Use of stream sampling for salinity to target airborne electromagnetic surveys – examples from eastern Australia

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Airborne geophysical mapping in eastern Australia, especially airborne electromagnetics (AEM), has demonstrated that most salt is stored in well defined subsurface locations. These salt stores become a significant problem only when mobilised by groundwater.

The Bureau of Rural Sciences (BRS) has developed an approach to target AEM surveys to ensure the most cost effective use of this technology. This involves a preliminary assessment of the likely salt store locations within a catchment. Salinity data obtained from permanent stream gauging stations, groundwater level data and any known land salinisation data are analysed. Streams are then sampled to identify where salt is entering the stream. These results are used with the groundwater flow systems framework to locate which subcatchments are contributing salt.

This approach has been applied to the Mid Macquarie region, the Billabong, Castlereagh and Jugiong catchments in New South Wales, the Ovens/Kiewa catchment in Victoria, and the Mt Lofty Ranges in South Australia.

Using stream sampling to target AEM surveys to assist with salinity management means that interventions can be more efficiently focused on those areas that are generating the salt problems. Using this approach, it has become evident that, in eastern Australia, salinity management will not require extensive land use change. Incorporating community and land manager involvement in this approach increases ownership of the solutions, and ensures greater uptake of the results.

Introduction

To manage salinity more effectively, we need to know the locations of salt stores in the landscape, whether these are likely to be mobilised by groundwater, and the extent to which they may pose a risk to assets such as agricultural lands, water quality, the environment and infrastructure.

A first step towards establishing the extent and likely source of a catchment's salinity problem is to undertake systematic sampling of stream salinities. This information can then be combined with any pre-existing water quality and groundwater data to help identify which sub-catchments within the larger system are contributing the major salt loads. The results will help catchment management authorities to choose areas for detailed AEM. The AEM data are used in conjunction with hydrogeological modelling to identify where salt is stored in the landscape, and which areas are at risk from salinisation as a result of mobilisation of stored salt by water, as well as to identify catchment sources of freshwater that may need protecting. Once this information is known, managers can develop specifically targeted strategies to cope with salinity.

In 2004 the "Review of Salinity Mapping Methods in the Australian Context" facilitated by the Academy of Science and the Australian Academy of Technological Services and Engineering concludes that "*a robust first step in determining if a catchment is likely to have a problem with salt discharging into local streams is to undertake systematic in-stream sampling of salt concentrations across the catchment. The approach can be readily applied to catchments of many hundreds of thousands of hectares in size down to small catchments of just a few thousand hectares. The outcomes of the in-stream sampling help target the sub-catchments that have higher areas of transportation of salt load and therefore areas that require further investigation. This can be done using EM techniques (typically airborne electromagnetic techniques) that can then give a measure of salt load at depth, its location and approximate concentrations. Airborne EM and magnetics may also provide crucial*

information on structural and permeability factors that control subsurface ground water flow. EM mapping is the only broad acre mapping technique currently available for remote sensing of salt loads below the surface".

One of the strengths of this approach is the level of community engagement in conducting the rapid stream surveys. This approach allays community concerns and provides people with an opportunity to address, and be a part of, local natural resource management issues.

This paper details the work conducted in the Billabong Creek catchment and the Mid Macquarie region. Other study areas are also indicated in Figure 1.

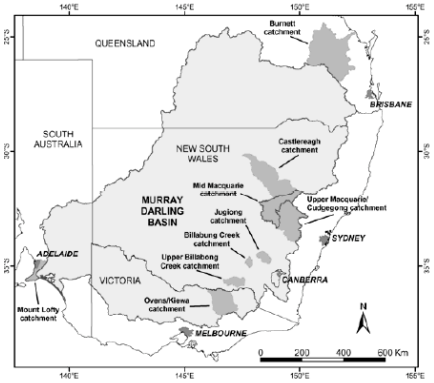

Figure 1Location Map showing other catchments with stream salinity surveys. Billabong Creek catchment

There is little surface salinity expression in this catchment and the groundwater quality is generally good. Stream salinity measurements were taken during September and November 1999 and January 2000 to pinpoint the cause of reported electrical conductivity rises at the permanent gauging station. This work indicated that stream salinities were low east of Culcairn but increase to the west primarily in Kangaroo and Simmons Creek catchments (Figure 2).

The results of this work resulted in an AEM survey being flown in 2001. The results of this survey confirmed the stream sampling results, with the two major salt stores being located to the west of Culcairn in the Kangaroo and Simmons Creek catchments.

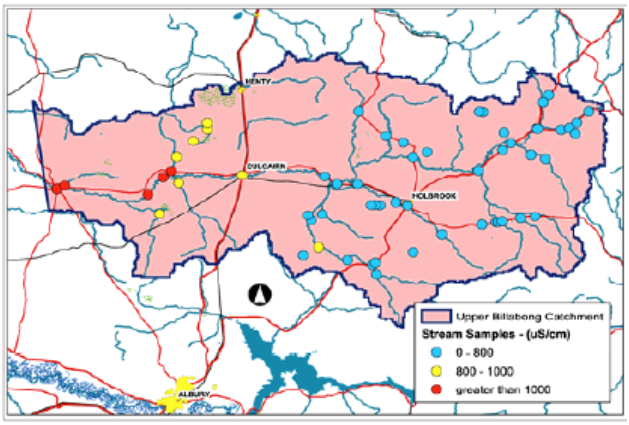

Figure 2 Combined stream salinity readings for Billabong Creek, Mid Macquarie region

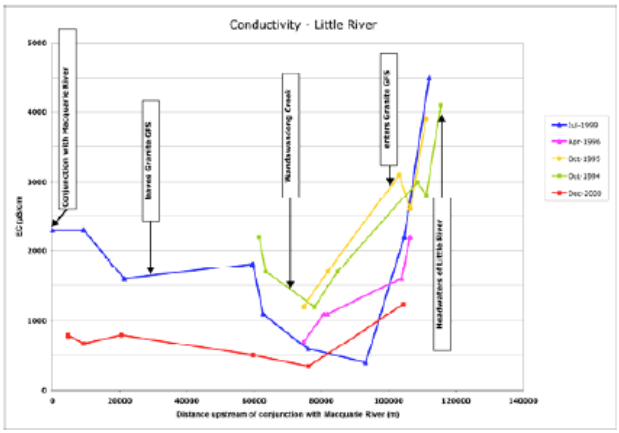

Figure 3 Longitudinal profile of salinity along the Little River (Baker and Evans 2003) Mid Macquarie region

The Mid Macquarie region is located in central west of New South Wales. Two of the main catchments are the Talbragar River in the east and the Little River in the south. In 1994 a rapid stream survey showed that streams in parts of the catchment were highly saline, with some sites exceeding 10,000 µS/cm. The region was considered to be at serious risk of land and stream salinisation and a major contributor to salt loads in the Macquarie River.

Rapid stream surveys were undertaken by members of the community to provide a quick method of delineating areas of high stream salinity. As part of this BRS led project, four surveys were conducted in July 1999, December 1999, December 2000 and February 2001. From this work the Talbragar and Little River catchments were identified as the major sources of saline discharge in the region. It should be noted, however, that this study demonstrated that over 50% of the stream salinity identified at Dubbo was generated upstream from the Mid Macquarie region.

Figure 3 shows a longitudinal cross-section of the measurements for all the stream salinity

surveys conducted in the Little River catchment from the confluence with the Macquarie River to the Little River headwaters. The high salinities in the headwaters reflect contributions from the Middle Devonian Volcanic sediments, with salinities decreasing rapidly when the Little River flows through and is sourced by the granites. This indicates that the granites provide predominately fresh baseflow to the Little River with the increase in conductivity after the granites is primarily due to the contributions from Wandawandong and Gundy creeks.

Implications for policy and management

The rapid stream survey approach used has been recognised and endorsed by the joint science academies as a valuable first step in determining whether a catchment is likely to have a problem with salt discharging into streams. The results from rapid stream surveys, together with an analysis of existing information on geology, borehole and land use data, can be used to identify the sub-catchments that are making the larger contributions of salt to streams. Where appropriate, further investigation may be undertaken using airborne electromagnetic techniques.

The results to date have demonstrated that saline discharge into streams are area specific and are often located in areas which have not previously been identified as a source of salinity. Historically, monitoring has been undertaken at the lower end of catchments and, where monitoring has indicated a salt problem, it is usually presumed that the problem is indicated for most if not all of the catchment. This presumption is not supported by the evidence.

This has significant implications for policy and management and, importantly, public investment. By identifying where salt is entering streams, targeted AEM surveys can be conducted to precisely delineate those salt stores that are the cause of the problem to ensure the right mitigation activities are conducted in the right place. This also means that fresh water sources, providing important dilution flows, are protected.

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