A systematic numerical study on the controls of perched aquifer hydraulics

In some groundwater systems, small patches of lower permeability, often clay lenses, are embedded in larger permeable aquifers. Recharging groundwater may become ‘perched’ above such a zone. In this case, a temporary aquifer may form called “perched aquifer”. Its presence can often be deduced from the occurrence of ephemeral springs, i.e. springs that start running after rainfall events but stop flowing after a few days or weeks.

Despite their small size, perched aquifers can be used for small-scale groundwater abstraction since they are often found at shallow depths. In many (semi)arid zones of the world, they play a major role for drinking water supply for small rural communities. On the other hand, they can quickly run dry after extended periods of drought and are vulnerable to contamination.

The formation and hydraulic performance of a perched aquifer is controlled by: (i) its geometry and the spatial extent of the low permeability zone, (ii) the permeability contrast between the clay lens and the surrounding aquifer (iii) the groundwater recharge rate. A schematic visualization of a perched aquifer is given below.

The present thesis aims at systematically investigating the hydraulic controls of perched aquifers. As a first step, the candidate will conduct an in-depth literature review of the topic. As a next step, the candidate will design a base case and certain variations of a conceptual flow model representing an idealized system with one or more local low permeability zone(s) within a larger, highly permeable aquifer. In the variations of the conceptual model, the candidate will modify the base case according to the above-mentioned conditions (i), (ii) and (iii). Subsequently, the candidate will use a numerical simulator and the different conceptual models to calculate the respective formation, longevity and saturated thickness of the perched aquifer, as well as spring discharge and recharge to the regional aquifer. An analysis of the results will allow the investigation of the hydraulic controls of perched aquifers.

Entry literature for the topic is given below.

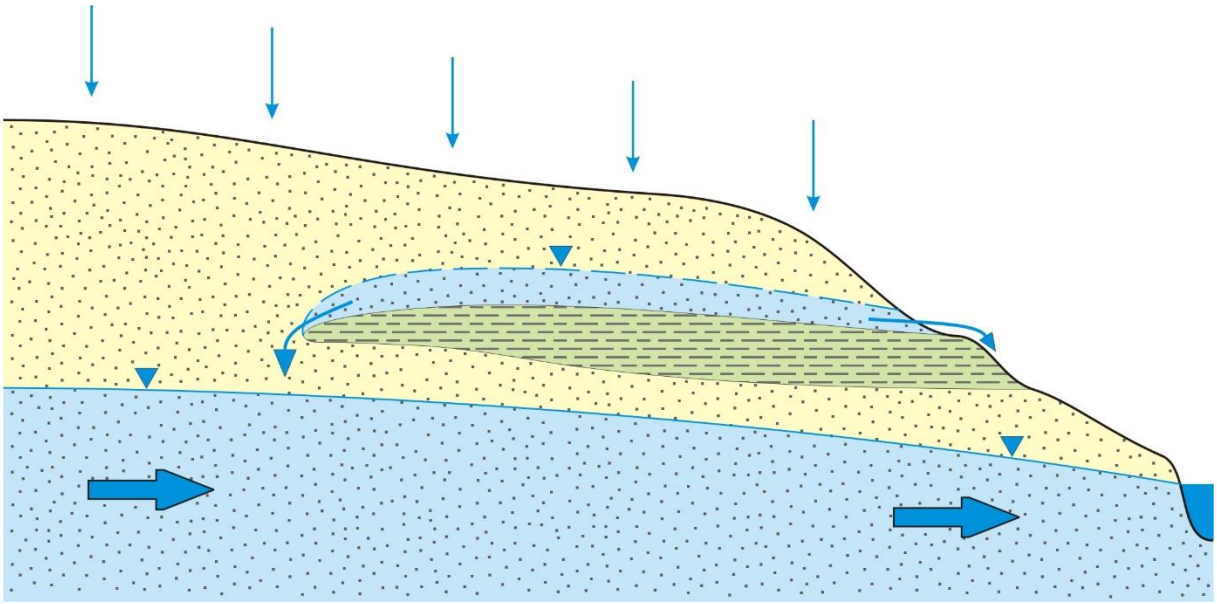

Figure: Schematic visualization of a perched aquifer on top of a local clay lens (green), above a regional aquifer.

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Literature:

Aguilera, H., Heredia Díaz, J., & de la Losa Román, A. (2021). A methodology for simulating perched conditions in multilayer aquifer systems with 2D variably saturated flow. *Vadose Zone Journal*, *20*(5), e20152.
Gómez-Escalonilla, V., Heredia, J., Martínez-Santos, P., López-Gutiérrez, J., & De la Hera-Portillo, Á. (2024). Modelling regional effects of artificial groundwater recharge in a multilayer aquifer characterized by perched water tables. *Hydrological Processes*, *38*(2), e15085.
Al-Yaqoubi, S., Al-Maktoumi, A., Kacimov, A., Al-Ismaily, S., & Al-Mayahi, A. (2024). Bailout test, HYDRUS-2D, and analytical modeling for estimating permeability of ephemeral stream bed. *Vadose Zone Journal*, *23*(6), e20386.