



MEMO

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To: Siobhan Barry – AGL Energy Ltd

Copy: **

From: John Ross

Job no: **

Subject: **PB Progress Report #1 – Groundwater Investigation and Monitoring Program at Broke**

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As a result of a request from the BCCC at its meeting at Bulga on Tuesday 11 August, PB has prepared a more comprehensive update on the groundwater monitoring program. Work packages are described under the following headings and are described as either completed or proposed (as at 31st August 2009):

- Installation of AGL water monitoring bores
- Baseline groundwater sampling
- Datalogger installations and operation/maintenance
- Falling head tests
- Pumping test of HB02 gas exploration test well

1. Installation of AGL water monitoring bores

Six groundwater bores were constructed and installed as part of a monitoring network between 9th and 20th March 2009. This was supplemented by an additional three very shallow bores constructed on the 15th July 2009. The bores were grouped into three locations at different distances from HB02. Monitoring bores were completed adjacent to BM01 and BM03 to provide groundwater monitoring in the immediate vicinity of gas exploration test well HB02. Site BM02 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* and summary details are provided in *Table 1*.

This work program is now completed and a final borehole completion report is in preparation.



Figure 1 Location of AGL Monitoring Bores

Table 1.....Summary of Water Monitoring Bore Construction Details

| Local Bore Number | Bore Depth (m) | Screened Interval (m) | Aquifer Monitored | Initial Water Level (mTOC) | Conductivity $\mu\text{s/cm}$ |
|-------------------|-----------------------|-----------------------|--------------------------------|----------------------------|-------------------------------|
| BM01s | 6.6 | 1.5-6 | Shallow alluvium | 2.47 | 3470 |
| BM01a | 10 | 6-10 | Deep alluvium | 2.5 | 3940 |
| BM01b | 68 | 56-68 | Shale and sandstone | 3.55 | 7560 |
| BM01c | 220 | 160-220 | Whybrow Coal Seam | 4.95 | 7160 |
| BM02s | 7.5 | 1.5-6 | Shallow alluvium | 3.26 | 2150 |
| BM02a | 13 | 7-13 | Deep alluvium | 3.58 | 5770 |
| BM03s | 5 | 1.5-5 | Shallow alluvium | 2.82 | 1810 |
| BM03a | 10 | 4.5-10 | Intermediate and deep alluvium | 3.15 | 1600 |
| BM03b | 96 (backfilled to 74) | 68-74 | Shale and minor sandstone | 4.94 | 3550 |

2. Baseline groundwater sampling

A comprehensive baseline groundwater quality survey of the newly installed bores is being undertaken over two primary rounds (known as the “wet” and dry” sampling events). The first baseline sampling event in April/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 September 2009. The water quality surveys 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 is provided below (shaded analytes comprise the basic sampling program).

As well as the nine AGL monitoring bores, basic water quality sampling has been completed on three private water bores near Broke to assess the chemical characteristics of groundwater used for local uses.

Tabulated water quality data is expected to be circulated for information and peer review once the results of a complete sampling event are available.

| Chemical suites | Individual Analytes | Reason for sampling |
|-------------------|--|--|
| 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);
 pH – a measure of acidity or alkalinity;
 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

3. Datalogger installation and operation/maintenance

An automated data transceiver (known as a datalogger) has been set into each water monitoring bore (nine sites) 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. This time series water level and salinity data is important in understanding the natural variability (primarily rainfall recharge events and extended dry periods) and the impact of any private pumping over the period of observation.

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 exploration test well HB02. The dataloggers will be reset to collect data at shorter time periods (generally around 30 minutes) during the proposed pumping test. A datalogger is to be installed in HB02 when the pump is installed. The final datalogger download will be about 10 days after the completion of the pumping test.

4. Falling head tests

Short 'falling head' tests have been completed in each of the alluvial monitoring bores to determine the permeability of the main 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 provides an indication of the permeability of these shallow alluvial aquifers compared to the permeability of the deeper coal seam aquifers. This data will assist in confirming the conceptual model for the area i.e. to confirm that the shallow sand aquifers have higher permeability (and greater recharge and lateral flow characteristics) compared to the deeper coal and fractured rock aquifers.

5. Pumping test of HB02 gas exploration test well

The proposed pumping test 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 is to be kept as constant as possible.

Groundwater level data and water samples will be collected from HB02 and the surrounding monitoring bores 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 and one sampling event after water levels have fully recovered (probably 7 to 10 days after the completion of the test depending on water level recovery trends).

The pumping test is timetabled for September 2009.



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