# 3D resistivity monitoring for seepage assessment at an earth dam abutment: System design and early results

Karl E. Butler[1], Daniel E. Boulay[1]

*(1) Department of Earth Sciences, University of New Brunswick, Fredericton, NB, Canada*

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Interfaces between water-retaining embankments and rock or concrete abutments, known to be regions of elevated risk for the development of concentrated seepage, are not well suited to investigation by the 2D electrical resistivity imaging (ERI) methods most commonly employed along dam crests. We present here the design and early performance of a 3D ERI system commissioned to investigate such an interface at the 670 MW Mactaquac hydroelectric generating station on the Saint John River in eastern Canada. The station, which opened in 1968, includes a 500 m long embankment dam with a clay-till core, rising 32 m above its toe and up to 58 m above its foundation.

The ERI system currently employs five parallel lines (5 m apart), of 20 electrodes (3 m apart) running from crest to toe on the downstream face of the dam adjacent to the abutment. The electrodes include 70 stainless steel rods, 91 cm in length, and 30 'non-polarizing' paste electrodes used for a prior self-potential (SP) study. Moderate contact resistances (commonly < 2 kOhm except during mid-winter) and the use of multi-day/multi-survey averaging with outlier rejection have contributed to the collection of highly repeatable data sets from a low power (10 W) resistivity meter (Lippmann 4ptlight) sustained by a solar-charged battery. A pole-dipole electrode configuration is used to improve depth of exploration (~20 m); importantly, we discovered it was necessary to force the transmitter to apply a sufficiently large voltage across the ~500 m long current dipole to prevent current regulation from being adversely affected by strong anthropogenic noise at the site.

The first high quality data were acquired in June 25, 2019, and the system has been running autonomously since late Oct., 2019, although ground freezing and a wiring break limited data availability in the depths of last winter. Resistivity models obtained using the RES3DINV smoothness-constrained inversion code reveal a dominantly bimodal distribution of subsurface resistivities: 50 – 200 $\Omega$m in the clay-till core, and generally 1000 – 4000 $\Omega$m in the more heterogeneous rockfill zones. Resistivities are noticeably lower within ~10 m of the concrete abutment, which could be indicative of increased water content although the influence of the relatively conductive concrete itself has yet to be determined. Changes in resistivity over weeks to months show spatially coherent patterns, especially in the uppermost 8 m, probably related to changes in temperature and rainfall-related moisture, although we speculate that road salt applied on the dam crest could help explain one large change, up to 200%. Monitoring is expected to continue for at least four more years to further develop the data acquisition and processing techniques that will be needed to identify any seepage-related anomalies that would be expected to arise from seasonal changes in water saturation or in the temperature and TDS content of water seeping through from the dam reservoir.

Figure Caption: 500 m long embankment dam and Diversion Sluiceway at Mactaquac Generating Station.