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Analytical Solutions for Steady Phreatic Flow Appearing/Re-emerging Toward/from a Bedrock/Caprock Isobaric Breach: The Polubarinova-Kochina–Numerov and Pavlovsky Problems Revisited

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Abstract

© 2015, Springer Science+Business Media Dordrecht. Analytical solutions for steady, confined and unconfined Darcian flows in aquifers breached by “windows” in caprocks or bedrocks with applications to hillslope hydrology are presented. As compared with classical Polubarinova-Kochina, Numerov and Pavlovsky analytical solutions, the aquifers are sloping and the “window” is a finite-size isobaric segment, which due to the aquifer dip brings about a nonconstant head boundary condition. The velocity hodograph, method of boundary value problems and conformal mappings are used for obtaining solutions of essentially 2D seepage problems with Laplace’s PDE as a governing equation and the nonlinear phreatic surface for an unconfined flow. The second-order hydraulic theory with Picard’s iteration is used for deriving and solving a nonlinear ODE with respect to the shape of the water table, that is, compared with standard Dupuit–Forchheimer computations. The size of the “window,” incident flow parameters upstream of the “window” and the angle of tilt determine the disturbance to a main aquifer, mundanely normal “longitudinal” flow, which may completely dive or unexpectedly extravasate into a commingled adjacent subjacent–superjacent layer.

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Keywords

Complex potential, Darcian velocity, DF approximation, Hydraulic theory, Sloping aquifer