Caroona Coal Project

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Community Information Paper

Groundwater Study and Modelling

September 2011

In this information paper

Key points

- Underground longwall mining has the potential to impact the alluvial and bedrock aquifers. Detailed scientific groundwater studies are being completed by BHP Billiton to provide information to determine whether underground longwall mining will impact aquifer areas.
- The detailed information collected during the baseline groundwater studies will be used to develop a three dimensional (3D) numerical groundwater model. The model will be able to simulate the operations of an underground longwall mine and predict the potential impact on the local and regional groundwater systems. The model will also provide an understanding of how the different mining methods and sequences can be used to minimise or mitigate these impacts.
- The likelihood of impacts to the groundwater system is greatly restricted by BHP Billiton commitments to:
  - no longwall mining underneath the floodplain;
  - no longwall mining underneath the deep alluvial irrigation aquifers;
  - no open cut mining anywhere within the EL;
  - no mining of any description outside of the target area.

Introduction

The Caroona Exploration Licence (EL) covers an area of approximately 344 square kilometres (km^2) and is situated within the Liverpool Plains.

The terrain within the EL Area varies from the near flat floodplains to elevated ridge country.

There are numerous aquifer systems present in the Caroona area, which include:

- the deep alluvial aquifers that lie up to 100 metres below the surface of the Liverpool Plains floodplain;
- fractured rock aquifers of varying water quality found under parts of the floodplains and under the ridge country;
- coal seams, which can contain significant volumes of water of varying, but generally inferior quality;
- regolith aquifers, which are generally low yielding aquifers of poor quality in weathered rock material within 100 metres of the surface below the ridge country.

BHP Billiton understands the importance of the groundwater systems, in particular the alluvial aquifers, within the EL Area not just for agriculture, but for the broader community of the Namoi Catchment. The deep alluvial aquifers are the most significant groundwater supply in the Liverpool Plains region, as they sustain extensive irrigated agriculture and are important to the water supply for a number of local villages and regional towns.

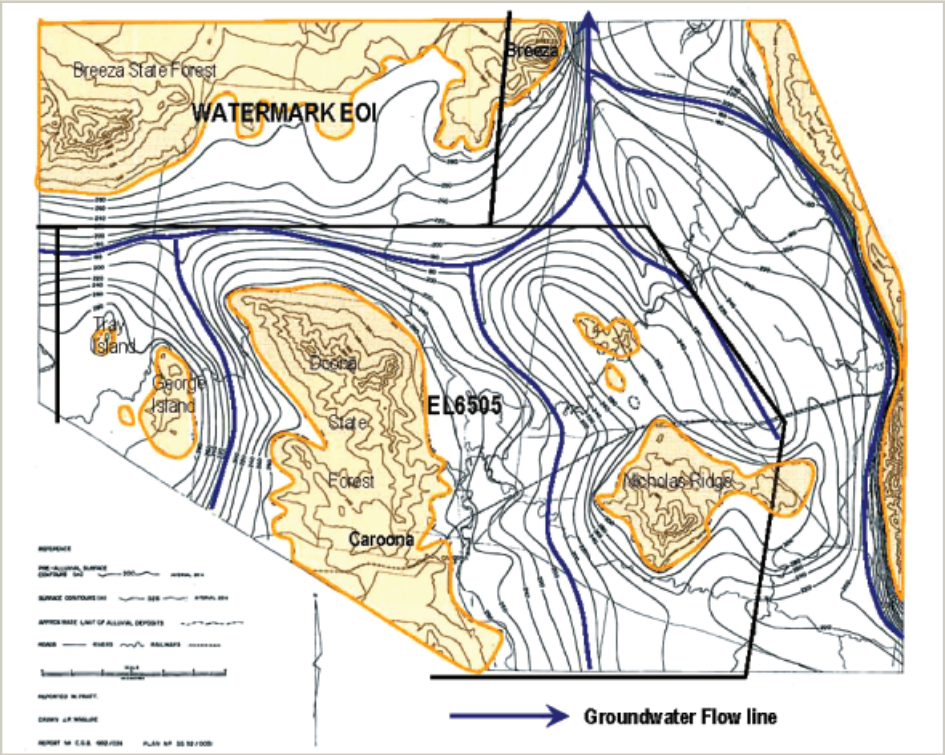

Figure 1: Groundwater flow within the EL Area.

Understanding Aquifers

Prior to the granting of the Caroona EL in 2006, NSW Government agencies and local landholders had collected a wealth of information on the deep alluvial aquifers under the Liverpool Plains (refer Figure 1). There are in excess of 380 recorded bores that have been sunk across the plains within and around the Caroona EL Area for various purposes, including:

- to lift water for irrigating crops;
- to lift water from shallow aquifers for stock and domestic water;
- to monitor aquifer flow and quality.

Through the exploration phase of the Caroona Coal Project, BHP Billiton is building on this knowledge to create a detailed 3D model of groundwater systems (including the alluvial aquifer, fractured rock aquifers, coal seam aquifers and regolith aquifers) within the EL Area and surrounding land.

Protecting the Groundwater Systems

BHP Billiton's commitments and EL conditions significantly reduce the likelihood of impacts on groundwater systems. BHP Billiton has committed to:

- no longwall mining underneath the floodplain;
- no longwall mining underneath the deep alluvial irrigation aquifers;
- no open cut mining anywhere within the EL;
- no mining of any description outside of the target area.

These voluntary commitments were captured by amendments made in conjunction with the NSW Government to the Conditions of the EL which means no mining lease application can consider longwall mining under the deep alluvial aquifers or the floodplains. BHP Billiton publicly stated in 2006 that they would not put forward a proposed mining development that would negatively impact the deep alluvial irrigation aquifers

The potential for impacts to groundwater systems are minimised by these commitments for the following reasons:

- no open cut mining anywhere within the EL Area – eliminates the risk of alluvial aquifer systems being impacted by open cut mining practices;
- no longwall mining underneath the floodplain – eliminates the potential of bedrock layers, which form the base of the alluvial aquifers, being cracked by subsidence and leading to loss of water through these cracks;
- avoiding subsidence in the floodplain area means that recharge areas within the floodplain will not be disturbed.

How is the groundwater study being completed?

BHP Billiton has engaged independent groundwater specialists to investigate and collect data in regard to the groundwater systems within the EL Area. The study involves understanding the hydraulics of the groundwater system and monitoring the quality of water within the system. The groundwater scientists will use this data to develop a detailed 3D numerical groundwater model. The methodology used to complete this is based on sound scientific principles and recognised industry best practice. The methodology has been independently reviewed by a recognised industry expert and the same person will also be reviewing the 3D numerical groundwater model once development of the model is complete.

Mining activities and aquifer interference – what are BHP Billiton's requirements?

Any future underground mining operations at Caroona would intercept groundwater in the fractured rock aquifers and coal seams. BHP Billiton, like any other groundwater user, would need to apply for and be granted groundwater licences from the NSW Government limited to extracting and monitoring groundwater. In order to ensure continued safe mining operations, the water would need to be removed from underground mining areas to storages, probably located on the surface. Extracted groundwater may subsequently be used as part of the mining process and, depending on the quantity and quality of the water produced, after treatment it could be made available for other uses such as stock water or irrigation.

BHP Billiton groundwater study and the Namoi Catchment Water Study

A key concern for local landholders and regional stakeholders is the interconnectedness of groundwater systems throughout the Namoi Valley, and the potential cumulative effect of exploration and mining development on these groundwater systems. These concerns led to the establishment of the NSW Government Ministerial Oversight Committee chaired by

former NSW Farmers president Mal Peters, to facilitate a Namoi Catchment Water Study.

BHP Billiton joined with the Australian Government and a number of mining and gas companies to commit funding to this independent study. The Namoi Catchment Water Study has recently produced a Phase 2 report with the modelling process expected to be completed in April 2012.

BHP Billiton is providing data from groundwater monitoring sites and other data sourced from studies such as flood modelling to the Namoi Water Catchment Study. There is a significant difference between the two studies when considering the scale at which data can be collected and modelled. The Namoi Catchment Water Study area is 42000 km^2 compared to the BHP Billiton Caroona groundwater study area which is 1050 km^2. The much smaller area provides BHP Billiton with a greater capacity to make accurate determinations at a local level and in particular within the targeted area for exploration.

BHP Billiton groundwater environmental baseline study

The ongoing hydrogeological investigations (groundwater studies) within the EL Area has been undertaken to develop an understanding of the groundwater systems. A groundwater system includes the aquifer recharge mechanisms (ie, how waters gets into the aquifer), the direction (paths) of groundwater flow and discharge, as well as the degree of interconnection between aquifers. Gathering a baseline understanding of the groundwater system is imperative for developing a 3D numerical groundwater model. This type of model can represent complex groundwater systems and simulate the potential impacts of longwall mining.

The investigation to date has included the installation of an extensive array of monitoring bores within the EL Area on both alluvial plains and ridge areas. The monitoring bores are installed with data loggers set to monitor groundwater level fluctuations at 6 and 12 hour intervals in response to recharge events (rainfall/flooding) and discharge events (natural and irrigation).

There are 47 monitoring bore sites (example site refer Figure 2) throughout the EL Area with 29 monitoring bores located in the alluvial aquifers, 4 in the coal seams, 3 in the Clare sandstones and 11 through the ridge areas. There are also 110 vibrating wire line piezometers installed to monitor the changes in groundwater pressure. The monitoring program collects information such as:

- water levels and bore flows;
- pH;
- electrical conductivity;
- dissolved oxygen; and
- other parameters such as dissolved minerals.

Other specific groundwater investigation activities have been completed including:

- pumping tests conducted at monitoring bore sites to determine the level of groundwater flow in alluvial and sandstone aquifers and coal seam aquifers;
- isotope dating of groundwater to determine the relative age of the water which indicates whether there has been inter-mixing of water between aquifers;
- airborne geophysical surveys to define thickness and extent of the alluvium.

The information gathering has included the flood modelling and floodplain definition environmental studies to gain an understanding of how these processes and features contribute to the groundwater system.

Floodplain aquifer impact assessment

Longwall mining within the target areas (ridge areas) of the EL that may have the following adverse impacts on groundwater systems:

- dewatering and depressurisation of the coal seams, neighbouring sandstones and interburden;
- subsidence and cracking beneath the ridge areas affecting runoff from the ridges to the alluvial floodplain and also groundwater flow through the regolith to alluvial aquifers.

The development of a 3D numerical groundwater model will allow these types of impacts associated with longwall mining and related infrastructure (including mine layout, scale of mining completed and mining sequence) to be evaluated in relation to the groundwater systems.

How does the groundwater model work?

The Murray Darling Basin Commission (MDBC) Groundwater Modelling Guidelines describes a model as *'a computer based representation of the essential features of a natural hydrogeological system that uses the laws of science and mathematics'*.

A model is built from all available data combined with appropriate simplifying assumptions to ensure the model is fit for purpose. The model must consider the critical components of the groundwater system and be at a 'resolution' that will meet the modelling objectives. To achieve this it will consist of thousands to hundreds of thousands of cells. Each cell is interrelated to neighbouring cells. The model is then used to calculate the water level in each of the cells at the same time. These levels will be changing constantly through 'flow' of water to and between neighbouring cells. Due to the large amount of cells and all of them interacting at once the mathematics becomes complex, hence the requirement for a numerical model. A 3D numerical model has been chosen for

Figure 2: Groundwater monitoring bore site located in the EL Area.

this study to allow flow to be assessed both horizontally and vertically. The chosen model is well recognised as best practice for this type of study pursuant to MDBC Groundwater Modelling Guidelines.

As the model runs, cells interact throughout the model and 'water' can move from cell to cell based on the cell characteristics and corresponding "water" levels ie. a cell with a higher water level will flow to a neighbouring cell with a lower water level dependant on the model parameters. The parameters (which are based on data collected from groundwater monitoring) control the rate at which the water will move between cells (eg, permeability of layers).

When the model is calibrated it can then be used to simulate different scenarios by taking water out of the model cells representing the underground mine (ie, replicating the dewatering process).

Developing a 3D numerical groundwater model

The 3D numerical groundwater will be developed in compliance with the standards set by the MDBC Groundwater Modelling Guidelines with the following stages:

1. data collection and collation
2. conceptualisation
3. model generation
4. model calibration
5. review of the calibration
6. scenario simulations

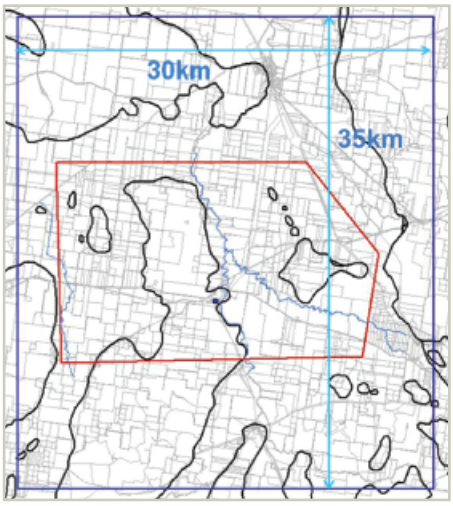

Figure 3: Groundwater model area.

The model being developed for the project is currently in the data collection and collation, conceptualisation stages and early stages of generation. The boundary scope of the model is greater than the EL Area itself to ensure that any potential impact incorporates interactions to aquifers that extend outside of the EL Area boundary. The boundary extent for the 3D groundwater model study is indicated below by the outer dark blue box (Figure 3) with the EL area shown in red.

What can a 3D numerical groundwater model simulate?

A 3D numerical groundwater model is capable of:

- assessing impact on recharge areas to alluvial aquifers;
- determining the volume and rate of leakage from an aquifer to a mined area;
- considering the cumulative impact of mining, irrigation and stock/domestic groundwater use and interaction on the groundwater system;
- determining the radius of influence of depressurisation of the bedrock aquifers;
- evaluating the behaviour of groundwater during mining operations;
- calculating the volume of groundwater (potential water generated during some of the mine processes) that will be available for other uses within the mine or required to be managed (including onsite storage requirements).

Where to from here?

- The groundwater monitoring study is on-going.
- Development of the 3D numerical groundwater model will continue and as more data becomes available it will added to the model, including results from 3D Seismic Studies completed within the EL target areas.
- The 3D numerical groundwater model development and methodology used will continue to be independently reviewed by a recognised industry expert.
- The 3D numerical groundwater model will also be reviewed with consideration to any outcomes of the Namoi Catchment Water Study.

When complete the model will:

- Provide predictions on the potential changes to the local and regional groundwater regime resulting from underground mining which will be based on sound scientific information and current best practices.

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