Approximate solutions for drawdown and wellbore flowrate due to constant-head pumping for flow with considering skin effect

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A variety of mathematical models describing groundwater flow due to constant-head pumping (CHP) in a confined aquifer had been proposed. The predicted drawdown or wellbore flowrate from the solution of the model may be overestimated or underestimated when a skin zone is present around the wellbore but neglected. If the skin has a finite thickness and the flow in the skin zone is included in the mathematical model, its solution is then referred to as two-zone solution (TZS). In contrast, it is named as skin-factor solution (SFS) if the skin properties are lumped as a factor in the model. The TZS is much more complicated and difficult to evaluate than the SFS. Therefore, this study aims at developing a novel SFS based on a steady-state groundwater equation with time-dependent outer boundary for CHP tests with a partially penetrating well in a confined aquifer. The results from this new SFS show good match in the drawdown and wellbore flowrate with the TZS. Moreover, the present SFS coupled with the simulated annealing algorithm is used to analyze field observed data from a CHP test for the estimation of the aquifer parameters. The result demonstrates that the new SFS has merits of good accuracy and less computing time in the parameter estimation.

Keywords: constant-head pumping, partial penetrating well, skin effect, approximate solution

Constant-head pumping

Initial potentiometric surface

s

s_w

Impervious layer

Wellbore skin

b_2

b_1

z

r

Confined aquifer
$K_r \, K_z \, S_s$

b

Impervious layer

r_w

Well radius

$R(t) = r_w + \sqrt{\pi K_r t / S_s}$

Constant-head moving boundary