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Modelling the effect of undetected barriers on groundwater drawdown and recovery

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In the Pilbara region of Australia, large, open-pit iron-ore mines require high rates of dewatering. Predictions of drawdown are required both during mining and after it has ceased (groundwater recovery). The hydrogeology of the region is complex, with aquifers dissected by extensive dolerite dykes. Sharp hydraulic head gradients and pumping tests across these dykes demonstrate that many are impermeable barriers and inhibit groundwater flow. However, dykes may exist in areas that have not yet been affected by mine dewatering. These are therefore unlikely to have been detected and act as a source of structural uncertainty in models predicting groundwater drawdown and recovery.

This paper develops non-dimensional solutions to analytical models of groundwater flow to a well, utilising the methods of images. It explores conditions under which impermeable barriers may be undetected during groundwater pumping, yet still control the recovery of groundwater levels. The results show that even if a barrier is undetected during pumping, drawdown during recovery could be significantly greater than if that barrier were not present (on the pumping side of the barrier). The results are exemplified for a hypothetical aquifer with an unknown barrier 3 km from a pumping well. During ten years of pumping, the presence of the barrier increases drawdown by < 1 m adjacent to the barrier. However, 40 years after pumping has ceased, the presence of the barrier causes approximately 50 m of additional drawdown. The results have implications for the development of regional-scale models in areas affected by impermeable barriers.