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Periodic Hydraulic Testing for Hydraulic Property Estimation

Abstract:

Traditional methods of hydraulic testing involve the use of pumps or slugs to manipulate groundwater levels or pressures. From the drawdown responses measured over time, hydraulic properties and aquifer confinement status can be interpreted. Limitations of traditional methods include poor signal-to-noise ratios, temporal limitations due to excessive drawdown in pumping tests, and insignificant forcing magnitudes in slug tests. As an alternative, periodic methods of hydraulic testing have been developed since 2000. These also use pumps (for indirect displacement) or slugs (for direct displacement). The results of both methods can be interpreted in terms of the attenuation of the amplitude of a periodic forcing signal, and/or the phase shift. Our research involves developing new, cost-effective methods of periodic pump and slug testing. Our novel pumping test design involves the use of an electronic valve, in combination with a constant rate pump, to generate sinusoidal forcing signals. Our slug test design involves the use of a customized winch driven by a stepper motor to generate sinusoidal forcing signals. We are currently lab testing the periodic pumping test design, with the intention to commence field testing later this year. Periodic slug test design development is currently underway, but testing is yet to commence. The open research questions we intend to address through this research include the following. Periodic methods are known to be frequency-dependent at a range of scales. The existing, unproven hypothesis is that this effect is due to subsurface heterogeneity. Specifically, that the maximum pore diameter sampled is a function of forcing signal frequency. We intend to assess this hypothesis through comparisons of multi-frequency testing to traditional testing. We also aim to compare the relative efficacy and cost of periodic pump and slug testing designs. Past implementations of periodic methods have been limited to aquifer characterization. We intend to expand the applicability of these methods to low permeability media, including aquitards and streambeds. We also hope to combine periodic testing with geophysical methods, such as self-potential surveys.

Chris is a hydrogeologist at the CSIRO in Adelaide, Australia, where his work includes the interpretation of groundwater ages derived from environmental tracers. His other research interests include the estimation of hydraulic properties from pressure responses to barometric loading, and Earth and ocean tides. Chris is undertaking a PhD on a part-time basis, co-supervised by Professor Roseanna Neupauer. The focus of his PhD is developing and promoting the use of adjoint state methods for calculating the sensitivities of outputs generated by numerical models.