INDEPENDENT ADVISORY PANEL FOR UNDERGROUND MINING

ADVICE RE:

NARRABRI UNDERGROUND MINE

STAGE 3 EXTENSION PROJECT

September 2021

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Abbreviation	Term
DgS	Ditton Geotechnical Services Pty Ltd
DPIE	Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
GDE	Groundwater Dependent Ecosystems
IESC	Commonwealth Independent Expert Scientific Committee
LW	Longwall
MLA	Mine Lease Area
NRAR	NSW Natural Resources Access Regulator
SWAT	Soil Water and Assessment Tool
TARP	Trigger Action Response Plan
VWP	Vibrating wire piezometer
WSP	Water Sharing Plan

1.0 SCOPE OF WORKS

The Narrabri Mine is an underground coal mine located 17 km south-east of Narrabri and approximately 70 km north-west of Gunnedah. The mine has been operating since 2010 and is licenced to produce 11.0 Mt run of mine coal per annum, principally by longwall mining. Six longwall panels of 306 m width and two longwall panels of 409 m width have been extracted to date.

Mine operator, Narrabri Coal Operations Pty Ltd, is currently seeking approval for a major southern extension to the existing Narrabri Underground Mine, named the Narrabri Underground Mine Stage 3 Extension Project (SSD-10269) (the Extension Project). It is proposed that seven as-yet-undeveloped longwalls would be extended from their existing approved length of about 4 km to approximately 10.2 km. An additional longwall with an approximate length of 3.93 km is also proposed. The Extension Project would also extend the mine's operating life from the currently approved July 2031 to 2044.

The Department publicly exhibited the Extension Project's Environmental Impact Statement (EIS) for a period of 42 days from 5 November 2020 until 16 December 2020. There were no individual community objections during the exhibition. However, three local community groups objected to the Project. A key basis for objection was the Project's potential impacts on groundwater resources used by surrounding landholders to provide stock water, particularly during times of drought.

On 16 June 2021, the NSW Department of Planning, Industry and Environment (DPIE) requested the Independent Advisory Panel for Underground Mining (the Panel) to provide advice in relation to the Extension Project, including to:

- *….give particular consideration to the potential water resource impacts of the Project, with a focus on groundwater modelling and the groundwater resource impacts for neighbouring landholders.*

Given that the Extension Project largely involves the extension of existing approved longwall panels, DPIE conveyed to the Panel that it does not consider that the subsidence assessment for the Project presents any difficulties or uncertainties. However, DPIE has advised the Panel that the potential groundwater impacts of the Extension Project on nearby grazing properties (in particular, potential impacts of groundwater drawdown on bores used for stock water) have been of significant concern to local landholders. In addition, the potential surface and groundwater resource impacts of the Extension Project have been of concern to DPIE's Water Group (DPIE Water) and the Commonwealth Independent Expert Scientific Committee (IESC).

The Chair of the Panel nominated the following members of the Panel to prepare the advice:

- Em. Professor Jim Galvin – Chair – subsidence
- Em. Professor Rae Mackay – groundwater
- Professor Neil McIntyre – surface water

2.0 METHOD OF OPERATION

COVID19 constraints prevented the Panel from meeting in person and from undertaking a site inspection. Instead, the Panel convened by videoconference throughout the preparation of its advice and was administratively supported by Secretariat staff provided by DPIE's Energy and Resources Policy Team.

A wide range of documents was reviewed by the Panel in preparing this review, the principal ones being:

Document Reference	Document Name
EIS	Narrabri Coal Stage 3 Extension Project Environmental Impact Statement – including relevant Appendices • Appendix A – Subsidence Assessment • Appendix B – Groundwater Assessment • Appendix C – Surface Water Assessment
Narrabri Consent	Narrabri Stage 2 Consolidated Approval MOD6
Narrabri Subsidence Assessment Peer Review	Narrabri Underground Mine Stage 3 Extension Project Subsidence Assessment – Peer Review (Em. Professor Bruce Hebblewhite)
Narrabri Groundwater Assessment Peer Review	Narrabri Underground Mine Stage 3 Extension Project Groundwater Assessment – Peer Review (Brian Barnett)
Narrabri Surface Water Assessment Peer Review	Narrabri Underground Mine Stage 3 Extension Project Surface Water Assessment – Peer Review (Em. Professor Thomas McMahon)
DPIE Water Advice (2020)	Advice to DPIE - Planning & Assessment regarding the Narrabri Underground Mine Stage 3 Extension Project (SSD 10269) EIS (OUT20/13350) (received via Planning Portal 18 January 2021)
IESC Advice (2020)	IESC 2020-119: Narrabri Underground Mine Stage 3 Extension Project (Narrabri Mine Extension) (State Ref No 9882) – Expansion (15 December 2020)

DPIE Water Advice (April 2021)	Advice to DPIE Planning & Assessment regarding the groundwater model for the Narrabri Underground Mine and the Stage 3 Extension Project (SSD-10269) (OUT21/4438) (19 April 2021)
Submissions Report	Narrabri Underground Mine Stage 3 Extension Project Submissions Report (received 2 June 2021)
Narrabri Amendment Report	Narrabri Underground Mine Stage 3 Extension Project Amendment Report (received 2 June 2021)
Applicant's Response to DPIE Water and IESC Submission (2021)	Letter to DPIE – Narrabri Underground Mine Stage 3 Extension Project – IESC and DPIE-Water Responses and Groundwater Monitoring Clarifications (received 22 July 2021)
DPIE Water Advice (August 2021)	Detailed advice to DPIE Planning & Assessment regarding the Narrabri Underground Mine Stage 3 Extension Project (SSD-10269) RTS and Additional Information (OUT21/7458) (11 August 2021)

2.1. SUBSEQUENT INFORMATION, SUPPORTING DOCUMENTS AND MEETINGS

The Panel convened several times over the course of preparing its advice. DPIE's Resource Assessments Team was invited to several of these meetings to provide technical briefings and updates to the Panel as needed.

The Panel also submitted questions to the Applicant which were addressed by way of written responses and additional documentation.

These documents, queries, responses and meetings are identified in chronological order below:

Document Reference	Document Name
Panel Meeting (22 July 2021)	Initial briefing session
Panel Meeting (29 July 2021)	Subsidence and surface/groundwater discussion
Responses to Panel queries (16 August 2021)	Applicant Response to Panel queries (of 03/08/2021), dated 16/08/2021.
Panel Meeting (27 August 2021)	Discussion of proposed Panel recommendations and indicative timeframe for report completion.

Panel Meeting (3 September 2021)	Subsidence and surface/groundwater discussion as well as guidance on finalising drafting of Panel’s Advice
Longwall quarterly face positions (7 September 2021)	WHC - 2019 FEA P3X02 G08 R16 S10 - 20200401 PPP QTR LOM
Panel Meeting (17 September 2021)	Report finalisation

3.0 SUBSIDENCE ADVICE

3.1. Surface Impacts

There are two components of subsidence above longwall mine workings, being subsurface effects and surface effects. Subsurface effects can have significant implications for groundwater and, as a consequence, surface water. Surface effects can have significant implications for natural and man-made surface features, including for surface water. DPIE advised the Panel in its request for advice that it *'does not consider that the subsidence assessment for the Project presents any particular difficulties or uncertainties'*.

There is a degree of uncertainty associated with all surface subsidence prediction methodologies. Suffice to state that, on this occasion, the EIS relies on a recognised subsidence prediction methodology originally developed on the basis of data sourced from the Newcastle Coalfield and calibrated to subsidence behaviour monitored to date over Narrabri Underground Mine. This methodology is presented in Appendix A – Subsidence Assessment of the EIS, prepared by Ditton Geotechnical Services Pty Ltd (DgS).

Resources Strategies Pty Ltd requested Professor Bruce Hebblewhite to undertake a peer review of this subsidence assessment, with his terms of reference requiring an iterative review of DgS' responses to matters raised by Professor Hebblewhite and the preparation of a subsequent final report (presented in Attachment 6 of the EIS). Having reviewed the finalised DgS report, the Panel endorses Professor Hebblewhite's findings, both in respect of subsurface and surface subsidence.

In respect of surface impacts, the Panel agrees with DPIE that the subsidence assessment does not present any particular difficulties or uncertainties.

3.2. Subsurface Impacts

Hydrogeological impacts above the mined horizon depend on the height of connective fracturing, or complete depressurisation, and the potential for this fracturing to intersect with the expected surface fractured zone. The height of connected fracturing at Narrabri has been determined using the Ditton and Merrick methodology (Ditton and Merrick, 2014).[1] Over the last decade, considerable controversy has been associated with the geotechnical and hydrogeological merits of the various methodologies for predicting the height of complete depressurisation, primarily arising from the significant differences between methodologies in terminologies and predicted heights of connective fracturing. This matter was reviewed in some detail by the Independent Expert Panel for Mining in the (Sydney Water) Catchment (IEPMC, Galvin et al, 2019)[2], which concluded that considerable uncertainty surrounded the reliability of all mainstream prediction methodologies in use in NSW at that point in time.

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[1] Ditton, S., & Merrick, N. M. (2014). A New Sub-surface Fracture Height Prediction Model for Longwall Mines in the NSW Coalfields. Paper presented at the Australian Earth Sciences Convention.

[2] Galvin, J. M., McIntyre, N., Young, A., Williams, R. M., Armstrong, C., & Canbulat, I. (2019). Independent Expert Panel for Mining in the Catchment Report: Part 1. Review of Specific Mining Activities at the Metropolitan and Dendrobium Coal Mines. Sydney: NSW Department of Planning, Industry and Environment.

This situation remains unchanged and is illustrated in Table 1 reproduced from the DgS subsidence assessment. Table 1 refers to LWs 101 to 111 of the current approval for Narrabri Underground Mine. It shows the significant differences between the heights of connective fracturing predicted by four methodologies that find application in NSW. Of particular note is that the Ditton and Merrick (2014) model used to estimate hydrogeological impacts above the Narrabri mine produces the lowest estimates of height of connective fracturing.

Table 1. Comparison between height of connective fracturing predicted by four methodologies that find application in NSW (Source – Appendix A of EIS for Narrabri Underground Mine Stage 3 Extension Project).

LW	Panel Width W (m)	Cover Depth H (m)	Effective Panel Width W' (m)	Mining Height T (m)	W/H	Predicted Maximum A-Zone Height above Longwall (m)		Depth to U95%CL A-Zone	Other Models		
						Geology Pi-Term	Geometry Pi-Term	Geology Pi-Term	CSIRO, 2007 (43T)	SCT, 2008 (W-1.5W)	Tammetta, 2013
101 to 106	306.1 - 306.4	165 - 255	231 - 306.5	4.2 - 4.3	1.2 - 1.86	**121 - 208**	105 – 168	37 - 87	181 - 185	306 - 460	327 - 393
107 to 111	408.8 - 410.3	240 - 360	336 - 410	4.3	1.14- 1.70	**174 - 282**	134 - 211	72 - 149	185	409 - 615	472 - 535

Bold - Maximum values predicted closest to longwall performance to-date.

The potential impact of height of connective fracturing on mining-induced impacts on groundwater is a function of the depth of mining. In respect of the longwalls associated with the Extension Project, DgS states that[3]:

> *Based on a depth of surface cracking of 15 m and possible connectivity between the A- and B-Zones, it is assessed that there is a 25% probability ('possible') that connective cracking could reach the surface for the proposed longwalls.*
>
> *However, investigation boreholes and site observations at Narrabri indicate that the near surface strata above the eastern panels (LW203 and 210) consist of weathered, thinly bedded sandstone and siltstone associated with the Purlawaugh Formation and Garrawilla Volcanics. These units are likely to shear into thinner units and 'unlikely' to develop deep vertical cracks that extend into the A-Zone (below 20 m depth).*

Professor Hebblewhite concluded that:

> *The DgS subsidence predictions have included an assessment of the level of connective cracking between the mining horizon and the zones of surface cracking (10 – 20m below surface usually). Based on the predictions made, and the accuracy of the various models used to make such predictions (which are premised on a number of assumptions and estimates), it is expected that mining will result in connective cracking extending through most underground aquifer horizons, and potentially intersecting with surface cracking in some situations. Once again, remedial work should be prepared to deal with any cracking interference to surface water flows, storage and drainage.*
>
> and
>
> *.. further monitoring of potential connective cracking impacts on should (sic) be conducted in order to gain an improved understanding of the impacts of mining on the overburden strata units and any groundwater horizons contained within them.*

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[3] Page 62 of DgS Subsidence Assessment.

The Panel concurs with Professor Hebblewhite's assessment and recommendations.

The modelling of groundwater impacts due to fracturing above the mine is considered in the next section. It is sufficient to note here that, because the surface recharge rates are predicted to be low (<4 mm/annum) for the outcrop formations above the mine footprint, even if the height of connected fracturing and complete depressurisation is greater than predicted, it is unlikely to result in a meaningful increase in groundwater inflow to the mine.

4.0 GROUNDWATER ADVICE

DPIE requested the Panel to provide advice on the potential water resource impacts of the Extension Project, with a focus on groundwater modelling and the groundwater resource impacts for neighbouring landholders. The request noted that the potential surface and groundwater resource impacts of the Project are of concern to DPIE Water and the IESC.

The Groundwater Assessment is reported in Appendix B of the EIS for the Extension Project. It is based on regional groundwater modelling that has been undertaken by Australian Groundwater and Environmental Consultants Pty Ltd. Both the groundwater assessment and the groundwater model were peer reviewed by Brian Barnett of Jacobs (Attachment 6, Peer Review Letters).

The Panel's advice in relation to the groundwater assessment is considered in six parts. These are:

1. Adequacy of the groundwater modelling for the purposes of assessing groundwater impacts
2. Groundwater impacts above and close to the planned mine footprint
3. Groundwater impacts on the Namoi Alluvium aquifer
4. Groundwater impacts on Groundwater Dependent Ecosystems (GDEs), in particular the identified springs
5. Groundwater monitoring requirements
6. Impacts of disposal of brines to the goaf at the end of the mine life.

4.1. THE GROUNDWATER MODEL

The groundwater model has been constructed with MODFLOW-USG, which allows for cell size variation to match to regions requiring greater or lesser resolution to improve model accuracy whilst minimising simulation times. The model covers an area of approximately 3,970 km^2, 75 km from west to east and 52.9 km from south to north and comprises approximately 31,000 cells horizontally. The number of layers modelled is 11, corresponding to the major geological formations identified in the geological sequence with subdivision of the Napperby formation into 3 layers to incorporate the Napperby Sill. Formation layers are discontinuous across the modelled area, with the formations dipping in a westerly direction with the Arkarula formations and above outcropping to the east of the major Namoi alluvium aquifer (see Figure 1). The Pamboola formation is grouped with other underlying early Permian Units to form the bottom layer of the model. This layer persists across the full extent of the modelled area. This simplification has implications for the modelled connection between the Namoi alluvium and the regional flow system. Several formation layers above the Hoskissons coal are further divided into sub-layers to improve vertical resolution of the model in the vicinity of the mine.

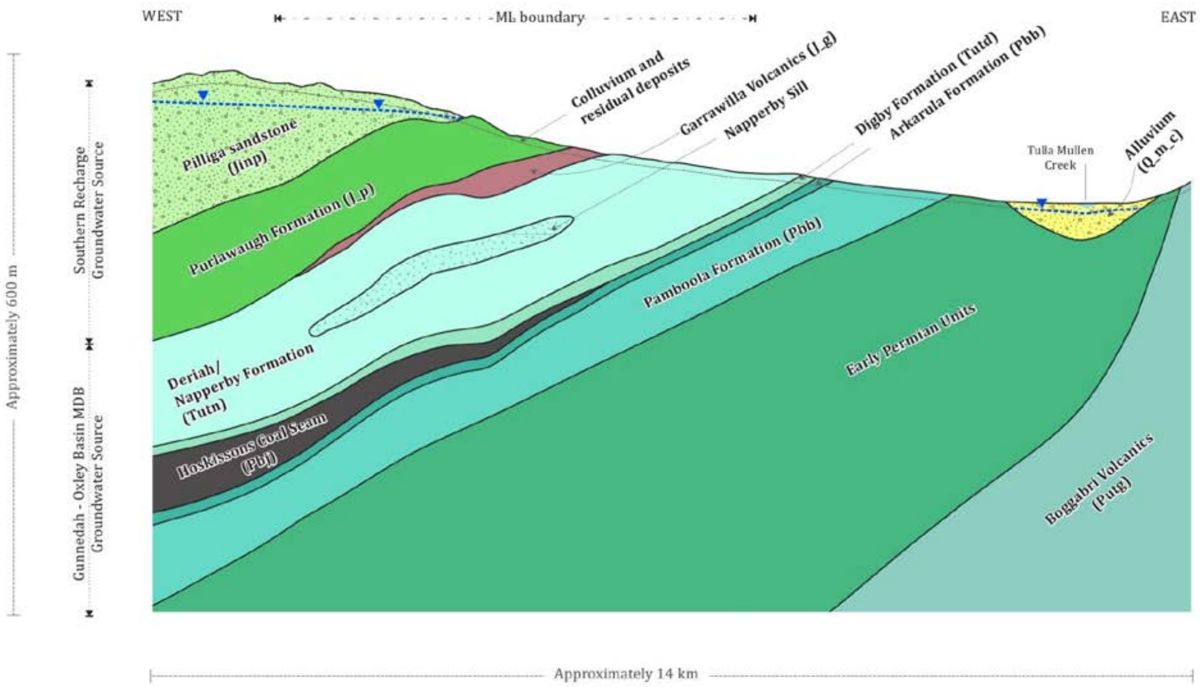

Figure 1. Conceptual Geological Profile West-East through the mine licence area (reproduced from Figure 5.18 of the EIS, Appendix B - Groundwater Assessment)

The hydraulic properties of the formations are determined from the available data with large initial estimates and ranges for hydraulic conductivity anisotropy (Kh/Kv) for the Purlawaugh and Napperby formations of 1,000 and 100 to 10,000, respectively.

Recharge depends on the outcrop formation, with highest recharge rates to the alluvium and the Pilliga sandstone and low recharge rates elsewhere including above the mine area. Initial recharge estimates were determined using Chloride Mass Balance and the Soil Water and Assessment Tool (SWAT) methods. The results of both approaches are generally consistent for the non-alluvium outcrops. An initial estimate for calibration using the SWAT model estimate of 4 mm/annum was assumed for all low conductivity formation outcrop areas. Calibration values were found to be generally less than the initial estimate. Post mining recharge values above the mined area were not changed due to mining.

The transient model has adopted stacked drains to represent the impact of mining on the groundwater system above the mined horizon during mining. Changes to vertical and horizontal hydraulic conductivity are introduced to the near-surface fracture zone during mining but then returned to pre-mining levels following mining. The zone of fracturing above the mine (zone A) is represented by stacked drain cells during mining and then replaced with higher hydraulic properties based on equations adapted from other modelling exercises and calibration. The increase in hydraulic conductivity is based on initial estimates of the change in fracture aperture at different heights above the mining horizon. The presentation of this part of the model does not make it clear how the estimates were made, and the calibration performed. Increases in vertical and horizontal conductivity above the mined area following mining are represented in the model using a multiplication factor that varies with height above the mined horizon. The multiplication factors used are based on the work of Guo et al. (2007)[4]. For the vertical hydraulic conductivity the factors are quite low (<50). This increase is small given the very low initial vertical hydraulic conductivities estimated for the formations above the mining horizon.

Calibration was performed using a pilot point methodology with many model parameters allowed to vary to obtain the best fit. The overall statistics for the calibrated model appear globally satisfactory but still show significant deviations at a local level. The errors between model and observation for the mine area appear to be rather greater than would be desirable for prediction of flows in this locality. One concern is the magnitude of the anisotropy for Kh/Kv for the Purlawaugh, Garrawilla and upper Napperby formations that all lie above the planned mine area. These are not substantially altered by the fracturing model for the zone above the mine area and, therefore, raise some concerns about the reliability of the model in this region. The calibration tended to lower the values for direct recharge below the initial best estimate values, which is rather surprising given the data used to prepare the initial estimates. The Panel has some concerns about calibration that allows both material parameter values and boundary conditions to be adjusted during the calibration process.

Sensitivity studies have been completed using a constrained Monte-Carlo methodology. In many locations of interest, the range of heads generated by the sensitivity analysis do not encapsulate the observations. This raises some questions about the applicability of the sensitivity results for interpretation of risks, in other words there may be local impacts on groundwater levels that this type of model cannot predict. However, it is recognised that for the purposes of the EIS, the ability to predict all local impacts is not essential and that matching spatial and temporal trends is probably sufficient. This has been accepted by the Panel in assessing the model's applicability as an assessment tool for mining approval.

Key model features are the distinctively different groundwater environments encapsulated within the modelled region and the significant hydraulic conductivity anisotropy adopted for the major formations around the mined area. There is a major change in hydrogeological functioning between the Namoi alluvium to the east of the modelled area and the Pilliga aquifer area to the west in terms of both hydraulic properties and consumptive uses. Importantly the mine area is connected to the alluvium by low hydraulic conductivity units (<0.01 m/d) implying low risk of strong connections between the alluvium and the mine. Equally important, the mine area is connected to the surface and to the Pilliga Sandstone aquifer by units with very low vertical hydraulic conductivity. The reliability of the low vertical conductivity values is uncertain, particularly for the post-mining conditions. The mine is surrounded laterally and vertically by low conductivity formations. This suggests that post mining the long-term recovery of the groundwater system can be anticipated to return to close to pre-mining conditions with long times for return flows to the surface from the mined horizon.

Overall, the model can be considered an appropriate model for assessing the regional flow systems and for assessing the likelihood of impacts on the regional aquifer systems. While the groundwater system is finely resolved around features of interest in proximity to the mine, the

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[4] Guo, H., Adhikary, D., and Gaveva, D. (2007). Hydrogeological response to longwall mining, ACARP Report C14033, CSIRO Exploration and Mining: Australian Coal Industry's Research Program (ACARP).

model is unlikely to provide assurance in relation to impacts on the area of mining on surface water features, stock water bores and groundwater dependent ecosystems, including the springs. These aspects are discussed more fully below.

The Applicant's plan to update the model 2 years after the commencement of the proposed mining and every 5 years thereafter is appropriate subject to no unexpected differences between observed behaviour and modelled behaviour. If significant impacts on groundwater above the mine are identified, then the Panel recommends reducing the period from 5 years to 3 years for at least the second update to capture the new knowledge acquired. This adaptation requires updating of the groundwater monitoring network to capture above mine impacts more fully, particularly for the first longwalls to be completed after mine extension approval. It is noted that a commitment to update the model in the case of significant changes in understanding is included in the Water Management Plan for the Extension Project. The Panel acknowledges this commitment but suggests that a 3-year update cycle is sufficient to meet the objectives of the updates.

4.2. GROUNDWATER IMPACTS ABOVE THE MINE FOOTPRINT

The nature and height fracturing of the superincumbent strata above extracted longwall panels is based on the Ditton and Merrick methodology as described in Section 3.2.

The height of Zone A fracturing, as defined by the Ditton and Merrick methodology, of the formations above extracted longwall panels generally intersects the outcrop formations above the mine and the expected zone of surface cracking intersects the top of Zone A over much of the planned mine area. The available data for the nested monitoring facility (P57) that lies over longwall 108 shows the impact of subsidence with depressurisation impacts occurring over all depths below the water table once longwall mining starts and drawdowns are observed at all monitored depths when mining approaches approximately within 200 m of the monitoring facility. The monitoring facility fails once it is undermined. This type of response can be expected across the whole of the mine and would indicate that significant impacts on the upper formations could generally be expected to occur.

Most of the other near-surface bores lie outside of the previously mined region and do not present a clear picture of near-surface impacts. There is some evidence in the piezometric data to suggest that near-surface water table impacts are limited to regions close to extracted areas. This could be expected given the low horizontal hydraulic conductivity values for most of the outcrop formations. Interestingly, the groundwater model suggests a patchy spatial distribution of likelihood of water table declines of more than 2 m above the mine area, with less than 50% of the mine area suggesting drawdowns exceeding 2 m to be likely. Additionally, a high likelihood of drawdowns exceeding 2 m is identified to the east of the mine. The modelled likelihood of low drawdowns appears optimistic based on the observations from the P57 monitoring facility. The lack of groundwater monitoring above the planned mine area should be rectified prior to commencement of any expansion of the mine to identify whether the results at P57 are generally applicable across the mine.

Low surface recharge rates (<4 mm/annum) are predicted for the outcrop formations above the mine footprint. These low values are not increased for the simulation of the period post mining in the model. It appears to be assumed that the near surface fractures will be infilled within a relatively short period of time and that recharge rates will return to their pre-mining values. Due to the low recharge rates estimated for the area, even if the height of connected fracturing is underestimated, the predicted inflows to the mine are unlikely to be substantially underestimated by the model.

Even with the controversy and uncertainty currently associated with calculating the height of connected fracturing, the Panel does not consider that there are significant issues identified by the groundwater model results and their interpretation for the area in the vicinity of the mine.

4.3. GROUNDWATER IMPACTS ON THE NAMOI ALLUVIUM AQUIFER

To the east of the mine area the Namoi alluvium overlies the older Permian units and is disconnected from the formations above the Hoskissons coal seam given the limited eastward extent of their outcrops. The Namoi alluvium intersects or overlies all the upper formations above the Hoskissons coal seam to the north of the mine area.

The low hydraulic conductivity suggested for the older Permian units implies that very little groundwater flow can be expected from the Namoi Alluvium to the mine from the east of the mine area. A marginally larger flow might be expected to flow southwards from the northern intersection of the Namoi alluvium to the mine. However, the flow from the alluvium to the mine at its peak is likely to be only a small fraction (roughly 1%) of the total inflows and outflows to the Namoi alluvium. This rough assessment is backed up by the groundwater model water balance which shows an expected reduction of flow to the alluvium of 140 ML/annum. Overall, there is little to suggest that the Namoi alluvium will be impacted significantly by the mine inflows.

It is noted that the Water Management Plan proposes to monitor groundwater level changes between the Namoi alluvium and the mine to confirm the model predictions for flow changes to the alluvium. This is appropriate as a precautionary measure, but unless the hydraulic properties of the formations as modelled are significantly in error and very large increases in groundwater inflows begin to be detected, the current model results predicting low impacts on the alluvium are likely to be applicable.

4.4. GROUNDWATER IMPACTS ON THE GDES AND SPRINGS

Three springs are identified as potentially significant. The Mayfield Spring lies immediately to the east of the mine and has historically been used for stock-watering. The other two springs are the Hardys Spring and Eather Spring, located approximately 3.5 km and 5.5 km south of mine lease area (MLAs) 1 and 2, respectively.

The Mayfield spring appears to lie in a channel incised into the Purlawaugh formation. This spring would appear to be groundwater fed based on the available groundwater level data and so is likely to be impacted by any decline in groundwater levels caused by the mine. The groundwater modelling suggests that the drawdowns at the Mayfield spring should be negligible but, given its proximity to the mine workings, this should not be assumed for the reasons given for the groundwater levels above all the mine area. Monitoring should be required to establish any impacts on the spring of drawdowns due to mining.

Hardy’s spring appears to lie in a shallow channel in the Pilliga sandstone. The Eather springs are in a shallow channel and appear to be located close to the contact between the Pilliga/Purlawaugh and Garawilla formations. Unfortunately, there is no readily available groundwater level observations for either the Hardy’s or Eather springs to establish whether they may be groundwater fed or whether they rely on shallow surficial deposits for water storage and seepage. It is noted anecdotally that the Eather springs have not flowed for about a decade. Both the Hardy's and Eather springs are located at some distance from the southern edge of the mining area and mine dewatering impacts on shallow groundwater at these locations may be expected to be low. However, as proposed in the Applicant's Groundwater Assessment, these locations should be monitored to observe changes due to mining given their listing as high priority sites in the updated water sharing plan (WSP).

Other GDEs located at distance from the mine area are not likely to be affected significantly by mining, while those close to the mine area are more likely to be affected. As noted in the modelling report, it is not clear to what extent the GDEs that have been identified are dependent on the regional groundwater system or whether they are dependent on local shallow groundwater storage in surficial deposits only. Irrespective of this lack of information, the uncertainty in the groundwater modelling means that there is a requirement for monitoring to demonstrate that the low potential for impacts on the major GDEs is valid.

Underground GDEs including Stygofauna presence appear to be adequately covered by the proponent.

4.5. GROUNDWATER MONITORING

The current network of monitoring points requires expansion to better reflect the scale of the extension and the potential for greater impacts above the mine area than currently predicted by the groundwater model. The recommendations in Section 8.2 of the Applicant's Groundwater Assessment identify additional monitoring along the creeks and at the springs but do not consider additional monitoring above the mine. This is necessary to improve understanding of mining impacts. In addition to the off-mine monitoring, the Panel recommends that at least three vibrating wire piezometer (VWP) monitoring sites should be prepared. This should include one additional multilevel piezometer nest at the northern end of Longwall 111 (LW111) on the centreline of the longwall and directly east of existing monitoring point P17. The other two nests should be within the extension mine area along the centreline of each of the first two longwalls to be mined (LW203 and LW204), 300 m from their southern limit. Monitoring depths should be to the middle of each of the main formations.

DPIE Water has suggested that monitoring and measurement of near-surface water take is needed in addition to mine water take to provide information for offsets. It is not clear that this can be performed with the rigour needed to account for additional offsets. Near-surface water balances are notoriously difficult to measure with precision and there can be both positive and negative feedbacks in water fluxes near surface due to an increased capacity for deep infiltration. Recharge can be enhanced, and evapotranspiration can be reduced. The Panel does not view this to be a productive additional monitoring requirement. Clearly it is important to monitor well bore changes to water depths and pumping capacity and to monitor impacts on surface dams in terms of capacity. These do not form part of offsets but would form part of any compensation arrangements for the local farmers.

4.6. IMPACT OF BRINE DISPOSAL

The mine's western limit sits more than 200 m below the major natural groundwater discharge zones for deep groundwater flows from the mine after full recovery of the groundwater heads across the region after mining. The short-term post mining hydraulic gradients will all be towards the mine. The long-term driving flows will be very low given the limited driving head gradients across the region, particularly at depth. Consequently, the flows during groundwater recovery will not transmit the brine and the long-term flow rates through the goaf following recovery will be very low given the very low conductivity of the surrounding rocks and low head gradients. They will likely be countered by density gradients caused by the higher density of the brine. It is therefore reasonable to consider that any brine reinjected into the goaf at the mining depth will effectively be trapped in the mine with little prospect for contaminating any of the surrounding shallow aquifer systems.

IESC has suggested that a tracer test should be undertaken in the goaf to understand mobility of any contamination. The Panel questions if this is appropriate for two reasons. First, and most importantly, the primary controls on leakage of contamination from the mine will not be dispersive or transmissive properties of the goaf but, rather, will be the transmission properties of the surrounding formations and the low hydraulic gradients operating across the mine. Second, significant spatial and temporal heterogeneity can be expected in the properties of the goaf such that any single test will have a high level of uncertainty for regional application.

It does not seem likely that there will be any significant requirement for rehabilitation of the underground systems to manage groundwater or groundwater quality once mining has been completed.

4.7. CONCLUSION AND RECOMMENDATIONS

While there is a need for an increase in monitoring and responses to the findings from the monitoring in terms of groundwater model updating and compensations for impacts on the local farming community, there is little in the groundwater assessment to suggest that the impacts from mining will be excessive at a regional scale both during mining or once mining has been completed. There appears to be little requirement for significant consideration of the long-term groundwater flows through the mine for mine rehabilitation.

The Panel provides the following recommendations for additional monitoring above the mine, which go further than the mine operator’s current proposals:

- Reducing the period from 5 years to 3 years for at least the second update of the Groundwater model to capture new knowledge acquired as mining progresses if significant impacts on groundwater above the mine are identified through increased monitoring above the excavated mine.

- Three multilevel VWP monitoring sites should be prepared. One additional multilevel piezometer nest should be at the northern end of LW111 on the centreline of the longwall and directly east of existing monitoring site P17. The other two nests should be within the extension mine area along the centreline of the first two longwalls to be mined (LW203 and LW204), 300 m from their southern limit. Monitoring depths should be to the middle of each of the main formations.

5.0 SURFACE WATER ADVICE

This surface water advice is based on the Surface Water Assessment in Appendix C of the EIS, considering also the IESC Advice (2020) and DPIE Water Advice (April and August 2021), the Submissions Report and the Applicant's Response to DPIE Water and IESC Submission (2021). Because the Panel was requested by DPIE to focus on groundwater modelling and groundwater impacts, this surface water advice does not aim to comprehensively address the surface water issues raised in the IESC Advice (2020) and DPIE Water Advice (April and August 2021) or in other submissions.

The Surface Water Assessment is mainly qualitative, concluding that impacts to surface water resources due to the proposed project will be minor to negligible and that detailed quantitative analysis of potential impacts is not warranted for the purpose of the EIS. Considerable weight is placed on the monitoring and adaptive management yet to be proposed in an updated Water Management Plan. The Panel agrees with this approach with some reservations, which are covered below in turn for each of the main surface water impact types.

5.1. FLOW IN CREEKS

The potential for flow loss or change to flow regime is considered by the Applicant (Surface Water Assessment, Section 8.2) to be low enough so that more detailed consideration in the EIS is not warranted.

The creeks identified in the Surface Water Assessment (Section 4.3) as significant and with potential to be impacted are Kurrajong Creek and Tulla Mullen Creek Tributary 1. Kurrajong Creek Tributary 1 has a catchment area overlying the mining area that is comparable to that of Tulla Mullen Creek Tributary 1 and, in the Panel's view, deserves equal attention in assessment and monitoring. Due to the ephemeral nature of these creeks and the low expected frequency of surface-seam fracturing, it is unlikely that measurable impacts to these creek flows (losses or changes to flow regime) will occur. Predictive modelling is possible but, considering the absence of surface flow data for model calibration and validation, surface flow modelling would be highly theoretical and unlikely to be accurate enough to usefully predict the potential for flow losses. The Panel therefore agrees with the Applicant's Response to DPIE Water and IESC Submission (2021) that there will be no benefit in undertaking predictive surface flow modelling for the purpose of the EIS.

The Panel also agrees with the Applicant's Response to DPIE Water and IESC Submission (2021) that installing an accurate weir or deriving an accurate, stable stage-discharge curve in the project area's creeks is unlikely to achieve the required accuracy. Construction of an adequately accurate weir would be a significant construction project that is not commensurate with the potential benefit. Due to the natural variability of climate and creek flows, even a pair of accurate weirs (one upstream, one downstream of the subsidence impact area) may not allow separation of mining-induced losses from natural flow variations. However, it is unsatisfactory that anecdotal evidence of baseline flows is being relied upon after 15 years of observing the waterways as outlined in the Applicant's Response to DPIE Water and IESC Submission (2021) (p20). Formal records of creek flow conditions (not necessarily requiring a flow gauge) should be kept at selected sites to improve understanding of the hydrology and to interpret water quality and erosion observations.

The Panel notes the Submissions Report identifies that consultation with NSW Natural Resources Access Regulator (NRAR) is underway to ensure satisfactory licensing of surface water take. The Panel also notes the DPIE Water Advice (August 2021) advises the need for quantitative surface water take estimates to demonstrate that sufficient water take entitlement can be acquired. As noted above, estimates of surface water take are likely to be highly uncertain due to the difficulty of modelling and accurate flow gauging, and absence of relevant baseline data.

There are farm dams downstream of the project area (Surface Water Assessment, Figure 4.9) that potentially draw on creek flows and may require compensation measures should surface flows or water quality be impacted by the project. Criteria for potential compensations should be detailed in the Water Management Plan (as proposed in the Surface Water Assessment, p91).

5.2. Erosion

The potential erosion and associated changes to geomorphology and water quality are considered in the Surface Water Assessment (Sections 8.1, 8.4) to be minor and short-term. The Panel considers the erosion risks to be understated – there is considerable potential for enhanced erosion within the mining footprint due to subsidence impacts, and land clearance and construction associated with access roads, gas drainage and other facilities. The water quality data in the Surface Water Assessment (T4.4) do not suggest significant increases in suspended solids due to previous mining; however, the information available in the EIS regarding soil types, extent of land clearance, erosion control and soil management, and geomorphological impacts of previous mining does not allow the risks to be well understood. Further monitoring and assessment will be essential part of the updated Water Management Plan including additional water quality data, details of controls, and erosion and water quality performance measures, indicators and Trigger Action Response Plans (TARPs).

5.2.1. Water quality impacts due to discharges from the pit top area

Detailed modelling has been undertaken of the proposed project water balance, which indicates the capacity to manage water quality of controlled discharges and to minimise frequency of uncontrolled discharges. As recognised in the Surface Water Assessment (p71), the adopted method of sampling from the historical record of rainfall provides a limited representation of potential future water balance variability. Improved modelling of the likelihood of uncontrolled discharges should be included in future updates to the water balance model.

5.2.2. Groundwater springs

Advice regarding springs is included in the Section 4.4 of this advice.

5.3. Conclusions and Recommendations

The surface water assessment for the project is high-level and most of the risk management is deferred to an updated Water Management Plan. There are significant uncertainties and risks, principally related to erosion, uncontrolled discharges, water quality changes and impacts on GDEs, which require attention in that Plan.

The semi-arid, ephemeral nature of the project area, with no widespread connection between surface water and groundwater, makes it more difficult and less critical to accurately predict or measure surface water losses from creeks than in more humid and perennial systems. The Applicant is justified in its view that predictive surface water modelling and installation of accurate flow measurements in creeks are not suitable in this case.

The absence of non-anecdotal records of the creek hydrology to inform impacts assessment is poor practice and should be addressed.

The Panel provides the following recommendations in relation to surface water matters:

- DPIE should seek an independent review by the Panel or other third party of the adequacy of the Water Management Plan after it has been updated.
- Formal records of creek flow conditions should be initiated at selected sites.
- Alternatives to measuring or predicting creek flows should be proposed for purpose of supporting water take licensing.

6.0 CONCLUSIONS

In preparing this advice, the Panel has carefully consider the reviews of DPIE Water and the IESC, the Applicant's responses to those reviews, as well as other relevant information as outlined in Section 2. The Panel notes the concerns of local landholders for potential impacts to nearby grazing properties (in particular, potential impacts of groundwater drawdown on bores used for stock water) have been of significant concern to local landholders. The Panel has considered subsidence, groundwater and surface water impacts likely to generated throughout the life of the proposed Extension Project and has made several recommendations to assist DPIE in its assessment of the application.

Subsidence

- In respect of subsidence impacts on the surface, the Panel agrees with DPIE that the subsidence assessment does not present any particular difficulties or uncertainties in relation to surface subsidence impacts.

- In respect of subsidence impacts on the subsurface, even if the height of connected fracturing and complete depressurisation is greater than predicted, it is unlikely to result in a meaningful increase in groundwater inflow to the mine due to the low surface recharge rates (<4 mm/annum) predicted for the outcrop formations above the mine footprint.

- The Panel has not made any further recommendations on this matter.

Groundwater

- The Panel considers there is little in the groundwater assessment to suggest that the impacts from mining will be excessive at a regional scale both during mining and once mining has been complete. There appears to be little requirement for significant additional consideration of the deep groundwater flows through the mine during mine rehabilitation. The Panel considers there is merit in undertaking additional monitoring above the mine, which go further than the mine operator's current proposals.
- The Panel has made several recommendations for DPIE's consideration in Section 4.7.

Surface Water

- The Panel considers the surface water assessment for the project is high-level and most of the risk management is deferred to an updated Water Management Plan. Whilst the Panel does not object to the Applicant's approach, it does have some reservations. There are significant uncertainties and risks, principally related to erosion, uncontrolled discharges, water quality changes and impacts on GDEs, which require attention in that Plan. The Panel considers the Applicant is justified in its view that predictive surface water modelling and installation of accurate flow measurements in creeks are not suitable in this case due to the semi-arid and ephemeral nature of the project area with no widespread connection between surface water and groundwater. However, the absence of non-anecdotal records of the creek hydrology to inform impacts assessment is poor practice and should be addressed.
- The Panel has made several recommendations for DPIE's consideration in Section 5.3.