Project **WATER BUDGET STUDY – HOLLAND, MASKINONGE AND BLACK RIVERS WATERSHEDS**

Client **Lake Simcoe Region Conservation Authority (LSRCA)**

Objectives

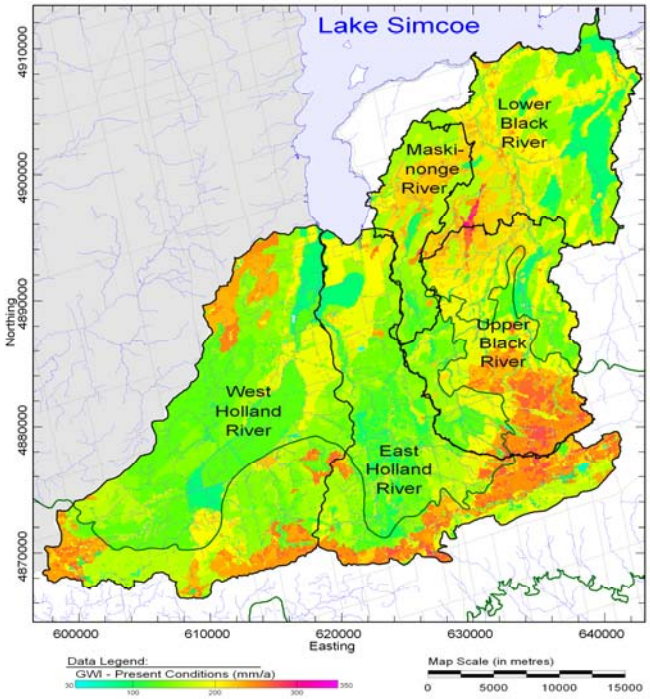
- Develop a watershed-scale water budget based on groundwater, surface water and climate model simulations
- Evaluate current and future land use changes and wellfield pumping under average and drought conditions.
- Address requirements of the Oak Ridges Moraine Conservation Plan (ORMCP) source water protection regulation.

Outcomes

- By combining the RETRO-G distributed recharge model with the MODFLOW groundwater flow model, the LSRCA now has a powerful tool for evaluating urbanization, pumping and climate variation.

Key Aspects

- Distributed recharge modelling with RETRO-G allowed more representative (i.e. spatially variable) values of climate, recharge and land use to be incorporated into the model.
- High resolution (100-m cells) provided detailed representation of the entire stream network, including the smallest, most sensitive, headwater tributaries.
- Regional-scale multi-watershed approach allowed evaluation of lateral inflows from adjacent watersheds.
- Detailed 8-layer groundwater model simulated deep (inter-catchment) groundwater flow pathways.



Net ground water infiltration from the spatially distributed RETRO-G model.

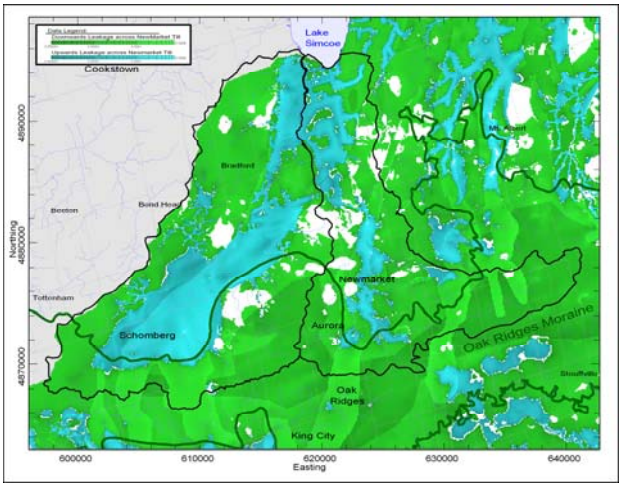
Project Description

The Oak Ridges Moraine Conservation Plan (ORMCP) is the first watershed planning regulation in Ontario that specifically requires water budget modelling (many of the concepts and goals of the ORMCP are now included in the province-wide Source Water Protection initiative). The Holland, Black and Maskinonge River watersheds include a number of significant stresses, including rapid urbanization, extensive agricultural irrigation, significant wellfield pumping and sensitive high recharge areas. Water budget modelling is required to understand and developed a balanced response to water use, development and environmental protection.

An eight-layer high-resolution groundwater flow model of the Oak Ridges Moraine was developed as part of a long-term CAMC groundwater protection strategy. The model is based on detailed hydrostratigraphic interpretation of the moraine; to date over 112,000 geologic layer picks have been made to define the complex layering and erosional channels in the area. Very small model cells (100 m) were used across the entire study

area to allow for detailed representation of the stream network. All streams were represented, including the smallest, most sensitive, headwater tributaries.

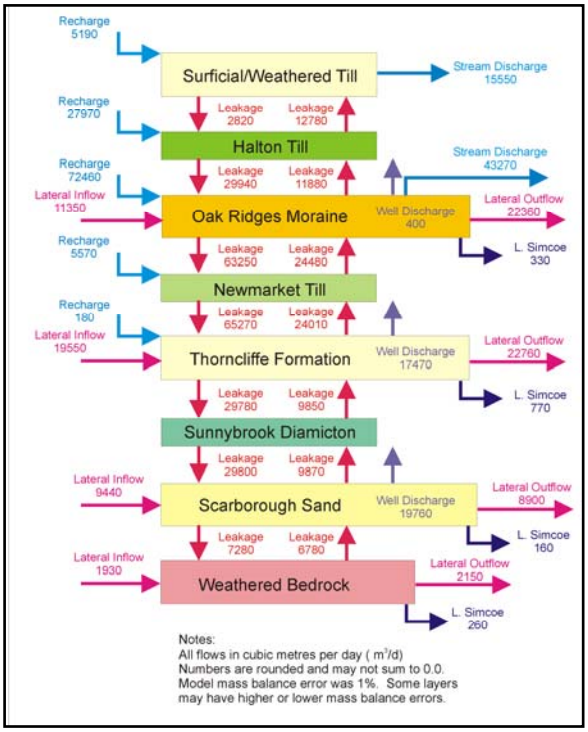
Changes in land use and climate were identified as important scenarios for water budget planning purposes. Precipitation varies by over 25% across the watershed. Rapid urbanization and increased water use is occurring in many of the communities. These spatially varying stresses require a detailed analysis approach as local changes can have significant impact on individual stream reaches.



Flux across the Newmarket aquitard showing recharge (green) and discharge (blue) areas

A new recharge model, developed by Earthfx with the support of Clarifica Inc., was used to simulate the complex partitioning of precipitation into evapotranspiration, runoff and groundwater infiltration. This new spatially distributed model, named RETRO-G, is based on the catchment-based WABAS model (Clarifica., 2002). RETRO-G (Rainfall, ET, Runoff, Groundwater) is a significant improvement over catchment averaging approaches (such as WABAS and HSPF) or unit response approaches because it simulates the unique local combination of climate, land use, soil properties, and vegetation in each of the nearly one million cells in the regional groundwater model. RETRO-G simulates the complex surficial processes using a physical model approach, including processes such as the accumulation of snow and subsequent melting as temperatures increase.

RETRO-G was used to calculate groundwater recharge on a cell-by-cell basis, for use in the MODFLOW model, which was then used to estimate the water balance in the subsurface. Detailed water balances were prepared for each land-use and climate change scenario on a watershed, sub-watershed, and cell-by-cell basis. Water budget results for each scenario were presented in a number of insightful formats, including:



Box diagram showing fluxes into and out of each aquifer layer

- Spatial maps of flux across key aquifer layers (showing significant recharge/discharge areas)
- Box diagrams of flux into/out of each aquifer layer (useful for understanding overall stresses on each aquifer layer)
- Change in baseflow in each stream reach (presented as both percent and total change maps)
- Discharge by steam class (nearly 30% of the total groundwater discharge occurs to the smallest headwater tributaries.)

The resulting model has provided the LSRCA with ability to better manage the future stresses on the watershed. Pumping remains a significant direct stress with continued development moving into the smaller communities. Continued urbanization and the resulting change in infiltration capacity is a smaller scale but locally significant stress on individual stream reaches. The combination of RETRO-G and MODFLOW allows LSRCA to understand the linkage between precipitation in high recharge areas, deep municipal pumping and baseflow discharge.