

## Preliminary Helicopter EM Survey Results over the Brandon Channel and Assiniboine Delta Aquifers, Brandon, Manitoba

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### Summary

VTEM helicopter time-domain EM survey results over the Brandon Channel and Assiniboine Delta aquifers, near Brandon, Manitoba, have been studied using unconstrained layered earth modeling. The resistive sand and gravel layers are distinguished from the more conductive shale basement and reveal localized thickening from blind gravel channels cut into its floor. They further distinguish a lower aquifer separated by a conductive clay layer from shallow sands of the Assiniboine Alluvial aquifer and the Assiniboine Delta Aquifer. The Brandon Channel is mapped, including a secondary channel further north. The western extent of Assiniboine Alluvial aquifer is defined and evidence for the Pierson Valley aquifer extending west from Brandon is also indicated.

### Introduction

Buried valley aquifers are important sources of groundwater supply in the Prairie Provinces of Canada, consisting of permeable sand and gravel deposits in eroded bedrock valleys. In Manitoba buried valley aquifers have been difficult to define because they are often partially eroded, have complex lithology and are hidden amongst other shallow sand and gravel aquifers within thick glacial overburden.

Recent investigations of the Spiritwood Valley aquifer, which extends into Manitoba from North Dakota by the Geological Survey of Canada and other workers, have included helicopter time domain EM surveys (Oldenborger, 2010a; 2010b; Oldenborger et al., 2010; 2011; 2012; Sapia et al., 2012; 2013; Legault et al., 2012; 2013; Prikhodko et al., 2013). In February, 2013, the Department Manitoba Conservation and Water Stewardship commissioned a similar helicopter EM survey of a region surrounding the city of Brandon to map the Brandon Channel aquifer (Fiset et al., 2013). While the Brandon Channel aquifer was known to exist in the area where it is an important source of water for local industries, the boundaries of the aquifer, its complex internal structure and water bearing zones remained enigmatic.

### AEM Survey Results

The helicopter time-domain EM survey used in Brandon was the Full Waveform VTEM system (Legault et al., 2012; 2013) and horizontal magnetic gradiometer. The block was flown in a southwest to northeast (N 15° E azimuth) direction with traverse line spacing of 400 metres and tie lines were flown perpendicular to the traverse lines at a spacing of 5000 metres respectively (Figure 1). As shown the survey extended along the Assiniboine river valley with survey lines clipped to avoid populated areas of the city of Brandon to the west and the town of Shilo to the east. A total of 645 line-kilometres of geophysical data were acquired during the survey over an area of 244 square kilometres. Figure 2 presents the VTEM EM decay time-constant (TAU) that highlights conductivity highs (warm colours) and conductivity lows (cool colours) that relate to the subsurface geology. Highlighted are resistive lineaments that represent buried gravel channels that have cut into the more conductive basement shale units.

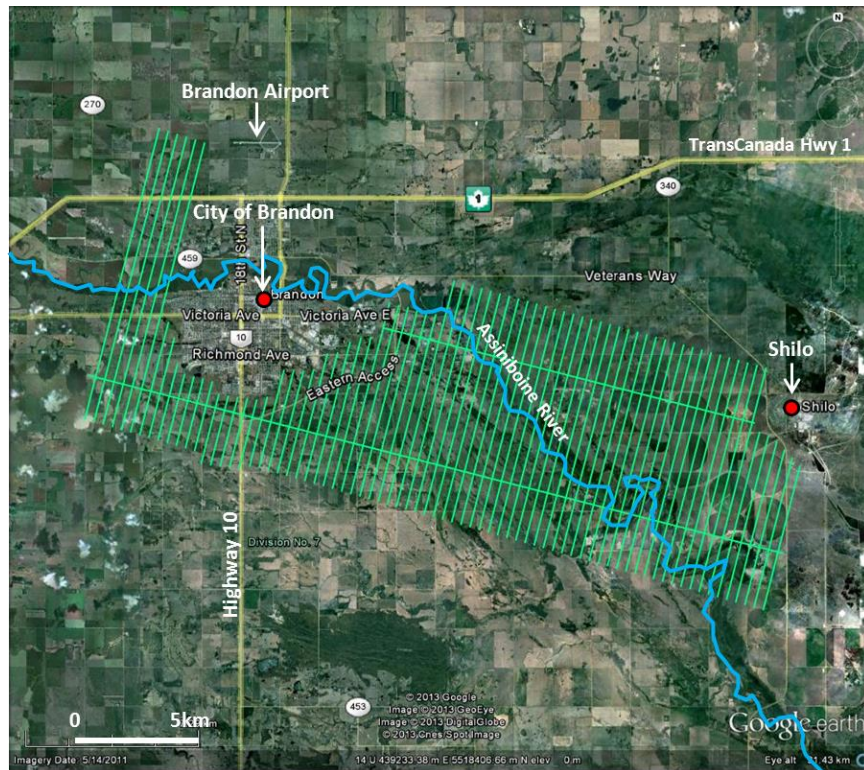


Figure 1: Brandon survey area and VTEM flight lines, in Google earth.

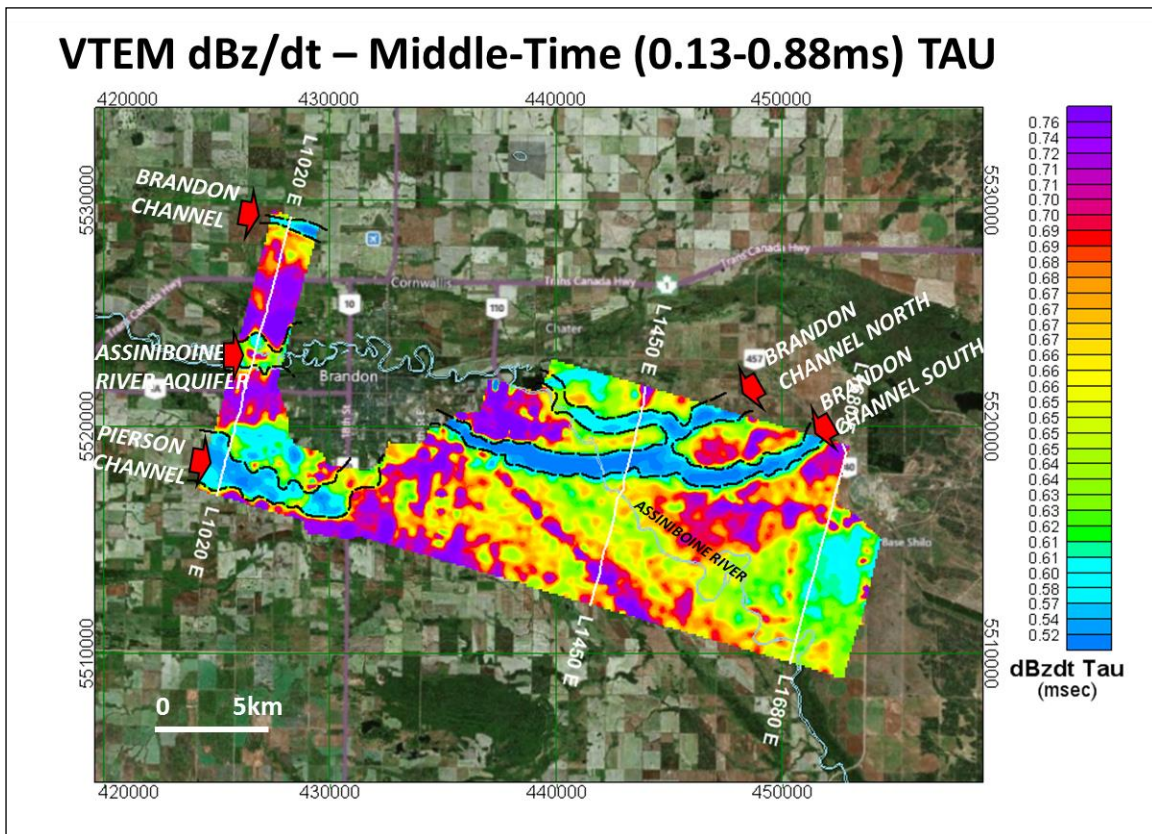


Figure 2: VTEM dBz/dt middle-time EM decay time-constant (TAU), with interpreted hydrogeologic features and locations of LEI sections shown in Fig. 3.

## 1D Layered-Earth Inversions

The VTEM dBz/dt EM data were converted to their equivalent cross-sectional resistivity-depth distribution using the Airbeo one-dimensional (1D) layered-earth inversion (LEI) program by CSIRO (Chen and Raiche, 1998) that models the EM decay response using discrete layer thicknesses and resistivities. The data were decimated to ~12m intervals and soundings using all available decay channels (0.031-8.083 msec) were fit to a 4-layer model using the same initial model, with no lateral constraints. Pseudo-2D resistivity sections were then constructed for all 76 lines. Figure 3 presents three representative LEI cross-sections from the western (L1020), central (L1450) and eastern (L1680) survey areas.

The sections in Figure 3 reveal a conductive basement (<10 ohm-m) whose interface is easily defined from the thicker (30-100m) more resistive (>10-500 Ω-m) glacio-fluvial overburden units that lie above it and are composed of at least three layers: 1) a thin (<50m) resistive (>100 Ω-m) surficial layer, which represents glacial-fluvial sands and gravels that form the upper aquifer; 2) a thin (<10-30m), more conductive layer (~10 Ω-m), likely clay-rich, which may act as an aquitard; and a deeper more resistive (>100 Ω-m) basal layer, which represents the lower aquifer and whose thickness varies greatly between <10m to >100m, forming secondary valleys cut into the basement shales and which correspond to lower buried channel aquifers. Easily identified are the Brandon Aquifer, which appears to split into two channels (north & south), the Assiniboine River Aquifer, only visible to the west (see L1020), and similarly evidence of the Pierson Channel which extends west of Brandon.

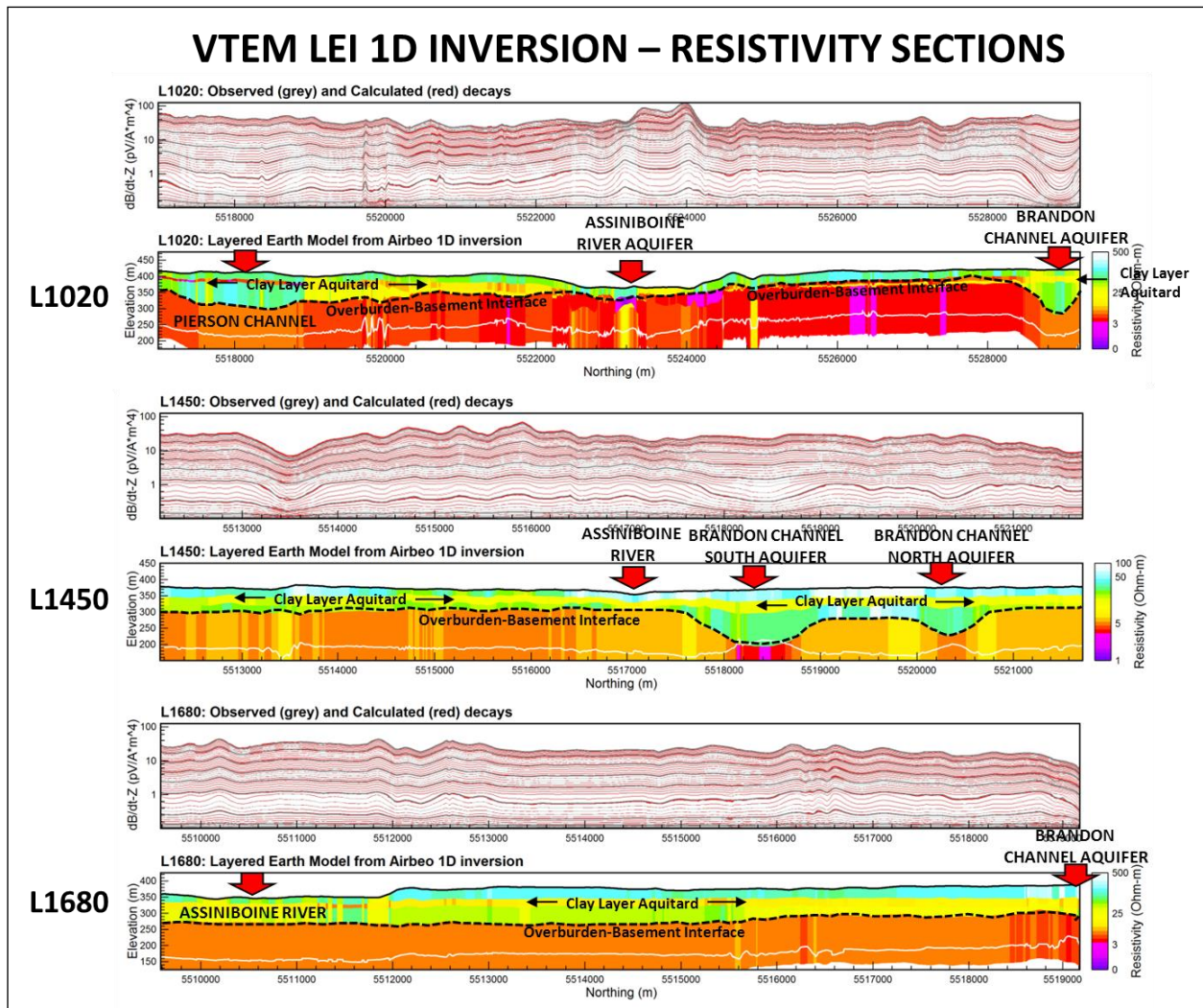


Figure 3: VTEM 1D Layered Earth Inversion (LEI) resistivity cross-sections for selected lines (see Fig. 2)

## Conclusions

Preliminary analysis of VTEM helicopter time-domain EM survey results near Brandon, Manitoba, which have been studied using unconstrained layered earth modeling, reveals the boundaries of the Brandon Channel including a secondary valley cut into its floor. They further distinguish a lower aquifer separated by a conductive clay layer from shallow sands of the Assiniboine Alluvial aquifer and the Assiniboine Delta Aquifer. Evidence for the Pierson Valley extending west from Brandon is also indicated.

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