

Response to referee #1:

Thank you for giving me the opportunity to read your manuscript. It is well written and interesting. Your results provide novel and important information to the scientific community. You did a great job describing the rather complex methods in a way that is easily understood by the readers. Your discussion on the implication of the findings to catchment water movement is well described, and provides direct, actionable, and targeted advice to hydrologic planners. Overall, I was very impressed and I only have minor revision requests:

RESPONSE: We thank the referee for the highly positive appraisal of our manuscript; we are particularly pleased that the description was easily understood. We appreciate the suggestions for minor revisions, and are pleased to incorporate them in the revised manuscript. We detail our responses point-by-point, below.

Line 79 Introduction: I recommend breaking the last paragraph of the introduction into two paragraphs. The first should provide more literature on chemical tracers (namely Br and D₂O/H₂O, used in your study) and any other literature that has studied on water transport as it relates to chemical tracer behavior. Additionally, this should include the literature of Fickian and non-Fickian (anomalous) transport models and how they apply to water behavior, as you have mentioned in your abstract. The second paragraph should describe your objectives and include the more specific explanation of your methods shown in lines 79 – 85.

RESPONSE: We have revised the introduction to expand upon the topics suggested by the reviewer. Namely, we have added a paragraph to further discuss the use of inert chemical tracers and included four new references: “Measurements of any inert chemical tracer transported by the flow of water in a catchment are often assumed to be suitable for inferring water TTDs. Ion tracers, such as bromide, have been used widely to study chemical transport in natural catchments, as they are relatively inexpensive and easy to measure (Levy and Chambers, 1987; Bowman, 1984). Their use has since been expanded to investigate broader aspects of catchment hydrology, including groundwater recharge and evapotranspiration (Chen et al., 2021), and catchment baseflow (Rai and Iqbal, 2015).” In addition, text was expanded in the subsequent paragraph, to describe the nature of non-Fickian transport and its relation to conservative tracers vs. water isotopes: “Moreover, in many catchments subject to chemical transport with relatively high Peclet numbers, conservative chemical tracers exhibit long-tailed breakthrough curves, a non-Fickian behavior that cannot be explained by the traditional

advection-dispersion equation (ADE). This behavior, also referred to as anomalous transport, arises from the heterogeneous nature of the porous media through which the tracer plume travels (Berkowitz et al., 2006a). Water isotopes are therefore regarded as an optimal tracer of water, compared to other chemical tracers, as they are assumed to essentially represent water flow and not chemical transport (McGuire and McDonnell, 2006).” Finally, as suggested by the referee, the last paragraph of the Introduction was split into two, to better highlight the objectives and methods. The description of the methods was expanded to note the use of porous media columns that are known to exhibit non-Fickian transport conditions, and to mention consideration of related catchment properties.

Line 258: Explain Fickian and non-Fickian transport in 1-2 sentences.

RESPONSE: As suggested, we have added text to clarify the difference between Fickian and non-Fickian transport: “However, in many cases, the velocity distribution often gives rise to non-Fickian (or anomalous) transport, which can be manifested by, e.g., the occurrence of long tails in measured breakthrough curves (Cortis et al., 2004), which cannot be captured by the traditional implementation of Fick’s law in the ADE that assumes a symmetrical temporal breakthrough curve.” See also the previous comment, for text added to describe non-Fickian transport in the Introduction.

Conclusion: I recommend providing one more paragraph summarizing the findings that your results may indicate smaller aquifer thickness requirements. I also recommend providing a sentence or paragraph on the applicability of this research to global aquifers/catchments to provide a global perspective/conclusion to this research.

RESPONSE: As suggested, we have split the Conclusions into two paragraphs, expanding the second to focus on the implications for estimates of aquifer thickness in catchment studies and the possible implications at the global scale: “Consequently, studies that rely on water isotopes to estimate water TTDs must recognize this subtle but critical inequality between apparent mean water and mean tracer velocities, and not use them interchangeably to represent the actual travel times of tracers and water isotopes. Our findings also indicate that selecting the correct velocity for aquifer thickness calculations can yield significantly smaller thickness estimates—an effect that could have even greater implications when applied at the global scale, beyond the illustrative example shown here.”