Alberta Oil Sands Area regional groundwater quality

Cynthia McClain
Alberta Environment and Parks, Calgary, AB, Canada
Jean Birks, Michael Moncur, Emily Taylor, Don Jones
InnoTech, Calgary, AB, Canada
John Manchuk, Clayton Deutsch
Centre for Computational Geostatistics, University of Alberta, AB, Canada
Yi Yi, John Gibson
InnoTech, Victoria, BC, Canada
James Brydie, Ernie Perkins
InnoTech, Edmonton, AB, Canada
Guy Bayegnak
Alberta Environment and Parks, Edmonton, AB, Canada

ABSTRACT
This study aims to investigate regional groundwater quality in the Athabasca Oil Sands (AOS) area of northern Alberta, Canada, in light of mining activities and regional land use planning. Within the 50,000 km^2 AOS area, a database of 546 water quality parameters measured in 5,118 water wells between the 1960's and 2015 was compiled, cleaned and analyzed by hydrostratigraphic unit (HSU), including the main Quaternary and Cretaceous aquifers. Among the 12 main HSU's there are a variety of distinct water types including Ca-bicarbonate, Na-bicarbonate, mixed-cation bicarbonate and Na-Cl, reflecting variable lithology, ion exchange, and mixing. Geochemical anomalies within each HSU were identified by Principal Components Analysis. For example, within the Empress Formation geochemical anomalies in Total Dissolved Solids (TDS) and Cl likely result from mixing with the Colorado Group Shales. Spatial (within and between HSU's) and temporal trends in water quality were assessed using (geo)statistical methods in ArcMap and R, and compared to "interim trigger values" (concentrations specified by the Lower Athabasca Regional Plan Groundwater Monitoring Framework to detect changes in water quality). Median concentrations for multiple water quality parameters exceeded interim trigger values. For example, in most HSU's, median TDS concentrations exceeded interim trigger values. Statistically significant temporal changes in water quality were detected in the 2000's in small areas of shallow surficial sand aquifers and the McMurray Formation. The surficial sands exhibited increasing Na, Cl, and HCO_3 concentrations while the central McMurray Formation exhibited increasing TDS, Cl, B, and alkalinity concentrations. The compiled dataset highlights the lack of publically available data for some aquifers, particularly in the central portion of the study area, where in situ oil sands mining activity is located. Thus, recommendations for enhancing understanding of regional groundwater quality in the Athabasca Oil Sands area include: continued groundwater monitoring (with expansion of monitoring in the central area, and to regions with surface water-groundwater interaction), collection of a consistent set of water quality parameters, and continual database maintenance and analysis.

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