CROSSHOLE ELECTRICAL IMAGING OF AQUIFER PROPERTIES AND PREFERENTIAL FLOW PATHS AT THE BOLIVAR ASR SITE

A Ph.D. Thesis

by

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ABSTRACT

This PhD project is a comprehensive application of crosshole resistivity tomography to image aquifer properties and preferential flow paths at the Bolivar ASR site, north of Adelaide. This site is being used to demonstrate the possibility of artificial recharge and recovery operations from a 50m thick aquifer, 100m below ground surface. The project involved consideration of hydrology, well logging, resistivity surveying, electrical modelling and inversion, data processing and interpretation, and, designing and building a 3-D physical resistivity modelling system.

I have derived all formulas for 3-D numerical resistivity modelling and developed a 3-D resistivity modelling program. I also modified 2.5-D numerical resistivity modelling and inversion programs for speeding the calculation, handling large size inversions and filtering out artefacts in the inversion results. These programs had very important roles in numerical resistivity modelling and inversion for interpretation of synthetic data as well as real field data.

The project has entailed significant experimentation and testing of numerical resistivity modelling and inversion to simulate the field surveys and some special model effects, such as the water effect in a crosshole survey and the possibility of inverting a vertical contact of two layers between two wells. These experiments are very helpful in interpreting the field surveys, especially for the Bolivar time-lapse crosshole resistivity surveys. These experiments also disclosed some very interesting features, such as turning points in an apparent resistivity profile and stacked profile patterns.

I built multi-electrode cables and collected 10s of surface, surface-to-borehole, and borehole-to-borehole electrical survey data at the Bolivar Test Site as a part of the ASR trial project. Specifically, seven time-lapse crosshole resistivity surveys at different stages of fresh water injection partly reveal the injected water flow direction. I processed all survey data and interpreted them with the aid of the above numerical resistivity modelling and inversion experiments.

I designed a fully automatic 3-D physical resistivity modelling system with a large water tank. To obtain high efficiency for modelling, the system was designed to be fully automatic, which includes automatic positioning of electrodes, automatic current injection
(on and off) and automatic data logging. Unfortunately, I did not completely finish building the system due to the lack of technical support. The intention to complete it is a late (post-doctoral) project.