



Locating and quantifying direct groundwater discharge at the reach scale: MacKay River, Alberta

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ABSTRACT

In order to properly evaluate development impacts and identify critical monitoring locations, the Canada-Alberta Joint Oil Sands Monitoring Plan (JOSM) requires an understanding of how and where groundwater interacts with local rivers. However, there are considerable logistical and technical challenges to efficiently and effectively identify groundwater discharge areas in large river systems that occur in complex geological and remote settings. These challenges often arise from disparities in scale; searching for local or reach-scale groundwater discharge within a regional-scale river. This makes the use of conventional groundwater-well networks and regional surface water monitoring programs (e.g. single or sparsely spaced gauging stations) inadequate to identify and detect areas of groundwater discharge to these rivers. Using the MacKay River north of Fort McMurray, Alberta as a test river, this work was aimed at improving methods for detecting and quantifying groundwater discharge to rivers in the oil sands region. A 125 km section of the MacKay River was selected for the study. Initial screening (i.e. aerial infrared thermography, stable isotope and geochemical methods) of the river identified potential locations of groundwater discharge and inventoried the locations of surface water contributions from lower-order tributaries. Determinations of the groundwater flux to individual reaches were determined using water balance principles and high-precision differential stream gauging. Stream flow was measured using an acoustic Doppler current profiler (ADCP). Considerable efforts were taken to minimize measurement uncertainty and maximize statistical power to improve the detection resolution. Stable isotope and geochemical parameters were also determined to provide a mass balance dimension for testing the consistency of the ADCP flow measurements. Both open water and under-ice periods were investigated. The approach developed provides a relatively rapid assessment of the role and importance of groundwater discharge to a river by providing information on where, and where not, aquatic habitat and surface water quality may be most vulnerable to changes in the quality and quantity of groundwater discharge.