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Mapping hydrogeological architecture beneath the lower Balonne floodplain, Queensland, Australia

A. Fitzpatrick, J. D. A. Clarke, and R. Lane

Cooperative Research Centre for Landscape Environments & Mineral Exploration, Geoscience Australia, GPO Box 378, Canberra, ACT 2601, Australia

The sedimentary architecture of the sediments beneath the floodplain of the Lower Balonne River is of crucial importance for managing ground water levels and salinity loads in this area of irrigated cotton growing and dryland farming. The area is characterised by highly variable thickness of fluvial sediment, locally reaching 200 m, deposited in and over-filling a series of incised palaeovalleys. There is no hint of this complexity in the surface geomorphology, remotely sensed data, or in the aeromagnetic data sets. These features were poorly resolved by existing data sets, including drilling and geophysics. Therefore an extensive program of high resolution Airborne Electo-Magnetics (AEM) has been undertaken to improve understanding of the subsurface architecture, the data from the survey being calibrated with down-hole geophysics and integrated with bore-hole geological and hydrological data.

Time domain airborne electromagnetic data using the TEMPEST system was acquired over an area covering 18000 km^{2}of the Lower Balonne catchment, at 250 and 400 metre line spacing. A 3-D distribution of conductivity data was predicted and assessed from the AEM data using a layered earth inversion in conjunction with electromagnetic borehole conductivity measurements. The AEM conductivity data showed correlations ranging from 0.6 to 0.9, with independent ground conductivity measurements for depths up to 120 metres.

AEM proved to be an effective technique in the Lower Balonne study area for mapping the buried bedrock topography, conductive weathered bedrock, areas of high conductivity associated with near-surface salinity anomalies, and areas of potential recharge delineated by highly resistive zones associated with shoestring river sands. The AEM conductivity data were not able to map individual sand stringers deeper in the sub-

surface because of a much-reduced conductivity contrast between channel sands containing slightly saline water and conductive flood plain silts and clays. Of particular interest was the visibility in AEM layered earth inversion depth slices of incised valley features too narrow to be effectively detected by the widely space bore-holes. The AEM sections also showed the variable nature of conductive zones in weathered bedrock, contrary to laterally uniform “layer cake” interpretations based on drilling, and thin dendritic conductive zones that may be related to bedrock weathering related to buried first order streams.

The upper and lower disconnected aquifers were spatially mapped from the AEM conductivity data. The water table surface of the unconfined saline upper alluvial aquifer is identified by drilling. There was a marked increase in the AEM conductivity below the water table due to the increase in water saturation. This interface could therefore be mapped between bore holes using the AEM conductivity data. Hydrogeochemical and hydrogeological data identified four main hydrostratigraphic units, and determined their connectivity and flow directions. Resolution by AEM methods of these units, as is recognition of different lithologies within the sediments, is difficult. However, the less saline, lower alluvial aquifer is differentiated from the conductive bedrock by being more resistive than both the underlying bedrock and the shallower aquifers..

The scale of landscape elements identified in this survey is of importance to future salinity-related work in the region. Although flown at 200 and 400 metre line spacing and intended for farm scale investigations, the main features of the landscape were still visible when the survey was re-sampled to approximate an AEM survey flown at line spacing of 1000-2000 metres. Thus, further studies extending beyond the current study area could be flown at broader line spacing and hence at lower cost for sub-catchment to catchment scale management.

Airborne electromagnetic data has been an extremely useful tool for interpolating between drillhole information to produce a three dimensional sedimentary architecture of the Lower Balonne catchment. An integrated geoscience approach has revealed a complex sedimentary architecture, consisting of stacked, disconnected aquifers concealed beneath a low relief landscape will be important factor in future hydrogeological models.