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HYDRUS and analytical modeling of seepage in porous banks of commingled ephemeral streams having triangular flash-flood hydrographs: emergence and extinction of an "ephemeral" unconfined aquifer

Wednesday, 2 June 2021 10:00 (15 minutes)

Perched aquifers(PA) are important sources of groundwater in arid/semiarid climates where surface water resources are irregular (see, e.g., Intermittent⋯, 2017). PAs as hydrostratigraphic units are commonly conceived as being created/maintained by vertical infiltration from a vadose zone above aquifer's phreatic surface and vanished due to a) vertical percolation, which descends into a subjacent vadose zone under aquifer's thin low-permeable bed, and b) vertical ascending seepage flow driven by evapotranspiration. In our work, we study "ephemeral"aquifers, whose advent and disappearance are controlled by prevalently horizontal fluxes, one into a vadose zone and another into a conterminous ephemeral stream. Initial-boundary value problems to the Richards 2-D equation, 1-D Boussinesq equation, and 2-D Laplace equation are solved in models of saturated-unsaturated and purely saturated flows. At t<0, both the stream and adjacent bank (wedge-shaped in a vertical cross-section) are dry. At t>0, a flash flood takes place. Wadi's water first imbibes into the bank and later exfiltrates back through the slope, which is made of two discharging segments: a seepage face and ponded interface between stream's water and the aquifer (Fig. 1a).

The process is controlled by a specified wadi hydrograph. We focus on the case of a constant rate drawup-drawdown regime,i.e., the wadi stage rises-drops linearly with time. Analytical (Barenblatt et al.,1984) and numerical (HYDRUS-2D,Šimůnek et al.,2016) solutions compare well. Dynamics of bank's phreatic surface (conjugated with the wadi water level), transient fluxes, pore-water storage in the bank, loci of the tips of the wetting fronts (propagating along a bedrock of an emerged "ephemeral"unconfined aquifer), pore pressure isobars (in particular, the position of the crest of an evolving groundwater mound), piezometric contours, vector fields of Darcian velocity, isotachs, and streamlines in the three models are studied. Fig. 1b illustrates a snapshot of HYDRUS pore pressure heads for the drawup phase. A rapid drawup of the wadi level and slow post-flash-flood drawdown generate an intricate topology of groundwater and soil moisture motion, viz. the three phases of expansion-slumping-evanescence (E-S-E). For example, in the slumping phase, a stagnation point emerges on the bedrock at a certain time and flow bifurcates into one halve, which keeps moving to the right in Fig. 1a, and another discharges through the slope.The mound may or may not be intercepted by a dormant (not-pumping) well in the riparian zone.The well is tracked by HYDRUS observational nodes. Depending on the phase of aquifer's evolution ("yes"-"yes"-"no"in the example of Fig.1b), the distance between the well and wadi, screen's depth, and hydraulic properties of soil, the phreatic surface either intersects the well or not. If yes, a well operator can start abstracting groundwater. Implications for intelligent interception of short-lived groundwater pockets by on-bank farms and for groundwater banking in MAR projects are discussed. Another application of our HYDRUS and analytical models is in the ecohydrology of riparian phreatophytes (e.g., the Christ-thorn trees, Al-Maktoumi et al., 2020).Ecotones of this wild vegetation are aligned with wadis'and can serve as bioindicators of the post-flash-flood extension of ephemeral aquifers in Fig. 1a.

Time Block Preference

Time Block B (14:00-17:00 CET)

References

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