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Modelling perched river recharge to the Wairau aquifer, New Zealand

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The Wairau Aquifer in Marlborough, New Zealand, consists of coarse, high-conductive alluvial gravels and is almost exclusively recharged by surface water from the braided Wairau River. Recent experimental evidence suggests that the river is perched in the upstream recharge region of the aquifer. The aquifer serves as the major drinking water resource for the city of Blenheim and the surrounding settlements on the Wairau Plain and thus is a key natural resource for the region. To ensure the sustainable management of the resource, it is essential to better understand the limits and the mechanics of the recharge mechanism.

One efficient way to test hypotheses of the mechanisms for river-groundwater exchange fluxes between the Wairau river and aquifer is by data integration into numerical models that mimic the flow regime of the coupled hydrological system. For that purpose, a Modflow model for the Wairau Aquifer was to set up and calibrated under summer conditions when the flow in the river is low and the aquifer is most vulnerable to over-allocation. The model is constrained by knowledge about the hydrogeological settings as well as observations of groundwater levels, river and spring flow gaugings, and analysis of aquifer pumping tests.

Both historic and more recent concurrent river flow measurements under low flow conditions suggest that approximately 7-8 m^3/s is recharged into the aquifer along the upper and middle reaches, at least partly under perched conditions. At the eastern side of the aquifer, a small proportion of that water flows back into the river, whereas a greater proportion emerges in springs. Spring creek is the largest spring with an estimated mean flow of 4.0 m^3/s. This flow rate is vulnerable to an excessive decline in groundwater levels.

The simulations with the calibrated flow model fit well to the observations of current mean groundwater heads as well as to mean Wairau river and Spring creek flows. Modeling results suggest a large spatial variability of recharge fluxes along the river. Model calibration to the different data types turned out to be challenging and required a powerful multiobjective optimization approach and parameter regularization techniques. The proposed approach yielded parsimonious parameter fields with relatively low variability that are generally in agreement with estimations from bore-log analysis.

First steps were taken to simulate the dynamics of the river recharge mechanisms and to evaluate the current monitoring scheme with respect to the utility of individual observations. Transient simulations under different flow regimes will improve the knowledge about the Wairau river-groundwater exchange fluxes and thus assist in providing more confidence in managing the valuable resource.