

# Executive summary

AGL Energy Ltd (AGL) is currently exploring for gas from deep coal seams in the vicinity of Broke and Bulga. Impacts on water catchments and groundwater resources were raised as a possible consequence of the activity and hence substantial investigations have been completed by AGL since March 2009. This summary outlines the project objectives and explains in plain English, the project tasks, results and conclusions.

## **Background**

Parsons Brinckerhoff (PB) has conducted the groundwater investigation and monitoring program in the Broke area. The objectives of the program are to:

- Provide more information on groundwater in the area by determining whether the water bearing zones (aquifers) are connected (or not) at various depths.
- Help the community understand what impacts, if any, there might be on local water supplies and groundwater as a result of gas exploration.

There were six main tasks associated with the 2009 groundwater program:

1. Drilling and installation of water monitoring bores around the gas exploration test wells at Broke.
2. Routine (baseline) groundwater sampling and laboratory analysis (wet, intermediate and dry events across a 6 month period from Autumn to Spring 2009).
3. Continuous monitoring of water levels (using dataloggers).
4. Testing the rate at which water can flow through the different sediment and rock layers (falling head tests).
5. Pump testing of gas well HB02 (and creating a drawdown zone around the well) involving pumping, and water level and water quality monitoring across both the pumping and recovery periods.
6. Reporting and peer review.

The works program was developed in consultation with members of the Bulga Community Consultative Committee (BCCC) and endorsed by the peer reviewer for the program, Professor Garry Willgoose from the University of Newcastle.

## **Program**

The program investigated the main water supply aquifer located near surface through to the deeper coal seams and provided baseline data on water levels and water chemistry under both natural (non pumping) and operational (gas test well pumping) conditions. The intent of the investigation was to prove through water level and water quality studies the natural variability, origin, age and connectivity of the shallow aquifers in the sandy sediments (to 15 metres depth) and deeper aquifers in fractured rock and coal seams (to 350 metres depth).

Water level variations were used as the primary proof of the connectivity between aquifers while water chemistry and specialised isotope analyses were used as verification data sets to further assess the origin, age and potential connectivity of aquifers.

A conceptual understanding of groundwater recharge, discharge and flow in each of the different water bearing zones was developed to test and confirm.

The two main types of aquifers that occur in the local area are:

- alluvial aquifers
- bedrock aquifers.

The alluvial aquifers are the high permeability zones in the loose sediments that have been deposited by streams on the floor of the Wollombi Valley. The aquifers usually comprise sand and gravel. They are essentially primary permeability aquifers where groundwater occurs within the sediment voids and moves freely through these void spaces. The bedrock aquifers (mostly coal seams and some sandstone units) are dual permeability aquifers comprising limited primary permeability (minimal movement of water through the pore spaces) and enhanced secondary permeability (most water movement is through fractures).

Recharge to the alluvial aquifer is predominantly from direct surface infiltration from rainfall, the occasional fresh flows along Wollombi Brook, run off from the valley sides and a small contribution from the bedrock aquifers. Groundwater flow is down valley, and natural discharge is likely to permanent pools in streams, evaporation and transpiration by vegetation. Recharge to the bedrock aquifers also occurs from rainfall and is only likely to occur where the permeable and fractured bedrock outcrops. Flow between the overlying and underlying aquifers in the sedimentary rocks is likely to be minimal due to similar water levels (except at depth), the low permeability of the rocks and confining claystone layers. The coal measures crop out around seven kilometres to the north-east of Broke. A combination of recharge in this area and the relatively lower permeability of the different rock types results in long residence times for groundwater in these bedrock aquifers compared to groundwater in the alluvial aquifers.

Natural conditions were studied first to identify whether there were any substantial seasonal variations from the wetter Autumn to the drier Spring periods in 2009. The deeper coal seams were then depressurised by extracting more than 160,000 litres of groundwater over a period of 12 days to determine whether shallow aquifers were likely to drain to the deeper coal seams. Recovery water levels and water samples taken at the conclusion of the recovery period were used to determine if there were any aquifer changes that might suggest leakage from shallower aquifers.

### **Results**

The investigation involved:

- The construction of nine monitoring bores in and around the main gas well HB02 identified for testing (on the northern outskirts of Broke).
- Continuous monitoring of water levels at these monitoring sites (some since May and most since July 2009).
- Analysis of rainfall and water level trends during the pumping test at all sites.
- Five water quality sampling events at these monitoring sites (a wet event in April, an intermediate event in July, a dry event in September, several samples during the pumping test event in October, and a recovery event in November).
- Some water level monitoring of Xstrata bore sites and water quality monitoring of private water supply bores.
- Using special techniques and analyses to determine the origin and age of groundwater in the different aquifers.
- Analysis of salinity, pH, temperature and other chemical trends.

The natural characteristics of the groundwater from the 6-month baseline program indicate that:

- Water levels are less than 5 metres below ground surface for all aquifers (except for the deep coal seams where water levels are much deeper at around 50 metres).
- Water levels have been mostly static with only slight rises in water levels over Winter and slight declines coming into the drier Spring period.
- Water quality in the shallow sediments is mostly slightly brackish (this groundwater is a useful resource for stock, limited domestic and occasional garden and irrigation use):
  - ▶ fresher water quality occurs at the water table in the alluvium
  - ▶ more saline water quality occurs at depth at the base of the alluvium
  - ▶ fresher water quality occurs closer to Wollombi Brook and around the edges of the floodplain (i.e. in the areas where rainfall recharges the aquifer).
- Water quality in the deeper rocks and coal seams is brackish to slightly salty (water has limited beneficial uses and is typical of water from coal seams).
- All water in all aquifers originates from rainfall recharge.
- Water in the shallow aquifers (less than 15 metres below ground) is modern being a few years to about 250 years old; groundwater in the upper rock aquifers (less than 200 metres below ground) is older at 3,000 to 10,000 years old; groundwater within the coal seams (more than 300 metres below ground) is much older again at more than 20,000 years old.

Results for the 12-day pump test on the gas exploration well HB02 indicated:

- A water level drawdown of around 90 metres was created in the gas well in the deep coal seam under test. The lateral extent of the drawdown (the cone of depression around the gas well) was most likely in the range 40 to 400 metres.
- No pumping induced changes in water levels were evident in the adjacent monitoring bores.
- No substantial changes in the water type or the quality of the groundwater in the pumped gas well and monitoring bore network were evident.

To conclude:

- The primary water level data collected and used in this investigation to prove (or disprove) the connectivity of aquifers suggests there is a strong disconnection between shallow aquifers and deep coal seam aquifers proposed for coal seam gas exploration. There is no evidence in the water level monitoring data at any of the monitoring bore sites to suggest there is any drainage or connectivity with deep (coal seam) aquifers.
- The water quality for the alluvial, shallow bedrock and deeper coal seam aquifers is brackish (alluvial aquifers) to slightly saline (rock and coal seam aquifers). Water quality characteristics are typical for this environment and there was little variability across the baseline, pumping test and recovery monitoring periods. There is nothing in the water quality data from the gas test well or monitoring bores to suggest that there is water draining vertically from upper productive aquifers.
- Environmental and radioisotopes were valuable data sets to understand the origin, age and connectivity of different aquifers. The environmental isotopes indicated that all water in all aquifers was sourced from rainfall recharge. Radioisotope results (carbon-14 and tritium) suggest that modern recharge water only occurs in the alluvial aquifers while the groundwater in the coal seams ranges between 3,000 years BP for the shallow coal seams to more than 20,000 years BP for the deep Blakefield Coal Seam.

- These distinct differences in radiocarbon ages and tritium concentrations differentiate the groundwater in the alluvial aquifers, shallow bedrock aquifers and deeper coal seam aquifers. There were slight differences in the radiocarbon ages and tritium results between sampling events in gas well HB02. These are not deemed significant, nor are they corroborated by other sampling results, or indicative of mixing with younger water from overlying aquifers.

Based on this investigation, gas exploration activities are considered to have negligible effect on the local productive alluvial and shallow bedrock groundwater supplies.