Stream-upland connections and the effects of stream discharge on transient storage processes

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INTRODUCTION

Stream-catchment connections and the linkages between stream discharge and transient storage processes remain poorly understood. We seek to explore stream-catchment connections and the impact of discharge magnitude on transient storage dynamics. Previous studies of transient storage in streams have suggested that hyporheic exchange should dominate transient storage as discharge decreases because of reduced stream cross-sectional area relative to the cross-sectional area of the hyporheic zone. However, no direct relationships have been developed between stream discharge and transient storage influence on soluble transport. We tested the hypothesis that the influence of transient storage on soluble transport increases with decreasing stream discharge.

The study area is a 500-m reach of the Maimai Stream, a 6th-order stream with 290 m of channel length, located in the South Island of New Zealand. Four reaches were selected for the study based on the topographic map of the 10.9-ha R. K. catchment. The study area was selected to provide a range of stream types and discharge conditions.

STUDY SITE

MODELLING METHODS

Stream Tracer Solute Transport Modeling

Three LBR injections were used to model the 290-m stream reach. Each injection was modeled using the UCODE computer code throughout the experiments, based on EC. An EC-Q relationship was determined, and the EC breakthrough curves were simulated using the transient-storage-stream model.

RESULTS AND DISCUSSION

PART I: MODELING RESULTS

Streambed slope and cumulative elevation determine the relative contribution of hyporheic exchange to the storage zone exchange rate. Streambed slope provided the most spatial variability in local storage storage exchange rate. Streambed slope and cumulative elevation were used to model stream channel discharge at each cumulative elevation

Local inflow of area to the stream channel was measured during the two steady state Br- tracer injections. The following equation was used to calculate discharge at each steady state Br- injection point:

\[ Q = \frac{C}{A} \]

where, C is the solute concentration in the stream (meq L^-1), A is the storage zone exchange rate (s^-1), and Q is the stream discharge (L s^-1)

Figure 3. Observed (points) and simulated (black line) breakthrough curves and hydrographs at t = 150 and 250 min from injection point. During the three experiments, discharge decreased from 1.11 to 0.14 L s^-1 at the injection point, and from 2.52 to 0.72 L s^-1 at 290 m. Br concentration plateaus were increasing due to a decrease in discharge.

Field/Dem Analysis Results/Discussion

The storage zone area to stream area ratio (A_s/A) increased with decreasing stream discharge. The ratio is generally higher for lower discharge because the storage zone is a function of both the storage zone exchange rate and the storage zone cross-sectional area. The ratio is generally higher for lower discharge because the storage zone exchange rate is generally higher for lower discharge.

DISCUSSION OF MODELING RESULTS

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We also tested the linkage between local subsurface water inflow to the stream channel and local storage. We found no differences in the linkage between hyporheic and incremental changes in discharge. We plan to further assess the significance of these differences.

We found pronounced variability in local inflow and SO2 concentrations based on stream water sampling. We found pronounced variability in local inflow and SO2 concentrations based on stream water sampling.

CONCLUSIONS

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The data were analyzed using UCODE, a universal computer code for model optimization (Poste and reference).

Figure 2. (A) The Maimai catchments are located in the South Island of New Zealand. (B) The locations of the 4 study reaches are indicated on the topographic map of the 10.9-ha R. K. catchment. (C) The locations of the 4 study reaches are indicated on the topographic map of the 10.9-ha R. K. catchment.

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Figure 4. OTIS parameter composite scatted sensitivities (CSS) for each experiment. CSSs represent the potential to confidently optimize a parameter from a particular data set.

Figure 5. Lateral inflow of water (liters/meter) and stream discharge liters/second.

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