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Conceptualisation of groundwater recharge from the Wairau River, New Zealand

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The braided Wairau River is the main source of recharge to the Wairau gravel aquifer in Marlborough, New Zealand. Flow measurements indicate a 6 to 15 m3/s loss as the river traverses the Wairau alluvial fan, a distance of 15 km. The hydrological processes regulating this flow loss are not well understood.

Theoretically, the relationship between a river and groundwater can be considered as being hydraulically connected (gaining or losing), disconnected, or transitional (Brunner et al. 2011). A disconnected river is distinguished from a hydraulically connected river by a partially saturated zone between the river bed and the aquifer. The aim of this study is to improve our conceptual understanding of how flow losses occur, and to test a new hypothesis that much of the river is hydraulic disconnected from the aquifer.

It is practically difficult to make direct observations of the saturation status beneath a river bed. However, indirect observations can be employed to characterize the nature of the river-aquifer exchange, and we have used a variety of data sources (stratigraphy, piezometric surfaces including LiDAR, temperature and radon tracers). Several lines of evidence from these data sources indicate that the dominant recharge reach of the river is hydraulically disconnected, or at least transitional in nature. This simplifies the prediction of transient flow losses, which only requires knowledge of near-surface Kz and wetted river area values.

The hydraulic mechanism for a disconnected river condition is the anisotropy of the sandy gravel sequence. The braided river depositional process has formed a finely layered sequence of silt, sand and gravel lenses. This stratification, combined with clast and particle imbrication, has formed a highly anisotropic hydrogeology. Results from aquifer tests analyzed for leakage have typical Kx values of 500 m/d and Kz values of around 0.5 m/d. The large Kx/Kz ratio enables the aquifer to potentially discharge more rapidly in a lateral direction than it can be recharged from above. We propose that this stratigraphic anisotropy can inherently create hydraulic a disconnection in a braided river environment.

A numerical model of the Wairau Aquifer has been developed to test our conceptual understanding of river-aquifer exchange dynamics (Wöhling et al. 2015). The numerical model is only able to integrate and accurately simulate the variety of available observational types if disconnected conditions are simulated consistently over the majority of the recharge area. This confirms our hypothesis drawn from indirect observations.

References

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