Characterization of Hydraulic Conductivity in an heterogeneous aquifer using Heat-Pulse Flowmeter

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Abstract

Heat-pulse flowmeter is a logging tool for measuring the flow velocity in a borehole under a constant pumping or injection rate. We established a circulation system for measuring water flow velocity through a pipe under constant head to evaluate the performance of heat-pulse flowmeter in the laboratory. The system was designed to minimize the error due to turbulent flow and frictional loss. Based on results of test under various flow rate, an empirical formula was developed for calibrating the measured flow velocity.

The measurement precision is about 4% based on the standard deviation of 8 duplicate tests for a specified pumping rate. The measured error increases exponentially from approximately 5% to 50% as the flow rate decreases from 1.0 cm/sec to less than 0.2 cm/sec. The setting position of flowmeter may cause an increasing error approximately 4% to 15% with a decreasing flow rate. In order to reduce this error, various shapes and materials were designed for a diverter to seal the space between the probe and the casing. We found measurement with a diverter can further improve the accuracy, precision and the range of flow velocity further. Besides, free convection plays an important role in driving the upward flow during the measurement, especially at a low flow velocity. Integrating results of measurements in both directions, however, it is possible to calibrate the flow velocity influenced by free convection.

We then chose a monitoring well to conduct a field measurement of vertical flow velocity over the range of an aquifer. Prior to flowmeter measurements, a pumping test and well logging were conducted to obtain background hydrogeologic information. The measured hydraulic conductivities for highly permeable layers are 3 to 5 times greater than the averaged hydraulic conductivity, implying that contaminant migration rate could be underestimated in a heterogeneous aquifer.

Reference

U.S. Environmental Proection Agency, 1998: Application of the electromagnetic borehole flowmeter, EPA/600/R-98/058, 53 p.

Gerasimos-Akis Tselentis, 1984: An investigation of the principles of operation of the heat-pulse flowmeter Journal of Hydrology, Volume 69, Issues 1-4, 335-349.