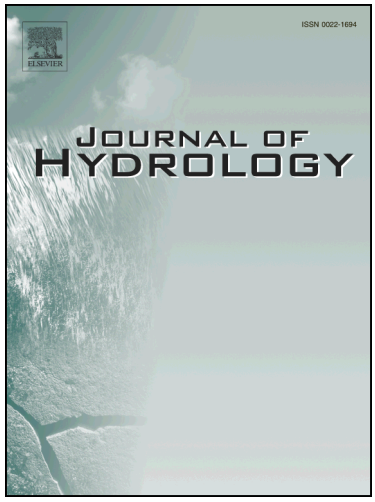

Accurate and efficient calculation of response times for groundwater flow

E.J. Carr, M.J. Simpson

PII: S0022-1694(17)30841-7
DOI: https://doi.org/10.1016/j.jhydrol.2017.12.023
Reference: HYDROL 22434

To appear in: *Journal of Hydrology*

Received Date: 12 July 2017
Revised Date: 5 December 2017
Accepted Date: 5 December 2017

Please cite this article as: Carr, E.J., Simpson, M.J., Accurate and efficient calculation of response times for groundwater flow, *Journal of Hydrology* (2017), doi: https://doi.org/10.1016/j.jhydrol.2017.12.023

Accurate and efficient calculation of response times for groundwater flow

E. J. Carr[a,*], M. J. Simpson[a]

[a]*School of Mathematical Sciences, Queensland University of Technology (QUT), Brisbane, Australia.*

Abstract

We study measures of the amount of time required for transient flow in heterogeneous porous media to effectively reach steady state, also known as the response time. Here, we develop a new approach that extends the concept of mean action time. Previous applications of the theory of mean action time to estimate the response time use the first two central moments of the probability density function associated with the transition from the initial condition, at $t = 0$, to the steady state condition that arises in the long time limit, as $t \to \infty$. This previous approach leads to a computationally convenient estimation of the response time, but the accuracy can be poor. Here, we outline a powerful extension using the first k raw moments, showing how to produce an extremely accurate estimate by making use of asymptotic properties of the cumulative distribution function. Results are validated using an existing laboratory-scale data set describing flow in a homogeneous porous medium. In addition, we demonstrate how the results also apply to flow in heterogeneous porous media. Overall, the new method is: (i) extremely accurate; and (ii) computationally inexpensive. In fact, the computational cost of the new method is orders of magnitude less than the computational effort required to study the response time by solving the transient flow equation. Furthermore, the approach provides a rigorous mathematical connection with the heuristic