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Devonian Aquifer Depressurization at the Kearl Mine

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Summary

Kearl mine is actively depressurizing the Prairie Intact Laminite (PIL) Aquifer within the Devonian Elk Point Group (Walker et al., 2017) underlying the Kearl mine North Pit area to limit the inflow of Devonian groundwater into the open pit. Depressurization is the preferred mitigation method because of the site-specific conditions encountered in the North Pit area. Vertical wells were used initially and recently a horizontal well has been implemented into the network.

Theory

There are three site specific conditions that favor active depressurization mitigation to limit Devonian inflows at the Kearl mine site. First, the Kearl mine is located in an area of intense dissolution where the majority of the Elk Point evaporites have been removed relative to areas to the west of the mine, resulting in collapse of the overlying Devonian section and the presence of "hydraulic windows" connecting the PIL aquifer to the overlying Devonian. Secondly, the McMurray basal aquifer is either absent or occurs as a thin and discontinuous distribution in the North Pit area and therefore does not provide a continuous "drainage blanket" to attenuate any Devonian inflows. Finally, as the Kearl mine is located, relative to mines to the west, more proximal to the subcrop edge of the Prairie Evaporite Formation to the east where the aquifer receives direct recharge, the PIL aquifer water quality is non-saline (<4,000 mg/L), which allows for management of produced water at reasonable costs.

The PIL aquifer hydraulic properties and hydraulic connectivity to other units has been characterized based on historical pumping tests and the ongoing operational depressurization activities at the Kearl mine. Similar to most karst aquifers, the PIL Aquifer shows strong scale dependency. Wells at Kearl often test macro features resulting in transmissivity in the magnitude of 10^{-4} m^2/s based on a nominal 10 m saturated thickness and hydraulic conductivity in the magnitude of 10^{-5} m/s. However, widely spaced but very permeable channel networks have also been identified, referred to as "conductive corridors". The aquifer is confined with a storativity in the magnitude of 10^{-5} to 10^{-4}.

Results

In 2019, the first Devonian horizontal depressurization well was drilled at the Kearl mine within the PIL aquifer. The well intersected a conductive corridor that was previously identified based on total losses in circulation from an existing well that provided a well-defined conductive corridor for the horizontal well. Intersecting this conductive corridor resulted in a relatively large cone of depression as the well is producing from the most permeable feature in the groundwater system. The test data from the pumping well and from a relatively high-density monitoring network, both spatially and vertically, were used to interpret the groundwater system response. The well scale transmissivity, hydraulic conductivity and storativity were consistent with previous results. High diffusivity (< 10 m^2/s) drawdown responses were measured throughout the North Pit area, which indicates good hydraulic connectivity under, through or around the overlying Keg River Formation reefs. Vertical connectivity above the aquifer was limited, which indicates the monitoring wells were not positioned within “hydraulic windows” but does not rule-out their presence. At nested grouted-in vibrating wire completions, the response in the PIL aquifer and underlying Keg River Formation ramp were similar, which suggests either the two strata were behaving as a single aquifer or that vertical pathways are providing good vertical hydraulic connectivity between the strata. This evolving conceptual model continues to inform planning and execution of the ongoing Devonian PIL depressurization aquifer program.

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References

Walker, James, Istvan Almasl, Frank Stoakes, Ken Potma and Jennifer O’Keefe (nee Crenshaw), 2017. Hypogenic Karst Beneath the Athabasca Oil Sands: Implications for Oil Sands Mining Operations. CSPG Publication, Volume 65, Number 1, March 2017, Pages 115 to 146.