Grand River Source Protection Area

ASSESSMENT REPORT

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24.0 STATE OF CLIMATE CHANGE RESEARCH IN THE LAKE ERIE SOURCE PROTECTION REGION

Recent climate change studies focus on modeling a doubling of CO_2 in the atmosphere. Studies of the consequences of this climate change scenario specific to the Grand River watershed include Bellamy *et al.* (2002), de Loe and Berg (2006), de Loe *et al.* (2001) and Southam *et al.* (1999). As well, research on the broader Lake Erie basin give predictions on local scale impacts of climate change for the Grand River watershed, accounting for the meso-climatic influences of the Great Lakes.

Many recent studies have incorporated the changes already seen in the Great Lakes regional climate (such as Bruce *et al*., 2006; Chiotti and Lavender, 2008; Kunkel *et al*., 2009; Zhang *et al*., 2000). Research into climate change and water resources in the last decade are thought to be more reliable than previous studies (IPCC-TGICA, 2007). Recent studies have the advantage of analyzing observed changes as well as the availability of better modeling tools. Many recent studies agree that greater and more frequent extremes in temperature and precipitation are expected in the Lake Erie basin. More specifically, an annual average increase in both temperature and precipitation are the driving predictions for Ontario and the Lake Erie basin; both of which have the potential to dramatically impact water resources (Kling *et al*., 2003).

Annual average air temperature in the Lake Erie basin (including the Grand River watershed) is expected to increase only slightly; McBean and Motiee (2008) estimate 0.8^0C increase by 2050. The small increase, however, masks the intra-annual changes, as seasonal temperatures and diurnal temperatures are expected to fluctuate more dramatically (Cunderlik and Simonovic, 2004; Jyrkama and Sykes, 2007; Kunkel *et al.*, 2002). In particular, studies show much warmer winter temperatures will occur (Bruce *et al*., 2000; Cunderlik and Simonovic, 2004; Jyrkama and Sykes, 2007; Kunkel *et al*., 2002; Mortsch *et al*., 2000). Summer daily temperatures are projected to gradually increase towards 2030 and then a more rapid increase could have daily average summer temperatures 10^0C higher than the 1960-1990 average by 2100 (Kling *et al*., 2003).

For precipitation, the projected effects of a doubling of CO_2 are extensive. Annual total precipitation is predicted to increase over the next 50 years in the Great Lakes basin (McBean and Motiee, 2008); however net basin water supplies are projected to decrease due to greater evapotranspiration and runoff. The distribution of precipitation throughout the year will be altered, as Sharif and Burn (2006) estimate that only the months of January, March and October will have increased monthly precipitation. The other months may see a decrease in precipitation, including the months between April to September when water demand is the highest. The form of winter precipitation is expected to shift to rain instead of snowfall, as winter temperatures rise (Bruce *et al.*, 2000; Mortsch *et al.*, 2000). The extreme events for precipitation will be more intense and higher frequency (McBean and Motiee 2008), at the expense of the more gentle and persistent rainfall events (Mortsch *et al.*, 2000).

Warmer winter temperatures are predicted to be the most influential change for water resources in the Grand River watershed. Some of the changes predicted include more winter precipitation as rain, a smaller snowpack, higher evaporation from open water bodies that no longer freeze and an earlier and smaller spring freshet (Barnett *et al*., 2005; Bruce *et al*., 2000; Environment Canada, 2004; Jyrkama and Sykes, 2007; Mortsch *et al*., 2000). Soil moisture will start higher in the spring but drop lower in summer with anticipated higher evapotranspiration. This will lead to greater demand for water resources for irrigation and more frequent drought occurrence (Brklacich, 1990; McBean and Motiee, 2008). Precipitation trends show more intense storms, causing a decrease in infiltration and groundwater recharge (de Loe and Berg, 2006; McLaren and Sudicky, 1993), higher sediment and nutrient loading in the creeks due to greater erosion (McBean and Motiee 2008) and fewer number of days with rain or longer dry periods (Mortsch *et al.*, 2000). Net basin supplies are projected to decrease, following decreases in runoff, infiltration, higher surface water temperatures and greater evapotranspiration (Lofgren *et al.*, 2002; Mortsch *et al.*, 2000) Overall, climate change is expected to shift the means in temperature, precipitation and evaporation which will lead to increased variability, more frequent and intense events (Francis and Hengeveld, 1998)) in de Loe *et al.*, 2001).

24.1 Potential Effects of Climate Change on Water Quantity and Quality

The predictions on climate change in the Grand River subwatersheds have implications to both water quality and quantity. In terms of water quality, the increased air temperature and greater occurrence of extreme precipitation events will lead to degraded water quality with lower dissolved oxygen rates and higher stream temperatures (Bruce *et al*., 2000; Chiotti and Lavender, 2008; Cunderlik and Simonovic, 2004). Higher sediment and nutrient loading are expected in the creeks due to greater erosion (McBean and Motiee, 2008), and coupled with increase in water temperature, will allow for an increase in nutrient concentrations and a rise in the number of cyanobacteria and algal blooms. The blooms will lead to more taste and odour problems in drinking water, a higher risk of water-borne diseases and increased treatment costs (Chiotti and Lavender, 2008; Hunter, 2003; de Loe and Berg, 2006). Decreases in runoff and baseflows from climate change are also important changes with respect to the dilution of sewage treatment effluent because less water will be available for waste assimilation (de Loe and Berg, 2006). The problem of reduced waste assimilation capacity is exacerbated by the projected increase in future populations in these areas and the ability of the system to meet wastewater discharge criteria (Bruce *et al*., 2000; Cunderlik and Simonovic, 2004).

In terms of water quantity, climate change is expected to shift the timing of seasonal events, including an earlier and lower spring freshet and changing levels in Lake Erie to rise and fall one month earlier on an annual basis, due to increased lake surface temperatures (Lenters, 2001; Lofgren *et al*., 2002; Millerd, 2006). The longer frost-free periods lead to increased potential evapotranspiration and an increase in drought occurrence (Environment Canada, 2004; McBean and Motiee, 2008), meaning that longer, drier and warmer growing seasons will lower soil moisture (more deficit) and increase the demand for irrigation (Brklacich, 1990; McBean and Motiee, 2008). Rainfall is expected to fall with more intensity but on fewer days, leaving longer dry spells that may exacerbate seasonal water shortages during low flow periods (Mortsch *et al*., 2000). Projected reductions in groundwater recharge to drawdowns of 2-7m will require wells to be drilled deeper, increasing costs to land owners and municipalities and could lead to rural domestic and urban water use conflicts (de Loe and Berg, 2006; McLaren and Sudicky, 1993). The reliability of water resources is compromised and unpredictability of the hydrologic cycle will demand more planning and adaptation by water managers (de Loe and Berg, 2006).

24.2 Potential Impacts of Climate Change on Lake Erie and Reservoir Levels

Impacts to Lake Erie will have important consequences with the changing climate. Anticipated changes in Lake levels are a function of the altered water balance of the basin including higher precipitation, a decrease in runoff, higher evapotranspiration and an increase in lake surface temperature (Jones *et al*., 2006; Lofgren, 2006; Millerd, 2006). Increasing water temperature in both summer and winter are projected for Lake Erie, causing large increases in evaporation especially in winter months as ice cover would minimize these losses. Net basin water supplies will be diminished (Mortsch, 2006), as any increases in precipitation are not expected to overcome the decreases in water due to evapotranspiration (Millerd, 2006). The reduction in winter ice formation on Lake Erie is expected to be considerable and perhaps non-existent in some years (Lofgren *et al*., 2002). Typically, Lake Erie would nearly freeze over in the months of January and February and limit the lake's influence on snowfall (Kunkel *et al*., 2009). As a consequence of open water in winter months, the lake-effect storm season off Lake Erie will be longer (Mortsch *et al*., 2000), however more of this precipitation will fall as rain due to a decrease in the frequency of air temperatures between optimal ranges for snow (-10^0C to 0^0C, (Kunkel *et al*., 2002). The seasonal variation in Lake Erie levels is also projected to increase, with low levels occurring more frequently, being most pronounced in the shallower western portion of Lake Erie (Lofgren *et al*., 2002; Mortsch *et al*., 2000; de Loe and Kreutzwiser, 2000). The decline in annual Lake Erie levels could as much as between 0.60m-1.36m from the International Great Lakes Datum of 1985 of 174.18m, according to the results of 3 Canadian GCM scenarios (Millerd, 2006; Mortsch *et al*., 2000). Jones *et al.* (2006) concluded that Lake Erie is possibly the most vulnerable of the Great Lakes to the effects of climate change, as they are the most southerly, shallowest and lowest volume and thus more susceptible to changes in thermal regime and lake levels. The consequences of Lake Erie level declines to the Lake Erie drinking water intakes would be costly if dredging or pipe extensions were required and, with less depth over the intake, raw water quality could be degraded.

Reservoirs in the Grand River watershed will be affected by climate change similar to the Great Lakes, just at a smaller scale. Winter ice cover is expected to be reduced, with some years without any cover at all, and consequently an increase in evaporation off the reservoirs and decrease in levels (de Loe and Berg, 2006; Lofgren et al., 2002). The operation of reservoirs will need to be modified, as flood risks will be less predictable in all seasons (Cunderlik and Simonovic, 2005). More frequent thaws in winter will cause snow-melt induced maximum flows to decrease while high-river flows may be more frequent (Cunderlik and Simonovic, 2005). The greater flood risk in winter months will be at the expense of an earlier and lower spring freshet, which will also alter reservoir operations for low flow augmentation in summer months (Bruce et al., 2000; Mortsch et al., 2000). The decrease in ice cover may have an effect on the amount of erosion from the banks of the reservoirs and the amount of sediment build-up behind the dam structure.

24.3 Effect of Projected Climate Changes on Assessment Report Conclusions

Projected climate changes may affect the assessment report conclusions with respect to the groundwater and surface-sourced drinking water supplies in the Grand River watershed. There is uncertainty regarding the net quantitative and temporal impacts to the Grand River water budget as precipitation, evapotranspiration, runoff, recharge and water use rates change. A Tier Two Assessment was completed for the Grand River Watershed in 2009 (AquaResource 2009a, 2009b), which identified subwatersheds and groundwater assessment areas that contain municipal water supply systems that had an elevated (*Moderate* or *Significant*) potential for hydrologic stress from a surface water or groundwater perspective. The water quantity stress analysis indicates that eleven municipal water systems are in areas with moderate or significant potential for stress: Elora/Fergus in the Township of Wellington Centre; Rockwood and Hamilton Drive in the Township of Guelph/Eramosa; the City of Guelph system including the Eramosa intake; Elmira, West Montrose, Conestogo Plains, and the Integrated Urban System in the Regional Municipality of Waterloo; Lynden in the City of Hamilton; and Bright in the County of Oxford. The Ontario Ministry of Environment and Climate Change (MOECC) released a set of updated Technical Rules (MOECC, 2017), which included the previous requirement of Tier

Three Assessments to be completed in subwatersheds that have a *Moderate* or *Significant* water quantity stress in areas that supply municipal drinking water. Tier 3 Water Budget and Risk Assessments were completed for the following municipal drinking water system study areas; the City of Guelph and the Township of Guelph / Eramosa, the Region of Waterloo, Whitemans Creek Tier 3, and Centre Wellington Tier 3. The purpose of the Tier 3 Assessments is to provide a measured assessment of current and future sustainability of municipal drinking water systems in light of municipal growth and development and climate change. Specific climate change scenarios have been included in the City of Guelph and the Township of Guelph / Eramosa Tier 3 and in the Centre Wellington Tier 3.

Changes in precipitation and flow regimes may also require revisions to reservoir operations to address water quality impacts upstream and downstream of these structures. The large reservoirs in the upper portions of the watershed are operated to augment downstream flows for water taking and wastewater assimilative capacity needs as well as flood management. Increasing nutrient loads and water temperatures have the potential to increase the occurrence of taste and odour problems in the riverine surface water intakes for the Guelph, Waterloo Region, Brantford and Ohsweken municipal water supplies. In addition to the potential for surface water quality problems, the Lake Erie intake for Dunnville, at a depth of 2.7 metres, is somewhat vulnerable to declining Lake Erie water levels.

25.0 CONSIDERATION OF GREAT LAKES AGREEMENTS

Under the Clean Water Act, the following Great Lakes agreements must be considered in the work undertaken in Assessment Reports:

- Canada-United States Great Lakes Water Quality Agreement (GLWQA)
- Canada – Ontario Agreement on Great Lakes Water Quality and Ecosystem Health (COA)
- Great Lakes Charter
- Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement

The Great Lakes Water Quality Agreement and the Canada – Ontario Agreement generally deal with water quality concerns, while the Great Lakes Charter, the Great Lakes Charter Annex, and the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement provide principles for joint water resources management and water quantity and quality concerns in the Great Lakes Basin.

25.1 Grand River Watershed and Great Lakes Agreements

The Grand River watershed drains directly into Lake Erie and has the potential to contribute pollutants to the lake. These pollutants, including sediments and nutrients, as well as organic and inorganic contaminants, contribute to the overall water quality of the nearshore of Lake Erie, including, but not limited to the IPZ-1 and 2 of the Dunnville drinking water intake.

The GLWQA, first signed in 1972 and updated in 2012, is a commitment between the United States and Canada to protect, restore, and enhance water quality in the Great Lakes and prevent further pollution and degradation of the Great Lakes Basin ecosystem (Government of Canada & Government of the United States of America, 2012). To contribute to the achievement of water quality goals and objectives set under the GLWQA, Canadian and United States federal governments are addressing Areas of Concern (AOC) through Remedial Action Plans (RAP). No AOCs were identified in the Grand River watershed area in the GLWQA, and thus no RAPs are in place.

The federal governments of Canada and the United States have developed Lakewide Action and Management Plans (LAMPs), to support commitments under the GLWQA. The Lake Erie LAMP is an ecosystem-based strategy to protect and restore water quality in Lake Erie and the St. Clair-Detroit River System (ECCC & US EPA, 2021). Since its establishment in 2000, the Lake Erie LAMP has focused research and projects on nutrient management, biodiversity and habitat, emerging Issues, and monitoring.

The Lake Erie Binational Nutrient Management Strategy is an associated project which was developed in 2011. This strategy is a coordinated response from Canada and the United States that outlines nutrient management goals, objectives, targets, and actions to reduce excessive phosphorous loading and prevent further eutrophication of Lake Erie (Lake Erie LaMP, 2011). This strategy is an important foundation for future Great lakes targets under the Clean Water Act. For the period 2003-2016, the Grand River contributed approximately 35% of the Total Phosphorus loading from major tributaries to the Eastern Basin of Lake Erie (Bocaniov et al., 2023). Reducing the load from the Grand River will be an important focus of long-term water quality objectives for Lake Erie.

As part of the Southern Grand River Rehabilitation Initiative under the Lake Erie Lake-wide Management Plan, targeted research and monitoring was undertaken in the lower Grand River to help identify areas of concern with respect to water quality and aquatic habitat. Intensive water quality monitoring in the summer and fall of 2003 and spring of 2004 at 15 sampling sites helped to characterize nutrient, dissolved oxygen and suspended sediment throughout the lower Grand River and tributaries. Important conclusions from this assessment show that the southern Grand River is nutrient-rich with high levels of phosphorus and nitrogen. Most of the samples analyzed for total phosphorus and nitrate do not meet the provincial or federal objectives. Preliminary trend analysis indicates that phosphorus concentrations are decreasing over the past 20 years while nitrate concentrations are increasing. Overall, the high nutrient and suspended sediment levels of the southern Grand River likely reflect the cumulative inputs from the watershed above Brantford.

The purpose of the 2021 COA is to restore, protect and conserve Great Lakes water quality and ecosystem health to support the vision of a healthy, prosperous, and sustainable region (MECP & ECCC, 2021). The work undertaken and described in this Assessment Report contributes to the achievement of Annex 6: Lakewide Management. This Annex includes commitments to identify and assess potential threats to the Great Lakes as a safe drinking water source and undertake early actions to manage risks. This includes commitments from the Government of Ontario to identify sensitive areas and mitigate risks to drinking water; provide available datasets to support the identification and assessment of drinking water issues and threats; and foster education and outreach opportunities on the protection of drinking water sources.

The 2005 Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement is a good faith agreement between the 8 U.S. Great Lakes States and the Provinces of Ontario and Quebec intended to implement the Great Lakes Charter and the 2001 Great Lakes Charter Annex. The Agreement sets out objectives for the signatories related to collaborative water resources management and the prevention of significant impacts related to diversions, withdrawals and losses of water from the Great Lakes basin (Government of Ontario, 2005). The agreement sets out conditions under which transfers of water from one Great Lake watershed into another (intra-basin transfer) can occur. The surface water intakes in the Grand River watershed are not considered to be intra-basin transfers since wastewater is discharged back into the Lake Erie watershed.

26.0 CONCLUSION

The Grand River Source Protection Area Assessment Report provides a summary of the results of technical studies undertaken to identify the threats to municipal drinking water sources in the Grand River watershed. Assessment Report findings have been used to develop policies for a Source Protection Plan to protect the sources of drinking water for the Southgate, Grand Valley, Amaranth, East Garafraxa, Shelburne, Wellington North, Mapleton, Centre Wellington, Guelph-Eramosa, City of Guelph, Waterloo Region, Perth East, Halton Hills, Oxford County, Brant County, City of Brantford, City of Hamilton, Six Nations and Haldimand County water supply drinking water systems in the Grand River watershed.

26.1 Watershed Characterization

The Grand River Source Protection Area is located in southwestern Ontario and covers an area of approximately 6,800 km^2 draining to Lake Erie. Much of the land of the watershed is used for agriculture. The main urban areas are the Cities of Guelph, Waterloo, Kitchener, Cambridge and Brantford. There are two First Nations bands: Six Nations of the Grand River and Mississaugas of the New Credit.

Residents in the Grand River watershed receive drinking water from both private and municipal supplies. Within the Grand River watershed there are 50 municipal systems and one First Nation system that provide water to 865,500 residents in the watershed (**Table 26-1**).

Table 26-1: Drinking water sources within the Grand River watershed

Region	Community	Drinking Water Source
Grey County	Dundalk	Groundwater wells
Dufferin County	Waldemar, Grand Valley and Marsville, Shelburne	Groundwater wells
Wellington County	Arthur, Moorefield, Drayton, Centre Wellington, Hamilton Drive, Rockwood	Groundwater wells
City of Guelph	Guelph	Groundwater wells and Eramosa River surface water intake
Perth County	Milverton	Groundwater wells
Region of Waterloo	Waterloo, Kitchener, Cambridge, Elmira, St. Jacobs (Integrated Urban System), Hidden Valley, Wilmot Centre	Groundwater wells and Grand River surface water intake
	Ayr, Branchton Meadows, Roseville, Linwood, St. Clements, Wellesley, Foxboro Green, New Dundee, New Hamburg, Conestogo, Heidelberg, Maryhill,	Groundwater wells
Oxford County	Bright, Drumbo, Plattsville	Groundwater wells
Brant County	Paris, Brantford Airport, St. George and Mount Pleasant	Groundwater wells
City of Hamilton	Lynden	Groundwater wells
City of Brantford	Brantford, Cainsville	Grand River surface water intake

Region	Community	Drinking Water Source
Haldimand County	Dunnville	Lake Erie surface water intake and Emergency Grand River Intake
Haldimand County	Caledonia and Cayuga	City of Hamilton Lake Ontario surface water intake in Halton-Hamilton SP Region
Haldimand County	Hagersville	Nanticoke Lake Erie surface water intake in Long Point Region SPA
Six Nations of the Grand River	Ohsweken and parts of the Reserve	Grand River surface water intake
Mississaugas of the New Credit	Parts of the Reserve	Nanticoke Lake Erie intake in Long Point Region SPA

The physiography of the Grand River watershed is dominated in the north and west by the Dundalk and Stratford Till Plains, in the centre and east by the Hillsburg and Waterloo Hills and the Horseshoe Moraines, and in the south by the Haldimand Clay Plain.

The Stratford Till Plain, which dominates in the northwest, is characterized by silty, clay-rich soils which are generally level and often poorly drained. Artificial drainage has made this a rich and productive agricultural region and, as a consequence, only a small portion of the land remains in woodlot, marsh or rough pasture.

The Horseshoe Moraine region consists of a series of moraines surrounding much of southwestern Ontario. The eastern leg of the horseshoe runs along the eastern boundary and through the central part of the Grand River watershed from the Town of Erin in the north, past Guelph and Cambridge to Paris and Brantford in the south. Some of this region is very hilly, often with steep irregular slopes and small enclosed basins. This region has large sand and gravel deposits with many extraction operations in southern Wellington County, southern Waterloo Region, and northern Brant County. This dynamic region provides extensive habitat including 5,000 hectares of wetlands. Approximately 30% of the moraine region is forested and fencerow vegetation is often well developed. The region hosts a number of cold-water watercourses that receive groundwater discharge including the Eramosa River and Mill Creek. Groundwater discharge also feeds the Grand River itself, between Cambridge and Brantford, providing a significant portion of the river’s flow during summer months. The Waterloo Hills region, located in the centre of the watershed, is characterized by sand hills, gravel terraces and many swampy valleys. The soils of the hilly areas are rich and well drained.

The Haldimand Clay Plain south of the City of Brantford is characterized by heavy clay soils; much of the land is poorly drained and is used predominantly as livestock pasture and for soybean, corn and hay production. In this area, groundwater is generally obtained from the bedrock because sufficient quantities of water cannot be obtained from the overburden. Groundwater drawn from the bedrock aquifers in this area is often poor in quality as a result of naturally elevated concentrations of sulphur, salts and minerals in the water. For this reason, municipal and First Nations drinking water supplies have tended to be sourced from the Grand River or Lake Erie.

The geology of the Grand River watershed varies widely across the region. The entire watershed is underlain by carbonate bedrock formations which form north to south trending bands. Unconsolidated sediments, or overburden, deposited in relation to the movement of glaciers across the landscape over time overlay the bedrock formations. The overburden sediments are classified into three common groupings within the north, central and southern portions of the watershed. Overburden within the northern part of the watershed, are commonly tills and till-related materials. The central portion of the watershed contains a series of complex moraine systems, ice-contact, and outwash deposits, whereas the southern portion of the watershed is comprised of fine-grained glaciolacustrine, or clay-rich, sediment.

The majority of the population of the Grand River watershed relies on groundwater as a clean, safe, drinking water supply. In addition to providing a safe source of drinking water, groundwater is used in agriculture, commercial, and industrial applications. Groundwater also plays a pivotal role in sustaining sensitive natural features and aquatic habitats such as streams and wetlands. It has long been recognized that groundwater has a vital role in the hydrologic function of the watershed. Groundwater provides critical baseflow to many parts of the watershed, thereby supporting aquatic and wetland ecosystems.

The northern portion of the watershed contains primarily till deposits, which do not to contain extensive or significant aquifer units. Communities such as Dundalk, Grand Valley, Waldemar, Marsville, Fergus, Elora, Guelph-Eramosa, and the City of Guelph rely on groundwater obtained from the Guelph, Goat Island, and Gasport Formations for municipal supply. Communities in Wellington North, such as Arthur, Moorefield, and Drayton obtain municipal water from aquifer units located in the overburden.

The Waterloo Moraine is one of the largest moraines within the Grand River watershed. A number of aquifers situated within the moraine are used by the Region of Waterloo for drinking water supply. The moraine is situated within the west-central part of Waterloo Region in the central portion of the watershed.

Located in the southwest portion of the watershed, the Norfolk Sand Plain is a significant source of groundwater within the overburden sediments. Groundwater from the aquifers located within the sand plain is used as a drinking water resource, and also relied heavily upon for crop irrigation and to meet agricultural water needs. Groundwater from these shallow aquifers also provides critical baseflow to Whitemans Creek which supports cold-water fisheries. The chemical characteristics of groundwater within the Grand River watershed are derived from two sources: (1) the ambient chemistry, where the composition of the groundwater reflects its relative residence time in the aquifer and the nature of the substrate through which it flows, and (2) anthropogenic impacts to the quality of the groundwater through various land use activities such as road salting, fertilizer and manure applications to agricultural fields, and industrial chemical use. In the Grand River watershed, three distinctive land use activities have impacted groundwater quality: road salting, the application of manures/fertilizer, and the use of industrial chemicals.

Surface water quality in the Grand River is influenced by the geology and current land use. Surface water quality parameters of interest within the Grand River include: chloride, sodium and nitrates. Chloride concentrations reflect the influence of urban point and non-point sources but levels in the Grand River do not exceed the aesthetics guideline for drinking water supplies of 250 mg/L. Levels do, however, approach the guideline for the protection of aquatic life (150 mg/L) albeit occasionally, usually during the spring freshet. Nitrate levels above 10 mg/L, the drinking water quality guideline for treated water, may cause concern for municipal supplies. Research in the watershed indicated that shallow tile drainage may have an important role in the elevated nitrate concentrations seen in the upper central Grand River area. Progress to address data gaps identified in the Grand River watershed characterization report have been made and include; detailed Tier 3 water budget studies which contain updated local geologic and groundwater flow data determined through detailed field investigations and modeling.

26.2 Water Quantity Risk Assessment

Municipal water supply accounts for just over 57% of the consumptive water use in the Grand River watershed. Industrial and agricultural uses account for about 5% and 9% of the consumptive water use.

The surface water subwatershed stress assessment classified three subwatersheds as having a moderate potential for stress under existing conditions (Eramosa River Above Guelph, Whitemans Creek and McKenzie Creek).

The groundwater stress assessment classified three assessment areas as having a moderate potential for stress under existing conditions (Canagagigue Creek, Upper Speed, and Mill Creek), one additional assessment area as having a moderate potential for stress under future conditions (Irvine River), one assessment area as having a moderate potential for stress under drought conditions (Whiteman’s Creek), and one assessment area as having a significant potential for stress under existing conditions (Central Grand).

Tier 3 local water quantity risk assessments were required for ten municipal systems (**Table 26-2**):

Table 26-2: Municipal systems requiring Tier 3 water quantity risk assessments

Assessment Area	Municipality	Water Supply System
Canagagigue	Waterloo Region	Elmira
Canagagigue	Waterloo Region	West Montrose
Canagagigue	Waterloo Region	Conestogo Plains
Upper Speed/Eramosa	City of Guelph	City of Guelph wells and Eramosa River intake
Upper Speed/Eramosa	Guelph-Eramosa	Rockwood wells
Upper Speed/Eramosa	Guelph-Eramosa	Hamilton Drive wells
Central Grand	Waterloo Region	Integrated Urban System wells
Irvine River	Centre Wellington	Fergus-Elora Integrated System wells
Whiteman’s Creek	Oxford County	Bright wells
Whiteman’s Creek	County of Brant	Bethel wells

26.2.1 Tier 3 Water Budget and Risk Assessments

Tier 3 Assessments aim to determine if a municipality is able to meet their current and future water demands. Specifically, Tier 3 Assessments estimate the likelihood that a municipal drinking water aquifer 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. Tier 3 Assessments consider current and future municipal water demand, future land development plans, drought conditions, and other water uses as part of the evaluation.

Within the Grand River watershed, Tier 3 studies have been completed for municipal drinking water systems within the City of Guelph, Guelph/Eramosa Township (G-GET), Centre Wellington, Region of Waterloo, the Bethel Wellfield in the County of Brant, and the Bright Wellfield in Oxford County. Further information on the Region of Waterloo Tier 3 study can be found in Chapter 19. The results of the Whitemans Creek (Bethel and Bright Wellfields) Tier 3 study can be found in Chapter 20. The detailed results of the Centre Wellington Tier 3 study are discussed in Chapter 22. The G-GET Tier 3 study results will be incorporated into the assessment report through future updates.

Tier 3 Assessments were completed for the Town of Halton Hills and the Town of Orangeville. Although the Town of Halton Hills and the Town of Orangeville do not have wells located within the Grand River watershed, the Wellhead Protection Area for Quantity extends into the Grand River Source Protection Area.

Region of Waterloo Tier 3 Water Budget and Risk Assessment

The vulnerable areas in the Waterloo Tier 3 Assessment are represented by four Water Quantity Protection Areas (WHPA-Qs). The WHPA-Q1-A underlies the western portions of Kitchener and Waterloo and extends north to the town of Heidelberg, south to New Dundee, west to St. Agatha and east toward the Grand River. The WHPA-Q1B underlies the majority of the urban portion of Cambridge, and extends in a northwestward direction toward Guelph. The WHPA-Q1B extends into Guelph, as the northern model boundary condition for the Cambridge Model coincides with the pumped groundwater level elevations for the aquifers in Guelph. The WHPA-Q1C area is a small drawdown cone located around the Blair Road Wells (Wells G4 and G4A). The WHPA-Q1D area is represented by a 100 m buffer surrounding the Conestogo Plains Well Field (Wells C3 and C4). The consumptive water users and potential reductions to groundwater recharge within the WHPA-Q1s were not classified as Significant or Moderate water quantity threats, therefore no water quantity policies were developed within the WHPA-Qs.

Whitemans Creek Tier 3 Water Budget and Risk Assessment

A Tier 3 Assessment was completed for the Bright Wellfield in Oxford County and the Bethel Wellfield in the County of Brant. The WHPA-Q for the Bright Wellfield is a circle of 100 m radius around each production well, with a *low* risk level for water quantity impacts. The WHPA-Q for the Bethel Wellfield is a 6 km^2 area with a significant risk level for water quantity impacts. This finding was based on the production well's inability to meet future demand under drought conditions, and the potential for impacts to neighbouring shallow private wells and wetlands under worst-case conditions for water quantity impacts. Water quantity policies were developed for only the Bethel Wellfield as the WHPA-Q is classified with a significant risk level.

Centre Wellington Tier 3 Water Budget and Risk Assessment

A Tier 3 Assessment was completed for the Centre Wellington (Fergus and Elora) drinking water system. A WHPA-Q was delineated surrounding the Centre Wellington municipal wells and around other water takers in the portions of neighbouring townships of Woolwich, East Garafraxa, Mapleton, Guelph/Eramosa, Wellington North and Towns of Grand Valley and Erin.

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 Water Supply Master Plan's (WSMP) 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 population demand and outlined a process whereby the municipality will locate and test new water supply wells. 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). Additionally, 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.

Town of Orangeville Tier 3 Water Budget and Risk Assessment

A Tier 3 Assessment was completed for the Town of Orangeville. Although the Town of Orangeville in not located within the Grand River watershed, the WHPA-QA extends to portions of the Townships of Amaranth and East Garafraxa which are located within the Grand River watershed. Risk assessment scenarios resulted in a Significant Water Quantity Risk Level for WHPA-QA. Threats for the Orangeville WHPA-QA within the Grand River watershed included 44 consumptive water takings.

Town of Halton Hills Tier 3 Water Budget and Risk Assessment

A Tier 3 Assessment was completed for the Town of Halton Hills in the communities of Georgetown and Acton. Although the communities of Acton and Georgetown are not located within the Grand River watershed, the WHPA-Q surrounding the municipal supply wells in Acton includes a small portion of Grand River Watershed. Threats for the Halton Hills WHPA-Q within the Grand River watershed included 9 consumptive water takings.

26.3 Water Quality Risk Assessment

WHPAs are mapped for each municipal groundwater supply system based on a quantitative assessment of lateral groundwater flow in the vicinity of the municipal wellfield. A WHPA consists of four zones which are based on the time it takes for groundwater to travel from the water table surface to the municipal well. Using the calibrated groundwater flow models, capture zones in the Grand River watershed have been delineated through time of travel assessments using backward and forward particle tracking.

An aquifer vulnerability analysis is a physically-based evaluation of the geologic and hydrogeologic character of the sediments and bedrock overlying the municipal aquifer. The resulting calculations provide a rating of the intrinsic vulnerability for the aquifer of interest. Numerous approaches are available to estimate groundwater intrinsic vulnerability such as the Intrinsic Susceptibility Index (ISI), Aquifer Vulnerability Index (AVI), Surface to Well Advective Time (SWAT), Surface to Aquifer Advective Time (SAAT). To obtain the vulnerability score within a WHPA, a scoring matrix is applied which intersects the WHPA zones with the aquifer vulnerability classification. The presence of transport pathways are considered following the initial vulnerability assessment, and may result in a revision to the vulnerability assessment.

The Intake Protection Zone (IPZ) is the primary vulnerable area to be delineated to ensure the protection of the municipal surface water supply. For each drinking water system, an IPZ-1, IPZ-

2 and IPZ-3 can be delineated. Surface water intakes are classified according to their location, with four different classifications (Types A, B, C, or D). Vulnerability scoring is based on the attributes of the intakes (e.g., length and depth), type of source water body, and the physical characteristics of the environment it is situated in.

In determining the potential impact of certain types of land use activities on municipal water quality, the percentage of managed lands and the livestock density in the surrounding area must be considered. Managed lands are those lands to which agricultural source material, commercial fertilizer, or non-agricultural source material are applied. Livestock density is a surrogate measure of the potential generation, storage, and application of agricultural source material within a given area, and is expressed in nutrient units generated per year, per acre. In addition, impervious surface area mapping is used in the scoring and assessment of threats related to road salt application.

In the Grand River watershed, drinking water threats within either WHPAs or IPZs of municipal drinking water systems were identified through the following:

- An activity prescribed by the Act as a Prescribed Drinking Water Threat;
- An activity identified by the Source Water Protection Committee as an activity that may be a threat and (in the opinion of the Director) a hazard assessment confirms that the activity is a threat;
- A condition that has resulted from past activities that could affect the quality of drinking water; or
- An activity associated with a drinking water Issue.

Enumerated significant water quality threats are summarized in each municipal chapter of the Assessment Report. All significant threats must be addressed in the Source Protection Plan. The LESPR SPC may choose to develop policies to address low or moderate drinking water threats.

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28.0 MAP REFERENCES

These maps are for information purposes only and the Grand River Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within these maps.

The following references apply to all maps, unless otherwise noted:

Additional references for specific maps are given in the table below:

Map #	Description	Reference
Map 2-5:	Population and Population Density in Watershed by Municipality and Reserve	Grand River Conservation Authority, August 2018. Summary of Population Statistics for Grand River Watershed.
Map 2-7:	Physiography of Grand River Watershed Area	Physiography of Southern Ontario Geological Survey dataset MRD228, Chapman, L.J. and Putnam, D.F. 2007. Ministry of Northern Development and Mines, Copyright © Queen's Printer, 2010.

Map #	Description	Reference
Map 2-8:	Hummocky Topography	Various Authors, 1967-1993, Quaternary and Pleistocene Geology, Southern Ontario, Ontario Geological Survey. Ministry of Northern Development and Mines, Copyright © Queen's Printer, 2003.
Map 2-10:	Bedrock Topography	Gao, C., Shirota, J., Kelly, R.I., Brunton, F.R. and van Haaften, S. 2006. Bedrock topography and overburden thickness mapping, southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 207.

Map #	Description	Reference
Map 2-11:	Bedrock Geology	Paleozoic Geology of Southern Ontario, Ontario Geological Survey dataset MRD219, Armstrong, D.K., Dodge, J.E.P., 2007. Ministry of Northern Development and Mines, Copyright © Queen's Printer, 2010.
Map 2-12:	Quaternary (Surficial) Geology	Various Authors, 1967-1993, Quaternary and Pleistocene Geology, Southern Ontario, Ontario Geological Survey. Ministry of Northern Development and Mines, Copyright © Queen's Printer, 2010.
Map 2-13:	Overburden Thickness	Holysh, S., Pitcher, J., and Boyd, D. 2001. *Grand River Regional Groundwater Study.* Grand River Conservation Authority, Cambridge, ON.
Map 2-14:	Water Table Surface of the Grand River Watershed	AquaResource Inc. 2009a. Integrated Water Budget Report, Grand River Watershed: Final Report, June 2009.
Map 2-15:	Potentiometric Surface of the Grand River Watershed	AquaResource Inc. 2009a. Integrated Water Budget Report, Grand River Watershed: Final Report, June 2009.

Map #	Description	Reference
Map 2-17:	Groundwater Discharge Map	Groundwater Discharge derived from Figure 70 (page 169) of: AquaResource Inc., June 2009. Final GRCA Integrated Water Budget Report.
Map 2-18:	Average Annual Temperature	Based on Environment and Climate Change Canada data. Produced using information under License with the Grand River Conservation Authority © Grand River Conservation Authority, 2019.
Map 2-19:	Average Annual Precipitation	Based on Environment and Climate Change Canada data. Produced using information under License with the Grand River Conservation Authority © Grand River Conservation Authority, 2019.
Map 18-2:	Groundwater Discharge Map in the Grand River Watershed	Groundwater Discharge derived from Figure 70 (page 169) of: AquaResource Inc., June 2009. Final GRCA Integrated Water Budget Report.
Map 18-4:	Water Quantity Stress Levels by Groundwater Assessment Area within the Grand River Watershed	Adapted from AquaResource Inc. 2009. Tier 2 Water Quantity Stress Assessment Report: Grand River Watershed, Final Report December 2009. AquaResource Inc., Breslau, ON.
Maps 19-1 to 19-12:	Region of Waterloo Tier 3 Water Budget and Risk Assessment	Matrix Solutions Inc. 2014. Region of Waterloo Tier Three Water Budget and Local Area Risk Assessment. Matrix Solutions Inc., Waterloo, ON.
Maps 20-1 to 20-12:	Whitemans Creek Tier 3 Water Budget and Risk Assessment	Earthfx Inc., 2018. Whitemans Creek Tier Three Local Area Water Budget and Risk Assessment: Risk Assessment Report.
Maps 22-1 to 22-8:	Centre Wellington Tier 3 Water Budget and Risk Assessment	Matrix Solutions Inc. 2020. Centre Wellington Tier Three Water Budget Final Risk Assessment Report. Matrix Solutions Inc., Guelph, ON.

APPENDIX B
Written Notice from Director Classifying Intakes per Technical Rule 55.1
Requests for Approval of Alternative Approach

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APPENDIX C
Correspondence Regarding Excavation that Breaches the Aquitard

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