Comment on hess-2021-461

The paper "A hydrological framework for persistent river pools" by Sarah Bourke and colleagues presents a framework to classify the hydraulic mechanisms that support persistent pools. To do this, five mechanisms are defined: perched surface water, alluvial through-flow, groundwater outflow due to a regional aquifer pinching out, groundwater outflow at catchment constraints, and topography-controlled groundwater outflow. A suite of diagnostic tools is given and applied to the Hamersley basin (Australia) to demonstrate the framework can be used to distinguish between the different key hydraulic mechanisms. The susceptibility of the pools to groundwater withdrawals and climate shifts is determined and explained, as well.

As stated by the authors, there is a lack of understanding the mechanisms and water resources that support persistent river pools, which leads to limited effective water resource management. In my opinion, it is therefore relevant to set up a hydrological framework for persistent river pools as the hydrology is yet poorly understood. Especially in semi-arid regions it is important to know how the persistent pools are supported in order to predict the impact of changes in climate or groundwater abstraction.

The authors give a clear explanation of the different hydraulic mechanisms, and the accompanying figures help to understand them. In addition, the summary of the hydrological framework in Table 1 gives a direct overview of the different mechanisms. In the last section useful recommendations to improve the measurements and framework are listed. In general, the paper is clearly written and easy to understand, but the main focus is on the theorical framework itself instead of the application of it. These issues are explained below in more detail. Moreover, determining the susceptibility of the pools to improve effective water resource management seems to be the main reason to investigate their hydrology, but the explanation why this is important is missing in the introduction. Therefore, I would suggest the paper needs some major revisions and then a new review before it is approved.

The following major issues need to be considered.

(1) Ideally, a paper introduces the topic, the importance of the research, and what will be investigated in the introduction. In their introduction, the authors state that a hydrological framework is needed that incorporates relevant literature, along with a modern suite of tools (lines 76-79). However, it is left out that these tools will be applied to identity the key supporting mechanisms in real world situations. This is a problem, because the authors want to set up a framework for persistent river pools that is also applicable in the real world, which is not mentioned in the introduction. Only in section 3 (lines 276-277) and section 5 (lines 512-514) is explained that these tools are needed to distinguish the key hydraulic mechanism(s) of a persistent pool. The consequence of not presenting the necessary applicability of the framework in the introduction, is that the application appears as an isolated part in the report. Since the aim of the paper is to understand the supporting mechanisms to improve effective water resource management (lines 47-48), it should be made clear in the introduction that the framework needs to be applicable to real world situations to identify the pools' supporting mechanism(s) and with that knowledge determine its susceptibility.

(2) In section 5 the framework is applied to the Hamersley Basin, to see if the suite of tools can be used to identify the key hydraulic mechanism supporting a persistent pool. To show this, a subset of 22 pools is said to be investigated. However, only data of three of these is presented as case study. In the three case studies the data is explained and used to establish the dominant hydrologic mechanism supporting the pool. The 19 other pools are only mentioned at page 25 to make a general distribution of the mechanisms supporting pool persistence across the landscape. This is a problem, because no hard data is provided to prove that the five dominant mechanisms are all present in the Hamersley

Basin, as stated in Figure 5. Without this data, the reader cannot examine the measurement results and check the conclusions drawn by the authors. Moreover, the generalised explanation of the locations of the different type of pools appears as a repetition of section 2, mainly because no results are given to prove the statements made. As a result, the application does not convince the reader that the suite of tools can be used to distinguish all five different hydraulic mechanisms that support persistent pools. My recommendation is to expand the case studies with the data of the other 19 pools to at least show the five different supporting mechanisms. If similar data is present for different pools they can be compared and only then conclusions on the general location in the landscape can be drawn.

(3) In the conclusion, the authors summarise the main hydraulic mechanisms supporting persistent pools and indicate the susceptibility to hydrological changes. However, the results of the application of the framework to the Hamersley Basin are not mentioned. Subsequently, as the conclusion is written now it focusses on the framework itself presenting it as being purely theoretical, while the application proves it to be practical, as well. Line 784 states that the presented suite of tools makes it possible to apply the framework to the real world. The authors explain the application of the framework in section 5, but do not mention this in the conclusion. The fact that the suite of tools can be applied to identify the different mechanisms, shows the value of the framework to determine the susceptibility which is a steppingstone to improve effective water resource management. Because of this, it should be made clear in the conclusion that the constructed framework and suite of tools have been shown to be applicable to real world situations.

In addition, the following issues should be considered.

- Section 2.3 divides groundwater influenced pools into two broad categories, however it is not specified based on what this decision made. Springer and Stevens (2009), as also referenced in this section, present twelve type of springs, but this already existing classification is not used in this new framework. So, please provide an explanation why this decision is made.
- In section 3.3 various tools are mentioned, but the methods of these tools are not given. Hamilton et al. (2005) and Siebers et al. (2016), for example, clearly explain the methods for ^{18}O isotope measurements and how to interpret the results. They also mention the locations of measurements, including the requirement to measure the isotopic composition in alluvial groundwater, which is not mentioned in the paper. Thus, please also provide the methods of the tools in section 3.3, including how to execute the measurements, which instruments to use, and which frequency is necessary for reliable results.
- The third paragraph of the case study of the Plunge Pool gives the conclusion, but it is not well substantiated. Why is the mechanism explained in section 2.3.1 not the key mechanisms in this case? Please give a better explanation based on what this conclusion was drawn. Actually indicating the position of the dykes in Figure 8c would assist in this explanation.
- Section 3.2 extensively explains different water balances per supporting mechanism, but these balances are not specifically mentioned or used in the application of the framework. Please use the water balance in the application or leave it out of section 3.
- The second paragraph of section 2.3.2 explains the difference between the two mechanisms; topography intersects regional aquifer and groundwater outflow at geological contacts. Please expand this explanation, as the difference is not clear to me now.
- The sentence “In the… aquifer (900 mS/cm).” in lines 602-604 on page 29 can be interpreted in two ways. Because the rainfall is not given in Figure 8b, “in the absence of rainfall” can reference to either a decreasing pool depth, and in these periods the EC increases (not

equilibrating around groundwater EC), OR to the moment shortly after a high pool depth is reached when the EC does gives values of approximately the groundwater EC. Please rewrite this sentence that it can be interpreted in only one way.

- The third paragraph of section 5.2.3 indicates measurements were done at the "top" of pool 1. Does this mean the upper part of the pool or the upstream part? Please elaborate if the measurements for the Radon-222 activity were done with a vertical or horizonal transect, or a combination.

List of minor issues:

- Page 5, lines 125-127 contain the sentence "For example…many pools". Please rewrite this sentence as it is lengthy and not formulated clearly.
- Page 14, line 299 mentions snapshot sampling. Please give a short explanation of what is meant with this.
- At page 15 the abbreviations NDVI, NDWI, and AEM are used. Please also give the full meaning of these abbreviations.
- Page 18, lines 404-407 contain the sentence "For example…flood event." Please rewrite this sentence as it is missing a verb and not formulated clearly. Also, put "value" before "re-equilibrated with the groundwater EC" instead of after it.
- Page 25, line 535 mentions the "mode of occurrence" of pools. Please specify what is meant with this, as I could not come up with a definition from the context.
- Page 27, Figure 6 gives the location of the persistent pools in the study area and the 22 pools chosen as subset, but it does not give the location of the three case studies specifically, which I think would be an addition to the map. Also, I think a digital elevation model (DEM) of the study area would be an addition since the topography of the area can determine the existence and persistence of pools. So, please indicate the location of the case studies on the map and add a DEM.
- Page 28, lines 586-587 mention the Marra Mamba Formation, but this subsurface layer is not indicated in Figure 8c. Please change the legend of Figure 8c to contain this name or change the name in the text to one of the layers that is mentioned in the legend. It could also be helpful to mention the hydraulic conductivity of the different formations, to give an indication of their permeability and the presence of aquicludes.
- Page 29 mentions the ADH. Please first give the meaning of this abbreviation, as this indication of a reference level is probably not known to non-Australians.
- Page 29, lines 592-595 mention the measured groundwater level at two monitoring wells. As their number is given in Figure 8c, it may be useful for the interpretation if the number is also mentioned in the text.
- Page 31, line 634 mentions the abbreviation BIF. Please give an explanation of this abbreviation or write it in full, since it is not used as abbreviation afterwards.
- Page 32, lines 658-659 mention "the water table drops below the pool" which references to Figure 8c, but the groundwater level is not given in this figure and cannot easily be compared to the water table in Figure 8b because of a different time scale. Please remove this part of the sentence as it cannot be checked now or add a graph of the water table to Figure 8c.
- Page 32, lines 673-675 state that a threshold groundwater level for inflow of groundwater to the pool can be found from the isotopic data. This cannot be concluded from the explanation of Figure 9d, as explained in the third paragraph in section 5.2.2. Please explain how this threshold value was found.

- Page 35, lines 710-711 states that pool 1 dries out as the dry season progressed, but the deeper parts of pool 1 persisted throughout the dry season. Please rewrite this sentence to resolve the contradiction for pool 1.

List of technical comments:

- Page 4, line 79: “mechanisms” instead of “mechanism”
- Page 10, line 198: “mechanisms” instead of “mechanism”
- Page 10, line 200: “purpose” instead of “purposes”
- Page 10, line 202: “Springer and Stevens (2009)” instead of “Springer (2009)”
- Page 15, line 315: add “as” before “a”
- Page 21, line 471: “may” instead of “my”
- Page 21, line 471: insert “the” before “subsurface”
- Page 29, line 598: move reference to Figure 8b to line 601 after “catchment”
- Page 29, line 601: add “period” after “dry”
- Page 29, line 603: substitute “that of the” instead of “the that of”
- Page 30, Figure 8c: What does “mRL” mean?
- Page 31, lines 650-651: move the closing bracket after “12th Nov 2018” to after “7th Dec 2018”
- Page 32, lines 665-672: move the sentence “Based on … (Fig. 9e).” to the end of the paragraph, so after the sentence “As a result ... this pool.”
- Page 34, line 690: move the position of the reference of Figure 10a to after “Marra Mamba Formation” in line 693
- Page 37, Figure 10e: add a legend for the orange subsurface layer

References

Hamilton, S. K., Bunn, S. E., Thoms, M. C., & Marshall, J. C. (2005). Persistence of aquatic refugia between flow pulses in a dryland river system (Cooper Creek, Australia). *Limnology and Oceanography*, *50*(3), 743-754.

Siebers, A. R., Pettit, N. E., Skrzypek, G., Fellman, J. B., Dogramaci, S., & Grierson, P. F. (2016). Alluvial ground water influences dissolved organic matter biogeochemistry of pools within intermittent dryland streams. *Freshwater Biology*, *61*(8), 1228-1241.

Springer, A. E., & Stevens, L. E. (2009). Spheres of discharge of springs. *Hydrogeology Journal*, *17*(1), 83-93.