INDEPENDENT ADVISORY PANEL FOR UNDERGROUND MINING

ADVICE RE:

DENDROBIUM EXTENSION PROJECT

SSI-33143123

July 2022

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1.0 SCOPE OF WORKS

On 1 June 2022, The Director of Resource Assessments, NSW Department of Planning and Environment (Jessie Evans) requested the Independent Advisory Panel for Underground Mining (the Panel) provide preliminary advice in relation to the Dendrobium Extension Project (SSI-3314123). Specifically:

> *The Department is seeking preliminary advice from the Panel regarding any matters that should be addressed by the applicant in their Submissions Report. This may include clarifications, questions or additional information required in order to assist the Panel in its overall review of the Project*
>
> *In providing this preliminary advice, the Panel may wish to consider:*
>
> - *whether the Project has addressed the residual issues of the Panel in relation to the previous Dendrobium Mine Extension Project (SSD 8196);*
> - *any residual or new issues that arise from the changes to the proposed mine plan and assessment of impacts associated with the Project;*
> - *whether the assessment of alternative mining methods, mining parameters and longwall layouts plan warrants further investigation; and/or*
> - *any recommendation of further information required by the Panel to inform its consideration of the Project.*

The Chair of the Panel (Em. Professor Jim Galvin) nominated the following members of the Panel to prepare the advice:

- Em. Professor Jim Galvin – Chair – Subsidence and Mining
- Em. Professor Rae Mackay – Groundwater
- Professor Neil McIntyre – Surface Water
- Dr Ann Young – Swamps and Ecology

2.0 PRELIMINARY RESPONSE

This response to the Department's request addresses each of the bullet points that the Department has suggested the Panel could consider. This underpins the clarifications, questions and additional information that the Panel advises should be addressed in the applicant's response to submissions.

2.1 CONSIDERATIONS

- *whether the Project has addressed the residual issues of the Panel in relation to the previous Dendrobium Mine Extension Project (SSD 8196);*

The Panel considers that the revised mine layout results in a significant reduction in the scale of mining impacts, both in terms of areal extent and the significance of potentially impacted features. The Panel acknowledges the associated improved environmental outcomes reported in the EIS. It places particular importance on increasing the setback distance from Donalds Castle Creek to over 400 m by effectively removing two longwall panels trending parallel and close to this watercourse, reducing the number of swamps mined beneath by some 40%, and reducing the number of Aboriginal Heritage Sites directly undermined. Other significant concerns of the Panel in respect of mine closure planning have also been addressed, notably the revision of the groundwater model to reflect the higher hydraulic conductivity of mine roadways and the conceptual plan to install bulkheads to seal the mine inbye of Area 1.

Notwithstanding this, some residual issues remain. The Panel is conscious that there is a limit to the extent to which environmental impacts can be reduced further while still retaining a financially viable mine plan and, therefore, there will always be some residual issues. Nevertheless, the Panel considers that some issues still require further and/or more in-depth consideration. These include:

i. The EIS still does not include a sensitivity analysis of the effect of longwall panel width on environmental impacts, especially in regard to groundwater.

ii. The reliability of aspects of the groundwater modelling, albeit that the groundwater model is in general of a high standard.

iii. The applicant's independent determination of what constitutes 'key stream features' and its nomination of setback distances to support the applicant's stated purpose of reducing the potential impacts of subsidence on first and second order streams.

iv. The timescale over which mining-induced impacts develop in swamps and the ultimate consequences of these for swamps and associated ecology.

- *any residual or new issues that arise from the changes to the proposed mine plan and assessment of impacts associated with the Project;*

i. In principle, the Panel considers the construction of engineered seals in the main roadways between Area 1 and Area 2 to be an effective approach for promoting the recovery of inbye groundwater levels after mine closure. It is likely that little can be done to cause groundwater levels to recover in interconnected, defunct and possibly uncharted old mine workings outbye of the proposed seal site. In any case, avoiding the uncertainties that would likely arise around flow patterns and water quality if old mine workings were resaturated could also prove be a positive outcome. However, the approach gives rise to a

new residual issue, being the monitoring of the state of these seals in perpetuity to provide timely warning of excessive leakage and adequate time to implement remedial measures or contingency plans to avoid uncontrolled outflow presenting a risk to downstream community and surface infrastructure. This residual issue is one that should be able to be dealt with effectively through risk assessment and design at the time of mine closure.

ii. A new issue that does not arise directly out of proposed changes to the mine plan but rather from field performance since the Panel prepared its October 2022 advice (in relation to the Dendrobium Mine Extension Project - SSD 8196) relates to the impact of groundwater recovery on the discharge of contaminated water into the catchment. This behaviour was postulated at the time by the Panel and discussed in its advice. Subsequently, there is evidence of this behaviour, at least on a small scale, adjacent to an area of Wongawilli Creek impacted by longwall mining.

- *whether the assessment of alternative mining methods, mining parameters and longwall layouts plan warrants further investigation;*

i. Given the geotechnical and ventilation factors associated with the considerable depth of mining (average depth 370 m), market requirements and financial considerations, it is unlikely that any other mining method than longwall mining would be viable.

ii. Reductions in longwall panel width offer the potential to reduce the scale of environmental impacts on groundwater but (as in the case of the original Dendrobium Extension Project SSD-8194) the Panel cannot assess the technical (and financial) potential of this control measure because the EIS does not include a sensitivity analysis of longwall panel width.

iii. In respect of environmental impacts on natural surface features due to the non-conventional component of surface subsidence (as detailed in the Panel's advice of October 2020 relating to Dendrobium Extension Project SSD-8194) longwall panel width would need to be reduced to such an extent to significantly reduce the predicted environmental impacts and consequences that mining would almost certainly be uneconomic.

iv. The seam height of the Bulli Seam is relatively low and due to geotechnical, operational and financial considerations, it is likely that there is limited scope to extract less than the full seam thickness (as the application envisages).

v. There are environmental benefits to be had by removing more longwall panels from the mine plan but this control is likely constrained by economic considerations. The Panel does not have the necessary financial assessment information to conclude a view on the viability of this option.

- *any recommendation of further information required by the Panel to inform its consideration of the Project.*

i. The Panel's consideration will be aided by the information being sought from the applicant in the next section of this advice.

ii. Once the Panel has had the benefit of reviewing the applicant's response to submissions, which is expected to clarify and resolved some outstanding issues for the Panel, the Panel may request further information.

3.0 QUESTIONS FOR IMC

3.1 SUBSIDENCE

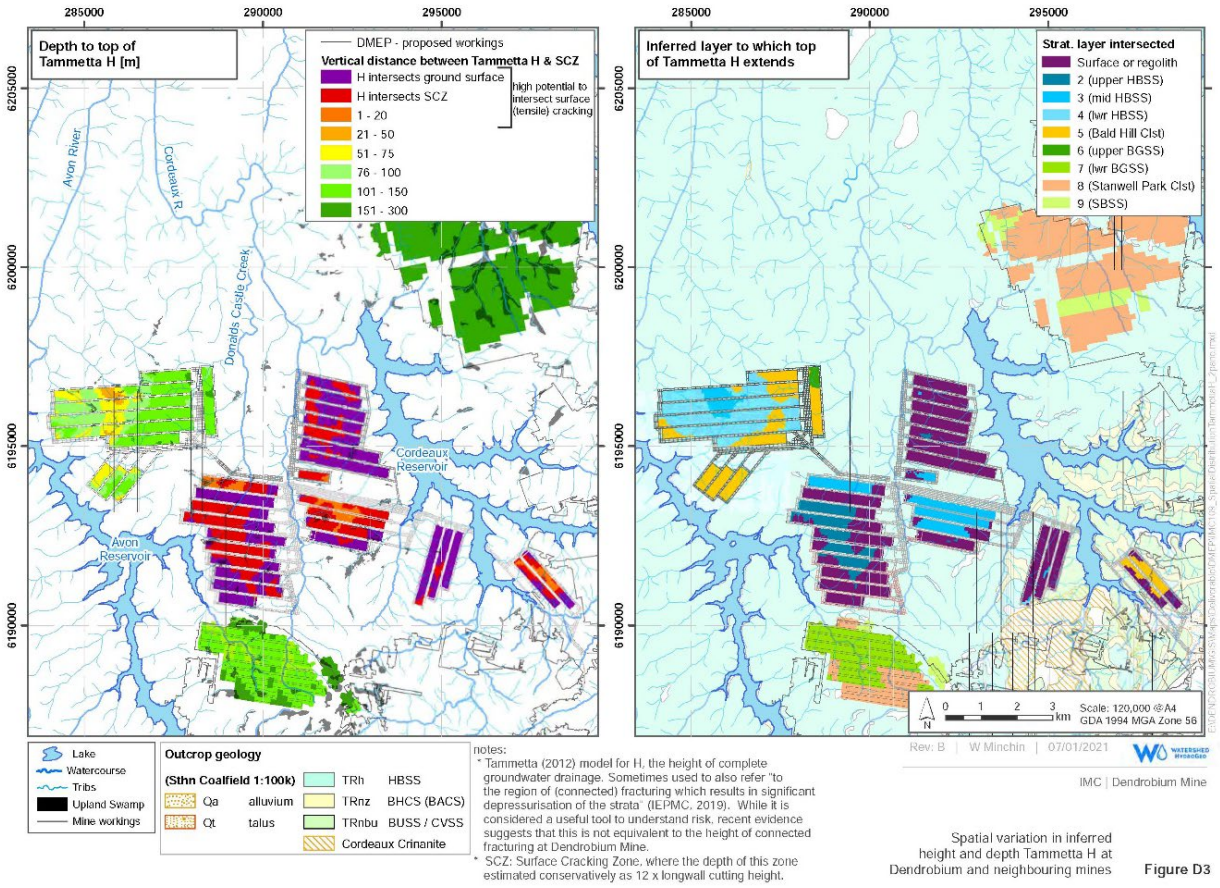
Subsurface Subsidence

Issues:

- Two submissions (BCD – Part 2 and WaterNSW) question the predictions that the height of connective fracturing (HOCF) will not reach the surface.
- The EIS does not present an assessment of the effect of longwall panel width on environmental impacts, especially in respect to groundwater.

Question:

The following figure extracted from the Groundwater Study (Appendix B of the EIS) shows the predicted height of complete groundwater drainage based on the Tammetta Equation.



Spatial variation in inferred height and depth Tammetta H at Dendrobium and neighbouring mines **Figure D3**

i. Can IMC please provide a suite of figures based on the above figure for longwall panel widths of 150 m, 200 m, 250 m and 305 m and which, additionally, include figures showing the upper and lower bounds (error bands) of predictions based on the Tammetta equation.

Conventional Surface Subsidence

Issue: The empirical Incremental Profile Method used for predicting surface subsidence in Area 3B has been recalibrated for Area 5 and the numerical modelling code UDEC has been utilized to assist in validating the recalibration. The geological settings in Area 3B and Area 5 are very similar – the main differences from a subsidence perspective only being a slight reduction in average depth of cover and a reduction in mining height in Area 5. However, it appears that the material properties inputted into UDEC have had to be changed significantly in order for the model to produce reasonable predictions of vertical subsidence in Area 5.

Question

ii. Is the need to change the material properties inputted into UDEC, to produce predictions of vertical surface displacement that reasonably match the predictions of the recalibrated empirical model, a reflection that the recalibration methodology is deficient or that the numerical model is not sufficiently sound from a mechanistic perspective, or a combination of both? Please provide a detailed response.

Non-conventional Surface Subsidence

Issue: The EIS appears to have had regard to a number of past advices from the IEPMC and the IAPUM in respect to the veracity of the rockbar model for predicting environmental impacts due to valley closure.

Questions

iii. Can IMC please provide a more detailed description of the revised prediction methodology.

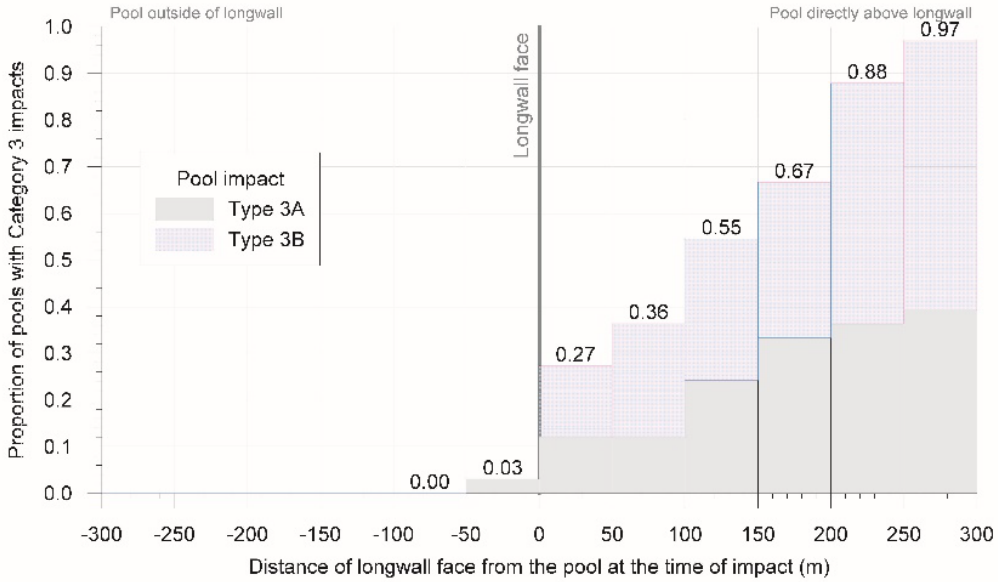


Fig. 3.14 Proportion of pools with Type 3 impacts along Drainage Line WC21 in Area 3B

There were no Type 3 impacts observed in the pools along Drainage Line WC21 prior to the longwalls approaching within 50 m of it. Type 3B impacts were observed shortly after the longwall face mined directly beneath the stream, with these impacts initially representing 27 % of pools directly mined beneath. After the longwall face had mined 250 m to 300 m beyond the stream, these impacts increased to 97 % of the pools.

iv. The figures quoted in the text under the above figure for the percentage of pools experiencing Type 3B impacts appear from the graphic to also include Type 3A impacts; that is, the quoted percentages appear in the graph to be made up of both Type 3A and Type 3B impacts. Please clarify.

v. Can IMC please provide a tabulation comparing the predictions based on the previous rock bar model with those based on the revised model for the circumstances associated with the revised mine plan for the DME?

3.2 GROUNDWATER

Area 5 Water Balance

Issue: The Area 5 water balance presented in Tables 6.5 and 6.6 of the Groundwater Assessment show an unexpected net groundwater outflow of +6Ml/d. It is unclear how this outflow arises unless it is due to flow along the roadway linking Area 5 to Area 3. However, if this is the case, then should this not be identified as mine inflow?

Question

i. Can IMC please provide a detailed explanation for the occurrence of the net groundwater outflow from Area 5 and its significance in terms of the model calibration and the assessment of mine inflows?

Groundwater Model Uncertainty Analysis

Issue: A small number of uncertainty scenarios have been undertaken in lieu of a formal sensitivity analysis. The rationale for the reduced sample space for uncertainty analysis is clear, but the explanation for the selection of the uncertainty assessments and the presentation of the outputs from the uncertainty assessments is not.

Questions

ii. Can IMC please provide further justification for excluding from scenario analysis the uncertainties in the height of fracturing above the goaf and the uncertainties in the parameterisation of evaporation from the groundwater table?

iii. Can IMC show how the random sampling of hydraulic properties for the model layers was actually implemented and what the impact of using the random fields (realisations 2 and 3) on the major outputs of the model were, including stream losses, mine inflows, reservoir take and groundwater level changes above Area 5.

iv. Can IMC please provide a more detailed explanation of the graphical information provided in Appendix L?

3.3 SURFACE WATER

Issue: In its advice on the original project proposal, the IAPUM recommendations regarding the management of key stream features included:

- *As a matter of due diligence, independent verification of the scope and appropriateness of the selected key stream features.*

- *In respect of stream classification, whether any of the streams impacted by the proposed mining warrant classification as being of special significance.*

Question

i. The EIS for the current proposals does not appear to present any new evidence of consultation with stakeholders on this matter. Has any consultation taken place and if so, please provide details.

Issue: Groundwater Modelling

Questions

ii. Why have the historic simulations of inflow to the mine voids been smoothed rather than showing fluctuations in time (5.3.2 of Groundwater Assessment – Appendix B), and how does this smoothing affect the peak predicted Dendrobium surface water loss.

iii. What consideration has IMC given to the validity of the comparison with observed changes in median flows (5.3.4 of Groundwater Assessment – Appendix B), and the implied use of median flows for volumetric loss accounting?

3.4 SWAMPS

Issue: How long does it take for swamps to experience the full environmental impacts of mining and what potential consequences does this ultimately have for swamps.

Questions

i. Can IMC provide an analysis of the risk over the long-term (20-50 years) to Upland Swamps within Area 5, drawing on prior observations in Dendrobium Areas 2 and 3, and discussing the inter-related possible consequences of

   - lowered shallow groundwater levels in the near-surface Hawkesbury Sandstone
   - reduced frequency of water tables within the swamps being close to baseline levels
   - lower soil moisture levels in the swamp sediments, especially within the root zones of groundwater-dependent species and sub-communities
   - observed drift towards drier sub-communities within the CUS EEC and to increased invasion by woodland species
   - increased susceptibility to fire-related impacts such as erosion and loss of organic-rich sediments

ii. Can IMC provide clarity about the long-term viability of the population of Littlejohn's tree frog within and near Area 5 under the current mining layout? This would include an estimation of the numbers of frogs and their dependence on specific sites within the project area, and on the potential impacts of reduced flow into the pools adjacent to or downstream of the project area.

3.5 ENVIRONMENTAL RISK ASSESSMENT

Issue: The SEARS state that:

> *……. the EIS must include an environmental risk assessment to identify the potential environmental impacts associated with the infrastructure.*
>
> *Where relevant, the assessment of key issues below, and any other significant issues identified in the risk assessment, must include:*
>
> - *adequate baseline data*
> - *consideration of the potential cumulative impacts due to other developments in the vicinity (completed, underway or proposed); and*
> - *measures to avoid, minimise and if necessary, offset predicted impacts, including detailed contingency plans for managing any significant risks to the environment.*

Appendix M of the EIS presents a qualitative risk assessment based on a consequence/likelihood matrix. This methodology involves making basic judgements of likelihood and consequences in general categories (NSW Government Guideline MDG-1010 (2011)), which is this case comprises five levels of likelihood and seven levels of consequence. Each category has been assigned a score that is based on, effectively, a fixed weighting (multiplication/division) factor of 3 between each category in the case of both likelihood and consequence. Risk magnitude has been calculated by multiplying the likelihood weighted ranking score by the consequence weighted score to produce a risk magnitude score. The residual risk of any factor with a risk magnitude score of 30 or less after applying controls has been deemed to have been reduced to 'As Low as Reasonably Practical' (ALARP).

Semi-quantitative risk analysis and quantitative risk analysis are the other two forms of risk assessment. Semi-quantitative risk analysis also involves risk calculation based on the selection of categories but endeavours to rank likelihood on the basis of quantified values. Quantitative risk analysis involves the calculation of actual probability of occurance (as opposed to ranking likelihood).

Questions:

i. Given the criticality of environmental impacts to the Dendrobium Mine Extension Project (DMEP), why was a qualitative risk analysis approach adopted?

ii. Did the Environmental Risk Assessment team include any subject specialists who were not involved in preparing the EIS and, if so, what were their specialist areas?

iii. Is there any evidence base to support the scores assigned to each category of likelihood and consequence in the risk assessment? For example, is there a database that confirms that an event which could occur within a 5 to 20 year period (Unlikely) is actually three times less likely to occur than an event which could occur within a 5 year strategic budget period (Possible), which in turn is actually 3 times less likely to occur than an event that could occur in 1 to 2 years (Likely)?

iv. The first 5 of the 7 consequence categories place a finite time limit on the duration of an environmental impact, presumably meaning that mining-induced environmental impacts

of a permanent nature, such as reductions in swamp moisture content, reduction in groundwater table, and fracturing of watercourses that results in diversion of water subsurface should be classified in one of the top two consequence categories. In that case, the associated consequence score of (at least) 300 would inevitably result in the combined risk ranking (Consequence x Likelihood) exceeding the 'As Low as Reasonably Practicable' (ALARP) threshold. Justification is sought, therefore, on the appropriateness of the criteria for classifying environmental consequences in the circumstances applying to the DMEP.

Dendrobium Mine Extension Project – Environmental Risk Assessment

The probability and consequence combine to determine the risk ranking as presented in Table 4.

Table 4 – Risk Ranking Table

Likelihood	Consequence					
	Low 1	Minor 3	Moderate 10	Significant 30	Major 100	Catastrophic 300
10 Almost Certain	10	30	100	300	1,000	3,000
3 Likely	3	9	30	90	300	900
1 Possible	1	3	10	30	100	300
0.3 Unlikely	0.3	0.9	3	9	30	90
0.1 Rare	0.1	0.3	1	3	10	30
0.03 Very Rare	0.03	0.09	0.3	0.9	3	9

The risk rankings below the bold line represent rankings that are within or below the 'As Low as Reasonably Practicable (ALARP)' region.

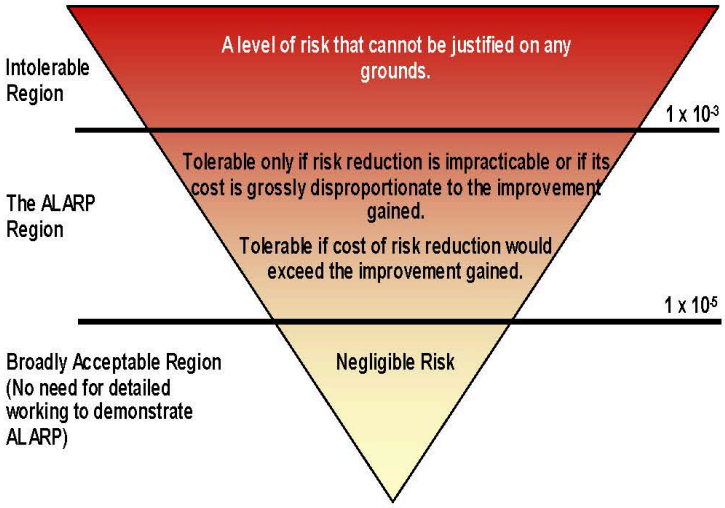
v. In respect of the risk matrix (above), is there any evidence base in the mining and environmental circumstances pertaining to the DMEP to support the premise that a risk magnitude score of 30 corresponds to 'as low as reasonably practicable' (ALARP) ?

vi. In the case of environmental impacts, what is the basis for accepting that all events which have a risk magnitude score of 30 present the same level of tolerable risk? For example, what is the basis for why 'Likely' events that result in 'Moderate' consequences (score 30) present the same level of tolerable risk as 'Possible' events that result in 'Significant' consequences (score also 30)?

vii. What basis is there for accepting that events which could result in 'Major' or 'Catastropic' consequences are tolerable at all?

viii. Is it proposed that a risk rating of ALARP is sufficent justification for acceptance/tolerance of environmental risks?

Figure 5: Risk Criteria "ALARP"



ix. What do the values '1 x 10^{-3}' and '1 x 10^{-5}' correspond to in the above figure?

x. How do these values relate to ALARP in the preceding risk matrix?

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		and riparian vegetation.										
HSAHS. 14	High Scientific Significance Aboriginal Heritage Sites (Site 52-2-1780 [Upper Avon 43])	Mine subsidence results in impacts to high archaeological Aboriginal heritage sites and/or heritage values.	30	3	Feature located within feasible metallurgical coal resource and CCL 768.	90	Economic mine plan has minimum distance of 170 m from longwall mining in Area 5.	With the minimum distance of 170 m from longwall mining, experience in the Southern Coalfield has indicated impacts are not expected to occur. It is worth noting that the feature is within feasible metallurgical coal resource and CCL 768, but would not be directly mined beneath by the proposed mine plan. Potential for mining-induced fracturing on this site has been assessed by MSEC (2022) as very rare (less than 1%).	0.1	30	3 (ALARP)

xi. A minimum standoff distance of 170 m from a longwall panel apparently accounts for the reduction in likelihood rating from 'Likely' (3) to 'Rare' (0.1). This results in a 30-fold decrease in likelihood score. The text describes MSEC assessing the likelihood of fracturing as *'very rare (less than 1%)'*. Is it proposed that a qualitative likelihood rating of 'Very Rare' corresponds to a quantitative likelihood of 1% and, if so, what is the source of this correlation?

Table 7 – Risk Ranking for Other Features and Risks

Ref	Feature (Representative Feature)	Hazard	Uncontrolled Risk Ranking				Controlled Risk Ranking				
			Consequence	Likelihood	Justification/Ranking Basis	Risk	Controls	Evidence Basis for Ranking	Residual Likelihood	Residual Consequence	Residual Risk
MSAHS.35	Moderate Scientific Significance Aboriginal Heritage Sites (Site 52-2-1730 (Ricki Lee 2))	Mine subsidence results in impacts to moderate archaeological Aboriginal heritage sites and/or heritage values.	3	0.1	220 m away from longwall mining (no further control required). Potential for mining-induced fracturing on this site has been assessed by MSEC (2022) as rare (less than 5%).	0.3 (ALARP)					
LSAHS.36	Low Scientific Significance Aboriginal Heritage Sites (Site 52-2-1566 (Donald Castle Creek Site 5))	Mine subsidence results in impacts to low archaeological Aboriginal heritage sites and/or heritage values.	3	0.3	Directly mining beneath could cause impacts to Aboriginal heritage sites (no further controls proposed). Potential for mining-induced fracturing on this site has been assessed by MSEC (2022) as unlikely (less than 10%).	0.9 (ALARP)					
SFS.63	Second and First Order Streams (AR19)	Loss of surface water supply and biodiversity values for streams due to subsidence-related impacts.	3	10	Directly mining beneath is likely to cause surface deformation or changes to groundwater resulting in changes to water losses and loss of biodiversity values.	30	Offset water losses and biodiversity values for species up to 400 m upstream/downstream of longwalls, if required.	Precautionary basis for biodiversity and water impacts related to streams. Regulatory process is to avoid a net-loss of values. Repeatable process using accepted government calculation for offsets. Surface water loss offsets intended to be based on real-life data (e.g. flow monitoring) and value determined by IPART.	10	1	10 (ALARP)
SW.73	Swamps (Den86)	Mine subsidence, including far field effects, causes surface deformation or changes to groundwater resulting in changes to erosion potential, swamp size and swamp vegetation.	3	10	Directly mining beneath could cause surface deformation or changes to groundwater resulting in changes to erosion potential, swamp size and swamp vegetation.	30	Offset impacts to swamp and relevant biodiversity values, if impacted.	Precautionary basis for biodiversity and groundwater impacts related to swamps. Regulatory process is to avoid a net-loss of values. Repeatable process using accepted government calculation for offsets.	1	3	3 (ALARP)

xii. Was the risk assessment undertaken specifically for stream AR19 and swamp Den86 or have these features been named as examples of the type of feature for which the risk assessment scores apply? This query applies in general to all listings of features.

xiii. In the case of second and first order streams (AR19), the offsetting of impacts affects consequence rating (3/1) but not likelihood rating (10/10), while in the case of upland swamps (Den 86) located on top of a stream, the offsetting of impacts affects likelihood rating (10/1) but not consequence rating (3/3). How is this explained?

xiv. Given that offsetting does not prevent environmental impacts from occurring, why does the risk assessment not continue to reflect the magnitude of risk associated with actual environmental impacts (with offsetting noted as compensation for environmental consequences that exceed a desirable level)?

Dendrobium Mine Extension Project – Environmental Risk Assessment

Ref	Feature (Representative Feature)	Hazard	Uncontrolled Risk Ranking				Controlled Risk Ranking				
			Consequence	Likelihood	Justification/Ranking Basis	Risk	Controls	Evidence Basis for Ranking	Residual Likelihood	Residual Consequence	Residual Risk
KSF.29	Key Stream Features (large pools on any order of stream or >5 m step) (DC8-Pool 16)	Mine subsidence and reduced groundwater pressures reduces water quantity within key water stream features. Loss or degradation of aquatic habitat and riparian vegetation.	10	3	Feature located within feasible metallurgical coal resource and CCL 768.	30	Economic mine plan has minimum distance of 50 m from longwall mining, remediation of potential impacts and offset of biodiversity values up to 400 m upstream/down stream of the proposed longwalls.	Potential impacts from subsidence are possible. Based on observations at Dendrobium Mine, potential loss of biodiversity and habitat could occur as a result of loss of flow. At this distance from longwall mining there is potential for subsidence impacts (e.g. fracturing) that may cause loss of pool water (Type 3 impact) based on previous experience at the Dendrobium Mine or in the Southern Coalfield.	0.1	10	1 (ALARP)

xv. Was the risk assessment undertaken specifically for DC8 - Pool 16, or has this feature been named as an example of the type of Key Stream Feature for which the risk assessment score applies?

xvi. Fracturing associated with longwall mining near watercourses is known to occur up to some 400 m distance from the footprint of longwall panels. In the case of the DMEP, longwalls are proposed to be set back 50 to 100 m from Key Stream Features. The above extract records the likelihood rating decreasing from 3 (Likely) to 0.1 (Rare) after this action has been implemented. However, field performance reveals that cracking within 50 to 100 m of a longwall panel is quite common and likely. What is the basis for the revised likelihood rating?

xvii. If the revised likelihood rating is based on also having regard to the stated controls of *'remediation of potential impacts and offset of biodiversity values up to 400 m upstream/downstream of the proposed longwalls',* how do these remediation activities and compensatory actions come to influence likelihood rating?

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xviii. In some instances, the risk magnitude has been reduced to its residual value as a result of reducing the likelihood of an event occurring. Given the uncertainty associated with estimating likelihood and that some consequences are unacceptable irrespective of likelihood rating, risk assessment guidelines advise that risks be ranked both in terms of risk magnitude and consequence magnitude. Have risks been ranked in terms of only consequence magnitude and if not, can that be undertaken and supplied?

xix. Were cumulative environmental impacts, including on water quality, assessed and if so, how?

xx. The Environmental Risk Assessment concludes that *'The risk rankings are within the "low/medium (ALARP)" range and consequently the potential outcomes can be integrated into the existing management systems for effective review and monitoring.*' What is the which logic that determines that because risk rankings are within ALARP, potential environmental outcomes can be integrated into existing management systems?

REFERENCES

MDG-1010. (2011). *Minerals Industry Safety and Health Risk Management Guideline*. Sydney: NSW State Government.