



## **Project Plan: Broke Groundwater Monitoring Program for AGL Hunter Gas Project**

### ***Introduction***

Parsons Brinckerhoff (PB) has been contracted by AGL undertake a groundwater monitoring program in the Broke area of the Hunter Valley in NSW.

The objectives of the groundwater monitoring program are to:

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

### ***Background***

AGL are currently exploring for gas from Coal Measures in the vicinity of Broke and Bulga. The Blakefield Coal Seam is exposed in exploration test well HB02 at a depth of 323 metres at Broke.

This is in comparison with most water supply bores in the area that are generally less than 15 metres deep. Impacts on water catchments and water sources have been raised by the community for the exploration activity. The groundwater monitoring program proposed by PB investigates the main aquifers from near surface through to the deeper coal seams, and provides baseline data on water levels and chemistry under both natural (non pumping) and pumping/recovery conditions.

The groundwater data collected and the investigation reports produced would be available for review by members of the Bulga Community Consultative Committee (BCCC), the independent peer reviewer, and state government agencies.

### ***Project plan***

There are six primary tasks associated with the groundwater monitoring program:

1. Drilling and installation of water monitoring bores
2. Baseline groundwater sampling and laboratory analysis
3. Datalogger installation and operation/maintenance for the balance of the field program
4. Falling head tests
5. Pumping test of HB02 exploration test well
6. Final reporting

To achieve the objectives and tasks, PB (on behalf of AGL) has designed a network of monitoring boreholes around the AGL HB02 gas exploration test well at Broke to monitor the aquifers at different depths across the local area. The main monitoring focus is the shallow groundwater in the alluvium which is used for local water supply but the slightly deeper coal seam aquifers are also targeted.



After monitoring bores are installed, groundwater monitoring to gather baseline samples and data on aquifer water quality and water levels follows. Two primary monitoring events (a “wet” and a “dry” event) are proposed to gather baseline data prior to a pumping test on HB02. An intermediate sampling event is also proposed prior to testing. To understand the variability of water quality in the alluvial aquifers, this information is also supplemented with water samples from selected private water bores. Water level information is collected continuously by data loggers at selected sites.

A pumping test of HB02 is proposed on completion of the baseline water quality data collection. The pumping test is designed to obtain aquifer parameters of the Blakefield Coal Seam at 323 to 330 metres below ground level (mbgl). The groundwater monitoring network will be used to detect any potential hydraulic impacts to the shallow aquifers during the pump test of the deeper aquifer. Water samples will be taken at the end of the pumping test (and after the recovery of water levels) to determine if there are any water quality changes across the monitoring network that might suggest leakage from shallower aquifers.

The conceptual model is that there is sufficient thickness of low permeability rock between the Blakefield Coal Seam and shallower aquifers so that the shallow water supply aquifers (both water levels and water quality) will not be impacted during coal seam methane (CSM) extraction. The investigation program will assist in determining connectivity (or lack of connectivity) between aquifers and increase knowledge of groundwater recharge, discharge and flow across the area.

Two reports will be prepared for the groundwater monitoring program – an initial monitoring borehole completion report (describing the monitoring bore completions) and a final groundwater investigation report (with all water chemistry, permeability and pumping test analyses). In addition, AGL proposes to circulate tabulated data to the BCCC and the peer reviewer when the “wet”, “dry” and pumping test sampling data becomes available.

The work program and results will be peer reviewed by independent reviewer Professor Gary Willgoose from University of Newcastle.

## **1. Installation of monitoring bores**

Six groundwater bores were constructed and installed as part of a monitoring bore network between 9<sup>th</sup> and 20<sup>th</sup> March 2009. This was supplemented by an additional three very shallow bores constructed on the 15<sup>th</sup> July 2009. The bores were nested in groups at three locations at different distances from HB02. Clusters of monitoring bores were completed at BM01 (4 bores) and at BM03 (3 bores) to provide groundwater monitoring in the immediate vicinity of exploration test well HB02. Site BM02 (2 bores) is located approximately 1km from HB02 and assumed to be outside the zone of influence of HB02 and therefore it will be used as a background control point for the alluvial aquifers. Bore locations are shown on *Figure 1*.

### **BM01**

Four monitoring bores are located at site BM01 which is situated 250 metres north of HB02. The bores comprised:

- BM01s – a very shallow bore constructed to monitor the groundwater in the alluvium at the water table between 1.5 metres and 6 metres below ground level.
- BM01a - shallow bore constructed to monitor groundwater in the alluvium between 6 metres and 10 metres below ground level.



- BM01b - medium depth bore constructed to monitor the groundwater within a hard rock aquifer located between 56 metres and 68 metres below ground level.
- BM01c - deep bore constructed to monitor groundwater within a coal seam located between 216 metres and 219 metres below ground level. The screened interval is 160 to 220 metres below ground level.

### **BM02**

Two monitoring bores are located at site BM02 situated adjacent to the corner of Nelson Street and Broke Road on the northern edge of Broke:

- BM02s – a very shallow bore constructed to monitor the groundwater in the alluvium at the water table between 1.5 metres and 6 metres below ground level
- BM02a – shallow monitoring bore the alluvium between 7 metres and 13 metres below ground level

### **BM03**

BM03 is situated approximately 20 metres north of HB02, and three water monitoring bores are located here:

- BM03s – a very shallow bore constructed to monitor the groundwater in the alluvium at the water table between 1.5 metres and 5 metres below ground level
- BM03a – shallow monitoring bore the alluvium between 4.5 metres and 8.5 metres below ground level
- BM03b – medium depth monitoring bore constructed to monitor shallow coal seam aquifer between 68 metres and 74 metres below ground level.

All of the above monitoring boreholes have been installed and completed with painted steel standpipe covers which have been concreted in place. The area surrounding each of the sites in the first drilling program in March was moderately impacted by drilling but they have now been reinstated. There was minimal impact associated with the second drilling program in July. The reinstatement works include: backfilling the drilling water collection pits, grading the area and reseeding the ground.

### **Report**

A drilling completion report is being prepared that summarises the water bore installation activities and includes geological logs, initial water levels and water quality data, and the Department of Water and Energy's Form A documentation as supplied by the driller.

## **2. Baseline groundwater sampling**

A comprehensive baseline groundwater quality survey of the newly installed water bores is being undertaken over two primary rounds (known as the "wet" and dry" sampling events). The first baseline sampling event in May 2009 is complete and is the "wet" sampling event. An intermediate comprehensive sampling round was also completed in July 2009. The "dry" sampling event is timetabled for early September 2009. The water quality surveys will establish the natural characteristics (and any variability) of the aquifers during wet and dry conditions.

The surveys determine the static water levels, water quality parameters (taken at the time of sampling) and provide a full chemical characterisation of the groundwater. Samples are also

collected for stable and radio isotopes to determine the origin of waters, residence time and recharge, discharge and flow characteristics. The chemical suite for laboratory analysis is provided in the table below.

Basic water quality sampling is also proposed for a selection of private water wells not constructed by PB or AGL as part of this monitoring program. Three private bores have been sampled to obtain some baseline water quality characteristics of the water used for local uses. These sites are located on an AGL property along Oakley Lane (4km north east of Broke), and at properties along Nelson St and Howe St in Broke.

The comprehensive and basic water quality suites for the sampled groundwater are described in the following table. The basic water quality sub-set is those chemical suites that are shaded:

<b>Chemical suites</b>	<b>Individual Analytes</b>	<b>Reason for sampling</b>
Field parameters	EC, pH, Eh and temperature	General water quality
Major ions	Calcium, magnesium, sodium, potassium, chloride, sulphate, dissolved silica	General water quality
Sulphide	Sulphide	General water quality
Nutrients	Nitrate, nitrite, Reactive phosphorus Ammonia, Total phosphorus Total Organic Carbon	General water quality
Metals	<i>Dissolved metals</i> – Al, As, Ba, Br, Co, Cu, Fe, Li, Mn, Ni, Pb, Sr, Zn	General water quality
Hydrocarbons	TPH/BTEX	General water quality
Hydrocarbon Gases	Methane	Methane present in aquifer
Stable Isotopes	Oxygen-18 and Deuterium	Water source and amount of mixing occurring between aquifers
Radiocarbon	Carbon 13 and Carbon 14	Age of aquifer water ( 50yrs – 50000yrs)
Tritium	Tritium	Time since water was last at the surface (up to 50yrs)

Key EC – Electrical Conductivity (a measure of salinity);  
Eh – Oxidation – reduction potential (a measure of chemical species to be oxidised or reduced)  
Al – aluminium, As – arsenic, Ba – barium, Br – bromine, Co – cobalt, Cu – copper, Fe – iron, Li – lithium, Ni – nickel, Pb – lead, Sr – strontium, Zn - zinc

Prior to sampling groundwater in each aquifer, the stagnant water in each monitoring bore requires purging so that a representative sample of aquifer water can enter the bore and be sampled.

Several techniques to collect the water samples from the bores are used:

- In the shallow monitoring boreholes BM01s, BM01a, BM02s, BM02a, BM03s, and BM03a, PB use a small pump to remove approximately three bore volumes and allow natural groundwater to enter before sampling from the pumped water.
- In the deep monitoring bore BM01c, PB use a small pump to remove between one and three bore volumes (depending on the variability of water quality parameters) and allow natural groundwater to enter before sampling from the pumped water.



- In the deep test well HB02 and intermediate depth monitoring bores BM01b and BM03b, the volume of water that is required to be removed is large and in this situation PB use a variety of sampling techniques. For the baseline sampling, a low flow sampling system is used. This is called micro-purge™ and it is designed so that a very small volume of water is removed directly from the screened interval opposite the water bearing zone and in this way only a few litres of water is required to be removed as opposed to hundreds or thousands of litres. For the very deep gas exploration test well HB02 a “hydrosleeve” is the backup sampling technique for the before and after sampling events (because micro- purge™ samples could be difficult at this depth). For the end of pumping test sample, the sample will be taken at surface from the water being pumped from the HB02 exploration well.

### **3. Datalogger installation and operation/maintenance**

An automated data transceiver (known as a datalogger) has been set into each monitoring bore following the first sampling round. These dataloggers are set to collect data at 12-hourly intervals so as to analyse water level and salinity trends. Water levels in shallow alluvial boreholes are expected to rise and to become less saline after a rainfall event while no appreciable changes are expected with the deeper monitoring locations. Water level declines would only be evident if there was an extended dry period or there was nearby groundwater pumping. This time series water level and salinity data is important in understanding the natural variability and the impact of any private pumping between the wet and dry sampling rounds.

All dataloggers are now in place (including two installed in nearby Xstrata monitoring bores) and these will be downloaded and checked prior to the pumping test on gas test well HB02. The datalogger is to be installed in HB02 when the pump is installed in early September. The final datalogger download will be about 10 days after the completion of the pumping test.

For the pumping test program, several of the dataloggers will be reset to obtain water level and salinity data at shorter time periods (probably every 30/60 minutes). The datalogger in HB02 will be set at 15 minute intervals. Continuous salinity measurements cannot be included with the logger for HB02 however numerous samples will be obtained from the pumped groundwater during the test to track trends.

### **4. Falling head tests**

Short ‘falling head’ tests have been completed in each of the alluvial monitoring boreholes to determine the permeability of the alluvial aquifer across the area. The test consists of adding an amount of fresh water or natural groundwater to the bore to artificially raise the water level above the static water level. The length of time that the water takes to return to the static water level is recorded and is a measure of the permeability of the aquifer.

This data will provide an indication of the permeability of these surficial aquifers compared to the permeability of the deeper coal seam aquifers.

### **5. Pumping test of HB02**

The proposed pumping test on HB02 will extract water from the deep Blakefield Coal Seam at a moderate rate for approximately seven (7) days. The intent is to depressurise the coal seam aquifer and to note if there are any water level changes in the shallower aquifers. A number of parameters are to be collected and assessed during the pumping test on HB02. Water



depressurisation levels (or drawdown) and water quality parameters (as per the comprehensive chemical suite in the table above) will be collected. A longer pumping period may be required if insufficient drawdown or unusual trends are observed during the pumping test. A pumping rate of between 0.1 and 0.25 litres per second (L/s) is expected. The pumping test will be continuous and the extraction rate will be kept as constant as possible.

Groundwater level data and water samples will be collected from HB02 and the surrounding monitoring network during the pumping test. Dataloggers will continuously record pressure levels so that water level trends can be captured and analysed at multiple sites. There will be one water sampling event during the pumping test (probably towards the end of the test) and one sampling event after water levels have fully recovered (probably 7 to 10 days after the completion of test depending on water level recovery trends). If the pumping test program is extended beyond the expected seven days then there would have to be a longer period allowed before the recovery water samples could be obtained.

## **6. Final reporting**

A complete data, analysis and interpretation report will be prepared on the

- Conceptual (and confirmed) hydrogeological model (describing the main aquifers and aquifer connectivity in the Broke area)
- Water level and hydraulic characteristics of the different aquifers (essentially water level trends during periods without pumping and then with pumping from the coal seam aquifers)
- Water quality characteristics - baseline monitoring (wet, dry and intermediate events) and then changes (if any) during and after the pumping test.

The conceptual model of groundwater occurrence, recharge, discharge and flow will be described in some detail to provide an explanation about the different aquifers and the natural recharge/discharge processes and possible connectivity (if any).

All water level data and all water chemistry data will be presented for all sites. Hydraulic parameters for the different aquifers will be presented together with an assessment of the connectivity (if any) of the different aquifer zones that are monitored.

Chemistry and isotope results will be presented for the different aquifers together with an assessment of the connectivity (if any) of the different aquifer zones that are monitored. Water chemistry obtained during the pumping test is essentially a verification method to confirm the results of the hydraulic testing and aquifer connectivity.

### ***Peer review***

Reports and water quality data for each event will be provided to the peer reviewer as they are finalised and become available. The independent peer reviewer (Professor Gary Willgoose) will be asked to provide two reports for AGL and the BCCC:

- the first brief report will be on the suitability of the adopted investigation program to address the objectives of the groundwater program, and
- the second report will be on the data, analysis and conclusions of the whole groundwater investigation and monitoring program.

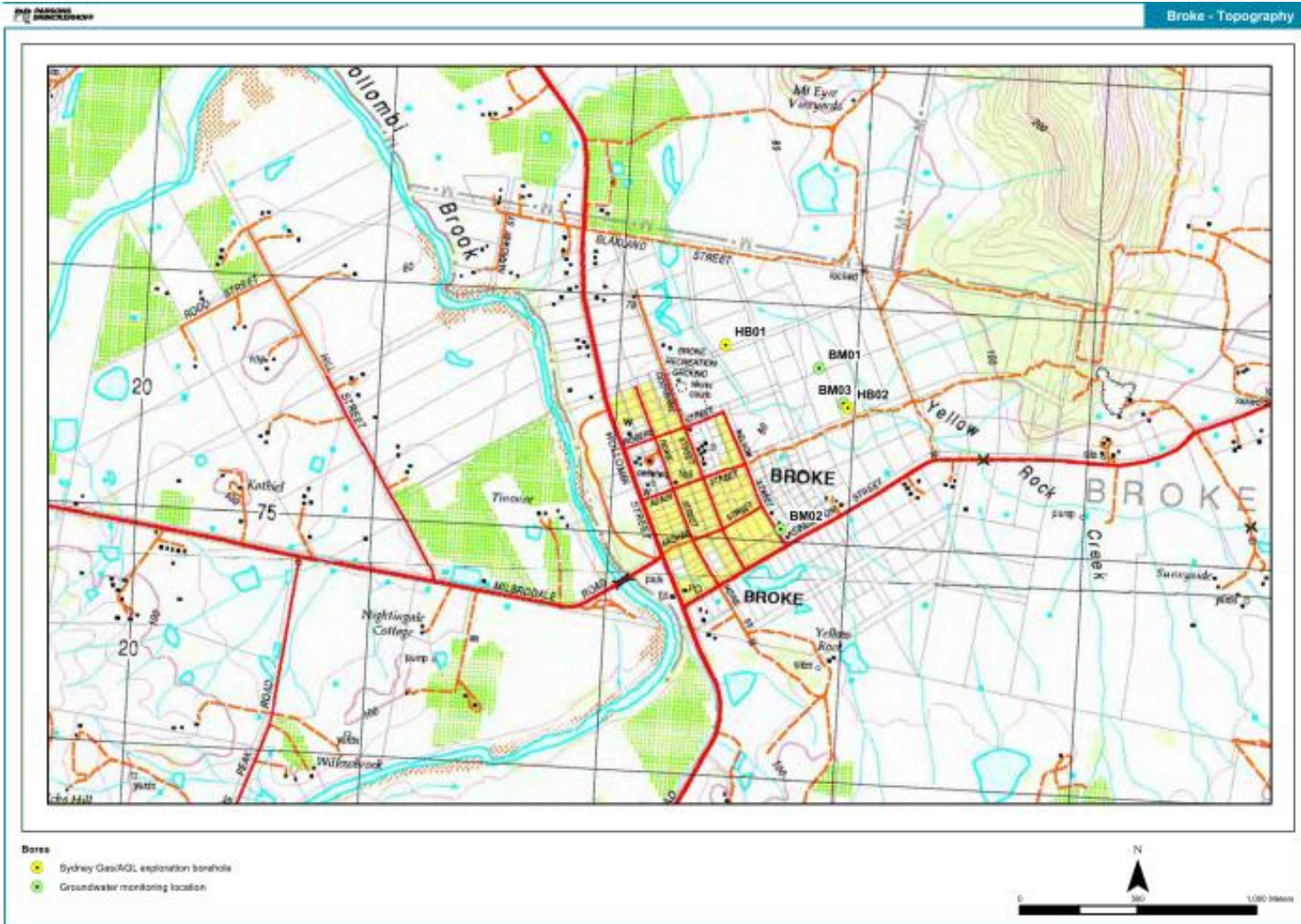


Figure 1 AGL Gas Wells and Groundwater Monitoring Bores at Broke