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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Hydrological functions of sinkholes and characteristics of point recharge in groundwater basins" *by* N. Somaratne et al.

Anonymous Referee #5

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This study of karst hydrogeology, a generally neglected aspect of hydrogeology in Australia, could be an important addition to the literature (particularly in Australia), but unfortunately at present it is not sufficiently well argued to justify the conclusions made, and cannot be accepted in its current form. However, I would encourage the authors to make the suggested changes so this becomes a worthwhile and significant study.

Firstly, the authors need to become more familiar with the principles of karst hydrology. In the well-cemented limestones that characterize much of North America and Europe, karst conduits (caves) carry the bulk of groundwater flow. In the porous limestones of SE Australia, groundwater flow is shared between the granular porosity and karst conduits, but the groundwater flow through even a porous limestone aquifer is generally mostly through the conduits, because groundwater in the conduits flows several

orders of magnitude more quickly than in the granular porosity (Waterhouse's study of the Gambier Limestone shows this clearly). In a bore it is easy to intersect groundwater within granular porosity, but very difficult to intersect a conduit, so the former contribution to the overall groundwater flow in the limestone aquifer is emphasised at the expense of the latter (this is the mistake that Ordens et al. have made). Point recharge (at sinkholes) feeds karst conduits with very rapid groundwater flow; it is important to realize that sinkholes almost always feed conduits (otherwise the sinkholes would not exist). Some of the recharge around sinkholes will also seep slowly into the granular porosity around the recharge point. However, most of the recharge to the granular porosity of the aquifer is through surface recharge across the entire surface of the aquifer; recharge to the granular porosity from the point recharge areas would be a relatively minor contribution restricted to those areas. The authors need to reinterpret their data with this in mind; studying the recharge to the granular porosity around point recharge areas is useful, but remember that most groundwater flow is through the conduit that is fed by the sinkhole.

Therefore, applying the CMB method to the groundwater in the granular porosity around a point recharge area will always underestimate the amount of recharge through the sinkhole, because it is not sampling the conduit groundwater flow, which is completely separate. To estimate the conduit recharge, using the minimum groundwater chloride in the granular porosity around a point recharge area will give the best value, but this will still be an underestimation.

Furthermore, on a Cl del18O plot, conduit flow directly recharged through a sinkhole will plot near rainfall, because the very rapid recharge allows only minimal evaporation. Groundwater in the granular porosity will have been recharged mainly through surface infiltration, and will have been subjected to evapotranspiration during infiltration, so it will have elevated chloride and heavier del18O, and will plot well away from rainfall. Groundwater in the granular porosity around recharge points will have been recharged partly by relatively rapid recharge through the sinkhole, so will plot in an intermediate

position between rainfall and most groundwater. However, a lack of intermediate points between rainfall and most groundwater does not discount point recharge (contrary to Ordens et al), it just indicates either that there is little seepage into the granular porosity around the recharge point, or that this was not sampled, or both.

To summarise, to determine point recharge using groundwater chemistry requires analyses of the conduit flow fed by the point recharge. Analysing groundwater within the granular porosity cannot accurately determine the amount of point recharge (although it can give an indication).

In the introduction, the authors need to refer to the definition of karst in the classic texts (e.g. Ford & Williams, White & White). The difference between allogenic and autogenic recharge is not important for the Uley Basin aquifer, which is entirely autogenic in the area of study (this is shown incorrectly on Fig. 9). Dissolution cavities in karst aquifers are automatically hydraulically connected (this is integral to how they form); this is not due to 'further' dissolution, it is due to karst dissolution processes that are continually acting on these aquifers.

There needs to be a methods section, giving details of sampling and analysis.

The freshwater in the Murray Group limestone (is this the Gambier Limestone) around Poocher Swamp would be better referred to as a lens rather than a 'bubble'. This catchment is stated to generate 50-2000k m3 of freshwater a year; how was this calculated?

For the discussion of mixing, presenting the groundwater chemistry as Scholler plots would be far easier to interpret than Piper plots. The Mt Gambier data shows that groundwater is flowing in conduits (these may be enlarged fractures, but are better termed conduits).

The modeling of surface runoff gives very important numbers. I presume that there is no surface drainage in any of the three catchments, so this runoff is entirely diverted underground. The amount of granular flow in each catchment can be calculated us-

ing Darcy's Law, and compared with the surface runoff numbers. The excess will be conduit flow.

In section 4.2, 'equilibrium' is used incorrectly; it has a very specific chemical meaning.

Section 4.3 needs to be thought through more clearly using the concepts given above. In particular, the CMB method will reliably estimate point recharge if you have an analysis of water from a conduit that was directly recharged at the sinkhole. The discussion needs to be changed to reflect this.

It is unwise to use Hutton's formula to estimate rainfall chloride, although because all 3 sites are relatively close to the coast, the estimates are probably reasonable.

For each basin, the map needs to be based on a DEM (the freely available SRTM DEM is OK); an accompanying surface geology map of exactly the same area would be useful. The locality map needs to include a blow-up of South Australia showing the location of each area. It is not necessary to show roads and urban areas. For each basin, a cross-section with horizontal and vertical scale is needed. The Uley Basin 3D diagram is good but is not to scale. It is important to know the thicknesses of the various units.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 11423, 2013.