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Hydrology and Earth System Sciences Discussions



# *Interactive comment on* "Dynamic analysis of groundwater discharge and partial-area contribution to Pukemanga Stream, New Zealand" *by* V. J. Bidwell et al.

**V. J. Bidwell et al.**

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Anonymous Referee #1 Received and published: 12 September 2007 Summary This article addresses the problem of hydrograph separation. The baseflow contribution to streamflow in the Pukemanga Stream (catchment size 3 ha) is studied, in view of potential nitrate contamination problems. The article does not present a clear conceptual model of the catchment.

Our conceptual model is described on page 2464-6-24. The reviewer's comment about lack of clarity is addressed by a replacement sentence at 2464-7 in response to another review comment.

The numerical model is a lumped, partially physically based model with a number of calibration parameters. Uniqueness and robustness of the calibration is not sufficiently demonstrated.

Our test for robustness is described on page 2470-22-23. We offer the technique of fitting the model to seven separate years of daily data as a practical measure of robustness.

The physical meaning of various model parameters is not discussed in detail.

The following statement about the parameters will be inserted at page 2649-13:

Thus the hydrometric model of groundwater discharge has four parameters to be calibrated from climate and streamflow data: groundwater catchment area Agw; value of soil water drainage DT that determines partitioning between recharge to groundwater and near-surface flow; hydrometric residence time Tv of the vadose zone; and the dynamic parameter alpha of groundwater discharge.

Various modeling concepts from the literature are combined and the article does not present novel conceptual ideas. The focus is onthe application to a real catchment. However, the study lacks a clear practical focus. A model is always built to answer a concrete question and not to simulate reality in some abstract sense. What is the intended use of this model? The article should include a demonstration of the intended application.

We believe that a valid use of models is for improving process understanding by quantifying process dynamics. It has been our experience in New Zealand that the relevance of the groundwater flow path for streamflow generation has been underestimated because of past emphasis on surface water research. One of the consequences has been, until very recently, a lack of appreciation of the role of groundwater in nitrate transport from land use.

Main Comments - The introduction starts out with a section on the importance of landcover for nitrate export. The link to the abstract and to the main focus of the article is not clear.

At page 2463-11-22 we discuss the relevance of water flowpaths to transportation of nitrate from land use to water from the catchment. The Abstract begins with a description of this flowpath issue.

- In the coupled US-zone / groundwater model, there are at least 4 fitting parameters (possibly more): alpha, D_T, T_v and A_gw. The authors briefly mention calibration on page 2469, but no info quality of fit, parameter correlations (which I expect to be significant, e.g. D_T and A_gw) etc. is given.

The criterion for quality of model fit is explained at page 2469-15-23. The number of fitting parameters and their description is defined at page 2470-13-15. Details of the stepwise calibration procedure are explained in section 2.6. As explained in page 2470-22-23, robustness of the parameters was considered by fitting to each of the seven sets of year-long daily data. We offer this approach as a surrogate for the full parameter correlation matrix.

Moreover, it is conceptually unclear, why these parameters should be time-variable (particularly A_gw).

Our basis for the concept of time-variable groundwater catchment area is provided by Winter et al. (2003;p. 996), who report: "Three examples of field studies are presented where the movement of groundwater divides has been documented. The sites are in Nebraska, North Dakota, and Germany."

DT could be expected to vary because of seasonal variations in soil infiltration rates caused by moisture variations, especially in clay soils.

- The hydrometric model should be able to simultaneously explain streamflow and groundwater level data. It appears that the authors used groundwater data and streamflow data separately to calibrate various parameters. Why not fit all parameters simul-



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taneously, using the entire dataset?

The simultaneous approach involves appropriate weighting of different kinds of observations. This difference between groundwater levels and stream discharge is not simply a function of measurement errors but also the differing uncertainties of process knowledge. We chose our sequential modelling approach, described in section 2.6, in order to calibrate the dynamic behaviour (system eigenvalues) from the better understood groundwater discharge process, and then used this parameter basis to examine the less well understood parameter structure of the piezometric data. In general, piezometric data are more sensitive to spatial variation of catchment/aquifer properties than is the integrative nature of groundwater discharge.

- Conceptually, it is hard to understand what a reduction of A_gw means: Does it mean that the groundwater recharged on the remainder of the catchment flows to another stream? Or does it infiltrate into deeper aquifer units? Or does it just discharge a little further down into the Kiripaka Stream? (In that case it would not make a big difference for nitrate loads). No physical explanation is given for this concept, although this appears to be a key point in the article.

We have undertaken a 2D-vertical streamfunction analysis of this situation (not reported in the manuscript) that illustrates how groundwater recharge from the higher parts of the catchment flows beneath the Pukemanga stream gauging site and most likely into the Kiripaka Stream (next order in the stream network). The relevance to nitrate loads is that the spring-fed wetland of the first-order, Pukemanga Stream is a different kind of riparian zone (with associated denitrification potential) than that of the higher order Kiripaka Stream. We have not conducted the relevant riparian denitrification studies but we think that our quantification of groundwater flow paths and contributing areas is a contribution to the understanding of this kind of research.

Overestimation of streamflow could probably also be corrected with reduced infiltration capacity and consequently higher actual ET.



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We found that the dynamic response of groundwater discharge is such that realistic values of ET and infiltration, for the 3 ha area, cannot generate the input recharge values required to achieve satisfactory prediction of low streamflow.

I suspect that the choice and parameterization of F(a,w) has a significant effect on the simulated water balance, but this is not at all discussed in the article.

We describe the characteristics of F(a,w) for the selected value of 'a' at page 2468-4-6. During initial studies, we found that water balance is not particularly sensitive to the value of 'a'.

- The concept of different contributing areas should be re-examined. The discussion given on page 2475 does not sufficiently clarify the issue.

We would modify the sentence beginning at page 2475-5 to read:

The groundwater contribution to a particular stream gauging location can be different from the topographical catchment area. This difference raises the question of how to report the partitioning of catchment drainage flowpaths: either as unit land area hydrological processes ("unit area"); or weighted according to groundwater catchment area and topographical catchment area ("weighted").

Details 2462-14-16: It is stated that 58-83 % of streamflow is baseflow. At the same time 78- 93% of the flow generation on a unit area basis is baseflow. Contradiction? Please rephrase.

This statement will be rephrased as:

Groundwater was calculated to be 58-83% of observed annual streamflow from the topographical catchment. When the smaller groundwater catchment area is taken into account, the groundwater contribution to streamflow is 78-93% on a unit area basis.

2463-3: Where is the Waikato region? Is it similar to the region studied here?

The revised manuscript will include an additional sentence at 2463-10:



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The Pukemanga Catchment, which is the subject of the present study, is located in the Hakarimata Ranges.

Page 2465-4 will be modified to include:

...in the hill country of the Hakarimata Ranges near the west coast...

2463-78: Load usually indicates a quantity in mass per time. Mass per volume is a concentration.

This correction will be included in a revised manuscript.

2464-7-10: Rephrase. The first principle is hard to understand.

The first principle will be restated as:

Firstly, the dynamic response of groundwater discharge to recharge from soil-water drainage can be differentiated from that due to streamflow contributions from near surface processes such as overland flow and lateral subsurface flow.

Figures: Observed discharge is compared to predicted groundwater discharge in figs 3-5. The model also produces overland flow / interflow. Why then not compare simulated and observed total discharge?

For the purposes of the model, there was no requirement to simulate the more rapid dynamics of overland flow/interflow. A suitable dynamic description would have been necessary to achieve satisfactory model fit to total streamflow for daily and hourly time intervals.

Fig 1: How was the catchment of the Pukemanga stream delineated?

The catchment is defined by surface topography that would contribute to the streamflow gauge on an overland flow basis.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 2461, 2007.