Hume Coal Project and Berrima Rail Project

Submission to the Independent Planning Commission

March 2019

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Submission to the Independent Planning Commission (SSD7172 and 7171)

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Report Number

J12055 RP#3

Client

Hume Coal Pty Limited

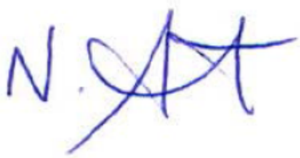
Date

6 March 2019

Version

Final

Prepared by



Nicole Armit
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06 March 2019

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06 March 2019

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1 Introduction

1.1 Background

Hume Coal Pty Limited (Hume Coal) proposes to construct and operate an underground coal mine in the Southern Coalfield of New South Wales (NSW) (the Hume Coal Project) and associated rail infrastructure (the Berrima Rail Project). The mine will produce metallurgical coal with a secondary thermal coal product. Around 50 million tonnes (Mt) of run-of-mine coal will be extracted from the Wongawilli Seam via a non-caving mining system, resulting in approximately 39 Mt of saleable coal over a project life of about 23 years, including construction and rehabilitation. The Hume Coal Project and Berrima Rail Project areas are located to the west of Moss Vale, in the Wingecarribee local government area (LGA).

Hume Coal is a wholly-owned subsidiary of POSCO Australia Pty Limited (POSA), the Australian subsidiary of POSCO. POSCO is a leading steel manufacturer and one of the largest buyers of Australian coal and iron ore.

The development applications and accompanying environmental impact statements (EIS) for the Hume Coal Project (EMM 2017a) and the Berrima Rail Project (EMM 2017b) were publicly exhibited between 31 March 2017 and 30 June 2017. Following the public exhibition of the EIS for the two project's and the submission of a Response to Submission Report (RTS) by Hume Coal, the NSW Department of Planning and Environment (DPE) undertook an assessment of the project and prepared an Assessment Report (DPE 2018). The NSW Independent Planning Commission (IPC) is the determining authority for the project.

The Hume Coal Project and Berrima Rail Project together are herein referred to as the project.

1.2 Document purpose

Hume Coal has reviewed the DPE's Assessment Report (December 2018) into the project and submits that the report contains numerous errors, misinterpretation of the information presented in the EIS and RTS, and statements that are not supported by fact or evidence.

The purpose of this submission is to provide the IPC with Hume Coal's view on the DPE's Assessment Report and clarify a number of the key matters identified as issues within this report.

1.3 Summary of key issues and project justification

The key issues raised in DPE's Assessment Report focussed on the aspects of the groundwater impacts and mitigation, mine design, and economic benefits. The issues raised, and a summary of Hume Coal's response, are provided in Table 1.1. Detailed responses to the issues are provided in chapters 2 to 5 of this report.

Table 1.1 Key issues raised in DPE's Assessment Report of the project

DPE issue	Hume response
Groundwater impacts	
Make good arrangements not suitable	Make good is clearly technically feasible. DPE expert (Hugh Middlemis) response: 'Depressurisation does not dewater an aquifer unit, it simply lowers the pressure level, which can leave areas of saturated aquifer that can support groundwater pumping'.

Table 1.1 Key issues raised in DPE's Assessment Report of the project

DPE issue	Hume response
Make good arrangements not practical	Make good arrangements are standard administrative practice and implemented elsewhere, including in the Southern Coalfields, and have been for many years. Access arrangements are already in place with 20 landholders (step 1 in the process for make good). 'Make Good' is a landholder entitlement. If a landholder does not choose to exercise that right, then there is no dispute. It is an 'opt in' arrangement. DPE expert response: 'The strategies for make good are reasonable in principle.'
Residual uncertainty	One of the most comprehensive water assessments for a mining project in NSW. DPE expert response: 'The Hume Coal Model is fundamentally a good example of best practice of design and execution'.
Lack of geological data and modelling of the interburden layer	Over 345 exploration holes have been drilled in the project area, and interburden between Hawkesbury Sandstone and coal correctly represented. DPE expert response: 'The Hume Coal model has been set up with an appropriate representation of the interburden'.
Significant impacts on highly productive aquifer	Environmental impact of the mine is modest, and not significant or 'unprecedented'. Groundwater impacts from other mines are much greater in terms of drawdown, inflow and time to recover. DPE expert response: 'Dewatering of one horizon of the aquifer (ie the mined coal seam) does not preclude saturated aquifer conditions above'.
Class 2 status challenged, and therefore uncertainty of model results and adoption of conservative model results	The model is Class 2 and the modelling of uncertainty is world class. DPE expert response: 'Downgrading of the model by DPI Water (2017) and Anderson (2017) to class 1 is invalid'. 'DPI Water have now agreed the model is Class 2'. 'Class 2 is justified'. Model is 'fit for purpose'.
Concerns Hume will be able to acquire necessary groundwater licences	Hume Coal easily acquired 93% of required groundwater licences (1,909 ML), which covers inflow up until year 16 of the project. These licences were acquired prior to DPE's Assessment Report being prepared. Hume Coal very confident that the small remaining amount (150 ML) can be acquired.
Mine design	
'Untested' and 'unconventional' mining method and design	The mine design is based on long established mine design principles. Similar layouts have been, and are, used at numerous other underground mining operations. An innovative mine design does not affect the ability for the project to be approved. Notably, the NSW Resource Regulator published an Innovation Policy in January 2019, which states that: *'We are committed to having a responsive and effective regulatory framework for work health and safety that supports the development, trial and adoption of new technologies, systems and products.'*

Table 1.1 Key issues raised in DPE's Assessment Report of the project

DPE issue	Hume response
A substantial degree of uncertainty about the methodology underpinning the geotechnical model, and the level of risk assessment undertaken.	There are no outstanding issues of any substance remaining with regards to the 3D geotechnical model. The model was developed using state of the art software; appropriate material properties with conservative, down-rated values; it was conducted by a leading international expert, Professor Keith Heasley; and it was calibrated against an appropriate case study from the neighbouring Berrima Colliery. The DPE's own experts conceded at the expert's meeting in March 2018 that the model was appropriate. A number of risk assessments have been undertaken for the project and attended by experts in the fields of mine design, geotechnical engineering, geology and hydrogeology. The risk assessments considered the proposed non-caving mining method, and the risk of inrush and inundation, and the outcomes were used to inform the final proposed mine design and layout.
The combination of the 'untested' mining method with the storage of large quantities of mine water underground, claiming this is likely to result in serious operational safety risks.	As mentioned above, the proposed mine design is based on long established mine principles. Many mines also store water underground. Notably, water will be stored *downdip* of the bulkheads in the majority of the mine workings, with the exception of one area towards the end of mine life where the seam dip flattens out (refer to Figure 3.4 in this submission). There is therefore no information to support DPE's claim that the mine design, combined with the storage of water underground, will result in serious safety risks is rejected.
Economics	
The estimated net economic benefits of $373 million is relatively low in comparison to many other coal mining projects in the Southern Coalfield and across NSW.	This is incorrect. Analysis of a range of other projects recently assessed by DPE shows that the estimated net economic benefit associated with the project of $373 million is significant, and on par with or greater than other approved coal mining projects.

As can be seen in Table 1.1, the DPE's Assessment Report contains numerous errors in its assessment of the project. The Department's finding that the project should be refused based on this flawed assessment is therefore an unjustified position.

As described in the EIS and Response to Submission Report for the project, a range of physical, economic and environmental attributes combine to make the project area suitable for the proposed underground mine. The project area is highly suitable for this purpose being close to rail infrastructure that links directly to the Port Kembla coal terminal, currently an under-utilised asset that is ready to accept coal from the project. It is also in close proximity to the Moss Vale Enterprise Corridor, an area established by the local council to encourage an increase in industrial, employment generating land uses in the area. The surface infrastructure area has been carefully situated on predominantly cleared land so as to avoid sensitive environmental features and is in an area with limited neighbouring sensitive receivers. Due to the underground, non-caving nature of the mine, existing land uses will continue across 98% of the project area, without impacts from mine-induced subsidence.

The DPE confirmed in its Assessment Report that the potential impacts relating to noise and vibration, air quality and greenhouse gas, traffic, biodiversity, heritage, agriculture and rehabilitation with the project are 'likely to be able to be managed, mitigated or offset to achieve an acceptable level of environmental performance'.

The remaining potential impacts on water resources are shown in this submission to also be an aspect that can be effectively managed and mitigated.

The project will enable the orderly and efficient development of a dormant publicly owned resource – Wongawilli Seam Coal – which will be of significant benefit to the local and broader NSW communities. With all relevant factors considered, the associated benefits are considered to outweigh costs and the proposed project is strongly justified.

2 Water resources

2.1 Introduction

This chapter address the issues raised in DPE's Assessment Report relating to water resources, primarily in Section 6.2 of its report. The key areas raised in the DPE report are summarised in Table 2.1.

The DPE's report considers some aspects of the Department's own expert (Hugh Middlemis) report, but appears to rely more heavily on the NSW Department of Industry, Water Division (DoI Water) submission. It is noted that DoI Water did not reference or take into consideration any of the advice from DPE's expert. Therefore, many of the concerns from DoI Water (which have been referenced in the DPE Assessment Report), have been addressed and considered 'fit for purpose' by DPE's expert.

Table 2.1 Summarised DPE concerns

DPE comment	Hume response	DPE expert (Middlemis)
Residual uncertainty	One of the most comprehensive water assessment for a mining project in NSW.	'Hume Coal Model is fundamentally a good example of best practice of design and execution'.
Lack of geological data and modelling of the interburden layer	Over 345 drill holes undertaken, and interburden between Hawkesbury Sandstone and Coal correctly represented.	'The Hume Coal model has been set up with an appropriate representation of the interburden'.
Significant impacts on highly productive aquifer	Environmental Impact of the mine is modest not 'unprecedented'. Other mine impacts much greater in terms of drawdown, inflow and time to recover.	'Dewatering of one horizon of the aquifer (ie the mined coal seam) does not preclude saturated aquifer conditions above'.
Class 2 status challenged, and therefore uncertainty of model results and adoption of conservative model results	Model is Class 2. Modelling uncertainty is world class.	'Downgrading of the model by DPI Water (2017) and Anderson (2017) to class 1 is invalid'. 'DPI Water have now agreed the model is Class 2'. 'Class 2 is justified'. Model is 'fit for purpose'.
Make good arrangements not suitable	Make good is clearly technically feasible.	'Depressurisation does not dewater an aquifer unit, it simply lowers the pressure level, which can leave areas of saturated aquifer that support groundwater pumping'.
Make good arrangements not practical	Make good arrangements are standard administrative practice and done elsewhere. Access arrangements are already in place with 20 landholders (step 1 in the process for make good).	'The strategies for make good are reasonable.'
Concerns Hume will be able to acquire necessary groundwater licences	Hume Coal easily acquired 93% of required groundwater licences (1,909 ML) which covers inflow up until Year 16. Hume Coal very confident it can acquire additional 150 ML.	No comment.

Additional questions relating to groundwater have been raised by the IPC, which have been specifically addressed in Appendix A. These matters are:

- water quality of the emplaced reject and excess water in relation to the surrounding groundwater source and how this may change over time (ie following full recovery);
- the options considered for the discharge of excess water during mining (ie shallow reinjection into the Hawkesbury Sandstone and consideration for a water treatment plant);
- differences between 67th%ile and 90th%ile in terms of number of bores and inflow volume;
- the actual usage from registered bores (ie as a percentage of their entitlement) assumed in the groundwater model;
- the percentage of Hume Coal water take compared to the overall availability of water in the surrounding catchment, and in comparison to the requirements of the Sydney Catchment Authority; and
- general questions around the options for 'make good' generally and how this will be undertaken.

2.2 Key issues – government agencies

2.2.1 Department of Industry, Water Division

DoI Water raised the following concerns:
i) that an unprecedented number of bores would be adversely affected by the project;
ii) whether the proposed make good strategy is "logistically viable"; and
iii) some residual concerns about the technical aspects of the model.

i Unprecedented number of bores

The project, compared to other coal and mining projects in NSW, occurs within a relatively high-density area of water supply bores. The higher density of bores, compared to other areas where mining occurs, is a result of smaller (rural) property sizes; shallow available groundwater; and rural residences with extensive landscaped gardens and lawns.

Conservative groundwater modelling estimates that 94 privately owned bores will experience a drawdown of greater than 2 m as a result of the project. This compares to nearby Tahmoor Coal Mine (Tahmoor), where cumulative impacts from mining (including the proposed Tahmoor South Project) will result in 94 bores experiencing a drawdown of in excess of 2 m. It is also noted that overlying properties experience subsidence related impacts due to the longwall mining techniques being used at that mine. Make good agreements have also been successfully implemented at Tahmoor for many years.

Importantly, the number of bores predicted to experience drawdown by Southern Coalfields projects is not reflective of the extent of environmental impact from the mine; it is reflective of the density of bores overlying the mine. In other areas of NSW, such as the Hunter Valley, there is a much lower density of bores, and so less bores experience drawdown as a result. The lower bore density in the Hunter and other areas compared with the Southern Highlands is likely a result of larger property sizes, more rural agricultural blocks opposed to rural/residential, and less prospective groundwater resources (ie lower quality and yield).

The groundwater impacts (drawdown and inflow) for most other coal mines in NSW are similar or more significant than the project, however, these impacts are not being 'felt' by as many landholders as there are fewer bore numbers.

ii Viability of the make good strategy

The predicted groundwater drawdown for the project is mostly concentrated within the area overlying and immediately adjacent to the mine area. There are 94 landholder bores directly overlying and in close proximity to the mine workings predicted to experience greater than 2 m of drawdown. The majority of these bores will remain viable with minimal works or activities (ie financial contributions for increased pumping costs or lowering of bore pumps).

The number of bores experiencing drawdown greater than 2 m (94) may be considered large in comparison to other mines, although noting it is relatively similar to the cumulative effect of mining at Tahmoor Mine, noting also that make good measures for bores effected by mining have been successfully implemented at Tahmoor for many years. The large number of potentially affected bores should not be considered in isolation, and should be considered in conjunction with the fact that Hume Coal has not purchased all of the land overlying the mine (so overlying properties remain viable and with surface operations unaffected by the presence of the mine). Other aspects of the perceived greater impact as a result of a large number of bores is the relatively small property size, the presence of shallow usable groundwater, and the large gardens and lawns requiring irrigation. These aspects have resulted in a moderate to high density of water bores in the area.

The number of landholder bores likely to be affected is therefore not indicative of a widespread environmental impact and or larger than average drawdown from the mine itself, but is instead an indicator of a large number of small properties, all with bores and the resulting moderately high density of water bores (see Figures 2.2 to 2.4 in Section 2.5 for comparison level of environmental impact irrespective of number of bores).

iii Concerns relating to technical aspects of the model

Refer to the response provided below in Section 2.4.1.

2.3 Groundwater - background

Section 6.2.3 Background - As a background to the discussion on groundwater in Section 6.2, DPE state that *"all underground mines have some level of impact on groundwater resources as the extraction of the coal seam leads to depressurisation and fracturing of the overlying strata".*

This statement by the DPE is incorrect. Not all mines lead to fracturing of the overburden, and not all mining leads to depressurisation of the overlying strata. Whether any fracturing occurs and whether any depressurisation occurs is dependent on the mining method, mine layout and overburden geology (Hebblewhite 2019).

2.4 Methodology

In section 6.2.4 of its assessment report, the DPE states there are three areas of residual concern relating to the methodology utilised in the groundwater assessment, particularly relating to the complex modelling involved, as follows:

- the class of the groundwater model;
- characterisation of the local geology; and
- uncertainty and sensitivity analyses.

These residual areas of concern are discussed in the sub-sections below.

2.4.1 Groundwater model class

Section 6.2.4 – it is stated that the groundwater model in the EIS was criticised by DoI Water and various community submissions as not meeting the requirements of Class 2 or Class 3, and therefore not fit for purpose. Whilst acknowledging there is now general agreement that the revised groundwater model (as part of the Response to Submissions report) is an improved model, several 'experts' (ie DoI Water, UNSW's Doug Anderson and PSM's Dr Steven Pell's) do not consider the model Class 2.

Whilst stating the above in its assessment report, the DPE go on to point out that its own expert concluded the model is Class 2 "even if there are individual aspects of the model that do not necessarily meet the criteria in the Modelling Guidelines".

In Section 6.2.4, under 'Model Class', the DPE quotes comments from its expert (Hugh Middlemis) that suggest the clarity of reporting in the EIS could be improved and that Middlemis recommended model changes. The comments from DPE's expert also go on to state that:

> 'this review finds that the Hume Coal model itself is suitable for the mining impact assessment purpose (Class 2 confidence level)'.
>
> 'Downgrading of the model by DPI Water (2017) and Anderson (2017) to class 1 is invalid …. Accordingly, any criticisms based on this invalid premise are also not necessarily valid'.
>
> 'DPI Water and Anderson have relied heavily on the demonstrably false premise of a Class 1 model to base their initial claims of inadequate modelling for impact assessment purposes'.
>
> It is understood that 'DPI Water have now agreed the model is Class 2'.
>
> **'…** cherry-picking one guideline comment rather than considering all the attributes suggested in the table does not constitute a valid agreement to support the claims by others of poor model performance'.
>
> '… it is my professional opinion that the Hume Coal model is fundamentally consistent with best practice in design and execution'.
>
> 'The model software, design, extent, grid, boundaries and parameters form a good example of best practice in design and execution'.

It appears the questions raised in the DPE Assessment Report on the model class are conflicting, which is likely due to DPE reliance on the DoI Water submission which did not consider the findings on the model class review by DPE's own expert.

The modelling and the uncertainty analysis undertaken by Dr Noel Merrick of Hydrosimulations throughout the RTS is world class and cutting edge, and Hume Coal was fully committed to undertaking a very robust and conservative approach to the groundwater model, knowing it would be a key aspect for consideration for the project. The project was the first project to undertake uncertainty analysis at this scale and to fully adopt and implement the draft IESC uncertainty guidelines.

DPE's expert stated 'the model is considered to be confirmed as Class 2: suitable for impact assessment'.

2.4.2 Local geological data

Section 6.2.4: DPE stated that "*understanding of the local geology has been a key criticism" and that "both of the independent experts on mine design raised concern about the lack of geological data, particularly in relation to the presence and nature of geological structures*".

In his response to DPE's Assessment Report, Dr Bruce Hebblewhite (2019 – refer to Appendix C) comments that the amount of data provided was quite considerable, and certainly on a par with similar mining projects at this stage of evaluation and development. Clearly geological data and information continues to be gathered as a project proceeds, and detailed mine planning is modified as required to accommodate any new or additional information.

The geological and hydrogeological data for the project considered the extensive, 345 individual drill holes for the project area (179 of which are within the proposed mining area). The hydraulic conductivity data in the model calibration is extensive and all available data for the project and surrounding mines was utilised in this calibration. The data set was extensive and the groundwater model set-up and calibration followed best practice in that all data and natural variations were considered.

There is natural variation in testing methods, with pumping tests bias towards higher conductivities (due to bores used for pumping tests always being the highest yielding bores in the district ie those that intercepted localised fractures). Core permeability provides the lower end range of conductivity. Figure 2.1 below shows that all of this data a was considered in developing the model. The model calibration was in line with best practice and considered all of this data and DPE's expert states that:

> 'Calibration of aquifer property values (Kh, Kv, S, Sy) has been well constrained by pumping test estimates of property values, and by simultaneously honouring observed groundwater levels, along with the measured Berrima mine inflow (deep system) and inferred stream baseflows (shallow system)'.
>
> On model calibration 'This is a best practice approach that reduces model non-uniqueness problems'.
>
> 'My professional opinion is that the Hume Coal model is fundamentally a good example of best practice in design and execution'.
>
> 'It is fit for mining project impact prediction purposes and the results presented are reasonable in terms of inflows and drawdown predictions.'

The IPC appeared interested in the usage from private bores as a percentage of the entitlement. This question was asked of many landholders during the public hearings held on 26 and 27 February 2019 and also asked Hume Coal in terms of the assumed percentage adopted in the groundwater model.

At the public hearing, most of the landholders asked whether they used their full entitlement stated that 'yes' they did, and particularly in dry years they definitely used all of their entitlement. These statements from landholders aligns to the model assumptions on usage. The groundwater model noted that although there was no metering of usage data, pumping from stock and domestic bores was estimated at 3 ML/yr. Pumping from high yield bores was varied during calibration with an optimal rate equivalent to 94% of the entitlement. It is noted that this percentage appears relatively high, but likely takes into account pumping from unlicensed bores and potential over-extraction from some bores (as most bores do not have meters).

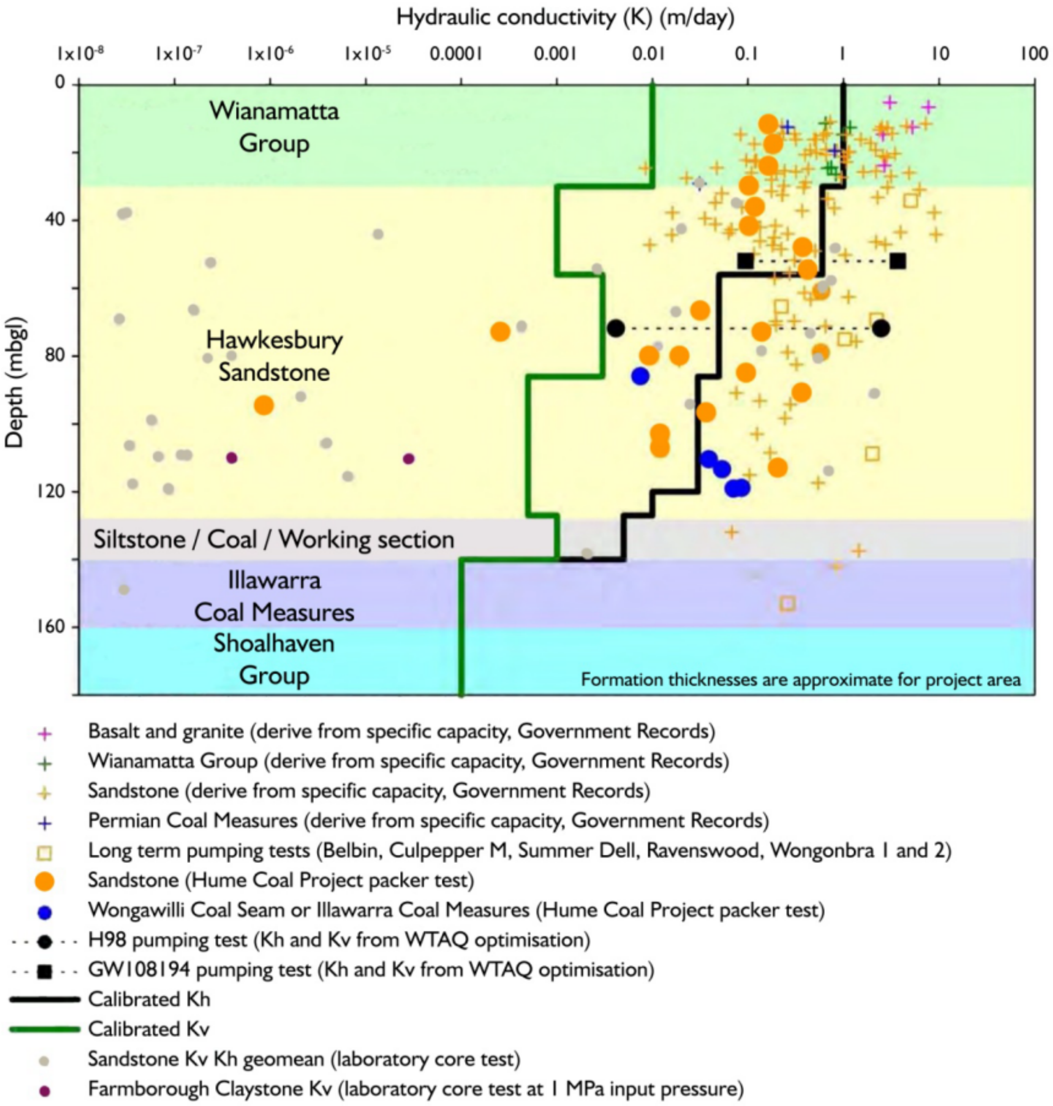


Figure 2.1 Hydraulic conductivity data considered during model development

2.4.3 Uncertainty and sensitivity analysis

Section 6.2.4 - The Department state that the final aspect of the methodology in which there is residual concern is the level of uncertainty and sensitivity analyses undertaken.

Section 6.2.4 – In the summary of this section, the Department states that given the residual uncertainties, a precautionary approach should be adopted, and the model's more conservative estimates should be used.

DPE note that its expert states Hume Coal's "combination of uncertainty and sensitivity analysis, in consultation with the regulator, is consistent with the latest best practice".

This statement is not consistent with DPE stating uncertainty and sensitivity analysis as an area of key concern. This inconsistency between DPE's comments and its expert is likely a result of the DPE reliance on the DoI Water submission which did not consider the Middlemis review.

The uncertainty analysis for Hume Coal was developed in consultation with DoI Water. The uncertainty analysis focused on the most sensitive model parameter, hydraulic conductivity. The Hume Coal model uncertainty analysis tested a large range of hydraulic conductivity values from known data within the area, but produced a relatively 'tight' range of inflow volume and drawdown. This equals high confidence in model results (ie drawdown and inflow).

When considering uncertainty, standard modelling adopts a 'most likely' approach, which in the context of uncertainty analysis would be the 50th%ile. It is known that many projects do undertaken uncertainty, but only report this 50th%ile at the recommendation of the groundwater modellers as their 'most likely scenario'.

The difference between uncertainty and sensitivity is that sensitivity analysis uses multiple model runs to assess the importance of particular parameters values on model predictions. This was undertaken for Hume Coal and it was determined that hydraulic conductivity was the most sensitive parameter, and hence why it was then the parameter that was subject to the detailed uncertainty analysis.

Uncertainty analysis tests ranges of known measurements (in Hume Coal's case, this was a known and measured range of hydraulic conductivity data). This method of uncertainty analysis allows for more robust quantification of uncertainty.

In terms of reporting results:

- 50th %ile (ie median) is used in most models that are prepared to support an EIS;
- all standard models are 50th %ile;
- Pilbara uncertainty analysis recommended 20th%ile to 80th%ile range should be used; and
- in many known mining cases, uncertainty analysis is undertaken, and then the standard 'base case' model is either adopted or amended and then results that align to the 50th%ile are submitted in the EIS.

Hume Coal adopted the 67th %ile (ie rather than the 50th%ile) in reporting results, because of known community and social concerns and a desire to be conservative. It is considered inappropriate to go to the next level and adopt the 90th%ile results due to the following reasons:

- 90th %ile is extremely conservative – '*Not likely to occur even in extreme conditions'* (IESC 2018). This description is taken from the IESC Explanatory Note, Uncertainty Analysis in Groundwater Modelling. The IESC have developed text descriptors for the different categories to *'help avoid subjective decision-making biases by the water manager or the project proponent'*;
- the volume of water being licensed by Hume Coal is the physical take of water, plus the inflow to the void (which remains in the groundwater source). No other mines in NSW licence both 'take' and the 'inflow to sealed/disused workings'. In most cases the net take is licensed, and not the indirect inflow to workings with is very rarely modelled or reported;
- the volume of water being licensed is 2,059 ML, which is the maximum 'interception' in year 17. The physical take maximum (ie 'to sump' water) in year 17 is only 1,009 ML (the underground mine sump is where groundwater inflow to underground workings will be captured);
- the 50th%ile is used in all other mines in NSW, many with much less robust modelling or uncertainty analysis than what Hume Coal has undertaken; and
- adoption of the 90th%ile will establish a precedent for mine approvals that will be counter to the science and openness involved with modelling uncertainty.

Table 2.2 Description of probability class

Narrative Descriptor	IESC Probability Class	HydroSimulations Percentile Class	Description	Colour Code
Very likely	90-100%	0-10%	Likely to occur even in extreme conditions	
Likely	67-90%	10-33%	Expected to occur in normal conditions	
About as likely as not	33-67%	33-**67%**	About an equal chance of occurring as not	
Unlikely	10-33%	**67**-90%	Not expected to occur in normal conditions	
Very unlikely	0-10%	90-100%	Not likely to occur even in extreme conditions	

2.5 Impact assessment outcomes

2.5.1 Predicted drawdown and impacts

Section 7 (page 40) - Level of impact

DPE state that *'the project is predicted to have significant impacts in a highly productive groundwater aquifer'*... and that ....*'the predicted drawdown impacts on this aquifer would be the most significant for any mining project that has ever been assessed in NSW'*.

The NSW Aquifer Interference Policy (AIP) defines highly productive aquifers as those that have bores that can yield in excess of 5 L/sec and a salinity level of less than 1,500 mg/L. The project has been assessed by DPE under the AIP as a 'highly productive aquifer'. However, in accordance with information on the relevant NSW Government database (NSW DPI Water, 2015 PINNEENA Version 11.1 Groundwater Works database), the yield of bores within 9 km of the project area has an average yield of 2 L/sec, which is lower by more than half of the definition of a highly productive aquifer. Notwithstanding, Hume Coal has conducted the assessment on the basis of the aquifer being defined as highly productive. This demonstrates the conservative approach taken by Hume Coal to assess and consider the impacts from the project, and also suggests that DPE has overrepresented the productivity of the aquifer based on the information available on the Groundwater Works database.

The depressurisation and drawdown extent from Hume Coal operations is modest compared to many other assessed mining projects in NSW and is by no means the '*most significant of any mining project that has ever been assessed in NSW'*.

The groundwater depressurisation (impact) for approved coal mines across NSW have been considered over recent times and results presented in a series of graphs (Figures 2.2 to 2.3). It is presumed that the mines have been approved on the basis that the levels of impact are deemed to be acceptable to the NSW Government and the people of NSW. When considering the project in comparison to other coal mines, the project compares favourably.

Comparison of Hume Coal to many other coal mines that are already approved or currently being considered for approval provides context for the concern that DPE has that the project represents 'unprecedented levels of impact'. In many circumstances, the predicted change in water pressures and levels as a result of the project is far less that other currently operating and approved mines. These comparisons are illustrated in Figures 2.2 to 2.4, where publicly available data from the NSW Major Project website has been researched and graphed to provide context. Not all information is available for all aspects of each project, as reports and assessments do not always report the exact same information, and mines are across various coal basins and are a mix of underground and open cut. Regardless of the different project location, size, mining method, depth of cover etc, the graphs provide context for decision makers in considering the project in comparison to other mines and provides context to the DPE claim about an 'unprecedented' level of impact.

In the presentation by a DPE representative, Clay Preshaw, at the Public Hearing for the project on 26 February 2019, Clay clarified that the DPE claims of 'unprecedented level of impact' only applies to the number of bores impacted and not the level of environmental impact (ie drawdown or inflow).

The distance to the maximum 2 m drawdown contour (as required to be considered under the AIP is tabulated for 11 mining projects in NSW, with the drawdown extent predicted for the project being 25% lower than the average drawdown predicted across these 11 projects (Figure 2.2).

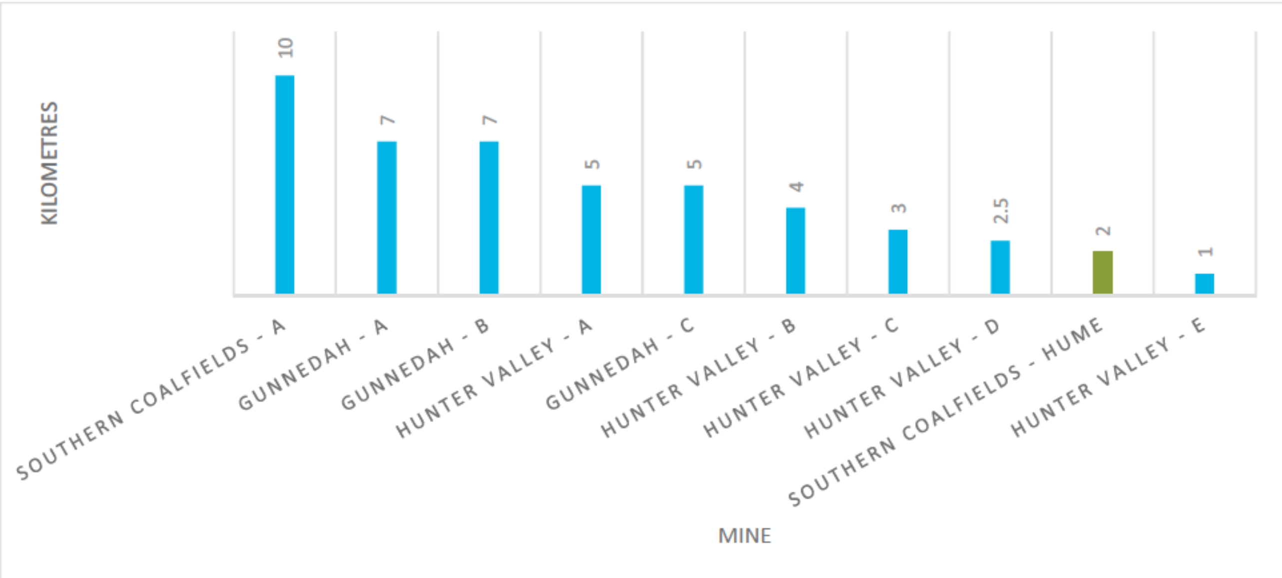


Figure 2.2 Distance to 2 m drawdown in landholder bores

The time taken for the mining induced drawdown to recover to within 2 m of all bores for the project is relatively minimal (72 years) compared to other operating and approved mines in NSW (in excess of 1,000 years) (Figure 2.3).

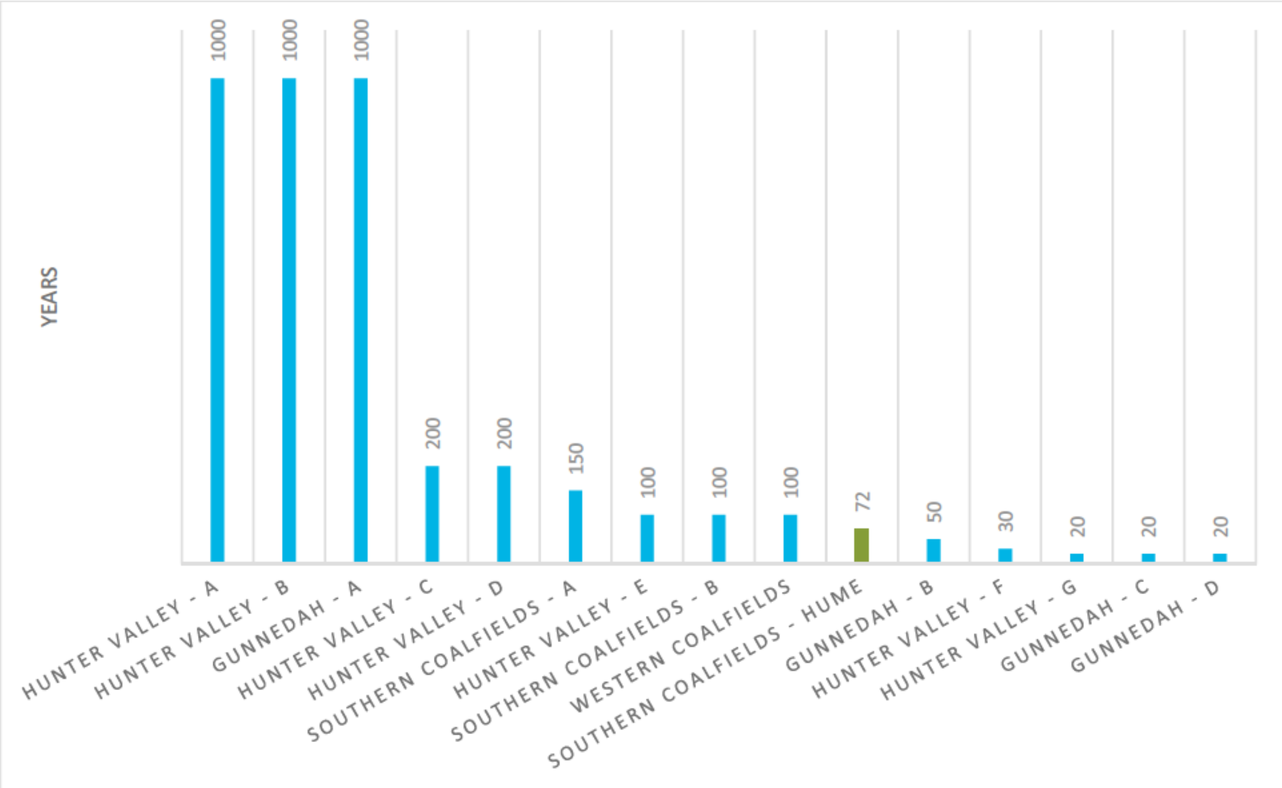


Figure 2.3 Time to recovery within 2m of the original groundwater level

The volume of groundwater inflow to the mine workings is similarly compared to other approved and accepted mines in NSW. It is clearly demonstrated here that the inflow to the Hume Coal mine is within what is commonly expected of an operational coal mine. The maximum inflow to the Hume Coal Mine includes both water that is taken from the groundwater source for operational needs, and also that groundwater that inflows to sealed voids following mining (ie remaining in the water source). Many of the approved mines are currently operational and do not have undue impacts or operational concerns with the management of the actual inflow volume (Figure 2.4).

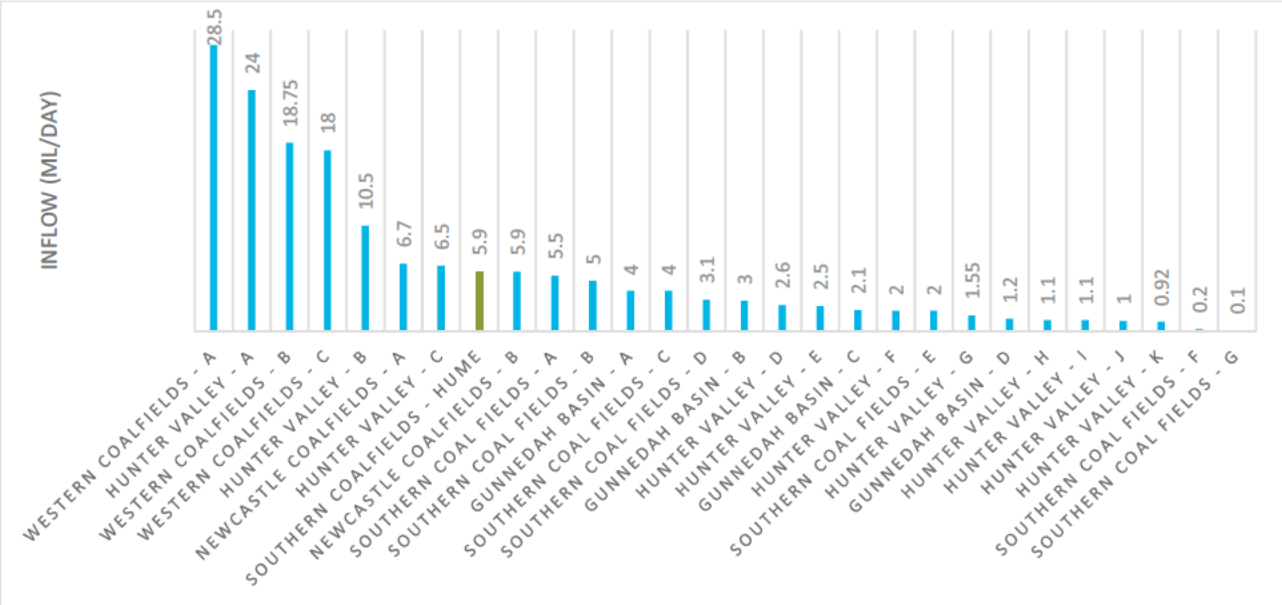


Figure 2.4 Volume of groundwater inflow to coal mine workings

Section 6.2.5 – **Predicted drawdown** – The Department note that the EIS and Response to Submission report adopt the 67th percentile to make predictions relating to the probability of groundwater drawdown. They then go on to say this means there is a 33% chance that the actual drawdown impacts would be greater than the predictions.

Therefore, the Department considers a more conservative range of predictions should be used to assess groundwater impacts.

Section 6.2.5 - consideration of drawdown impacts – The Department claim that the precise level of impacts that are predicted is not certain, given the range of modelling results provided to date.

Section 6.2.5 - **consideration of drawdown impacts** – The Department claims that even the less conservative predictions would amount to the most significant impacts on groundwater drawdown for any mining project that has been assessed in NSW. DoI Water also state that the drawdown on 94 privately owned bores is unprecedented in similar projects.

The environmental impacts from the Hume Coal Project are modest compared to other assessed (and many approved) mining project in NSW. The number of bores impacted is relative to the number of bores and ownership of overlying land and is not relative to the environmental impact of the mine.

2.5.2 Water quality

Section 6.3.5 - If the project was amended to include a water treatment plant and surface water discharges, that would be a significant amendment to the existing Hume Coal Project. It would require a detailed assessment of the impacts associated with the construction and operation of such infrastructure, and the water quality of the discharges.

The IPC questioned the quality of the water and reject emplacement underground and the resulting long-term groundwater quality of the overall groundwater source.

i Surface water management

The mine water management system has been designed to ensure that no coal contact water is released to surface waters. Runoff from coal contact areas will be captured in various basins and dams (SB01, SB02, MWD05, MWD06 and MWD07), and will be transferred to the Primary Water Dam (PWD). The revised water balance base case modelling adopting groundwater inflow estimates has demonstrated that there will be no releases or overflows from sediment basins (SBs) and main water dams (MWDs) capturing coal contact water (ie no releases or overflows from PWD, SB01, SB02, MWD05, MWD06 or MWD07). The results of the revised water balance modelling are provided in Section 3 of the Revised Surface Water Assessment report (WSP, 2018) contained within the RTS.

Predicted releases from SB03 and SB04 are provided in Section 3.2.2.3 of the Revised Surface Water Assessment report (WSP, 2018) contained within the RTS. The maximum annual releases to Oldbury Creek from SB03 and SB04 were 30.6 ML/yr and 41.1 ML/yr, respectively, based on 107 water balance realisations. The maximum 19-year sum of releases to Oldbury Creek from SB03 and SB04 were 277 ML and 302 ML, respectively, based on the 107 water balance realisations. In the event that water quality in SB03 and SB04 does not meet the discharge limits, water will not be released to Oldbury Creek and will be contained within the mine water management system.

The PWD has the capacity to store all runoff from SB03 and SB04 catchments, if required. Additional water balance modelling adopting groundwater inflow estimates predicts a peak stored volume of 714 ML in the PWD if there are no releases from SB03 and SB04 to Oldbury Creek based on the 107 water balance realisations. The predicted peak stored volume of 714 ML is lower than the modelled capacity for the PWD of 730 ML.

The water quality of the PWD and the underlying groundwater source (following emplacement of tailings) was considered in detail in both geochemisty reports and in hydrogeochemical analysis and modelling of both systems.

ii Primary water dam

The PWD modelled water quality is neutral with a range of pH values from 6.03 to 8.25. The PWD will remain neutral over the mine life, including during the modelled dry period where evapoconcentration is dominant (RGS).

The major ion composition of the PWD is dominated to Chloride (Cl), Sodium (Na), bicarbonate (HCO3), sulfate (SO4) and calcium (Ca) with lesser magnesium (Mg) and potassium (K). Although some metal(oid) concentrations were above drinking water (ADWG) and ANZECC criteria for freshwater ecosystems, none of the metal(oids) exceeded the ANZECC criteria for livestock (RGS). There are no releases to surface water systems from the PWD. It has been designed and modelled to ensure it does not spill, even during wet weather sequences.

iii Emplacement of tailings and excess water from the PWD underground

Water management options

Shallow reinjection of excess water from mining operations in the Hawkesbury Sandstone was one of the original strategies considered for water management. Hume Coal undertook two detailed desktop studies to consider and model reinjection into the Hawkesbury Sandstone. It was a preferred option for the management of surplus water as it would reduce drawdown impacts, reduce the reduction of baseflow and provide efficient emplacement of water back into the key area of the water source. Hume Coal considered this option in some detail, including numerical modelling of the option detailed scoping for an injection trial. The reason this option did not progress was the inability of Hume Coal to secure a licence from DoI Water that allowed a trial reinjection test to occur on site. Steps taken to obtain a licence for a reinjection trial by Hume Coal include:

- Hume Coal applied for a licence to reinject (on 28 May 2015), with a detailed proposal and reporting of potential impacts, an outline of the reinjection design and the volume associated with the 7-day reinjection trial (including where water would be licensed and sourced from for the trial);

- 12 months of negotiations followed lodgement of this application and shifting of potential approvability between officers and NSW Government agencies including DoI Water, Water NSW and the EPA;
- Hume Coal were then told that there was no licence mechanism within either the NSW *Water Management Act 2000* (WM Act) or the NSW *Water Act 1912* to do this activity;
- Hume Coal continued to attempt to negotiate for another two years with DoI Water on this matter, and then gave up due needing to progress other alternatives for the EIS; and
- it is noted that prior to and during these negotiations, Iluka Resources Limited ran several long-term pumping and reinjection trials at its Balranald Mineral Sands Project that occurred for periods in excess of 30 days and involved very large volume of groundwater. These activities were licenced under the NSW *Water Act 1912* and Hume Coal was aware of these examples at the time and did reference this in negotiations with DoI Water.

Hume Coal was effectively prevented from exploring shallow reinjection of excess water further due to the inability to obtain approval or a licence from DoI Water. Apparently, there appears no mechanism in NSW to approve the activity of reinjection of groundwater, irrespective of the ability for Iluka Resources Limited to obtain licences for the same activity.

As a result, Hume Coal then made a decision to progress with pumping the water into down dip and or sealed panels in the underground workings.

Water quality considerations

Once mined, the panels will contain open voids that will be used for the emplacement of coal reject (the coarse and fine rock separated out of the coal during processing). All coal rejects will be alkaline amended with limestone (to buffer any acid generation) and mixed with water from the coal preparation plant in a 60% solid, 40% water mixture and then emplaced underground. Excess water from the PWD will also be pumped underground into these open (downdip) panels, and then bulkheads installed. This method is international leading practice to minimise impacts to the environment (RGS 2018). This method was selected in consultation with DPE and to give the following social and environmental benefits (RGS 2018):

- eliminates co-disposal of rejects and tailings at the surface;
- significantly reduces visual, dust and noise impacts associated with surface emplacement;
- reduced surface disturbance; and
- allows groundwater to recover more quickly.

The chemistry of the combined reject and added groundwater within the panels during operation and at the completion of mining was assessed by RGS in 2018.

The underground voids water quality are neutral with a range of pH values from 6.06 to 6.11 (note that the average pH of the Wongawilli Seam is 5.5 (RGS 2018)).

The groundwater quality in the void is dominated by bicarbonate (HCO3), alkalinity, chloride (Cl), sodium (Na), sulfate (SO4) and calcium (Ca) with much lesser magnesium (Mg) and potassium (K). It should be noted that the metal(oid) concentrations are predominantly equal to or lower than the average ambient groundwater conditions in the Wongawilli Seam. The nickel (Ni) concentration remained well within the range in the baseline measurements for Wongawilli Seam, although the average increases slightly (RGS 2018).

A total of 25 Kinetic Leach Column (KLC) tests completed for the Hume Coal Project on various composite coal, coal reject and drift spoil materials, and columns were leached with either deionised water or groundwater (sampled from the Wongawilli Seam). The results of these tests emulated conditions experienced by coal reject materials after underground placement and groundwater recovery. Results indicate low metal/metalloid release rates under these conditions (Geosyntech 2016).

The KLC and hydrogeochemical modelling results demonstrated that crushed limestone addition to coal rejects was beneficial and resulted in leachate that is indistinguishable from natural groundwater quality (Geosyntech 2016), and therefore is highly unlikely to change the quality of the groundwater resource.

Whilst some groundwater interaction with the stored coal reject materials may occur over time, the interaction is very small and any trace levels of coal processing chemicals remaining in the coal reject slurry will be significantly diluted and indistinguishable from the natural groundwater quality (Geosyntech 2016). Therefore, the potential for any changes in water quality for users accessing coal seam groundwater down gradient of the proposed mine is considered non-existent.

The process of osmosis has been considered at the request of the IPC. Osmosis is defined as being the passive movement of water from solutions of low concentration of solutes (ie low salinity water) into those of high concentration (ie high salinity), thereby causing the concentrations to move toward being more equal in concentration. For the project, the water quality of the emplaced rejects and water into the underground workings is 'indistinguishable' in solute concentration and signature to the groundwater within the Wongawilli Coal Seam. Therefore, the process of both osmosis will be minimal (as water qualities are similar) and the downgradient impact to water quality along the long term flow path (ie once groundwater recovers) will be non-existent, and measurable change will not be detected.

2.5.3 Make good strategy

i Technical feasibility of make good

The DoI Water did not raise any major concerns about the technically feasibility of the proposed options for make good. Section 6.2.5 of the DPE Assessment Report states that:

> 'while the Department agrees that the options of deepening or replacing the bores may present challenges, the department generally accepts that the Applicants proposed make good options are technically feasible.'

On the subject of technical feasibility of make good, DPE's expert states:

> 'all these arrangements are reasonable in principle'
>
> 'Dewatering of one horizon (the mined coal seam), does not preclude the occurrence of saturated aquifer conditions above';
>
> 'Depressurisation does not dewater an aquifer unit, it simply lowers the groundwater pressure level'; and
>
> 'Berrima Colliery demonstrates that depressurization and or dewatering of coal seams does not preclude access to viable aquifer resources, even overlying the mined area'.

The schematic in Figure 2.5 illustrates the manner in which depressurisation of a groundwater source can occur without dewatering. Although bores above the mine will be depressurised (ie experience drawdown), the formation will remain saturated throughout mining and bores will continue to operate, all be it at a lower pressure head and likely at a lower yield.

The make good strategy is therefore very flexible in its approach and will be tailored for each individual landholder depending on their respective and individual needs and the location they are in (ie are they immediately above the workings or to the side). Some landholders may require a make good agreement that replaces their one deep bore with several shallower, larger diameter bores to maintain the required yield, whereas, some landholders with lower yield requirements may prefer a large above ground tank or dam, with assistance with increased pumping costs to run the pump more frequently.

Options are many and varied and may include one or more of the following:

- financial assistance to cater for increased pumping costs (ie for increased electricity requirements from having to pump from a bore with a lower head);
- deepening of pump inside bore casing (this may or may not be feasible depending on bore construction and current condition);
- replacement bore/s, which may include:
    - several bores to maintain required yield;
    - larger diameter bores (providing higher yields than narrow diameter bores);
    - deeper bores (ie below the coal seam), provides either/or:
        - larger storage volume of water;
        - greater available pumping head; and
        - larger yields if deep fractures encountered;
    - bores located on other areas of the property (ie for some larger properties, moving the bore away from the mine will be sufficient to avoid impacts); or
    - alternate water supply, which may include enhanced surface water capture (enlarging dams, new dam).

The number of bores requiring these different options are listed in Table 2.2 (in Section 2.5.3(iii)(a)).

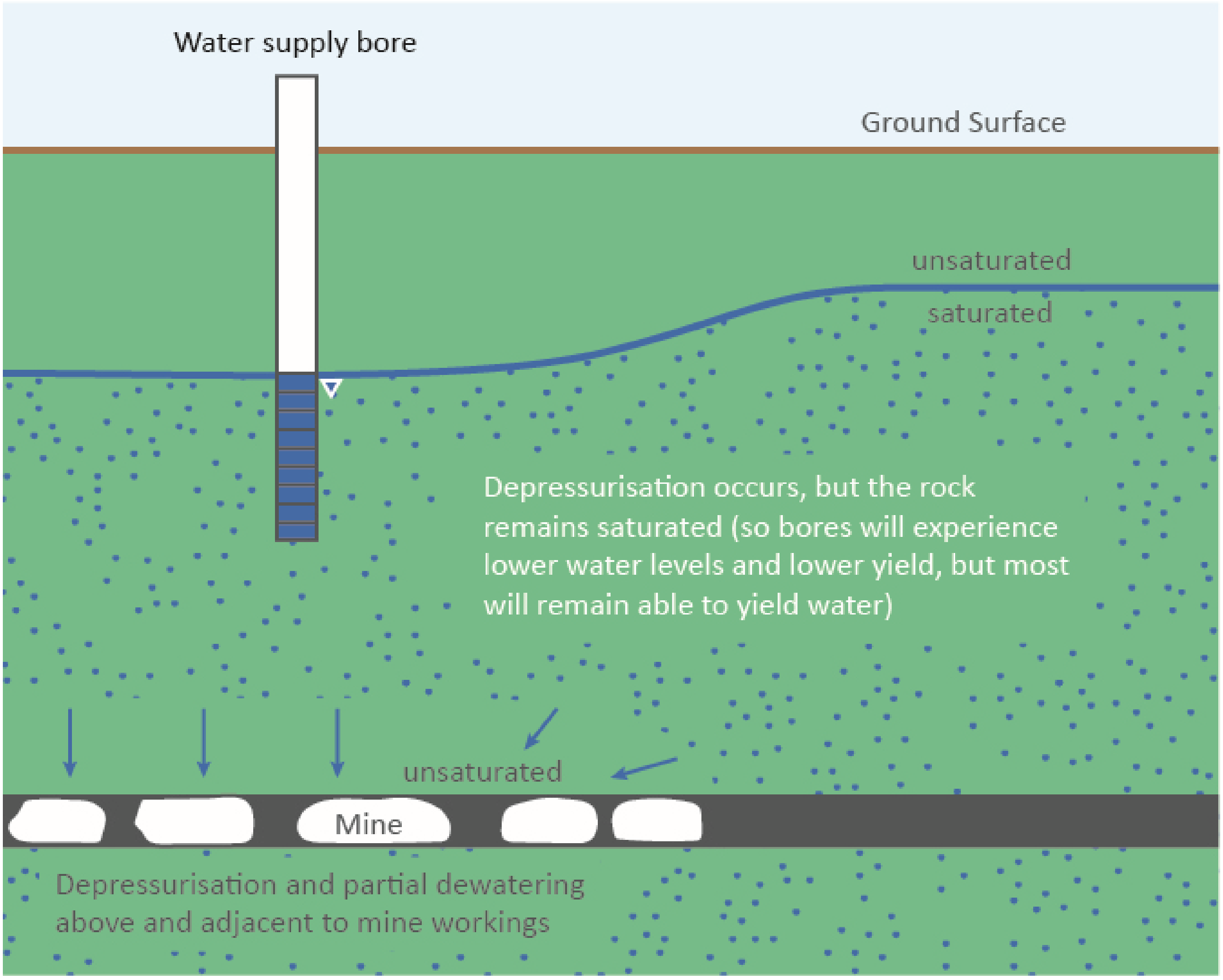


Figure 2.5 Depressurisation versus dewatering

ii Environmental v social aspects of make good

It is noted that whilst the DPE agrees the options of deepening or replacing the bores may present administrative challenges, the Department generally accepts Hume Coal's proposed make good options are technically feasible. DPE's expert, Hugh Middlemis, states that:

- dewatering of one horizon (the mined coal seam), does not preclude the occurrence of saturated aquifer conditions above;
- depressurisation does not dewater an aquifer unit, it simply lowers the groundwater pressure level; and
- Berrima Colliery demonstrate that depressurization and or dewatering of coal seams does not preclude access to viable aquifer resources, even overlying the mined area.

iii Suitability and practicality of make good

Section 6.2.5 [pg 24] – it is stated that the Department considers there are several important reasons that mean the provision of make good arrangements for up to 118 bores is not suitable or practical, as follows:

i) there would be substantial disruption to the community through a difficult, ongoing process of negotiating and implementing make good arrangements;

ii) there is considerable disagreement between Hume Coal and landholders about both drawdown impacts and the proposed make good options. Whilst a particular make good option may be technical feasible, it may not align with the landowner's preference; and

iii) the process is likely to rely heavily on dispute resolution to resolve disagreements between Hume Coal and the landowner. The Department states that it is reasonably foreseeable it will be in a position of managing an extremely large number of ongoing disputes throughout the life of the mine and beyond.

There is agreement from DPE, DPE's expert, and Hume Coal that make good is technically feasible. Other mining projects in NSW are generally approved with conditions that 'make good' of impacted landholder bores needs to be implemented should the project cause groundwater drawdown of greater than 2 m in a landholder bore. Due to the large number of bores involved for Hume Coal a staged approach to make good is proposed, and this is similar to how Tahmoor undertake their make good requirements.

Therefore, the main area of concern is not whether 'make good' can be undertaken, it is whether there will be unacceptable levels of community disruption. The issue is therefore not technical or practical or impact related, it is about community participation.

The perceived lack of community participation in 'make good' is subjective, and not considered to be a substantial reason for the recommendation to not approve the project. These DPE comments potentially undermine the proponent to have a fair and rationale assessment of the project.

The reality is:

- access arrangements with over 20 landholders have already been agreed and monitoring is underway;
- the average drawdown for all bores in the area is only 6 m; and
- only 16 bores are required to be made good in the first five years of mining.

Community engagement for the project can be addressed with support and endorsement from the NSW Government for the project and in support of the NSW Governments own 'make good' process that is applied via the AIP. Support for the make good process and clear policies on reasonableness and dispute resolution would assist with not only this project, but others in NSW.

The key issues with the make good as stated by the DPE are disruption to the community, disagreement on the actual impacts and optimal 'make good' measures, and NSW Government needing to be involved in large numbers of ongoing dispute resolutions. These issues are addressed below.

a Disruption to the community

Disruption to the community has been carefully considered and a staged approach to make good is proposed. There are 16 bores are predicted to be impacted by more than 2 m within the first five years of mining and these landholders have been contacted and advised of this (Table 2.2). The advice to them included the fact that they are likely to be impacted by more than 2 m, the associated hydrograph prediction of their level of impact has been provided, and advice that they are eligible for 'make good' arrangements. Hume also offered to undertake a site visit and bore assessment so that discussions around what would constitute a suitable 'make good' arrangement for these individual landholders can commence.

In summary the minimisation of disruption to the community is summarised as:

- make good staged in five years lots (other operations do this in line with extraction management plans);
- strategy is flexible and suitable operational arrangements will be made for each individual landholder and may consist of one or more options (ie may be a replacement bore and above ground tanks, and compensation for increased pumping costs);
- the legal construct for 'make good' is that it is a landholder entitlement. Therefore, if individual landholders don't choose to exercise that right, then there is no dispute. It is an 'opt in' arrangement;
- there are only 16 bores in first five years that need to be made good; and
- 64 bores (68% of all affected bores) can be made good with minor strategies such as increased pumping costs and lowering pumps.

Table 2.3 Make good staged approach

Time when bore first impacted by 2 m drawdown	0-5 yrs	5-10 yrs	10-15 yrs	15-20 yrs	20-25 yrs	+25 yrs	Total
1. Increased pumping costs	-	3	7	9	5	7	31
2. Deepen bore	6	9	13	3	2	-	33
3a. Replace stock/domestic bore	5	4	2	2	1	1	15
3b Replace an irrigation bore	5	8	1	1	-	-	15
Totals	**16**	**24**	**23**	**15**	**8**	**8**	**94**

b Disagreement on the actual impacts and optimal 'make good' measures

The predicted drawdown impacts for individual bore has been modelled using the regional model developed to predict mine inflow and regional depressurisation and drawdown. The model predicts results for bores with reference to the nearest model cell for the location of the bore, and the bore screened depth is attributed to one of more model layers. The model is very accurate at the regional scale, but there will be differences between model predictions and reality at a local scale (ie at a bore level). This is known and over time with additional data from individual landholder bores and inclusion of local refinements to the model the differences will converge. It is also noted that the model has been based on conservative assumptions, and as such the actual impacts are also anticipated to be less than predicted.

The model results are based on average climate data, with consideration for wet and dry sequences. This is best practice because the ‘impact’ of the mine is being assessed (ie the difference). Therefore, the results for drawdown in bores as a standing water level (SWL) below ground will depend on the climatic sequence. For example, if an average climate sequence a bore has a SWL of 10 m, and the impact from the mine is 5 m of head in that bore, then the maximum water level it will experience is 15 m. If this same bore is in a dry sequence, its SWL may be naturally at 15 m, and then with the mine the reduction is the same (5 m), but in this dry sequence the maximum water level it will experience is 20 m (ie 5 m due to dry climate and 5m due to the mine). Conversely, in wet years the actual drawdown levels will be less.

Model verification, and fine tuning of the model over time is a firm commitment that Hume Coal has made and is a key component of the make good strategy. Hume Coal wants to work with the community as much as possible to ensure the model accuracy at the local scale can be matched to actual impacts and therefore minimise the disagreements and community angst surrounding impacts.

As stated above, the regional model is very accurate, and the level of depressurisation and drawdown in bores is accurate at this regional scale. Therefore, although differences do occur they are most likely to be in areas of high/low relief, and or due model layers and climate averages. However, the total drawdown (ie the maximum) is very well known, and Hume Coal are very confident that even with local differences the regional impacts and number of bores that will require make good is very accurate. This is demonstrated via the uncertainty analysis which shows a modest increase in the number of bores when moving from 67^{th}%ile to 90^{th} %ile. This small increase in the number of bores provides a high level of confidence in the accuracy of the model and predicted impacts to bores.

Make good measures will be negotiated openly with individual landholders. Provided both parties are agreeable and not unreasonable in demands, Hume Coal sees no reason why suitable make good arrangements cannot be made with each landholder. Hume Coal understands that the NSW Government has undertaken some work and potentially has a draft paper that considers the ‘reasonableness’ of make good measures. This work is understood to set out a process and consider what a reasonable request is (ie from a landholder) for access to water or compensation, and considers examples where landholders may claim make good for levels in excess of current entitlements or current use. Equally, it sets out what is reasonably expected to be offered by the proponent in options for individuals to make good.

c NSW Government needing to be involved in large numbers of ongoing dispute resolutions

The legal construct for ‘make good’ is that it represents a landholder entitlement. Therefore, if individual landholders do not choose to exercise that right, then there is no dispute. This is an ‘opt in’ arrangement.

Disputes over the ‘reasonableness’ of make good proposals may occur once negotiations commence. However, Hume Coal is committed to ensuring landholders maintain their level of access to water, so provided landholders do not have unreasonable levels of expectations and demands there should be no dispute. If the NSW Government does have a draft paper or a policy on reasonableness of make good, then this would be very beneficial for not only the project, but also other projects (tunnels, mines etc) as a benchmark.

2.5.4 Water licensing

The project will need to licence the maximum interception volume in year 17 of 2,059 ML from within Management Zone 1 of the Sydney Basin Upper Nepean Groundwater Source. For perspective, this volume is compared to the volume of water within the groundwater source:

- 16% (approximately) of available water within Management Zone 1;
- 2% of the available sustainable yield (LTAAEL) within the Sydney Basin Upper Nepean Groundwater Source;

- 0.9% of the total annual recharge to the Sydney Basin Upper Nepean Groundwater Source; and
- 0.003% of the water in storage within the Sydney Basin Upper Nepean Groundwater Source.

For additional perspective the Hume Coal maximum licence volume compared to WaterNSW's licence volume is:

- 0.209% of the WaterNSW licence take volume for the Warragamba Catchment; and
- 0.0082% of the total dam storage managed by WaterNSW.

It should be noted that the above statistics are for the maximum licence volume required in year 17 of the project (2,059 ML). The average take of water from this groundwater source (ie not including water that inflows to the void but is not extracted) is 482 ML and is approximately four times less than the maximum licence volume that Hume Coal has agreed to hold.

The groundwater presence, availability and licences for the Sydney Basin Nepean Groundwater Source are shown in Figure 2.6. The information used to create this diagram as sourced from the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*, the background document to the WSP (NOW 2011), and from a recent search of the NSW Water Register (DPI Water 2016).

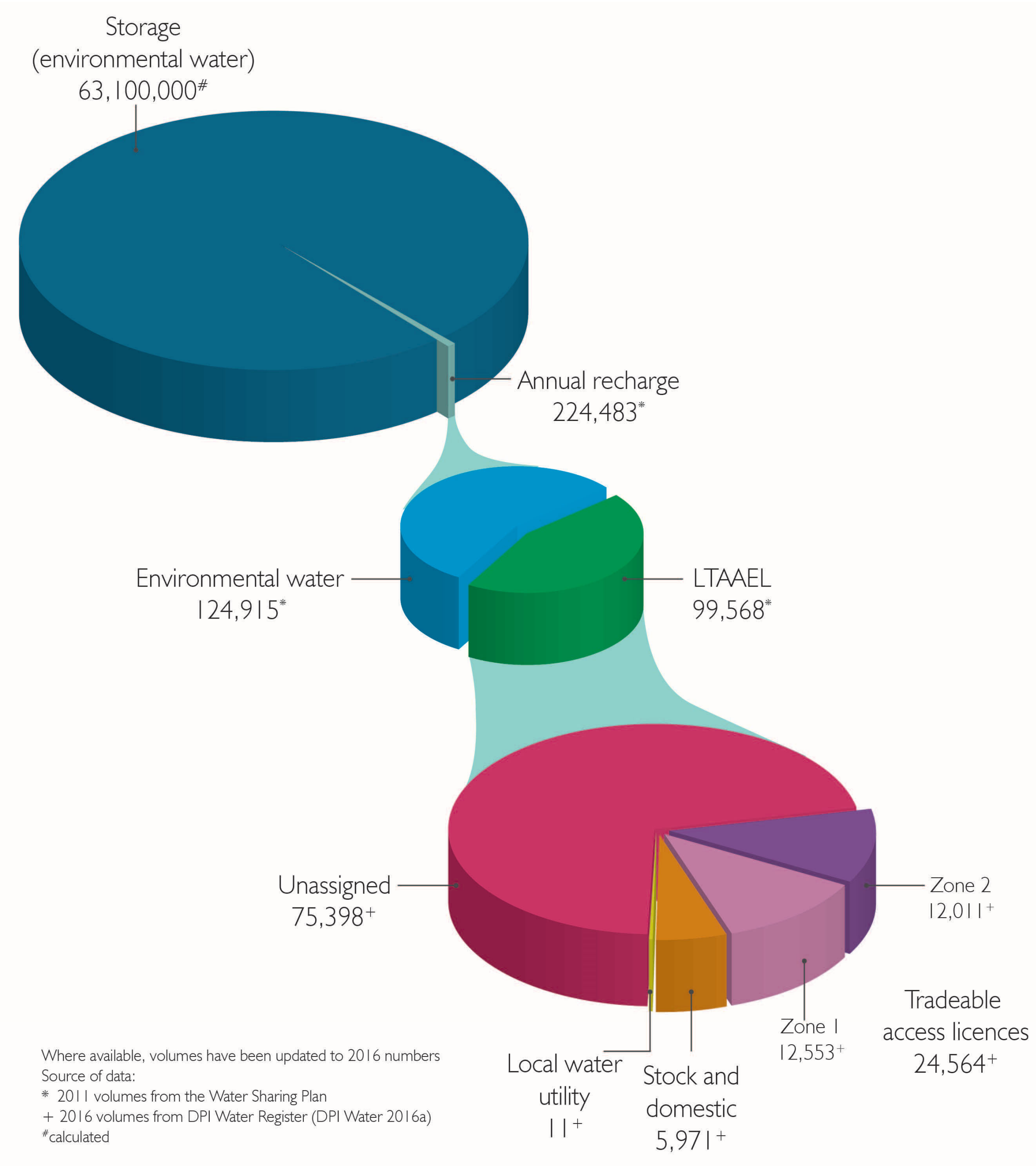


Figure 2.6 Sydney Basin Nepean Groundwater Source provisions (ML/yr)

There is clearly ample groundwater available in the regional groundwater source and surrounding catchments, and entitlements are still being granted via a controlled allocation process within Sydney basin Management Zone 2, which is approximately 2 km from the boundary of the project. The volume of water being licensed by Hume Coal is for the maximum 'interception' of water in year 17 of mining (2,059 ML). For all other years the 'interception' of water is less; the average is 1,315 ML.

Section 6.2.6 [pg 25] – it is noted that Hume Coal has based its licence requirement on the predicted groundwater inflows at the 67th percentile probability. The Department and DoI Water consider that a more conservative range of predictions should used.

The Department suggest Hume Coal should further consider its ability to acquire the necessary licences based on 90th percentile predictions, which would mean an outstanding volume of 366 ML would need to be secured.

The DPE comments regarding use of the conservative 90th%ile are based on the DoI Water concerns about model uncertainty. It is noted that in formulating this position, the DoI Water did not consider DPE's expert, Hugh Middlemis, who states the model and the uncertainty analysis are 'fit for purpose'.

Hume Coal have taken a very conservative approach to licensing of water for the project. The groundwater model predicts groundwater inflow to the mine workings in two parts, inflows to the active mining areas that can be used and recycled ('to sump' water), and inflow to sealed and down dip mining areas that is untouched and will remain in the water source ('to void' water). For the 67th%ile the combined volume of water has an average of 1,315 ML/yr with a peak in year 17 of 2,059 ML (this is the licence target). Conversely the actual water 'taken' is the 'to sump' water, and the average of the 'to sump' water is 482 ML/yr, with a peak of 1,009 in year 17. Therefore, in the peak mine inflow and year, Hume Coal will hold a licence where 950 ML of the licensed water is not physically removed from the groundwater source.

In other mining examples, the groundwater models focus on the 'to sump' water only, and the licence of the 'net/actual' take is licenced (and not the 'recovery' water that inflows to sealed mine areas as Hume Coal have proposed). The reason Hume Coal have taken this approach is because of a conservative interpretation of the AIP, and general community angst about water and licensing. Hume Coal have therefore elected to licence both the 'to sump' water and the 'to void' water, which effectively doubles the required licence volume (Figure 2.7).

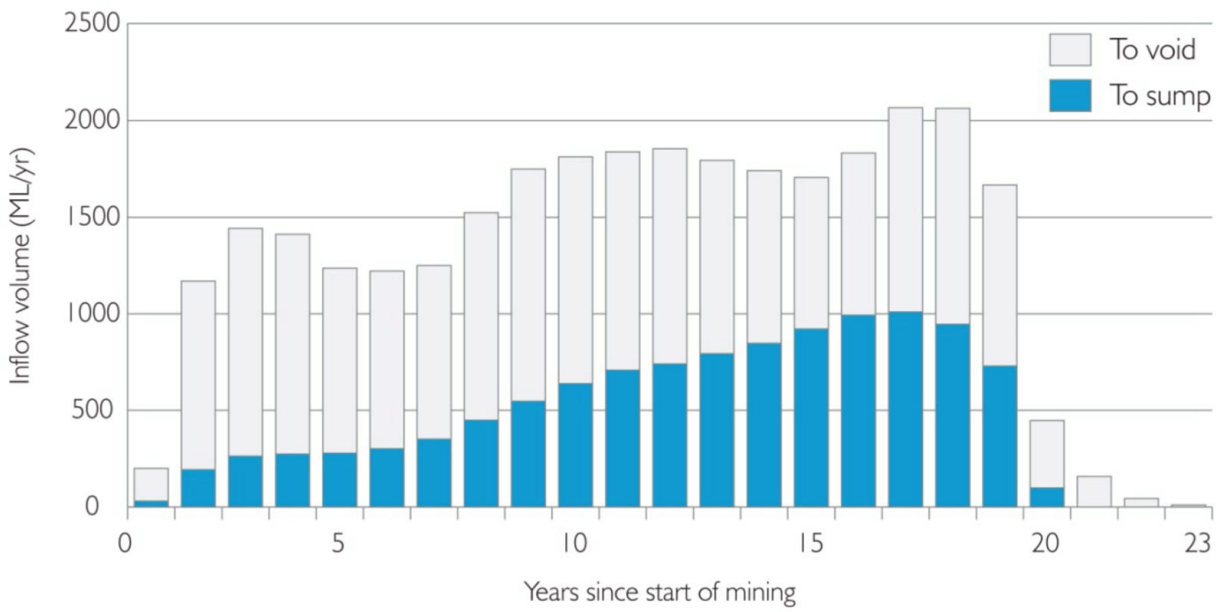


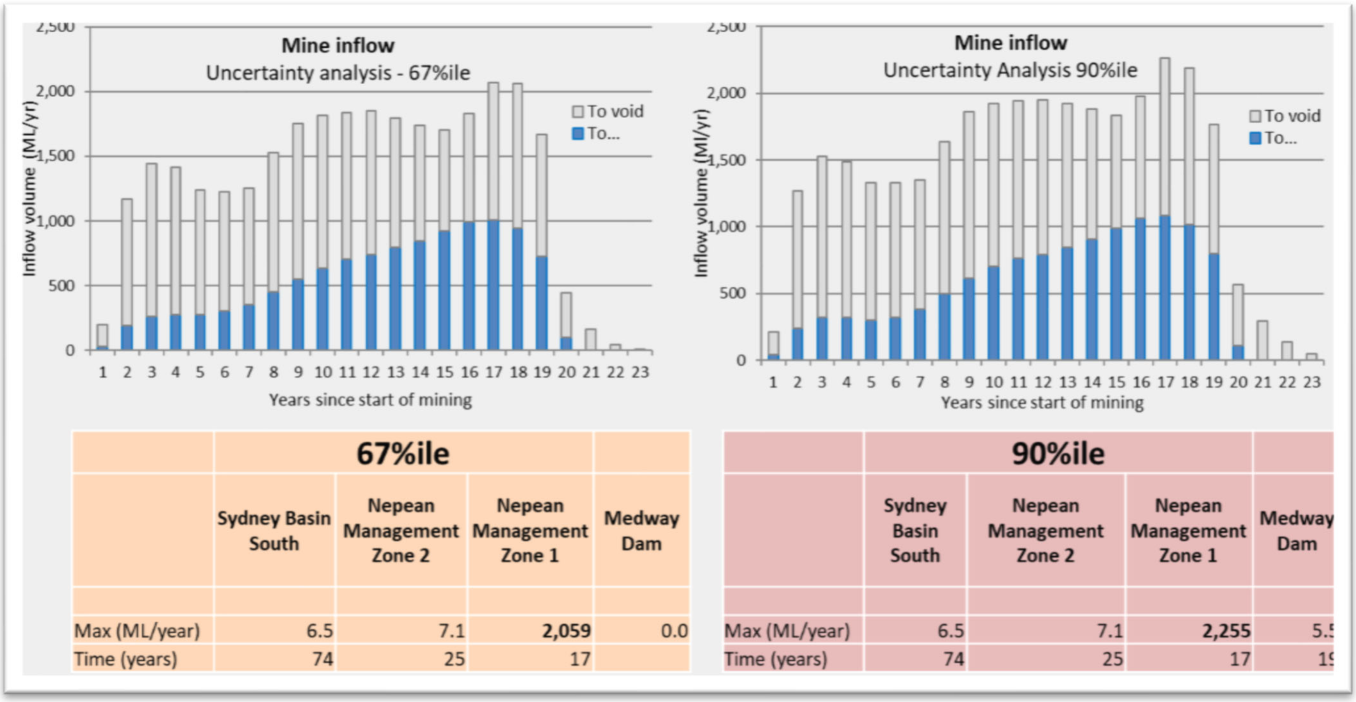
Figure 2.7 Groundwater inflow to workings

The IPC noted there is no 'return flow regulation' in place (IPC Private Briefing notes with Proponent, February 11 2018), would allow Hume to seek licence credit for this 'to void' water volume, effectively halving the licence requirement for the project. It is also noted that although announced in 2015, this return flow policy and regulation for groundwater was never introduced and is therefore unfortunately unavailable for Hume Coal, or other operations that return water to the groundwater sources they are sourced from.

The IPC questioned whether Hume Coal considered using managed aquifer recharge technology to emplace water back into the upper Hawkesbury Sandstone during mining (refer to the IPC questions in Appendix A). Hume Coal did investigate this in some detail and it was the preferred option for some time, as it assisted to offset some of the drawdown impacts in landholder bores. Two detailed desktop studies were undertaken and several model runs undertaken to consider this option. The barrier to implementing this for the project was the alleged inability of the DoI Water to 'administratively' licence this activity. Hume Coal attempted to undertake an active trial of reinjection, but were told by DoI Water that the licensing of 'injection' activities was not possible under the NSW *Water Act 1912*, or the WM Act. This is despite other reinjection trials in NSW being approved, such as the Balranald Project, which ran several high volume injection trials, some of which were in excess of 30 days continual injection into the Murray Basin. Hume Coal eventually were effectively forced to abandon the option to reinject into the Hawkesbury Sandstone.

Hume Coal have easily acquired the majority (1,909 ML) of groundwater licences for the project 'to sump' and 'to void' water at the 67^{th}%ile level (required volume is 2,059 ML). The remaining volume to be acquired is only 150 ML.

The DPE state that due to potential model uncertainty a more conservative approach to licensing should be adopted. However, Hume Coal dispute that the model results are uncertain based on the detailed modelling and uncertainty analysis undertaken. The model is deemed 'fit for purpose' by DPE's expert and therefore the adoption of 67^{th}%ile should be retained. The decision on the licensing should also consider the conservative approach taken whereby both 'to void' and 'to sump' water is being licenced.



	67%ile			
	Sydney Basin South	Nepean Management Zone 2	Nepean Management Zone 1	Medway Dam
Max (ML/year)	6.5	7.1	**2,059**	0.0
Time (years)	74	25	17	

	90%ile			
	Sydney Basin South	Nepean Management Zone 2	Nepean Management Zone 1	Medway Dam
Max (ML/year)	6.5	7.1	**2,255**	5.5
Time (years)	74	25	17	19

Figure 2.8 Comparison of 67th %ile and 90th%ile

Should Hume Coal be required to licence the 90th%ile for the ‘to sump’ and ‘to void’ water (as suggested by DoI Water and DPE), then an additional 345 ML will be required (Figure 2.8). This increase is not significant as illustrated in Figure 2.8, and this would be easily purchased on the water market from the available total pool of 12,055 ML for the Sydney Basin Upper Nepean Groundwater Source, Management Zone 1.

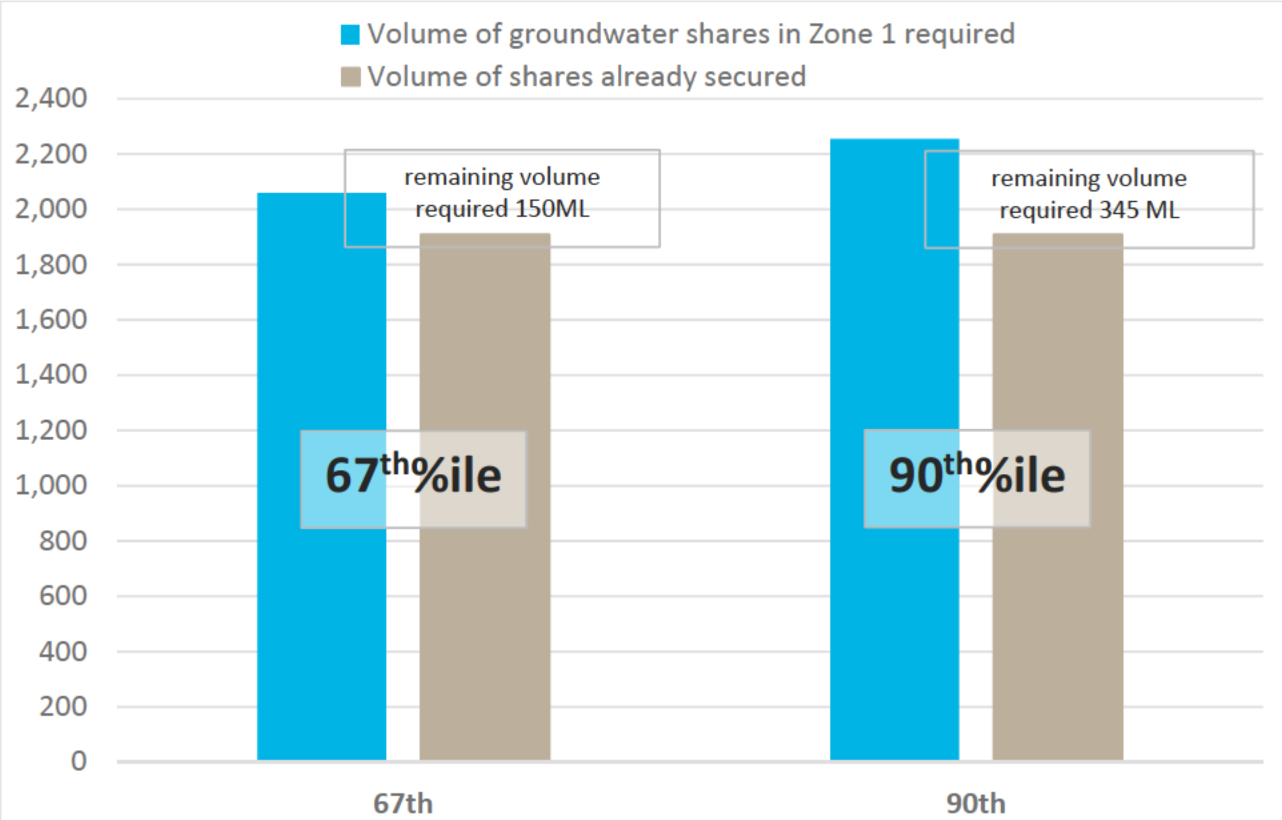


Figure 2.9 **Difference between 67th and 90th %ile licence volumes**

2.6 Summary and conclusion

Section 6.2.7 [pg 25] – The Department states that the key assessment issue for the project is the impacts on an important and highly productive groundwater aquifer, particularly in relation to the impacts on privately owned bores. Further, the Department does not consider the make good arrangements suitable or practical for the scale of impacts proposed.

The Hawkesbury Sandstone Groundwater source does not technically fit the definition of a 'highly productive aquifer' as defined by the AIP as the average bore yield within 9 km of the project area is 2 L/sec (the criteria for a 'highly productive aquifer is >5 L/sec). However, Hume Coal have taken a conservative approach to the assessment and have adopted the 'highly productive aquifer' criteria for the assessment.

The project is a low impact underground first working mine, which will not subside following mining. The design has been carefully considered to minimise impacts to overlying groundwater and surface water sources. The environmental impacts from the mine (drawdown) is modest in comparison to other approved and assessed mines in NSW, with drawdown in landholder bores extending for a maximum of 2 km from the mine workings. The inflow of groundwater to the workings is comparable (and within a similar range) to other and approximately half of this inflow remains in the water source and is never extracted.

3 Mine design

3.1 Introduction

This chapter addresses comments in DPE's Assessment Report relating to the proposed mining method and mine design, primarily in Section 6.3 of the report. The responses in this chapter are based on information provided primarily by Dr Bruce Hebblewhite. Dr Hebblewhite is the chair of mining engineering at the University of NSW and has over 40 years of experience in the mining industry, specialising in mining geomechanics, mine design, mine planning and mine safety. Additional information relating to the mine design and mining method from Russell Frith of Mine Advice Pty Ltd (Mine Advice) is also provided in Appendix C.

As discussed in Chapter 1, the assessment undertaken by DPE raises three key issues with respect to the proposed mine design:

1. the use of an 'untested' and 'unconventional' mining method and design;
2. a substantial degree of uncertainty about the methodology underpinning the geotechnical model, the local geology, and the level of risk assessment undertaken; and
3. the combination of the 'untested' mining method with the storage of large quantities of mine water underground, claiming this is likely to result in serious operational safety risks.

The issues raised in this regard by DPE, in the order they are raised in the assessment report, are addressed in this chapter.

3.2 Key issues – government agencies

3.2.1 Resource regulator

Section 5.4 [pg 15] - The Resource Regulator noted that *"the mining method is untested and has residual concerns about mine worker safety. It confirmed that the mining method represents secondary extraction, which means the proposed mining is subject to the High Risk Activity notification process.."*

The claims made that the mine method is untested and that it represents secondary extraction are addressed in the sub-sections below. The reference to a High Risk Activity is discussed in Section 3.9.

i The method is untested

There are multiple references throughout DPE's Assessment Report to the use of an untested and unconventional mining system. However, there are a number of the key individual elements of the method have been used in other mining systems in NSW and elsewhere, including the use of narrow pillars (for example fenders in pillar extraction, web pillars in highwall mining or yield pillars adjacent to longwall installation roads). The fact that a method in totality has not been tested previously is not a reason to reject it. What is important is that appropriate risk-based management practices are set in place, as in any responsible new mining operation, to ensure that a safe workplace is provided and maintained in the context of all potential risk factors present.

The Resource Regulator has also confirmed that the proposed pine feather mine design is a variation of the Wongawilli pillar extraction method (as per the DPE Assessment Report, p.31). The two methods of mining have significant aspects that are identical or very similar, as described below.

The mains development for both systems of mining are identical as shown in Figure 3.1, using the same continuous miners and associated mining equipment, the same heading widths and heights, and the same pillar size. Depending on the mine the number of headings may change, but this generally ranges from four to seven headings and is often associated with ventilation requirements.

The panel development for both systems of mining are also identical as shown in Figure 3.1, using the same continuous miners and associated mining equipment, the same heading widths and heights, and the same pillar size. The number of headings in a panel varies but is usually two to three.

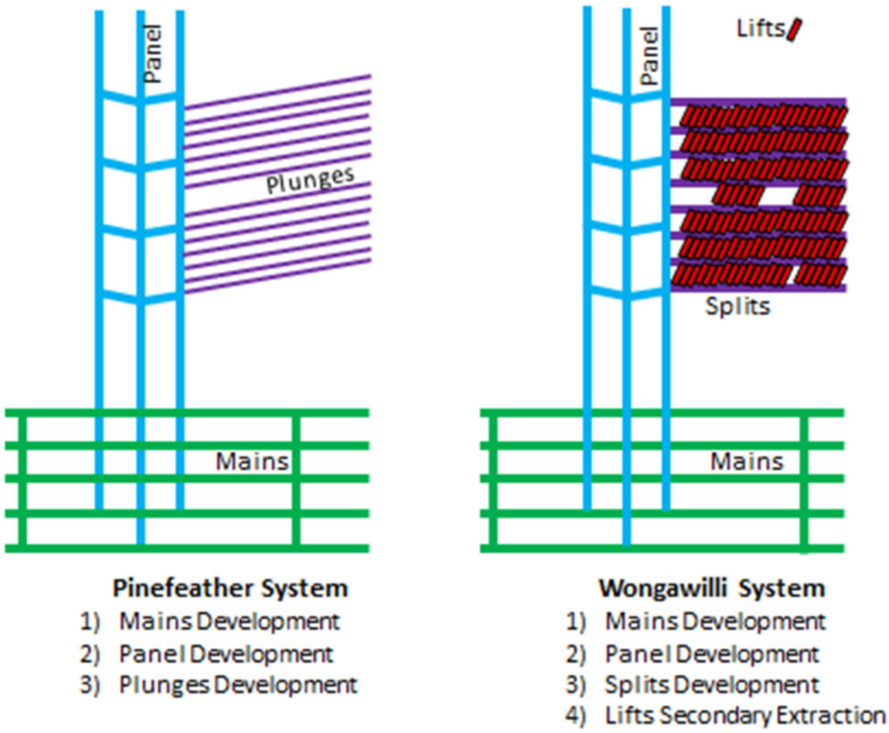


Figure 3.1 Comparison of the Pine Feather method with the Wongawilli mine method

The plunges associated with the pine feather method are driven at 70° from the panel direction, whereas the splits associated with the Wongawilli method are generally driven at 90° from the panel direction, as shown in Figure 3.1. In the pine feather system, the plunge (heading) width is 4.0 m in thickness, whereas the width in the split (Wongawilli) will typically be the normal mining width of around 5.5 m in width. These variations are so slight as to make the two mining systems effectively the same in this regard.

Hume Coal's plunges will be developed using state of the art continuous miners with an on-board navigation system, developed for highwall mining, supported by continuous haulage systems for coal haulage currently in use in Australia and overseas. What is different about pine feather to the Wongawilli is the bringing together of these various machines and technologies in a planned configuration in an underground mine.

The Wongawilli method of mining that requires splitting of the pillar and lifting of the fender (lifts) is secondary extraction. It is a clear example of developing a caving and developing of a goaf. This form of extraction presents a higher risk than simply development of roadways. It differs from the pine feather system in that the fender (web pillar) is left in place and not extracted; there is no holing of pillars, there is no goaf formation or caving, and therefore there is no secondary extraction.

Widths of the web pillars in the pine feather system will vary slightly with the depth of mining, from a minimum of 3.5 m width, increasing with depth of mining to 6.0 m width at the greater depths (170-180 m). With greater depth comes greater vertical stress/loading. A summary of the pillar and panel geometries proposed is provided in Table 3.1.

Table 3.1 Pillar and panel geometries for the maximum working height of 3.5 m

Depth of cover	Web pillar width (m)	Intra panel barrier width pillar (m)	Web panel width (excluding barriers) (m)
170	6.0	22.8	54.0
150	5.1	20.7	58.6
130	4.4	18.0	54.4
110	3.8	16.4	58.6
90	3.5	14.0	56.5

Hume Coal's mining system was called "pine feather" rather than a variation of the Wongawilli system of mining because it is not considered to include secondary extraction and is not a variation of pillar extraction.

Under the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014*, as it currently stands, permission from the Resource Regulator is not required to drive roadways of less than 250 m in length. The pine feather plunges are less than half this at 120 m in length.

In relation to safety, it is noted that pine feather;

a) does not involve the extraction of pillars between plunges; and

b) no people are required to be within the plunge.

Further, and as acknowledged by DPE, this system has come about as a result of rigorous analysis by Hume Coal to come up with a method that will result in minimal impact on the surface. The fact that it is unconventional, and there is no previous experience, does raise issues that require sound and diligent risk management approaches, but this should not be the basis for rejection of the method.

The NSW underground coal industry has seen previous successful examples of new methods introduced under such strict but appropriate risk-based management regimes. Examples include the introduction of place-change mining at Myuna Colliery in the 1980s; the first use of such a system in Australia. Another example was the introduction of longwall top coal caving (LTCC) at Austar Mine in 2006; the first adoption of this mining system outside China. More recently, the Planning Assessment Commission granted development consent to the Wallarah 2 Coal Project, which involves conventional longwall mining, but also incorporates underground stowage of brine in old mined out panels.

Innovation in mining is an important feature that offers important opportunities for continuous improvement in mining performance standards in all respects; mine safety, environmental compliance and operational efficiency. It is critical that innovative approaches not be rejected simply on the basis that they are unconventional or untested.

Further, the importance of innovation in the mining industry has been recognised by the NSW Resource Regulator, who published a policy on innovation in January 2019. This policy states that:

> We are committed to having a responsive and effective regulatory framework for work health and safety that supports the development, trial and adoption of new technologies, systems and products.
>
> The purpose of this policy is to make clear how we will ensure that the regulatory framework for work health and safety at mines and petroleum sites:
>
> - supports continuous improvement of health and safety through design, technology, product and system innovation and development
> - does not directly, or indirectly, inhibit investment in the development and adoption of improved technologies and products.

ii The mining method represents secondary extraction

The assertion or interpretation that the proposed mining method represents secondary extraction is challenged as being inappropriate. Underground coal mining can be divided into primary development or first workings, and secondary extraction. Secondary extraction is a term that has been used in the coal mining industry for many decades to refer to the process of removing solid regions of coal *after* the main roadway development has been completed. It is usually mined in a different manner, involving more than straight roadway drivage and is usually mined on the retreat. The main examples of secondary extraction are partial or total pillar extraction (by various methods); and longwall mining.

In the case of the pine feather method, each production panel is mined by development of roadways during the development process. It does not involve any subsequent extraction of pillars or solid blocks of coal and is therefore considered to constitute first workings, as opposed to secondary extraction.

A recent review of the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014* in April 2018 resulted in some changes to the definition and examples of 'high risk activities' related to 'secondary extraction', as described in Table 3.2.

Table 3.2 Changes to the definition of 'High Risk Activity'

Period	12/12/14 – 12/04/18	13/04/18 to date
Definition of 'High Risk Activity' relating to secondary extraction	"Schedule 3 High Risk Activities Cl 16 Secondary extraction or pillar extraction, splitting or reduction 1. The following are identified as high risk activities: a) secondary extraction by longwall mining, shortwall mining or miniwall mining, b) pillar extraction, c) pillar splitting, d) pillar reduction."	*Changed to* "Section 3 Definitions ***Secondary extraction*** includes pillar extraction, pillar splitting and pillar reduction."

Table 3.2 Changes to the definition of 'High Risk Activity'

Period	12/12/14 – 12/04/18	13/04/18 to date
Definition of 'High Risk Activity' relating to driving underground roadways	"Schedule 3 High Risk Activities 12 Driving underground roadway that is wider than 5.5 metres 1. Driving an underground roadway with a width greater than 5.5 metres is identified as a high risk activity."	*Remain unchanged*
Definition of 'High Risk Activity' relating to widening of roadways	"Schedule 3 High Risk Activities "Clause 13 Widening underground roadway to more than 5.5 metres 1. Widening an existing underground roadway to a width greater than 5.5 metres is identified as a high risk activity. …"	*Deleted*

For example, the 2018 review removed the process of "roadway widening beyond 5.5m width" from the definition of 'High Risk Activity', deeming it no longer requiring classification as a high-risk activity. This could be because the NSW Government deemed the activity should be dealt with in the strata and ground control principal hazard management plan.

Up to 13 April 2018, 'secondary extraction' was defined as an exhaustive list of longwall, shortwall or miniwall mining only, ***excluding*** 'pillar extraction, pillar splitting, and pillar reduction'. Under that definition, Hume Coal's mining method clearly would not be 'secondary extraction'. From 13 April 2018, the definition of 'secondary extraction' was expanded as a non-exhaustive list to ***include*** "pillar extraction, pillar splitting and pillar reduction".

All of these example activities are clearly secondary mining activities involving removal of formed up blocks of coal conducted after the primary development and pillar system has been completed. The pine feather method does not fit within any of these stated examples. It is certainly the case that the design and management of the pine feather web pillars and production panels would be a critical part of the relevant strata and ground control principal hazard management plan. Therefore, it is arguable that Hume Coal's mining method is not secondary extraction under the new laws.

Notwithstanding, irrespective of whether the definition of the mining method proposed is first or secondary extraction, the fact that High Risk Activity notification will be required is common practice in the industry, and required by the majority of underground mines, as discussed further below in Section 3.9.

3.2.2 Subsidence Advisory NSW

Section 5.4 [pg 15] - Subsidence Advisory NSW noted "the *predicted worst-case subsidence predictions and considered that subsidence is unlikely to result in any impacts to surface infrastructure".*

This view is endorsed as appropriate and recognises that the proposed mining method is clearly minimalist in terms of surface impacts, when compared with other conventional underground mining systems of a similar level of extraction. Some additional useful information has recently been provided by Hume Coal based on current site surface subsidence monitoring stations. These confirm that the level of surface vertical movements due to natural climatic variation (rainfall or drought), with no mining present, can be of the order of at least 20 mm. Recent results from the Site 3 monitoring are shown in Figure 3.2.

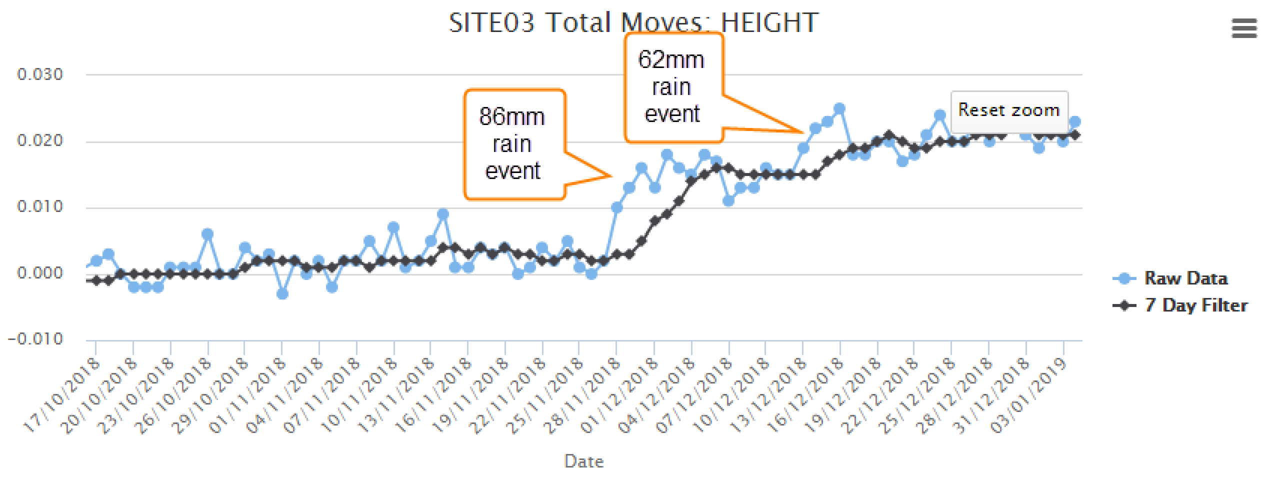


Figure 3.2 **Hume Coal Site 3 – Vertical surface movement due to rainfall events**

3.3 Independent review process

Section 6.3.2 [pg 26] – In this section the Department acknowledges that "*the issues relating to mine design, geotechnical modelling and safety are extremely complex".*

Hume Coal acknowledge that the mine design and geotechnical modelling issues require a considerable level of detailed investigation, especially as a result of the truly three-dimensional nature of the geotechnical design concept and the innovative nature of the mining system. It is not considered appropriate to consider the safety issue as complex. Whilst it is acknowledged the geotechnical modelling is complex, the safety issues are readily managed through existing frameworks established for example by the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014*. The mine design has been based on elements that are well established and in use at other mines.

Section 6.3.2 Initial advice on the EIS [pg 26] - Reference is made to criticism by the independent experts about the initial geotechnical model, and the subsequent recommendation that the Applicant prepare a 3D numerical model.

This criticism should be seen in the correct context, where Hume Coal had been working in accordance with a responsible and incremental approach to modelling and mine design over a number of years. The initial geotechnical design work assessed by the experts was always acknowledged as a "work in progress". Hume Coal did not wait for the independent experts to recommend a 3D modelling study. This topic had been under review for at least 12 months prior to the expert reports being produced, and Hume Coal had made a decision, prior to receiving the expert reports, to proceed with commissioning a 3D modelling study.

Section 6.3.2 Joint expert meeting [pg 26] - In reference to the Joint Expert Meeting, it is stated by DPE that Emeritus Professor Ted Brown (who was chair and facilitator of the meeting for DPE held on 28 March 2018) is a highly regarded mining engineer from Queensland.

This is incorrect. Professor Brown is not a mining engineer. He is a civil engineer with specialised experience and expertise in geotechnical engineering; the field where he is highly regarded internationally. By his own admission, he is not in any way an expert or experienced in underground coal mining.

It is also noted that DPE acknowledges in this section of the report that Hume Coal's approach to 3D numerical modelling and its choice of experts were appropriate in the circumstances.

3.4 Mining method

Section 6.3.3 What is the proposed pine feather method? [pg 27] - In discussion of the different types of pillars involved in the pine feather method (inter-panel pillars, intra-panel pillars and web pillars), the statement is made by DPE that *"the stability of each of these types of pillars and the overlying strata is fundamental to determining the safety of operations and potential subsidence at the surface".*

This statement is not correct and is also not supported by the reports and views of the DPE's independent experts. The method is designed to rely on the integrated 3D distribution of overburden loading on the pillar system as a whole, such that even if local regions of web pillars yield or lose stability, the overall impact on the overburden and surface will be negligible.

Whilst such loss of stability is not expected, the design has incorporated sufficient regional load-bearing capacity to be capable of adequately and safely responding to such a hypothetical situation. This hypothetical scenario was investigated in the 3D modelling study by deliberate removal of pillars and panels of web pillars. Total removal of web pillars is obviously an extreme worst-case situation. In reality, in the very unlikely event that a region of web pillars yielded, they will not shed their load completely but will continue to carry a proportion, albeit reduced component of overburden load.

The DPE minutes of the joint experts meeting on 28 March 2018 recorded the following points on this issue, supporting the comments above:

- Localised yielding of a web pillar would not necessarily lead to global instability.
- The experts generally agree that the stability of the system as a whole is the key factor, not the strength of the web pillars.
- The experts generally agree that subsidence is likely to be negligible-minor and is not the key assessment issue.
- Even if all web pillars are artificially removed, the 3D model is likely to predict that the change in subsidence would be very minor.

Section 6.3.3 Where has pine feather been used? [pg 28] - Reference is made to Emeritus Professor Galvin's report which acknowledges two significant differences between the pine feather method and highwall mining, these being: the plunges are mined from a 5.5 m wide underground roadway rather than a highwall; and they are mined at 70 degrees as opposed to right angles.

Professor Galvin, one of DPE's experts, raises the latter point as a concern in relation to ability of forming each successive plunge at the correct separation distance from the previous one. In fact, it is reasonable to argue that in an underground environment, a turn-away at 70 degrees is much easier to carry out with precision and minimal floor disruption than a 90 degree turn.

Similar designs to that proposed for the project have been use in Australia and around the world. These include Clarence Colliery near Lithgow in NSW, South Bulga Colliery in the NSW Hunter Valley, Myuna Colliery which is an underground coal mine under Lake Macquarie, NSW, Cook Colliery in Central Queensland, and Murray Energy mine in Ohio, United States of America. All of these mines have unsupported roofs in their design, and almost all include plunges at 70 degrees.

Section 6.3.3 Where has the proposed impoundment of water been used? [pg 29] – The DPE consider the impoundment of water behind bulkheads unconventional, particularly in the Australian context.

It is acknowledged that the issue of impoundment of water using bulkheads underground is a critical one for this mining system. It is agreed that if not carried out correctly, could raise serious safety implications. It is for this reason that bulkhead design and bulkhead placement is a critical issue that is already being addressed by Hume Coal as an integral part of the mine design and future operational risk management strategy. Whether the proposed practice is either "conventional" or common practice or not, is not directly relevant, provided appropriate engineering design and management strategies are adopted. Notwithstanding, a number of mines store water underground. Table 3.7 (Section 3.9) lists mines in NSW known to store water (11 mines). Further discussion on underground water storage and bulkheads is provided in Chapter 2.

3.5 Geotechnical model

Section 6.3.4 Introduction [pg 29] – DPE states that the "*issues relating to this project's mine design present complex technical challenges that have resulted in substantial amount of disagreement between the relevant experts, particularly in relation to the geotechnical model*".

This statement is challenged as conveying an impression of disagreement on major or fundamental issues, whereas in fact, the overall principles of the geotechnical model and the methodology adopted, in principle, were accepted with broad agreement by the experts. The only areas of disagreement were on a number of points of detail regarding specific pillar performance parameters; however, were acknowledged by all as being of lesser consequence or significance.

Section 6.3.4 Geotechnical model [pg 29, 30] - In this section the DPE discuss specific pillar design approaches and failure criteria.

Discussion on the specific pillar performance parameters is provided above.

The extent of pillar strength variations between use of different pillar strength criteria is not considered to be excessive, with all methods involving different levels of uncertainty and assumptions. It is not valid or appropriate to assume that one particular mainstream method is 100% accurate and any variation produced by other methods represents erroneous results.

Reference is also made in this section of DPEs report to comments in DPE's experts reports about the lack of appropriate strain-softening criteria in the modelling work. However, as has been discussed in previous reports and in the outcomes of the Heasley 3D modelling analysis, the results produced from the modelling never reached a point where stresses exceeded peak strength values (at which point yielding and strain-softening behaviour may have initiated), and so this is an academic difference of opinion rather than one which is likely to result in any substantive changes in performance outcomes.

The issues discussed by DPE here as being matters of "substantial disagreement" may have a minor influence on design parameters but are not considered to result in any changes or issues of any substance, at this stage of the project. Clearly, as further experience develops and further geotechnical data becomes available, detailed mine design studies will continue and will be informed by further results, as is the case in any mining operation.

There is an over-arching question through the assessment report about the methodology underpinning the geotechnical model.

Such criticism by DPE is unfounded and is not supported by the detailed commentary in the body of the report, as discussed above. Whilst there may be points of detail under question regarding aspects of the model, the fundamental principles of the modelling methodology have been supported by all experts. The minor points of detail under question are not considered to produce substantive changes to the modelling outcomes.

3.6 Geological data

Section 6.3.4 Introduction [pg 29] - DPE also state that there are "*residual concerns about the adequacy of the baseline geological data…*" It is noted that this claim has been raised by groups objecting to the project also.

The assertion that there is a lack of baseline geological data is unfounded. As described in Section 2.4.2, in his expert peer review of the project, Dr Bruce Hebblewhite confirmed that the data provided was quite considerable, and certainly on par with similar mining projects at this stage of evaluation and development.

Hume Coal has extensive geological data over Authorisation 349, including historic holes drilled by previous title holders as well as exploration holes drilled by the company, totalling 345 holes in A349 (an area of 89 km^2). There are 179 bores in the proposed mining area itself (an area of 35 km^2). Figure 3.3 illustrates the extent of boreholes in the project area.

All Hume Coal boreholes have been geophysically logged with a diverse suite of geophysical logs. These holes have been critically analysed and used to develop a robust geological model.

In addition to the drilling of boreholes, extensive aerial magnetic and radiometrics surveys have been conducted over the entire Authorisation. Surface magnetic surveys were also undertaken targeting specific geological structures that were located by the aerial surveys. Surface surveys for seismic were undertaken in the Belanglo State Forest and property owned by the company. In total approximately 36 line km of data was obtained.

Geological mapping was undertaken on accessible properties and where drilling was undertaken.

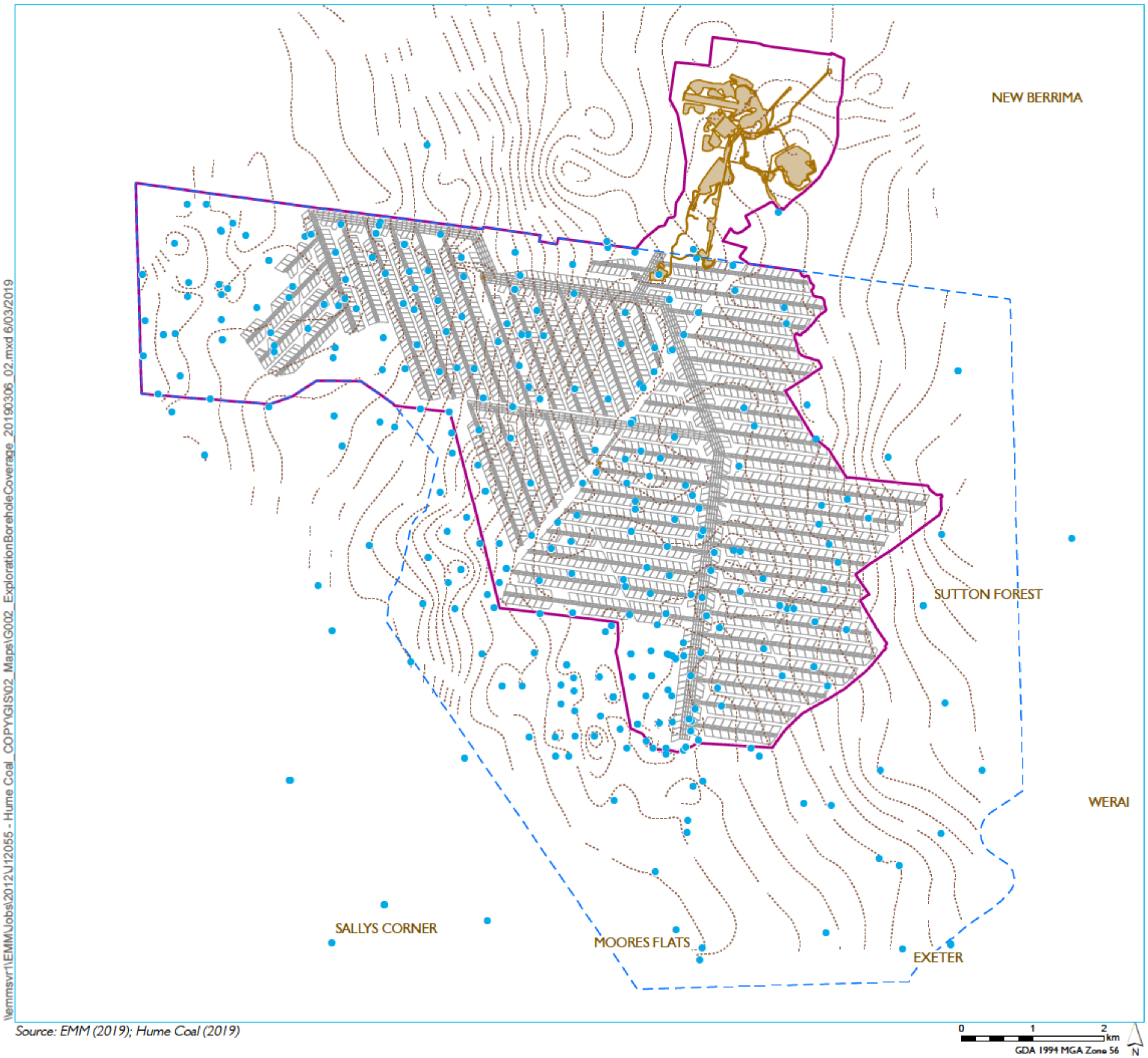
Extensive coal quality sampling was conducted on all cored holes. This data was tested at accredited testing facilities such as ALS and SGS.

The data described above is stored on fit for purpose geological software, which has developed the geological model for analysis and assessment of geological structures, and in turn has been used to develop the mine plan.

The NSW Division of Resources and Geoscience reviewed the EIS with regard to resource recovery and utilisation. In its submission on the project dated 11 July 2017, the Strategic Resource Assessment and Advice Unit of the Division stated that:

> The Division has verified that the project will provide approximately 50 million tones of ROM coal and approximately 40 Mt of product coal over the project life. The Proponent has completed coal resource and reserve estimation for the project in accordance with the Australasian Code for Reporting and Exploration results, Mineral Resources and Ore Reserves 'the JORC Code'. The JORC Code is an industry-standard professional code of practice that sets minimum standards for public reporting of minerals exploration results, mineral resources and ore reserves.

It is also noted that claims were made by objectors to the project that geological data has been withheld from the community. However, Hume Coal maintained a shopfront throughout the development of the EIS (initially in Moss Vale and then in Berrima) for members of the community to obtain information about the project, and to ask questions about areas of interest, such as this geological information. It is also noted however that it is not usual practice to make such data widely available, given the commercially sensitive nature of the data.



Source: EMM (2019); Hume Coal (2019)

The extent of exploration boreholes drilled across A349

Hume Coal Project and Berrima Rail Project
Submission to the Independent Planning Commission
Figure 3.3

Section 6.3.4 Lack of geological data [pg30] – Reference is made to comments made by Dr Canbulat in relation to the lack of detail about the Berrima case study that was used for initial calibration of Professor Heasley's LaModel 3D modelling studies.

Dr Canbulat is correct in noting that this detail was not contained in Professor Heasley's report. However, he has failed to acknowledge that full details of the Berrima data were presented to him and all participants of the joint expert meeting held on 28 March 2018 by Mr Alex Pauza from Hume Coal. There was considerable discussion of the Berrima data at that meeting. This included reference to data from both single and adjacent multiple panels. Once again, this is confirmed by the minutes of that meeting which include the following points of relevance:

- The 3D model has been calibrated to Berrima Colliery data and then de-rated.
- Based on Mr Pauza's presentation, the experts generally agree that the company's approach to the numerical modelling is appropriate and will assist the Department in its assessment process.

3.7 Risk assessment

Section 6.3.4 Risk assessment [pg 30] - DPE reference a comment made by Professor Jim Galvin: "*many of the matters raised in the report could reasonably be expected to have been evaluated by the mine owner(s) in a risk assessment of the mining concept prior to deciding to lodge a Development Application".*

Section 6.3.4 Introduction [pg 29] - DPE also state that there are "*residual concerns about the adequacy of the baseline geological data…" and the level of risk assessment that has been undertaken*".

Professor Galvin is correct and this is exactly what took place; not just in one risk assessment, but in multiple risk assessments.

In relation to the level of risk assessment, Dr Bruce Hebblewhite states that "*I can testify from first-hand involvement that the project has involved extensive and multiple risk assessment processes leading up to the present design approach. Criticism of the level of risk assessment undertaken is therefore not considered to be justified".*

A risk assessment workshop was held in 2015 in relation to the project's mining system concept design. This risk assessment was facilitated by Palaris Australia and attended by members of the Hume Coal team and experts in the field of mine design, geotechnical engineering, geology and hydrogeology. The risk assessment participants are summarised in Table 3.3.

Table 3.3 Mine design risk assessment – participant list

Name	Role	Company
Alex Pauza	Manager – Mine Planning	Hume Coal
Grieg Duncan	Project Director	Hume Coal
Rod Doyle	Exploration Manager	Hume Coal
Kim Hyo Jin	Technical Coordinator	Hume Coal
Dr Bruce Hebblewhite	Consultant and Chair of mining engineering at UNSW	UNSW/BKH
Liz Webb	Hydrogeologist	EMM Consulting
John Hoelle	Highwall Mining	Braemar Geotech
Russell Frith	Consultant – Principal Geotechnical Engineer	Mine Advice
Michael Barker	General Manager Gas and Study Systems	Palaris

Table 3.3 Mine design risk assessment – participant list

Name	Role	Company
Richard Prouse	General Manager Engineering and Projects	Palaris
Heath Shepherd	Mine Planning Engineer/Geologist	Palaris
Mick Bevan	Mining Consultant/Facilitator	Palaris
Steven Robinson	Facilitator	Palaris

The specific scope of the risk assessment is shown in Table 3.4.

Table 3.4 Mine design risk assessment scope

System	Sub-system	Process
Modified Pine Feather System	Pre-driven gate roads, in on the intake side and out on the return side	Layout
		Geotechnical design parameters
		Mining sequence
		Working section selection
		Mining equipment
		Labour requirements
		Productivity assumptions
		Ventilation
		Gas
		Spontaneous combustion
		Reject emplacement
		Explosion suppression
		Water management
		Services extension and retraction
		Consumables supply

A second risk assessment workshop focussed on the potential for inrush and inundation associated with the proposed mine design was also held in 2015. This risk assessment was also facilitated by Palaris Australia and attended by members of the Hume Coal team and experts in the field of mine design, geotechnical engineering and mineral processing. The attendees are listed in Table 3.5.

Table 3.5 Inrush risk assessment – participant list

Name	Role	Company
Alex Pauza	Manager – Mine Planning	Hume Coal
Grieg Duncan	Project Director	Hume Coal
Rod Doyle	Exploration Manager	Hume Coal
Kim Hyo Jin	Technical Coordinator	Hume Coal
Russell Frith	Consultant – Principal Geotechnical Engineer	Mine Advice
Michael Barker	General Manager Gas and Study Systems	Palaris
Richard Prouse	General Manager Engineering and Projects	Palaris
Heath Shepherd	Mine Planning Engineer/Geologist	Palaris
Steven Robinson	Facilitator	Palaris
Darren Mathewson	Process Engineer	QPS

The primary purpose of this workshop was to conduct a risk assessment on inrush hazards. The specific scope of the risk assessment is shown in Table 3.6.

Table 3.6 Inrush risk assessment scope

System	Sub-system	Process
Principal mining hazard – Inundation and Inrush	Panels/plunges	Water
		Mud/backfill/reject
		Expulsion of an oxygen deficient or poison atmosphere
		Atmospheric contaminants
	Backfilling operation	Mud/backfill/reject
	Old workings from abandoned mines	Water
		Expulsion of an oxygen deficient or poison atmosphere
	Open boreholes	Water
	Drifts and shafts from surface	Water
	Groundwater system	Water
	Geological features	Water
	Other seams	Water
		Expulsion of an oxygen deficient or poison atmosphere
	Other services	Water

As discussed at the private briefing with the IPC on 11 February 2019, Hume Coal would be pleased to meet with the Commission to further discuss the outcomes of these risk assessments.

Section 6.3.4 – First or secondary workings [pg 31] - DPE provides a discussion on whether the pine feather method is first or second workings, stating that the Resource Regulator considers the method to be a variation of the Wongawilli pillar extraction method, and as such, is secondary extraction. The DPE then links this issue to the detail of risk assessment information provided or required.

This linkage of issues is not valid. The level of risk assessment was quite comprehensive, regardless of the classification of the method. Further, the view formed by the Resource Regulator that the proposed mining method is a variation of the Wongawilli pillar extraction method and is therefore secondary extraction, is questioned. There is very little similarity between these methods. In the mining method proposed by Hume Coal, there is no open goaf edge involved, there is no extraction on the retreat, and there is no deliberate creation of overburden failure in a goaf region; all of which are fundamental to Wongawilli pillar extraction.

3.8 Potential hazards and safety risks

Section 6.3.5 Introduction [pg 31]– DPE note that the unique nature of the project's mine design presents a range of potential hazards and safety risks, including pillar stability risks and water impoundment issues.

Pillar stability risks [pg 32] - '*Ultimately, the Department considers that the issue of pillar stability has not been adequately resolved by the 3D numerical modelling, and that there are significant residual risks to worker health and safety.'*

Firstly, it is noted that DPE acknowledge "subsidence is not the key issue for this project".

In relation to pillar stability risks, it has already been pointed out that apart from minor details of pillar performance criteria used (in a field which is not an exact science or where there is only one appropriate methodology), the role of the web pillars is not critical to the overall regional stability of the mine layout. This is confirmed by quotes from both Professor Galvin and Dr Canbulat included in this section of the DPE report.

However, DPE then takes this argument further with the same incorrect assumption they have relied on earlier (p26); that "the proposed pine feather mining method relies on narrow "web pillars" (with very small width-to-height ratios) remaining stable in the long term". This is simply not the case and is a fundamental mischaracterisation of the assessment, the outcomes of the Experts Meeting, the numerical modelling *and* the supplementary expert reports. It has also been agreed not to be the case by both Professor Galvin and Dr Canbulat. The method certainly does not rely on long-term stability of these pillars. The stability of the pillar system as a whole is the key consideration as to whether the proposed layout designs are fit-for-purpose, and not the strength and stability of individual web pillars. This was agreed to at the Experts Meeting (including the experts engaged by DPE) on 28 March 2018. Further, the numerical modelling undertaken by Emeritus Professor Keith Heasley demonstrated that the surface subsidence consequences of long-term pillar instability (regardless of likelihood) are insignificant.

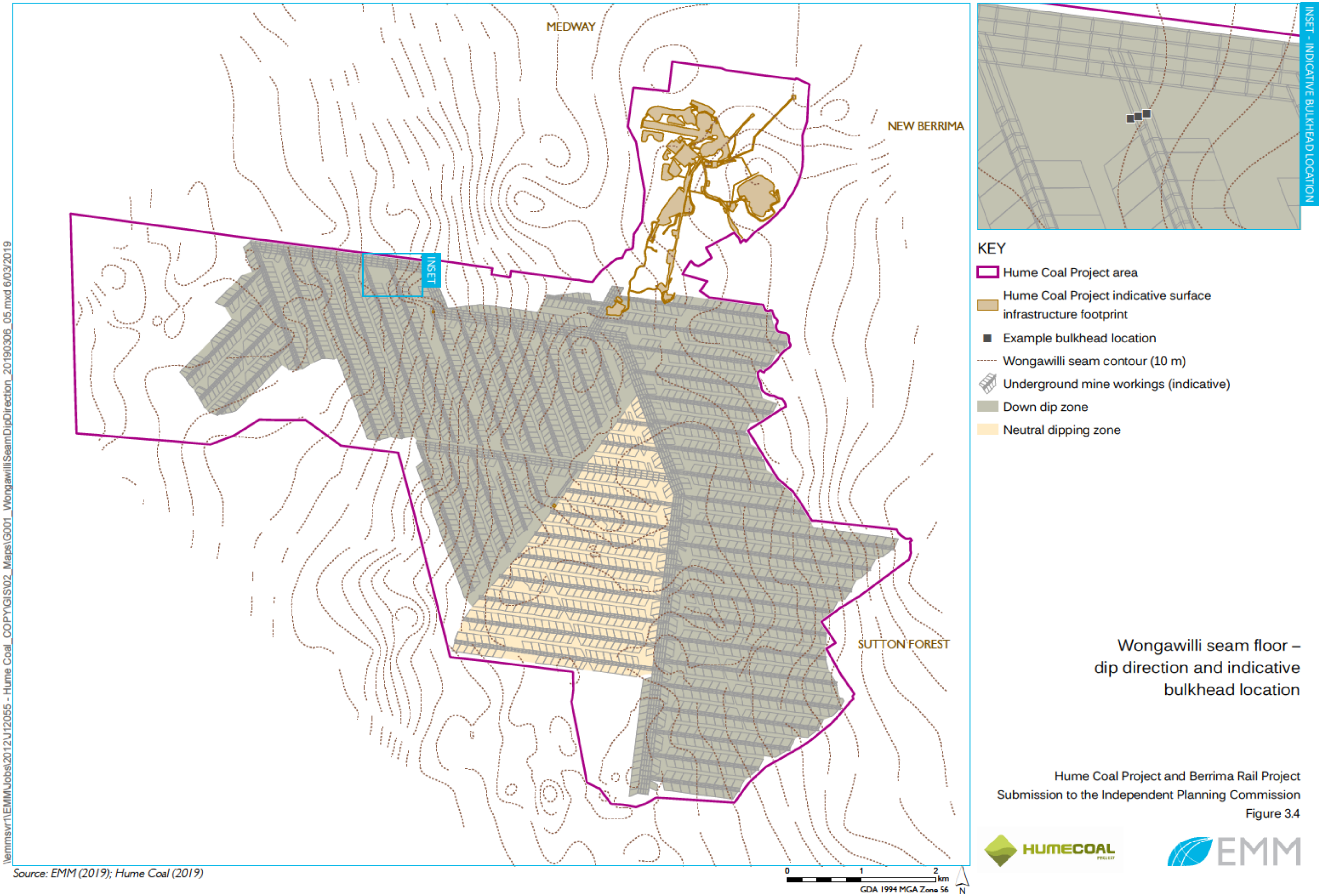
DPE take this erroneous argument further by claiming that such web pillar failures may pose a direct risk to worker health and safety as a result of roof falls and ground falls. If such falls were to occur in roadways between the web pillars, it is highly unlikely to impact on worker safety, since no personnel will be operating in such roadways at any time. In the unlikely event of a web pillar failure (or more likely, a pillar yield scenario), localised shallow roof falls may occur as in any underground mining, but in this method, there will be no personnel present in the immediate vicinity to be impacted by such a fall of ground.

Discussion then turns to risks posed by geological structure such as cleating, especially when such a structure is parallel to the rib line orientation of the web pillars. Rib falls could then compromise the pillar stability. This is a valid comment, but once again, it is no different to many other underground mining scenarios. It is the type of issue that can be dealt with in ongoing operational management and planning where individual panels can be modified, either in direction or web pillar width, to cope with such localised issues, if required. It is not a project-stopping issue.

Similarly, the issues raised by Dr Canbulat regarding ventilation, equipment entrapment and off-line cutting are all valid points that should be the focus of ongoing detailed planning and operational risk management.

Further, the risks to worker health and safety are no different from other forms of underground mining such as partial pillar extraction and full extraction bord and pillar mining. In fact, the proposed use of remotely controlled or semi-autonomous mining equipment significantly reduces worker exposure to face hazards, as compared with these methods.

In relation to 'water impoundment issues', as explained above water is stored underground at many other underground mines. Importantly, the mine layout and water storage system has been designed at Hume Coal such that water will be stored 'downdip' of the bulkheads throughout the majority of the mine, except for one section where the floor is reasonably flat, as illustrated in Figure 3.4.



Source: *EMM (2019); Hume Coal (2019)*

Wongawilli seam floor – dip direction and indicative bulkhead location

Hume Coal Project and Berrima Rail Project
Submission to the Independent Planning Commission
Figure 3.4

\\emmsvr1\EMM\Jobs\2012\J12055 - Hume Coal_COPY\GIS\02_Maps\G001_WongawilliSeamDipDirection_20190306_05.mxd 6/03/2019

3.9 Classification as a 'high risk activity'

***Page 31**: In its latest advice, the Resources Regulator has confirmed that the proposed pine feather mining method is not only first workings but rather a "variation of the Wongawilli pillar extraction method and as such is secondary extraction". Under Work Health and Safety legislation, as the web pillars are less than 1/10th depth or 10m, they would be non-conforming pillars and are classified as a 'High Risk Activity'.*

As Professor Galvin noted, the Resources Regulator therefore "has the power to prevent the formation of a pillar … if the regulator considers that it presents a serious risk to health or safety of a person".

***Page 33**: However, the Department is concerned that the various safety risks associated with pillar stability and water impoundment may result in the need to transfer additional mine water from underground to the surface. This is particularly the case as the Resources Regulator has classified the mining method as a 'High Risk Activity' and may choose to prevent certain hazardous activities from occurring underground.*

***Page 34**: In summary, the Department considers that the wide variety of safety risks associated with pillar stability and water impoundment (including its classification as a 'High Risk Activity') may lead to the transfer of additional mine water to the surface. This would require significant amendments to the existing project and a substantial amount of additional assessment.*

The references made by the DPE to "High Risk Activity" throughout the Assessment Report are used in a manner that is potentially misleading.

The descriptor of a "High Risk Activity" is one that is sourced from the NSW *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014*.

Under clause 33 of that Regulation, there is a requirement on the operator of a mine site to ensure that any "high risk activity identified in Schedule 3 and that applies to the mine … site pursuant to that Schedule is not carried out at or in relation to the mine … site" unless the notification requirements set out in clause 33 are complied with.

Schedule 3 of the Regulation identifies numerous types of "High Risk Activities". Examples of such activities listed in Schedule 3 include:

- barrier mining;
- emplacement areas; and
- coal extraction by use of secondary extraction by longwall mining, shortwall mining or miniwall mining; pillar extraction; pillar splitting and pillar reduction.

It is trite to observe that the overwhelming majority, if not all, mining projects in NSW involve the conduct of some type of activity which is classified, for the purposes of the NSW *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014* as a "High Risk Activity". This is because all mine sites involve the carrying out of operations which have the potential to be dangerous in the absence of appropriate safety measures and precautions being in place.

The fact that an element of the project involves a "High Risk Activity" is not unusual for a mining project in NSW. Yet, by using the descriptor of "High Risk Activity" out of context in its Assessment Report, the DPE has created an inaccurate impression of the ramifications of such a classification for the Project.

A summary of the high risk activity notifications for existing underground mining operations is presented in Table 3.7 below. This table shows that all of the 20 mines undertake a number of High Risk activities as part of their day to day operations. The table also shows that many of the mines store water underground in their workings, either deliberately or inadvertently.

Table 3.7 High risk activity notifications

Operation (coalfield)	Mining method	Stores water underground?	High Risk Activity Notifications: Electrical work on energised electrical equipment	Development of a new mine entry (including by sinking a shaft or drift or raise boring)	Connecting electricity to the mine so that the total connected voltage underground is greater than 12,000	Working in inrush control zone	Single entry development of a roadway or drift for more than 250 metres without an intersection	Shotfiring if it has not been undertaken within a year before the intended time of shotfiring	Sealing (other than emergency sealing)	Conduct hot work in a hazardous zone	Driving underground roadway that is wider than 5.5 metres	Use of high voltage plant and cables in a hazardous zone if the plant or cable: • is associated with longwall mining	Formation of non-conforming pillars	Coal extraction by any of the following methods: • secondary extraction by longwall mining, shortwall	Shallow depth of cover mining (<50m)	Mining operations in outburst control zones.	First applications of explosion inhibitors	Use of explosives designed for use in coal mines if the explosive has previously been used in the state.	Use of an explosive not designed for use in coal mines	First use of a vehicle with a fire-protected diesel internal combustion engine (other than an engine that is	First use of an explosion barrier other than a water barrier or bagged stone dust	Emplacement areas - the establishment, operation or decommissioning of an emplacement area	Barrier mining
Gunnedah	longwall	Not deliberately	y	y	n	n	y	y	y	y	y	y	n	y	n	y	y	y	y		n	y	n
Hunter	longwall	Not deliberately	y	y	n	u	y	y	y	y	y	n	y	y	n	n	y	y	n		u	n	y
Hunter	longwall	Not deliberately	y	y	n	n	y	y	y	y	y	n	n	y	n	n	n	y	y		u	n	n
Hunter	longwall	Not deliberately	y	y	n	y	y	n	y	y	y	n	n	y	n	n	y	y	n		u	n	n
Newcastle	Top coal caving	Not deliberately	y	n	n	n	y	u	y	y	y	n	y	y	n	n	n	y	n		u	n	n
Newcastle	Miniwall- moving to B&P	Not deliberately	y	n	n	n	n	n	y	y	y	n	n	y	n	n	n	y	n		u	n	n
Newcastle	longwall	old workings - flooded - Cooronbong	y	y	n	y	y	y	y	y	y	n	y	y	n	n	y	y	y		n	n	n

Table 3.7 High risk activity notifications

Operation (coalfield)	Mining method	Stores water underground?	High Risk Activity Notifications																				
			Electrical work on energised electrical equipment	Development of a new mine entry (including by sinking a shaft or drift or raise boring)	Connecting electricity to the mine so that the total connected voltage underground is greater than 12,000	Working in inrush control zone	Single entry development of a roadway or drift for more than 250 metres without an intersection	Shotfiring if it has not been undertaken within a year before the intended time of shotfiring	Sealing (other than emergency sealing)	Conduct hot work in a hazardous zone	Driving underground roadway that is wider than 5.5 metres	Use of high voltage plant and cables in a hazardous zone if the plant or cable: • is associated with longwall mining	Formation of non-conforming pillars	Coal extraction by any of the following methods: • secondary extraction by longwall mining, shortwall	Shallow depth of cover mining (<50m)	Mining operations in outburst control zones.	First applications of explosion inhibitors	Use of explosives designed for use in coal mines if the explosive has previously been used in the state.	Use of an explosive not designed for use in coal mines	First use of a vehicle with a fire-protected diesel internal combustion engine (other than an engine that is	First use of an explosion barrier other than a water barrier or bagged stone dust	Emplacement areas - the establishment, operation or decommissioning of an emplacement area	Barrier mining
Newcastle	Bord and pillar-partial extraction	old workings - flooded	y	n	n	n	n	y	y	y	y	n	n	y	n	n	n	y	n		u	n	n
Southern	longwall	yes - old workings	y	n	n	n	y	n	y	y	y	n	y	y	n	y	n	y	n		u	n	n
Southern	longwall	yes	y	y	n	n	y	y	y	y	y	n	y	y	n	n	y	y	u		n	n	n
Southern	longwall	uncemented reject- trial only	y	n	n	n	y	n	y	y	y	n	y	y	n	y	n	y	n		u	n	n
Southern	longwall	old workings - flooded	y	n	n	n	y	n	y	y	y	n	y	y	n	y	n	y	n		u	y	n
Southern	longwall	old workings - flooded	y	n	n	n	y	n	y	y	y	n	y	y	n	y	n	y	n		u	n	n

Table 3.7 High risk activity notifications

Operation (coalfield)	Mining method	Stores water underground?	High Risk Activity Notifications																				
			Electrical work on energised electrical equipment	Development of a new mine entry (including by sinking a shaft or drift or raise boring)	Connecting electricity to the mine so that the total connected voltage underground is greater than 12,000	Working in inrush control zone	Single entry development of a roadway or drift for more than 250 metres without an intersection	Shotfiring if it has not been undertaken within a year before the intended time of shotfiring	Sealing (other than emergency sealing)	Conduct hot work in a hazardous zone	Driving underground roadway that is wider than 5.5 metres	Use of high voltage plant and cables in a hazardous zone if the plant or cable: • is associated with longwall mining	Formation of non-conforming pillars	Coal extraction by any of the following methods: • secondary extraction by longwall mining, shortwall	Shallow depth of cover mining (<50m)	Mining operations in outburst control zones.	First applications of explosion inhibitors	Use of explosives designed for use in coal mines if the explosive has previously been used in the state.	Use of an explosive not designed for use in coal mines	First use of a vehicle with a fire-protected diesel internal combustion engine (other than an engine that is	First use of an explosion barrier other than a water barrier or bagged stone dust	Emplacement areas - the establishment, operation or decommissioning of an emplacement area	Barrier mining
Southern	Bord and pillar-partial extraction	yes	y	n	n	y	y	y	y	y	y	n	n	y	u	n	y	y	n		u	y	n
Western	Bord and pillar, miniwalls	unknown	y	y	n	n	n	n	y	y	y	n	n	y	u	n	y	y	u		u	n	n
Western	Partial pillar extraction using FCT	yes	y	n	n	n	n	n	y	y	y	n	n	y	u	n	n	y	u		u	n	n
Western	longwall	yes	y	y	n	n	y	y	y	y	y	n	n	y	n	n	y	y	n		n	n	n
Western	longwall	yes	y	n	n	n	y	n	y	y	y	n	y	y	n	n	n	y	n		u	n	n
Western	longwall	yes	y	u	n	n	y	n	y	y	y	n	n	y	n	n	n	y	y		u	n	n
Western	longwall	Not deliberately	y	y	n	n	y	y	y	y	y	y	n	y	n	n	y	y	n		n	y	n

3.10 Hard coking coal

During the private briefing with the IPC, Hume Coal was asked about the difference between hard and soft coking coal, and the claims made relating to the Southern Coalfields being a major source of hard coking coal.

There are different grades of coking coal, from 'hard' which is the best grade of coking coal, though to the lower grades of 'soft' and 'semi soft'. Further information on the difference between the types of coal is provided below.

3.10.1 Coking Coal Types and Hume Coking Coal Classification

i Coking Coals

Australian metallurgical coal products are generally classified into four product types; hard coking coals (HCC), semi-hard coking coals (SHCC), semi-soft coking coals (SSCC) and pulverised coal injection (PCI). Coking coals are usually combined by the end user into a blend of different coking coal types, and converted to coke through controlled thermal decomposition, before being charged to the blast furnace for steelmaking. The 'hardness' of coking coals is essentially a description of the coal to make a strong, coherent blast furnace coke.

PCI coals are pulverised and injected directly into the blast furnace and are important for reducing the amount of coke used, with pricing often determined by the coke replacement ratio.

ii Distinction between SSCC, SHCC and HCC Products

SSCC products are used in a coking blend but would struggle to make a strong, coherent coke on their own; they are used in a blend with hard coking coals to produce a satisfactory blend, and where used efficiently, benefit the end user with cost savings by reducing the amount of hard coking coal used.

The Hunter Valley SSCC products primarily come from coals which generally have a rank range of 0.70 – 0.80% (R_oMax), and only from designated seams which have higher vitrinite contents. SSCC coals generally do not have sufficient rank to generate good coke strength after reaction (CSR) values. Other SSCC products can be marketed from slightly higher rank coals from seams with lower vitrinite content, such as the Rangal Coal Measures in the Bowen Basin (Stanmore's Isaac Plains or BMA's Blackwater).

HCC products are considered capable of making strong, coherent blast furnace cokes on their own due to their inherent physical and chemical properties. Australian HCC products are generally low to mid volatile HCCs that have CSR values typically greater than ~58 - 60; the main contributors to high CSR are the rank range (generally > 1.10%), ash chemistry (lower base acid ratio) and maceral content.

Most Australian HCC products are sourced from Queensland's Bowen Basin and the Illawarra region of NSW, where coal seams have sufficiently high rank. The benchmark indices include the Peak Downs LV benchmark (CSR 74), Platts QLD LV benchmark (CSR 71) and HCC64 mid volatile benchmark (CSR 64).

The SHCC classification is broadly a commercial description as opposed to a specification definitive technical classification. It generally refers to coking coal products that are clearly superior to SSCC products, but do not have the coke strength of HCC.

SHCC products can include high volatile coking coals where rank is insufficient to generate high coke strength (Tahmoor, Kestrel, Austar). The classification can include lower rank, higher fluidity coals (for example Kestrel, Gregory Crinum or Austar). Alternatively, AHCC products can be generated from coals with lower vitrinite and / or poorer ash chemistry, such as products from Rangal Coal Measures mines in Queensland (Blackwater, Poitrel, Carborough Downs). SHCC products trade at a discount to HCC products, and the relativity in pricing is generally compared to the Platts QLD LV benchmark (CSR 71). The pricing relativity that a SHCC achieves is largely based on CSR values, and may typically trade in the range of 80 to 90% of QLD LV HCC pricing.

Table 3.8 shows the indicative ranges for various coking coal types produced in Australia and illustrates the difference between SHCC and SSCC products.

Table 3.8 Indicative ranges for Australian coking coal product types

Coking Coal Classification	Reflectance R_oMax %	Vitrinite %	Ash %	VM %	CSR	CSN	Fluidity ddpm
Premium LV HCC	1.35 - 1.45	>65	< 9.3	< 22	67 - 75	> 7.5	100 - 500
Tier 2 / MV HCC	1.15 - 1.60	> 55	< 9.5	22 - 27	58 - 67	> 7	100 - 2000
Semi-Hard Coking	0.80 - 1.20	> 45	< 10	27 - 35	45 - 60	5 - 8	10 - 20,000
Semi-Soft Coking	0.70 - 0.80		< 10	> 34	< 40	3.5 - 6	< 150

iii Hume SHCC Coking Coal Product

Hume Coal is expected to produce a primary SHCC and secondary thermal product with two stage processing. This is a common approach for coals with moderate vitrinite contents or coals with a coarser size fraction with poorer coking attributes.

From small scale carbonisation testing of coking clean coal composites, Hume Coal samples returned CSR values between 58 and 61. This plots the coke strength of Hume Coal well above Hunter Valley SSCC products, which are not recognised as providing coke strength to the blend.

POSCO has undertaken a review of the usability of Hume Coal, in which it was determined that Hume Coal would produce a good blending coal with better quality than Hunter Valley SSCC. The Hume Coal product was compared to the higher value Gregory Crinum (care and maintenance) high volatile coking coal type.

The difference between the expected Hume Coal SHCC product specification, and typical Hunter Valley SSCC is shown in Table 3.9 below. While the Hume Coal has marginally higher ash, the coking attributes including CSN, fluidity, dilatation and coke strength are clearly superior to Hunter Valley SSCC. The SHCC product will attract significantly higher prices (Hunter Valley SSCC may trade at 70% o the QLD LV HCC pricing compared to 80-90% for Hume SHCC).

Table 3.9 Comparison between Hunter Valley SSCC and Hume Coal SHCC

Attributes	Unit	Hunter Valley SSCC	Hume Coal SHCC
Total moisture	% ar	10	9
Ash	% ad	9	9.5
Volatile Matter	% ad	35	32 - 34
Total sulphur	% d	0.50	0.60
CSN		4 - 6	7
Gieseler fluidity	ddpm	50 - 150	650
Vitrinite content	%	70	65 - 70
Reflectance (R_oMax)	%	0.75	0.80 - 0.90
Coke strength after reaction (CSR)		~20- 40	58 - 61
Total dilatation	%	-	68

As explained in Chapter 24 of the Hume Coal Project EIS (EMM 2017a), the remaining unallocated prime coking coal resources in the Southern Coalfield are in the Bulli and Balgownie Seams underlying the Campbelltown-Camden-Picton region, and in the Wongawilli Seam in the southern part of the coalfield. Further mine development in much of the Campbelltown-Camden-Picton area is constrained by its closeness to existing and planned urban areas. Conversely, mining in the Wongawilli Seam in the project area is relatively unconstrained and has the substantial advantage of closeness to rail infrastructure that links directly to the Port Kembla coal terminal. The project seeks to draw on these positive features.

iv POSCO utilisation

POSCO utilise coking coal in its blast furnaces. The coking coal type mix depends on the capacity of the blast furnace. An approximate mix is:

- Hard Coking coal - 20%
- Semi Hard Coking coal - 30%
- Semi Soft Coking coal - 50%

Examples of two different blast furnace mixes are provided in Table 3.10.

Table 3.10 Examples of different blast furnace mixes

Coking Coal Type	A (Smaller)	B (Bigger)
Hard	20	21
Semi Hard	30	32
Semi Soft	50	47

The deposits of HCC are very limited globally. In NSW, the Hunter Valley is a major region of SSCC (along with thermal coal) production. The Southern coalfield, where the Hume Coal Project is located, is a unique area for HCC production.

POSCO has invested in the Hume Coal Project to diversify its sources of HCC.

4 Economics

4.1 Introduction

This chapter addresses comments in DPE's Assessment Report relating to the economic assessment of the project, primarily in Section 6.4. The responses in this chapter have been written with the assistance of BAEconomics, who prepared the Economic Impact Assessment of the project, and Mr Alex Pauza, Manager – Mine Planning, Hume Coal Project.

The primary point raised with respect to the economic assessment of the project by DPE relates to its net economic benefit. In this regard DPE questions the likely quantum of economic benefit. Notably however, the Department accepts there is a valuable coal resource available in the project area and acknowledges the project would lead to economic benefits.

4.2 Net economic benefits

Section 6.4.1 [pg 35] Introduction - DPE states that "*there is residual uncertainty about the likely quantum of economic benefits*"

There is some uncertainty about the likely quantum of economic benefits for all coal mining projects which are subject to commodity price and exchange rate fluctuations, and geological uncertainty. Notwithstanding, these uncertainties were taken into account in the economic assessment for project. For example, geological structures have been allowed for in the mine design where there is a relative degree of certainty over its location. Furthermore, an additional 5% reduction in tonnage has been applied over and above the allowances made in the mine plan, to allow for unknown geological structures which may require resource to be sterilised.

Furthermore, Hume Coal has designed the project to internalise almost all potential externalities, such as impacts on air quality, biodiversity, and heritage, and has purchased almost all of the required groundwater licences on the free market.

Notwithstanding the above, irrespective of the quantum, the economic assessment clearly demonstrates the project will have net economic benefits to the state of NSW and at a local level for the Wingecarribee LGA.

Section 6.4.1 [pg 35] Introduction - DPE states that "*the relatively low rate of production and the Applicant's intention to export coal are likely to reduce economic benefits to the State.*"

The economic benefits calculated by BAEconomics are based on "the relatively low rate of production" and fully take into account the "intention to export coal". It is therefore incorrect to state that these factors are "likely to reduce economic benefits to the State", since the assessed net benefits associated with the project of net present value (NPV) $373 million direct plus NPV $149 million flow-on benefits (totalling NPV $522 million direct and flow-on benefits) are based on these very assumptions.

It is also noted that the economic benefits to the State would be reduced to zero if the project is refused.

Section 6.4.2 [pg 35] Net Economic Benefits - DPE states that "*The Applicant's economic assessment (prepared by BAE Economics (sic)) concluded that the project would have a net present value of $373 million.*"

The economic assessment valued the project's NPV to the state of NSW at between $492 million and $522 million, depending on which measure of flow-on benefits is incorporated: value-added ($119 million), or disposable income ($149 million).

Section 6.4.2 [pg 35] Net Economic Benefits - DPE states that "*The Department's independent expert, Mr Andrew Tessler of BIS Oxford Economics, has estimated the net economic benefits at approximately $127 million. One of the key points of difference is the inclusion of 'employment benefits' and associated 'tax benefits', which Mr Tessler considers should not be included in the cost-benefit analysis. This is based on NSW Treasury Guidelines that make it clear that, on first principles, labour should be considered as a cost rather than a benefit. That is because it is assumed that labour is already fully employed and must be drawn away from elsewhere.*"

Labour as an opportunity cost for public projects

The idea that labour should be regarded as a cost rather than a benefit in a cost benefit analysis (CBA) is not supported by the NSW Treasury guideline (2017). It appears therefore that DPE has misrepresented and/or misunderstood this guideline.

The Treasury Guideline states: "the cost of labour is its opportunity cost, which is the reservation wage" (Appendix 7, p 56)[1].

When read in its correct context, this has a different meaning from "*labour should be considered as a cost rather than a benefit"* as asserted by DPE. It is also noted that DPE's assertion that "labour should be considered as a cost" is also not an accurate representation of what its appointed expert (BIS Oxford Economics) says in its report, that "a standard CBA considers labour to be an (opportunity) cost". 'Cost' is not the same as 'opportunity cost'. That is an elementary economic concept.

What the Treasury guideline means is that there is a *component* of labour that is not a net benefit (that component being the 'reservation wage'), which must be subtracted from the gross benefits to obtain a net benefit of labour. This is consistent with the approach taken by BAEconomics.

Other errors

Furthermore, BAEconomics has demonstrated that there is no credible case where BIS Oxford Economics' assessment of $127 million of net benefits is correct, as described below.

In its updated assessment BAEconomics (2018, pp.42-3) estimates that the central case project NPV is $373 million, with a range of $226 million to $511 million when taking into account price and exchange rate risk at the central discount rate of 7% real. These estimates are based on the then most recently available Commonwealth Government long term export coal price projections for Australia.

In its review of the Hume Coal economic assessment, BIS Oxford Economics (2018, p.7) refers to prices of $A 70 per tonne (t) and $A 120/t for thermal and coking coal respectively. There is no indication in the report as to whether these prices are expressed in Free on Board (FOB) terms or whether they have been adjusted for expected mine grade. Further, BIS Oxford Economics (2018, p.11) suggests that average coal prices over the life of the project would be $US 91/t for thermal coal and $US 95/t for coking coal. These projections are said to be sourced from the US Energy Information Administration (USEIA), but no exact citation is provided.

These prices do not appear to be consistent with the Commonwealth Government's most recent long-term projections and the relativity between them is inconsistent with recent market behaviour in seaborne coal markets. This may reflect the US domestic focus of the USEIA. In the case of the seaborne coal market the price of hard coking coal expressed in US dollars was 2.2 times that of the price of thermal coal in 2017. Typically, since China entered the world seaborne coal market in a significant way in the early 2000s the premium of hard coking coal prices relative to thermal coal prices has been around double. It follows that the coal price estimates quoted by BIS Oxford Economics under-state the coking coal premium and do not appear to be consistent with the more optimistic projections made by the Australian Government, Department of Industry, Innovation and Science (2018).

[1] NSW Treasury, 2017, NSW Government Guide to Cost-Benefit Analysis

Analysis by Hume Coal shows that the projections made by the Australian Government, Department of Industry, Innovation and Science (2018) are around 15% lower than the average coal price in real 2018 Australian dollars over the past ten years, which incorporates a full price cycle.

It is also noted that no Australian dollar exchange rate assumption is provided by BIS Oxford Economics. Given that the Australian dollar is widely regarded a commodity currency (Australia's exports are dominated by minerals and agricultural products), it is customary for commodity price forecasts to be accompanied by an exchange rate forecast or assumption, since commodity prices and the exchange rate are correlated. It is not clear, given the lack of a reference, if BIS Oxford's chosen coal price assumption had an accompanying exchange rate forecast, or what exchange rate assumption was applied by BIS Oxford Economics. Sensitivity analyses routinely demonstrate the high level of importance of exchange rate assumptions on Australian dollar economic analyses of mining projects.

Based on the foregoing and the estimates presented in BAEconomics (2018), BAEconomics estimates that the central case project NPV is $373 million which is almost three times that quoted by BIS Oxford Economics (2018). Allowing for long term parity of the Australian exchange rate with the $US (a low probability outcome) and low coal prices (lower in real terms than Australia has experienced since 2004) would still result in an estimated project NPV of $226 million, almost twice the estimate quoted by BIS Oxford Economics. On this basis alone BAEconomics and Hume Coal do not accept that the BIS Oxford Economics estimate of the NPV of the project provides a fair assessment of the project's value to NSW.

Section 6.4.2 [pg 35] Net Economic Benefits - DPE states that "*Another key point of difference is the approach taken in valuing externalities, particularly in relation to the impacts on water resources*."

There is no uncertainty in the valuation of water externalities, especially in relation to the cost of groundwater inflows to the mine. On this matter, BIS Oxford Economics is incorrect. Mining companies are required to hold licensed groundwater entitlement (shares) for all 'take' of groundwater. Water shares and/or allocations are traded on a free-market and completely separable from land. There is no need to use other techniques to value groundwater licences, or any commodity that is traded on a free market, because their economic value *is* the price, as determined by the market.

The assumption made by BIS Oxford Economics (2018) in its attempt to reverse engineer the value of groundwater licences is that land in the Southern Highlands has zero value if it has no access to groundwater. This is not logical since rural properties are regularly traded without any water access licence (WAL) and/or water licence shares or allocation. The fact that WALs are separable from the land and tradeable on the free-market (ie willing buyers and sellers) means that all of their economic value is captured by their price. There is no other economic value associated with a WAL. Hume Coal has purchased a number of water allocations on the market (sometimes with land and sometimes the allocation by itself), and it would be incorrect to suggest that the properties with which they were previously associated are now worthless.

Furthermore, Hume Coal has acquired water licence shares (entitlement) for more than 90% of the predicted groundwater take for the project, fully internalising this cost. The remaining 10% will be acquired either permanently or temporarily via the trading market, and some may be catered for via carry-over provisions allowed for under the Water Sharing Plan for the Water Source. This is a significantly conservative approach, given that under the WM Act, WALs (and associated licence shares) are only required to be held when the water is "taken". In the case of the project, the peak inflow occurs in about year 17, but 90% of this peak take volume is already held, and will not be used until year 17. The purchase of groundwater shares by Hume Coal at this early stage therefore removes any uncertainty relating to this aspect of the project.

Section 6.4.2 [pg35] Net Economic Benefits - DPE states that "*Mr Tessler has also considered a range of risks and uncertainties associated with the project, particularly in relation to the mine design and the difficulties associated with 'make good' provisions. For example, there is a risk that the operational safety issues may result in an unexpected sterilisation of coal.*"

Elsewhere in their assessment report, DPE acknowledge that Hume Coal's proposed make good provisions are "technically feasible", and the Department's expert, Mr Middleton stated that "all these arrangements are reasonable in principle". It is therefore unclear what economic risks and uncertainties are associated with the proposed "make good" provisions, other than that some people may elect not to take them up.

The author of the BIS Oxford Economics report, Mr Tessler, has no qualifications or expertise in underground mining techniques. Mr Tessler's CV provides his university degrees as comprising a Bachelor of Arts and a Master of Commerce, so it is unclear why he is commenting on operational mine safety issues, according to DPE's statement.

Furthermore, contrary to BIS Oxford Economics' assumption, the impact to production volumes should areas of coal be sterilised due to geological structure will be to shorten the mine life, and not to materially reduce the annual production tonnages. This fundamental difference in production impacts will result in markedly different valuation outcomes in present value terms, where values toward the end of the mine life are heavily discounted compared to values closer to the present day. In this respect, the assessment by DPE's expert is technically flawed. Notwithstanding, Hume Coal has already made allowances for coal to be sterilised by known and unknown geological structures in the production schedules used for the assessment as described above.

Section 6.4.2 – Net Economic Benefits

DPE states that "*Ultimately, Mr Tessler concluded that none of these risks or uncertainties is likely to make the project economically unviable, however he noted that "it could substantially reduce the economic case" for the project.*"

DPE appears to be misinterpreting project viability and an acceptable benefit-cost ratio, ie greater than 1.

BIS Oxford Economics lists four areas that they see as being key areas of uncertainty in terms of economic costs and benefits:

1. Risks associated with the mine volumes and prices.

2. Impact on water resources.

3. Impact on heritage.

4. Impact on local economy (mining vs other growth).

The errors in the assumptions and techniques underpinning BIS Oxford Economics' assessment of the risks associated with mine volumes and prices is addressed above.

BIS Oxford Economics (2018, pp.11-14) contains an extensive discussion of the issues that have been raised by stakeholders regarding groundwater resources. Hume Coal has published more details of its proposed make good provisions for any estimated impacts on water resources and these costs have been included as project costs in the revised CBA set out in BAEconomics (2018).

Given that Hume Coal has either already purchased or has made provision to purchase water allocations sufficient to cover its needs, and the costs of other known externalities have been accounted for in the CBA, it follows that all such groundwater resource costs have been fully internalised in the economic impact assessment.

BIS Oxford Economics (2018) conducts an analysis where it attempts to estimate the amount of agricultural land that would need to be taken out of production to offset the net benefit of the project. While this theoretical exercise is possible it has no practical merit in this case. If the argument is that this calculation is a proxy for the value of the groundwater resources then this is incorrect, because the vast majority of agricultural pasture and crop production in the vicinity of the project is rain fed and does not depend on groundwater or irrigation (NSW Government 2001 and Bureau of Meteorology 2012).

In addition, the WM Act vests in the Crown the right to control all water both above and below ground thus effectively separating any previous 'right' to water implicit in a land title (Mckenzie 2009). It follows that the value of land itself is now separate from the value of any water licences that may or may not be held by a land owner because the land and the water licences can be exchanged separately.

BIS Oxford Economics (2018, pp.14-15) conducts a similar theoretical analysis on the potential loss of heritage value needed to offset its estimate of the net benefit of the mine. This theoretical exercise again has no practical merit, particularly given BIS Oxford Economics' (2018, p.14) own observation that "no definitive loss in local heritage value appears to have been quantified in these submissions".[2]

In terms of impacts on the local economy, BIS Oxford Economics (2018, p. 15) states:

> As is the case with heritage values discussed above, many of these concerns are difficult to quantify in a tangible sense. The argument appears to be that other economic growth would be preferred to growth arising from mining. Externalities, aside, technically speaking, it is difficult to exclude benefits (or economic growth) within the context of a CBA based on the argument that they are the "wrong type" of economic growth.

And later BIS Oxford Economics states:

> Moreover, it is also the case that mining and tourism have long co-existed in other regions – the Hunter Valley being an obvious example of this.

In conclusion, BIS Oxford Economics (2018, p.17) note that 'none of the above mine production, groundwater, heritage and growth/quality of life issues are, in isolation, likely to make the project economically unviable'. However, BIS Oxford Economics then goes on to state that some of these factors could potentially act in combination to 'substantially reduce' the economic case of the project. Given that BIS Oxford Economics has not identified adverse externalities that have not been internalised it is not logical to suggest that such factors can act in combination to cause downside risk.

The BIS Oxford Economics report and DPE also fail to consider areas where benefits may act in isolation or combination to provide increased project upside. In this respect, DPE's assessment is not balanced and is incomplete.

Section 6.4.4 – Summary

DPE states that "*Even the Applicant's estimated net economic benefits of $373 million is relatively low in comparison to many other coal mining projects in the Southern Coalfield and across NSW. The scale of these benefits needs to carefully weighed up against the potential impacts of the project on the environment and the community*

Pursuant to section 4.15(1)(b) of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), the IPC, in determining the project, is required to consider "the likely impacts of that development, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality".

To that end, the economic benefits of a project should be assessed on their own merits and that it would be erroneous to adopt a "relativity" approach to assessing the economic benefits of a project.

One of the objects in section 1.3 of the EP&A Act is "to promote the orderly and economic use and development of land".

[2] 'Submissions' in this case refers to stakeholder submissions on heritage matters.

Objects in section 3A of the NSW *Mining Act 1992* include:

- "to recognise and foster the significant social and economic benefits to New South Wales that result from the efficient development of mineral resources"; and
- "to ensure an appropriate return to the State from mineral resources".

If approved, the project would result in:

- direct employment of around 415 full time workers during the construction phase of the project and up to 300 full time workers during the operations phase of the project;
- net economic benefits of $373 million for NSW in NPV terms;
- royalty payments of $114 million to the State in NPV terms; and
- provision of high quality coking coal.

In the context of the economic benefits of the project, it is also worth noting that the land upon which the project is proposed to be constructed is not biophysical strategic agricultural land. Therefore, the objective of promoting the orderly and economic use and development of land would be better served by approving the project for its limited life of 23 years. If it is not approved, the material benefits which are listed above will be squandered.

Notwithstanding, it is submitted that $373 million is not 'relatively low' when compared to other mining projects, as demonstrated in the below table. DPE's comments in relation to the net economic benefits of the project compared to other approved mine are contradictory with statements made in other recent assessment reports for coal mining projects, as illustrated in Table 4.1.

It is acknowledged that some of the projects mentioned in the table below are new State Significant development applications (ie greenfield development or site), and some relate to the extension of existing mines (ie brownfield developments or sites). The DPE observed during the IPC public hearings on 26 and 27 February 2019 the economic benefits of a greenfield and a brownfield mining development cannot be compared as it is not comparing 'apples with apples'. It is submitted that this observation is invalid. Regardless of whether a planning application relates to a greenfield site or the extension or modification of an existing mine (brownfield site), an economic assessment is required to be carried in accordance with the *Guidelines for the economic assessment of mining and coal seam gas proposals* (NSW Government 2015). This is to provide the necessary information relating to two matters that the consent authority must take into consideration to meet some of the requirements of section 4.15(1) of the EP&A Act in determining a development application, again irrespective of whether it is a new development application or the modification of an existing development consent:

- the public interest; and
- the likely impacts of that development, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality.

Table 4.1 Comparison of the net economic benefit of other mining projects

Project	Net direct benefits to NSW (NPV)	DPE/PAC findings
Bylong Revised Project	$301M	Comment from DP&E's Final Assessment Report: "there are significant net benefits".
Springvale Mine Extension Project	$200M	"The Department remains satisfied that the project would provide major economic and social benefits for the Lithgow region and for NSW as a whole. These benefits include the…total estimated net economic benefit in excess of $200 M (Net Present Value)." Source: *Addendum report, State significant development, Springvale Mine Extension Project (SSD 5594)', page 1.*
Moolarben stage 1	$341M in royalties	"On a broader level, Moolarben's economic assessment, indicates that the project would have a considerable net benefit to the region and to the State" *MAJOR PROJECT ASSESSMENT Moolarben Coal Project - General's Environmental Assessment Report', page 45*
Moolarben Stage 2	$311M	"The Department also recognises the significance of the coal resource and the major economic and social benefits the pr oject would provide…" "However, in this instance the Department is satisfied that the project would generate substantial economic benefits for both the Stage and region." *Source: 'Major Project Assessment' Moolarben Coal Project Stage 2 and Stage 1 Mod (MOD 3)- Director-General's Environmental Assessment Report', page 2 and page 65*
Airly Mine Extension Project	$125M	"The Airly Mine Extension Project would result in significant social and economic benefits for the local area and the State of NSW" Source: *DPE's Final Assessment Report, page 1*
Wallarah 2	DPE Final Assessment Report: $531 million Determination Report: In the range of $32M to $1,561M	"The Department recognises that thermal coal remains a highly sought-after energy source in the Asian markets, particularly the North Asian markets of Korea, China and Japan." "The Department considers that these are significant benefits, which should be given significant weight in assessing the development's overall merits." "While the Department accepts that the estimation of NCB is not a precise science, and will vary from one expert to another or in response to any sensitivity analysis, it is satisfied that the findings of the CBA are robust in this instance, and that any of the criticisms of this CBA would not materially change the broad conclusion that the project would result in a net benefit to the community." Source: *DPE's Final Assessment Report*

Table 4.1 Comparison of the net economic benefit of other mining projects

Project	Net direct benefits to NSW (NPV)	DPE/PAC findings
Russell Vale Colliery Underground Expansion Project (Southern Coalfield)	$34M estimated royalties, (Preferred project report, page 199)	Comments from DP&E's assessment report: "the Department is of the view that the UEP [the Russell Vale Underground Expansion Project] would result in significant socio-economic benefits to the local and regional areas and to the State of NSW" Comments from DP&E's Addendum Report: "In summary, the revised CBA estimates the project would have net social benefits to Australia of a minimum of $23 M minus the cost of greenhouse emissions ($0.15 M) and hence is considered desirable and justified from an economic efficiency perspective." "In summary, the Department considers that the project would result in an unequivocal socio-economic benefit to the region and the State"
Wongawilli (Southern Coalfield)	$57 million (NSW royalties only, note that no externalities were included and a CBA was not undertaken).	Comments from the Director General's Assessment Report (page iii): "The Department also recognises that the project would provide significant economic and social benefits for the Illawarra region and to NSW…" "On balance, the Department believes that the project's benefits sufficiently outweigh its residual costs, and that it is therefore in the public interest and should be approved, subject to conditions."
Metropolitan (Southern Coalfield)	$436 million (proponent's CBA net benefits estimate from the Director General's Assessment Report)	Comments from the Director General's Assessment Report (pages 55-56): "The PAC considered that the [proponent's] CBA had probably underestimated the net present value of the project. It substituted an alternative price forecast for coking coal, to reflect increasing resource scarcity and/or demand." "The Department is satisfied that HCPL has adequately assessed the social and economic impacts of the project and that the social and economic benefits that would accrue from the approval of the project would outweigh the social and environmental impacts that are likely to occur."

Further, the weighing of tangible costs and benefits has already been undertaken by Hume Coal, since the direct economic benefit is presented net of externality costs.

In addition, the net benefit of the project is not $373 million as stated by DPE, but rather in the range of $492-$522 million, when taking into account indirect benefits calculated to be between $119 million and $149 million by BAEconomics.

In terms of local effects, the BAEconomics analysis (2018) found that the project would provide direct benefits of $107 million in NPV terms and $54 million of indirect benefits in NPV terms. By recommending refusal, DPE is denying each of the 19,000 households in the Wingecarribee LGA $8,473 in NPV terms.

4.3 Steel making and power generation

Section 6.4.3 [pg 35] Steel making and power generation - DPE states that "*the Department does not consider that there is any existing shortage in coking or thermal coal that needs to be filled. The Southern Coalfield already produces up to 15 million tonnes of coking coal per year, and the state of NSW produces up to 175 million tonnes of thermal coal per year.*"

DPE (2018, p.35) "acknowledges that an additional source of coking and thermal coal would make a contribution to steel-making and power generation, respectively' but then states that it does not consider that there is 'any existing shortage in coking or thermal coal that needs to be filled". This is tantamount to claiming that there is no economic value derived by NSW from the export of either coking or thermal coal when clearly an economic benefit does arise where the returns from sales exceed the full costs incurred by the community in extracting the resource.

DPE also does not provide any evidence for its claim that it doesn't consider there to be an existing shortage of coal. The export coal price is determined by global supply and demand. Prices for both coking and thermal coal are presently quite strong, indicating that there is a healthy global demand for both types of coal, relative to their supply. Further, it is also noted that POSCO, as one of the world's largest steel producers, is much better placed than DPE to ascertain market conditions and need for coking and thermal coal.

In addition, the Southern Coalfield has never produced 15 million tonnes (Mt) of coking coal in a year. According to Coal Services statistics, total saleable production from the Southern Coalfield (which includes some thermal coal) was 11.7 Mt in 2016, 8.1 Mt in 2017 and 7.9 Mt in 2018, although this is of little relevance to the global market.

Section 6.4.3 – Steel making and power generation

DPE states that "*Blue Scope Steel in Port Kembla currently sources its coking coal from a range of different sources, including existing local coal mines at Tahmoor, Metropolitan, Appin, West Cliff and Dendrobium*."

DPE fails to mention that Appin, Westcliff and Dendrobium are all owned by South32 and form part of the integrated "Illawarra Coal" business unit. This means that there are only three parties in the Southern Coalfield capable of supplying coal to BlueScope.

Tahmoor is nearing the end of its current approval, although noting that a development application has recently been submitted by Tahmoor Coal for the Tahmoor South Project to extent its operations by 13 years.

Dendrobium is also nearing the end of its current approval and is currently preparing a new development application to extend its operations.

When assessing the proposed acquisition by South 32 of Metropolitan Colliery, the Australia Competition and Consumer Commission (ACCC) found that there were significant barriers to entry for new producers in the Southern Coalfield. The ACCC also found that BlueScope would face significantly higher costs to source coal from alternative suppliers (for example, in the Bowen Basin), and that "Australian customers of coking coal currently benefit from local competition between the coal producers in the Illawarra region." (ACCC, 2017).

POSCO has indicated that coking coal sales from Hume Coal would be made on a competitive basis, and not as a captive supply to POSCO's steel making operations.

It is almost certainly the case that coal purchases from BlueScope are not enough to provide the economies of scale required to support the various mines operating in the Southern Coalfield, nor the coal industry in the Southern Coalfield when considered as a whole, including suppliers and service industries. Coal exports through Port Kembla Coal Terminal therefore act to support the industry as a whole. Dwindling volumes, due in part to legacy mines failing to secure ongoing government approvals, and a lack of new entrants jeopardise the economic viability of the Port Kembla Coal Terminal. Should the Port Kembla Coal Terminal fail to remain economically viable, this will have major flow-on implications for the coal mining and steel making industries in the Illawarra. DPE has failed to adequately consider the impact of the failure of new entrants on the industry as a whole, as well as downstream industries.

Section 6.4.3 – Steel making and power generation

DPE states that "*the Department does not consider that the project would make any material difference to power generation in NSW or reduce electricity prices for consumers.*"

DPE's statement is curious. Hume Coal has never claimed that the project would reduce electricity prices for consumers and has not assumed any benefits arise from using the coal for local power generation.

4.4 Conclusion

Section 6.4.4 – Summary

DPE states that "*The Department notes that there are fundamental difficulties in efficiently recovering the coal resource for this project, particularly due to the shallow depth of the coal and the risk of environmental impacts.*"

It is unclear how DPE comes to the conclusion that there are "fundamental difficulties" in efficiently recovering the coal resource due to its "shallow depth" and "risk of environmental impacts". To the contrary, the "shallow depth" is a benefit when considering the various technical merits of the project, in terms of gas content, seam access and likely geotechnical conditions. Hume Coal does not consider that there is any risk of land use conflicts when it is understood that even unrealistically worst-case geotechnical modelling returns maximum subsidence values in the same order of magnitude as natural ground movements.

5 Other issues

5.1 Precautionary principle

Section 6.4.1 [pg v] Introduction - *"the Department considers that there is a threat of serious harm to both groundwater and surface water resources, and there is currently considerable scientific uncertainty about the level of environmental damage to both. As a result, the 'precautionary principle' is triggered and the project as currently proposed should not be considered an 'ecologically sustainable development".*

In Telstra v Hornsby Shire Council [2006] NSWLEC 133 at [128], Chief Judge Preston said:

> The application of the precautionary principle and the concomitant need to take precautionary measures is triggered by satisfaction of two conditions precedent or thresholds: a threat of serious or irreversible environmental damage and scientific uncertainty as to the environmental damage. These conditions or thresholds are cumulative. Once both of these conditions or thresholds are satisfied, a precautionary measure may be taken to avert the anticipated threat of environmental damage, but it should be proportionate.

Hume Coal rejects DPE's assertion that the first criterion for the operation of the precautionary principle is satisfied in respect of surface water resources, on the basis that there is no reasonable basis upon which it can be concluded that there is "a threat of serious harm". As a result, the first criterion for the precautionary principle to operate in the context of impacts to surface water resources is not satisfied and the precautionary principle thus has no further application in that context.

As to DPE's assertion that there is a threat of serious environmental harm in respect of groundwater resources, Hume Coal acknowledge that there will be impacts to the groundwater aquifer in terms of drawdown, "take" and diversion. There is not, however, "scientific uncertainty" as to the predicted impacts or "environmental damage" of those impacts, with the consequence that the second criterion for the precautionary principle to operate is not enlivened. The DPE's own expert groundwater peer reviewer, Hugh Middlemis, found that the "*Hume Coal Model is fundamentally consistent with best practice in design and execution*", and it follows therefore that confidence can be placed in the outputs of the model and the subsequent predicted impacts. Further, the world class uncertainty analysis undertaken of the model further reduces the 'scientific uncertainty' relating to the predicted impacts of the project.

Further, it has been agreed by DPE, DoI Water and Hugh Middlemis that the make good arrangements proposed by Hume Coal to mitigate the potential impacts on groundwater quantity (ie drawdown) are technically feasible. The proposed impacts are not irreversible.

Even if both criteria were satisfied in respect of impacts to groundwater resources, the triggering of the precautionary principle would require a proportionate response (as stated by Chief Judge Preston in Telstra at [128]). Refusal of the project would not be a proportionate response and, in any event, the enlivenment of the precautionary principle does not dictate refusal of the proposed development (Telstra at [179]).

5.2 Mining SEPP and land use compatibility

Section 4.3 [pg 10-11] Permissibility - *"In particular, clause 12 of the Mining SEPP requires the consent authority to consider whether the project is compatible with other land uses, including "existing, approved and likely preferred land uses". In that regard, the zoning provisions of the LEP are relevant to the extent that they influence the existing, approved and likely preferred land uses in the project area and its surrounds.*

The Department considers that the project is not necessarily incompatible with the existing or likely land uses in RU3 or SP2. However, the objectives of the E2 and E3 zone are aimed at protecting existing historic, ecological, cultural and aesthetic values. Similarly, the RU2 zoning is focussed on maintaining 'rural landscape character' and 'encouraging sustainable primary industry'.

Importantly, both the E3 and RU2 zones include non-mandatory objectives, which reflects that there are specific characteristics of the existing land uses that Council would like to protect. Based on the limited list of permitted land uses and the non-mandatory objectives in both zones, the Department is concerned that a new coal mine may not be compatible with the "existing, approved and likely preferred land uses" of these zones.

Hume Coal considers the suggestion that a new coal mine may not be compatible with the "existing, approved and likely preferred land uses" of the E3 and RU2 zones to be inaccurate speculation that fails to have regard to the fact that the project:

- is of a temporary nature, having a project life of 23 years;
- is an underground mining project rather than an open cut project;
- does not propose to have any surface tailings facilities or permanent waste rock emplacement areas;
- has been designed to minimise environmental impacts. In particular, and unlike most other coal mines in the Southern Coalfields, a non-caving underground mining method was chosen to specifically avoid any subsidence impacts on the surface and so that the existing land uses could continue throughout the mine life on the vast majority (98%) of the project area; and
- the site will be able to be rehabilitated to its earlier, pre-disturbance state in a manner that is compatible with existing, approved and likely preferred land uses in the vicinity of the project site.

In Hume Coal's view, the "concerns" raised by the DPE in its consideration of clause 12 of the Mining SEPP are not supported by evidence and ignore the important features of the project as described in the EIS, which indicate land use compatibility of the project with existing, approved and likely preferred land uses in neighbouring areas.

The suitability of the site is summarised in Chapter 24 of the EIS (EMM 2017) which explains that principally, the project will efficiently recover an economic coal resource beneath privately-owned land where underground mining is permissible. Resources extracted in this way will avoid land use conflicts by continuing existing land uses at the surface and minimising impacts to significant environmental, cultural and built features. The site is well served by necessary services and infrastructure, particularly nearby rail infrastructure and Port Kembla. A range of commitments have been made by Hume Coal to mitigate potential impacts on surrounding land uses. When these commitments are applied, the project is unlikely to have a significant land use impacts.

It should also be recognised that the land upon which the project is to be constructed is currently subject to an exploration licence under the NSW *Mining Act 1992* and, as noted on page 9 of the DPE's Assessment Report, has been subject to an exploration licence since 1985. Therefore, mining activities in the form of exploratory drilling and prospecting has been an existing land use in the area for many years. More broadly, 11 mines have operated in the Southern Highlands region, with mining undertaken in the region for 150 years.

It should also be recognised that neighbouring landowners would have been well aware of the fact that the land on which the project is proposed to be built has, since 1956 (when the mining lease was issued, and consolidated into the present form in 1985), always had the potential to be the subject of a mining project.

5.3 Submissions

Section 7 Evaluation [Page 40]: *"The vast majority of the community has expressed its opposition to the project, particularly those in close proximity to the proposed mine site."*

Hume Coal acknowledges that community responses are aspects of the public interest that is to be taken into account under section 4.15(1)(e) of the EP&A Act. However, Hume Coal considers that it is misleading for the DPE, in considering the factor referred to in section 4.15(1)(e) of the EP&A Act, to claim that the "vast majority of the community has expressed its opposition to the project, particularly those in close proximity to the proposed mine site". This is because:

- There are "over 47,000 people in the Wingecarribee Shire Council local government area" (p 8 of the DPE Assessment Report);
- There were 5,131 objections to the project from persons within the Wingecarribee Shire Council local government area (p 16 of the DPE Assessment Report);
- It is recognised that 5,131 objections out of the 47,882 people in the LGA (ABS 216) equates to only 10.7% of persons in the LGA objecting to the proposal. This being so, it is not true that the "vast majority of the community has expressed its opposition to the project"; and
- The "silent majority" of persons in the Wingecarribee LGA who did not make a submission in respect of the Project cannot be assumed to be against the proposal.

6 Conclusion

The Hume Coal Project and Berrima Rail Project have been the subject of rigorous assessment for many years, both by the proponent and the many consultants and expert independent peer reviewers engaged to undertake environmental, social and economic assessments of the proposals, and by the DPE and their expert independent peer reviewers.

In their assessment report the DPE conclude that after a comprehensive assessment of the full range of potential impacts including economics, noise and vibration, air quality, greenhouse gas emissions, traffic, biodiversity, heritage, agriculture and rehabilitation, the potential impacts of the project would be similar to or less than other approved underground mining projects. Further, the Department accepted that the impacts relating to these aspects are likely to be managed to achieve an acceptable level of environmental performance.

However, the DPE also concluded that the economic benefits of the project cannot be realised without significant adverse impacts on the environment and community in relation to groundwater impacts.

The potential impacts relating to groundwater resources associated with the project can be separated into two aspects; the predicted impacts to groundwater quality and quality, and the ability to manage and mitigate (ie to 'make good') these impacts on privately owned bores.

In relation to the first aspect and as explained in Chapter 2 of this submission, the time predicted for the mining induced drawdown from the project to recover to within 2 m in all bores is relatively minimal (72 years) compared to other operating and approved mines in NSW (in excess of 1,000 years). Importantly though, these impacts need to be considered within the context that Hume Coal holds almost all (in excess of 93%) of the peak groundwater licences that will be required for the project. Further, the predicted groundwater depressurisation and drawdown extent as a result of the project is modest compared to many other assessed mining projects in NSW and is by no means the '*most significant of any mining project that has ever been assessed in NSW*', as claimed by the DPE. This claim in DPE's Assessment Report is an example of the errors in their report. As explained in Chapter 2, DPE relied upon the advice of DoI Water in forming their view of the impacts to water resources from the project; advice that was not based on the findings of their own independent expert, Hugh Middlemis. In fact, DoI Water did not reference or take into consideration any of the advice from DPE's expert.

In relation to the second aspect of being able to 'make good' impacts to privately owned bores, the DPE, DoI Water and DPE's independent expert all agree that the measures proposed by Hume Coal to make good impacts are technically feasible; and are therefore suitable and practical. It follows then that DPE's concerns relating to groundwater impacts, and therefore their grounds for recommending refusal of the project, relate to an administrative matter in facilitating the implementation of these make good measures. Hume Coal does not accept that this is a valid reason for recommending refusal of the project, given that procedures for implementing 'make good' are commonly implemented at numerous mines, including others in the Southern Coalfield such as Tahmoor Mine, and have been for many years.

The mine design and method proposed for the project has been subject to a rigorous design and review process, with input and review by pre-eminent experts in the field. The mining method proposed is based on long established mine design principles and is supported by a robust 3D geotechnical model. As explained in this submission, the overall principles of the geotechnical model and the methodology adopted, in principle, have been accepted with broad agreement by the experts engaged to review the mine plan by both DPE and Hume Coal.

Further, the net economic benefit of the project, estimated at $373 million, is significant and on par with, or greater than other approved coal mining projects in NSW.

The conclusions of the EIS for the Hume Coal Project therefore still stand. The project will develop a valuable, publicly owned natural resource – Wongawilli Seam coal. The project's design and proposed management procedures are based on a comprehensive understanding of environmental conditions in and around the project area, and the design avoids threats of serious or irreversible environmental damage. The project is clearly justified on economic, social and environmental grounds.

7 References

ACC 2017, https://www.accc.gov.au/system/files/public-registers/documents/MER17%2B1962.pdf accessed 05/03/2019.

Department of Planning and Environment December 2018 *Hume Coal Project and Berrima Rail Project State Significant Development Assessment.*

EMM Consulting Pty Ltd (EMM) 2017a, *Hume Coal Project Environmental Impact Statement.* Prepared by EMM for Hume Coal Pty Ltd.

2017b, *Berrima Rail Project Environmental Impact Statement.* Prepared by EMM for Hume Coal Pty Ltd.

Geosyntech 2016, Hume Coal Project Hydrogeochemical Assessment, Lange Jorstad and Bruce Sass, Geosyntech Consultants Pty Ltd.

Hebblewhite B. K. 2019, *Independent Review of the NSW Government Department of Planning & Environment – State Significant Development Assessment: Hume Coal Project and Berrima Rail Project.*

Mine Advice February 2019, *Response to DP and E Assessment Report, Hume Project.*

NSW Department of Primary Industries (DPI Water) 2016, NSW Water Register, viewed 21 November 2016, www.water.nsw.gov.au/waterlicensing/registers

NSW Department of Primary Industries Office of Water (NOW) 2011, *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources – Background document*, NSW Government.

RGS 2018, Hume Coal Hydrogeochemical Modelling Assessments, RGS Environmental Pty Ltd.

WSP 2018, *Hume Coal Project Response to Submissions Revised Surface Water Assessment*. Prepared for Hume Coal Pty Ltd by WSP.

Appendix A

Response to questions from the IPC

A.1 Response to questions from the IPC

The Independent Planning Commission provided a number of questions to Hume Coal on 1 February 2019. These questions are presented below along with a response to each one. Responses to questions relating to the mine design have been developed with input from Russell Frith of Mine Advice, and Dr Bruce Hebblewhite.

Table A.1 Reponses to questions from the IPC

Question	Response
Surface water	
Is the project viable if water that is in excess of processing needs and that has been in contact with coal has to be treated to Australian Drinking Water Guidelines before discharge to surface waters?	The mine water management system has been designed to ensure that no coal contact water is released to surface waters. Runoff from coal contact areas will be captured in stormwater basin (SB) 01, SB02, and mine water dams (MWD) 05, MWD06 and MWD07, from where it will be transferred to the Primary Water Dam (PWD). The revised water balance base case model, which adopted groundwater inflow estimates from the Mean K Groundwater Model UA67%ile static average climate, demonstrated there will be no releases or overflows from SBs and MWDs capturing coal contact water (ie no releases or overflows from PWD, SB01, SB02, MWD05, MWD06 or MWD07). The results of the revised water balance modelling are provided in Section 3 of the *Hume Coal Project Response to Submissions Revised Surface Water Assessment report* (WSP, 2018). Runoff from areas where there is a low risk of coal contact (ie runoff from areas that do not contain coal stockpiles or the processing plant but that could contain small amounts of coal due to mine vehicle traffic) may be released to local creeks after collection of the first flush has been diverted into storage and reuse dams (such as SB03 and SB04), and monitoring shows that post-first flush runoff is of an acceptable quality to release. Predicted releases from SB03 and SB04 are reported in Section 3.2.2.3 of the *Hume Coal Project Response to Submissions Revised Surface Water Assessment report* (WSP, 2018). The predicted maximum annual releases to Oldbury Creek from SB03 and SB04 are 30.6 ML/yr and 41.1 ML/yr, respectively, based on 107 water balance realisations. The maximum 19-year sum of releases to Oldbury Creek from SB03 and SB04 are 277 ML and 302 ML respectively, based on the 107 water balance realisations. In the event that water quality in SB03 and SB04 does not meet the discharge limits, water will not be released to Oldbury Creek and will be contained within in the mine water management system. Notably, the PWD has the capacity to store all runoff from SB03 and SB04 catchments, if required. The predicted peak volume required in the PWD if there are no releases from SB03 and SB04 to Oldbury Creek is 714 ML, based on the 107 water balance realisations. The PWD has been designed with capacity of 730 ML, which is greater than the peak storage volume required. The project can and has considered a treatment plant for the management of water. Given the net economic benefit associated with the project of $373 M, the cost of a water treatment plant would not significantly affect the viability of the project. However, whilst the project would remain viable if a water treatment plant was included, as explained above and detailed in the *Hume Coal Project Revised Water Impact Assessment Report* (Appendix 2 to the Response to Submissions, EMM 2018), a treatment plant will not be needed.

Table A.1 Reponses to questions from the IPC

Question	Response
Should mine safety and operational reasons prevent the underground storage of mine water, what treatment process would Hume need at the surface to meet environmental requirements?	Mine safety will not be compromised. Most panels storing water during mining are down dip (down hydraulic gradient). The only ones that are not are at the end of mining and not used to store significant water. As a minimum, should water be unable to be stored underground, an assessment against NorBE criteria would need to be undertaken and calculated on the final volume (ie it will not be the total volume).
The EPA has recommended that there are no deliberate or inadvertent discharges from the PWD to Oldbury Creek. Can this be achieved even in cases of prolonged wet weather?	The adopted capacity of the PWD is 730 ML, which is significantly larger than the volume required to meet a 500 year ARI event. This volume was determined by the water balance modelling under historical climate conditions as able to prevent discharges for all 107 climate sequences. The risk of any inadvertent discharges in the case of prolonged wet weather from the PWD is therefore highly unlikely. Water balance modelling for the Hume Coal Project has been based on historical daily rainfall and evaporation data for the site for the period 1889 to 2015 (sourced from Data Drill), which includes prolonged wet periods. The revised water balance base case modelling predicts a peak simulated stored volume of 625 ML in the PWD over the 19-year mining period based on the 107 water balance realisations modelled. The peak simulated volume in the PWD of 625 ML is significantly lower than the modelled storage capacity of 730 ML, indicating a very low risk of overflow from the PWD based on the modelled climate data.

Table A.1 Reponses to questions from the IPC

Question	Response
Explore further Hume's proposal to inject treated mine water in excess of production requirements into the Hawkesbury Sandstone aquifer?	Shallow reinjection of excess water from mining operations in the Hawkesbury Sandstone was one of the original strategies considered for water management for the project. Hume Coal undertook two detailed desktop studies to consider and model reinjection into the Hawkesbury Sandstone. It was a preferred option for the management of surplus water as it would reduce drawdown impacts, reduce the reduction of baseflow and also provide efficient emplacement of water back in the key area of the water source. Hume Coal considered this option in some detail, including undertaking numerical modelling of the option and detailed scoping for an injection trial. The reason this option did not progress was the inability of Hume Coal to secure a licence that allowed a trial reinjection test to occur on site. Steps taken to obtain a licence for a reinjection trial by Hume Coal include: • Hume Coal applied for a licence to reinject (of 28th May 2015), which included a detailed proposal and reporting of potential impacts, an outline of the reinjection design and the volume associated with the 7-day reinjection trial (including where water would be licensed and sourced from for the trial); • 12 months of negotiations followed lodgement of this application and the shifting of potential approvability between officers and NSW Government agencies including DoI Water, Water NSW and the EPA; • Hume Coal were then told that there was no licence mechanism within either the *Water Management Act 2000* or the *Water Act 1912* to undertake this activity; and • Hume Coal continued to attempt to negotiate for another two years with NSW DoI Water on this matter to no avail, and moved to progress investigations into other water management strategies for the EIS. It is noted that prior to and during these negotiations, Iluka Resources Limited (Iluka) ran several long term pumping and reinjection trials at Balranald, NSW, that occurred for periods in excess of 30 days and involved very large volume of groundwater. These activities were easily licensed under the *Water Act 1912,* and Hume Coal referenced this example in negotiations with DoI Water at the time. Hume Coal was therefore effectively prevented from exploring shallow reinjection of excess water further due to the inability to obtain approval or a licence from DoI Water, with the mechanism to approve the activity of reinjection unable to be confirmed. Hume Coal then made a decision to progress with pumping the water into down dip and or sealed panels in the underground workings.
If Hume's ability to "make good" on bores on affected properties is insufficiently effective, would direct supply of treated water to these properties be a feasible alternative?	Yes for some landholders (nearby ones) this option may be a good solution and is one of the options under consideration. This will be investigated as negotiations with individual landholders progress and assessed on a case by case basis.

Table A.1 Reponses to questions from the IPC

<table>
<tr><th>Question</th><th>Response</th></tr>
<tr><td colspan="2">Groundwater</td></tr>
<tr><td>Could Hume Coal explain how it will operate if the drawdowns on private bores are larger than predicted and the NSW Government allocates less than one megalitre per share in any water year? Available Water Determinations (AWD) less than one megalitre per share are rare for groundwater systems, but it has happened elsewhere</td><td>The prediction of drawdown on private bores has been undertaken in great detail with detailed uncertainty analysis. The drawdown at the 67th%ile has been considered, although this level is unlikely to occur. Should additional drawdown (ie 90th%ile occur) then the impacts manifest as additional bores being affected by drawdown, not the severity of the existing drawdown. Therefore, the same approach to licensing and make good would be required, just more landholders would be involved.

The NSW Government can only reduce allocations via an AWD on an entire water source (ie not on a management zone). Considering Zone 2 is under allocated (ie 73 GL of remaining allocation in the water source) Hume Coal consider an AWD on the Sydney Basin Nepean Groundwater source highly unlikely. Notwithstanding, if it did occur, it would not impact on private bore make good in any case; it would impact on the licence volume allowed to be extracted in a year.

Provided the unlikely AWD does not occur in year 17 (ie peak take) it is unlikely to have any effect on the project. If it did, then additional allocation could be traded in (temporarily for that year), or production slowed for that year, or until the AWD returned to 100%.</td></tr>
<tr><td>What will Hume Coal do for private bore owners if the option to deepen a bore or drill a new bore isn't successful as it doesn't yield sufficient water for the existing business to carry on successfully?</td><td>Options include:
Financial assistance to cater for increased pumping costs (ie for increased electricity requirements from having to pump from a bore with a lower head);
Deepening of pump inside bore casing (this may or may not be feasible depending on bore construction and current condition);
Replacement bore/s, which may include:
several bores to maintain required yield;
larger diameter bores (providing higher yields than narrow diameter bores);
deeper bores (ie below the coal seam), provides either/or:
larger storage volume of water;
greater available pumping head; and
larger yields if deep fractures encountered;
bores located on other areas of the property (ie for some larger properties, moving the bore away from the mine will be sufficient to avoid impacts); or
Alternate water supply, which may include enhanced surface water capture (enlarging dams, new dam).</td></tr>
</table>

Table A.1 Reponses to questions from the IPC

Question	Response
How will Hume Coal compensate for loss of water rights well into the future. Recovery of groundwater levels are estimated to take 75 years?	A staged approach will be implemented to make good; that is impacts will be mitigated prior to the impact occurring. There will be no loss of water 'rights'; the impact will be drawdown in the bore. Water rights will still be retained by the owner and impacts mitigated. Make good arrangements will be for the 75 year period as that is how long it takes for the last bore to recover. • The average recovery occurs after 53 years from commencement of mining, with the average time that a bore is drawn down in excess of 2 m being 41 years; • Three bores experience drawdown beyond 2 m for less than a year, • The first bore to recover fully occurs after 29 years from the commencement of mining (ie < 10 years following mining concluding). • The average drawdown 6m. Therefore, make good arrangements, once established, will be the mechanism to maintain water rights (ie water rights/access to water is not lost as a result of the project).
Is there a risk to the quality of adjacent groundwater from the storage of slurried mine waste and excess mine water in mined out sections of the mine?	No. Whilst some groundwater interaction with the stored coal reject materials may occur over time, the interaction is very small and any trace levels of coal processing chemicals remaining in the coal reject slurry will be significantly diluted and indistinguishable from the natural groundwater quality (Geosyntech 2016). Therefore, the potential for any changes in water quality for users accessing coal seam groundwater down gradient of the proposed mine is considered non-existent. The process of osmosis has been considered at the request of the IPC. Osmosis is defined as being the passive movement of water from solutions of low concentration of solutes (ie low salinity water) into those of high concentration (ie high salinity), thereby causing the concentrations to move toward being more equal in concentration. For the Hume Coal Project, the water quality of the emplaced rejects and water into the underground workings is 'indistinguishable' in solute concentration and signature to the groundwater within the Wongawilli Coal Seam. Therefore the process of both osmosis will be minimal (as water qualities are similar) and the downgradient impact to water quality along the long term flow path (ie once groundwater recovers) will be non-existent, and measurable change will not be detected.
What proportion of the mine can be constructed so that current workings are consistently up-drift from stored water?	Mining will always be 'up dip' or relatively flat to the storage of water. There will be no mining down dip of stored water.

Table A.1 Reponses to questions from the IPC

Question	Response
Class of groundwater model - Comment on difference of opinion between experts in relation to whether "the model is Class 2 as there are specific aspects of the model that only meet Class 2 criteria" (page 20)	The model is Class 2. NSW Government Independent expert High Middlemis, states: • 'cherry-picking one guideline comment rather than considering all the attributes suggested in the table does not constitute a valid agreement to support the claims by others of poor model performance'. (Middlemis 2017) • 'the Hume Coal model itself is suitable for the mining impact assessment purpose (Class 2 confidence level) Hugh Middlemis stated *'the model is considered to be confirmed as Class 2: suitable for impact assessment '*
Local geological data - Comment on the dot points that summarise the issues raised about the geological data. Has the additional bore data been provided? If not can this be done (page 20).	• There are 345 boreholes in the project area: 179 of which are in the proposed mining area. • Interburden thicknesses are variable in the model and reflect actual field data • The model has the correct representation of the interburden data – not explicitly reported in EIS • Triassic interburden layer (8) has a minimum thickness of 0.4m and does not unduly constrict vertical groundwater flow into the mine workings. • Permian interburden (layers 9 and 10), have a min thickness of 0.29m, max of 4m and do not unduly restrict inflow into the mine workings. • Middlemis confirms: *…the Hume Coal Model has been set up with an appropriate representation of the interburden properties…*
Uncertainty and sensitivity analysis - Comment on difference of opinion of experts (page 21)	This is dealt with through the independent expert peer review by Hugh Middlemis and the agreement with DoI Water during the RTS on how and what to undertake sensitivity on. The difference of opinion is from lobby groups, not the independent expert or the Hume Coal peer reviewer.

Table A.1 Reponses to questions from the IPC

Question	Response
Comment on "Revised groundwater model provides a range of predictions that can be used to make a reasonable assessment of the potential impacts. However, given the various residual uncertainties, the Department has adopted a precautionary approach and considers that the revised model's more conservative estimates should be used" (page 21)	In terms of reporting results: ○ 50^{th} %ile (ie median) is used in most impact assessment ○ All standard models are 50^{th} %ile ○ Pilbara uncertainty analysis recommended 20^{th}%ile to 80^{th}%ile range should be used ○ In many known mining cases, uncertainty analysis is undertaken, and then the standard 'base case' model is either adopted or amended and then results that align to the 50^{th}%ile are submitted in the EIS for approval. Hume Coal adopted the 67^{th} %ile (ie rather than the 50^{th}%ile) because of known community and social concerns and a desire to be conservative. It is considered inappropriate to go to the next level and adopt the 90^{th}%ile results due to the following reasons: ○ 90^{th} %ile - extremely conservative – '*Not likely to occur even in extreme conditions*' (IESC 2018). This description is taken from the IESC Explanatory Note, Uncertainty Analysis in Groundwater Modelling. The IESC have developed text descriptors for the different categories to *'help avoid subjective decision-making biases by the water manager or the project proponent'***;** ○ The volume of water being licence by Hume Coal is the physical take of water, plus the inflow to the void (which remains in the groundwater source); ○ The volume of water being licenced is 2,059, this is the maximum 'interception' in year 17, but the physical take maximum (ie 'to sump' water) in years 17 is only 1,009 ML; ○ No other mines in NSW licence both 'take' and the 'inflow to sealed/disused workings'. In most cases the net take is licensed, and not the indirect inflow to workings with is very rarely modelled or reported; ○ The 50^{th}%ile is used in all other mines in NSW, many with much less robust modelling or uncertainty analysis than Hume Coal have undertaken; and Adoption of the 90^{th}%ile will establish a precedent for mine approvals that will be counter to the science and openness involved with modelling uncertainty.

Table A.1 Reponses to questions from the IPC

Question	Response
Consideration of drawdown impact - "level of drawdown impacts is very significant across all predictions"; the impact identified in the dot points (page 22); and the unique set of factors in the dot points (page 23). "Given the fundamental nature of these factors (ie a combination of hydrology, geology, and land use), there are very limited options to avoid or minimise the drawdown impacts….only remaining option is to mitigate or compensate for any impacts via "make good arrangements""(page 23)	The project, compared to other coal and mining projects in NSW, occurs within a relatively high-density area of water supply bores. The higher density of bores, compared to other areas where mining occurs, is a result of smaller (rural) property sizes; shallow available groundwater; and rural residences with extensive landscaped gardens and lawns. Importantly, the number of bores predicted to experience drawdown is not reflective of the extent of environmental impact from the mine; it is reflective of the density of bores overlying the mine. In other areas of NSW, such as the Hunter Valley, there is a much lower density of bores, and so less bores experience drawdown as a result. The lower bore density in the Hunter and other areas compared with the Southern Highlands is likely a result of larger property sizes, more rural agricultural blocks opposed to rural/residential, and less prospective groundwater resources (ie lower quality and yield). The groundwater impacts (drawdown and inflow) for most other coal mines in NSW are similar or more significant than the project; however, these impacts are not being 'felt' by as many landholders as there are fewer bore numbers. In recognition of the requirement to mitigate impacts, Hume Coal has undertaken extensive work to develop a strategy to 'make good' all bores with the potential to be affected by greater than 2 m of drawdown as a result of the project. Importantly: • access arrangements with over 20 landholders have already been agreed and monitoring is underway; • the average drawdown for all bores in the area is only 6 m; • only 16 bores are required to be made good in the first five years of mining; and • 64 bores (68% of all affected bores) can be made good with minor strategies such as increased pumping costs and lowering pumps.
<u>Proposed make good strategy</u> - Comment on Table 9 and Figure 11 (Page 23 and 24)	Hume Coal has clearly articulated, mapped and graphed the drawdown impact for each individual landholder. The number of bores may appear large, but this does not equate to adverse environmental impact. Other mining projects have much greater drawdowns (laterally, vertically and temporarily) and greater inflows.

Table A.1 Reponses to questions from the IPC

Question	Response
Suitability and practicality of make good - Comment on reasons in this section (page 24)	The NSW DoI Water did not raise any major concerns about the technical feasibility of the proposed options for make good. Section 6.2.5 of the DPE Assessment report states that: *'while the Department agrees that the options of deepening or replacing the bores may present challenges, the department generally accepts that the Applicants proposed make good options are technically feasible.'* The NSW Government independent peer reviewer, Hugh Middlemis, on the subject of technical feasibility of make good, states: • *'all these arrangements are reasonable in principle'* • *'Dewatering of one horizon (the mined coal seam), does not preclude the occurrence of saturated aquifer conditions above';* • *'Depressurisation does not dewater an aquifer unit, it simply lowers the groundwater pressure level'; and* • *'Berrima Colliery demonstrates that depressurization and or dewatering of coal seams does not preclude access to viable aquifer resources, even overlying the mined area'*. The make good strategy is therefore very flexible in its approach and will be tailored for each individual landholder depending on their respective and individual needs and the location they are in (ie are they immediately above the workings or to the side). Some landholders may require a make good agreement that replaces their one deep bore with several shallower, larger diameter bores to maintain the required yield. Whereas, some landholders with lower yield requirements may prefer a large above ground tank or dam, with assistance with increased pumping costs to run the pump more frequently.
Please supply for discussion: • All 90th percentile modelling results for predicted drawdown impacts on privately owned bores and predicted mine inflows to complete tables 7and 10 in the DP&E assessment report (Dec 2018);	This is provided in figure 2.5 (refer to Chapter 2).
• Simulated hydrographs at six private bores where the bore's water level is impacted by 2 meters or more. The hydrographs should contain enough information to show both water table decline, and water pressure decline at these sites. Labelling should show the model layers and associated pressures changes for the mining period and for an equivalent period post mining; and	Hydrographs for private bores are provided in the Hume Coal Project Make Good Report (EMM 2018). Six of these hydrographs are included in Appendix B. These hydrographs are for six of the bores that would be subject to make good measures in Stage 1. These hydrographs don't have the requested water table and pressure decline on them, as this requires the model to be re-run. However, this work is currently being undertaken, and the updated hydrographs will be provided to the Commission when completed.

Table A.1 Reponses to questions from the IPC

Question	Response
• Similarly, hydrographs are requested at four locations that may have terrestrial groundwater dependent ecosystems or where there is a hydraulic connection to a surface water feature (stream, dam).	An assessment of the potential for impacts to GDEs was undertaken as part of the EIS and updated in the RTS. This assessment found that the upper reaches of Belanglo Creek and a patch of terrestrial vegetation south of Wells Creek are predicted to have a high risk of impact (approximately 13 ha and 6 ha, respectively). Hydrographs from virtual piezometers were reviewed for Belanglo Creek and Wells Creek to determine the modelled time of maximum drawdown and recovery at these streams. These hydrographs were presented in the RTS in Figure 13.4. This figure is reproduced in Appendix B. The locations of the virtual piezometers were shown in Figure 13.3, and this figure is also reproduced in Appendix B. As explained in the GE assessment in the RTS, the risk of drawdown impact in the ecosystems identified in Figure 13.3 must be interpreted in the context of the level of dependence of these ecosystems on groundwater. If the ecosystems had an entirely/obligate dependence on groundwater, any changes to the system would likely result in a permanent impact on the ecosystem's function. Terrestrial vegetation has a facultative (opportunistic) dependence on groundwater, but can exist using other water sources outside of periods of prolonged drought. Accordingly, no impacts are expected to these ecosystems on Belanglo Creek and south of Wells Creek if periods of prolonged drought are not experienced during mining. Monitoring and management triggers were therefore proposed in the Biodiversity Assessment Report for terrestrial vegetation in the event of prolonged drought during mining.

Table A.1 Reponses to questions from the IPC

Question	Response
Geology and Mine Design	
Do you think there are still outstanding questions or unresolved issues regarding the reliability of the 3D geotechnical model?	There are no outstanding issues of any substance remaining with regards to the 3D geotechnical model. The model was developed using state of the art software; appropriate material properties with conservative, down-rated values; it was conducted by a leading international expert, Professor Keith Heasley; and it was calibrated against an appropriate case study from the neighbouring Berrima Colliery. The DPE's own experts conceded at the Expert Conclave meeting in March 2018 that the model was appropriate. In their peer review reports (commissioned by the DPE), Jim Galvin and Ismet Canbulat raise a small number of points of detail regarding failure criteria and related representation of web pillar behaviour. There will always be minor differences of opinion or technical assessment in the field of geomechanics which is quite complex and not readily defined by single, proven behavioural models. These minor differences are considered to be primarily of academic interest only, and regardless of the approach taken in the modelling, it is not considered that these issues would create any substantive changes in the modelling outcomes. Mine Advice (2019) also explains that the various technical issues raised by the two independent experts in their second review reports are demonstrably not material to the integrity and robust nature of the 3D geotechnical models. The 3D geotechnical modelling studies included sufficiently broad input parameter sensitivity analyses and also extreme scenario modelling whereby one or even a full panel of web pillars were removed from the model, such that it is inconceivable that modifying one or more input parameters in the manner being suggested by the independent experts, would materially change the modelling conclusions in terms of the post-mining long-term stability of the remnant mine layout. Further, the proposed mine layout design does not solely rely on the 3D geotechnical models, but rather has been determined and evaluated using several different methodologies as outlined in Mine Advice 2019, all of which lead to the same conclusion, namely that the remnant stability of the proposed mine layout is fully fit for purpose in terms of adequately mitigating surface and/or sub-surface impacts due to mining.
Do you agree with the Department's statement in the Assessment Report (p.32) that 'the issue of pillar stability has not been adequately resolved'?	Disagree. The issue of pillar stability has been adequately addressed and has also been acknowledged as of lesser significance (when referring particularly to web pillars). Further, and as outlined in the response to the first question above and discussed in more detail in Section 4 of Mine Advice (2019), having initially developed mine layouts using a relevant and credible empirical design method, testing the robustness of those layouts using calibrated 2D and 3D numerical models that were run by a recognised world-authority in the subject area of numerical modelling in coal mine design, and having interpreted the modelling results in terms of both load-based and displacement-based stability criteria, there is no credible basis for the layout design outcomes being sufficiently misleading or fragile such that the various conclusions arrived at from the modelling cannot be relied upon for mine approval purposes. In this context, Hume Coal and Mine Advice vehemently disagree with the Department's statement.

Table A.1 Reponses to questions from the IPC

Question	Response
Do you intend to provide information on the risk assessment workshops undertaken for the mining concept and the use of bulkheads?	Further information on the risk assessments undertaken is provided in Section 3.7 of this submission. As described, risk assessment workshops were held in 2015 in relation to the proposed Hume Coal Project mine design concept and into the risk of inrush and inundation. This risk assessments were facilitated by Polaris Australia and attended by members of the Hume Coal team and experts in the field of mine design, geotechnical engineering, geology and hydrogeology. As discussed at the private briefing with the Commission, Hume Coal would be happy to meet with the Commission to further discuss the findings of these risk assessments.
The Resources Regulator regards the mining method as secondary extraction and regards the web pillars as non – conforming. The mining method is classified as a 'high risk activity'. Is there any new information to provide on this issue?	The definition as secondary extraction is challenged as being inappropriate, as discussed in Section 3.2.1ii of this submission. As described in Section 3.9 of this submission, the references made by the DPE to "High Risk Activity" throughout the Assessment Report are used in a manner that is mischievous and potentially misleading. The descriptor of a "High Risk Activity" is one that is sourced from the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014. Under clause 33 of that Regulation, there is a requirement on the operator of a mine site to ensure that any "high risk activity identified in Schedule 3 and that applies to the mine .. site pursuant to that Schedule is not carried out at or in relation to the mine … site" unless the notification requirements set out in clause 33 are complied with. A "high risk activity" classification does not imply any level of unacceptable risk but simply draws attention to the need for appropriate risk management measures to be adopted. Schedule 3 of the Regulation identifies numerous types of "High Risk Activities". Examples of such activities listed in Schedule 3 include: • barrier mining; • emplacement areas; and • coal extraction by use of secondary extraction by longwall mining, shortwall mining or miniwall mining; pillar extraction; pillar splitting and pillar reduction. Therefore, the overwhelming majority, if not all, mining projects in NSW involve the conduct of some type of activity which is classified, for the purposes of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 as a "High Risk Activity". This is because all mine sites involve the carrying out of operations which have the potential to be dangerous in the absence of appropriate safety measures and precautions being in place. The fact that an element of the Hume Coal Project involves a "High Risk Activity" is not unusual for a mining project in NSW.

Table A.1 Reponses to questions from the IPC

Question	Response
Given that there is some disagreement among technical experts about the thickness of the web pillars what would the effect on resource recovery be if these were to be made thicker?	As discussed with the IPC at the private briefing, there is no doubt that thicker web pillars would result in reduced coal recovery which ultimately would impact on the project economics. However, the important point to note is that the mining system provides considerable flexibility for local adjustments to pillar widths, plunge depths or plunge orientations to deal with any localised geological or other anomalies that may be detected. Such localised mine plan changes are operational management decisions that can be made on a panel by panel basis without threatening the overall project viability.

Table A.1 Reponses to questions from the IPC

Question	Response
There have been a number of questions about the lack of geological detail in the mine design. Hume Coal has replied that such detail is usual at the planning and assessment stage. Considering the mine design is unusual, and aspects of it are in contention have you given consideration to providing more geological detail?	In order to provide a meaningful response to this question, it is necessary to sub-divide the term "geological data" into two sub-sets, namely (i) the lithology and mechanical properties of the overburden, and (ii) the presence or absence of major geological structures such as faults, dykes or other igneous intrusions. In terms of the nature and mechanical properties of the overburden, it was clearly described in the original layout design report (Mine Advice 2016), that the proposed layout as it relates to the formation of web pillars and their consequent stability, was founded in limiting the span between intra-panel barriers (to no more than 60 m) with no consideration being given to any stabilising benefits of the overburden lithology when setting this maximum distance. The nature of the overburden is not part of the ARMPS-HWM design method, hence it could not be included as part of the initial layout designs, albeit it was recognised that being dominated by Hawkesbury Sandstone, the Hume Coal overburden would likely be generally advantageous. Therefore, the level of geological detail relating to the nature of the overburden is not material to the reliability of the proposed layout designs, accepting that a range of overburden conditions were included in the 3D modelling study in order to allow varying pillar load distributions to be returned, none of which caused the overall stability of the proposed mine layout to come into question. This is further evidence that the proposed layout designs have been developed to be highly insensitive to variations in overburden lithology, thereby rendering any concerns as to uncertainties in the level of available geological data as irrelevant. The proposed mine design solely relies on conservatively limiting the spans between barrier pillars, rather than using any spanning ability of the overburden lithology to maximise the distances between barriers. This issue was raised by both independent experts in their first review reports via stated concerns as to the reliance being placed on the spanning ability of the overburden by the proponent. Hume Coal have consistently rejected this notion, as it is entirely incorrect and demonstrably so. In terms of major geological structures such as faults and dykes, the mine layout as shown in the EIS in its entirety has been developed around currently known or inferred features, as well as the Hume Highway which cuts across the proposed mining area. It has never been intended or even suggested that web pillars will be formed up in close proximity to major structures and the layout fully confirms this intent. Like any underground coal mine at the time of being approved, the presence of unknown major geological structures that would require the mine layout to be modified cannot be eliminated as a credible possibility or residual risk; the response to this uncertainty logically being one of reviewing the mine layout on a case by case basis, as and when such structures are identified during mining operations.
<u>Geotechnical model</u> - Comment on difference of opinion between experts on revised geotechnical model (page 29)	The difference of opinion referred to is based on two specific aspects of the geotechnical model, namely the use of the Mark-Bieniawski formula and the use of an elastic-plastic constitutive law. These two issues are addressed in significant detail in Mine Advice 2019, the conclusion being that neither are material concerns as to the reliability of the 3D modelling outcomes in particular, and the overall mine layout stability assessment more generally.

Table A.1 Reponses to questions from the IPC

Question	Response
Lack of geotechnical data - Comment on this section. In particular, difference of opinion between app that mines do not typically present detailed geological information on conceptual mine designs in the planning and assessment phase of the project and Dept's/ other experts' opinion that as the mine in not typical of other mine designs, more detailed geological data may be required and question reliance on Berrima Colliery data. (page 30)	As previously discussed, the integrity of the proposed mine layout design is not reliant upon and has never been reliant upon a detailed understanding of the geological and geotechnical nature of the overburden, this issue having been raised by the Department's independent experts contrary to the stated position of Hume Coal. The only reason that the geological and geotechnical nature of the overburden has become a topic of discussion is in relation to the various assumptions made as part of the subsequent 3D geotechnical models, which in fact demonstrably prove that the stability of the proposed mine layout is insensitive to varying overburden conditions. Hume Coal and Mine Advice have always maintained the position that any mine design that is strongly predicated on the nature of the overburden providing stability would be almost impossible to approve with confidence, particularly in association with sensitive environmental constraints, due to the inevitable inherent uncertainties between actual and assumed overburden conditions. This is why the proposed mine layout design is founded solely on limiting key geometrical parameters; this then allowing the as-constructed mine workings to be confirmed as being fully compliant with the design assumptions on which they were based. The Hume Coal Project has relied on a considerable amount of both geological and geotechnical data to inform the overall mine design process, especially for the first half of the proposed mine life. In the opinion of Bruce Hebblewhite, "*it is certainly comparable to, or far better in terms of available data, and data coverage or density, than many other previous or current underground mine in NSW, or in the Southern Coalfield in particular*". The DPE experts also questioned the lack of evidence regarding the use of the Berrima case study, used for calibration. However, this is an erroneous claim, since the Berrima information was presented to the experts' conclave meeting in March 2018.
Risk assessment - Comment on Applicant's risk assessment work undertaken but not provided (page 30)	Refer to the response to above.
Comment on assessment of pillar design, impounding of water and environmental impacts that may result from transfer of water of additional mine water to the surface. Also comment on risks being considered at DA stage as well as by Resources Regulator. (page 31-34)	Refer to response in the surface water section above.

Table A.1 Reponses to questions from the IPC

Question	Response
Economics	
Different estimates of net economic benefits of the project ($373m or $127m) and the scale of economic benefits when weighed up against the potential impacts of the project on the environment and the community (page 36)	Net economic benefits are discussed in detail in Section 4.2 of this submission. One of the key points of difference between the net economic benefit assessed by BAEconomics in the Hume Coal Project EIS, and by the expert reviewer (Andrew Tessler of BIS Oxford Economics) engaged by DPE is the inclusion of 'employment benefits' and associated 'tax benefits', which Mr Tessler considers should not be included in the cost-benefit analysis. DPE claim this is based on NSW Treasury Guidelines that, on first principles, state labour should be considered as a cost rather than a benefit. However, as explained in more detail in Section 4.2, the idea that labour should be regarded as a cost rather than a benefit in a cost benefit analysis (CBA) is not supported by the NSW Treasury guideline. The BAEconomics estimate of the central case project NPV ($373 million) is almost three times that quoted by BIS Oxford Economics (2018). Allowing for long term parity of the Australian exchange rate with the $US (a low probability outcome) and low coal prices (lower in real terms than Australia has experienced since 2004) would still result in an estimated project NPV of $226 million, almost twice the estimate quoted by BIS Oxford Economics. On this basis alone BAEconomics and Hume Coal do not accept that the BIS Oxford Economics estimate of the NPV of the project provides a fair assessment of the project's value to NSW.
Other questions	
Berrima Rail Project - This will be the first coal mine in NSW to transport coal in covered wagons. As pointed out, grain is transported in covered wagons. Many grain trains take days to load. Many coal loading points have strict loading times for coal trains and this is often reflected in the freight rate. Do you have a design that will allow for rapid loading?	The systems used to load grain trains are very different to the systems used to load coal trains. Grain trains are generally loaded from a silo via much smaller infrastructure than what is available at a coal mine. In addition, loading has to be undertaken in a controlled manner to minimise the risk of spontaneous combustion from static electricity associated with the dry grain. The Hume coal load out system has been designed to load trains at the rate of up to 3,600t/hr, and will be fully enclosed. The trains proposed for the Hume Coal Project have an estimated payload of nominally 2,975 tonnes. The time to load a train will therefore be in the order of 45 to 50 minutes. Four trains per day are also proposed to be filled.

Table A.1 Reponses to questions from the IPC

Question	Response
Strategic context - Comment on suitability of site for a coal mine due to surrounding land uses and unique characteristics which have resulted in unconventional mine design that presents a range of uncertainties and risks.	As described in Chapter 24 of the EIS, the site is considered suitable for a coal mine for a number of reasons. Principally, the project will efficiently recover an economic coal resource beneath privately owned land where underground mining is permissible. The site is well served by necessary services and infrastructure, particularly nearby rail infrastructure and Port Kembla. The surface infrastructure area has been carefully sited so that the number of nearby sensitive receptors are limited, and is bordered by the Hume Highway. The location of the surface infrastructure also aligns with the existing industrial corridor south of, and parallel to, the Hume Highway; comprising the Berrima Cement Works, the Moss Vale Enterprise Corridor, and the industrial facilities at the junction of the Berrima Branch Line and the Main Southern Rail Line. As described in Section 5.3 of this submission, Hume Coal considers the suggestion by DPE in their assessment report that a new coal mine may not be compatible with the "existing, approved and likely preferred land uses" of the E3 and RU2 zones to be inaccurate speculation that fails to have regard to the fact that the project: • is of a temporary nature, having a project life of 23 years; • is an underground mining project rather than an open cut project; • does not propose to have any surface tailings facilities or permanent waste rock emplacement areas; • has been designed to minimise environmental impacts. In particular, and unlike most other coal mines in the Southern Coalfields, a non-caving underground mining method was chosen to specifically avoid any subsidence impacts on the surface and so that the existing land uses could continue throughout the mine life on the vast majority (98%) of the project area; and • the site will be able to be rehabilitated to its earlier, pre-disturbance state in a manner that is compatible with existing, approved and likely preferred land uses in the vicinity of the project site.
Policy context - Comment on how the project meets cl 12 of Mining SEPP, given existing uses and preferred uses and objectives in E3 and RU2 zones in LEP.	This is addressed in the main report in Section 5.3.
Public interest - Comment on ESD and “triggering“ of precautionary principle.	This is addressed in the main report in Section 5.2.

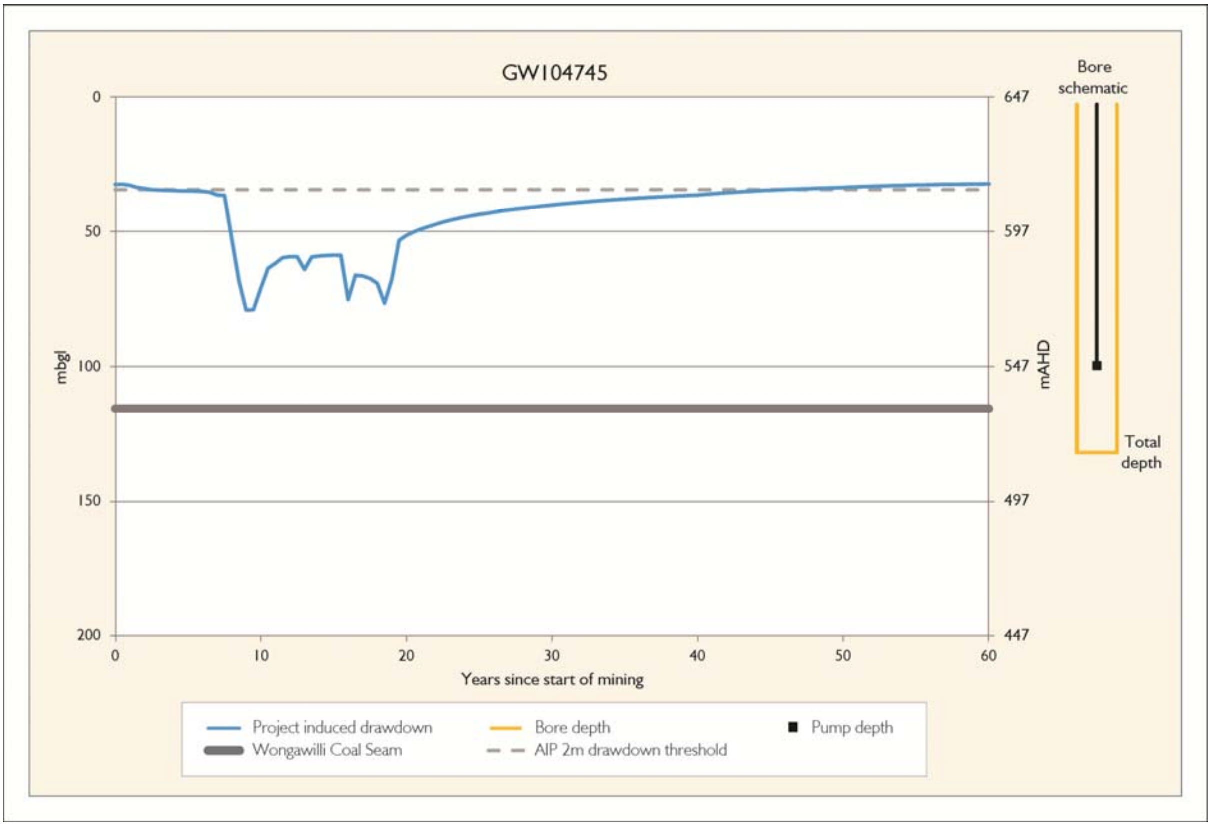
Appendix B

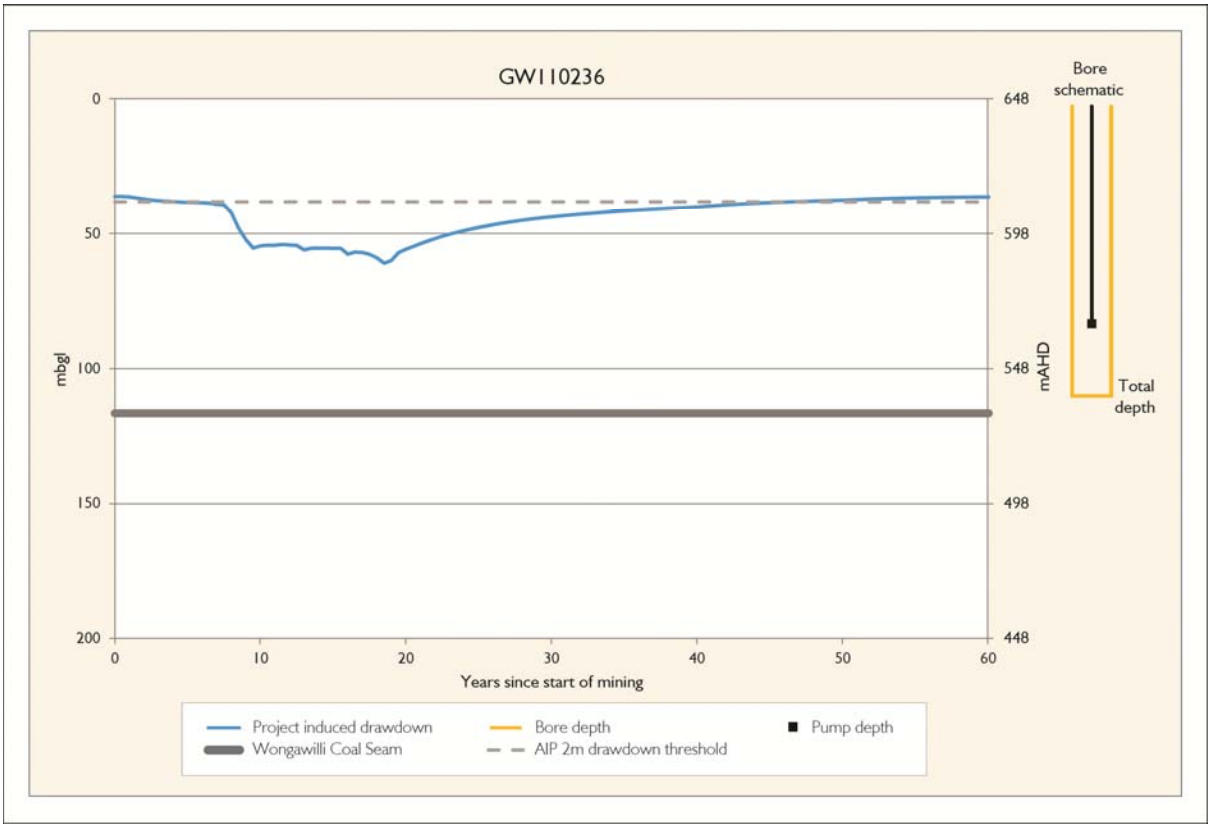
Hydrographs

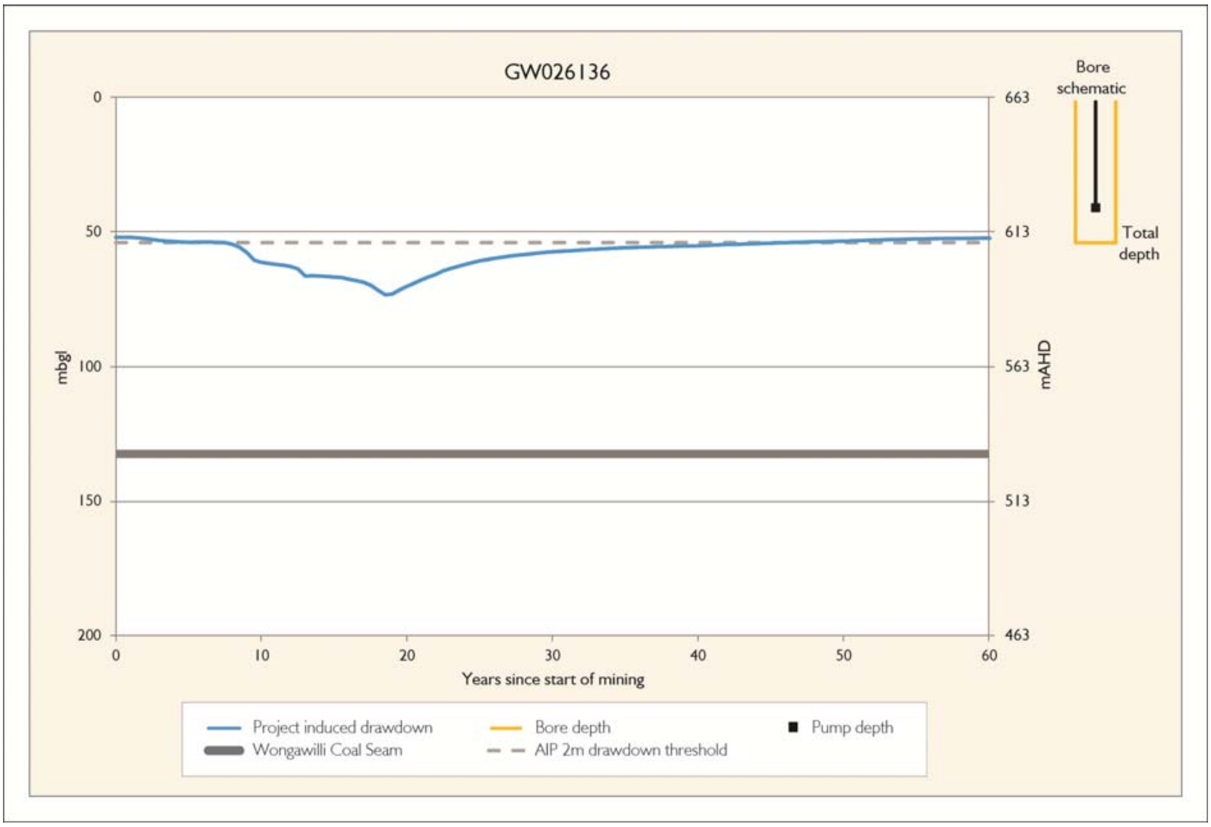
Stage 1 make good bores

Bore ID	GW104745	GW110236	GW026136 [2]
Coordinates	E 251266 / N 6174225	E 251246 / N 6174064	E 250554 / N 6174076
Water Access Licence (WAL) purpose	Domestic, stock	Irrigation, stock	Stock, irrigation
Approval Number	10WA110957	10CA112192	10CA112192
Bore depth (m)	130	108	53
Bore target	WG - Upper HSST	Middle HSST	WG - Upper HSST
Maximum project only drawdown (m)	46.8	24.8	21.4
Time to project only 2 m drawdown (year)	2.5	4	7.5[2]
Time to project only 2 m recovery (year)	51.5	52.5	52.5
Duration of project only 2 m drawdown (year)	49	48.5	45
Available head above pump pre mining (m)[1]	65.2	45	-12.3
Available head above pump at maximum drawdown (m)[1]	18.4	20.2	-33.7
Intersect mine working?	Yes	Yes	No
Preliminary Make good option	Replacement bore	Replacement bore	Replacement bore

Predicted drawdown in bores



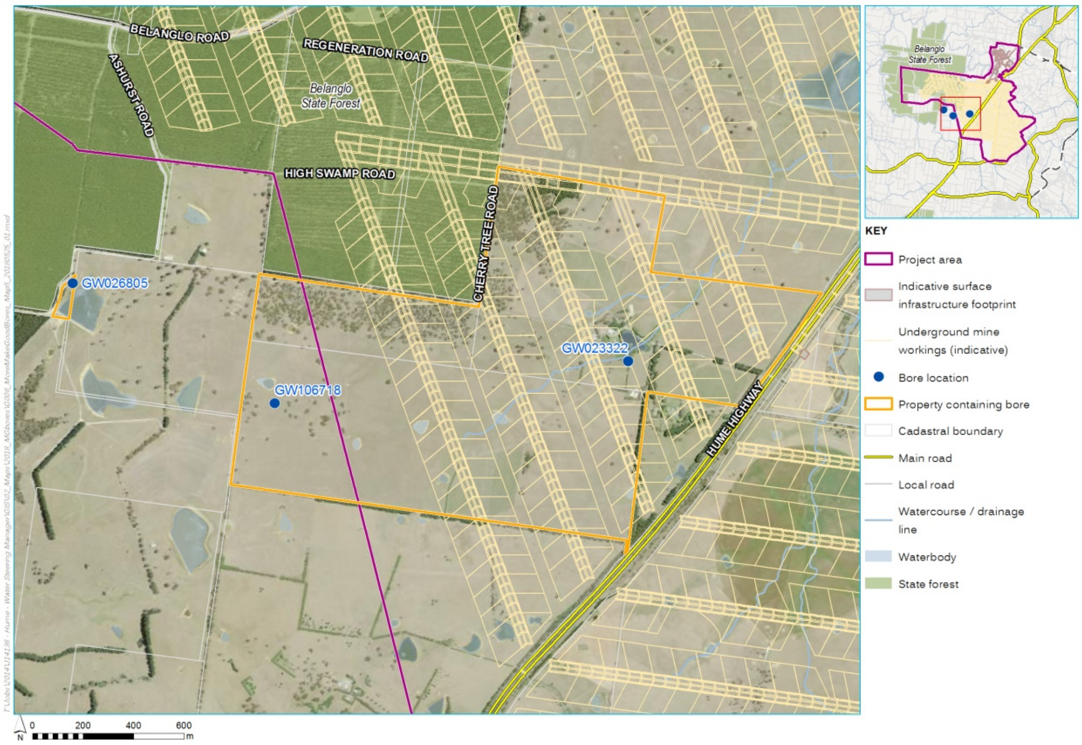




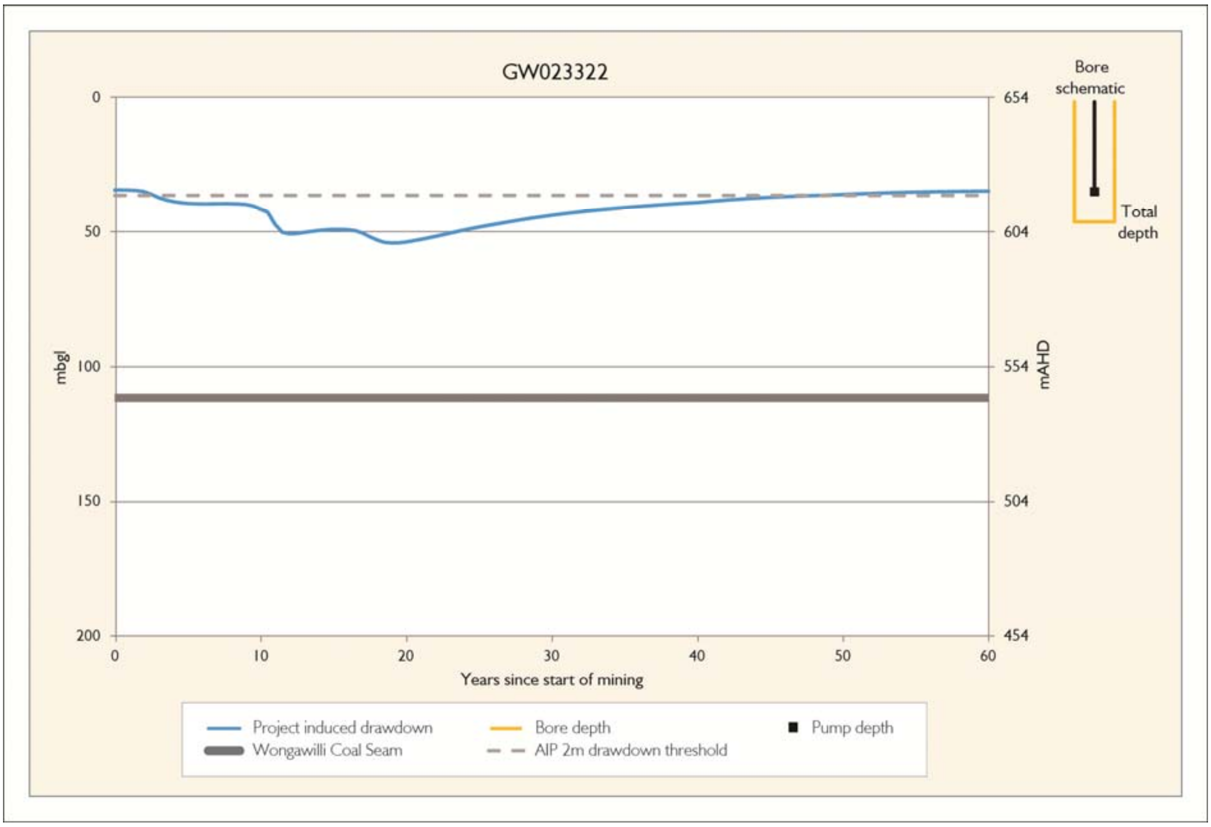
GW026136
Bore schematic
Total depth
mbgl
mAHD
0
50
100
150
200
663
613
563
513
463
0
10
20
30
40
50
60
Years since start of mining
Project induced drawdown
Bore depth
Pump depth
Wongawilli Coal Seam
AIP 2m drawdown threshold

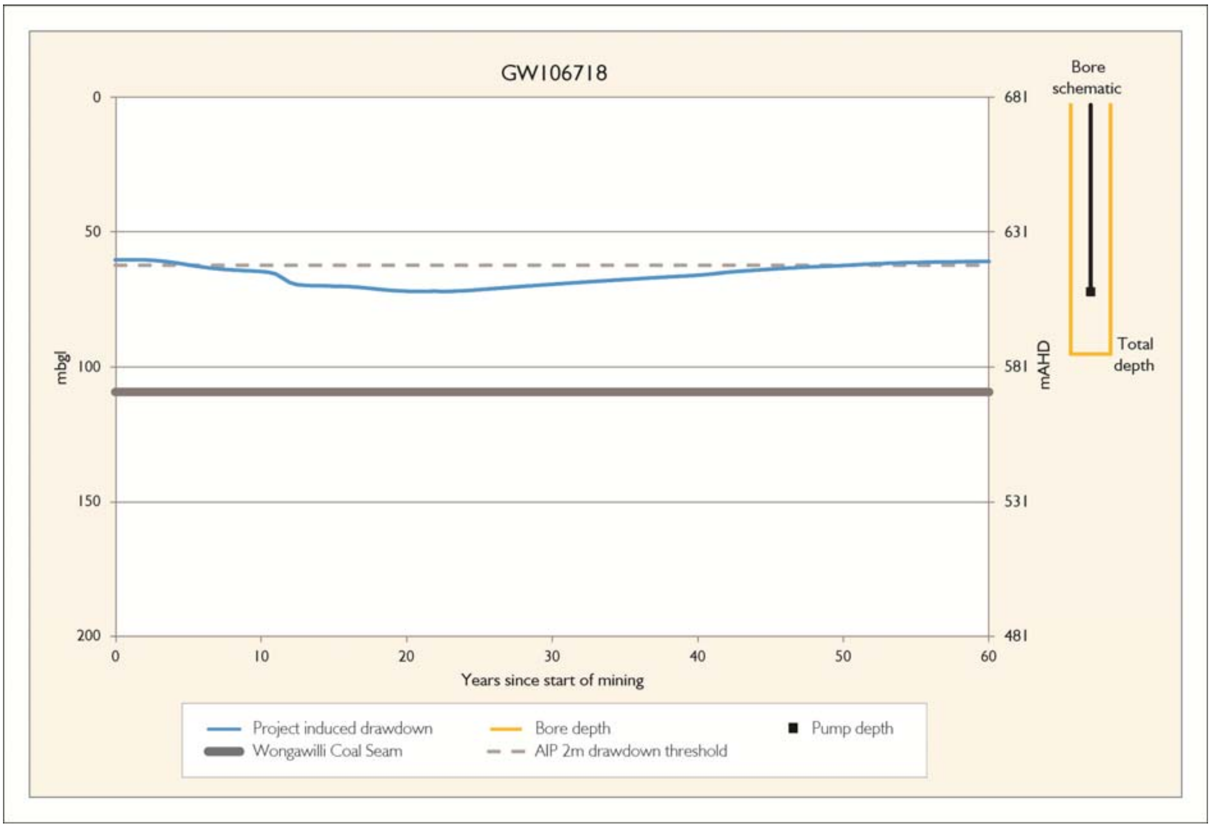
Stage 1 make good bores

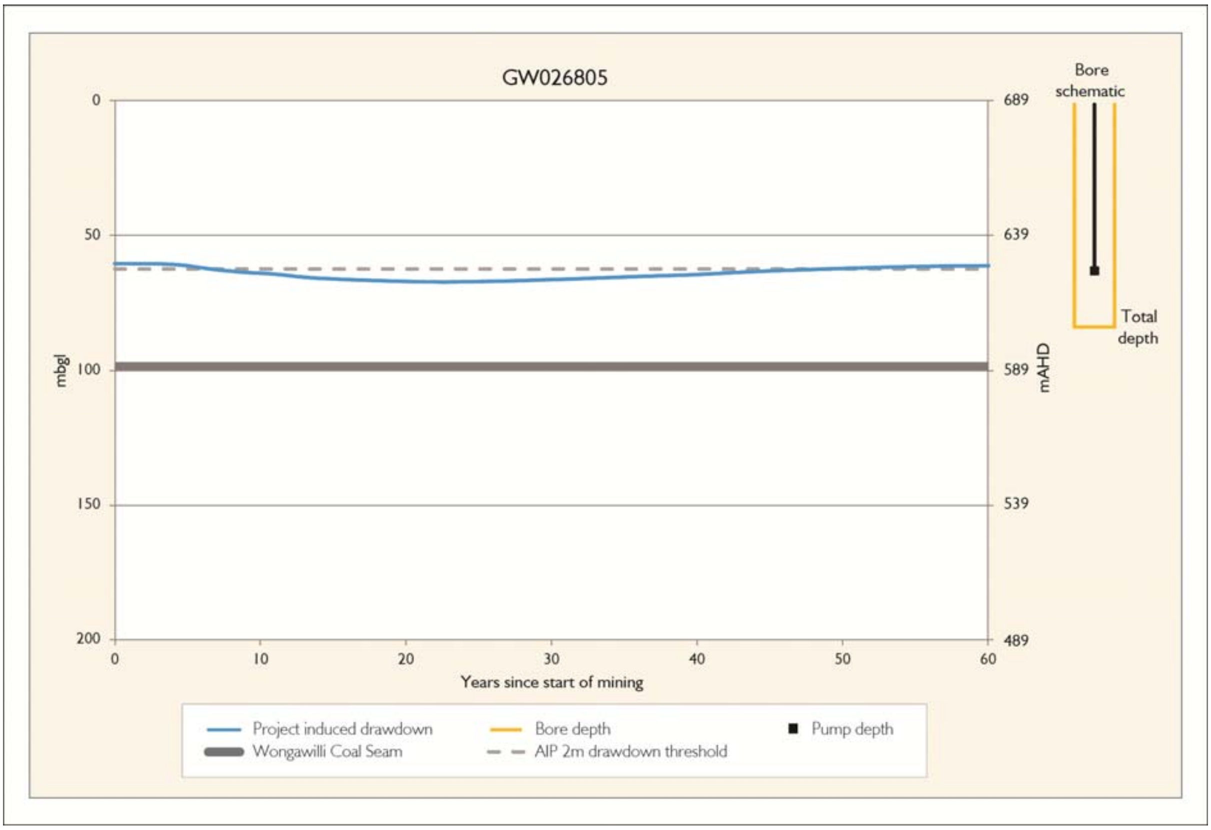
Bore ID	GW023322	GW106718	GW026805 [2]
Coordinates	E 248882 / N 6173630	E 247480 / N 6173463	E 246680 / N 6173940
Water Access Licence (WAL) purpose	Irrigation, domestic, stock	Irrigation, domestic, stock	Irrigation, domestic, stock
Approval Number	10CA112104	10CA112104	10CA112104
Bore depth (m)	45	93	83
Bore target	WG - Upper HSST	Upper - Middle HSST	WG - Middle HSST
Maximum project only drawdown (m)	19.7	11.8	6.8
Time to project only 2 m drawdown (year)	2.5	5*	6.5*
Time to project only 2 m recovery (year)	55.5	61.5	57.5
Duration of project only 2 m drawdown (years)	53	56.5	51
Available head above pump pre mining (m)[1]	-0.7	9.5	1.5
Available head above pump at maximum drawdown (m)[1]	-20.4	-2.2	-5.3
Change in available head (%)	2817	123	448
Intersect mine working?	No	No	No
Preliminary make good option?	Replacement bore	Deepen Pump	Replacement bore



Predicted drawdown in bores






GW026805
Bore schematic
Total depth
mbgl
mAHD
0
50
100
150
200
689
639
589
539
489
0
10
20
30
40
50
60
Years since start of mining
Project induced drawdown
Bore depth
Pump depth
Wongawilli Coal Seam
AIP 2m drawdown threshold

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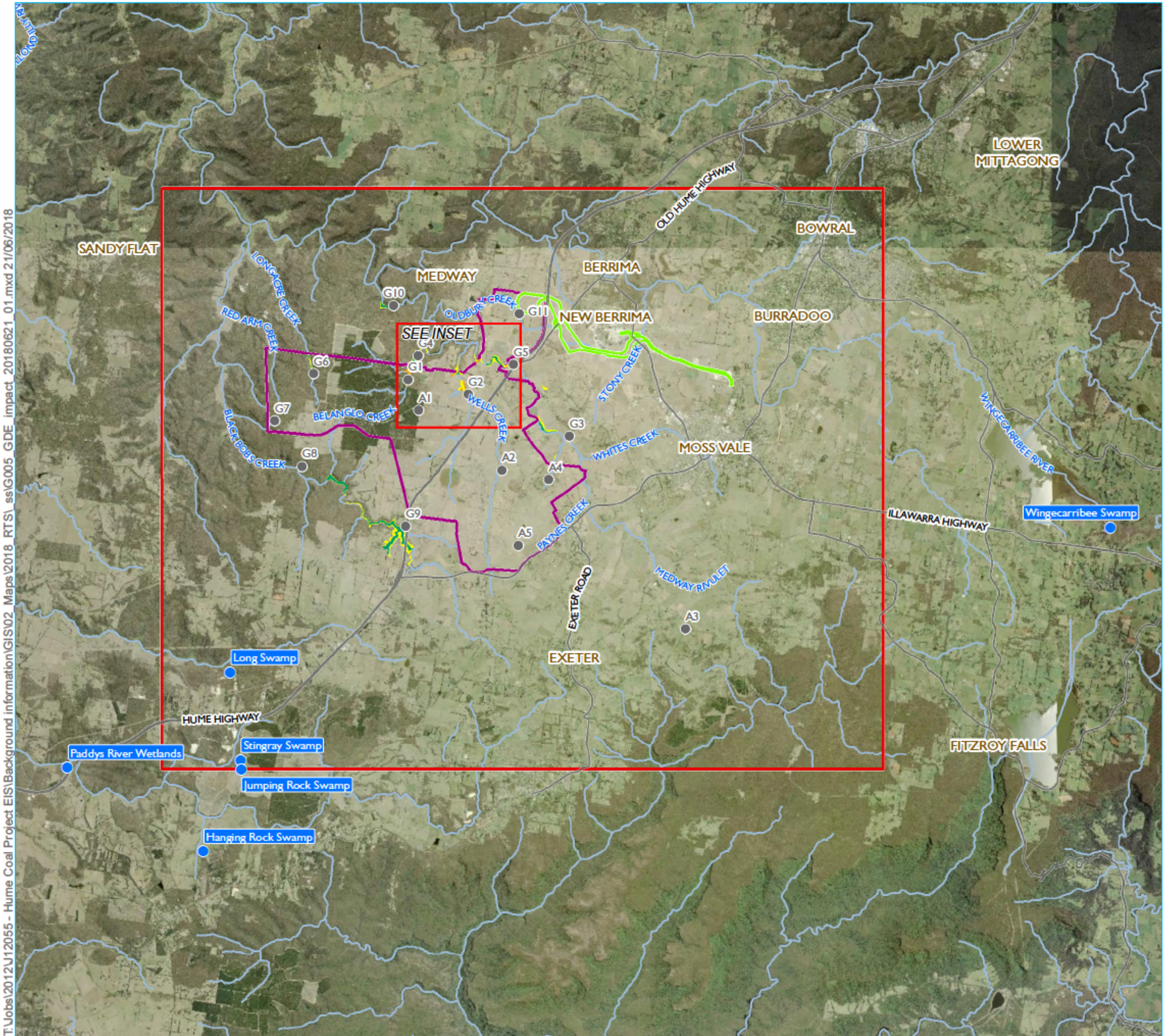
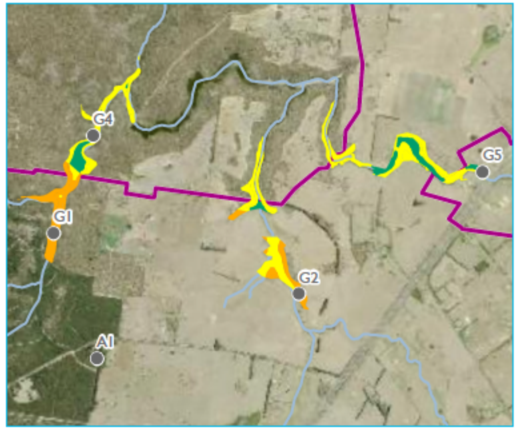


Source: EMM (2018); DFSI (2017); Hume Coal (2017); ABS (2016)

0 2.5 5 km

GDA 1994 MGA Zone 56

N



KEY

- Hume Coal Project area
- Berrima Rail Project area
- Biodiversity study area
- Virtual piezometer locations
- Swamps and important wetlands

Existing features

- Main road
- Watercourse

Risk assessment matrix

Pre-mining water level (mbgl)	Drawdown impact (m) 2-10	>10
0-3		
3-5		
5-10		

Potential groundwater dependent ecosystem impacts at maximum drawdown

Hume Coal Project and Berrima Rail Project
Response to submissions
Figure 13.3

HUMECOAL PROJECT

EMM

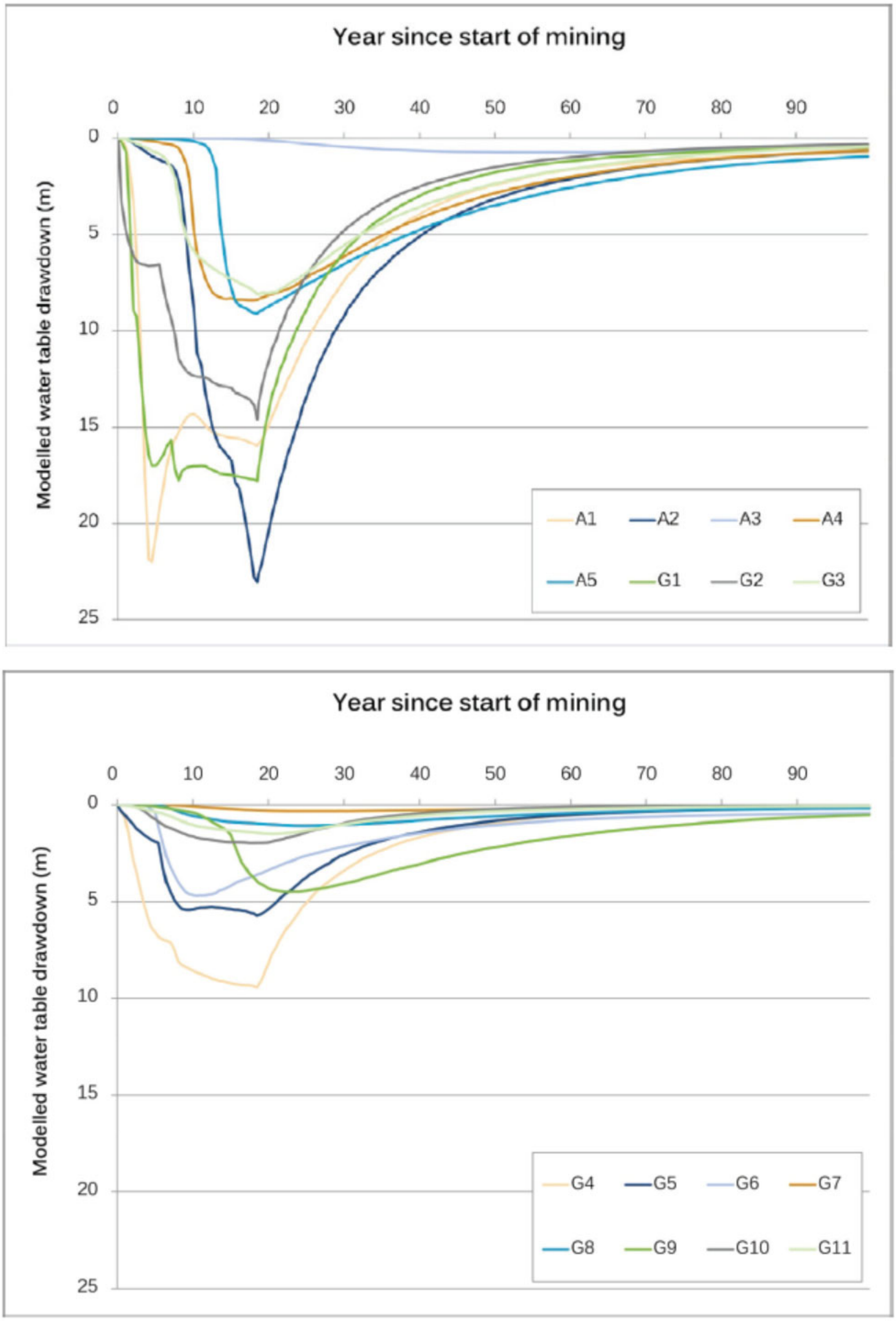


Figure 13.4 Drawdown at the water table at virtual piezometer sites

Appendix C

Response to DPE Assessment report by Mine Advice and Dr Bruce Hebblewhite

MINE ADVICE
A.B.N. 15 152 928 222

HUME COAL PTY LTD

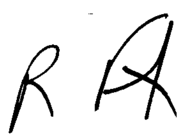
Response to DP and E Assessment Report, Hume Project

FEBRUARY 2019

REPORT: HUME22/2

Unit 7, 17 Babilla Close
BERESFIELD, NSW 2322
TEL: (02) 4088 0600 FAX: (02) 4028 6342
E-MAIL: admin@mineadvice.com

REPORT TO :	Alex Pauza Manager, Mine Planning Hume Project Hume Coal Pty Ltd
REPORT ON :	Response to DP and E Assessment Report, Hume Project
REPORT NO :	HUME22/2
REFERENCE :	Your Instructions to Proceed
PREPARED BY :	Russell Frith
REVIEWED BY :	Guy Reed and client's representative
DATE :	23rd February 2019



....
Russell Frith
Senior Principal Geotechnical Engineer

Disclaimer

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report contains a series of technical responses to queries and questions raised in relation to the proposed mine layout design at Hume by NSW DP and E's two independent experts, Emeritus Professor Jim Galvin and Dr. Ismet Canbulat. Each have been addressed in detail and none are considered to be of sufficient significance to detract from the integrity and suitability of the mine layout design that was proposed by Hume Coal in its 2017 EIS submission. In fact, it would be fairer to state that having been required to address those concerns, the level of confidence in the proposed mine layout design being fit for purpose, has increased. Therefore, it is clear that the independent review process has been of significant value.

Unfortunately, this does not appear to manifest in DP and E's project assessment report whereby in Section 6.3 they conclude that:

> *"Notwithstanding the Department's considerable efforts to resolve disagreements between experts, there is a substantial degree of residual uncertainty about the mine design and the geotechnical model. In that context, the Department must adopt a precautionary approach to its assessment".*

This has undoubtedly arisen as many of those residual mine design and geotechnical model uncertainties relate to the 3D numerical modelling work undertaken by Emeritus Professor Keith Heasley, the specifics of which the proponent and Mine Advice only became aware of upon publication of the DP and E assessment report, neither having had the opportunity to address those concerns, either formally or informally, prior to this time. In this sense, it is without question that DP and E's conclusion in this regard is premature, as it is fundamental to any peer review process that a proponent is given the opportunity to address issues raised before a final determination. That this hasn't occurred is extremely concerning.

Details of the author's responses to the "core" issues raised in the most recent independent expert review reports are contained herein and so will not be repeated in this summary. However most were either academic arguments about detailed technical issues, or mis-understandings on the part of the independent experts that have now been considered and clarified. Nothing raised has resulted in Mine Advice modifying its position on the proposed mine layout design, which as a professional consulting company maintaining substantial professional indemnity insurance, it would be required to do if it became aware that there were fatal flaws in what it was proposing. The original layout design as contained in the EIS submission, has now fully withstood two independent reviews commissioned by DP and E and a substantial 3D numerical modelling exercise conducted by an overseas expert. Therefore, Mine Advice remains fully resolved that the proposed layout design is fit for purpose and that the geotechnical model that supports it is as robust as can be achieved in practical terms at the pre-mining stage.

The author accepts and has always maintained that there are a number of management issues to be addressed and implemented in operations, in order to ensure that any significant deviations from the assumed conditions under which the general mine layout was developed, are identified and the mining layout and/or process modified to suit. This general process is endemic to all underground coal operations in NSW and Australia, where geological and geotechnical uncertainty cannot be eliminated at the pre-mining design stage, irrespective of how much exploration data and design work is conducted. No residual risk issue can be identified at Hume that is not amenable to this type of operational management process, which ensures that the as-formed mine layout design is fully fit for purpose in terms of both short to medium term requirements during mining operations, and the long-term requirements of on-going remnant mine stability for environmental reasons. The fact that the required detailed risk assessments and associated management plans have not yet been developed, should not be seen as a shortcoming in the EIS submission, and is certainly not a valid reason to deny an approval to proceed to mining operations, albeit with associated approval conditions.

1.0 INTRODUCTION

This report contains the various responses to the NSW Department of Planning and Environment's (DP and E) assessment report relating to the Hume Project (DP and E 2018), the focus of this assessment being the contents of the two independent expert reports that were appended to that report by Galvin and Associates (GAPL 2018) and Dr. Ismet Canbulat (Canbulat 2018). It is noted that both independent experts submitted previous reports in response to Hume Coal's EIS submission (GAPL 2017 and Canbulat 2017), following which Hume Coal submitted a formal response back to DP and E (Hume Coal 2018) which included the results of a numerical modelling study examining the proposed mine layouts in more details (Heasley 2018) and interpretations thereof (Mine Advice 2018).

The purpose of this response is to address:

(i) The technical basis of the mine layout design, in particular all of the aspects that in combination act to maintain the stability of the mine workings, in particular the low w/h web pillars and so mitigate unacceptable environmental impacts.

(ii) To provide comment on each of the issues, raised by the two independent experts in their most recent reports, as they relate to the integrity and reliability of the proposed mine layout design.

(iii) Using (i) and (ii), to present an updated summary of the reasoning that supports the proponents contention that the proposed mine layout design is fit for purpose in that it is suitably conservative and reliable in relation to both mitigating environmental impacts and mine safety during operations.

Each of these will be described in detail as part of formulating a formal response to the most recent independent expert review reports.

2.0 TECHNICAL BASIS OF THE HUME MINE LAYOUT DESIGN

Over and above main headings and three heading production panel developments, the Hume mine layout consists of web pillar "compartments" containing what are termed as "plunges" or "drives" separated by narrow web pillars, with each compartment being separated by what are termed as "intra-panel" barrier pillars – Figure 2.1. It is the stability of the low width to height ratio (w/h) web pillars that has been the primary concern of the independent experts, hence it is the technical basis of their design and justification that is the subject of this section of the report.

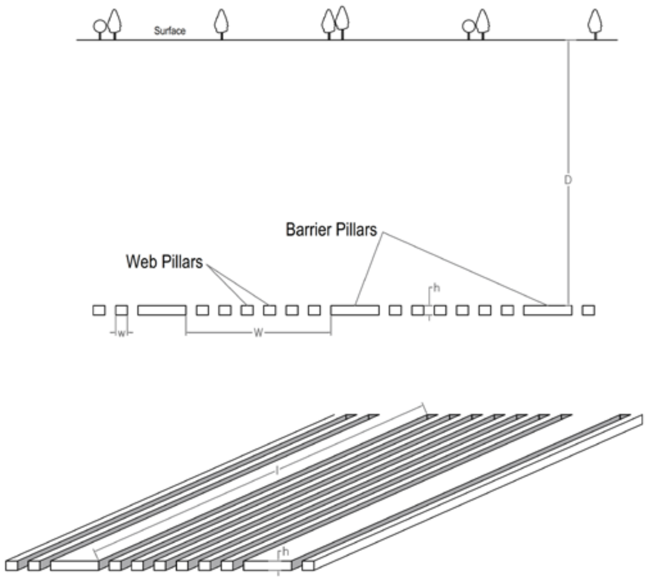

FIGURE 2.1. General Panel Features and Layout (Mine Advice 2016a)

It is accepted that for each compartment of web pillars to be considered individually, the various barrier pillars surrounding them need to be suitably stable. For demonstration purposes herein, this will be assumed to be the case, particularly as neither expert has raised major concerns in regards to barrier pillar stability.

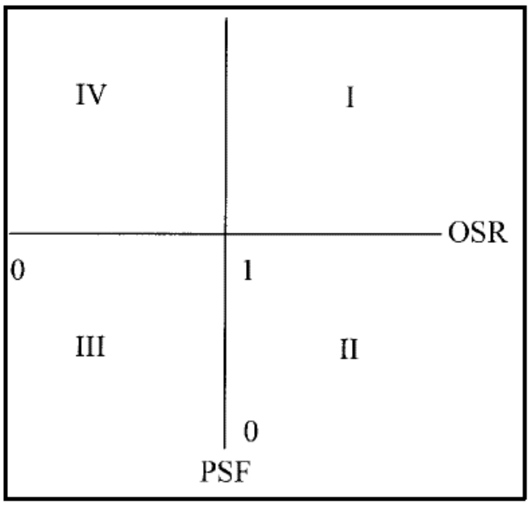

FIGURE 2.2. Plot of Overburden Stability Ratio (OSR) and Pillar Stability Factor (PSF) (NB values of <1 for either indicate imminent instability) – Van Der Merwe 1999

The design basis for the web pillars at Hume is one that includes the stabilising contribution of both the pillars themselves and most importantly, the overburden. This is not a new or novel layout design principle, the use of sub-critical spans between barriers in order to justify reduced pillar loadings and increased pillar stability between barriers having been previously recognised and addressed in both South Africa and the United States as part of other pillar design methods, as is now summarised.

Van Der Merwe 1999 presented a classification scheme (see Figure 2.2) to define the varying contribution to mine stability of both coal pillars and the overburden, the following descriptions being directly taken from that paper:

> *Quadrant I: both the overburden and the pillars are stable. This is the ideal situation for mains development.*
>
> *Quadrant II: the overburden is stable, although the pillars are unable to support the full weight of the overburden.*
>
> *Quadrant III: indicates a situation where both the pillars and the overburden will fail. This is the ideal situation for the snooks in pillar extraction. One wants both to fail in this situation.*
>
> *Quadrant IV: indicates that the pillars are able to support the overburden, even though the overburden may fail. This is also a safe situation, although gradual failure may occur over a long period as the pillars lose strength.*

This is a useful classification scheme as it outlines the four possible scenarios relating to remnant mine stability and the relative contributions of both coal pillars and the overburden. For example, empirically-based coal pillar strength determinations have been exclusively founded using case histories related to Quadrant IV, the idea being that by eliminating the self-supporting ability of the overburden, coal pillar loading at failure can be approximated by full tributary area (FTA) loading to surface, this then taken to be an indication of coal pillar strength in each case. The pillar strength equations of the University of New South Wales Pillar Design Procedure (UNSW PDP) are good examples of the outcome from such a process.

In contrast, the design of web pillars at Hume is consistent with either Quadrant 1 or Quadrant 2, which requires that the stabilising contribution of both the overburden and remnant web pillars be combined when determining a representative design Stability Factor (SF). The UNSW PDP does not provide any specific guidance in this regard, albeit that the various pillar strength equations can be applied under less than FTA even though FTA was the assumption used in their derivation. As stated by GAPL 2018:

> *"Once having derived the relationship between the probability of failure and the ratio of pillar strength to pillar load, any load can be used in the analysis to produce a safety factor that can be equated to a probability of failure".*

The stability of the overburden and the consequent reduction in pillar loading was also brought into pillar design in the US (Mark 2010), based on the realisation that for deep cover, coal pillars within what was termed as the Active Mining Zone or AMZ (see Figure 2.3 from Mark *et al* 2011), this being the area of production pillars between barriers, were commonly over-designed under FTA loading to surface. Based on the analysis of stable and failed cases at higher cover depths, it was identified that quite a number of stable cases contained SF values under FTA loading conditions < 1 (see Figure 2.4). As a direct result, the width to depth ratio (W/H) of the AMZ was included in the pillar design process, with pillar loading under sub-critical AMZ conditions being reduced to less than FTA (see Figure 2.5).

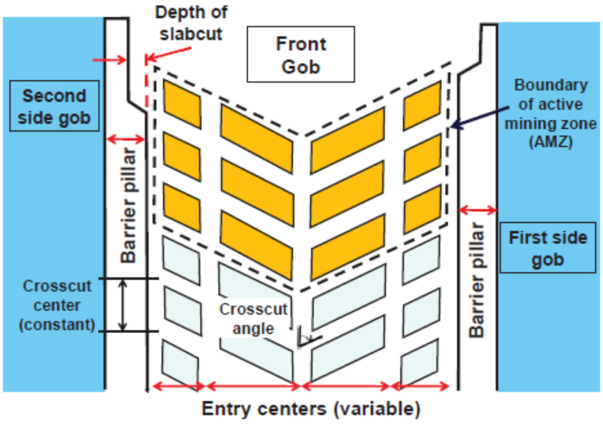

FIGURE 2.3. Geometry of Typical Retreat Mining Panel Showing the ARMPS Input Parameters (Mark *et al* 2011)

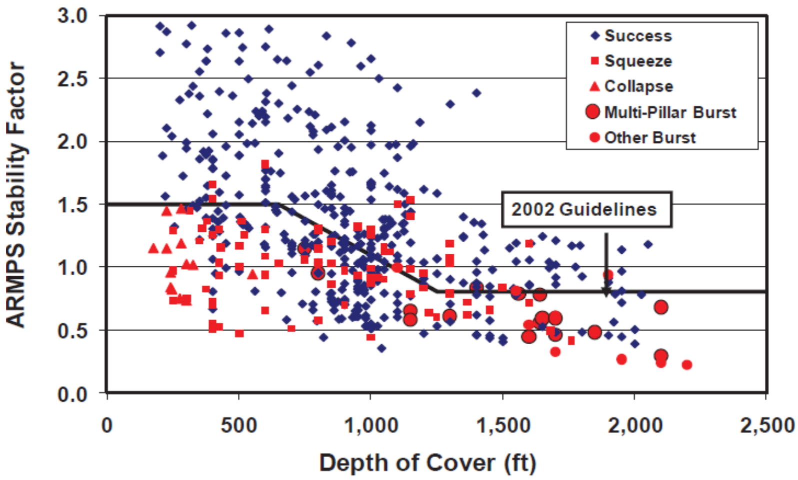

FIGURE 2.4. The 2010 ARMPS Deep Cover Data Base, Showing the Recommended ARMPS Production Pillar SF from the 2002 Deep Cover Study (Mark 2010)

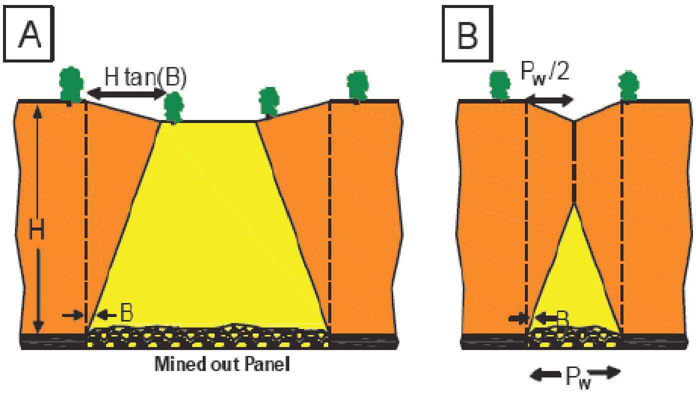

FIGURE 2.5. The "Abutment Angle" Concept Used to Estimate Loads in ARMPS (A) Supercritical Panel (B) Subcritical Panel (Mark *et al* 2011)

By including W/H as a pillar design consideration within the AMZ, the stabilising influence of the overburden was brought into the ARMPS design method and therefore used in combination with the stabilising influence of the coal pillars within the AMZ. This turned ARMPS from a Quadrant IV design method under the Van Der Merwe 1999 classification, to one that aimed to work within Quadrants 1 or 2.

This modification to ARMPS led to the realisation that for sub-critical AMZ conditions, the stability of production pillars within the AMZ and that of the adjacent barriers, became inextricably linked in that the production pillars could not collapse without the barriers also collapsing. This meant that the role of the barrier pillars was not simply to truncate a collapse of production pillars (this being the long-held definition of the role of barrier pillars), but to assist in preventing such a collapse in the first instance. This led to the development of a “system stability” design approach whereby the individual stabilising influence of both AMZ pillars and barrier pillars was combined, this approach being an integral part of the ARMPS-HWM method, as used to develop panel layouts for EIS purposes at Hume.

This concept was taken further by Frith and Reed 2017 and 2018, whereby based on both a conceptual model for the stability of the overburden as well as reference to published failed cases, a justification was presented for the coal pillar design problem being one where the coal pillars acted to reinforce rather than suspend the overburden (in the same way that the roof of mine roadways is reinforced by the action of roof bolts and long tendons). This is again consistent with the Van der Merwe 1999 classification, the suspension problem being Quadrant IV and the reinforcement problem being Quadrants I or II.

Frith and Reed 2018 outlined a general equation for the reinforcement of a mine roadway roof (based on that included in UNSW 2010) (Equation 1), as follows:

$$FoS = f(P_{roof}, P_{support})/\text{applied load} \quad [1]$$

where:

FoS = a measure of stability

P_{roof} = contribution to stability from the roof strata itself (e.g. Coal Mine Roof Rating)

$P_{support}$ = contribution to stability from installed roof support (e.g. PRSUP)

applied load = horizontal stress in the case of roadway roof reinforcement

This basic equation manifests in the statistically significant empirical relationships published by Colwell and Frith 2009 and 2012 relating to primary roof support design in normal width and wider coal mine roadways respectively. It is also the foundation of the AMCRR Method as published by Colwell and Frith 2010.

Equation 1 can be modified for general coal pillar design as follows:

$$FoS = f(P_{overburden}, P_{pillar})/\text{applied load} \quad [2]$$

where:

FoS = a measure of stability

$P_{overburden}$ = stability contribution from the overburden (linked to both the structural competence of the overburden and horizontal stresses acting as described in detail in Frith and Reed 2017)

P_{pillar} = stability contribution from coal pillars left in place

applied load = either horizontal stress or vertical stress based on the problem being reinforcement or suspension respectively (NB $P_{overburden}$ = zero represents the special case of full-tributary area loading to surface with the overburden being critically unstable, as per a Quadrant IV design problem).

There is little doubt that the general stability of mine workings within an AMZ (as previously defined) is a combined function of the stabilising influence of both the overburden between suitably designed and stable barrier pillars, and any remnant pillars that are left in place between such barriers. It has been recognised as such in South Africa, the United States and Australia for in the order of 20 years.

This approach was applied to the design of the low w/h web pillars and a suitable spacing between the intra-panel barrier pillars at Hume, both aspects being part of the ARMPS-HWM empirical design method (NIOSH 2012), which along with the general similarity between HWM layouts and those being proposed at Hume, is why ARMPS-HWM was selected as the primary EIS layout design methodology (Mine Advice 2016b). It also dictated the need to calibrate and include the geotechnical nature of the overburden within LaModel as part of the 2D and 3D numerical modelling exercises that further examined the stability of the proposed remnant mine workings (Heasley 2018).

With the overall design strategy for the low w/h web pillars being defined, it leads to the following three statements that need to be kept in mind when considering comments made by the independent experts and the associated responses herein, namely that:

(i) The stability of web pillars in isolation from barrier pillars, MUST be evaluated by considering the relative contributions of both the web pillars and the overburden within the span between barriers.

(ii) If the stabilising influence of the overburden is ignored in the mine stability assessment, then the stability of the low w/h web pillars MUST be combined with that of the adjacent barrier pillars as part of a pillar "system" stability approach.

(iii) Only if it can be demonstrated that the overburden between intra-panel barriers is likely to be critically unstable to surface (i.e. fully super-critical), as per the approach used by UNSW when selecting failed cases so that FTA loading to surface could be reasonably assumed, should the stability of the low w/h web pillars be considered in isolation from any other stabilising influence (i.e. the adjacent barrier pillars or the overburden).

This then provides the necessary background context to allow the reader to better understand (a) the reasoning for the various responses to concerns raised by the independent experts in their most recent reports (Section 3), and (b) the further explanation as to why the proponent believes that the proposed layout designs are generally fit for purpose in terms of reducing the risks associated with environmental impacts and mine safety during operations, to acceptably low levels (Section 4).

3.0 RESPONSES TO CONCERNS RAISED BY THE INDEPENDENT EXPERTS

Both of the independent expert reports have been reviewed and responses are provided herein on a point by point basis for clarity purposes. The two reports will be addressed separately noting that as GAPL 2018 is addressed first, some of the associated responses also address concerns raised in Canbulat 2018.

3.1 Galvin and Associates

3.1.1 Core Issue #1 – Numerical Modelling

3.1.1.1 Extreme Ranges of Pillar Sizes and Shapes

"As discussed in the December 2017 review by GAPL, because of the relatively extreme ranges in pillar sizes and shapes associated with the proposed Hume Coal mining layout, it is very challenging to assess the actual load acting on the various coal pillars without the aid of sound sensible numerical modelling. Even then, an error range is still associated with numerical modelling predictions of pillar load".

This has always been understood and so is accepted. It is for this reason that the design studies have included ranges of pillars loads in order to better understand the sensitivity of mine stability to such variations. The EIS layout design report (Mine Advice 2016b) considered two extreme pillar loading conditions, and the more recent numerical modelling studies included sensitivity analyses related to varying overburden stiffness for exactly the same reason. A primary control of pillar loading distribution is the stability and stiffness of the overburden between barrier pillars, the layout being deliberately designed to ensure that low w/h ratio web pillars are loaded by a reasonably stable and stiff rather than unstable and relatively soft overburden system. In this way, the stability of the web pillars is far less sensitive to pillar loading variations than might otherwise be the case.

3.1.1.2 Web Pillars Going into Yield

"*Of particular concern is the potential for web pillars to exceed their peak load carrying capacity and yield to some extent. This presents added challenges in satisfying the statutory requirement for a Strata Failure Management Plan to consider 'the strata support requirements for the mine and the pillar strength and stability required to provide that support and the probability of instability of any pillar taking into account the pillar's role*".

This statement seems to suggest that it may not be possible to satisfy this statutory requirement (taken from the NSW Regulations rather than the Act) for the low w/h web pillars by virtue of the reviewer's on-going stated concern that said web pillars may yield. It is noted that the "role" of the web pillars has been repeatedly defined as being part of a larger pillar system, hence it would logically be argued that the probability of instability of any web pillar is inextricably linked to that of the broader pillar and overburden system. Therefore, there is no obvious inevitable impediment that can be identified that would prevent Hume Coal from meeting this statutory requirement during mining operations.

3.1.1.3 Operational Safety

"*However, as apparent from the preceding discussion, the operation of the method in a confined space requires additional hazards to be risk assessed. The likelihood of some of the more critical hazards* *materialising, the magnitude of the consequences should they materialise, controls for eliminating or mitigating them, and emergency responses and contingencies, all rely to a considerable extent on pre-empting if web pillars may yield, what form any yielding may take (controlled or uncontrolled), and how conditions in a workplace may be impacted by yielding. This concern is yet to be fully resolved despite the numerical modelling undertaken to date*".

A statement made in GAPL 2017 provides a suitable summary of the proponents position on this issue, namely that "*…on this occasion and as advocated in the EIS, the restricted web panel spans associated with the Hume Coal Project might remove the risk of uncontrolled collapse of web pillars that comply with as-designed dimensions. Consideration still needs to be given for the potential for uncontrolled failure of undersize web pillars and pillars adversely affected by geological structure*". The issue of both the inadvertent formation of undersized web pillars and the de-stabilising influence of geological structures (on both coal pillars and the overburden) will be commented on later in the report. Suffice to state that both threats were recognised from the outset and are related to operational management, rather than the process of justifying a general mine layout under what may be termed as "normal" or "typical" geological conditions.

3.1.1.4 Imbedded Uncertainty in the Mark-Bieniawski formula

Four queries were raised under this heading, as follows (the numbering being as per the review report):

> *Query 1. Is the uncertainty inherent in the foundation Bieniawski equation embedded in the Mark-Bieniawski equation?*
>
> *Query 2. If not, should it be carried over?*
>
> *Query 2. What level of (additional) uncertainty in the Mark-Bieniawski pillar strength equation arises from the assumptions and approximations associated with its derivation?*
>
> *Query 3. As a result of queries (1) to (3), what factor of safety value should be used when assessing the stability of the web pillars on the basis of the numerical modelling outcomes?*

The reason for this series of queries is not clear nor is its relevance, as the Hume layout design does not ever rely upon the Bieniawski formula, nor the SF recommendations associated with its use as recommended by Bieniawski and quoted by the reviewer. It would appear that the reviewer is primarily interested in the knowledge of the author as to the specific statistical differences between the two stated pillar strength formulae. The author is not aware that such detailed knowledge of the historical development of coal pillar strength formulae is a mandatory pre-requisite for the use of such formulae for design purposes as part of a formal and published design process such as ARMPS-HWM. However, the basis of the queries will be addressed generally as follows.

The Mark-Bieniawski formula as a credible pillar strength formula for use within an empirically-based design methodology is presumably not being questioned by the reviewer. The formula is intrinsic to both the ARMPS-HWM and ARMPS pillar design methods, the latter of which is based on the back-analysis of some 692 case histories from 127 different coal mines covering all US coalfields and 67 different coal seams - see Figure 2.4 (Mark 2010). In contrast, the development of pillar strength equations by the UNSW was initially based on 14 collapsed and 16 stable cases, with the combined Australian and South African database as also analysed by UNSW, consisting of 116 stable cases and 61 failed cases (Galvin *et al* 1999). In other words, the general suitability of the Mark-Bieniawski formula has been empirically evaluated by reference to the largest single coal pillar database in the world and found to provide meaningful design outcomes according to its developer, Dr Chris Mark.

The UNSW pillar strength equations (based on 14 'collapsed case' data points) are relied upon by both Galvin and Associates and Dr. Canbulat in arriving at various conclusions in their reviews. However in his second report, Dr. Canbulat argues in relation to laboratory test data for Hawkesbury Sandstone at Hume, that a set of some 25 data points is "*insufficient for making accurate conclusions and decisions for the entire mine*". Since the introduction of the UNSW pillar strength equations two decades ago, to the best of the authors knowledge no comprehensive study has ever been undertaken to confirm or update the Probabilities of Failure associated with these formulae by analysing design vs actual outcomes, yet in the United States such a process has been on-going.

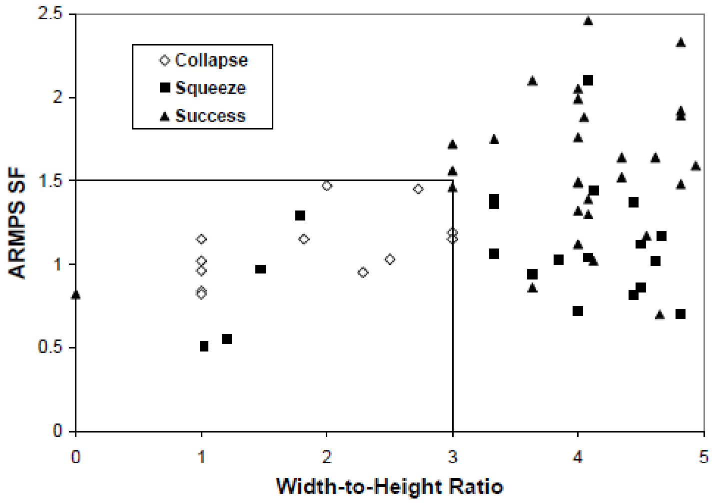

FIGURE 3.1. Pillar Collapse Case Histories from the US: ARMPS SF and width-to-height Ratio (Mark 2006)

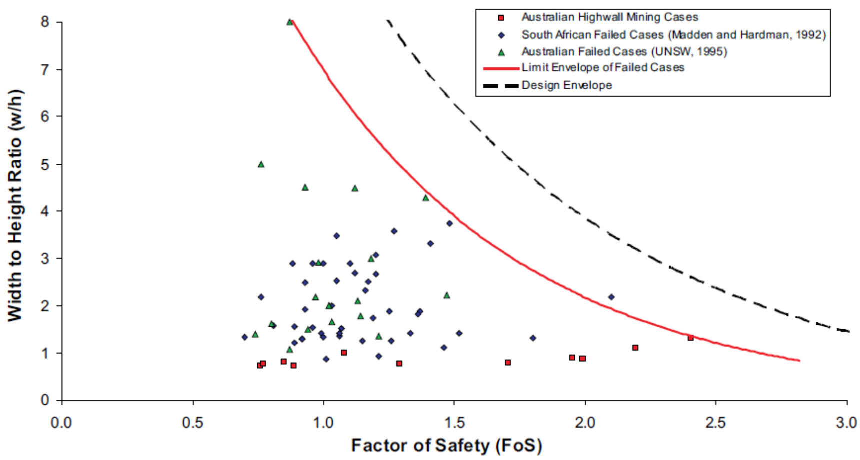

FIGURE 3.2 Database of Pillar Collapses – Width to Height Ratio v FoS (Hill 2005)

More generally, uncertainty in the accuracy of any pillar strength formula is addressed by the use of case history databases in determining suitable design recommendations and if possible, associated levels of design uncertainty. As both the pillar strength formula and the supporting databases vary from method to method, design recommendations in terms of SF and uncertainty levels cannot and should not be transferred between methods. This was understood from the outset when developing the Hume layout design guidelines.

It is also understood that the Mark-Bieniawski formula is typically used in conjunction with the w/h ratio of the pillar when designing against pillar collapses. As illustrated in Figure 3.1 and discussed by Mark 2006, all massive pillar collapses in the US can be characterised as having an ARMPS SF < 1.5 and a w/h < 3. He also notes that pillar collapses in South Africa all had w/h values < 4, which is generally true of the Australian cases as outlined by Hill 2005. Therefore, if pillars were to be designed with an ARMPS SF > 1.5 and w/h > 3, it could be reliably stated that there was no precedent for a massive pillar collapse for pillars designed to these two conditions within the ARMPS database consisting of > 600 case histories. A broadly similar statement can be made in relation to both the South African and Australian databases as presented in Figure 3.2, whereby it is clearly evident that the use of FoS and w/h ratio as a combined design criterion, provides for far more reliable design against pillar collapse, than FoS in isolation.

In answering the key question posed as to whether any uncertainty should be carried over, the answer given is “yes”, but on the strict proviso that pillar design also includes due consideration of pillar w/h ratio and overburden stiffness (as outlined in Section 2), rather than solely relying on calculated pillar stability in isolation.

The reviewer’s disagreement with combining pillar SF (or FoS) and w/h ratio into a broader-based pillar stability design criterion is known, and duly acknowledged (based on Galvin 2006). However Mine Advice’s position on this issue is fully consistent with that of Dr Chris Mark as the primary developer of ARMPS and ARMPS-HWM, as explained in more detail via the technical arguments outlined in Reed *et al* 2016.

3.1.1.5 Strength of a Low w/h Ratio Pillar Based on the Mark-Bieniawski Formula

Three queries were raised under this heading, as follows (the numbering being as per the review report):

> *Query 4. Could the reason for the numerical modelling predicting that the safety factor of the web pillars is greater than 1 be due to the higher pillar strength predicted by the Mark-Bieniawski pillar strength formula?*
>
> *Query 5. Is the reasoning correct that the safety factors produced by the numerical modelling to date need to exceed a value of 1.5*1.17 = 1.76 for 3.5 m wide web pillars, to 1.5*1.22= 1.83 for a 5.5 m wide web pillars in order to satisfy Bieniawski’s safety factor recommendations for bord and pillar workings?*
>
> *Query 6. How are the analysis outcomes and their interpretation impacted if pillar strength is defined by the UNSW power (rectangular) formula and the minimum acceptable safety factor for pillar stability is set at 1.55 (corresponding to a minimum probability of stability of 1 in 1000, which is a common standard in NSW)?*

The basis of the queries is assumed to relate to how to apply the various pillar strength equations according to the numerical modelling outcomes and also the inclusion of pillar length in the Mark-Bieniawski pillar strength equation as outlined in Table 2 of GAPL 2018 and the associated commentary (re-produced herein).

Table 2: Comparison between strengths of a 3.5 m wide and a 5.5 m wide, 3.5 m high, 120 m long web pillars as predicted by mainstream pillar strength formulae.

	Web Pillar Width = 3.5 m		Web Pillar Width = 5.5 m	
Pillar Strength Formula	**Strength (MPa)**	**% Increase in Strength Associated with using Mark-Bieniawski Strength Equation**	**Strength (MPa)**	**% Increase in Strength Associated with using Mark-Bieniawski Strength Equation**
Mark & Bieniawski, 1987	7.28	-	9.15	-
UNSW Power Salamon et al., 1996	5.69	28 %	7.16	28 %
UNSW Linear Salamon et al., 1996	5.12	42 %	6.42	43 %
Bieniawski, 1983	6.20	17 %	7.5	22%
Salamon & Munro, 1967	5.60	30 %	6.9	33 %

Table 2 shows a comparison between the strengths of 120 m long, 3.5 m wide and 5.5 m wide web pillars as predicted by the Mark-Bieniawski formula and by four other mainstream pillar strength formula that have had likelihoods of success assigned to their outcomes. The Mark-Bieniawski formula predicts strength increases that are 17% to 40 % higher than alternative mainstream formulae.

The first point to make in addressing these queries is that pillar length was introduced into pillar strength equations due to the recognition that the early strength equations such as those from Salamon and Munro 1967 and Bieniawski 1983, were either founded on databases of predominantly non-rectangular pillars, or the *in situ* testing of predominantly non-rectangular sections of coal. This was judged to result in such equations under-estimating the true strength of distinctly rectangular coal pillars, which resulted in both the UNSW and Chris Mark independently including pillar length in new strength formulations, as is evident in Table 2 from GAPL 2018. In other words, it should clearly be the case that a long rectangular pillar is stronger by some amount than a square pillar of the same w/h ratio. It is assumed that this general concept is not in dispute.

The manner by which pillar length was incorporated into their pillar strength equation(s) by Salamon and Mark-Bieniawski, varied. As stated by the reviewer, "*based on practical mining experience, Salamon et al (1996) adjudged that rectangular shaped pillars do not start to experience an increase in strength due to their shape until their width-to-height ratio approaches three (3) and that the full benefit is not realised until width to height ratio reaches six (6)*". To the best of the author's knowledge, this judgement on the part of Salamon has never been independently proven, but simply incorporated without question by UNSW into their rectangular pillar strength equations.

Mark and Bieniawski adopted a different technical approach, but again did not independently verify the accuracy of their method in the real world, other than by incorporating the resultant pillar strength equation into ARMPS and later ARMPS-HWM and reporting the outcomes of the database analyses, which included design recommendations in terms of SF etc.

It is therefore surely a matter of academic argument as to whether the judgements of Salamon or Mark/Bieniawski result in the more realistic incorporation of pillar length into pillar strength equations, such debate being well outside the domain of an EIS application and associated peer review process.

In terms of the specific queries, the following responses are provided:

> Query 4: the short answer is "no" as even though the numerical modelling study returned lower web pillar loading values than assumed by ARMPS-HWM for design purposes (which was based on the application of FTA Loading), all of the web pillar SF design outcomes from ARMPS-HWM are 1.3 or greater, as described in Mine Advice 2016b, a web pillar SF of 1.3 under FTA being the minimum design value under this method for the specific condition of the distance between intra-panel barriers being 60 m or less. Even when applying the UNSW Rectangular Power formula as was included in Mine Advice 2016b, the FoS of web pillars never falls below 1 under FTA loading.
>
> Query 5: as stated previously, the Bieniawski recommended design values have never been incorporated into the Hume layout design process. ARMPS-HWM provides specific SF design values for the web pillars, barrier pillars and overall pillar system stability that are based on the back-analysis of the US HWM database. Therefore, the query is unfounded and indeed makes no sense, as it would be totally inappropriate to modify design SF values related to the Bieniawski strength equation in this way due to the use of a different, albeit related pillar strength equation, particularly given that a HWM mining layout is fundamentally different to a bord and pillar layout, this being the assumed basis for the reviewers selection of an SF of 1.5 as the base value.
>
> Query 6: the first point to make is that it is assumed that the reviewer means probability of "instability" or failure rather than probability of "stability" in the query. Secondly, the source of an FoS of 1.55 corresponding to a minimum probability of <u>instability</u> of 1 in 1000 is not obvious to the author. Galvin 2016 provides data tables that state that for a PoF of 1 in 1000, the associated UNSW FoS is 1.85 for their linear formula and 1.63 for their power formula. In terms of there being a "*common standard*" for coal pillar failure probability in NSW, the author is unaware of any such standard or even guideline. It is assumed that the reviewer is actually referring to a probability of failure of 3 in 1000, which as stated in Galvin 2006, "*it is general practice in South Africa and Australia to design panels to have a minimum probability of failure of around 3 in 1000, which typically equates to a power law safety factor of 1.6*". "General practice" does not constitute a "standard" and there is no such stipulation in either the NSW Regulations, the NSW Strata Control Code of Practice or any other industry publication to the best of the author's knowledge. However, it is accepted that this may be a common informal criterion applied by the NSW inspectorate when reviewing pillar design applications based on the use of the UNSW PDP.

In more general terms, as the design basis of the Hume Coal layout was a combined function of pillar stability and overburden stability between barriers, this resulting in a "pillar system design approach" as was generally agreed by all experts at the meeting held on 28th March 2018, any application submitted to the NSW inspectorate relating to the formation of web pillars at Hume would inevitably not be based on the FoS or SF of said web pillars in isolation. Moreover web pillars would be included as one component of a larger pillar and overburden system whereby both the stability of barrier pillars and that of the overburden above web pillars was also included, this allowing their true probability of failure to be assigned a substantially higher value than that based on the application of the UNSW PDP to the design of web pillars in isolation, as being assumed in the query.

Nonetheless, an updated analysis of web pillar stability using the results of the numerical modelling and the UNSW PDP strength equations will be detailed in Section 4 of this report, in order to provide the most up to date numerical modelling interpretation.

3.1.1.6 Pillar Constitutive Law

A single query was raised under this heading, as follows (the numbering being as per the review report):

> Query 5: *How realistic is it to use an elastic-plastic constitutive law if pillar strength is based on other mainstream pillar strength formulae and design takes into account that failure can occur at safety factors less than or greater than 1. For example, if the modelling was re-run based on pillar strength defined by the UNSW power strength formula and a minimum acceptable probability of failure of 1 in 1000 (which corresponds to a safety factor of around 1.55 if the UNSW power pillar strength formula is invoked), would it still be appropriate to utilise an elastic, perfectly plastic constitutive law and, if so, why?*

This query by the reviewer again invokes the idea that the stability of web pillars needs to be evaluated individually, whereas as was stated as part of the EIS submission and subsequent responses by the proponent to earlier independent expert reviews, the design of the web pillars is as part of a larger pillar system which includes the stabilising contribution of both the overburden and adjacent barrier pillars. Therefore, the basis of the query is generally rejected by the author as it is inconsistent with the fundamental basis of the layout design strategy being applied.

Furthermore, the reason that 3D numerical modelling was undertaken by the proponent was to allow a better appreciation of the likely load distribution between the various pillars in the pillar system, this being an adjunct to, rather than alternative to the use of the 2D ARMPS-HWM as the primary layout design methodology. It also allowed the inclusion of the stiffness of the overburden based on geomechanical properties, whereas ARMPS-HWM was restricted to limiting the distance between intra-panel barriers in order to stabilise the overburden without consideration of the overburden type and its contribution to web pillar stability.

This query also leads to the issue of average pillar stress vs pillar stress distributions when evaluating coal pillar stability, which is a fundamental difference between empirical design methods and the associated pillar strength equations (which work to average pillar stress), and numerical modelling (which due to the need to discretise the pillar into elements, both vertically and horizontally, means that the model will develop vertical stress distributions within each pillar, this adding an additional level of analysis complexity, over and above the use of empirical methods).

The Mark-Bieniawski pillar strength formula has been incorporated into LaModel by Emeritus Professor Heasley with full knowledge of this difference in pillar loading approach. In his report he explains the logic by which the transition from a pillar strength equation based on average pillar stress, to a numerical model that generates vertical stress distributions within each pillar, was formulated and justified.

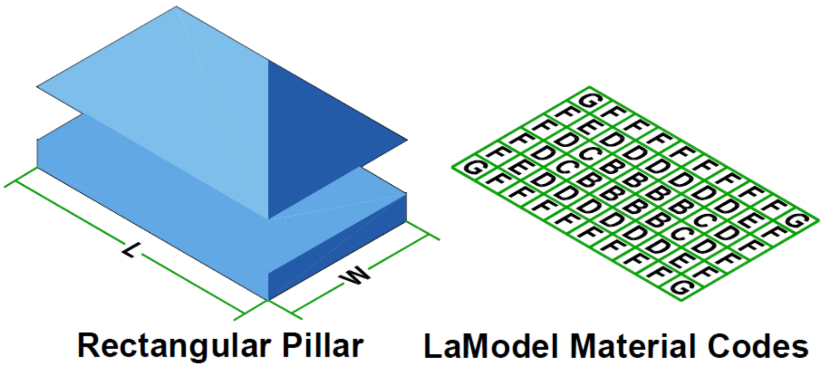

FIGURE 3.3. Schematic of Pillar Load and LaModel Element Mapping (Heasley 2018)

The reason for the inclusion of an elastic-plastic constitutive law for coal pillar behaviour in LaModel, was not to eliminate coal pillar yielding, but to allow the full peak-loading profile of each pillar to be generated at the point that peak pillar strength is achieved (see **Figure** 3.3), as also used in the derivation of the Mark-Bieniawski strength equation. As the outer elements of a pillar have lower defined peak loading levels than those within the inner section of the pillar (see **Figure** 3.3), a modelling mechanism is required to allow all elements of the pillar to attain their peak loading values at the same juncture, this then defining the pillar reaching its peak strength or maximum possible loading condition. The use of a strain-softening constitutive law for the behaviour of coal pillars in LaModel would prevent this from being simulated in the model and so act to substantially reduce the peak strength of each pillar, thereby rendering the model unable to apply the Mark-Bieniawski pillar strength equation and generate meaningful pillar SF values.

In terms of ensuring that the modelling was not in any way influenced by the lack of a strain-softening constitutive law for the web pillars, a review of individual SF values was conducted, this being to demonstrate that the SF values returned were sufficiently high so that web pillars remained well within the initial elastic portion of the stress/strain curve overall. The 3D models showed that at a cover depth of 80 m where the W/H ratio of the panel between barriers is at a maximum (0.7), the average web pillar SF is in the order of 1.8 to 1.9. For a cover depth of 160 m where the W/H value is at its lowest level (0.32), the average web pillar SF is lower at 1.43 to 1.46, all clearly remaining within the elastic portion of the pillar stress/strain curve.

Overall, the entire premise of the query is judged to be flawed in that (a) the use of an elastic-plastic constitutive law is specifically required for LaModel to produce outcomes that are consistent with the Mark-Bieniawski strength formula at peak pillar loading prior to any onset of yield or failure, and (b) as a result of (a) LaModel cannot evaluate post-peak pillar behaviour in a meaningful manner without corrupting the simulation of the peak strength condition of the pillar. Furthermore, the stated web pillar design basis remains that they must be treated as part of a larger pillar system, with the stability of the adjacent barrier pillars, which are acting to stabilise the web pillars by virtue of the restricted span between barriers, being well beyond any legitimate concern in regards to pillar yield.

In terms of the final comment made by the reviewer in that the numerical models may need to be re-run for the reasons stated, a response to this will be deferred until Section 4.

3.1.2 Core Issue #2 – The Pillar System

The section of GAPL 2018 discussing "the pillar system", raises three general "residual" issues that the reviewer has requested be addressed:

(i) Whether stability/instability of the web pillars poses any significant threat to the safety in the mine workings during operations or not?

(ii) The potential for safety threats associated with (i) to manifest either as a rapid pillar collapse, and/or (ii) a more gradual yielding in a controlled and non-violent manner.

(iii) Concern over uncertainty in the ability of the overburden to span between intra-panel barriers based on geological variations.

Each will be addressed in detail

3.1.2.1 Threat of Web Pillar Instability to Operational Safety

There is no doubt that the occurrence of a rapid and uncontrolled pillar collapse in an underground mine represents a significant safety threat to persons via either being trapped/directly impacted by the collapse or via any associated windblasts that propagate through the mine. This is far more so than the planned collapse of the overburden in a total extraction longwall panel for example due to the large plan areas of collapse that are commonly involved with pillar collapses.

Table 1.—Massive pillar collapses in coal mines

Case history	State	Depth, m (ft)	Pillar size, m (ft)	ARMPS SF	w/h ratio	Collapsed area, ha (acres)	Collapse size, m (ft)	Damage from airblast
A	WV	84 (275)	3 by 12 (10 by 40)	0.86	1.05	2.3 (5.7)	150 by 150 (500 by 500)	26 stoppings, 1 injury.
B1	WV	73 (240)	3 by 12 (10 by 40)	0.96	1.00	—	—	32 stoppings, fan wall out.
			3 by 18 (10 by 60)	1.10	1.00			
B2	WV	75 (245)	3 by 12 (10 by 40)	0.94	1.00	1.7 (4.1)	100 by 150 (350 by 500)	40 stoppings.
B3	WV	85 (280)	9 by 9 (30 by 30)	1.46	3.00	2.8 (6.8)	180 by 180 (600 by 600)	70 stoppings.
			6 by 12 (20 by 40)	1.47	2.00			
C1	WV	60 (195)	3 by 12 (10 by 40)	1.19	1.00	2.1 (5.2)	140 by 150 (450 by 500)	103 stoppings.
C2	WV	99 (325)	9 by 9 (30 by 30)	1.15	3.00	1.9 (4.8)	100 by 180 (350 by 600)	Minimal.
D	WV	69 (225)	6 by 6 (20 by 20)	1.15	1.82	1.7 (4.3)	100 by 160 (350 by 540)	37 stoppings.
			9 by 9 (30 by 30)	1.42	2.73			
E1	WV	91 (300)	3 by 12 (10 by 40)	0.79	1.42	7.4 (18.2)	240 by 290 (800 by 950)	Major damage.
E2	WV	91 (300)	3 by 12 (10 by 40)	0.71	1.11	6.7 (16.6)	220 by 275 (720 by 900)	Major damage.
F	OH	76 (250)	2 by 12 (7 by 39)	0.66	2.12	2.0 (4.9)	90 by 215 (300 by 700)	Minimal.
G	UT	168 (550)	12 by 12 (40 by 40)	0.95	2.29	7.9 (19.4)	150 by 490 (480 by 1,620)	Major damage, 1 injury.
O	WV	—	—	1.03	2.50	1.8 (4.5)	120 by 150 (400 by 500)	—
R	CO	120 (400)	4 by 24 (12 by 80)	0.57	1.71	2.8 (6.8)	180 by 150 (600 by 500)	Minor damage.

NOTE.—Dash indicates no data available.

TABLE 3.1. Massive Pillar Collapses in Coal Mines (Mark *et al* 1997)

Mark *et al* 1997 summarise a number of pillar collapses from the US, including the plan area that was involved (see Table 3.1), the range being 1.7 to 7.4 hectares or 17,000 m^2 to 74,000 m^2, all of which are substantially lesser in area than the infamous pillar collapse at Coalbrook in 1960, the major collapse covering an area of some 324 hectares or 3,240,000 m^2. The Mark *et al* 1997 paper provides summary descriptions of several "smaller" (in the order of 2 hectares) events in the US whereby whilst no-one was killed, persons were injured from being blown over and there were significant disruptions to mine ventilation.

There is no debate as to whether a rapid and uncontrolled pillar collapse in any underground coal mine is a tolerable safety threat, the layout design requirement being that the likelihood of one occurring must be reduced to the lowest practical level (ALARP).

In terms of gradual or controlled web pillar yield, which might also be termed as a "creep" or "squeeze", there are a number of known examples in both Australian mines and overseas that can be referred to in terms of assessing the resultant safety threats. To the best of the author's knowledge, whilst pillar creeps have rendered certain areas of mines as inaccessible and unsafe, no person has ever been significantly injured or killed as a direct consequence, the primary associated risks being either loss of coal reserves or loss of equipment.

In essence, the safety threats associated with a pillar creep or squeeze are highly amenable to being effectively managed through the formal operational management process, whereas it is far less certain when the pillar failure mode is rapid and uncontrolled, the latter therefore being the primary safety focus.

3.1.2.2 Impact of the Rate of Pillar Instability on the Safety Threat

The GAPL review appears to be accepting that the proposed Hume layout design generally meets the requirements of mitigating the impact of mining at surface to acceptable levels, the focus of their review shifting to workplace safety, which was not described in the EIS, the purpose of an EIS being an environmental assessment rather than a mine safety assessment. It is judged to be logical that if a mine has been designed to be long-term stable, the safety threat posed by a pillar collapse during mining operations should already be effectively catered for. Nonetheless, the concern will be addressed in further detail herein.

The question in relation to safety in the workplace rather than surface impacts, is whether the web pillars, in isolation from barrier pillars, can undergo a rapid and uncontrolled collapse or not, either during or subsequent to mining operations in any given production panel. There is no argument that with w/h ratios in the range of 1 to 1.57, web pillars are of sufficiently low w/h to allow such an event should the necessary pillar loading conditions eventuate.

Mark *et al* 1997 provide details of a number of such events within US underground coal mines associated with the formation of comparable w/h ratio remnant pillars, as summarised in Table 3.1.They also provide a summary description of those collapsed cases as follows:

- The ARMPS SF was < 1.5 in every case and less than 1.2 in 81% of the cases (it is assumed that this relates to FTA loading of the collapsed pillars)
- Pillar w/h values < 3
- Overburden judged to be "strong" in every case
- The minimum dimension of a collapsed panel suffering major damage was 110 m, with the minimum collapsed area being 1.6 ha.

In addition, the author notes that the minimum dimension of any collapsed case was 90 m at a cover depth of 76 m, with the general W/H ratio of collapsed areas being between 1 and 2.64, albeit ignoring the case from Mine G, which as described in the paper was influenced by overlying workings which are not relevant to Hume.

Mark *et al* 1997 outline a suggested design strategy for a "*containment*" approach to the formation of small pillars with low w/h ratio, which is based around two stipulations:

(i) Limiting the span above the area of small pillars to assist in stabilising the overburden.

(ii) Limiting the area of small pillars to reduce the damage potential should a collapse occur.

Specifically, they recommend limiting spans to no more than 90 m and compartment areas of no more than 1.2 hectares (12,000 m^2). In this regard it is noted that individual web pillar compartments at Hume are significantly less than both of these suggested limits, the maximum span between barriers being 56.5 m (at 80 m cover depth) and each compartment area being no more than 0.68 hectares.

In terms of assessing the likelihood of a web pillar collapse occurring in the first instance, two independent criteria need to be met:

(i) A portion of the overburden must be critically unstable so that the web pillars are being directly loaded by kinematically unstable material with zero inherent stiffness.

(ii) The web pillars become overloaded by that amount of overburden, so that both web pillars and the unstable overburden section can collapse in tandem.

The use of sub-critical spans between intra-panel barriers is designed to prevent (i) occurring for the overburden as a whole, the reliability of which increases with increasing cover depth as the W/H between barriers consequently reduces. Therefore, the only scenario by which (i) can come about is for a portion of the overburden to become critically unstable above a web pillar compartment, which in turn reduces the tributary area load influencing the web pillars, and so acts against such a collapse occurring.

As stated by GAPL 2018:

> *"Once having derived the relationship between the probability of failure and the ratio of pillar strength to pillar load, any load can be used in the analysis to produce a safety factor that can be equated to a probability of failure".*

Therefore, in order to further evaluate the potential for a web pillar collapse in operations by reference to the UNSW PDP, web pillar loading needs to be modified using the proportion of the overburden that might become unstable within the spans between intra-panel barrier pillars, as is now detailed.

With the maximum span between barriers being limited to 56.5 m, applying a W/H ratio of 1 returns an effective maximum depth of 56.5 m above the web pillars whereby the overburden might become critically unstable. At a maximum effective cover depth of 56.5 m, the following web pillar ARMPS SF and UNSW FoS values are found for the two extreme design cases at depths of 80 m and 160 m:

- H = 80 m: ARMPS SF = 2.38, UNSW FoS = 1.86
- H = 160 m: ARMPS SF = 3.72, UNSW FoS = 2.91

It is worth noting that as the ARMPS SF values are in excess of 2, this complies with the suggested "*prevention*" approach to massive pillar collapses outlined by Mark *et al* 1997, and with the web pillar

FoS values being in excess of 1.63, significantly so in the case of 160 m depth, the associated probabilities of failure under the UNSW PDP are now substantially < 1 in 1000.

With this analyses to hand, it is assessed that the threat to the safety of the mine workings from web pillar instability is reduced to the lowest practicable level, any residual threat able to be transferred to the operational management process.

3.1.2.3 Overburden Spanning Between Intra-Panel Barriers

Hume Coal made the following statement in their response to the independent experts reports, as quoted by GAPL 2018:

> "*The ability of the overburden to span across a panel is a function of both geometry, and to a lesser extent in terms of confidence levels, geology*"

In response to this, GAPL 2018 made the following statement:

> *"Caution is advised. Geology has a major influence on the stiffness of the overburden and, therefore, on confidence levels in the mine design since it determines the thickness of strata units, t', (laminations) and their mechanical properties such as modulus, E, and Poisson's Ratio, v. This is reflected in t', E and v being the critical input parameters to LaModel. On the other hand, the same geometry (excavation width, W, and mining depth, H) can be associated with a wide range of overburden stiffnesses, depending on geology. These principles are reflected in Figure 1 and Figure 2 by the wide range in vertical surface displacement that can be associated with a given W/H value and by the subsidence behaviour reported for Berrima Colliery".*

Hume Coal made the statement to address comments made by the reviewer in GAPL 2017, whereby it was suggested that significant reliance or confidence was being placed on the spanning ability of the overburden lithology or geology between intra-panel barriers as part of protecting web pillars from FTA loading and a soft overburden loading system that could cause an uncontrolled collapse of said pillars. The proponent is well aware of the basis of the concern that is being raised by the reviewer, which is why the design of sub-critical spans between barriers was based on using panel GEOMETRY and restricting said spans to sub-critical levels without any consideration of or reliance upon the overburden lithology. This is in fact part of the ARMPS-HWM design process as was clearly outlined in Mine Advice 2016b and has been intrinsic to the layout designs since they were first developed.

It would be fair to state that Hume Coal has taken a "cautious" approach to the issue of layout geometry since the commencement of the layout design process, hence it is not necessary for reviewers to advise caution in this manner as it could perhaps suggest that the proponent was not doing so in the first instance.

3.1.3 Core Issue #3 – The Role of Web Pillars

A number of technical issues were discussed by the reviewer under this heading, including:

(i) The assumption of FTA loading in calculating web pillar probabilities of failure, as was included in GAPL 2017.

(ii) The potential influence of rib spall and roof falls within the UNSW pillar database.

(iii) The potential impact of localised geological structures on web pillar strength

(iv) The potential influence of small remnant pillars (termed “stooks”) within the areas of full extraction at Berrima Colliery from which surface subsidence data was used for LaModel calibration purposes.

(v) The reliance being placed by Hume Coal on the spanning ability of massive strata protecting the integrity of web pillars.

A further point (point 6.) in GAPL 2018 was retracted by the reviewer as being a misrepresentation on his part, and will therefore not be considered further herein.

Each issue will now be addressed in detail.

3.1.3.1 Use of FTA Loading in Determining Web Pillar PoF Values

Hume Coal were quoted by the reviewer as follows:

> “*As discussed earlier, it is inappropriate to calculate probabilities of failure for individual web pillars in the pillar/overburden system as has been done by Galvin and Associates for the following reasons:*
>
> *1. The assumption of full-tributary loading is incorrect; and”*

In response, the reviewer made the following statement:

> “*The calculation of probabilities of failure does not depend on full tributary area load. Probability of failure has been determined by statistical analysis of the safety factors of both failed and unfailed cases, where safety factor was defined as the ratio of pillar strength to pillar working load. A probability of failure can be calculated for any loading situation – the load need not be tributary area load. As explained in GAPL’s December 2017 report and presented in detail in Galvin (2016), only tributary area loading cases were used to initially derive the probabilities of failure because they provided the highest degree of confidence that the pillar loading component of the safety factor was reasonably accurate. Once having derived the relationship between probability of failure and the ratio of pillar strength to pillar load, any load can be used in the analysis to produce a safety factor that can then equated to a probability of failure. The calculation of these loads is a primary objective of the numerical modelling as recommended by Professor Hebblewhite, Canbulat and GAPL. Numerical modelling is required because the mine layout does not satisfy the criteria required to apply tributary area load theory*”.

The author does not disagree with any of the comments made by the reviewer in this regard. However the reality is that the reviewer demonstrably included web pillar PoF values under the assumption of FTA loading in his initial review report (GAPL 2017). The quoted response was part of the proponent objecting to the inclusion of these figures in his review report specifically for Hume, on the basis that the assumed web pillar loading conditions were inconsistent with the intent of the proposed panel layout design, not that it would be inappropriate to reduce web pillar loading to less than FTA if it could be justified.

Clearly, the reviewer has mis-understood the reasoning for the proponents statement, hence his response requires no further comment.

3.1.3.2 The Potential Influence of Rib Spall and Roof Falls within the UNSW Pillar Database

Hume Coal were quoted by the reviewer as follows:

> *"Another key reason why this analysis is inappropriate is that typical levels of rib spall and roof falls are already taken into account in the UNSW pillar database to some degree…"*

It is important to understand the context behind Hume Coal making this statement, which has been omitted by the reviewer in his second review report. Specifically, it was made in response to the reviewer's analysis of web pillar stability based on 0.2 m increments of rib spall and roof spall for varying depths of cover (see page 35 of GAPL 2017, included herein as Table 3.2), in particular that pillar geometry variations of such a low magnitude would inevitably be unresolved within the UNSW pillar database. Therefore the proponent was arguing that such sensitivity analysis was an inappropriate application of the UNSW PDP, the result of which could be seen as being detrimental to the proponent.

Table 5: Analysis of sensitivity of web pillar stability to 0.2m of spall.

Depth (m)	Situation	Tributary Area Loading	
		UNSW PDP Factor of Safety	Probability of Failure
80	As-designed	1.30	8%
	0.2 m rib spall	1.19	20%
	0.2 m roof fall	1.24	12%
	0.2 m rib & 0.2 m roof spall	1.13	28%
160	As-designed	1.01	50%
	0.2 m rib spall	0.96	61%
	0.2 m roof fall	0.97	63%
	0.2 m rib & 0.2 m roof spall	0.91	70%

TABLE 3.2. Analysis of Sensitivity of Web Pillar Stability to 0.2 m of Spall (GAPL 2017)

It is noted that to the best of the author's knowledge, the original publications of the UNSW PDP did not raise the spectre of the need to undertake such rib spall sensitivity analyses as part of its use, this only having become a stated concern by custodians of the UNSW PDP more recently, including Canbulat 2010 which presented a detailed discussion on the topic of time-dependent pillar deterioration due to rib spall, concluding that:

> *"A similar study was also conducted for the Australian pillar collapse database in this paper. The results revelated that the collapsed cases included in the Australian database of Salamon et al 1996, were due to low nominal safety factors and there is no indication that these pillars collapsed due to a high level of spalling.*

This would seem to indicate that in spite of South African studies that attempted to link unexplained pillar collapses in the Vaal Basin to time-dependent rib spall, no such de-stabilising influence could be found in the small number of Australian collapsed cases.

It is accepted that it would be relevant to evaluate the de-stabilising impact of rib spall in conditions whereby significant rib spall was likely to occur, the main common driver for rib spall being cover depths > 200 m. However, this is judged not to be the case at Hume.

Contrary to the context of the Hume Coal statement quoted by the reviewer, he has seemingly taken it out of its intended context and provided a long commentary on the potential impact of rib spall and roof falls on pillar stability IN REALITY, rather than addressing the stated concern in regards to the analyses he undertook in GAPL 2017. The proponent stands by their original assertion that the reviewers analysis as contained in Table 3.2 is inappropriate, and not as per their understanding of the intended use of the UNSW PDP.

3.1.3.3 The Potential Impact of Localised Geological Structures on Web Pillar Strength

Hume Coal were quoted by the reviewer as follows:

> *"Mine Advice as well as peer reviewers from Hume Coal (Hebblewhite 2016) and DP&E (Galvin and Associates, 2017; and Canbulat, 2017) have all recognised the potential impact of geological structures on web pillar strength…..*"

In response, the reviewer stated that:

> *"Hume Coal has proposed a range of response measures for managing this hazard. Until experience is gained with them, it is difficult to form a view as to how effective some of these controls may prove to be".*

Given that all parties recognise that anomalous geological structures have the potential to modify web pillar strength and therefore, need to be managed in operations (as outlined by the proponent in Hume Coal 2018), it would have been more useful for the reviewer to provide comment on (a) whether they believe that the associated risk to mine stability can indeed by effectively managed during mining operations, (b) provide an outline of key considerations that need to be incorporated into future operational management processes, and (c) as a minimum conduct a review of what has been proposed by the proponent, even if only at a high level in terms of general principles.

3.1.3.4 The Influence of Small Remnant Pillars on Surface Subsidence at Berrima Colliery

Hume Coal were quoted by the reviewer as follows:

> *"……..the proposed areas of web pillars between barriers will be substantially subcritical, and that the overburden possesses considerable spanning potential at similar panel width-to-depth ratios to the highest proposed at Hume"*.

"*Importantly, the panels at Berrima contain no substantial remnant pillars…..*"

The quotations relate to the use of surface subsidence data from the adjacent Berrima Colliery in determining, by back-analysis, the geotechnical characteristics of the overburden at Hume for subsequent use in the numerical modelling study undertaken by Emeritus Professor Heasley. Essentially, the reviewer is questioning whether Hume's assumption in regards to (i) a lack of substantial remnant pillars in the various extracted areas at Berrima, is consistent with the measured surface subsidence of < 10 mm S_{max}, and (ii) whether any errors in this assumption have a significant impact on the numerical modelling results. Given the reliance that has been placed by the proponent on the numerical modelling outcomes in further justifying its case, resolving this concern is an important aspect of this response.

Based on the reviewers own stated experience in pillar extraction operations, including having statutory oversight, he has advised it to be "*unwise*" to apply the Berrima Colliery case study without more robustly validating the data and also carefully assessing if the associated mining circumstances apply to the Hume Coal Project if the data proves reliable. Therefore, this is exactly what has been done in response as now detailed.

The question posed by the reviewer is founded on the question as to whether the remnant coal left in place within areas of total extraction at Berrima, was sufficient to substantially modify the manifestation of surface subsidence, this data being the primary basis for calibrating the overburden in LaModel by Emeritus Professor Heasley. In addressing this question, there are only two possibilities, both of which will be addressed in detail:

(i) Remnant coal had no substantial influence on surface subsidence.

(ii) Remnant coal did have a substantial influence on surface subsidence.

If it can be shown that the manner by which the numerical models were set-up caters for both scenarios, then any concern or uncertainty related to this issue can logically be dismissed as being irrelevant.

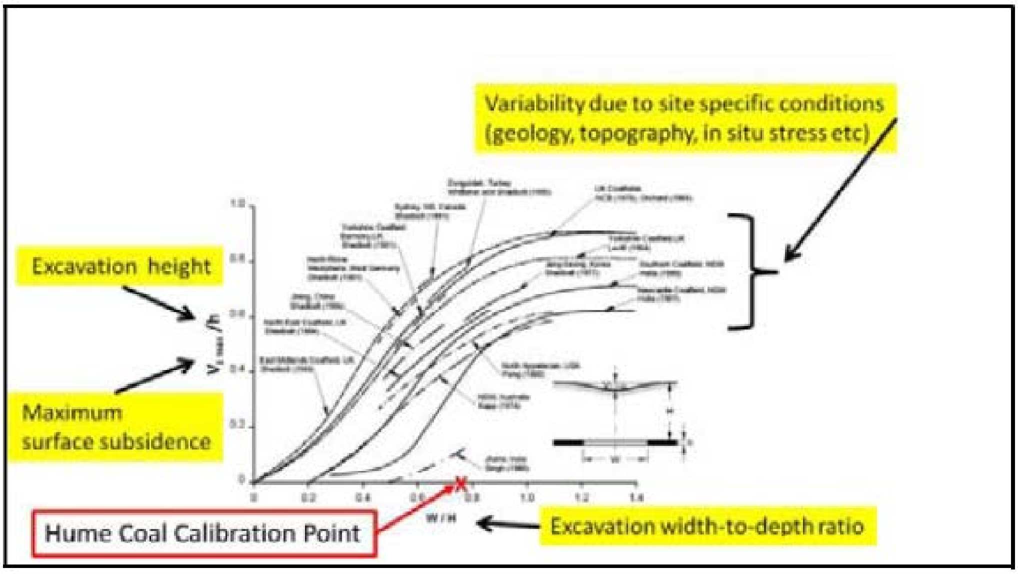

FIGURE 3.4. Illustration of the Extreme Nature of the Numerical Model Calibration Point by Reference to International Subsidence Behaviour (GAPL 2018)

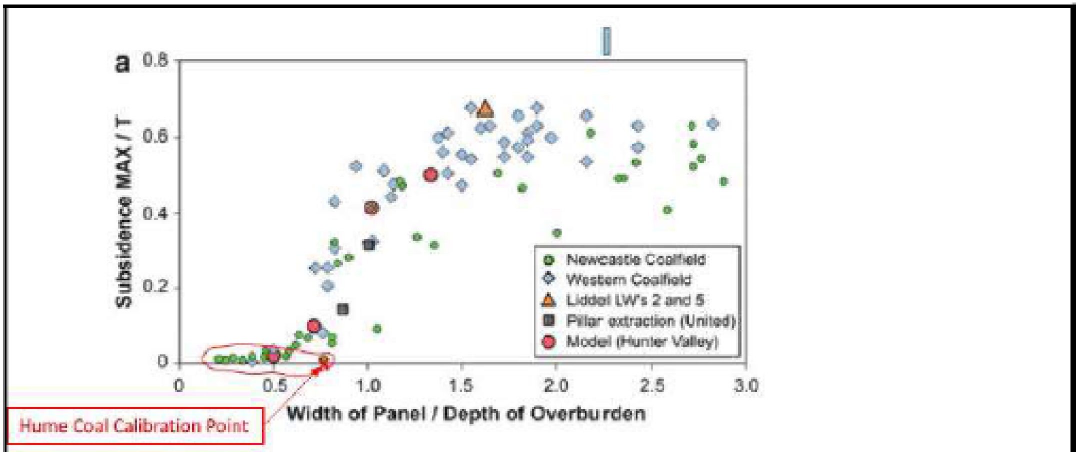

Figure 3: Empirical subsidence database showing effect of overburden/mining geometry on measured subsidence (after Galvin, 2016)

Figure 3.5. Illustration of Extreme Nature of the Numerical Model Calibration Point by Reference to Subsidence Outcomes in NSW Coalfields (GAPL 2018)

GAPL 2018 refers to two figures (reproduced herein as Figures 3.4 and 3.5) in explaining the basis of the concern raised. These will be referred to as required in formulating this response.

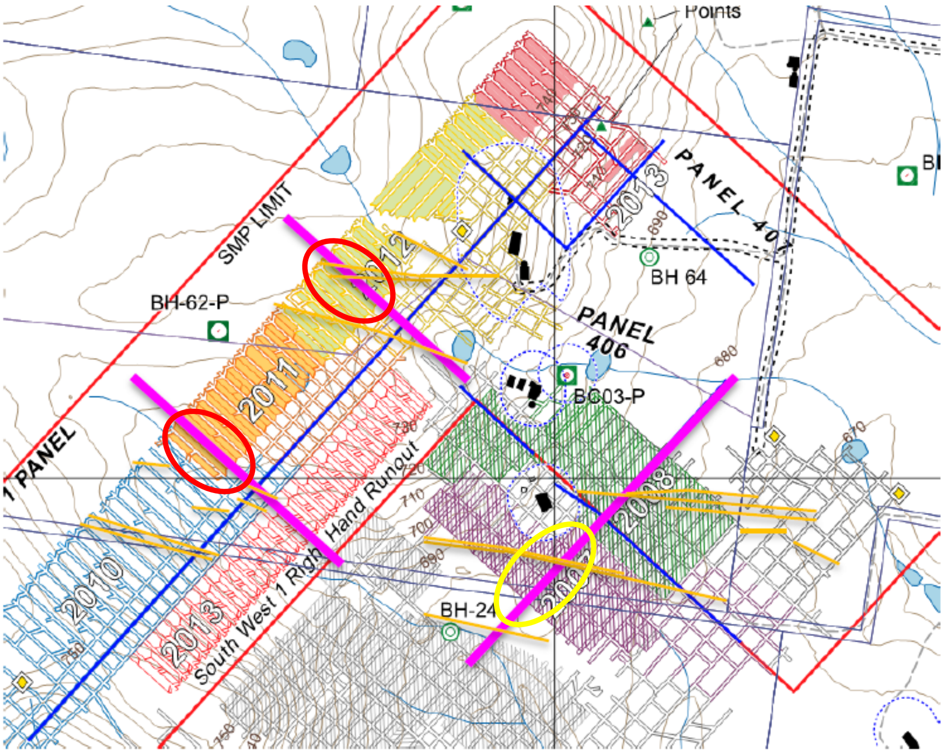

FIGURE 3.6. Berrima Colliery Workings and Subsidence Cross-Lines Above 404 and SW1 Panels

The first point to make is that the S_{max} magnitude that was used in calibrating the overburden in LaModel, was based on three measurements rather than one, such that any subsidence modifying influence at work must have presumably been of similar magnitude in all cases. The three subsidence cross-lines and the underlying mine workings from Berrima are shown in Figure 3.6 and the following comments are made:

(i) The specific areas from where surface subsidence data was taken from for use at Hume, are indicated as ellipses, the two from SW1 being in red and that from 404 in yellow.

(ii) As stated in DGS 2010, their surface subsidence predictions at Berrima were based on the assumption of 85% recovery within total extraction panels.

(iii) Examining the pillar layout in 404 Panel, due to the number of headings, cut-throughs and pillars within the area extracted in 2007, it is fully accepted that a significant number of small stooks would have inevitably been left in place during lifting operations, if for no other reason than to protect the stability of intersections (termed as Stook X in industry terminology). Therefore, the reviewers suggestion that measured surface subsidence might have been directly influenced by their presence, potentially has merit in 404 panel.

(iv) In contrast to 404, SW1 panel, which was the origin of two of the three subsidence measurements relied upon by Hume, contains a series of single headings driven across the full 120 m width of the panel. Therefore practical mining experience would logically suggest that the SW1 panel would be far less influenced by the planned leaving of remnant stooks than 404, yet the measured surface subsidence is broadly the same.

Consideration of the specific roadway and pillar layouts leads to the conclusion that there likely is a varying influence of remnant coal pillars on surface subsidence development at Berrima, with surface subsidence from above SW1 panel being far less likely to be directly influenced as compared to 404 panel.

If it is accepted for the sake of argument that surface subsidence above SW1 panel is not being significantly influenced by remnant coal in areas of attempted full extraction, the question then remains as to whether there are other reasons as to why the magnitude of S_{max} being < 10 mm is extremely low, as compared to comparable extraction panels, this being clearly indicated by the reviewer based on Figures 3.4 and 3.5.

In response to this question, the following points are noted:

(i) Whilst it is accepted that measured surface subsidence of < 10 mm for a panel W/H ratio in the order of 0.75 is very low in general terms, it is not so extreme to be substantially remote from other measured data, as can be gleaned from both Figures 3.4 and 3.5. Had the W/H ratio been 1.5 and S_{max} only 10 mm for example, that would have undoubtedly been a major departure from measured behaviour.

(ii) There is no argument that the measured surface subsidence as a function of W/H being 0.75 is significantly below the more typical behaviour for the major NSW coalfields – the Western and Newcastle Coalfields being shown in Figure 3.5 and single panel sag subsidence for three NSW coalfields, including the Southern Coalfield (which is where Berrima and Hume are located) being shown in Figure 3.7. The question therefore is whether there are any substantial differences between relevant subsidence controls at Berrima, as compared to these other NSW Coalfields more generally, that could explain the apparent “extreme” measured behaviour from Berrima?

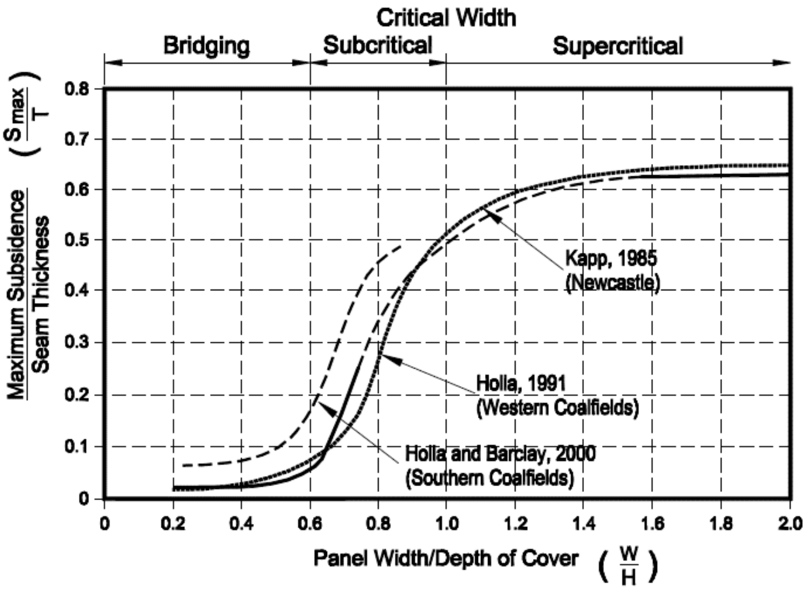

FIGURE 3.7. Sag Subsidence Over Single Panels (Mills *et al* 2009)

There are three relevant geotechnical considerations that could explain this difference in measured surface subsidence at Berrima for a W/H ratio of 0.75, according to known characteristics of the Berrima site as compared to other NSW coalfields more generally, and the NSW Southern Coalfield more specifically:

(a) The level of tectonic horizontal stress is substantially lower at Berrima and Hume, as was outlined in more detail in Mine Advice 2016a and summarised herein in Table 3.3.

(b) The overburden above the Wongawilli Seam locally is dominated by the Hawkesbury Sandstone (see Figure 3.7), whereas the overburden above most other mines in the NSW Southern Coalfield contains a range of different strata units in addition to the Hawkesbury Sandstone.

(c) As compared to the majority of the longwall panels in the NSW Southern Coalfield, Berrima is relatively shallow (< 200 m as compared to 400 to 500 m more typically), with S_{max} being known to increase for any given W/H ratio as cover depth increases (Ditton and Frith 2003).

The point being made is that there are at least three relevant geotechnical differences between the overburden above the Wongawilli Seam at Berrima and overburdens more generally in NSW, that could logically explain the apparent discrepancy between measured surface subsidence at Berrima as compared to that predicted by GAPL 2018 from more generic NSW coalfield-based empirical curves.

This general suggestion also fits with measured subsidence data from extraction panels with higher W/H ratios at Berrima (as reported by DGS 2010), with known super-critical total extraction panels whereby full overburden collapse to surface should occur returning S_{max}/T values well below the generally expected value in the order of 60% (the measured data points being included in Figure 3.9 to provide improved context). It is judged to be far less credible to suggest that small amounts of remnant coal in total extraction panels could substantially reduce surface subsidence in super-critical extraction panels, as compared to sub-critical panels such as SW1 and 404, the measurement data also being included in Figure 3.9 for reference purposes.

Location	Major Tectonic Stress Factor Range (average)	Major to Minor Conversion Factor Range (average)
NSW Southern Coalfield	0.7-1.4 (1.04)	0.46 – 0.82 (0.68)
NSW Newcastle Coalfield	0.84-0.84 (0.84)	0.65-0.69 (0.67)
NSW Western Coalfield	0.75-0.94 (0.81)	0.6-0.75 (0.67)
QLD German Creek/Lilyvale Seam	0.47-0.7 (0.6)	0.47-0.58 (0.54)
QLD Rangles Measures	0.46-0.56 (0.51)	0.48-0.55 (0.52)
QLD Moranbah Measures	0.64-0.66 (0.65)	0.54 (0.54)
HUME COAL - HU0040	0.44	0.73

TABLE 3.3. *In Situ* Horizontal Stress Parameters for Various Coalfields Compared with HU0040 (Mine Advice 2016a)

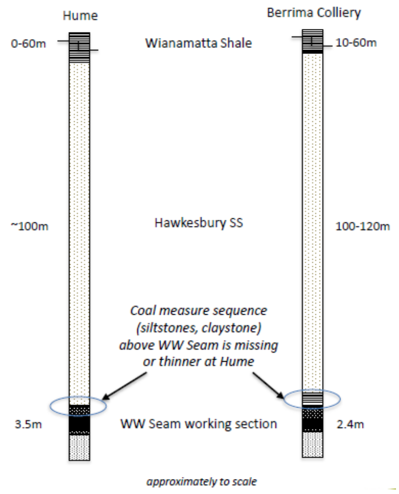

FIGURE 3.8. Comparison of Generic Overburden Lithology, Wongawilli Seam

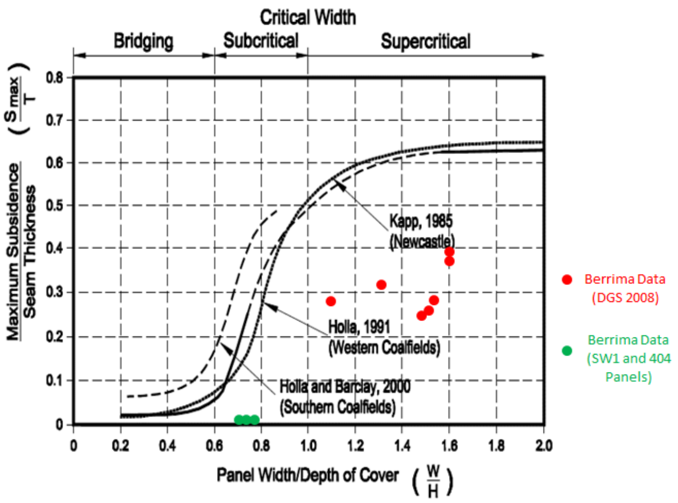

FIGURE 3.9. Sag Subsidence Over Single Panels (Mills *et al* 2009) and Measured Subsidence Data from Berrima

If it is assumed, based on the preceding discussion, that the measured subsidence data from Berrima was not substantially influenced by remnant coal within total extraction panels, then the conservative nature of the selected numerical modelling values for E and t for the overburden, cannot be argued. If however, it is the case that remnant coal did substantially reduce subsidence at surface and that this may have then resulted in an optimistic characterisation of the overburden in LaModel, then as stated by GAPL 2018 this would require said models to be re-run.

However, it first needs to be remembered that the overburden in LaModel was characterised by thickness or t values that were substantially less than those returned by the modelling back-analysis using the assumption that S_{max} = 10 mm at Berrima. The results of that back-analysis were reported in Mine Advice 2018 and are re-produced herein as Table 3.4. Of most interest is that the table contains the predicted S_{max} at Berrima for the chosen mid-range E (16.5 GPa) and t (30 m) combination for use at Hume, the value being 93.1 m, this being almost an order of magnitude higher than the measured value from Berrima of 10 mm.

GAPL 2018 contains the following statement referring to measured surface subsidence at Berrima:

> "*The extreme nature of the negligible subsidence is illustrated by reference to Figure 1 and Figure 2 (Figure 2 is incorrectly attributed to Galvin). As another point of reference, GAPL calculated predicted surface subsidence using the methodology and material values presented in the Hume Coal EIS. This approach predicts a surface subsidence of about 130 mm for the given dimensions*".

When it is also considered that the E and t combinations used in the numerical modelling extended to as low as E = 8.2 GPa and t = 20 m, it is evident that the LaModel predictions of S_{max} for Berrima are of a similar magnitude to those predicted by GAPL 2018. In other words, the cautious manner by which E and t values were selected for use at Hume based on the Berrima back-analysis, are not inconsistent with those that would be inferred using LaModel if the GAPL 2018 prediction of S_{max} without the influence of remnant coal were taken as being fully representative.

The conclusion from the analyses and discussion presented in this section of the report, is that whilst the concern raised by the reviewer that remnant coal in total extraction panels at Berrima may have blighted both the back-analysis to determine overburden characteristics for use at Hume, and hence the entire numerical modelling study, a more detailed consideration reveals that this uncertainty has no discernible impact due to the conservative manner by which the overburden was characterised and incorporated into LaModel in the first instance.

One final point is worth stating, and that relates to GAPL 2018 even suggesting that small amounts of remnant coal within total extraction panels might have the ability to reduce surface subsidence by more than an order of magnitude (i.e. 130 mm to < 10 mm). If this is correct, it actually represents an absolute proof of concept for Hume as it confirms that the leaving of low w/h coal pillars that are unable to fully support the overburden to surface within sub-critical spans between barriers, has the ability to stabilise the full overburden without undergoing any form of pillar failure. This is particularly encouraging when it is considered that:

(a) The extraction panels at Berrima were 120 m wide whereas the web pillar compartments at Hume are limited to no more than 60 m width.

(b) Reserve recovery in web pillar compartments at Hume is planned to be no more than 57%, whereas total extraction is commonly taken to achieve around 85% in-panel recovery.

The measured value of S_{max} at Berrima as used in the LaModel back-analysis, could only be achieved if the overburden between barriers at Berrima were also highly stable without the influence of remnant coal in the first instance, this also being a significant aspect of long-term remnant mine stability design at Hume.

3.1.3.5 Reliance on the Spanning of Massive Strata to Protect Web Pillars

Technical considerations relating to this issue were addressed in Section 3.1.2.3 and do not need to be re-stated herein.

3.2 Dr. Ismet Canbulat

The second review report of Dr. Ismet Canbulat (Canbulat 2018) is quite different to that of GAPL 2018 in that it is heavily focused on details pertaining to the numerical modelling undertaken by Emeritus Professor Keith Heasley and also providing a strong defence of the proponents criticism of the numerical modelling included in his first review report, Canbulat 2017.

The comments made herein will be largely restricted to those criticisms that are judged to be related to the confidence levels that can be placed in the currently proposed mine layout design, this being a function of the layout design work that has been conducted to-date and the level of design conservatism that has been applied. The comments made are in no priority order.

- The report continues to assert that the stability of the overburden between intra-panel barriers is strongly linked to the bridging capabilities of the Hawkesbury Sandstone. This is incorrect as has been stated several times by the proponent. The bridging or spanning of all or at least part of the overburden between barriers is a combined function of the both the W/H ratio and the lithology of the overburden. The initial layout design using ARMPS-HWM did not consider the nature of the overburden, only the magnitude of the span between barrier pillars. If the Hawkesbury Sandstone is less competent than assumed in the numerical modelling for example, the general geometry of the web pillar compartments remain sub-critical to surface, this becoming ever more so as cover depth increases, due to the span between barriers being limited independent of cover depth. This issue is also addressed in Section 3.1.2.3 in response to comments made in GAPL 2018.

- The report also raises the issue of the constitutive law used to define web pillar behaviour, namely the assumption of elastic-plastic behaviour. This was discussed and addressed in detail in Section 3.1.1.6 and does not need to be repeated.

- The statement that "*removing all web-pillars in all panels may not be representative of realistic conditions. Using strain-softening elements in all pillars, including at the edges of barrier pillars, may have represented a more realistic approach*" is technically correct, but fails to acknowledge the point of removing all of the web pillars in one of the numerical modelling scenarios. This was done, not to be realistic, but to demonstrate that even if all of the web pillars failed (without suggesting that this is a credible scenario), the barrier pillars would remain stable and surface subsidence effects would remain at low levels. It was also intended to usurp the various technical concerns that were introduced by the reviewers in regards to web pillar loading magnitudes and constitutive behaviour laws, both of which have been raised again in response to the numerical modelling that was undertaken by Emeritus Professor Heasley.

- The comment that the back-analysis conducted by Emeritus Professor Heasley as to the nature of the overburden at Berrima was "a very simple back analysis" as quoted in Canbulat 2018, cannot be found via a word search of Heasley 2018. The entire issue of the back-analysis of measured surface subsidence data from Berrima and what both reviewers consider to be anomalously low values of S_{max}, has been addressed in detail in Section 3.1.3.4 and needs no further comment herein.

- Canbulat 2018 states that "*Further to the above, no details of the Berrima Colliery back analysis were presented in Dr Heasley's report. The findings presented consisted solely of three lamination thicknesses and elastic modulus. If elastic, perfectly-plastic coal material properties were also assumed in the back analysis, this assumption may not be true for the total extraction panel(s). In addition, super-stiff overburden strata may indicate low subsidence magnitudes for an isolated panel. However, high stiffness overburden may result in increased load transfers onto the barrier pillars (as evidenced by reported LaModel results for Hume Coal), which may, in turn, impact their stability. These details should have been included in the report to review*".

  Firstly it is unclear as to why an assumption about coal constitutive behaviour has any link to the back-analysis of surface subsidence above an area of total extraction (i.e. assumed to contain no substantial remnant pillars) that is surrounded by highly stable pillars or solid coal. Nonetheless, the issue and significance of anomalously low S_{max} values at Berrima has been dealt with in Section 3.1.3.4 and requires no further comment.

- Issues relating to mine safety during forming of the unsupported drives were also raised in GAPL 2018. This has been considered and addressed in Section 3.1.2.2 using modified tributary area loading based on the width of web pillar compartments between intra-panel barriers and a W/H value of 1. The proponent does not believe there is any need or value in addressing this issue with further numerical modelling studies.

- The most substantial section (Core Issue #6) of Canbulat 2017 is a detailed response to the various criticisms raised by the proponent as to the relevance and interpretation of the numerical modelling outcomes contained in Canbulat 2017. As is stated in Canbulat 2018, this modelling "*sought to highlight some critical design considerations*" and so presumably was not intended for layout design purposes. Therefore, it is considered by the proponent that the numerical modelling outlined in Canbulat 2017 is substantially less credible than that conducted and reported by Emeritus Professor Heasley. As such, it has no bearing on the on-going mine assessment process and so requires no further comment herein.

- The statement is made on page 10 that "*Years to centuries may elapse before spalling is able to trigger a pillar failure. Van der Merwe and Madden (2010) comment in this regard; "Given sufficient time, any act of removing material from underneath the surface of the Earth will result in subsidence". The magnitude of subsidence will be determined by the amount of spalling, the size of the core of a pillar, and the overburden stiffness between the barrier pillars. I accept that the rate of spalling in the Wongawilli Seam may be very slow and it may take centuries for the pillars to fail but it will eventually happen, even if the pillars are not loaded at the levels of* *tributary area load. In my opinion, the crux of Hume Coal's assessment should be to demonstrate the potential consequences of failure rather than ascertaining whether the pillars will fail or not*". This statement does require a specific response.

The "scenario" numerical models reported in Heasley 2018 and interpreted in Mine Advice 2018 whereby all of the web pillars were removed, which by any standard is a grossly conservative if not unrealistically conservative modelling assumption, addresses the statement about demonstrating the consequences of web pillar failure, presumably at some indeterminate point in time in the very long-term. As well as surface subsidence effects being shown to be minimal should web pillar failure occur, the mine will inevitably be abandoned at that time hence there are no safety concerns to address, and on the basis that the mine is flooded and sealed, any associated overburden fracturing would have a negligible if not zero effect on sub-surface groundwater levels.

- The suitability of Young's Modulus testing results that were used in the numerical modelling has been questioned by the reviewer, stating that "*More test results from all parts of the mine will provide better understanding of the overburden modulus*". This is undoubtedly true, but the unstated inference that such an understanding is of real significance to the review and approval process at the current time requires a response.

  The numerical modelling study deliberately utilised the complete range of known E values from the available laboratory testing in order to determine the extent by which variations in E were of significance to the modelling predictions. By any standard it was clear-cut that pillar load distributions, which was the objective of conducting said modelling, did not materially change as a result of an E variation from 8.2 GPa to 23.2 GPa. Certainly, the overall interpretation of mine stability with an assumed E value of 8.2 GPa was not different to that at 23.2 GPa. This is not a surprising outcome when it is remembered that the spans between intra-panel barrier pillars were established from ARMPS-HWM, which gave no consideration to the nature of the overburden. In other words, the nature of the overburden was secondary to restricting the span between barriers, the numerical modelling results clearly bearing this out.

  In order to provide further justification for the range of E values used in the modelling, reference is made to the 109 UCS tests reported in Mine Advice 2016a and published relationships between E and UCS for Hawkesbury Sandstone (Pells 2004). The reported UCS values range from 9.4 MPa to 101 MPa with an average value of 43 MPa. Applying the average UCS value to Figure 3.10 returns an E range of just below 9 GPa to just above 20 GPa, which is entirely consistent with the numerical modelling assumptions used.

  A final point that needs to be made is that as discussed in Mine Advice 2018, E and t for the overburden are to some degree interchangeable, in that "*the influence of overburden properties E and t on overburden stiffness is multiplicative. This means that a model using E = 10 GPa and t = 20 m will return the exact same results as a model using E = 5 GPa and t = 40 m*". Therefore, if the assumed E values used in the Berrima back-analysis were significantly in error, the back-analysed value of t would directly compensate for this.

  Based on the above arguments, the proponent sees no need or benefit from collecting further borecore for Young's Modulus testing and conducting further numerical modelling runs on the basis of concern that the values used to-date are insufficiently comprehensive for EIS purposes.

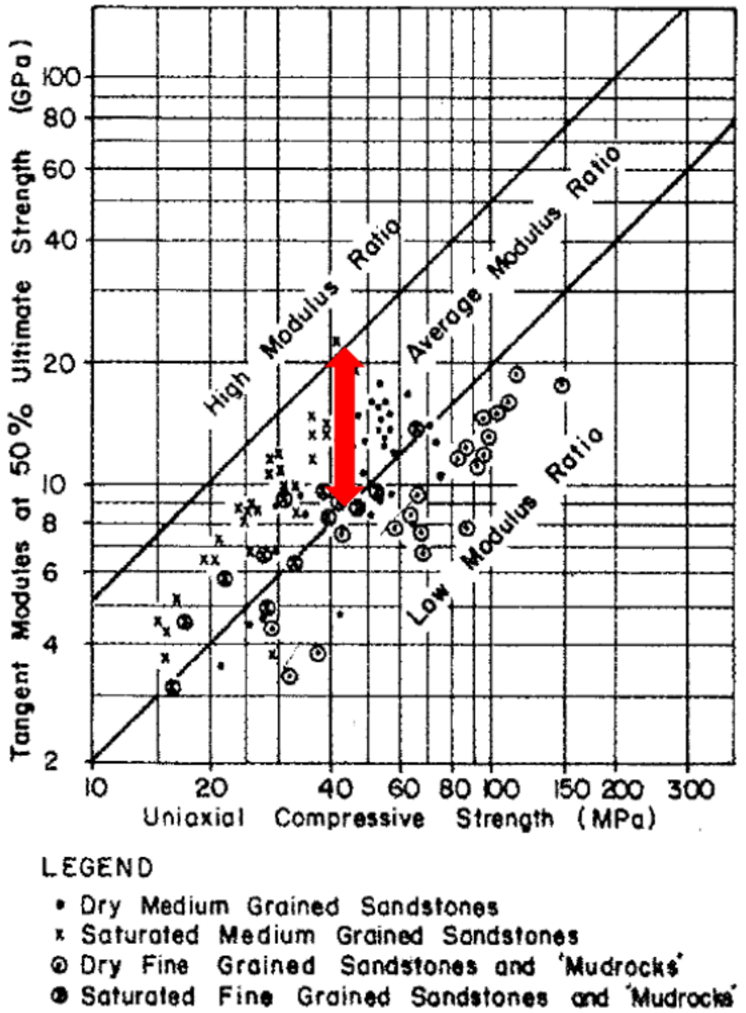

FIGURE 3.10. Data from Robson 1978, as Reported by Pells 2004.

The final section of **Canbulat 2018** provides comments and questions relating to the contents of **Mine Advice 2018**, which are now addressed where a specific concern has been raised that has not been addressed elsewhere in the report.

- Uncertainty as to the Berrima back-analysis has been raised on the basis of the potential presence of vertical joints in the overburden, to the point that "*In my opinion, significant vertical discontinuities present uncertainty and are residual risks and their existence should therefore be considered in any given layout. It is unknown if the Berrima panel(s) contained any significant vertical discontinuities. Thus, the appropriateness of the back analysis is unknown regarding the vertical discontinuities*".

  This entire issue was addressed in detail in **Mine Advice 2018** on the basis that vertical joints were omni-present within the overburden, the controlling influence on vertical joint stability and hence overburden stability, being horizontal stress. Furthermore, it was also confirmed that due to the very low predicted levels of overburden settlement due to mining, the impact on horizontal stress magnitudes would inevitably be minimal (which also directly impacts vertical conductivity of the overburden), such that joint condition should not materially change. It would have been far more instructive had the reviewer outlined any technical flaws in the arguments presented in Mine Advice 2018 than simply state the presence of unresolved uncertainty in terms of the influence of vertical joints and in doing so, bring the Berrima back-analysis into apparent question.

- Any concern over the use of ARMPS-HWM-defined web pillar SF values for long-term stability will be addressed in the Section 4 of this report, where a further detailed technical summary of the various empirical and numerical modelling outcomes will be provided, outlining ALL of the design parameters that are relevant to remnant mine stability, rather than continuing to focus on web pillar SF or FoS values in isolation.

- The following statement is made by the reviewer:

  "*P30 Smax=23.5mm in the panel failure case: I agree fully with the statement that the surface subsidence of 20mm or 23.5mm will not be substantial. However, it needs to be appreciated that if the web-pillars in one panel fail, there is a high likelihood that the web-pillars in adjacent panels will also fail. This will result in more loads on barrier pillars, which will result in more surface subsidence than 23.5mm*".

  As stated previously, the scenario models that the reviewer refers to were not intended to be credible predictions of the likely outcomes should web pillars fail, as by removing all of the web pillars, no coal was left in place. As discussed by GAPL 2018, such remnant broken coal will remain in place and so act in some way to mitigate the consequences of pillar failure. The primary reason for conducting these scenario models was to demonstrate that detailed technical arguments as to pillar constitutive laws and design SF values for web pillars were largely irrelevant and meaningless, as the overall layout design relied far more on the stability of barrier pillars than web pillars for surface protection.

- The following statement is made by the reviewer:

  "*Section 4 Displacement-based stability criteria: I agree with Dr Hebblewhite's view that this section presents a detailed technical discussion. I also believe that it exceeds Professor Brown's anticipated response, which he envisaged at the experts meeting. A detailed review of this section will take a significant amount time and resources, requiring detailed data from every single panel referenced in this section. I am not confident if it will add any benefit to the Hume Coal design*".

  The author did not pre-empt what Emeritus Professor Brown's anticipated response might be, other than picking-up on his stated view as raised by Emeritus Professor Galvin, that displacement-based rather than load-based stability criteria may be of benefit in evaluating mine stability supported with coal pillars. It is accepted that a detailed review may take significant time and resources if there is a need to obtain detailed data from every single panel referenced in the section. In effect the reviewer is suggesting that there is a need to review in great detail all of the case histories in the supporting databases for such empirical methods as the UNSW PDP, ARMPS-HWM, ARMPS and a host of others as well, before they can be used with confidence. Unfortunately detailed case histories that were used to formulate the UNSW PDP are unavailable.

The analysis presented by Mine Advice 2018 simply demonstrates based on published measurement data from a wide range of sources, that the predicted post-mining overburden settlements at Hume are a fraction of those that are known to be required before mass instability of the overburden commences at surface. In the context of the role of overburden stiffness and stability being an integral part of web pillar design (which has caused so much concern to be raised by the two independent experts), demonstrating the typical level of post-mining overburden stability between barriers should logically be of great assistance to the reviewers. For the reviewer to offer no opinion on this aspect as to its technical merits, but seemingly have sufficient knowledge to be prepared to dismiss its likely value, would appear to be contradictory.

4.0 UPDATED SUMMARY FOLLOWING REVIEW OF THE EXPERT REPORTS

Having reviewed both independent expert reports that were included in DP and E 2018, there are no issues identified that cause Mine Advice to change its view that the proposed mine layout design guidelines are fit for purpose, in that they are suitably conservative and reliable in relation to both mitigating long-term environmental impacts and mine safety during operations. This final section of the report will present the various reasons and arguments as to why Mine Advice still believe this to be the case.

On the basis that both reviewers appear to remain unconvinced as to the likely stability of web pillars post-mining due to their low w/h ratio and the associated FoS values under FTA loading, a further analysis will now be conducted aimed at demonstrating that the likely *in situ* values are substantially higher than those either quoted in Mine Advice 2016b under the design assumption at that time of FTA loading, or as part of analyses conducted by the reviewers. The aim of this is to demonstrate that the concern expressed by both reviewers as to whether the web pillars may yield or not, is substantially less significant than inferred by a FTA loading assessment.

There appears to be good agreement between the various parties that the Ground Reaction Curve (GRC) concept is useful, hence GRC representations will be developed for both the 80 m and 160 m deep designs to assist in providing all parties with a similar understanding of likely remnant mine stability.

The GRC concept (Figure 4.1) was originally developed in the early 1960's to assist tunnellers ensure that permanent, and often, stiff permanent tunnel linings were not damaged by excessive ground strains. This has since been applied by others to coal mining problems, such as tailgate standing support design and longwall shield design.

The ground curve (ABCD in Figure 4.1) contains a section of negative slope (ABC) initially whereby the overburden strata is incrementally losing its natural stability as a direct result of increasing vertical movement, followed by a section of positive slope (CD) whereby natural overburden stability has effectively been lost, with self-weight or dead-loading of kinematically unstable material then dominating overburden behaviour. The support response curve (PQR) contains an initially elastic response followed by some form of post-peak response to R. System equilibrium is achieved at point Q where the required support pressure to a certain contain convergence level, is generated by the support at that particular convergence level.

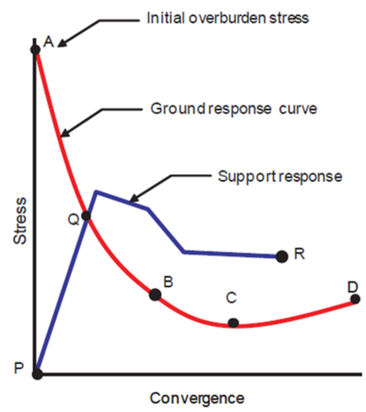

FIGURE 4.1. Generic Ground Reaction Curve (GRC) Representation

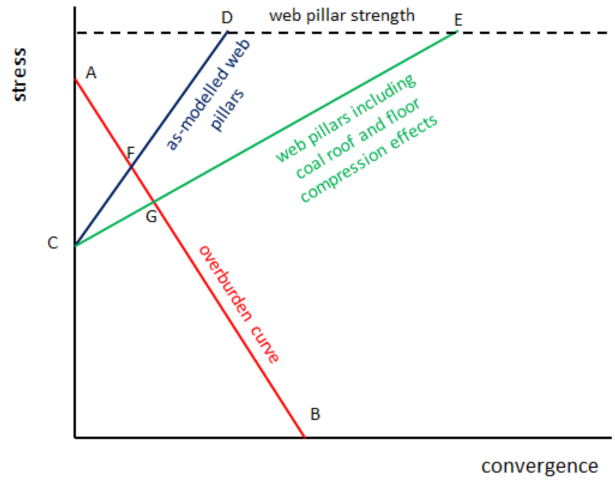

FIGURE 4.2. Schematic of GRC Representation Used

Figure 4.2 shows how a ground curve and pillar curve in this instance will be constructed from the available information, the following points of explanation being provided:

- Point A: tributary area stress on the centre web pillar.
- Point B: surface settlement in the centre of the web pillar compartment with all web pillars removed.
- Point C: *in situ* vertical stress acting on web pillars prior to mining
- Point D: overburden settlement required to drive the pillar to its peak strength (high stiffness roof and floor strata as assumed in LaModel)
- Point E: overburden settlement required to drive the pillar to its peak strength (low stiffness roof and floor strata consisting of defined thicknesses of coal)
- Points F and G: equilibrium conditions
- Line CD: stress-displacement response of a web pillar, pillar stiffness being based solely on an assumed E for coal of 2 GPa.
- Line CE: stress-displacement response of a web pillar, with pillar, roof and floor stiffness being based on an assumed E for coal of 2 GPa roof coal thickness of 3 m and floor coal thickness of 0.5 m, as per Mine Advice 2016a.
- Web pillar strengths have been assigned using the UNSW PDP Rectangular Power formula, as referred to by GAPL 2018 when raising the question as to web pillar probability of failure.
- The representation is for the centre web pillar only, the flanking web pillars inevitably being more stable than the centre pillar by virtue of being located closer to the adjacent intra-panel barriers within an otherwise sub-critical span.

It is noted that as system equilibrium is likely to occur before either the pillars or overburden exceed their elastic range, linear elastic parameters will be used, this assumption being further tested based on the analysis outcomes in terms of the indicated condition of both pillars and overburden at equilibrium.

Most of the defined points within Figure 4.2 are self-explanatory and do not require explanation herein, however Point B and the derivation of the Line C to E necessitate further discussion.

Point B is defined as the level of surface settlement that will occur if the vertical stress applied to the overburden by the web pillars is zero. Fortunately, LaModel was run for cover depths of 80 m and 160 m with all web pillars removed from the model, this being an exact simulation of this condition. Therefore the returned values of S_{max} from each model will be used to fully define Point B.

Mine Advice 2016a provided details as to how surface settlements related to pillar, roof and floor compression were to be calculated, Mine Advice 2018 noting that it was only the coal pillar that was included in LaModel for the reason that the model could not include such detailed near-seam lithology. However in reality, it is actually beneficial to include the influence of lower stiffness (E) roof and floor strata in a GRC analysis, as it tends to reduce the stiffness response of the pillar to vertical compression, thereby resulting in system equilibrium being achieved at a lower level of pillar stress than with a stiffer pillar response. The same method of calculating roof, pillar and floor compression for any defined pillar stress level will be used herein, as that outlined in Mine Advice 2016a.

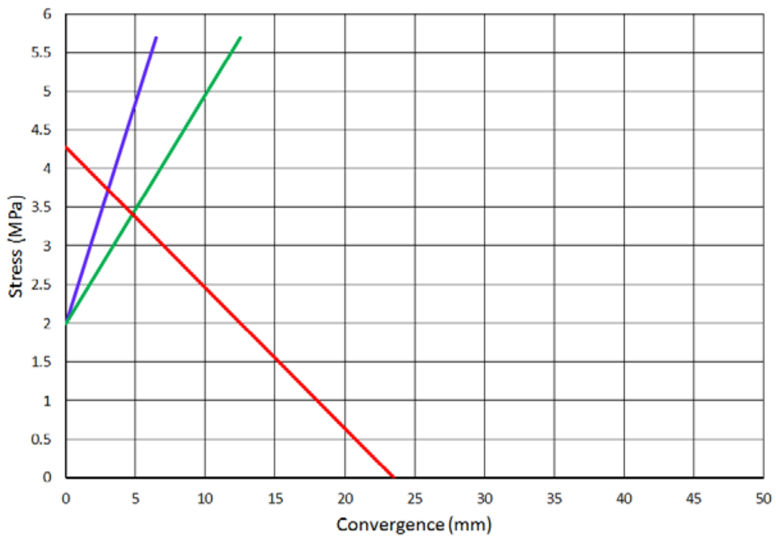

FIGURE 4.3. GRC Representation for 80 m Depth Layout Using UNSW PDP Strength Equation

Figure 4.3 shows the specific GRC curves for the 80 m depth layout based on the general representation of Figure 4.2. On the basis that the pillar curve that includes roof and floor compression effects (green line) is the most representative of actual conditions, it is found that at equilibrium (point G), surface settlement or overburden convergence is some 5 mm with the associated web pillar stress being 3.5 MPa, such web pillar loading being of lower magnitude than that indicated in the LaModel results due to the non-inclusion of coal roof and floor in those models.

It is noted that for the pillar only case, the equilibrium convergence is in the order of 3 mm whereas LaModel gave predictions in the range 2.1 mm to 2.4 mm, this variation relating to changing assumed overburden conditions.

With an equilibrium web pillar stress of 3.5 MPa and a web pillar strength of 5.69 MPa, the UNSW PDP FoS is found to be 1.63, this being exactly as per a PoF of 1 in 1000. However, when it is remembered that this only applies to the centre web pillar, it is self-evident that the PoF for the system of web pillars as a compartment between barriers, is less than 1 in 1000.

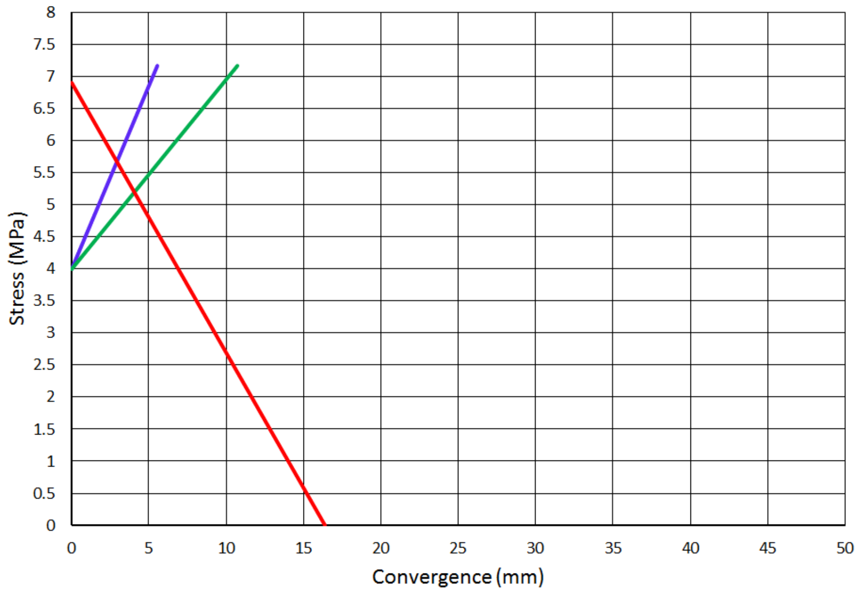

FIGURE 4.4. GRC Representation for 160 m Depth Layout Using UNSW PDP Strength Equation

Figure 4.4 shows the specific GRC curves for the 160 m depth layout, again based on the general representation of Figure 4.2. It is found that at equilibrium (point G), surface settlement or overburden convergence is some 4 mm with the associated web pillar stress being 5.2 MPa, this again being of lower magnitude than that indicated in the LaModel results due to the non-inclusion of coal roof and floor in those models.

With an equilibrium web pillar stress of 5.2 MPa and a web pillar strength of 7.16 MPa, the UNSW PDP FoS is found to be 1.38, this having a PoF in the order of 2 in 100. Again, when it is remembered that this only applies to the centre web pillar, it is self-evident that the PoF for the system of web pillars within a compartment between barriers, is somewhat less than 2 in 100. Critically, as will be discussed later in this section of the report, in understanding the probability for web pillar failure the W/H ratio of the web pillar compartment also needs equal if not greater consideration, which at a depth of 160 m is only 0.32, this being a factor of 3 times less than the commonly used minimum W/H of 1 for the onset of FTA loading to surface.

It is noted that for the pillar only case, the equilibrium convergence is in the order of 4 mm whereas LaModel gave predictions in the range 3.7 mm to 4.2 mm, this variation again relating to the assumed overburden conditions.

With these GRC outcomes to-hand, a final overall summary can now be given justifying the credibility of the proponents position in asserting that the proposed EIS mine layout designs are fit for purpose, in that they are suitably conservative and reliable in relation to both mitigating long-term environmental impacts following the completion of mining activities and safety risks during mining operations.

In summarising the design outcomes and their implications in terms of the requirements of the EIS and associated peer review process that has been conducted by the two independent experts, it is firstly necessary to succinctly state the objectives and associated limitations of a mine layout design process at this stage of mine development, this context being critical when considering the suitability of the design outcomes.

All geotechnical design in underground coal mining, regardless of the risk being designed against, should cater for two distinct elements:

1. Pre-mining designs based on what may be termed as normal or typical geological/geotechnical conditions.

2. The operational management of those risks that cannot be quantified prior to mining, usually in the form of unknown or inadequately defined geotechnical conditions.

By definition, being able to successfully use element 2. during operations, requires that the manifestation of residual risks is sufficiently slow to allow operators to both identify and respond accordingly, this including both the occurrence of unexpected conditions associated with a fully formed-up design and the identification of significant geological anomalies that may render a proposed design as ineffective, the operational response being to then modify the design to be implemented, either in terms of the mine workings or artificial controls such as ground support. This process is known more generally as “strata management” and has been endemic to the Australian coal industry via a formalised system for around two decades.

With this in mind, it is stated that the mine layout designs proposed by Hume have been developed with these two distinct aspects in mind, including the inevitable sources of uncertainty involved in the design process, either related to geotechnical characterisation or implementation during subsequent mining operations, the primary focus at the EIS stage inevitably having been the layout design and associated environmental impacts under typical geological/geotechnical conditions.

The mine layout designs as currently being proposed by Hume, have now been either designed or subsequently reviewed/tested by a range of methodologies, including:

- the ARMPS-HWM empirical method for the design of highwall mining layouts
- an assessment of individual coal pillars within the pillar system using the UNSW PDP strength equations
- 2D numerical modelling using LaModel
- 3D numerical modelling using LaModel
- a web pillar stability analysis under modified tributary area loading according to panel widths between intra-panel barriers using the UNSW PDP rectangular power strength formula
- a web pillar stability analysis using the Ground Reaction Curve method of analysis
- an assessment of post-mining overburden stability between barrier pillars using predicted overburden convergence against published case histories relating to measured surface conditions prior to known overburden collapses above standing mine workings.

The outcomes from each of the listed methods are summarised in **Table 4.1**, this then leading into a final holistic assessment of both remnant web pillar stability under assumed geological and geotechnical conditions, supplemented with operational management controls to effectively cater for residual risks that cannot be accounted for at the pre-mining design stage.

Stability Indicator	H = 80 m	H = 160 m
web pillar width (m)	3.5	5.5
web pillar w/h ratio	1	1.57
intra-panel barrier width (m)	14	20.9
barrier pillar w/h ratio	4	5.97
web pillar compartment span (m)	56.5	51.5
web pillar compartment w/h ratio	0.71	0.32
ARMPS-HWM SF web pillars under FTA Loading (design assumption)	1.68	1.31
ARMPS-HWM SF barrier pillars under FTA Loading plus Double Abutment Loading (design assumption)	2.69	2
ARMPS-HWM System SF	2.95	2.56
UNSW PDP web pillar FoS under FTA Loading	1.33	1.04
UNSW PDP barrier pillar FoS under FTA Loading	4.95	3.94
ARMPS SF web pillars under modified tributary area loading based on panel span	2.38	3.72
UNSW PDP web pillar FoS under modified tributary area loading based on panel span	1.86	2.91
UNSW PDP at GRC Equilibrium Point	1.63	1.38
Overburden Convergence at GRC Equilibrium Point	5	4
Overburden Convergence Safety Factor (using an assumed critical convergence of no less than 100 mm)	20	25

Note: figures in red are linked to ARMPS-HWM, those in blue to the UNSW PDP considering pillars in isolation, those in green to modified tributary area loading of web pillars due to the span between barriers, and those in brown to the GRC analysis which includes certain numerical modelling outcomes.

TABLE 4.1. Summary of Relevant Web Pillar Stability Indicators, EIS Layout, Hume Project

The contents of Table 4.1 allow the following summary points to be made:

(i) the initial ARMPS-HWM designs (in red) were fully compliant with the requirements of this experience-based design method, and included several deliberately included or inevitable sources of design conservatism over and above the returned values of SF and w/h (e.g. setting minimum web pillar w/h = 1, setting minimum barrier pillar w/h = 4, limiting spans between barriers to 60 m, recognising that planned drive lengths were substantially < than in HWM, recognising the significant stabilising influence of the absence of an open cut highwall in the underground environment).

(ii) the application of the UNSW PDP strength equations to web pillars and intra-panel barriers individually (in blue), returned highly stable barrier pillars, but raised questions as to the likely stability of the web pillars due to the low FoS values returned under FTA loading to surface. In the absence of any ability to readily modify the loading of web pillars to account for the restricted spans between barrier pillars, this uncertainty drove the need to conduct more detailed modelling studies where the stabilising influence of both the overburden and the third-dimension could be brought into the stability analyses.

(iii) the numerical modelling studies were conducted by a world leading expert in the field and the main developer of the LaModel modelling package. This approach is judged to be fully consistent with world's best practice in terms of the use of numerical modelling in evaluating the stability of bord and pillar type mine layouts. The overburden characterisation used in the models was based on a back-analysis of known outcomes at the adjacent Berrima Mine, the modelling outcomes being fully consistent with the original ARMPS-HWM layout designs in terms of the overall interpretation of remnant mine stability. There was no identified need to modify the proposed mine layout to cater for any concerns over pillar loading distributions that emanated from the modelling runs.

(iv) an evaluation of web pillar stability in isolation from barrier pillars under modified tributary area loading according to the panel width between barriers and a W/H ratio of 1 defining the lower limit of super-critical or unstable overburden behaviour (in green), returned ARMPS SF values in excess of 2, thereby complying with the suggested "*prevention*" approach to massive pillar collapses outlined by Mark ***et al*** 1997, and web pillar FoS values in excess of 1.63, resulting in probabilities of failure under the UNSW PDP that are substantially < 1 in 1000.

(v) the stability assessment of centre web pillars using a Ground Reaction Curve approach (in brown), returned individual PoF values of 1 in 1000 at 80 m cover depth (FoS = 1.63) and 2 in 100 at 160 m depth (FoS = 1.38). When these outcomes for the centre web pillar are expanded to all of the web pillars within a web pillar compartment in order to generate a PoF for the web pillar "system", it is inevitable that the resultant PoF values are < 1 in 1000 given the substantial stabilising influence of intra-panel barriers on the remaining web pillars.

(vi) an overall system stability assessment using a Ground Reaction Curve approach (in brown), confirmed that at the point that equilibrium is achieved between the overburden and web pillars, the overburden between barriers is retained in a highly stable state, with SF values relating to predicted overburden movements as compared to critical overburden movements whereby overburden instability and collapse becomes likely, being in the range of 20 to 25.

The stability of the overburden above the web pillars, which is in fact the critical EIS and operational safety consideration, can be summarised from the GRC analysis as a combined function of (a) the stability of the overburden between the intra-panel barrier pillars and (b) the web pillars themselves. The two aspects are inter-related in that the web pillars act to reinforce and so stabilise the overburden via its own self-supporting ability, and the level of stability in the overburden acts to protect the web pillars from excessive vertical compression levels that could otherwise drive them to yield and eventual collapse. When the level of overburden stability is combined with web pillar system stability, it is inevitably concluded that the proposed layout designs meet the previously stated design criterion:

> *"they are fit for purpose in that they are suitably conservative and reliable in relation to both mitigating environmental impacts and mine safety during operations"*

More to the point, the mine stability indicators that have been returned by these analyses are of the same order as would be applied to bord and pillar workings, albeit using a different pillar and roadway layout. This therefore addresses the need for previously worked areas of the mine to be accessed by persons for reasons of inspection and rejects emplacement.

With this outcome to hand, the final requirement is to provide high level commentary as to operational management processes.

Both the initial layout design process conducted as part of the EIS submission and subsequent review process, have highlighted a number of concerns that need to be included within the operational management process as part of ensuring that the intent of the mine layout design is always achieved in practice. Whilst it is inappropriate to develop an actual operational management plan and process at this stage of mine development due to the need to base it on a collaborative risk assessment process, key issues can at least be listed for completeness, as follows:

(a) ensuring that web pillar compartments are not directly influenced by major geological structures such as faults and dykes, this being due to the de-stabilising influence they can have on both coal pillars and in particular, the stability of the overburden.

(b) mapping of mine workings to identify such structures before the commencement of forming plunges in a given area, and potentially modifying the plunge layout to accommodate the presence of anomalous geological conditions.

(c) developing monitoring schemes that allow actual remnant mine stability to be tracked post-mining for both environmental impact and mine safety reasons. The current base-line surveys being conducted using GPS surveys is very encouraging in this regard.

(d) using best practice in terms of CM guidance during plunge formation, accepting that the major control of any impact of off-line drivage on stability, is limiting the number of drives between barriers so that irrespective of any off-line drivage, maximum coal recovery within any one web pillar compartment remains unchanged.

(e) the general requirements of operational strata management also apply, albeit that they are more focused on the safety of the mine workings in terms of changing conditions over time, which in itself may be used as a monitoring scheme for the stability of the overburden in already mined-out areas whilst ever access is available.

The final comment is a response to a statement made by Van Der Merwe 1999 when discussing the application of a Quadrant II mine design, as contained in Figure 2.2:

> "*In Quadrant II the overburden is stable, although the pillars are unable to support the full weight of the overburden. This is potentially the most dangerous situation because there could be a false impression of stability when the OSR is not much greater than 1. The pillars will be stable for as long as the overburden remains intact; however the moment the overburden fails, the pillars will also fail. This may occur because of time-related strength decay of the stressed overburden, or when mining progresses into an area with an unfavourably oriented unseen joint set in the overburden. The closer the OSR is to 1, the more dangerous the situation".*

This statement by another of the world experts in the subject of pillar design and remnant mine stability, is fully encapsulated in both the understanding of the proponent from the outset of the need to adopt a cautious approach to the design of the mine layout, and in particular the need to focus on stabilising the overburden by means other than the web pillars in isolation. The combined effect of the restricted spans between intra-panel barriers, the high stability of said barriers and the typical lithology of the overburden, is one of a highly stable overburden above web pillar compartments with a displacement-based Safety Factor against overburden instability in excess of 20. This is by far the most meaningful indication as to the level of design conservatism that is included within the proposed mine layouts at Hume, with the experts' technical debate in regards to web pillar stability being somewhat secondary in the overall scheme of things.

5.0 REFERENCES

Bieniawski, Z. T. (1983). New Design Approach for Room-and-Pillar Coal Mines in the U.S.A. Paper Presented at the 5th Congress Int. Soc. Rock Mech., Melbourne, E27-E36. Balkema.

Canbulat, I. (2010). Life of Coal Pillars and Design Considerations. Proc. 2nd Ground Control Conference, Sydney, pp 57-66.

Canbulat, I. (2017). Review of the Mine Plan and the Subsidence Risks Associated with the Proposed Mine Plan – Hume Project. Report prepared for NSW Department Of Planning And Environment, Report No. DPE/2017-1.

Canbulat, I. (2018). Response to “Responses to reviews of the Hume Coal Project by Galvin and Associates, and Professor Ismet Canbulat”. Report prepared for NSW Department Of Planning And Environment, Report No. DPE-HUME-2018-2.

Colwell, M. Frith, R. (2009). ALTS 2009 – A 10 Year Journey. Proceedings of the 9th Underground Coal Operator’s Conference, Wollongong NSW, pp. 37-53.

Colwell, M. Frith, R. (2010). AMCMRR – An Analytical Model for Coal Mine Roof Reinforcement. Proceedings of The Coal Operators Conference, University of Wollongong, pp 73-83.

Colwell, M. Frith, R. (2012). Analysis and Design of Faceroad Roof Support (ADFRS). Final Report to ACARP, Project C19008.

DP and E (2018). Hume Coal Project and Berrima Rail Project – Assessment Report.

Ditton, S. and Frith, R. (2003). Influence of Overburden Lithology on Subsidence and Sub-Surface Fracturing on Groundwater. Final Project Report. Brisbane, Queensland: ACARP Project C10023.

Ditton Geotechnical Services (2010). Subsidence Predictions and General Impact Assessment of the Proposed SW 1, 406 and 59 Pillar Extraction Panels, Berrima Colliery . Consulting report to Boral Cement.

Frith, R. Reed, G. (2017). Coal Pillar Design When Considered a Reinforcement Problem Rather Than a Suspension Problem. Proceedings of 36th ICGCM, Morgantown, West Virginia.

Frith, R. Reed, G. (2018). The Limitations and Potential Design Risks When Applying Empirically-Derived Coal Pillar Strength Equations to Real-Life Mine Stability Problems. Proceedings of 37th ICGCM, Morgantown, West Virginia.

Galvin, J.M., Hebblewhite, B.K. Salamon, M.D.G. (1999). University of New South Wales Coal Pillar Strength Determinations for Australian and South African Mining Conditions. Proceedings of the Second International Workshop on Coal Pillar Mechanics and Design. NIOSH Information Circular 9448, pp. 63-72.

Galvin, J.M. (2006). Considerations Associated with the Application of the UNSW and Other Pillar Design Formulae. Proceedings of the 41st US Symposium on Rock Mechanics, Golden, Colorado.

Galvin, J. (2016). Ground Engineering: Principles and Practices for Underground Coal Mining. Switzerland: Springer International Publishing, pp. 684.

Galvin and Associates. (2017). Independent Assessment: Hume Coal Project. Report prepared for NSW Department of Planning and Environment, Report No. 1716-12/1b.

Galvin and Associates. (2018). Supplementary Report - Independent Assessment: Hume Coal Project. Report prepared for NSW Department of Planning and Environment, Report No. 1716-12/2b.

Heasley, K. (2018). Pillar Design Analysis Using LaModel. Commercial consulting report to Mine Advice.

Hill, D. (2005). Coal Pillar Design Criteria for Surface Protection. Proceedings COAL 2005, Brisbane, QLD.

Hume Coal (2018). Response to Reviews of the Hume Coal Project by Galvin and Associates, and Professor Ismet Canbulat.

Mark, C. Chase, F. Zipf, K. (1997). Preventing Massive Pillar Collapses in Coal Mines. Proceedings of the New Technology for Coal Mine Ground Control in Retreat Mining, NIOSH IC 9446, pp. 35 - 48.

Mark, C. (1999). The State-of-the-Art in Coal Pillar Design. SME Transactions 308:8.

Mark, C. (2006). The Evolution of Intelligent Coal Pillar Design: 1981 – 2006. Proceedings of the 25th International Conference on Ground Control in Mining. Morgantown, WV: West Virginia University.

Mark, C. (2010). Pillar Design for Deep Cover Retreat Mining: ARMPS Version 6 (2010). 3rd International Workshop on Coal Pillar Mechanics and Design, University of West Virginia.

Mark C, Gauna M, Cybulski J, Carabin G (2011). Application of ARMPS (Version 6) to Practical Pillar Design Problems. Proceedings of the 30th International Conference on Ground Control in Mining. Morgantown, WV: West Virginia University.

Mills, K. Waddington, A. Holla, L. (2009). Subsidence Engineering. Australasian Coal Mining Practice, 3rd Edition, Monograph Series No. 12, Chapter 37.

Mine Advice (2016a). Environmental Impact Statement Subsidence Assessment. Report to Hume Coal, Report No. EMM01/2.

Mine Advice (2016b). Mine Design Justification Report, Hume Project. Report to Hume Coal, Report No. HUME12/2.

Mine Advice (2018). Interpretation of the Numerical Modelling Study of the Proposed Hume Project EIS Mine Layout. Report to Hume Coal, Report No. HUME22/1.

NIOSH (2012). Analysis of Retreat Mining Pillar Stability – Highwall Mining (ARMPS-HWM). User Manual for ARMPS-HWM software version 1.3.

Pells, P. (2004). Substance and Mass Properties for the Design of Engineering Structures in the Hawkesbury Sandstone. Australian Geomechanics, Vol. 39, No.3, September.

Reed G, McTyer K, Frith R (2016). An assessment of Coal Pillar System Stability Criteria Based on a Mechanistic Evaluation of the Interaction Between Coal Pillars and the Overburden. International Journal of Mining Science and Technology 2016;27(1): 9–15.

Salamon, M. D. G and Munro, A. H. (1967). A Study of the Strength of Coal Pillars. Journal of the Southern African Institute of Mining and Metallurgy 68: 56–67.

UNSW (2010). Strata Control Graduate Diploma Course Notes.

Van Der Merwe, J. N. (1999). The Role of Overburden Integrity in Pillar Failure. 2nd International Workshop on Coal Pillar Mechanics and Design, University of West Virginia.

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21st January 2019

Attn: Mr Alex Pauza
Manager, Mine Planning
Hume Coal Project

Report No. 1509/02.6

Re: Summary Independent Review:

NSW Government Department of Planning & Environment – State Significant Development Assessment: Hume Coal Project and Berrima Rail Project

I have been asked to provide an independent review of the above Assessment Report prepared by the Department of Planning & Environment (DPE) and released in December 2018. My review comments are focused on the Hume Coal Project specifically and are offered in the context of my mining engineering and related geotechnical engineering expertise. A copy of my summary CV, outlining my professional experience and expertise, is contained in Appendix A of this report.

I offer the following summary comments on the report which was provided to me in December 2018. Comments are provided in sequential order of issues as they appear in the report, and so do not indicate any relative priority or level of importance. A number of issues raised in the Executive Summary of the Assessment report warrant comment, however these have been dealt with in the sequence in which the issues also appear in the body of the Assessment Report. I will revert to any outstanding issues covered by the Executive Summary at the end of my review, if they have not already been adequately addressed by the review of the main body of the Assessment.

I will now proceed to offer specific comments, working through the report, with particular attention given to *Section 6: Assessment*, making reference to section headings, page numbers and paragraphs, where appropriate.

<u>Section 5.4: Key Issues – Government Agencies (p15)</u>

- Reference is made to the response from the Resource Regulator, who *"noted that the mining method is untested and has residual concerns about mine worker safety. It confirmed that the mining method represents secondary extraction, which means the proposed mining is subject to High Risk Activity notification process…"*. There are a number of points made here that should be discussed:

    - <u>The method is untested</u>: This statement is correct, taking the complete configuration and planned operational practice of the method. However, a number of the key individual elements of the method have been used in other mining systems in NSW and elsewhere, including the use of narrow pillars (fenders in pillar extraction, web pillars in highwall mining or yield pillars adjacent to longwall installation roads, for example). The fact that a method in totality has not been tested previously is not a reason to reject it. What is important is that appropriate risk-based management practices are set in place, as in any responsible new mining operation, to ensure that a safe workplace is provided and maintained in the context of all potential risk factors present.

    - <u>The mining method represents secondary extraction</u>: This assertion or interpretation is challenged as being inappropriate. Underground coal mining can be divided into primary development or first workings, and secondary extraction. Secondary extraction is a term that has been used in the coal mining industry for many decades, to refer to the process of removal of solid regions of coal, AFTER the main roadway development has been completed. It is usually mined in a different manner, involving more than straight roadway drivage and is usually mined on the retreat. The main examples of secondary extraction are partial or total pillar extraction (by various methods); and longwall mining.

      In the case of the pine feather method, each production panel is mined by development of roadways during the development process. It does not involve any subsequent extraction of pillars or solid blocks of coal and is therefore considered to constitute first workings, as opposed to secondary extraction.

      A recent (March 2018) review of relevant NSW legislation made some changes to the definition and examples of secondary extraction. It removed the process of "roadway widening beyond 5.5m width" from secondary extraction, for example, deeming it no longer requiring classification as a high-risk activity, but noting that it should be dealt with in the strata and ground control principal hazard management plan. It then defined or specified secondary extraction as including "pillar extraction, pillar splitting and pillar reduction". All of these example activities are clearly secondary mining activities involving removal of formed up blocks of coal conducted after the primary development and pillar system has been completed. The pine feather method does not fit within any of these stated examples. It is certainly the case that the design and management of the pine feather web pillars and production panels would be a critical part of the relevant strata and ground control principal hazard management plan.

- It is noted in this section that Subsidence Advisory NSW *"noted the worst-case subsidence predictions and considered that subsidence is unlikely to result in any impacts to surface* *infrastructure"*. This view is endorsed as appropriate and recognises that the proposed mining method is clearly minimalist in terms of surface impacts, when compared with other conventional underground mining systems of a similar level of extraction. Some additional useful information has recently been provided by Hume Coal based on current site surface subsidence monitoring stations. These confirm that the level of surface vertical movements due to natural climatic variation (rainfall or drought), with no mining present, can be of the order of at least 20mm. Recent results from the Site 3 monitoring are shown in Figure 1 below:

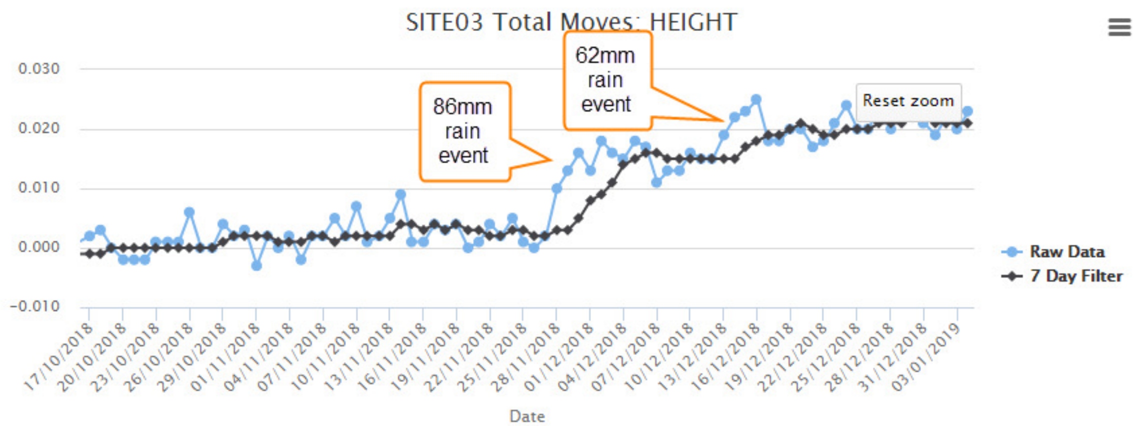

Figure 1. Hume Coal Site 3 – Vertical surface movement due to rainfall events

<u>Section 6: Assessment (p18 and following)</u>

- Section 6.2.3 Background (p19) – The statement that *"all underground mines have some level of impact on groundwater resources as the extraction of the coal seam leads to depressurisation and fracturing of the overlying strata"* is a very generalised statement that is challenged as being misleading, if not incorrect. Not all mines lead to fracturing of the overburden, and not all mining leads to depressurisation of the overlying strata. It is quite dependent on mining method, mine layout and overburden geology as to whether any fracturing occurs and whether any depressurisation occurs.

- Section 6.2.4 Methodology (p20) – It is claimed that *"understanding of the local geology has been a key criticism"* and that *"both of the independent experts on mine design raised concern about the lack of geological data, particularly in relation to the presence and nature of geological structures"*. I will leave it to Hume Coal to respond directly on this point – however I would comment that the amount of data provided was quite considerable, and certainly on a par with similar mining projects at this stage of evaluation and development. Clearly geological data and information continues to be gathered as a project proceeds, and detailed mine planning is modified as required to accommodate any new or additional information.

- Section 6.2.4 Methodology (pp20, 21) – It is noted that concerns have been raised about the *"level of uncertainty and sensitivity analyses"*. However, the report immediately proceeds to note that *"the Applicant has made considerable efforts to strengthen the uncertainty and sensitivity analyses in its groundwater impact assessment"* and then adds that Mr Middlemis notes that the Applicant's uncertainty and sensitivity analysis is *"consistent with latest best* *practice"*. Further comments about groundwater modelling and predictions are beyond the scope of my expertise and so no further comments are made.

- Section 6.3 Mine Design (p26 and following)

    - Section 6.3.2 Independent Review Process (p26) - The Department acknowledges that *"the issues relating to mine design, geotechnical modelling and safety are extremely complex"*. Certainly, the mine design and geotechnical modelling issues require a considerable level of detailed investigation, especially as a result of the truly three-dimensional nature of the geotechnical design concept and the innovative nature of the mining system. It is also not considered appropriate to consider the safety issue as complex.

    - P26 - Reference is made to criticism by the independent experts about the initial geotechnical model, and the subsequent recommendation that the Applicant prepare a 3D numerical model. This criticism should be seen in the correct context, where the Applicant had been working in a responsible, and incremental approach to modelling and mine design over a number of years. The initial geotechnical design work assessed by the experts was always acknowledged as a "work in progress". The Applicant did not wait for the independent experts to recommend a 3D modelling study. This topic had been under review for at least 12 months prior to the expert reports being produced, and the Applicant had made a decision, prior to receiving the expert reports, to proceed with commissioning a 3D modelling study.

    - P26 - In reference to the Joint Expert Meeting, it is stated by DPE that Emeritus Professor Ted Brown (who was chair and facilitator of the meeting for DPE held on 28 March 2018) is a highly regarded mining engineer from Queensland. This is incorrect. Professor Brown is not a mining engineer at all. He is a civil engineer with specialised experience and expertise in geotechnical engineering – the field where he is highly regarded internationally. By his own admission, he is not in any way an expert or experienced in underground coal mining.

    - P26 – DPE acknowledges that the Applicant's approach to 3D numerical modelling and its choice of experts were appropriate in the circumstances.

    - Section 6.3.3 Background (P27) – DPE acknowledges that the Applicant rigorously considered a wide range of potential mining methods prior to arriving at the pine feather mining method – with the objective of minimising mining impacts on the surface.

    - P27 – In discussion of the different types of pillars involved in the pine feather method (inter-panel pillars, intra-panel pillars and web pillars), the statement is made by DPE that *"the stability of each of these types of pillars and the overlying strata is fundamental to determining the safety of operations and potential subsidence at the surface"*. This statement is not correct and is also not supported by the reports and views of the DPE independent experts. The method is designed to rely on the integrated 3D distribution of overburden loading on the pillar system as a whole, such that even if local regions of web pillars yield or lose stability, the overall impact on the overburden and surface will be negligible. Whilst such loss of stability is not expected, the design has incorporated sufficient regional load-bearing capacity to be capable of adequately and safely responding to such a hypothetical situation. This hypothetical scenario was investigated in the 3D modelling study by deliberate removal of pillars and panels of web pillars. Total removal of web pillars is obviously an extreme worst-case situation. In reality, in the very unlikely event that a region of web pillars yielded, they will not shed their load completely but will continue to carry a proportion, albeit reduced component of overburden load.

The DPE minutes of the joint experts meeting on 28 March 2018 recorded the following points on this issue, supporting my comments above:

- *"The proposed web pillars and barrier pillars have been conservatively designed so that the pillars and overburden behave as a system.*
- *Localised yielding of a web pillar would not necessarily lead to global instability.*
- *The experts generally agree that the stability of the system as a whole is the key factor, not the strength of the web pillars.*
- *The experts generally agree that subsidence is likely to be negligible-minor and is not the key assessment issue.*
- *Even if all web pillars are artificially removed, the 3D model is likely to predict that the change in subsidence would be very minor".*

- P28 – Reference is made to Professor Galvin's report which acknowledges two significant differences between the pine feather method and highwall mining, these being: the plunges are mined from a 5.5m wide underground roadway rather than a highwall; and they are mined at 70 degrees as opposed to right angles. He raises this latter point as a concern in relation to ability of forming each successive plunge at the correct separation distance from the previous one. In fact, it is reasonable to argue that in an underground environment, a turn-away at 70 degrees is much easier to carry out with precision and minimal floor disruption than a 90 degree turn.

- P29 – The issue of impoundment of water using bulkheads underground is a critical one for this mining system. It is agreed that if not carried out correctly, could raise serious safety implications. It is for this reason that bulkhead design and bulkhead placement is a critical issue that is already being addressed by Hume Coal as an integral part of the mine design and future operational risk management strategy. Whether the proposed practice is either "conventional" or common practice or not, is not directly relevant, provided appropriate engineering design and management strategies are adopted. Further discussion on underground water storage and bulkheads is left to Hume Coal and other experts to comment on.

- Section 6.3.4 Methodology (pp29, 30) – DPE makes the statement that the *"issues relating to this project's mine design present complex technical challenges that have resulted in substantial amount of disagreement between the relevant experts, particularly in relation to the geotechnical model"*. This statement is challenged as conveying an impression of disagreement on major or fundamental issues, whereas in fact, the overall principles of the geotechnical model, and the methodology adopted, in principle, were accepted with broad agreement by the experts. The only areas of disagreement are in a number of points of detail regarding specific pillar performance parameters which, at the end of the day were acknowledged by all as being of lesser consequence or significance.

DPE also comments on *"residual concerns about the adequacy of the baseline geological data and the level of risk assessment that has been undertaken"*. The issue of geological data has already been discussed. In regard to risk assessment, I can testify from first-hand involvement, that the project has involved extensive and multiple risk assessment processes leading up to the present design approach. Criticism of the level of risk assessment undertaken is therefore not considered to be justified.

DPE then proceeds to discuss specific pillar design approaches and failure criteria. This has been referenced above in relation to specific pillar performance parameters. The extent of pillar strength variations between use of different pillar strength criteria is not considered to be excessive, with all methods involving different levels of uncertainty and assumptions. It is not valid or appropriate to assume that one particular mainstream method is 100% accurate and any variation produced by other methods represents erroneous results.

Reference is also made to comments in both the Galvin and Canbulat reports about the lack of appropriate strain-softening criteria in the modelling work. However, as has been discussed in previous reports and in the outcomes of the Heasley 3D modelling analysis, the results produced from the modelling never reached a point where stresses exceeded peak strength values (at which point yielding and strain-softening behaviour may have initiated), and so this is an academic difference of opinion rather than one which is likely to result in any substantive changes in performance outcomes.

My opinion is that the issues discussed by DPE here as being matters of "substantial disagreement" may have a minor influence on design parameters but are not considered to result in any changes or issues of any substance, at this stage of the project. Clearly, as further experience develops and further geotechnical data becomes available, detailed mine design studies will continue and will be informed by further results, as is the case in any mining operation.

- P30 (Berrima case study) – Professor Canbulat refers to lack of detail about the Berrima case study that was used for initial calibration of the Heasley LaModel 3D modelling studies. He is quite correct in noting that the detail was not contained in the Heasley report. However, he has failed to acknowledge that full details of the Berrima data were presented to him and all participants of the joint expert meeting held on 28 March 2018, by Mr Alex Pauza from Hume Coal. There was considerable discussion of the Berrima data at that meeting. This included reference to data from both single and adjacent multiple panels. Once again, this is confirmed by the minutes of that meeting which include the following points of relevance:

  - *"The 3D model has been calibrated to Berrima Colliery data and then de-rated.*
  - *Based on Mr Pauza's presentation, the experts generally agree that the company's approach to the numerical modelling is appropriate and will assist the Department in its assessment process.*

- Pp30, 31 (Risk assessment) – This has already been discussed, however a further comment is attributed to Professor Galvin: *"many of the matters raised in the report* *could reasonably be expected to have been evaluated by the mine owner(s) in a risk assessment of the mining concept prior to deciding to lodge a Development Application"*. He is correct and this is exactly what took place – not just in one risk assessment, but in multiple risk assessments.

The discussion then returns to the question of whether the pine feather method is first or second workings, and the DPE links this issue to the detail of risk assessment information provided or required. I would argue that this linkage of issues is not valid. The level of risk assessment was quite comprehensive, regardless of the classification of the method. It is then stated that the Resource Regulator considers the method to be a variation of the Wongawilli pillar extraction method, and as such, is secondary extraction. Whilst this is a view formed by the Regulator, this interpretation is questioned. There is very little similarity between these methods. There is no open goaf edge involved, there is no extraction on the retreat, there is no deliberate creation of overburden failure in a goaf region – all of which are fundamental to Wongawilli pillar extraction.

- Section 6.3.5 Assessment (Pp31, 32) – The first point to note and support is the DPE acknowledgement that *"subsidence is not the key issue for this project"*. DPE then proceeds to note that the key issues relate to pillar stability risks and water impoundment issues. In relation to pillar stability risks, it has already been pointed out that apart from minor details of pillar performance criteria used (in a field which is not an exact science or where there is only one appropriate methodology), the role of the web pillars is not critical to the overall regional stability of the mine layout (this is confirmed by quotes from both Galvin and Canbulat).

  However, DPE then takes this argument further with the same incorrect assumption they have relied on earlier (p26), that being that they assume *"the proposed pine feather mining method relies on narrow "web pillars" (with very small width-to-height ratios) remaining stable in the long term*". This is simply not the case and has also been agreed to not be the case by both Galvin and Canbulat. The method certainly does not rely on long-term stability of these pillars.

  DPE take this erroneous argument further by claiming that such web pillar failures may pose a direct risk to worker health and safety as a result of roof falls and ground falls. If such falls were to occur in roadways between the web pillars, it is highly unlikely to impact on worker safety, since no personnel will be operating in such roadways at any time. In the unlikely event of a web pillar failure (or more likely, a pillar yield scenario), localised shallow roof falls may occur as in any underground mining, but in this method, there will be no personnel present in the immediate vicinity to be impacted by such a fall of ground.

  Discussion then turns to risks posed by geological structure such as cleating, especially when such structure is parallel to the rib line orientation of the web pillars. Rib falls could then compromise the pillar stability. This is a valid comment, but once again, it is no different to many other underground mining scenarios. It is the type of issue that can be dealt with in ongoing operational management and planning where individual panels can be modified – either in direction or web pillar width, to cope with such localised issues, if required. It is certainly not a project-stopping issue.

Similarly, the issues raised by Canbulat regarding ventilation, equipment entrapment and off-line cutting are all valid points that should be the focus of ongoing detailed planning and operational risk management.

Executive Summary

- As indicated at the start of this report, the technical mining and geotechnical points raised in the Executive Summary have largely been addressed in discussion of the contents of the body of the report, above. However, it is worth making some closing comments:

    - There is an over-arching question about the *"methodology underpinning the geotechnical model"*. Such criticism by DPE is simply unfounded and is not supported by the detailed commentary in the body of the report, as discussed above. Whilst there may be points of detail under question regarding aspects of the model, the fundamental principles of the modelling methodology have been supported by all experts. The minor points of detail under question are not considered to produce substantive changes to the modelling outcomes.

    - There are also multiple references by DPE to use of an unconventional mining system. This is correct. As acknowledged by DPE, this system has come about as a result of rigorous analysis by the Applicant to come up with a method that will result in minimal impact on the surface. The fact that it is unconventional, and there is no previous experience, does raise issues that require sound and diligent risk management approaches, but this should not be the basis for rejection of the method.

      The NSW underground coal industry has seen previous successful examples of new methods introduced under such strict but appropriate risk-based management regimes. Examples include the introduction of place-change mining at Myuna Colliery in the 1980s – the first use of such a system in Australia. Another example was the introduction of longwall top coal caving (LTCC) at Austar Mine in the early 2000s – the first adoption of this mining system outside China. More recently, the DPE has granted approval to the Wallarah 2 Coal Project (February 2014) which involves conventional longwall mining, but also incorporates underground stowage of brine in old mined out panels.

      Innovation in mining is an important feature that offers important opportunities for continuous improvement in mining performance standards in all respects – mine safety, environmental compliance and operational efficiency. It is critical that innovative approaches not be rejected simply on the basis that they are unconventional or untested.

I trust these review comments are of assistance to Hume Coal. Feel free to contact me if you have further questions.

Yours sincerely,

Bruce Hebblewhite

Disclaimer

Bruce Hebblewhite is employed as a Professor within the School of Minerals & Energy Resources Engineering, at The University of New South Wales (UNSW). In accordance with policy regulations of UNSW regarding external private consulting, it is recorded that this report has been prepared by the author in his private capacity as an independent consultant, and not as an employee of UNSW. The report does not necessarily reflect the views of UNSW and has not relied upon any resources of UNSW.

APPENDIX A

SUMMARY CURRICULUM VITAE

Bruce Kenneth Hebblewhite

(Professor, Chair of Mining Engineering),
School of Minerals & Energy Resources Engineering, The University of New South Wales, &
Consultant Mining Engineer

DATE OF BIRTH 1951

NATIONALITY Australian

QUALIFICATIONS

1973: Bachelor of Engineering (Mining) (Hons 1) School of Mining Engineering, Univ. of New South Wales

1977: Doctor of Philosophy, Department of Mining Engineering, University of Newcastle upon Tyne, UK
1991: Diploma AICD, University of New England

PROFESSIONAL MEMBERSHIPS; APPOINTMENTS; AWARDS & SPECIAL RESPONSIBILITIES

Member - Australasian Institute of Mining and Metallurgy
Member - Australian Geomechanics Society
Member – Society of Mining and Exploration Engineering (SME), USA
Member - International Society of Rock Mechanics (President – Mining Interest Group (2004 – 2011))
Member – Society of Mining Professors (SOMP)
Secretary-General and Councillor (SOMP (2011-2018)); SOMP President (2008/09)
Emeritus Member (SOMP) - from 2017
Executive Director – Mining Education Australia (July 2006 – December 2009)
Chair, Governing Board – Mining Education Australia (2015)
Member, Branch Committee – AusIMM Sydney Branch (2017-2019)

Expert Witness assisting Coroner: Coronial Inquest (2002-2003): 1999 Northparkes Mine Accident
Chair: 2007-2008 Independent Expert Panel of Review into Impact of Mining in the Southern Coalfield of NSW (Dept of Planning & Dept of Primary Industries)
Expert Witness assisting NSW Mines Safety Investigation Unit – Austar Mine double fatality, April 2014.
Member (2012 – present): Scientific Advisory Board, Advanced Mining Technology Center, Uni. of Chile.
Trustee (2013 – present): AusIMM Education Endowment Fund
2012 Syd S Peng Ground Control in Mining Award – by SME (USA).
2017 Ludwig Wilke Award for contribution to international mining research and education (Society of Mining Professors).
2017 SME Award for Rock Mechanics (presented at 2018 SME Annual Meeting in Minneapolis, USA in Feb 2018).

PROFESSIONAL EXPERIENCE

2014 – present	University of New South Wales, School of Minerals & Energy Resources Engineering (formerly School of Mining Engineering) Professor of Mining Engineering (p/t)
1995 - present	Principal Consultant - B K Hebblewhite, Consultant Mining Engineer
2003-2014	University of New South Wales, School of Mining Engineering Head of School and Research Director, (Professor, Kenneth Finlay Chair of Rock Mechanics (to 2006); Professor of Mining Engineering (from 2006))
2006 – 2009	Mining Education Australia (a national joint venture between UNSW, Curtin University of Technology, The University of Queensland & The University of Adelaide) Executive Director (a concurrent appointment with UNSW above).
1995-2002	University of New South Wales, School of Mining Engineering Professor, Kenneth Finlay Chair of Rock Mechanics and Research Director, UNSW Mining Research Centre (UMRC)
1983-1995	ACIRL Ltd, Divisional Manager, Mining - Overall management of ACIRL's mining activities. Responsible for technical and administrative management of ACIRL's Mining Division covering both research and consulting activities in all aspects of mining and coal preparation.
1981-1983	ACIRL Ltd, Manager, Mining - Responsibility for ACIRL mining research and commissioned contract programs.
1979-1981	ACIRL Ltd, Senior Mining Engineer - Assistant to Manager, Mining Research for administrative and technical responsibilities. Particularly, development of geotechnical activities in relation to mine design by underground, laboratory and numerical methods.
1977-1979	ACIRL Ltd, Mining Engineer Project Engineer for research into mining methods for Greta Seam, Ellalong Colliery, NSW. Also Project Engineer for roof control and numerical modelling stability investigations.
1974-1977	Cleveland Potash Ltd, Mining Engineer and Department of Mining Engineering, University of Newcastle-upon-Tyne, UK - Research Associate. Employed by Cleveland Potash Limited to conduct rock mechanics investigations into mine design for deep (1100m) potash mining, Boulby Mine, N Yorkshire (subject of Ph.D. thesis).

SPECIALIST SKILLS & INTERESTS

- Mining geomechanics
- Mine design and planning
- Mining methods and practice
- Mine safety and training
- Mine system audits and risk assessments
- Mining education and training

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