Geophysical imaging of a shallow aquifer: initial field tests at Fredericton

K.E. Butler
Department of Geology, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick E3B 5A3, Canada

Advances in near-surface geophysical instrumentation and techniques over the past 10-15 years present new opportunities to improve our understanding of aquifer systems through the application of non-invasive geophysical imaging. The sand and gravel aquifer underlying the City of Fredericton, New Brunswick in the St. John River valley is a well-characterized and socially important example that could benefit from such technology. To date, the structure and stratigraphy of the aquifer, its overlying aquitard, and underlying bedrock have been determined almost exclusively by drilling. In November 1999, experimental field surveys were carried out in Fredericton comparing ground penetrating radar (GPR) and seismic methods. The main objectives were to evaluate the suitability of those techniques for (i) detecting breaks or 'windows' in the clay/silt aquitard, and (ii) mapping topography on the aquitard's upper surface. The identification of windows is important as they represent potential pathways through which contaminants spilled on surface could percolate into the aquifer. The surface topography of the aquitard is of interest because it influences contaminant flow paths.

Test surveys were carried out in the Wilmot Park and Smythe St. School areas of downtown Fredericton where the clay is covered by 5– 7 metres of surficial sands, and windows are known to exist. Preliminary results indicate that GPR is capable of mapping both the aquitard surface and the windows. Because radar signals are unable to penetrate through conductive clay layers, the window boundaries are marked by abrupt increases in the penetration depth of the radar signal. A paleochannel is visible in one of the radar sections, indicating that an erosional, channel scour process formed at least some of the windows. Seismic *P*-wave and *S*-wave refraction surveys carried out on either side of a suspected window boundary showed differences in arrival time patterns that correlate well with variations in GPR penetration depth.

The successful completion of the initial field trials encourages us to pursue further geophysical applications. Future plans include (i) field trials of resistivity, shallow electromagnetic, and streaming potential (SP) methods for window detection, and (ii) imaging of aquifer stratigraphy and bedrock topography using seismic reflection surveys. A promising, albeit limited, test of the latter has already revealed clear reflected arrivals originating from the top of bedrock at 60 m depth.

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