North Wambo Underground Mine Longwall 10A Modification

Groundwater Assessment -

Response to NSW Office of Water

FOR

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BY

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trading as

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OVERVIEW

This note has been prepared in response to issues raised by the NSW Office of Water at a meeting held on 15 January 2015 at the offices of the Department of Planning and Environment (DP&E), Sydney. The meeting was called by NOW in an email to DP&E dated 9 January 2015, which requested the meeting focus on the following issues:

1. uncertainties related to the model;
2. consequential impacts;
3. scale of impacts; and
4. potential means of measuring and mitigating any impacts greater than those predicted.

A couple of issues could not be addressed fully at the meeting and were taken on notice:

1. starting values of vertical hydraulic conductivities (K_z) in the adopted ramp functions for fractured zones; and
2. long-term recovery of groundwater levels and implications for water quality impacts.

These issues are addressed below.

FRACTURED ZONES

Several years ago HydroSimulations (formerly Heritage Computing) developed a technique for representing the enhanced K_z in fractured zones above longwall panels. This approach is now followed by most other consultants undertaking groundwater modelling for longwall coal mines. The enhanced K_z profile is represented as a log-linear ramp function constrained by adopted or calibrated K_z values at the top of the fractured zone and at the top of the caved zone.

An interpolation formula is used to sample the ramp function at the mid-elevation of each model layer within the fractured zone:

$$\log K_z(r) = \log K_{max} - \ grad * (r - \ h_{min})$$

where: $grad = \frac{\log K_{max} - \log K_{min}}{h_{max} - h_{min}}$

h_{min} and h_{max} are measured from the roof of the mined seam;

r is measured from the top of the caved zone;

r is the height of the mid-point of a model layer within the fractured zone;

h_{min} is the height of the caved zone (usually the thickness of the layer above the mined seam if less than or around 30 m thickness; otherwise h_{min} is zero - that is, the coal seam roof);

h_{max} is the height of the fractured zone (or A-zone);

K_{max} is the vertical hydraulic conductivity associated with h_{min} at the top of the caved zone;

K_{min} is the vertical hydraulic conductivity associated with h_{max} at the top of the fractured zone.

Normally, a single monotonic function is applied. However, modellers must ensure that the enhanced K_z is never less than the undisturbed host K_z. On these occasions, or for improved calibration to mine inflows or measured vertical hydraulic gradients, some layer K_z values might require manual adjustment.

In principle, if K_{min} is set at the host value at the top of the fractured zone, K_{max} is the only variable to be calibrated. This simplifies the model calibration procedure.

For the Wambo regional groundwater model, the modeller has elected to make some manual adjustments and has applied a two-segment ramp function, as shown in **Figure 1** for North Wambo Underground Mine extraction of the Wambo Seam, South Wambo Underground Mine extraction of the Arrowfield Seam, and United Collieries' extraction of the Arrowfield Seam (using separate west and east ramps). As the Bowfield Seam fractured zone occupies only one model layer before reaching the overlying Arrowfield Seam, a ramp function is not needed.

In **Figure 1**, the end-point K_{max} values adopted in the Wambo Coal Mine model are: 8.0×10^{-5}; 1.0×10^{-4}; and 1.1×10^{-4} m/d.

At other active Southern Coalfield Mines, where mine inflow measurements are available for calibration, the following end-point K_{max} values have been found: 2×10^{-6}; 5×10^{-6}; 1×10^{-5}; 5×10^{-4}; and 1×10^{-1} m/d.

As noted in Section 3.5.2 and Table 8 of the Groundwater Assessment, a K_z value of 10 m/d is applied in the model to the coal seam voids and caved zones. This value is applied independently of the enhanced K_z profile adopted for the fractured zones.

LONG-TERM RECOVERY

It is important to note that the Longwall 10A Modification could not be considered to have a significant impact on the recovery of groundwater levels.

At the meeting on 15 January, NOW observed the prediction of groundwater upflow, at the end of the 200-year recovery simulation, from the Permian rock sequence to alluvium along a section above Longwall 10A (LW10A), previous longwalls in the Whybrow Seam and approved future longwalls in the Arrowfield and Bowfield Seams.

To examine the timing of the upflow, a synthetic monitoring bore has been placed in the model at the location marked "LW10A" in **Figure 2**. The groundwater hydrographs in **Figure 3** suggest that upflow is expected to commence about 70 years after the cessation of mining, when the Upper Permian head first exceeds the Alluvium head. At 200 years, the upward head difference is predicted to be about 3.0 m, and the water table in the alluvium is predicted to remain about 8.5 m below current ground level.

The vertical flow pattern is indicated in **Figure 4** by groundwater head contours along a west-east cross-section passing through the monitoring bore LW10A. This shows mild upflow in the vicinity of LW10A.

In the vicinity of LW10A, there is expected to be an upwards head difference (associated with upflow) of up to 3 m along sections of Longwalls 10 and 10A, about 1 m between Longwall 10A and Wollombi Brook, and 1-3 m between Longwall 10 and Stony Creek and (South) Wambo Creek.

To place the upflow behaviour in context, the numerical model has been modified to simulate pre-mining conditions by removing all extractive stresses and returning all enhanced hydraulic conductivities and storage properties to undisturbed host values. This shows significantly more upwards head difference (up to 9 m), where Longwall 10A is planned, than predicted 200 years after mining has finished.

This further suggests that the risk of change in beneficial use of groundwater in the alluvium near Longwall 10A, compared to pre-mining conditions, is expected to be low.

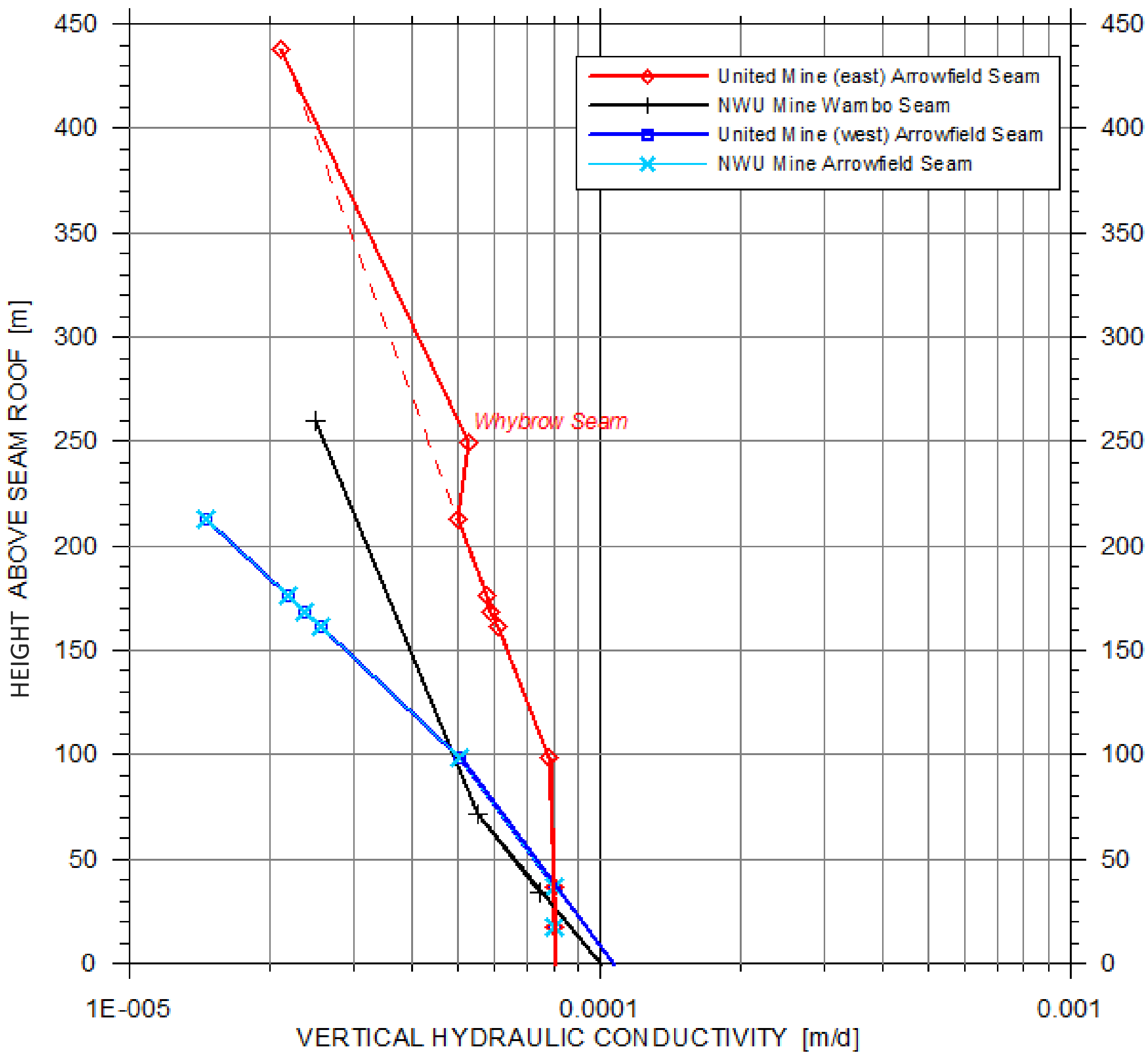

Figure 1. Ramp functions applied in the Wambo regional groundwater model

Figure 2. Location of the synthetic monitoring bore LW10A within the alluvial extent represented in the Wambo regional groundwater model

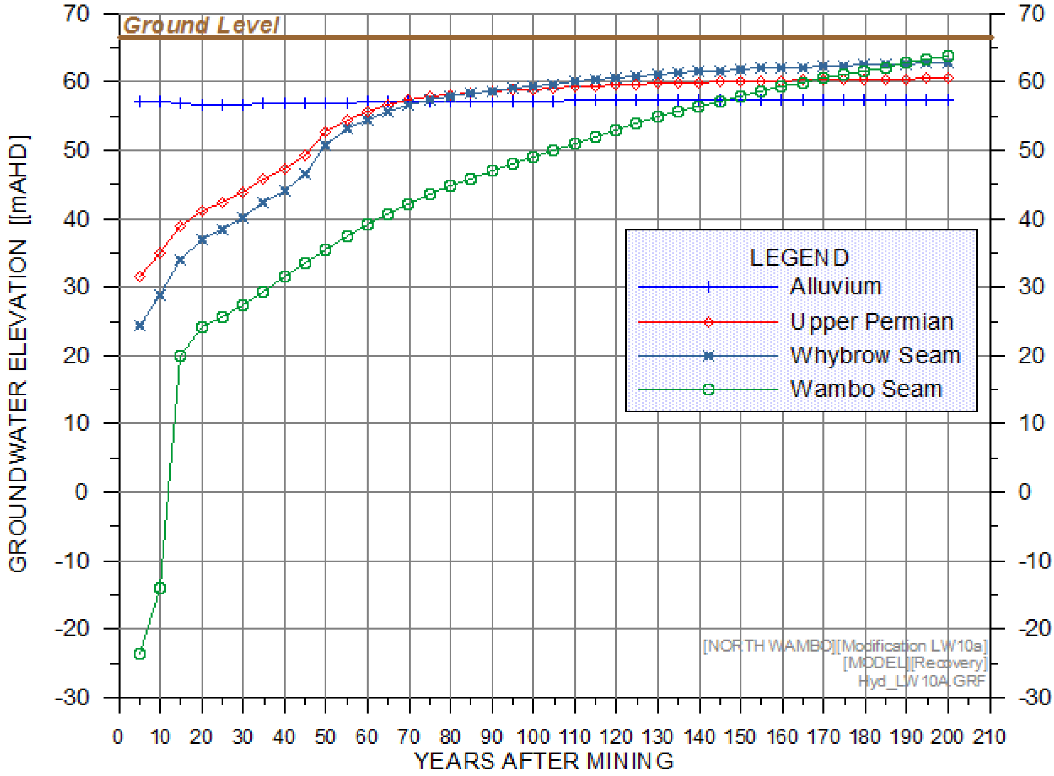

Figure 3. Recovery hydrographs at synthetic monitoring bore LW10A

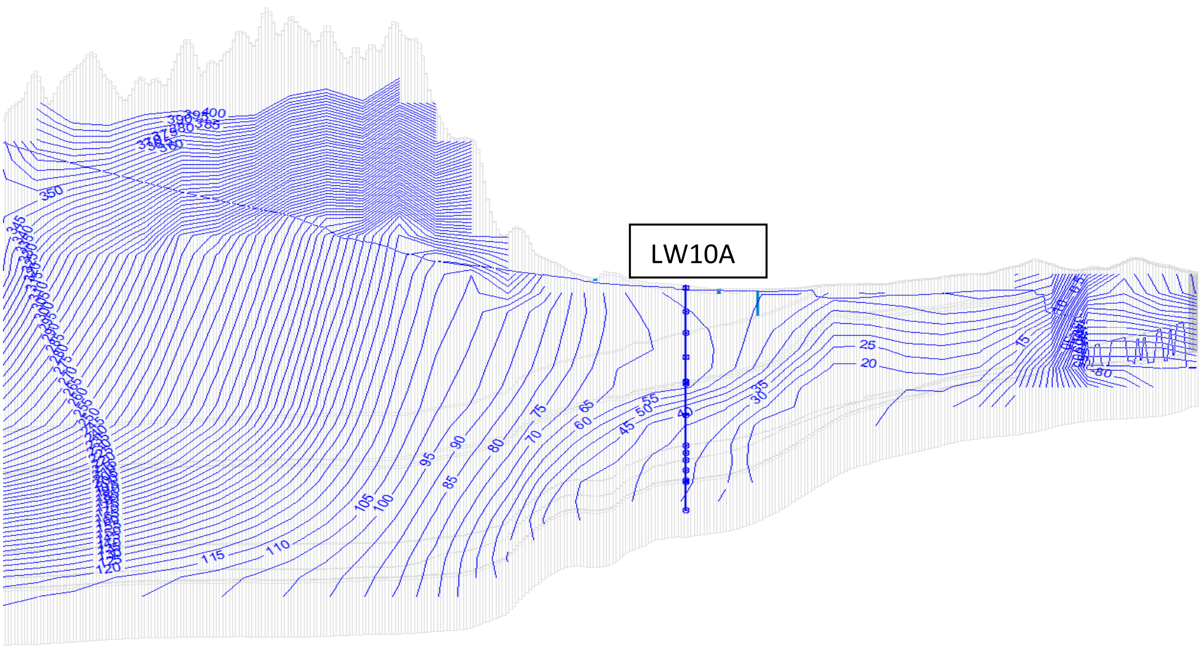

Figure 4. Groundwater head contours along a west-east cross-section passing through the synthetic monitoring bore LW10A