CTC Source Protection Region

Guidance: Water Balance Assessments

Version 1.0

April 19, 2018

NOTE TO READER:

This document has been provided in an attempt to standardize the water balance requirements to support development applications required to comply with the CTC Source Protection Plan Policy REC-1 and should be referred to for guidance purposes only. It is not a legal document and should not be used as such.

It is not the intent of the CTC Source Protection Region to prescribe the methodology, nor the data used to undertake water balance assessments. Rather, it is intended to provide responsible estimates based on current knowledge and evaluation of the conditions. Where the Qualified Person can show that alternate approaches or data can produce the desired results or even better, such methods and data should be considered. The Qualified Person is solely responsible for the water balance assessments provided to the Planning Approval Authority supporting Land Development Applications for any given site. This document should be used with other established manuals and practices.

Further, while this document may serve as an excellent starting point for undertaking water balance assessments, independent judgment and pre-consultation with the Planning Approval Authority and where appropriate, the conservation authority they are working with, is strongly recommended to determine the scope of your study.

Contents

1) Introduction

Water balance methods are an appropriate means for predicting the changes to the hydrologic cycle that result from urban development. They can be used to determine amounts of water that should be infiltrated to compensate for reductions caused by large paved areas or changes to vegetation. The maintenance of pre-development 'recharge' is a general requirement in the Oak Ridges Moraine Conservation Plan (ORMCP), the Credit Valley – Toronto and Region – Central Lake Ontario (CTC) Source Protection Plan and the Provincial Policy Statement (PPS) that is often captured in municipal Official Plans.

Groundwater frequently supports significant watershed features that are necessary components to the maintenance of a healthy watershed. As a result, a water balance analysis is required to estimate the pre-development and post-development infiltration and runoff for a number of development applications within the CTC Source Protection Region jurisdiction as outlined in Table 1. This document aims at providing a guidance to land development applicants and their consultants to use when completing water balance analysis.

Qualified Persons (QP) should exercise professional judgment and flexibly to adapt the data provided when considering specific site conditions and when new information or data becomes available. It is not the intent of the Toronto and Region, Credit Valley, or Central Lake Ontario conservation authorities to prescribe the methodology or the data used to complete the water balance assessment; but rather it is intended to provide responsible estimates based on current knowledge and evaluation of the conditions within each jurisdiction. Where there is an alternate approach or data available that can produce the desired results or even better, such methods and data should be considered.

Legislative Authority	Policy Requirements
Oak Ridges Moraine Plan	Site Water Balance, pre and post-development water balance required for all major development. Best efforts to maintain all water balance parameters.
Conservation Authorities Act	Feature Based Water required for all major development with requirement for hydroperiod to be matched on a monthly basis at a minimum.
York Region Official Plan - 2016 Consolidation Policy 2.3.7	Outside of the Oak Ridges Moraine Plan and the WHPA-Q2, an application for development within a Significant Groundwater Recharge Area (SGRA) will maintain pre-development recharge rates to the fullest extent possible.
CTC Source Protection Plan - Policy REC-1	Site Water Balance, pre and post-development water balance required for all major development within WHPA-Q2.
***Planning Act* - Stormwater Management Criteria**	The minimum erosion control requirement for all watercourses is retention of the first 5 mm of every rainfall event.

Table 1: Legislated Authority for water balance assessments within the CTC Source Protection Region

2) TIERED WATER BUDGET PROCESS

Through a tiered process of water budget analyses as set out in the *Technical Rules* under section 107 of the *Clean Water Act, 2006*, the CTC Source Protection Committee was required to identify the vulnerable areas, enumerate the activities that pose a drinking water threat, and determine the threat level of the activity. At the final stage (Tier 3 Water Budget analysis), specific vulnerable areas (Wellhead Protection Areas for Quantity called WHPA-Q) were delineated and significant drinking water threat activities identified.

- WHPA-Q1 refers to the area where activities that take water without returning it to the same source may be a threat.
- WHPA-Q2 refers to the area where activities that reduce recharge may be a threat.

In the CTC Source Protection Region, four Wellhead Protection Areas for Quantity (Figures 1 through 4) have been delineated:

Tier 3 Water Budget Area	Name of Water Quantity Threat Area	Risk Level
Orangeville-Amaranth-Mono	Significant Groundwater Quantity Threat Area	Significant
Acton	Significant Groundwater Quantity Threat Area	Significant
Georgetown	Future Significant Groundwater Threat Area	Moderate
York - Durham	Future Significant Groundwater Threat Area	Moderate

Table 2: List of Tier 3 Water Budget Areas in CTC Source Protection Region

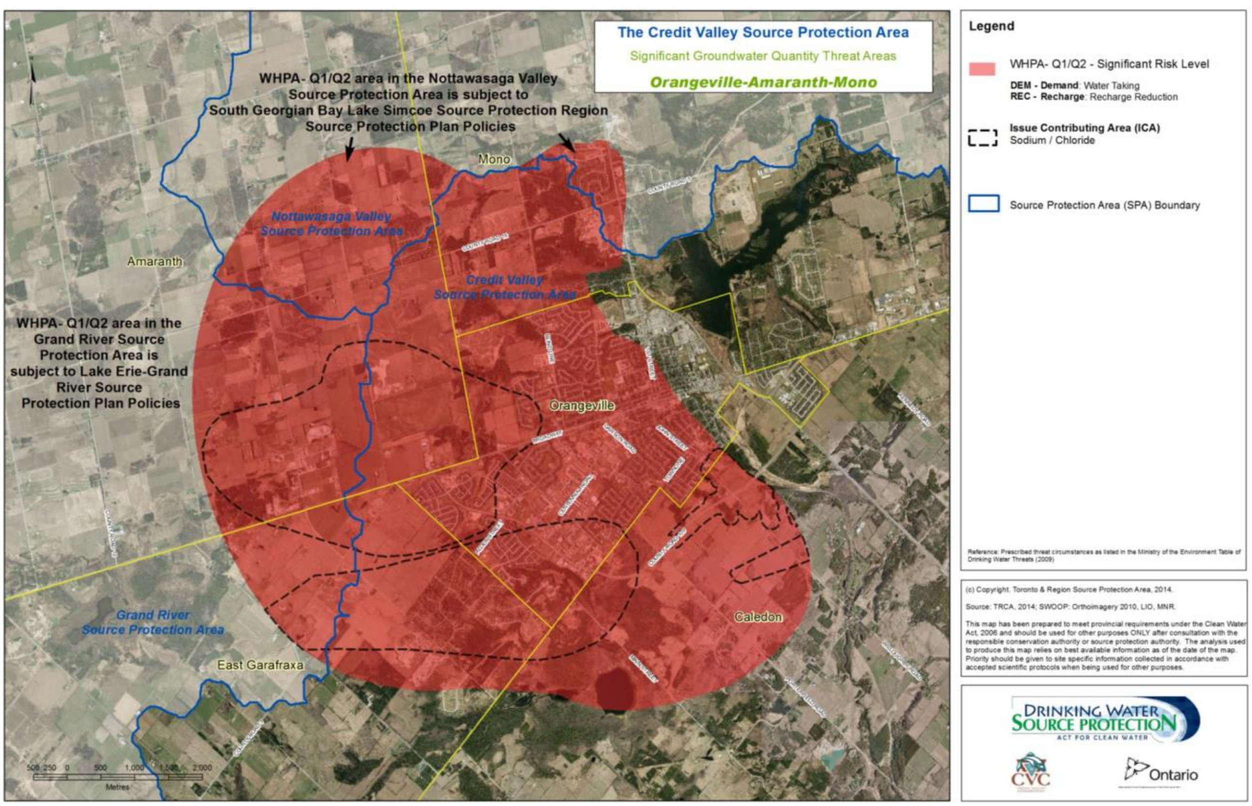


Figure 1: Orangeville – Amaranth – Mono Significant Groundwater Quantity Threat Area

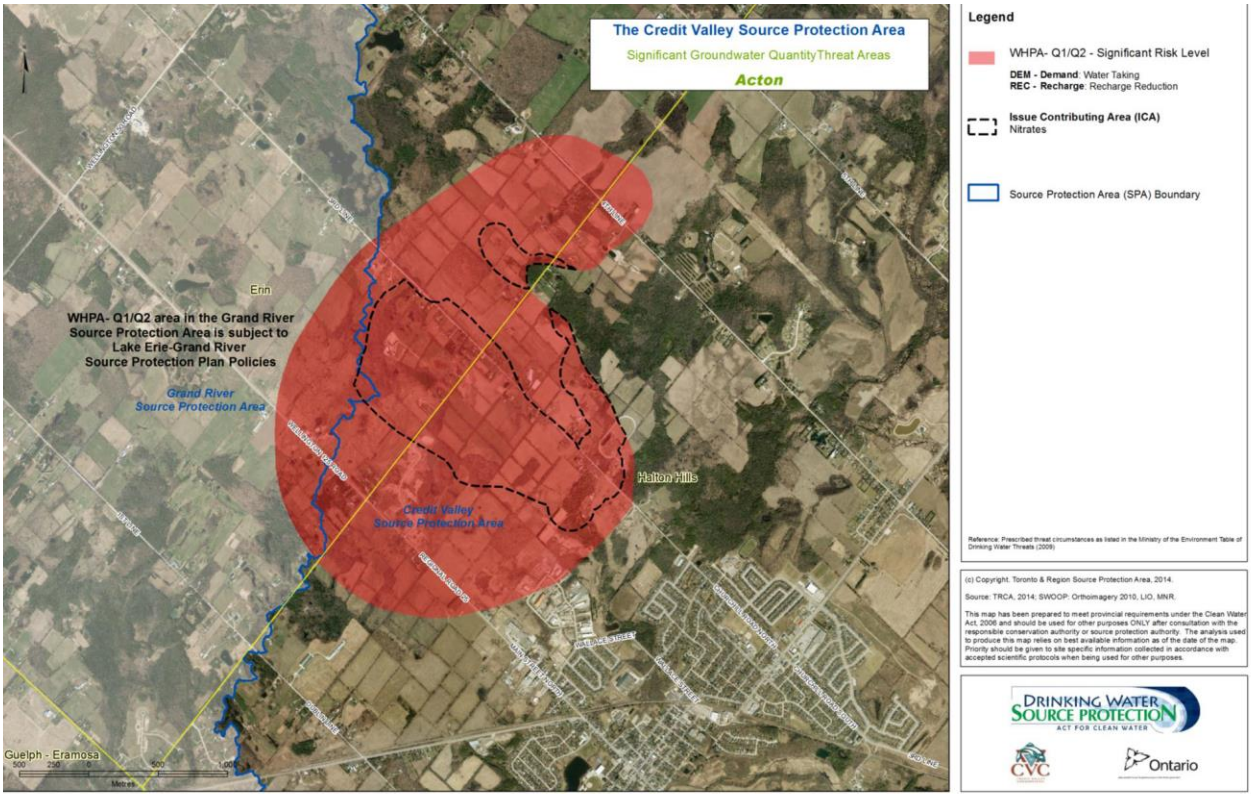


Figure 2: Acton Significant Groundwater Quantity Threat Area

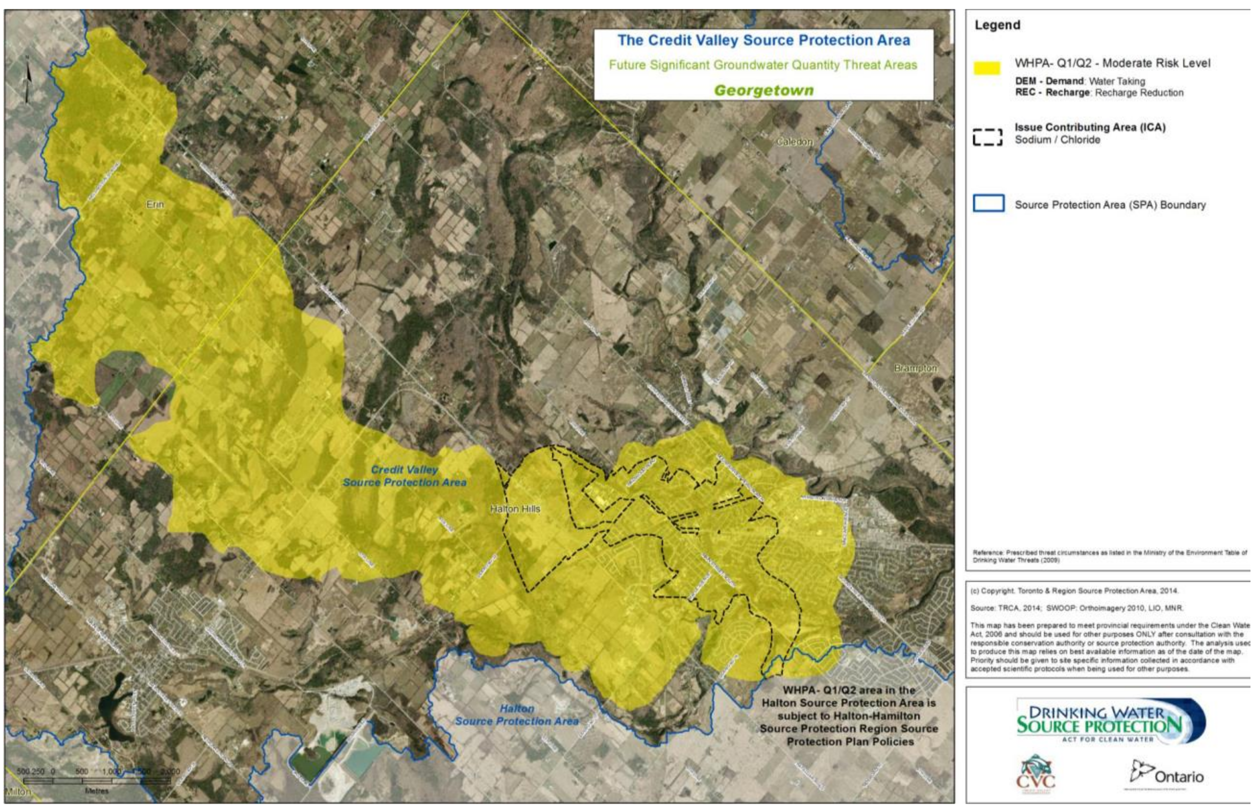


Figure 3: Georgetown Future Significant Groundwater Quantity Threat Area

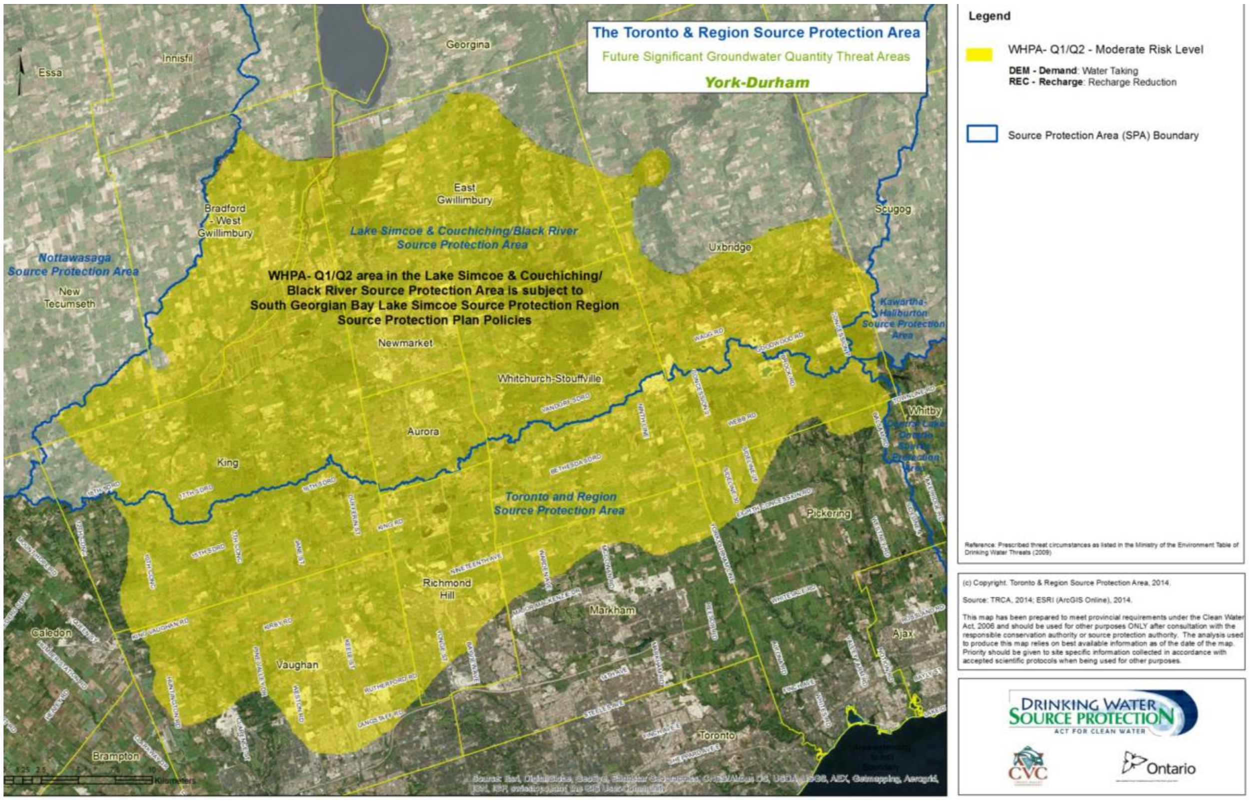


Figure 4: York – Durham Future Significant Groundwater Quantity Threat Area

3) Recharge Reduction as a Threat to Drinking Water Sources

When recharge to an aquifer is reduced, the available water supply becomes depleted and can impair the long-term viability of a water system. Typical examples which reduce recharge include existing and planned land use developments, such as residential subdivisions, employment areas, and undifferentiated suburban lands. Any conversions of land to an impervious surface, such as paved parking lots, do not let water travel through the ground to recharge the aquifer.

Activities that reduce the recharge of an aquifer reduce the water available for municipal water supplies. Impervious surfaces impede the ability for the aquifer to recharge and continue to provide water over the long term.

4) Policy REC-1: Regulatory Authority Under the *Clean Water Act, 2006*

The approved CTC Source Protection Plan (CTC SPP) developed by the CTC Source Protection Committee under the *Clean Water Act* took effect on December 31, 2015. One of the policies in the CTC SPP, **Policy REC-1**, specifies the following requirements:

> For applications under the *Planning Act* within the Tier 3 Water Budget WHPA-Q2 identified as having significant water quantity threats, the relevant Planning Approval Authority shall ensure recharge reduction does not become a significant drinking water threat by:

1) Requiring new development for lands zoned Low Density Residential (excluding subdivisions) or zoned Agricultural to implement best management practices such as Low Impact Development (LID) with the goal to maintain predevelopment recharge.

2) Requiring that all site plan (excluding an application for one single family dwelling) and subdivision applications for new residential, commercial, industrial and institutional uses provide a water balance assessment for the proposed development to the satisfaction of the Planning Approval Authority which addresses each of the following requirements:

   a) Maintain pre-development recharge to the greatest extent feasible through best management practices such as LID, minimizing impervious surfaces, and lot level infiltration;
   b) Where pre-development recharge cannot be maintained on site, implement and maximize off-site recharge enhancement (within the same WHPA-Q2) to compensate for any predicted loss of recharge from the development; and
   c) For new development (excluding a minor variance) within the WHPA-Q2 and within an Issue Contributing Area (for sodium, chloride or nitrates), the water balance assessment shall consider water quality when recommending best management practices and address how recharge will be maintained and water quality will be protected.

3) Only approving settlement area expansions as part of a municipal comprehensive review where it has been demonstrated that recharge functions will be maintained on lands designated Significant Groundwater Recharge Areas within WHPA-Q2.

4) Amending municipal planning documents to reference most current Assessment Reports in regards to the Significant Groundwater Recharge Areas within WHPA-Q2.

5) Policy REC-1: Policy Objectives

The intent of REC-1 is to ensure that the Planning Approval Authority makes decisions that do not result in recharge reduction from new development becoming a significant drinking water threat within a WHPA-Q2. The Planning Approval Authority, through the plan review process (i.e., *Planning Act* applications) will determine what is required, and determine the acceptability of the proposed actions, in the water balance assessments. In contrast with surface water quantity control approaches (i.e., 5 mm on-site retention) that focus on event-based simulations, water balance analyses under *Policy REC-1* consider total annual precipitation and recharge. However, measures that manage total precipitation can also reduce the extent of flood control infrastructure required to manage major events (i.e., 100 year storms).

It was the CTC Source Protection Committee intention for the Planning Approval Authority to have the flexibility to require the appropriate level of detail in a specific water balance assessment commensurate with the scale and location of a proposed development.

The intent of Part 1) of the policy is to avoid the burden on individual residential owners or agricultural operations by requiring that they undertake expensive hydrogeological assessments but to protect recharge by requiring instead that they implement best management practices that will reduce or eliminate any impact from their building or development activities that are subject to planning approvals. In general, on low density and agriculturally zoned lands, it is possible to ensure that roof and impermeable surface run-off can be directed to on-site infiltration and thus maintain recharge without requiring technical assessments.

The intent of Part 2) of this policy is to ensure *Planning Act* applications (excluding an application for one single family dwelling and lands zoned agricultural) include an assessment of the potential reduction in recharge so that specific measures are identified and implemented to ensure the proposal does not result in recharge reduction becoming a significant drinking water threat within a WHPA-Q2. This requirement applies to development on lands with the greatest potential for reducing recharge such as commercial, employment, institutional, industrial uses and includes residential subdivisions, but excludes an application for one single family dwelling. *Planning Act* applications applicable to Parts 2 (a) and (b) include site plan applications (excluding one single family dwelling and lands zoned agricultural), draft plan of subdivision applications, and any associated implementing official plan or zoning by-law amendment applications.

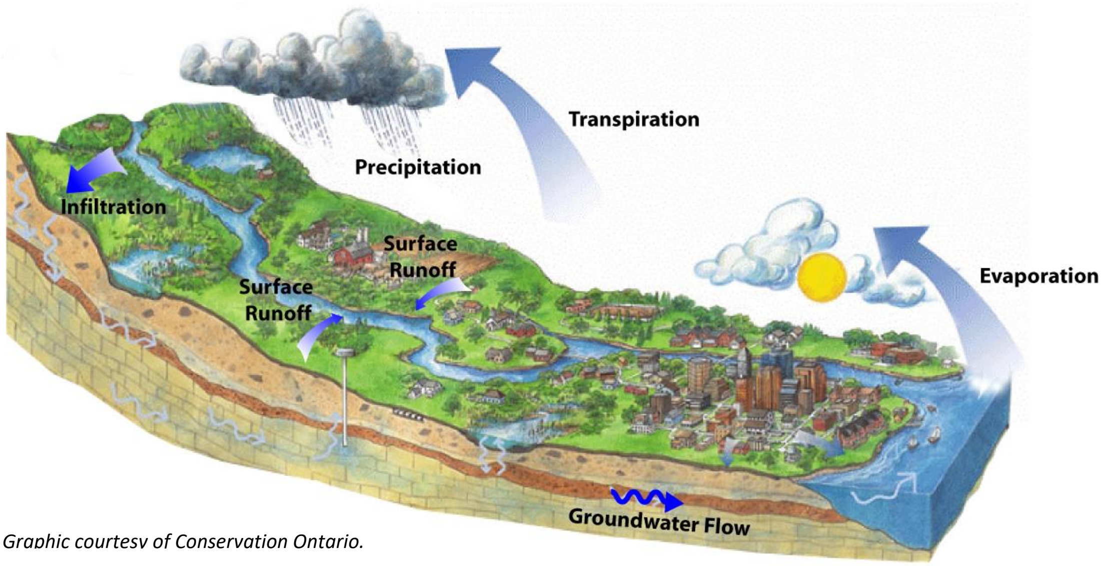
The intent of Part 2 (b) is to allow the municipality the option where it meets local requirements to require the applicant to locate compensating recharge on another site within the WHPA-Q2 where it is not feasible to protect pre-development recharge within the development site. The CTC Source Protection Committee concluded that the local municipality is best placed to determine the optimal actions to protect recharge and this provides them some local flexibility in their decision-making.

Part 2 (c) of this policy applies **only** to those parts of a WHPA-Q2 which are also within an Issue Contributing Area for Sodium, Chloride or Nitrate. These areas are shown on the maps in the appendices in the Source Protection Plan and also will be provided by the Source Protection Authority in other formats upon request to municipalities or other planning approval authorities. This requirement is intended to ensure that any risk management measure that is implemented to maintain recharge does not create a threat to source water quality. For example, infiltration of stormwater containing road salt in an Issue Contributing Area for Sodium or Chloride is a significant drinking water threat and subject to policies SWG-11 and SWG-12. The CTC Source Protection Committee has included Part 2 (c) of this policy for clarity to ensure that an implementing body does not inadvertently approve an activity to protect water quantity that is a threat to water quality.

The intent of Part 3) is to ensure municipalities evaluate planned growth against recharge reduction at a large scale and only proceed if the planned growth will not result in new significant drinking water threats. Once feasibility of the growth is confirmed, development proponents are subject to Parts 1) and 2) of this policy which are site-specific.

6) Water Balance Defined

In simple terms, precipitation that lands on the ground surface is distributed to the natural environment through three pathways. Some of the water infiltrates the ground (infiltration); some runs off the surface (runoff); and much of the remainder either evaporates or is consumed by plants (evapotranspiration). These processes are shown graphically on **Figure 5**. The distribution of water among these pathways is referred to as the water balance. In natural settings, most of the precipitation follows the infiltration and evapotranspiration pathways, which leaves a relatively small portion that becomes runoff. In built communities, the introduction of hard surfaces and the reduction in vegetated cover routes more water to the runoff pathway and less to evapotranspiration and infiltration. The resulting imbalance causes flooding and erosion on the land surface and lower groundwater levels that support our streams, wetlands, and groundwater resources.



Graphic courtesy of Conservation Ontario.

Figure 5: Components of a Water Balance

The basic water balance for a particular area can be expressed as:

P = RO + ET + RE + ΔS (Thornthwaite and Mather, 1957)

Where,

P	=	Precipitation (rain and snow)
RO	=	Runoff
ET	=	Evapotranspiration
RE	=	Recharge
ΔS	=	Change in Storage (assumed to be zero under steady state conditions)

Total precipitation and runoff can be easily measured, but evapotranspiration depends on many variables and is usually estimated by means of empirical equations or through numerical modelling. The purpose of the long term or steady-state water balance is to estimate some of these quantities via a method of accounting for each component of the budget over a long term in order to arrive at mean values for each of the components.

Extensive numerical modeling has been undertaken by municipalities and conservation authorities in order to complete the technical requirements under the *Clean Water Act, 2006.* This modeling has yielded a consistent understanding and mapping of water balance parameters across the CTC Source Protection Region. These calculated distributions of recharge, precipitation, evapotranspiration, and runoff are based on numerical modelling that was subject to extensive peer review and acceptance by the Ministry of Natural Resources and Forestry (MNRF) and the Ministry of the Environment and Climate Change (MOECC).

Completing a water balance assessment requires the expertise of a multi-disciplinary team of qualified professionals, typically including a terrestrial or aquatic ecologist, water resources engineer, and hydrogeologist. The input and analysis of appropriate professionals need to be integrated into the final water balance submission.

To assist with the pre-development determination of site-specific water balance values, Toronto and Region Conservation Authority and Credit Valley Conservation have developed applications which provides precipitation, evapotranspiration (actual), runoff, and recharge based on outputs from the numerical models developed under the Drinking Water Source Protection Program. Note that these values are based on a regional assessment of the water balance, and may be supplanted by site-specific data or modelling.

The TRSPA Water Balance Tool can be found at the following location.

The CVSPA Water Balance Tool can be found at the following location.

A number of reference resources have been developed to assist in the completion of hydrogeological water balance assessments. These resources include the Ontario Ministry of the Environment Stormwater Planning and Design Manual (2003), the Ministry of the Environment and Energy Hydrogeological Technical Information Requirements for Land Development Applications (1995), and the Hydrogeological Assessment Submissions – Conservation Authority Guidelines for Development Applications (2013). Consultants are strongly encouraged to consult early with municipalities determine the CTC Source Protection Plan policies applicable to the project and to assist in scoping the work needed to comply with any policies.

Excerpt from **Hydrogeological Assessment Submission – Conservation Authority Guidelines for Development Applications** (2013):

> The purpose of the water budget analysis is to reasonably estimate the current infiltration rates to the subsurface and to then determine how much this rate will change as a result of the proposed development. It is recognized that site specific water budgets are difficult to accurately estimate, the goal should be to assess the difference between pre-development and post development conditions and to mitigate for impacts on infiltration.
>
> The terms 'infiltration' and 'recharge' are commonly used interchangeably in development application supporting documents. Infiltration relates to the capacity for the soil to allow water to enter the subsurface. Some of this infiltration results in lateral movement in the shallow unsaturated zone where interflow may predominate and some of the infiltration is directed downward to the deeper aquifer system. Recharge is considered to be primarily water that reaches the saturated zone of the aquifer and becomes part of the regional groundwater flow system. The maintenance of infiltration rates is essential to the sustainability of the groundwater flow system which may support local significant ecological features. In addition, infiltration may move to a regional deeper flow system that may be important at a regional scale from either an ecological or water supply perspective.
>
> It is common practice and an accepted method (by most Conservation Authorities) to provide estimates of surplus using a Thornthwaite and Mather approach where surplus is estimated based on precipitation minus evapotranspiration (Steenhuis and Van Der Molen, 1986). Infiltration portion of the surplus can be estimated by applying the infiltration factors provided in the Ministry of the Environment and Energy Hydrogeological Technical Information

Requirements for Land Development Applications (1995). These factors consider slope, vegetation and soils. The remainder of surplus is considered to be runoff.

The water balance should be prepared by subdividing the development site into zones that reflect drainage outlets. In a simple case, there would be one catchment and one drainage outlet, whereas a more detailed case may have multiple stream catchments and several outlets. These catchments would be further subdivided by similar infiltration properties (i.e. grades, soils and vegetation). Pre-development and post-development water balances may have different catchments depending on the change in drainage patterns, grading, soil and vegetation as a result of the development. These changes should be clearly documented in the report and within a figure.

In most cases, one surplus value may be calculated for the entire site however, it may be requested that the surplus is calculated for each catchment for both pre- and post-development.

Post-development infiltration calculations/estimations should account for changes in imperviousness, vegetation, soil conditions, grading and site design by using adjusted infiltration factors based on these changes. These calculations should take into account the change in surplus (i.e. decrease in evapotranspiration) in areas where there will be impervious surfaces (e.g. roadways, driveways and rooftops). Where an amount of evaporation is assumed to occur on impervious surfaces these assumptions should be documented and supported accordingly. Generally, a 10-20% loss of precipitation is acceptable for these areas and is highly dependent on the drainage of the site.

Regardless of the water balance method applied, site-specific data and estimates should be incorporated as appropriate. The water balance should provide monthly calculations based on Thornthwaite and Mather to show Potential ET, Actual ET, and then use these to determine the annual surplus. However, a monthly water balance may be requested to take into account short-term or seasonal scale in addition to long-term or annual scale effects.

As much as possible, calculations should estimate the amount of infiltration necessary to maintain pre-development conditions. Detailed information on the proposed mitigation measures should be provided to account the loss of infiltration. These details should include location of enhanced infiltration (e.g. infiltration trench), the volume/rate and condition of the soils to support water being infiltrated.

At a minimum, the following are required when conducting a water balance analysis:

- Obtain precipitation values from a reliable source such as Environment Canada Meteorological Services for the area (utilize closest station with adequate data);
- Estimate of local values for major water balance components (evapotranspiration, surplus, runoff, and infiltration) for pre-development, post-development and post-development with mitigation conditions;
- Calculations of impervious areas that reflect actual conditions based on the proposed site plan or a reasonable range of impervious areas used in those cases where only a conceptual development plan is provided;
- Runoff coefficients consistent with generally accepted numbers (e.g. MOE guidelines);
- The water balance is required to take into account the changes to grading/topography and land cover;

- Grain size analysis for both the fill material and on-site soils to confirm fill material is similar to existing soil conditions (maybe recommended);
- Appropriate catchments should be used within the analysis (i.e. delineate catchments based on drainage, grades, vegetation, soils and show how infiltration and runoff will change within these zones for both pre- and post-development);
- Figure of catchments used within the pre- and post-development water balance; and
- All calculations should be provided in a table format which clearly demonstrates that inputs (precipitation, additional runoff, water from municipal wells, etc.) are equal to outputs (i.e. infiltration, runoff, water use).

7) Water Balance Mitigation Measures

Mitigation recommendations should address both the anticipated long-term and short-term impacts. A water balance can be achieved by implementing a number of the stormwater management practices outlined in the MOE Stormwater Management Planning and Design Manual (MOE, 2003) or in the CVC/TRCA Low Impact Development (LID) Stormwater Water Management Planning and Design Guide (TRCA and CVC, 2010).

The principal and most effective mechanisms for achieving water balance fall under the category of LID. Such practices are generally designed to manage rainfall and the resulting runoff at the source, which is more effective at reducing runoff volumes during frequent rainfall events than the larger centralized facilities known as "end of pipe" solutions.

Not all areas are suitable for recharge mitigation measures. For example, unsuitable conditions for recharge **may** include areas with:

- Slopes >20%;
- Bedrock within 1 metre of ground surface;
- Lands within 250 metres of a landfill site; and
- Wetlands and associated hydric soils.

Further, mitigation measures should address not only water quantity, but also the potential for water quality impacts on groundwater and surface water resources as a result of the development. Depending on the zoned use of the site, water quality concerns will vary. Infiltration of potentially contaminated water (i.e. parking lots, roadways) will be considered in the evaluation of the proposed mitigation measures.

In evaluating the post-development recharge, the approval authority or their designate will be looking for the proponent to make every effort to maintain overall infiltration across the site. Where a proposed mitigation measure to increase infiltration has been identified, the following points should be presented/discussed:

- The mitigation method(s) selected;
- Location of mitigation measures on the site plan;
- Impacts to groundwater and surface water quality;
- The amount (or range) of the annual enhanced infiltration estimated (based on available literature for each mitigation method recommended);

- Limitations - practical matters need to be considered (such as the nature of the native soil and its capacity to allow enhanced infiltration);
- The long term expected success of the measures, for example clogging or siltation of infiltration facilities is a common issue that needs to be addressed;
- Long term maintenance of the measure should be discussed (i.e. will maintenance be required and who will undertake such maintenance); and
- Post-development monitoring - often recommended as a condition of approval, but it is uncertain whether the monitoring actually occurs and to whom the data is being provided.

8) Options – Mitigation Measures

A number of mitigation strategies have been developed, tested, and proven to reduce post-development water balance imbalances. A short discussion of some alternatives is presented below and detailed descriptions are provided in the MOE Stormwater Management Planning and Design Manual (MOE, 2003) and the Low Impact Development Stormwater Management Planning and Design Guide (TRCA and CVC, 2010). Proponents can also obtain information from TRCA's Sustainable Technologies website at: http://www.sustainabletechnologies.ca/wp/.

Some of the potential measures include:

- **Rooftop runoff to pervious areas:** It was once common for rooftop downspouts to be connected to sanitary or storm sewer systems. However, most municipalities require downspouts to be disconnected, with downspout drainage being directed to lawns. In theory, this strategy should increase infiltration, but depending on the soil type and degree of compaction during construction, infiltration may be minimal. The amount of roof water that reaches the storm sewer system is reduced, but homeowners have been known to regrade drainage swales to make lawn maintenance easier. Such regrading may reduce the effectiveness of this strategy and cause undesirable surface ponding during larger storm events.

- **Roof top runoff to infiltration trench(es):** This approach collects roof water and directs it to an engineered infiltration trench. The trench surface area will depend on the depth to the water table, the infiltration capacity of the soil and the drawdown time for the trench. Depths should be no more than 1.5 m deep as per MOE criteria (MOE, 2003) to avoid compaction of the soil medium under the trench and a potential reduction in the infiltration rate across the bottom of the trench.

- **Green roofs:** Rooftop gardens have been widely recognized as providing significant private and public benefits to urban environments. These benefits include improved stormwater control, better air quality, lower energy use, moderated summer air temperatures, increased biodiversity, and healthier, more beautiful cityscapes. Broader recognition and appreciation of these values has been one of the drivers behind significant growth of the greenroof industry in the Greater Toronto Area (GTA) over the past decade.

- **Permeable pavements:** One of several LID practices that are being used to treat runoff and help increase infiltration in an effort to reproduce the pre-development hydrologic regime. Since these pavements replace conventional asphalt, they are ideally suited to older built-up areas that lack stormwater management and have little to no space for conventional stormwater facilities. They can also be cost effective in new development areas where runoff reductions from infiltration can reduce or eliminate the need for sewer infrastructure beneath the pavement (TRCA, 2012).

- **Additional topsoil depth**: Placement of additional topsoil provides additional storage across a development site. This approach is usually easily implemented, since most properties generate surplus topsoil during the site grading process. This measure increases evapotranspiration, since the additional topsoil can hold more water that can then be utilized during periods of drought. It is noted that grading or placing of topsoil in a regulated area under the *Conservation Authorities Act* may require a permit from Credit Valley Conservation or Toronto and Region Conservation Authority.

9) Water Balance Reviews For Compliance with Policy REC-1

The Implementing Body for Policy REC-1 is the Planning Approval Authority. It is their responsibility to ensure that recharge reduction from new development does not become a significant drinking water quantity threat within a WHPA-Q2.

Across the CTC Source Protection Region, arrangements have been made between Planning Approval Authorities and third parties to review the water balance assessments submitted to conform with Policy REC-1.

- All Planning Approval Authorities (lower tier municipalities) in the York Region portion of the York-Durham Future Significant Water Quantity Threat Area are relying on Toronto and Region Conservation Authority to provide the technical expertise needed to review the water balance assessments submitted by proponents.
- The Town of Orangeville is working with Credit Valley Conservation to provide the technical expertise needed to review the water balance assessments submitted by proponents in the Orangeville-Mono-Amaranth Significant Water Quantity Threat Area.

A typical review will consist of looking at each of the following components of the water balance to ensure that the intent of Policy REC-1 has been met:

- Pre-development infiltration and runoff volumes;
- Post-development infiltration and runoff volumes;
- Post-development estimates of recharge deficit or excess; and
- Proposed mitigation measures and design.

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