Simon Fraser University graduate student, Isabelle Larocque, completes a MSc thesis titled "The Hydrogeology of Salt Spring Island"

Coastal aquifers are particularly susceptible to natural and anthropogenic stressors because saline water can intrude inland and contaminate the freshwater resource. The goal of this research was to assess the sensitivity of a coastal aquifer to various stressors, including sea level rise (SLR), change in recharge, and development (pumping). The study site was Salt Spring Island, the largest and most populous island in the Gulf Islands, British Columbia.

Salt Spring Island is composed of sedimentary (sandstone and mudstone of the Nanaimo Formation) and older rocks that are primarily igneous. These rocks form the dominant aquifers on the island. Groundwater flows primarily through fractures, which control the hydraulic properties of the aquifer system. Recharge is dominantly by infiltration of rainfall across the island surface. At a local scale, the groundwater discharges into lakes and streams, but regional flow is toward the coast where the groundwater discharges to the ocean.

The groundwater chemistry of Salt Spring Island is similar to the other Gulf Islands. Groundwater evolves from a Na-Cl rainwater to a Ca-HCO_3 type through calcite dissolution. In the sedimentary rocks, cation exchange takes place whereby Ca is exchanged for Na, resulting in a Na-HCO_3 type water that is a common water type in the Gulf Islands. The Na is thought to have been emplaced on clay mineral exchange sites when the islands were submerged below sea level at the end of the last glaciation. Groundwater flowing within the igneous rocks does not undergo cation exchange. Mixing with a Cl-rich member is also a dominant process in both rock types. The source of Cl may be old seawater, possibly of Pleistocene age, or modern saltwater intrusion. Some wells near the coast are known to be impacted by saltwater intrusion.

Available pumping and tidal response tests for Salt Spring Island were analyzed in order to estimate the aquifer hydraulic properties. The values are similar to those reported for the other Gulf Islands and are remarkably similar between rock types. Transmissivity is estimated on the order of 10^{-5} to 10^{-4} m^2/s and hydraulic conductivity on the order of 10^{-7} to 10^{-6} m/s for both rock types. The pumping tests and tidal response tests, despite the differences in scale for testing, also yield similar averages.

A series of numerical groundwater models was developed for the Swan Point area on Salt Spring. Using Visual MODFLOW, a steady-state fresh groundwater flow simulation was carried out to generate a representative flow system and establish a reasonable range for the aquifer properties. A tidally-forced transient model was next used to investigate the tidal response of the aquifer and further constrain the aquifer properties. Next, a density-dependent flow and transport model was constructed in SEAWAT to simulate the current position of the saltwater interface, which was found to be near vertical at the coast (no traditional saltwater wedge that intrudes inland). The lack of a wedge reflects the relatively steep topography at this site and suggests that submarine groundwater discharge may occur. The SEAWAT model was then used to determine the sensitivity of the aquifer to climate change, encompassing an increase in mean annual recharge by ~1.5 % and SLR of 1.17 m by the end of this century, as well as pumping. Model results showed no significant impacts to the salinity distribution or saltwater wedge geometry at this particular site due to the steep topography. However, areas with less steep topography may have greater impacts and merit further research.

Isabelle Larocque defended her MSc thesis in the Department of Earth Sciences at Simon Fraser University in August 2014. Her senior supervisor was Dr. Diana Allen. This research was supported by a Pacific Institute for Climate Solutions (PICS) graduate fellowship to Isabelle, as well as a research grant by Natural Resources Canada, and a Natural Sciences and Engineering Research Council (NSERC) Discovery Grant to Dr. Allen. The Water Council Society and the Local Trust Committee provided support for field accommodation expenses.