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Airborne geophysics looks promising for catchment management

At the completion of the National Airborne Geophysics Project at the end of 1998, it was concluded that airborne geophysical surveys could significantly add to the information required for effective catchment management. Two Western Australian studies made major contributions to the outcomes of the Project. Dr Richard George and Russell Speed report on the accuracy and future application of the airborne geophysical technologies used to survey the Toolibin and Chapman Valley catchments.

The National Airborne Geophysics Project started in early 1996 to evaluate the accuracy and usefulness of three types of airborne geophysical technologies – electromagnetics (AEM) radiometrics, and magnetics.

The project was developed to answer farmers' concerns about what was happening under the soil surface. A major goal was to develop more effective systems for land and water management.

Airborne geophysics provides complex information on the physical nature of Western Australia's agricultural catchments. With careful use, the information significantly improves our ability to interpret the landscape. When combined with all other information assembled by farmers and government, a much better decision-making environment can be developed in which dryland salinity and other environmental issues can be tackled.

Areas such as Lake Dulbinning will benefit from more effective catchment management.
The geophysical data collected in both catchments improved knowledge of salt content, geology, and soil properties. Data will assist in interpreting the behaviour of groundwater systems and the physical processes associated with the development of salinity in the landscape.

The project included the surveying of five sites across Australia. Two were located in the Chapman Valley and Toolibin catchments of Western Australia. At Toolibin, the World Geoscience SALTMAP™ was used to acquire the geophysical data, while at Chapman Valley, the Geoterrex DIGHEMLAND CARE system was used.

Calibration and field testing obtained through drilling, soil assays, ground and downhole geophysics, airphoto interpretation and the direct input of farmers were essential for the validation and interpretation of the airborne data. In addition, a wide array of systems (including statistical and empirical methods) were used to interpret the data.

One of the highlights of the studies was the ability of the airborne geophysics to map physical features at 'paddock scale'. This meant that real variations in soils, geology, and salt store patterns within paddocks could be recorded with significantly greater accuracy than similar data available at the farm or catchment scales.

OUTCOMES

Airborne Magnetics

Magnetics was shown to have the ability to map geological structures not always apparent from outcrop or airphoto interpretation.

The data were used to map the region's geology at scales more detailed than currently available.

Airborne Radiometrics

Radiometrics was able to map patterns of soil properties, incorporating mineralogy and texture, more effectively and efficiently than existing landscape mapping systems.

With interpretation, soil maps could be produced at paddock scale. The data also allowed farmers to compare their soils with others in their catchment or region. In addition, farmers were able to use their detailed knowledge to improve mapping for their respective farms.

Airborne Electromagnetics

Electromagnetic data were up to 90 per cent accurate in predicting the variance in salt-store at depths from 5-10 metres down to bedrock. No other dataset available at present could do this more accurately.

Electromagnetic data could also be used to explain 75 per cent of the variations seen in the distribution of groundwater salinity.

The data helped identify features significant for catchment management, including the interpretation of deep valley sediments capable of transmitting large volumes of groundwater.

Combination

When all of the geophysics and associated data were combined, a pseudo 3-D view of the landscape and its geological attributes was possible.

In addition, conductivity patterns, affected by the distribution of salt-store, reflected the likely occurrence of hydrological and geological features.
Toolibin airborne geophysics evaluation

The Toolibin catchment is located about 250km south-east of Perth at the headwaters of the Arthur-Blackwood river system. About 6 per cent of the catchment is severely salt-affected and it is predicted that as much as 25 per cent-30 per cent could become saline if the water balance is not altered and groundwater levels continue to rise.

World Geoscience-Agraria was contracted to collect the airborne geophysical data with its own SALTMAP™ technology. Airborne magnetic and radiometric surveys were taken over a total of 70,000ha, which included the entire catchment. Only 35,000ha of this region was surveyed using airborne electromagnetics (AEM) due to the funds available.

World Geoscience-Agraria produced maps based on the survey data. The maps were of a high quality and considerably improved the geological understanding of the catchment.

In addition, water resource target maps correctly located areas of low salinity groundwater (less than 2000 mg/L) at three sites tested. The maps also showed areas of high salinity and located structures which may be significant for groundwater flow.

Salt hazard maps provided by World Geoscience-Agraria identified the mechanism likely to cause groundwater discharge. However, a lack of data on groundwater depth and rate of rise limited the application of these particular maps.

Chapman Valley airborne geophysics evaluation

Chapman Valley is located about 380km north-north-west of Perth within a 150,000ha catchment which drains to the Indian Ocean at Geraldton via the Chapman River. The total area of groundwater discharge within the survey area is 6.2 per cent. The salinity of discharging groundwaters range from fresh to brackish. The saltiest discharge water sampled was about half the salinity of seawater (15,000 mg/L).

Geoterrex was contracted to survey an area of about 20,000ha along the north branch of the Chapman River. The company used its own DIGHEMLANDCARE airborne electromagnetic system. Magnetics, radiometrics, and digital elevation data were also acquired.

As with the Toolibin surveys, the geophysical data provided definition of the geological structure of the basement rock, mapped detailed variability in the regolith, and variations in soil characteristics.
Geological and regolith features known to exist in the survey area appeared to be accurately defined by the airborne geophysical data. This included alluvial channel aquifers, which can contain groundwater resources.

The geophysical data also aided in the identification and delineation of features significant for catchment management.

**Restrictions**

SALTMAP™ could not reliably map the salt store between 0 and 5 metres below the surface or accurately quantify areas where the salt content was greater than 10 Siemens (extremely saline areas). This level of salt store was exceeded in more than 30 per cent of the Toolibin catchment.

In addition, regolith thickness or bedrock topography could not be mapped reliably at paddock-scale. Only with the use of data from drill holes and local knowledge could the data be used to determine a reliable average of depth to bedrock within the catchment.

Similarly, DIGHEM™ Landcare could not systematically map areas of groundwater discharge or dryland salinity, or determine regolith thickness.

However, DIGHEM™ Landcare electromagnetics appeared to sample deeper than the majority of supporting drill holes could confirm statistically. Interpretation required an intuitive combination of the electromagnetics, drill hole data and familiarity with the catchment.

World Geoscience SALTMAP™ (pictured below) was contracted to conduct airborne surveys over the Toolibin catchment. Geoterrex DIGHEM™ Landcare was contracted for the Chapman Valley surveys.
The application of the geophysical data for farm and catchment planning will be critically dependent on the availability of experienced hydrologists and skilled soil landform interpreters. Interpreters will need to link the data to ‘on-farm’ management.

Significant scope exists for improvements in airborne electromagnetics, such as the development of accurate near-surface mapping and better regolith thickness maps. Next generation systems such as the World Geoscience TEMPEST system are being developed to improve accuracy and reliability.

**Conclusions**

The information generated from the airborne geophysics studies for the Toolibin and Chapman Valley catchments has created much interest in the rural community.

The data has since been compiled on compact disc, with a ‘user-friendly’ viewing package for farmers. The software is being made available to farmers in the Toolibin catchment.

The increased knowledge of geophysical systems and understanding of the landscape has the potential to provide farmers with some certainty in decision-making.

In addition, early indications suggest the value of the geophysics information may justify the cost of collection and interpretation. Simple economic analysis suggests farmers and/or the community will require a combined return on investment of between $0.66–$1.66 per hectare per year over a period of 20 years, to make acquisition of the data profitable.

Future interpretation of airborne electromagnetics and radiometrics will require field validation. Drilling and logging of about 20 holes is viewed as essential for reliable interpretation of data in different geological settings.

Skilled interpreters will also be required to take the data into the landscape and assist farmers. At present, while the maps produced from the airborne surveys are of a reasonable standard, they need to be used in conjunction with assistance from local and qualified interpreters, as well as a sound knowledge of the landscape’s physical processes.

Airborne geophysical data is complex, and its application remains a developing science. Further evaluation and collection of data will be undertaken through the Western Australian Salinity Action Plan, particularly in areas where there is likely to be a priority use for the data.

Additional benefits to the minerals, forestry and water resources industries from collection of the data should also be considered as part of a broader context for the development of regional Western Australia.

There is no doubt that further consideration should be given to the potential costs and benefits of making this data available for catchment management.
Acknowledgements

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The above information is only a summary of the evaluation results. Evaluation reports with far greater detail on the Toolibin and Chapman Valley survey results are available.

The Toolibin catchment evaluation was edited by Dr Richard George of Agriculture Western Australia, with support from the Airborne Geophysics Technical Advisory Group (AGTAG). The group comprises representatives from Agriculture Western Australia, the Water and Rivers Commission, CSIRO, the Cooperative Research Centre for Minerals Exploration Technology, the University of Western Australia, Murdoch University, and Curtin University.

The Chapman Valley catchment evaluation was edited by Russell Speed of Agriculture Western Australia, with support from AGTAG members.

The Water and Rivers Commission contributed significant drilling support in both catchments.

Results are available on the internet on the Project website and will be placed on the Agriculture Western Australia website.

The internet address is: www.nrsc.com.au/nagp/nagphome.htm