Hydraulic Properties of the Northern Guam Lens Aquifer System, Territory of Guam, USA

Problem and Research Objectives

Hydraulic parameters such as hydraulic conductivity and storage parameters are essential elements of models used to manage groundwater availability and quality. Uncertainty in these parameters can result in erroneous model estimates and potential mismanagement of drinking-water resources. The objective of this work is to estimate aquifer properties of the northern Guam aquifer.

A three-dimensional ground-water flow and transport model will be developed in a subsequent study to evaluate the availability of Guam's groundwater resources under several recharge and withdrawal scenarios. This study will identify hydrologic parameters to constrain numbers that can be used as input for this model.

Methodology

Tidal-signal attenuation is conveniently used to estimate hydraulic properties, such as hydraulic conductivity and storage parameters of coastal aquifers and to determine the distance of tidal influence into the aquifer (e.g., Rotzoll et al. 2008). Jacob (1950) provided a now classic analytical solution for water levels in a one-dimensional, homogeneous, isotropic, confined, and semi-infinite aquifer with a sharp boundary subject to oscillating forcing. Moreover, salinity time-series at discrete depths also are available to estimate aquifer properties (Presley 2010).

Principal Findings and Significance

Analyses of current and historical tidal-signal data in an array of wells widely distributed across the NGLA indicate that a lower-permeability limestone rim causes a significant tidal-damping effect at the boundary. Wells on the periphery consistently exhibit two orders of magnitude lower hydraulic conductivities than wells in the interior. For assigned specific yields of 0.01 to 0.1, hydraulic conductivity ranges from ~10 to 300 m/d for the former, and ~1,000 to 20,000 m/d for the latter. An argillaceous limestone unit exhibits intermediate conductivity.

The lower permeability of the peripheral rocks relative to the interior rocks may best be explained by the effects of karst evolution: (1) dissolutional enhancement of horizontal hydraulic conductivity in the interior; with (2) case-hardening and concurrent reduction of hydraulic conductivity in the cliffs and steeply inclined rocks of the periphery; and (3) the stronger influence of higher-conductivity regional-scale features in the interior relative to the periphery. The study demonstrates that applying simple techniques can be beneficial when characterizing regional aquifers.

Publications Cited in Synopsis

Gingerich, S.B., and J.W. Jenson, 2010, Groundwater availability study for Guam; Goals, approach, products, and schedule of activities, U.S. Geological Survey Fact Sheet 2010–3084, 4 p.

Jacob, C.E., 1950, *Flow of ground water*, in Engineering Hydraulics, edited by H. Rouse, pp. 321–386, John Wiley, Hoboken, New Jersey.

Presley, T.K., 2010, “Using specific-conductance profiles and fixed-depth loggers to determine freshwater-lens thickness changes and aquifer properties during recharge events, Northern Guam Lens, Guam,” in *Seventh National Monitoring Conference – Monitoring From the Summit to the Sea*, Denver, CO, 25–29 April.

Rotzoll, K., A.I. El-Kadi, and S.B. Gingerich, 2008, “Analysis of an unconfined aquifer subject to asynchronous dual-tide propagation,” *Ground Water*, 46(2), 239–250.