Grand River Source Protection Area

Assessment Report

Chapter 17: Water Budget Framework and Methodology

Version 10.1

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17.0 WATER BUDGET FRAMEWORK AND METHODOLOGY

17.1 Overview of the Water Budget Framework

A water budget evaluates the quantity of water that enters a watershed, is stored, and leaves the watershed. This information can be used to assess the amount of water available for human uses, while ensuring natural processes, such as baseflow to streams and wetlands, are maintained.

The objective of the water budget framework is to help managers identify: 1) drinking water sources which may not be able to meet current or future demands and 2) threats which may potentially impact the quantity of water available for municipal supply. Water budgets are classified into three tiers, with each tier representing increased detail to the water budget.

A Tier 1 conceptual water budget is a watershed scale study which largely characterizes water use in the watershed. The Tier 1 water budget was not completed for the Grand River watershed as much of this data had been previously assessed as a part of earlier studies. Instead, a Tier 2 water budget study, which quantifies water use using numerical models, was completed for surface water subwatersheds and groundwater assessment areas within the Grand River watershed. Groundwater assessment areas were created in support of the Subwatershed Stress Assessment for groundwater. These new areas were created to encompass larger municipal groundwater supplies and their respective aquifer systems. The subwatersheds and assessment areas classified by this Subwatershed Stress Assessment may be under a Moderate or a Significant potential for stress. This classification is important for municipalities having water supplies located in those areas, because those municipalities may be required to complete a Tier 3 Water Quantity Risk Assessment. Tier 3 water budgets use detailed numerical models at the municipal scale to quantify local water use.

Tier 2 Framework

As part of the water budget assessment process, the *Clean Water Act, 2006* requires the completion of a Tier 2 Water Budget and Water Quantity Stress Assessment. A Tier 2 Water Budget estimates and compares existing and future water demands against available surface and groundwater supply for subwatersheds within the larger watershed region.

A Tier 2 Stress Assessment evaluates the level of potential stress within each subwatershed and assessment area. A Percent Water Demand is calculated for each of the subwatersheds by comparing water demands to the available surface water and groundwater supply for that area (AquaResource, 2009b). Where the ratio of water demand to water supply is high, subwatersheds are classified as having a moderate or significant potential for water quantity stress. Under the *Clean Water Act (2006)*, Source Protection Regions are required to complete a Tier 3 Assessment when municipal water supply wells are located within a subwatershed that is classified by a Tier 2 study as having a moderate or significant potential for water quantity stress (Matrix, 2015).

An Integrated Water Budget and a Tier 2 Stress Assessment was completed for the Grand River watershed (AquaResource, 2009a, 2009b). The Grand River water budget and Tier 2 stress assessment is documented in two reports: Grand River Watershed Integrated Water Budget – Final Report, June 2009 and Grand River Watershed Tier 2 Water Quantity Stress Assessment – Final Report, December 2009.

Tier 3 Framework

The Tier 2 Water Quantity Stress Assessment completed for the Grand River watershed (AquaResource, 2009b) identified several subwatersheds and groundwater assessment areas as having a significant or moderate potential for stress (**Table 17-1** and **Table 17-2**, respectively). This led to the requirement of municipal systems located within areas identified as having a significant or moderate potential for stress to be further evaluated through a Tier 3 Water Budget Study and Risk Assessment (Tier 3 study).

Table 17-1 Grand River Subwatersheds with a Significant or Moderate Potential for Stress

Subwatershed	Municipal Surface Water Supplies/Intakes
Eramosa Above Guelph Subwatershed	Guelph Eramosa / Arkell Intake
McKenzie Creek Subwatershed	None
Whiteman's Creek Subwatershed	None

Table 17-2 Grand River Groundwater Assessment Areas with a Significant or Moderate Potential for Stress

Groundwater Assessment Area	Municipal Groundwater Supplies
Big Creek	Lynden
Canagagigue Creek	RMOW (West Montrose, Conestogo Plains, Elmira)
Central Grand	RMOW (Integrated Urban System, St. Agatha, New Dundee)
Mill Creek	None
Upper Speed River	City of Guelph, Guelph/Eramosa, Rockwood
Irvine River (Future conditions only)	Elora, Fergus (Centre Wellington)
Whitemans Creek	Bright (County of Oxford), Bethel (County of Brant)

An addendum to the Tier 2 Water Quantity Stress Assessment for Big Creek Groundwater Assessment Area was prepared by the GRCA (2013, updated in 2015). Additional information pertaining to the percent water demand calculations, that was not available at the time of the Tier 2 study, was assessed. The revised water demand

numbers are considerably less than the values used in the 2009 Stress Assessment report. Additional information on some of the largest estimated water takers decreased uncertainty in water demand compared to the 2009 stress assessment report. The results were further confirmed by a sensitivity analysis which concluded that it is unlikely the Lynden municipal well would be affected by drought conditions because it is a deep overburden well that is screened in a confined aquifer. With this new information, it was determined that the Big Creek groundwater assessment area be classified as a low potential for stress. As a result, a Tier 3 Water Quantity Risk Assessment Study for the Lynden municipal supply well was not required. The Ministry of Natural Resources supported the change in classification to a low potential for stress for the Big Creek Groundwater Assessment Area through Memorandum dated September 3, 2013.

The purpose of a Tier 3 study is to determine whether a municipality is able to meet their current and future water demands under a variety of scenarios such as land use change, prolonged drought, and increased municipal pumping. Within the Grand River watershed, Tier 3 studies have been completed for municipal drinking water systems within the City of Guelph, Guelph/Eramosa Township (GGET), the 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 is found in Chapter 19. The results of the GGET and Whitemans Creek (Bethel and Bright Wellfields) Tier 3 studies will be incorporated into the assessment report through future updates.

17.2 Tier 3 Water Budget Methodology

A Tier 3 Water Budget Study is completed for municipal groundwater wells and surface water intakes that are located within subwatersheds that have been assigned a moderate or significant water quantity stress level within the Tier 2 Assessment.

The objective of the Tier 3 study is to estimate the likelihood that a municipality will be able to meet its planned water quantity requirements considering increased municipal water demand, future land development, drought conditions, and other water uses. The Tier 3 study uses refined numerical surface and/or groundwater flow models and involves a detailed study of the available groundwater or surface water resources. Various scenarios are evaluated using the models to assess the groundwater and the surface water flows and levels, and the interactions between them. The Tier 3 study evaluates the potential as to whether a community will be able to meet its current and planned water demands from a water source.

Tier 3 studies utilize detailed numerical groundwater flow and/or surface water models developed on a local scale to evaluate the water budget of a study area. Models are developed with the accuracy and refinement needed to evaluate hydrologic or hydrogeological conditions at a water supply well or surface water intake. The models developed for Tier 3 studies are scaled appropriately to screen for potential impacts of planned water demands on other water uses such as ecological requirements to maintain stream baseflow and wetland function.

The following section outlines the steps required to complete a Tier 3 Water Budget study:

Step 1: Develop Conceptual and Numerical Tier 3 Models. The first step in a Tier 3 study is to develop a conceptual model of the flow systems. A conceptual model is a representation of the hydrogeologic and/or hydrologic units of the groundwater and/or surface water systems. All high quality and detailed geological, hydrogeological, and hydrologic information is collected and assembled. This characterization is completed within and surrounding the municipal wells and intakes.

The conceptual model forms the basis for the development of numerical groundwater flow and surface water models for the study area. The numerical models are locally calibrated to represent typical operating conditions under average and variable climate conditions. The groundwater flow models and surface water models developed as a part of Tier 3 studies represent the best available science at the time of their development. The models are designed as a tool to complete the Tier 3 study and with proper management can be utilized into the future as a resource for municipal water managers.

Step 2: Characterize Municipal Wells and Intakes. Tier 3 studies require a detailed characterization of wells and intakes. Specifically, the low water operating constraints of those wells and intakes are identified. This step includes an extensive review and analysis of municipal pumping data and interviews with municipal well operators.

Step 3: Estimate the Quantity of Water. Based on the information collected in step 2, this task compiles and describes existing, committed, allocated, and planned pumping rates for municipal wells. Existing pumping rates refer to the quantity of water currently pumped from the municipal wells. Committed rates are defined as the quantity of water, greater than the existing demand, that is necessary to meet the needs of the approved settlement area within an official plan. The allocated rate is the quantity of water required to meet the committed rate up to the maximum allowable rate specified in the municipality's Permit to Take Water. The planned pumping rate is the specific quantity of water that is required to meet the projected growth identified within a master plan or class environmental assessment, but is not already linked to growth within an official plan.

A safe additional available drawdown is identified for each municipal well in the Tier 3 study. The safe additional drawdown is defined as the additional depth that water within a pumping well could fall relative to current pumping conditions and still maintain that well's allocated rate.

Estimates of consumptive water demand are a major component of Tier 3 studies. Consumptive water demand is defined as the amount of water taken from a water source (e.g., surface water or groundwater) and not returned to that water source. Tier 3 studies identify water uses (e.g., municipal and industrial) and estimate the consumptive demand for each use.

Step 4: Characterize Other Water Uses. The Tier 3 study identifies at a screening level other uses, such as ecological flow requirements and impacts to wetlands, that might be influenced by municipal pumping and identify water quantity constraints according to those other uses.

Step 5: Characterize Future Land Use. An evaluation of the potential impact of future land use changes on drinking water sources is completed. This task typically involves a comparison of Official Plans with current land use. The outcome of this task is to identify future areas of increased impervious land cover which may inhibit recharge to the groundwater system.

Step 6: Delineate Vulnerable Areas. Groundwater Quantity Vulnerable Areas referred to as WHPA-Qs (Well Head Protection Area for Water Quantity) are delineated using the calibrated Tier 3 numerical groundwater and surface water models. Similarly, IPZ-Qs, or Surface Water Quantity Vulnerable Areas, may also be delineated for surface water intakes.

A WHPA-Q is defined as the drawdown from the municipal water supply wells when pumping plus the additional drawdown of other permitted water takings (residential, industrial, commercial, institutional, recreational, etc.) when pumping. The WHPA-Q includes surface water drainage areas that contribute a significant proportion of surface water to the wells and any area where a future reduction in recharge (identified in Step 5) would have a measurable impact on the municipal wells.

An IPZ-Q is the drainage area that contributes surface water to the intake, and the area that provides recharge to an aquifer that contributes groundwater discharge to the drainage area.

Step 7: Evaluate Risk Assessment Scenarios. A series of scenarios defined by the Clean Water Act, 2006, Technical Rules are completed using the calibrated numerical groundwater and/or surface water models. These scenarios evaluate changes in municipal water levels (drawdown) and whether municipal current, committed, and allocated pumping rates can be achieved under current conditions, future growth (reduced recharge to the groundwater system), and drought scenarios.

The model-simulated drawdown at the municipal wells under each of the Risk Assessment scenarios is calculated and compared to the safe additional available drawdown at each municipal well. This identifies whether there is a potential for the wells to be unable to pump at their allocated rates.

A full list of the risk scenarios that are required to be completed for a Tier 3 study is available on the MECP website for technical rules under the *Clean Water Act, 2006*: https://www.ontario.ca/page/2017-technical-rules-under-clean-water-act#section-8 under Table 4a (Rule 103) and Table 4b (Rule 104).

Step 8: Assign Risk Level. Based on the results of the Risk Scenarios and how well municipal systems can meet demand as a part of that evaluation, a risk ranking of low, moderate, or significant is assigned to each WHPA-Q and IPZ-Q. An uncertainty level of high or low accompanies each Risk Level ranking. **Table 17-3** provides a summary of the circumstances that must be met for each risk level rating.

Table 17-3 Tier 3 Risk Levels

Risk Level	Circumstances
Significant Risk	• Municipal wells or intakes cannot meet their future municipal pumping rates under existing, drought, or planned land use conditions. • Impacts to other uses from municipal pumping violate existing permits or regulations. • Future pumping rates in planned wells that exceed their permitted rates reduce streamflow within coldwater fisheries by more than 20% of existing baseflow. • The tolerance of the existing system is low (ie. the existing system cannot meet peak water demands).
Moderate Risk	• Municipal wells or intakes can meet their future pumping rates under all scenarios; however, there is a measurable impact to other uses and there is a potential that this impact is harmful. For coldwater fisheries, this impact corresponds to a reduction of groundwater discharge greater than 10% of existing baseflow conditions.
Low Risk	• Municipal wells or intakes can meet their future pumping rates with no expected impact on other water uses.

Where these Risk Assessment scenarios identify a potential that wells or intakes will not be able to supply their future rates, the Vulnerable Area is assigned a significant water quantity risk level, and the consumptive water uses and reductions in groundwater recharge within those Vulnerable Areas are identified as significant drinking water threats. The risk scenarios also consider the need to meet the water demand requirements of other surrounding uses, particularly those that are required to be maintained by provincial or federal law such as wastewater assimilation flows or the ecological flow requirements of cold-water fish habitat. When these other water uses are impacted beyond prescribed thresholds, a moderate or significant risk level is assigned to the Vulnerable Areas and the consumptive water uses and reductions in groundwater recharge within those areas are identified as moderate or significant drinking water threats.

Step 9: Identify and Characterize Drinking Water Quantity Threats. Drinking water quantity threats within WHPA-Qs and IPZ-Qs with a moderate or significant risk ranking are identified and characterized. These include municipal and permitted non-municipal consumptive water demands as well as reductions to groundwater recharge.

Under the *Clean Water Act, 2006*, 8 activities have been identified as drinking water threats. Table 5, under part X.2 of the Technical Rules (MOECC, 2017) provides a list of the 8 activities with associated circumstances and areas where the activities would be considered a significant or moderate drinking water threat. For water quantity vulnerable areas with a significant risk level, all existing and new consumptive water takings located within the areas that draw water from within the WHPA-Q or the IPZ-Q or

activities that reduce groundwater recharge are classified as significant threats. These consumptive takings and recharge reduction areas are classified as *significant* threats regardless of their location within the WHPA-Q. Municipal permitted water takings are classified as significant threats only where increases in municipal pumping from a well may result in the water level in that same well to decline below its safe available drawdown threshold.