Spatial variability in surface water-groundwater fluxes using hydraulic methods

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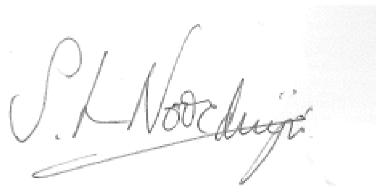
Declaration

I certify that this thesis does not incorporate without knowldege any material previously submitted for a degree or diploma in any other university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.



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Co-Authorship

Saskia L. Noorduij is the primary author on all manuscripts in this thesis. On all submitted papers, the co-authors provided intellectual supervision and editorial content.

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Summary

Quantifying the spatial variability of surface water-groundwater fluxes remains a challenge. The ability to either upscale point measurements or down scale reach/catchment scale measurement invariably introduces error into the estimation processes. This thesis addresses two methods that have been used to estimate surface water – groundwater flux, and investigates an approach to determining stream-aquifer connection state. The aims of this Doctoral thesis are to: 1) determine the representative scale at which standard hydraulic methods can be applied in this field of research, 2) quantify the variability in surface water – groundwater fluxes in ephemeral environments, and 3) develop methods of measuring hydraulic heads beneath and adjacent to streams.

In the first part of this research, the spatial scale of Darcy's law was investigated in the context of surface water – groundwater interaction. The primary supposition being that when applying Darcy's law to estimate groundwater discharge to a stream, the estimated discharge determined using a well at a distance of 50 m will encapsulate discharge over a greater proportion of the stream than a well at a distance of 10 m. This was investigated using numerical methods and stochastic K-fields to determine the influence of aquifer properties i.e., variance and correlation length of the K-fields on this question of scale. An estimate of the integrated hydraulic conductivity between the well and stream was determined by simulating a change in stream stage. The findings of this body of work suggest that an approximate 1:1 relationship exists between the distance of the observation well and the length of stream represented by the Darcian groundwater discharge estimate. In addition to this, the correlation length within the aquifer will strongly influence the variability in the discharge estimates. A similar approach was applied to a highly instrumented field site. The results of the field study concur with those of the numerical simulations i.e., variability in discharge estimates decreases as the distance of the well from the stream increases.

The second part focussed on determining the spatial variability in seepage flux beneath

an ephemeral channel. The use of flood front movement along a channel has emerged as a technique to determine the hydraulic conductivity of streambed sediments and thereby quantify the seepage flux for a given flow event. This approach was applied to a controlled flow event along a 1387 m reach of an artificial stream channel. We investigated the usefulness including surface water and groundwater data to assist in the calibration processes. The results of this study identified areas of high seepage flues in the upstream reaches and low seepage fluxes in the downstream reaches. A Latin Hypercube Monte Carlo analysis of the model indicated that specific yield had the strongest influence on the calibration.

The final part of this research investigated a well completion design which would enable the direct monitoring of the connection state of a stream, by enabling placement of wells beneath streams and floodplains. This approach required the well to be sealed so that surface water would be unable to enter, and the total pressure (from a non-vented pressure transducer) within the well could be monitored. A controlled laboratory experiment was used to compare the total pressure response in an open and sealed well to various water levels. The results indicated that the total pressure within the open and sealed wells were equal. Therefore, the groundwater response in the aquifer can be obtained using the total pressure data obtained from within a sealed well. The advantage of this approach is that it negates the need for tall standpipes and additional infrastructure, which would otherwise be damaged during high flow events.