GROUNDWATER INVESTIGATION FOR AGNES WATER/1770 WATER SUPPLY

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Abstract

An airborne electromagnetic survey for Miriam Vale Shire Council was undertaken to assist in determining the potential availability of viable groundwater resources within the Shire. The survey utilised the Hummingbird system, a combined electromagnetic and magnetic airborne data acquisition system, operated by Fugro Airborne Surveys. URS Australia Pty Ltd undertook advanced 2- and 3-dimensional processing to identify potential areas for groundwater supply. An integrated interpretation incorporating geology, hydrogeology and geophysics was completed and identified three potential areas. This has now enabled Miriam Vale Shire Council to assess the feasibility of these areas for water supply and has also assisted in developing a water supply strategy.

Key Words: Agnes Water, Airborne Geophysics, Electromagnetic Method, Groundwater, Hydrogeology

Introduction

Miriam Vale Shire Council (MVSC) instigated a groundwater review and investigation project into the Agnes Water area to determine the potential groundwater resources for the development of a town water supply scheme. Figure 1 shows the location of the project area.

Figure 1 Location of the Project Area.

The region is environmentally protected from development by difficult access, limited water and sewerage capacity, but has a predicted high growth rate. Such growth places pressures on the environment and infrastructure required to service the community. Miriam Vale Shire Council recognises this, and undertook a multi-phase project to assist the search for groundwater. This project combined an intensive geological/hydrogeological data review phase (Phase 1) integrated with a focussed geophysical study (Phase 2). Phase 2 utilised the electromagnetic survey method, undertaken as an airborne survey.

Historical Searches

Intensive, but localised hydrogeological investigations have been undertaken in the Miriam Vale and Agnes Water areas.

Trenches, located to the south of Agnes Water, and excavated on the western side of sand dunes were traditionally the main source of water for Agnes Water. Groundwater storage capacities and permeability of these dunes were variable, with little long-term storage potential.

A reservoir (1770 ML) incorporating an earth and rockfill dam, with a downstream cut-off...
trench, pumping station and pipeline to Agnes Water was proposed in 1995.

As part of a previous study instigated by MVSC, an investigation into palaeodraining was undertaken in an area known as Lots 12 & 17. Results indicated that an old watercourse existed within the area of investigation, with drilling results indicating yields of generally 0.5 to 1.0 L/s, with an average conductivity of 603 μS/cm.

Within these areas, significant drilling had occurred. By undertaking this conventional approach, limited spatial extents of the areas are covered, as although drilling provides detailed information, this drilling only provides localise, but detailed information.

By contrast, the planned Phase 2 geophysical survey provided a significant increase in the potential area of investigation.

**Phase 1 Investigations**

As indicated in Figure 1, the area of the initial investigation was large, approximately 50 km by 55 km. Three data types were incorporated into the interpretation. These were geology, hydrogeology and regional geophysical data sets (aeromagnetics and radiometrics).

The geological interpretation provided a basis for refining the area of hydrogeological investigation. Geographical Information System (GIS) layers of all the available data were created. These were sequentially overlain to determine the most prospective areas for conducting the Phase 2 investigation. Initially the geology highlighted those sections likely to be dominated by sediments and hence have the highest potential as a groundwater source. In addition, fracture dominated areas were also considered.

By sequentially overlaying each of the datasets, areas of thickest sedimentary units were targeted. The addition of sub-catchments further refined the search.

Based on these processes, seven zones with potential for groundwater were identified. Of these, two zones were given highest priority, and two were considered of moderate potential. From the distribution of these zones, an airborne geophysical survey was planned.

**Phase 2 Investigations**

The geophysical survey for the Phase 2 investigations was completed in the areas outlined by black polygons in Figure 2.

**Hummingbird System**

The survey method utilised was the Hummingbird system, operated by Fugro Airborne Surveys (FAS). This system is a combined electromagnetic and magnetic system, towed beneath a helicopter and is used to acquire data over large areas. Figure 3 shows the system, prior to takeoff. The instrument is the white object in front of the helicopter.
The electromagnetic method targets the contrast between conductive and non-conductive material. For the purpose of this survey, the aims were multiple. Firstly to map the interface between the weathered and more conductive near-surface material, which may provide an indication of the location of groundwater; secondly, map any slight increase in conductivity within resistive host rocks, *i.e.*, groundwater within sandstone; and thirdly to map the subsurface geology and determine the location of structures likely to trap groundwater.

Five frequencies of electromagnetic data are collected using the Hummingbird system. These frequencies are preset at 34133 Hz, 6606 Hz, 870 Hz, 7001 Hz and 980 Hz. There are two geometrical orientations of the coils recording these frequencies; horizontal and vertical. The combination of the five frequencies, and the two geometrical orientations, assist in the interpretation of the subsurface conductors. Information on the depth and orientation of the subsurface conductors is extracted from the interpretation of these different frequencies and orientations.

In addition to electromagnetic data, magnetic data are also recorded. The magnetic data are used in the interpretation of the geological structure in the surveyed area. All these data are acquired simultaneously, requiring only one traverse of the survey line. Typically, the distance between each traverse (called the line spacing) is designed based on a combination of target size, required resolution and available budget. For the Miriam Vale surveys, a line spacing of 150 m was selected. Although this is a broad-scale spacing, the data acquired provides a balance between high data resolution and cost-effective acquisition.

**Processing Methodology**

The field processing of the Hummingbird data involves an understanding of the calibration procedures of the system, and is best completed by those who undertake the acquisition. In this case, this level of processing was completed by FAS. A second level of processing is completed on these field processed data. It is this step which was undertaken by URS. The processing of these data was completed in one- two- and three-dimensions.

The one-dimensional analysis relies on producing a series of plans of the survey area, one for each of the frequencies and one for the magnetic data.

Cross-sections for each of the lines in the survey area were processed. These cross-sections are generated from the distribution of the conductive responses observed from the five frequencies and the two geometrical orientations of the coils.

The visualisation of these cross-sections in three dimensions can be useful to provide an understanding of the inter-relationships of the geological units.

**Interpretation Methodology**

In undertaking the interpretation of each of the survey areas five factors were considered. These were the geology of the survey area, the distribution of conductors from the electromagnetic data, the interpretation of fractures/faults from the magnetic data, an examination of each of the cross-sections, and finally the integration of borehole information and cross-sections to form an understanding of the hydrogeology of the area.

**Survey Area Interpretations**

As identified from the Phase 1 investigation, a significant effort for groundwater search had occurred within the region defined as Lot 12 and Lot 17. In excess of 50 boreholes had been drilled. A series of geophysical traverses were collected across these areas, with a view to providing a hydrogeological control on the geophysical interpretation. Figure 4 shows the apparent conductivity data of the 6606 Hz frequency from the Hummingbird survey. The black boxes indicate the position of the bores. Conductive regions are indicated by the red, orange and yellow regions in the image, whilst the blue areas of the image have low conductivity.
The area outlined by the red polygon represents the conductive region, defined by the geophysical data. An assessment of the bores within the survey area indicated that bores with “good” or “potable” water quality (either measured or observed) were located in areas of low apparent conductivity. Figure 5 is an example cross-section from the survey. One of the intersected boreholes is indicated by the black triangle on the section.

Figure 5 Cross-section of Lots 12 & 17 Survey Area.

The bore marked on this section (05-08/B04) did not encounter groundwater. From the geophysical interpretation of this section, a conductive zone is present near surface and is likely to represent a weathered, predominately clay layer. It is interpreted that this borehole did not encounter any groundwater due to the presence of the impermeable clay zone. By contrast, the area indicated by the red circle is interpreted to be a localised synform, and may potentially act as a trap for groundwater.

Of potential interest for the Miriam Vale Shire Council was the survey area closest to Agnes Water. This area contained some catchment regions and was in an area containing both Agnes Water Volcanics and Quaternary Alluvium. An interpretation of this region indicated that any groundwater likely to be associated with the alluvium had a strong chance of being highly conductive.

Similarly, an area of interest close to Miriam Vale was identified based on the presence of likely source lithologies and potentially favourable structural conditions. From the geophysical data, this area showed high conductivity. Figure 6 is an image of the 6606 Hz apparent conductivity data, with the conductive zones outlined in blue.

Figure 6 Apparent Conductivity (6606 Hz) for Miriam Vale Survey Area.

As an example a borehole (121315), with high conductivity fluid (i.e., poor water quality) was correlated with an area of moderately high conductivity from the geophysical data. Based on such assessments a correlation between high apparent conductivity and poor water quality was established within this survey area.

A zone of moderate potential for groundwater was identified within the Lowmead survey.
area. This was identified from the interpretation of the plans and cross-sections of the geophysical data. The area is an interpreted synform, with alluvium at the surface. Figure 7 shows the cross-section through the centre of the zone.

Figure 7 Cross-section in Lowmead Survey.

The prospectivity of this zone was considered to be low, as there is very limited potential for aquifer recharge and would not be suitable for groundwater supply.

The largest survey region completed was located to the south of Agnes Water and covered an area of 410 km². Within the survey area were potentially sedimentary, volcanic and alluvial sources. Figure 8 is the 6606 Hz apparent conductivity image for the survey area.

Strongly conductive drainage areas occur in the north and central portions of the survey area. These areas have been correlated with poor water quality, as recorded in nearby boreholes.

Figure 8 Apparent Conductivity (6606 Hz) for Baffle Creek Survey.

Two resistive areas, indicated by the white circles on Figure 8, were identified as having potential for high quality groundwater. Lithological indicators in these areas suggest that host stratigraphy for groundwater does exist.

Implications

The application of the geophysical method outlined above enables large areas of ground to be surveyed, in a cost-effective manner. The more traditional approach of drilling areas to determine the presence of water should not be abandoned. Geophysics alone does not provide all the answers. By integrating the geological and the hydrogeological interpretations with the geophysical interpretation, a more complete understanding is obtained. Once these phases have been completed, the focussed drilling approaches can be utilised. At this stage, there are now clearly defined target zones for the drilling and installation of groundwater wells.

For Miriam Vale Shire Council, the application of the electromagnetic method has enabled the identification of five regions, within three of the survey areas as having potential for groundwater. Of these, three areas are within the Baffle Creek survey area. These have the highest potential for groundwater, but are the located at the greatest distance for Agnes Water.

Conclusion

The identification of groundwater resources continues to be a critical issue for many industry sectors. The ability to rapidly assess large areas, without the need for access on the ground is a significant benefit of the application of airborne geophysical methods. For Miriam Vale Shire Council the integrated interpretation incorporating geology, hydrogeology and geophysics has enabled Miriam Vale Shire Council to assess the feasibility of the areas identified for water supply and has also assisted in developing a water supply strategy for the Council.
Author Biography

Andrea has fourteen years of experience in the field of geophysics and geology. Currently employed as an Associate Geophysicist with URS, Andrea has considerable experience in the utilisation of geophysical methods for the delineation of groundwater resources, contaminated fluid delineation around mining and processing applications. Her specialist geophysical skills have been developed through resource exploration with BHP Exploration and MIM Exploration. During her employment with MIM, Andrea was instrumental in integrating geophysical applications to assist mining and processing operations understand their environmental liabilities.

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