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Aquifer test interpretation using derivative analysis and diagnostic plots

Antonio Hernández-Espriú (1), Roberto Real-Rangel (2,3), Iván Cortés-Salazar (2,3), Israel Castro-Herrera (1), Gabriela Luna-Izazaga (1), and Emilio Sánchez-León (4)

(1) Hydrogeology Group, Faculty of Engineering, Universidad Nacional Autónoma de México (ahespriu@unam.mx), (2) Institute of Engineering, Universidad Nacional Autónoma de México, (3) Program of Master and Doctorate in Civil Engineering, Universidad Nacional Autónoma de México, (4) Department of Geosciences, University of Tuebingen, Germany

Pumping tests remain a method of choice to deduce fundamental aquifer properties and to assess well condition. In the oil and gas (O&G) industry, well testing has been the core technique in examining reservoir behavior over the last 50 years. The pressure derivative by Bourdet, it is perhaps, the most significant single development in the history of well test analysis. Recently, the so-called diagnostics plots (e.g. drawdown and drawdown derivative in a log-log plot) have been successfully tested in aquifers. However, this procedure is still underutilized by groundwater professionals.

This research illustrates the applicability range, advantages and drawbacks (e.g. smoothing procedures) of diagnostic plots using field examples from a wide spectrum of tests (short/long tests, constant/variable flow rates, drawdown/buildup stages, pumping well/observation well) in dissimilar geological conditions. We analyze new and pre-existent aquifer tests in Mexico, USA, Canada, Germany, France and Saudi Arabia.

In constant flow rate tests, our results show that derivative analysis is an easy, robust and powerful tool to assess near-borehole damage effects, formation heterogeneity, boundaries, flow regimes, infinite-acting radial stages, i.e. valid Theisian framework, and fracture-driven flow. In step tests, the effectiveness relies on high-frequency drawdown measurements. Moreover, we adapt O&G analytical solutions to cater for the conditions in groundwater systems. In this context, further parameters can be computed analytically from the plots, such as skin factor, head losses, wellbore storage, distance to the boundary, channel-aquifer and/or fracture zone width, among others. Therefore, diagnostic plots should be considered a mandatory tool for pumping tests analysis among hydrogeologists.

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