RAPID DETERMINATION OF SALT-LOADS ALONG THE RIVER MURRAY USING AN AIRBORNE ELECTROMAGNETIC SYSTEM

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INTRODUCTION

Salinity in the River Murray and in adjacent floodplains has important environmental, economic and social consequences. Methods to monitor the temporal state of river and particularly river-groundwater interactions, have been in place for many years now. However, few have the capacity to define variability at a resolution appropriate for developing salinity management strategies, such as localised salt interception schemes. One approach, currently employed with some success is the instream NanoTEM, a time domain ground EM system, deployed in a boat with the transmitter and receiver towed behind on a floating boom. Here we report on the potential for employing slightly different electromagnetic technology, namely a frequency domain helicopter EM system mounted in a towed bird, for generating similar information to the instream NanoTEM, though at a significantly faster rate and potentially lower cost, highly suited to mapping during flooding events.

METHODS

"instream" EM acquisition and processing

The "instream" EM data acquired for the Bookpurnong reach of the River Murray (shown in Figure 1), were collected using a floating version of Zonge Engineering's land-based NanoTEM system (Telfer *et al.,* 2004). A single-turn transmitting antenna (7.5 m x 7.5 m) and receiving antenna (2.5 m x 2.5 m) were mounted on a stiff PVC framework of four floating pontoons, towed behind a boat. Data were acquired in a nearly continuous mode every 4 seconds using 64 cycles at a repetition rate of 32 hertz and a sampling rate of 1.2 or 1.6 microseconds. An average boat speed of 5 km/h resulted in a TEM reading approximately every 5 to 8 metres along the river. Progress along the river was determined with a GPS/sounder which logged position and water depth approximately every 10 metres. All three data sets were time stamped and synchronised, resulting in an accurately located TEM sounding and associated water depth (Berens *et al.,* 2004). These data were inverted to a model resistivity vs. depth using STEMINV (MacInnes & Raymond, 2001).

AEM data acquisition and processing

The Bookpurnong area (Figure 1) was surveyed in July 2005 with the Fugro RESOLVE frequency domain helicopter EM system. RESOLVE is a six frequency EM system mounted in a bird towed beneath a helicopter at a nominal altitude of 30m. The bird contains horizontal coplanar coils, and in the Bookpurnong survey measured an EM response at 390Hz, 1798Hz, 8177Hz, 39470Hz and 132700Hz. It also has one coaxial coil pair which measured a response at 3242Hz. RESOLVE is a digital frequency domain EM system with internal calibration coils for automatic phase and gain calibration in the air. Twenty six lines of data orientated NW-SE were acquired over the study area with a line spacing of 100m. The EM data were inverted using a holistic inversion algorithm (Brodie & Sambridge 2006).

RESULTS

Inverted RESOLVE FDEM data for the Bookpurnong stretch of the River Murray, were compared with the Insteam NanoTEM data and available river-bed core data. The AEM data were not collected along the river itself, but extracted from gridded profile data flown in a WNW-ESE direction.

The HEM data show very similar trends in conductivity variation identified in the corresponding NanoTEM data as shown in Figures 1 and 2. There are some minor differences between the two images shown in Figure 1, but this is attributed to the NanoTEM data representing the conductivity of riverbed sediments, whereas the RESOLVE data represents the 1.5-3 metre depth from the waterlevel surface of the river. The inverted conductivity depth sections shown in Figure 2 provide a better means of comparing the two techniques. For this reach of the river the RESOLVE HEM and NanoTEM data effectively map gaining and losing stream conditions and provide significant insight into the interplay between an irrigation induced groundwater mound, the regional groundwater system and river salinity.

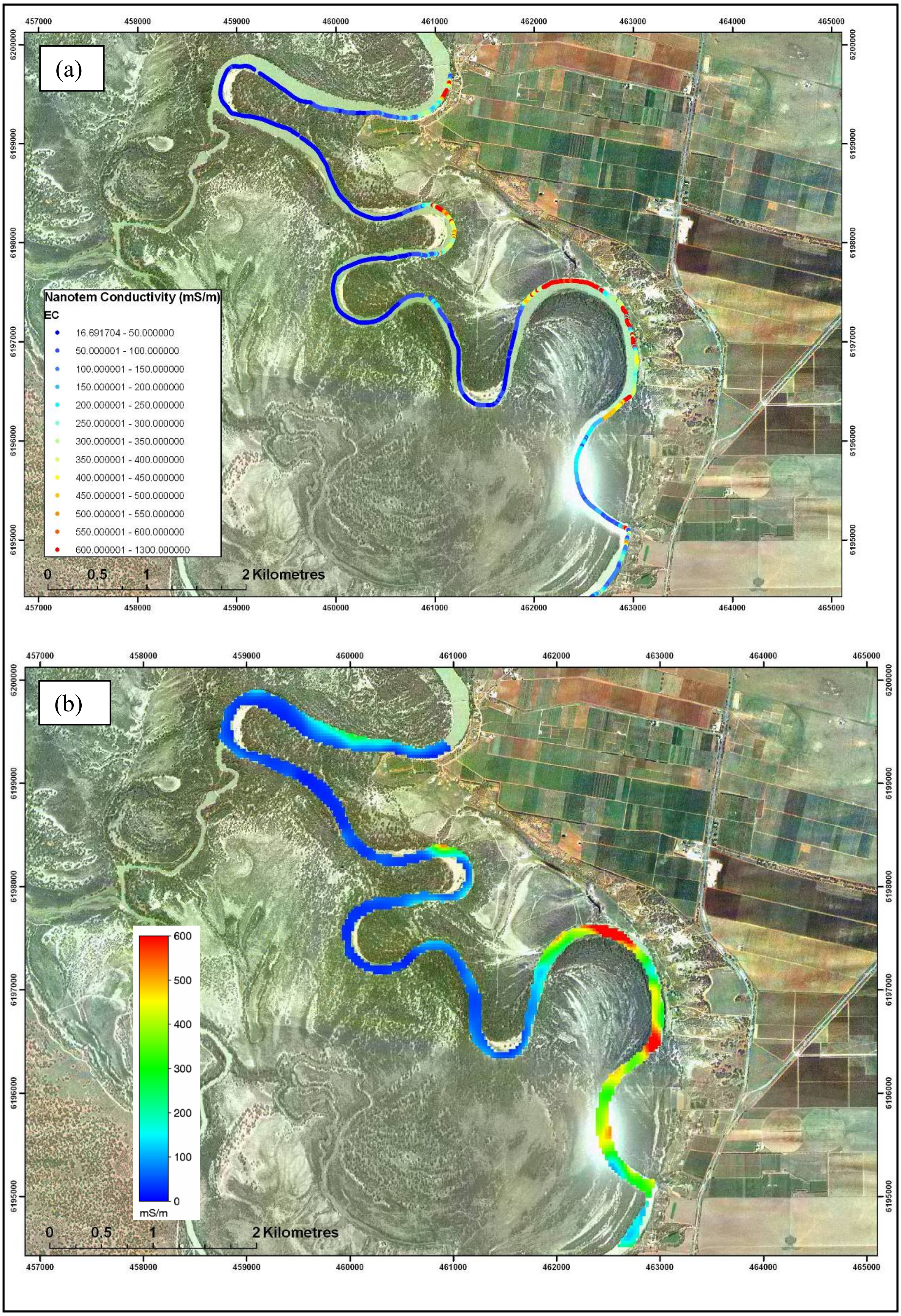

Figure 1. (a) Instream NanoTEM data for the Bookpurnong area of riverbed sediments, SA. (b) Inverted Resolve AEM conductivity data for 1.5-3 metre depth interval for the same stretch of river.

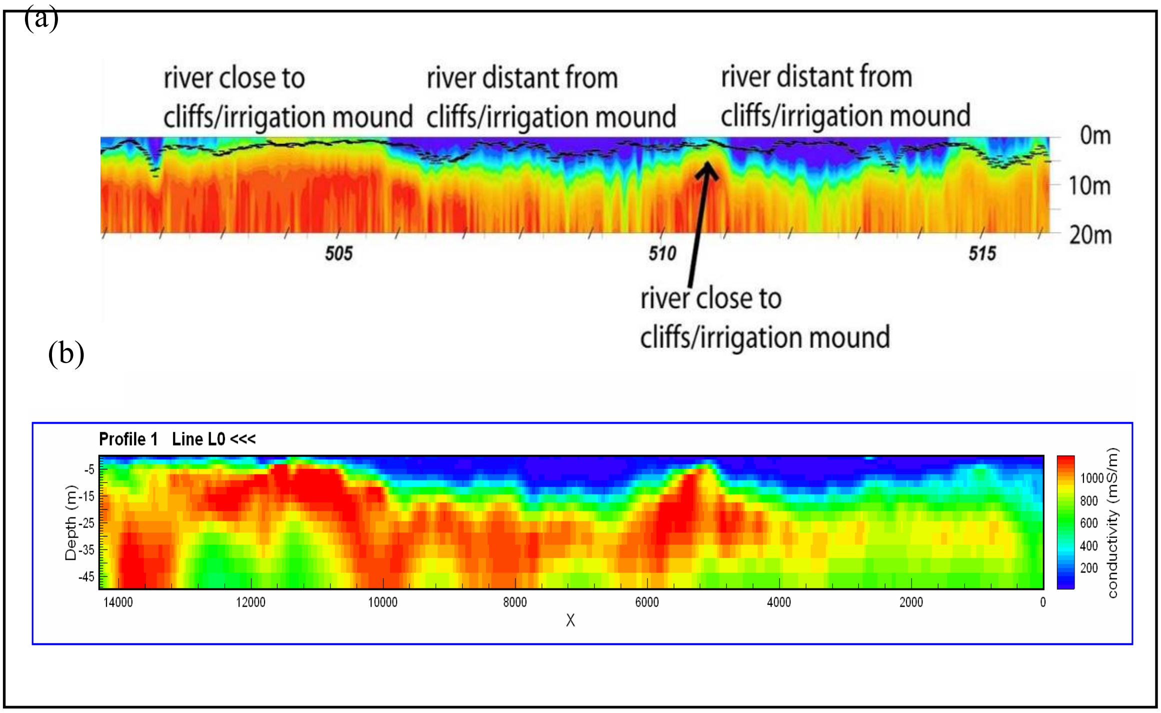

Figure 2. (a) Instream NanoTEM conductivity-depth section for the Bookpurnong area of riverbed sediments, SA. (b) Inverted Resolve AEM conductivity-depth section for the same stretch of river.

The results of the NanoTEM and RESOLVE conductivity data are compared with corelogs collected within the river (Figure 3). There is a good correlation in the shape of the profiles. There are differences in the magnitude in values between the RESOLVE and NanoTEM which may be the result of several factors. These include the different sized footprint of the two EM systems, i.e. the area they effectively measure, and that the airborne flight lines do not directly intersect the corelog position, in contrast to the in-stream NanoTEM transect.

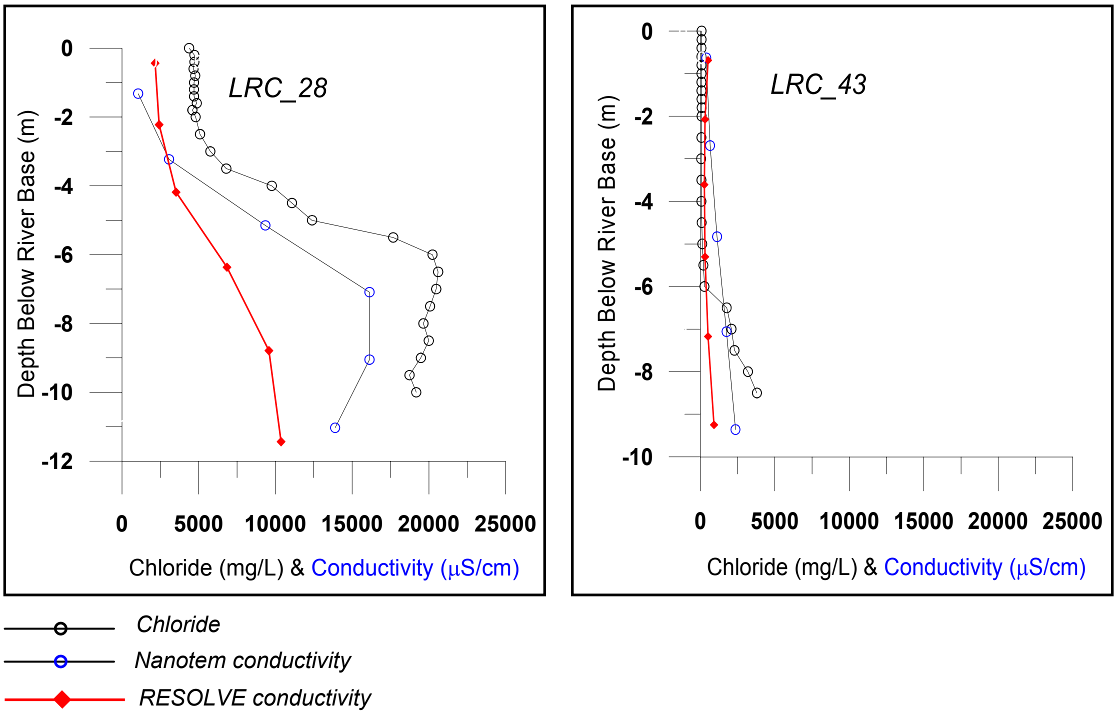

Figure 3. Instream NanoTEM and RESOLVE conductivity profiles plotted with chloride measurements from corelogs collected within the river.

COSTS

The cost differences between using in-stream NanoTEM with RESOLVE can vary depending on survey design. In the simple case of traversing down the river, the cost for in-river NanoTEM is in the order of $60 per line km compared to $120 per line km for RESOLVE data. However, in the case where a swath survey plan is designed where ground NanoTEM might be collected in addition to the in-stream data, then the cost becomes significantly higher, as ground NanoTEM surveying costs are in the order of $1000 to $2000 per line km. A swath approach taken using an airborne EM system as shown in Figure 4, would allow additional information on ground conductivity to be obtained in areas adjacent to the river. This may assist in the identification of areas of concern, which may not be identified by in-stream data alone. With the addition of new salt interception schemes along the Murray, HEM data have the potential to help monitor their performance.

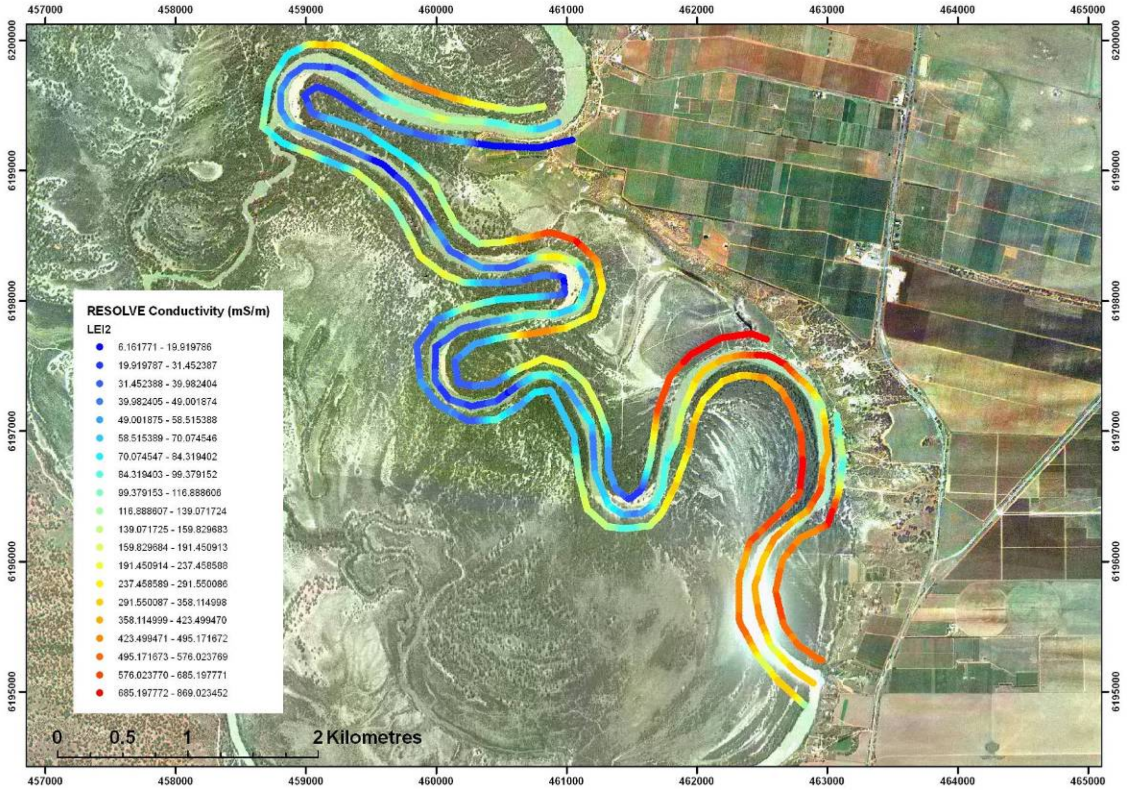

Figure 4. RESOLVE HEM data acquisition using a swath approach allows additional information to assist in determining gain and losing conditions of the river, and identify potential areas which should be monitored closely, which may not be revealed by in-stream measurements alone.

FURTHER WORK

At this stage CRCLEME is currently trialling a RESOLVE survey along the Murray River, in the Sunraysia area of Victoria. There are several issues regarding bird swing and survey speed, that are being addressed in this survey, not least because of the requirement for navigating a meandering flight path. Consequently we are have incorporated bird attitude sensors as part of the survey to help understand the significance of these issues on the observed conductivity. These data will be analysed to determine whether the acquisition of RESOLVE or a similar system is suitable for monitoring the condition of rivers such as the Murray. Although it may not be likely that RESOLVE will replace in-stream NanoTEM it's main advantage lies in the speed of acquisition. The results from this study may help determine the value and relevance of airborne systems in providing a snap-shot of the river's condition in certain time-critical situations – such as in a flood event.

REFERENCES

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GLOSSARY

EM: Electromagnetics

FDEM: Frequency domain electromagnetics

HEM: Helicopter electromagnetics

NanoTEM™: Time domain ground electromagnetic system designed by Zonge Engineering.

RESOLVE™: Frequency domain helicopter electromagnetic system designed by Fugro Airborne Surveys