumping rates were applied to the municipal wells within the groundwater model.

Existing Demand
Existing rates, or demand, refers to the amount of water currently taken from each well during the study period. The municipal pumping rates for the 2018 calendar year are considered Existing demand for the Tier 3 Assessment. **Table 22-9** summarizes these annual average demands along with the maximum permitted rate for comparison. These average annual Existing municipal pumping rates were applied in Risk Assessment Scenarios C, D, G(2), G(4), and H(2), which are summarized in **Table 22-7**. Demands for Well F2 were not included. This municipal well is inactive and modifications such as replacing or deepening of the existing well are currently under consideration.

Water demands associated with three municipal wells in the Town of Arthur (Wells 7b, 8a, and 8b) and one municipal well in the community of Marsville (Well 1) are also within the Study Area and represented in the Tier 3 model; however, as these wells are not the focus of this Tier 3 Assessment the 2016 rates compiled during model development were maintained for the Risk Assessment.

Future DemandAs part of the Water Supply Master Plan (WSMP) for Centre Wellington, AECOM (2019) reported the projected serviced population growth in Fergus and Elora and associated future water demands as summarized in **Table 22-8**. Serviced population refers to homes that are serviced by, or connected to, the Township's water distribution system. Some homes have access to municipal water but have not opted to connect, while other homes do not (and will not) have access to municipal water servicing.

Table 22-8: Projected Serviced Population and Water Demand Based (AECOM 2019)

Year	Centre Wellington Serviced Population	Average Demand (m^3 /day)	Max Day Demand (m^3 /day)
2011	17,141	4,936*	8,638
2016	19,331	5,021*	8,786
2021	22,905	6,110	10,692
2026	26,632	7,105	12,434
2031	31,970	8,523	14,916
2036	37,429	9,969	17,445
2041	41,698	11,104	19,433

*actual values
Current estimated average annual system capacity = 9,060 m3/day
Current estimated peak system capacity (30 day period) = 12,410 m3/day
Current estimated peak system capacity (7 day period) = 13,510 m3/day

The current lawful maximum daily pumping rate for the municipal system is 15,031 m^3 /day according to the current PTTW. Based on the projected serviced population growth and a max day ratio of 1.75, the current permitted capacity (15,031 m^3 /d) will be exceeded for max day demand by 2031 (see **Table 22-8**). However, the current configured system of wells and pumps can only achieve an average daily rate of 9,060 m^3 /day based on AECOM's well capacity assessment (AECOM 2019); this amount is equivalent to the projected average demand between 2031 and 2036.

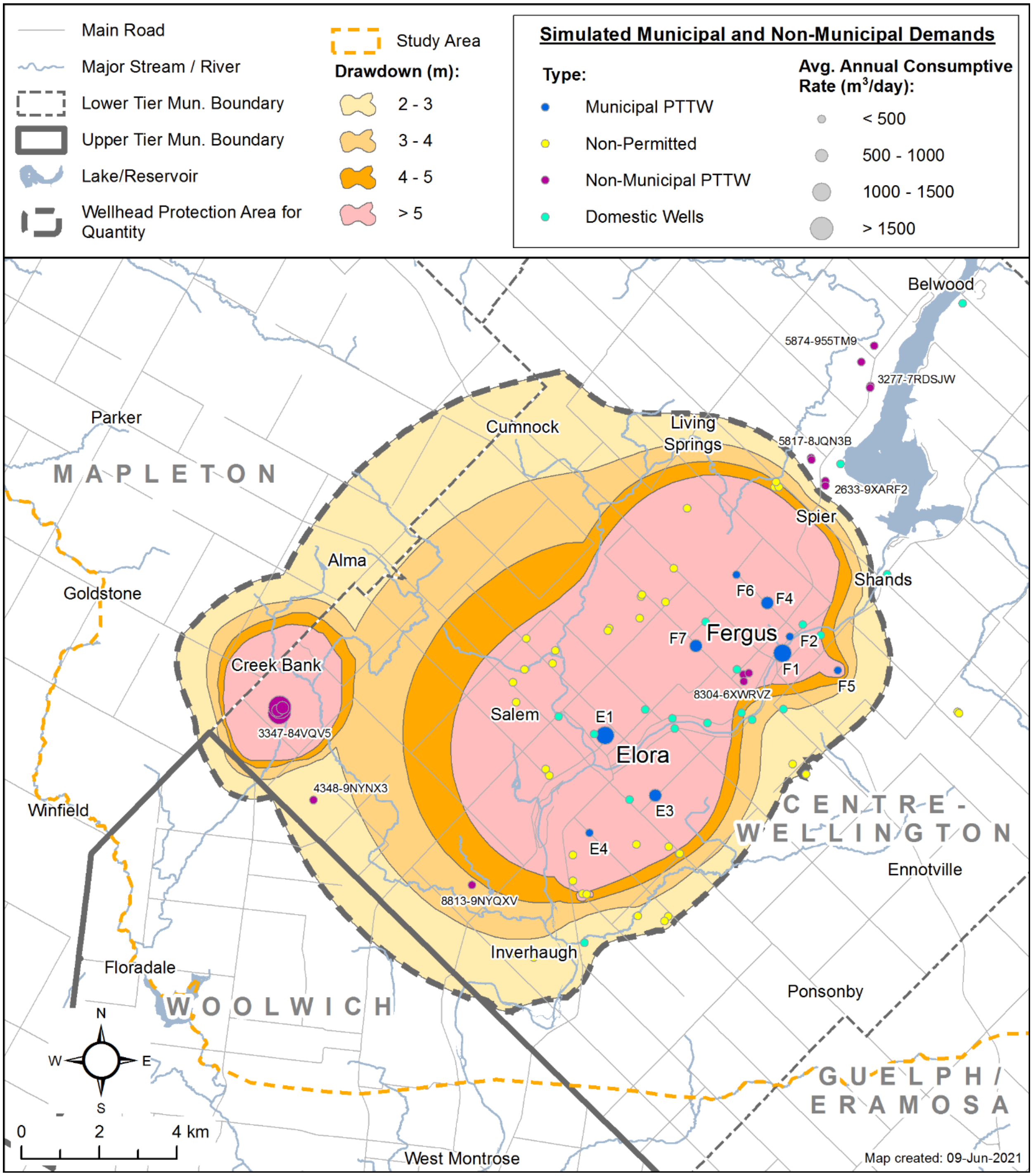
Therefore, for the purposes of this Tier 3 Assessment, the Future demands are based on this estimate of total average well capacity rather than the total permitted capacity (**Table 22-9**). The infrastructure required to meet the water demands associated with the full projected serviced population growth to 2041 (**Table 22-8**) has not been identified within a completed Master Plan or Class EA. Future demands shown in **Table 22-9** were applied in Risk Assessment Scenario G(1), G(2), H(1), and H(2) and used to delineate the WHPA-Q1.

Table 22-9: Municipal Pumping Rates Applied in the Risk Assessment				
Town	**Well Name**	**Maximum Permitted Rate (m^3/day)**	**Existing Rate (m^3/day)**	**Well Capacity / Future (Allocated) Rate (m^3/day)**
Fergus	Fergus - F1	1,833	730[1]	1,300
	Fergus - F2	409	0[1]	0
	Fergus - F4	1,964	1,023[1]	1,300
	Fergus - F5	1,963	372[1]	400
	Fergus - F6	1,964	517[1]	700
	Fergus - F7	1,964	616[1]	1,960
Elora	Elora - E1	1,741	868[1]	1,500
	Elora - E3	1,964	725[1]	900
	Elora - E4	1,228	252[1]	1,000
Total		**15,031**	**5,103[1]**	**9,060**
Arthur	Well 7b	1,965	335[2]	n/a
	Well 8a	2,261	316[2]	n/a
	Well 8b	2,261	317[2]	n/a
Total		**6,487**	**968[2]**	**n/a**
Marsville	Well 1	182	25[2]	n/a
Total		**182**	**25[2]**	**n/a**

[1] Existing Rate is for 2018 calendar year

[2] Existing Rate is for 2016 calendar year n/a - not applicable: Allocated and Committed Rates not developed for Arthur and Marsville as focus of Tier 3 Assessment is on Fergus and Elora

Map 22-7: Centre Wellington WHPA-Q



Risk Assessment Results

The model results of each Risk Assessment Scenario were evaluated relative to a set of thresholds. For the municipal wells, the model results were evaluated with respect to low groundwater elevation thresholds called ‘setpoints’ within the municipal wells. Groundwater level thresholds represent the water level elevation within a municipal pumping well where further drawdown may introduce operational problems. This elevation may be related to the well screen elevation, open bedrock interval, pump intake elevation, top of aquifer, elevation of highly productive zones, or other operational limitations (e.g., a water level below which the quality of the pumped water deteriorates). The groundwater thresholds, or setpoints, used in this Risk Assessment were based on those established as part of the Township of Centre Wellington Water Supply Master Plan.

For groundwater discharge along coldwater streams and Provincially Significant Wetlands, simulated impacts were evaluated based on whether groundwater discharge was reduced by 10% or more when increasing municipal demands from the existing to future rates.

The simulated water level elevations in all the Risk Assessment scenarios were greater than the setpoint elevations at each of the Centre Wellington wells as shown on **Figure 22-1**. These results indicated that the wells were able to pump at their Existing and Future rates (refer to **Table 22-9**) over the long-term (including drought conditions), under existing and future land use development conditions without impacting other water uses.

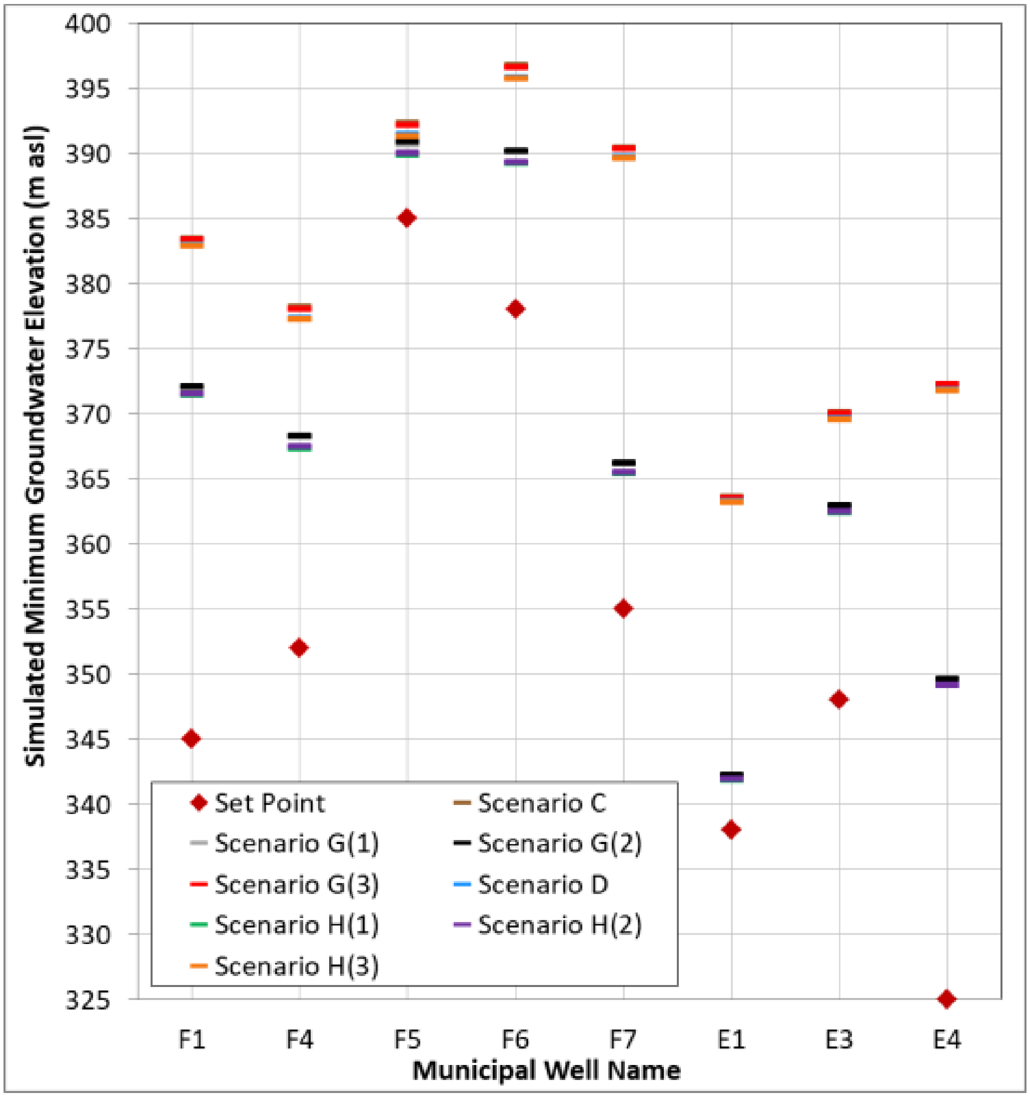


Figure 22-1: Risk Assessment Results – Simulated municipal well groundwater levels relative to each setpoint for risk assessment scenarios (Matrix, 2020)

Meeting the Future water demand however falls short of the Tier 3 goal of having a reliable water supply until 2041. **As a result, Centre Wellington's water supply source and its associated WHPA-Q is assigned a Water Quantity Risk Level of Significant.** With this classification, all consumptive water uses and reductions to groundwater recharge through land use change within this area are considered Significant drinking water quantity threats. In total, 2,741 consumptive water uses and 4.3 km^2 of recharge reduction areas were identified as Significant threats in this Vulnerable Area.

22.3.3 Significant Groundwater Recharge Areas

The hydrologic model utilized to simulate available recharge to the groundwater system (AquaResource and SSP&A 2014) for this Tier 3 assessment remained unchanged from that utilized for the earlier Tier 3 Assessments in the City of Guelph and Region of Waterloo. As such, Significant Groundwater Recharge Areas identified through the Tier 2 Assessment in the Study Area were not modified as a part of this Tier 3 assessment.

22.3.4 Water Quantity Threats Analysis

Drinking water quantity threats were identified within the WHPA-Q and assigned a Significant or Moderate Risk Level. Drinking water quantity threats were identified as follows:

- an activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body (i.e., a consumptive demand)

- an activity that reduces the recharge to an aquifer

As the WHPA-Q was assigned a Significant Risk Level, all existing consumptive demands or future areas of recharge reduction (due to land use development) within this policy area are classified as Significant water quantity threats. This classification is based on a consumptive demand or recharge reduction area occurring within the WHPA-Q and does not imply that an individual groundwater taking or recharge reduction activity will reduce the reliability of the municipal water supply.

New PTTW applications and associated groundwater takings within the WHPA-Q should require additional technical work to determine potential impact to the municipal water supply.

22.3.5 Reductions in Groundwater Recharge

The Technical Rules specify that reductions in groundwater recharge are a potential water quantity threat within the WHPA-Q. The Risk Assessment scenarios considered the impact of existing and future land development defined by the Official Plans in Fergus and Elora, on groundwater recharge and the resulting impact on water levels in the municipal wells. All reductions in groundwater recharge in Fergus and Elora within the WHPA-Q as identified through this Tier 3 Assessment are also classified as Significant water quantity threats.

Specific areas where recharge may be reduced according to land development in the Official Plan are illustrated on **Map 22-6**. Any additional or future areas where recharge may be reduced due to land development outside of Fergus and Elora but inside the WHPA-Q would also be considered and included as Significant water quantity threats in the future.

22.3.6 Significant Water Quantity Threat Enumeration

A summary of the number of municipal and non-municipal permitted, and non-permitted Significant water quantity threats, lying within the WHPA-Q, Grand River Source Protection Area, and municipal areas is provided in **Table 22-10** and on **Map 22-8**. A total of 26 permitted threats were identified within the WHPA-Q.

The Water Well Information System (MOECC 2017) was used to estimate the number of water wells that may represent non-permitted (e.g., domestic or non-permitted agricultural) takings within the various areas. These takings are exempt from permitting if they are taking less than 50,000 L/day. A total of 2,715 individual non-municipal, non-permitted Significant water quantity threats are found within the WHPA-Q.

Significant water quantity threats represented by areas of reduced groundwater recharge are also summarized in **Table 22-10: Count of Significant Water Quantity Threats by Threat Group** and on **Map 22-8**.

Map 22-8: Centre Wellington WHPA-Q Significant Water Quantity Threats

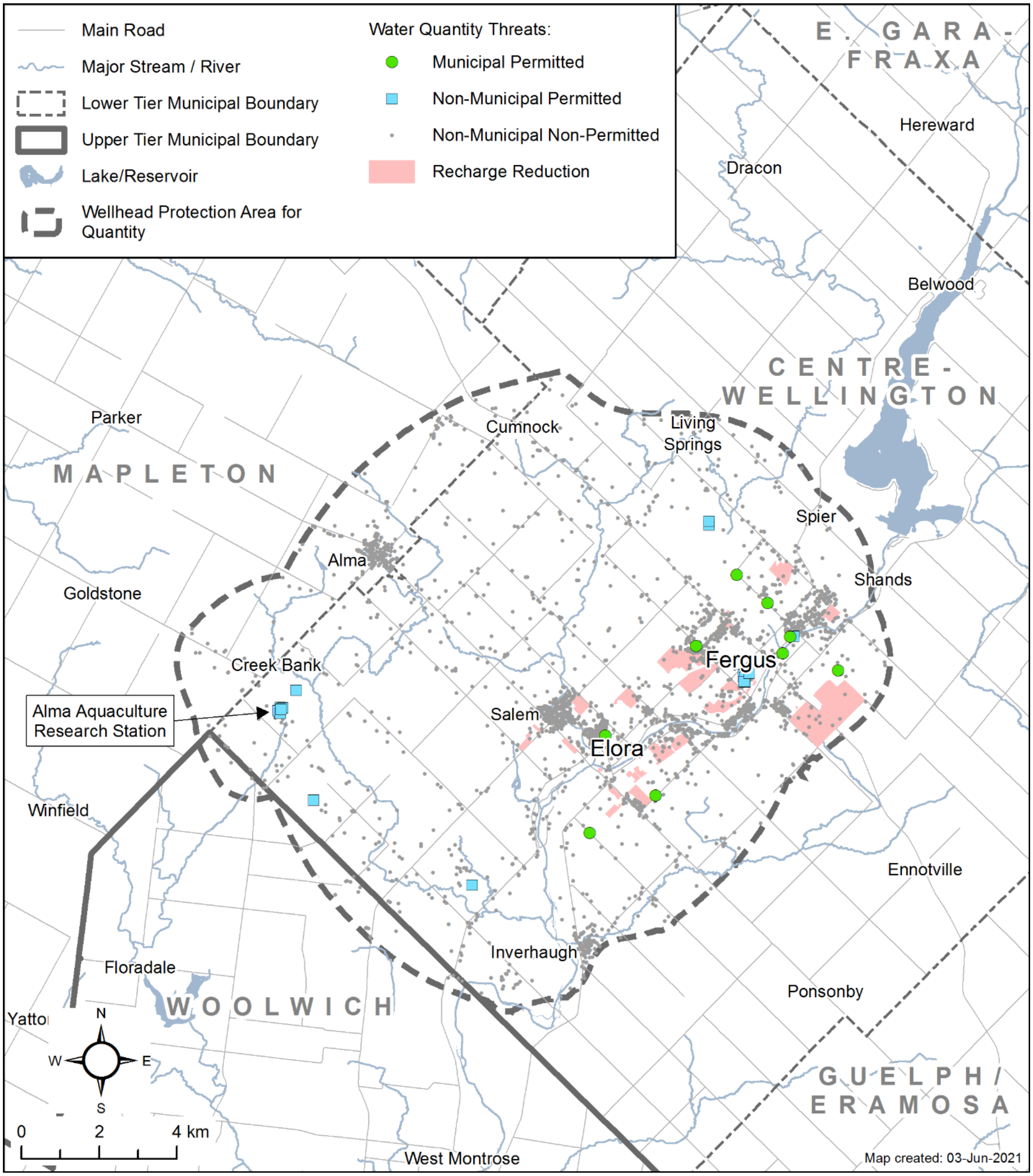


Table 22-10: Count of Significant Water Quantity Threats by Threat Group					
Threat Group	**Vulnerable Area**	**Source Protection Area**	**Municipal Area**		
	WHPA-Q	**Grand River Source Protection Area**	**Township of Centre Wellington**	**Township of Mapleton**	**Township of Woolwich**
Municipal Permitted	9	9	9	0	0
Non-municipal Permitted	17	17	17	0	0
Non-Municipal, Non-Permitted[1]	2,715	2,715	2,419	269	27
Recharge Reduction[2]	4.3 km^2 (2.2% of WHPA-Q)[4]	4.3 km^2 (0.1% of Grand River Source Protection Area)[4]	4.3 km^2 (1.0% of Township of Centre Wellington Area)[4]	n/a[4]	n/a[4]
Total Number of Significant Threats[3]	Within WHPA-Q of the Tier 3 Assessment: 2,741	Within all Source Protection Areas of the Tier 3 Assessment: 2,741	Within all Municipalities of the Tier 3 Assessment: 2,741		

[1] Only wells recorded in the Water Well Information System database (February 2017) are included.

[2] Recharge reduction threats are summarized by identifying the total area represented by recharge reduction polygons as a percentage of the total area of interest. Recharge reduction threats include only those located within the towns of Fergus and Elora/Salem.

[3] Total number of Significant threats does not include individual Recharge Reduction Polygons as those threats have been identified on a per-area basis.

[4] Only recharge reduction areas in Fergus and Elora/Salem were identified as part of this Tier Three Assessment.

[5]Average residential water usage per person per day in Canada was 251 litres/day in 2011 (Gov of Canada)

[6]Majority of domestic wells within the WHPA-Q are located in Centre Wellington (ie. Fergus, Salem, Elora, Aboyne) and the Mapleton wells are located in Alma.

22.4 Section Summary

22.4.1 Summary of the Water Budget Tools and Results

The Tier 2 Assessment completed for the Grand River Watershed (AquaResource 2009a, 2009b) identified the Irvine Creek Groundwater Assessment Area as having a Moderate potential for hydrologic stress when considering future water demands in a drought scenario. As a result, the Province initiated a Tier 3 Assessment for the municipality.

The Tier 3 Assessment involved a detailed review and representation of the physical system within the area of the Centre Wellington municipal water supplies.

A FEFLOW groundwater flow model was developed for the Centre Wellington area, with bedrock and overburden model layers that were based on the conceptual model developed during the characterization phase of the study. The areas of refinement were focused around the Tier 3 municipal wells to assess groundwater flow at a well field scale. The model was ultimately applied to evaluate a groundwater budget for the Study Area and to carry out a number of uncertainty scenarios as part of the Risk Assessment phase. Details regarding the uncertainty assessment are provided in Matrix 2020.

22.4.2 Risk Assessment Summary

A WHPA-Q was delineated surrounding the municipal wells and other water takers in the Study Area (**Map 22-7**). The area was delineated based on a combination of the cone of influence of municipal and non-municipal wells and land areas where recharge has the potential to have a measurable impact on the municipal wells. A set of Risk Assessment scenarios were developed to assess the impact of municipal wells pumping at Existing and Future rates, while considering land use change, drought conditions and impacts to other water uses (e.g., coldwater streams). The Tier 3 Assessment assessed existing permitted municipal water supply wells and non-permitted municipal water supply wells that have been tested and evaluated under the EA process.

In this study, average annual pumping rates for the 2018 calendar year were considered as the Existing demand. The Future demand represented the estimated average annual water supply system capacity of the existing municipal wells for the average amount of water that is available to meet current and future water supply requirements. According to the Township's WSMP (AECOM 2019), the average municipal water supply requirements will exceed this capacity sometime between 2031 and 2036. As a result, the Tier 3 Assessment can only evaluate the reliability of the current municipal wells in meeting future average annual demands to 2031-2036. The calibrated groundwater model was used to simulate groundwater level decline in the existing Centre Wellington municipal supply wells, and reduced groundwater discharge to cold water streams and Provincially Significant Wetlands.

The Risk Assessment scenarios predicted that there was a Low Risk Level associated with groundwater level decline at the municipal wells, and groundwater discharge to coldwater streams and Provincially Significant Wetlands when considering the Future pumping rates (approximately representing future demands between 2031 and 2036). However, the current municipal well infrastructure cannot meet the WSMP's estimated average annual 2041 water demand estimate. This circumstance results in a **Significant Risk Level designation for the WHPA-Q**. The WSMP evaluated alternatives to meet the 2041 serviced population demand and outlined a process whereby the municipality will locate and test new water supply wells. However, the preliminary water supply alternatives considered in the WSMP do not currently meet the requirements to be considered under this Tier 3 Assessment.

Following the Technical Rules, existing consumptive water users and identified areas of future recharge reduction in the WHPA-Q were classified as Significant water quantity threats. These consumptive water users include the permitted water demands (i.e., 9 municipal and 17 non-municipal takings) and non-permitted (e.g., domestic and agricultural) water demands (i.e., 2,715 non-municipal, non-permitted takings). Finally, 4.3 km^2 of reduced groundwater recharge areas were also identified as Significant water quantity threats within the boundaries of the towns of Fergus and Elora.

22.5 References

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