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Modelling of projected impacts of climate change on groundwater recharge in the Annapolis Valley, Nova Scotia, Canada

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Recharge rates across regional aquifer systems are governed by an interplay of geology, land use, and climate. Numerical simulations are a useful tool for integrating these factors together with climate change scenarios to define a plausible range of projections of both decadal trends in annual recharge and inter-annual variability. A recent study on climate change impacts on aquifer recharge across Canada has shown that the Maritimes region (in eastern Canada) has had decreasing trends based on historical records of both baseflow and well hydrographs. In the current study, the potential impact of future climate change on the evolution of recharge over the next decades was examined using the infiltration model HELP and five climate change scenarios from a regional climate model.

Specifically, the simulations explored aquifer recharge and its sensitivity to climate change during the 2041-2070 period for the Annapolis Valley in Nova Scotia, one of the major fruit growing regions of Canada. The study area extends over 546 km2 along the Bay of Fundy, between the North and South Mountains. The climate of the Valley can be described as humid and temperate, receiving on average 1180 mm/y of total precipitation (snow and rainfall) and with monthly temperatures varying between -5°C and +20°C. In a first phase of the study, two members of the second version and three members of the third version generated by the Canadian Regional Climate Model (CRCM), in combination with the A2 gas emission scenario, were utilized. In a second phase, four theoretical simulations using a mean increase of temperature for a given season were run to study their specific impacts on recharge. The one-dimensional model HELP, a commonly used diagnostic model that resolves the water balance equation based on the conservation of mass principle, was used for the soil and groundwater simulations, taking into account also snow accumulation, land cover, and plant growth. The model was modified in order to be run in batch mode, so that multiple cells covering the entire study region could be considered.

The model runs predicted mostly an increase in annual recharge over the 2041-2070 period, contrary to historical trends. On a seasonal basis, however, a marked increase of recharge during the winter and a significant decrease of recharge during the summer were observed in both the historical trends and simulation results. With the model, the increased evapotranspiration resulting from higher temperatures does not offset the significant increase in winter infiltration. Lower summer recharge is of concern for this region because water demand is highest during the growing season. In terms of individual water budget components, the model shows that marked differences were obtained between the different climate change scenarios, especially during the winter. Monthly recharge values were also found to vary quite significantly, even for a given climate scenario over the 30-year simulation.