

Advice to decision maker on coal mining project

IESC 2020-119: Narrabri Underground Mine Stage 3 Extension Project (Narrabri Mine Extension) (State Ref No 9882) – Expansion

Requesting agencies	NSW Department of Planning, Industry and Environment (DPIE) and the Australian Government Department of Agriculture, Water and the Environment (DAWE)
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Advice stage	Assessment

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) provides independent, expert, scientific advice to the Australian and state government regulators on the potential impacts of coal seam gas and large coal mining proposals on water resources. The advice is designed to ensure that decisions by regulators on coal seam gas or large coal mining developments are informed by the best available science.

The IESC was requested by the Australian Government Department of Agriculture, Water and the Environment and the New South Wales Department of Planning, Industry and Environment to provide advice on the Narrabri Coal Operations Pty Ltd's (NCOPL) Narrabri Underground Mine Stage 3 Extension Project in NSW. This document provides the IESC's advice in response to the requesting agencies' questions. These questions are directed at matters specific to the project to be considered during the requesting agencies' assessment process. This advice draws upon the available assessment documentation, data and methodologies, together with the expert deliberations of the IESC, and is assessed against the IESC Information Guidelines (IESC, 2018).

Summary

The proposed Narrabri Underground Mine Stage 3 Extension Project (the project) is a longwall mining extension to the existing underground Narrabri Coal Mine, located in the Gunnedah Basin Coalfields of NSW. The project will produce 11 million tonnes per annum (Mtpa) of run-of-mine coal (a combination of thermal and pulverised coal injectate) and extend the mine's life from July 2031 to 2044. The proposal also includes expansion and upgrades of existing surface infrastructure.

The project is located within the Namoi Water Management Area, a region with one of the highest levels of groundwater extraction in the Murray-Darling Basin (DPI, 2017). Surface water resources in the area include the Namoi River, located approximately 5 km east of the proposed extension, and tributaries of the ephemeral Kurrajong and Tulla Mullen creeks that traverse the proposed development area. Known groundwater-dependent ecosystems (GDEs) adjacent to or within the project area include Mayfield, Hardys and Eather Springs, as well as several facultative terrestrial GDEs, some of which are mapped as 'high priority' GDEs in Water Sharing Plans (WSPs) relevant to the project area. There are also 40 farm dams within the project area that are potentially impacted by subsidence.

Key potential impacts from this project are:

- drawdown within the saturated alluvium and porous rock aquifers leading to potential long-term reduction of available groundwater for springs, other GDEs, and agricultural water resources;
- ground deformation above longwalls, including subsidence and mining-induced fracturing, which changes hydraulic parameters of porous rock aquifers and the groundwater flux within them and the hydraulically connected alluvium, producing a permanent area of groundwater drawdown (or groundwater sink) within the larger regional groundwater flow system. These changes can alter flow regimes and cause ponding in undermined ephemeral streams, as well as induce surface water losses from farm dams;
- extensive remnant and riparian vegetation dieback over longwall goafs due to subsidence;
- possible discharge of saline water into the Namoi River above EC Guideline Values; and
- potential loss or alteration of habitat for species such as the Koala (*Phascolarctos cinereus*) listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The IESC has identified areas in which additional work is required to address the key potential impacts, as detailed in this advice. These are summarised below.

- Surface water modelling informed by data from baseline stream gauging is still required to assess impacts on ecologically important stream-flow components (e.g. spells of low- and zero flows) under a range of climatic scenarios relevant to the long-term nature of the impacts.
- Additional mitigation measures may be necessary, such as revising the mine layout and geometry to reduce subsidence-related strains and stresses, to protect water-related assets.
- Geophysical surveys and in-situ testing of hydraulic parameters are required to provide greater confidence in the extent and magnitude of predicted watertable drawdown within alluvium near the Namoi River.
- Expand the monitoring network at the site to better monitor changes in groundwater levels and quality, particularly in areas of suspected groundwater-surface water interactions, to monitor potential impacts to GDEs.
- Additional monitoring of the effects of ground movement on groundwater levels by multi-level VWP above the centreline of the first new longwall panels to support updates of the assessments on the groundwater system.
- Additional investigation using a suitable suite of water-tracers injected into existing goafs at the site to assist in modelling how the planned reinjection of brine could move in the groundwater system.

- Provide additional information about the treatment of mine-affected water and its water quality before releases are made into the Namoi River. Hydrochemistry of the receiving waters of the Namoi should also be monitored over time to establish background levels prior to water release.
- Address inconsistencies in the risk assessment of GDEs.
- Assess groundwater-dependence of trees in the zone of predicted groundwater drawdown, especially where subsidence will also occur. Quantify the use by arboreal fauna (e.g. Koala, Squirrel Glider (*Petaurus norfolcensis*)) of groundwater-dependent trees and those likely to be impacted by subsidence so that adequate mitigation measures can be developed.
- Collect detailed information on the ecohydrology of the three springs, including discharge and recharge rates, water quality and species diversity to inform risk assessments and mitigation strategies.
- Sample stygofauna in areas of predicted drawdown as well as unimpacted reference sites to assess the likely impacts of isolating stygofaunal habitat from the Namoi River alluvium.

Context

The Narrabri Mine (EPBC 2019/8427) is an existing underground coal mining operation located in the Gunnedah Basin Coalfield, approximately 25 km south-east of Narrabri and approximately 60 km north-west of Gunnedah, NSW. The proposed project will expand the existing operation, targeting the Hoskissons Seam. Mining has occurred at the Narrabri Underground Mine since 2010. The project proposes to extend the existing mine in a southerly direction to access an additional 82 Mt of run-of-mine coal until 2044. The project will use existing coal handling, processing and transportation facilities.

The project lies in the Namoi Water Management Area, a region with one of the highest levels of groundwater extraction in the Murray-Darling Basin (DPI, 2017). Surface water resources in the area include the Namoi River and several of its (mostly ephemeral) tributaries that form part of *The Lowland Darling River aquatic ecological community*, listed as an endangered ecological community (NSW DPI, 2007). The project area and its predicted zone of drawdown also contain groundwater-dependent ecosystems (GDEs) such as springs and terrestrial vegetation, some of which are classified as 'high priority' GDEs.

The project will undermine tributaries of Kurrajong and Tulla Mullen Creeks, as well as the eastern border of the Pilliga State Forest.

Response to questions

The IESC's advice in response to the requesting agencies' specific questions is provided below.

1. Overall, the IESC considers that there is still a material risk of impacts on water resources given the current intensive use of groundwater in the region, the predicted extent of subsidence and groundwater drawdown by the project, and the proposed development's proximity to significant water resources such as the Namoi River and its alluvium, springs, other GDEs and the state-listed *Lowland Darling River Aquatic Ecological Community* (NSW DPI, 2007). Many of these potential impacts were discussed in the IESC's previous advice (IESC, 2019) and are still not adequately addressed.

Question 1: To what extent can decision makers have confidence in the predictions of impacts on groundwater resources provided in the Environmental Impact Statement (EIS), groundwater inflows, drawdowns in aquifers and potential impacts on private bores and groundwater dependent ecosystems?

And

Question 2: Can the IESC comment on the assumptions made regarding the subsidence effects on the groundwater hydraulic model parameters?

Groundwater

2. A predicted maximum drawdown of the watertable > 10 m is indicated over a large area to the east and northeast of the proposed longwall panels. A steep gradient in the watertable predicted near the Namoi River is apparently related to lithological changes; however, no basis for the ground-truthing of the mapped extent and heterogeneity of these units has been provided. The extent and parameterisation of the hydrogeological units between the proposed longwall panels and the river is uncertain and also contributes to the uncertainty in the predicted net reduction in groundwater discharge to the Namoi River. The predicted reduction in groundwater discharge due to the project is 140 ML/year to the Namoi River by 2192 (AGE 2020, p. 113). The potential for long-term drawdown of the watertable in this water-stressed Groundwater Management Area is of concern and warrants further investigation, modelling and monitoring (Paragraph 22).
3. In particular, the IESC notes a number of issues with the proponent's assessment of groundwater impacts.
 - a. The groundwater model presented in the Gateway application has been revised, with the proponent undertaking additional work to address many of the issues raised in previous IESC advice. The groundwater modelling provided by the proponent presents extensive steady-state and transient 3D numerical groundwater models accompanied by a stochastic uncertainty quantification of simulated model outputs (AGE 2020, App D, p.12), which have undergone independent peer-review. However, the IESC does not consider that all relevant parameters (e.g. hydraulic conductivity and storativity) and boundary combinations have been considered in the proponent's assessment of potential impacts, which may result in an underestimate of potential impacts. Evidence of this potential underestimate is seen in the reported model-to-measurement misfits, where the calculated range of uncertainty of the modelled groundwater levels does not encompass the actual measured values (AGE 2020, App D, p. 2).
 - b. The proponent has provided maximum predicted groundwater drawdown maps for each formation. However, these maps only provide drawdown to a 2 m contour. Noting the proponent has not adequately sampled GDEs in the area (Paragraphs 5, 7, 14, 15, 16, 17, 30, 31), a greater resolution in the presented drawdown predictions is required to better assess the potential impacts of the project. For example, drawdown of 0.5 m may substantially alter spring discharge rates and adversely affect aquatic and semi-aquatic communities in the seepage zone. In alluvial sediments shallower than 2 m, a drawdown < 2 m may alter groundwater flux and reduce stygofaunal habitat.
 - c. The IESC notes the approximate heights (4.3 m) and widths (300-400 m) of the longwalls combined with the relatively shallow cover depths of 165-346 m will result in extensive subsidence and surface-to-seam cracking across the site. This in turn will result in increased hydraulic connectivity and drainage of impacted aquifers, resulting in permanent drawdown impacts. Currently, there is an inconsistency between the predictions of the Subsidence Assessment (DGS, 2020) and the conservative assumptions regarding the increases in hydraulic connectivity parameters resulting from this subsidence. Site-specific data should be used to justify the parameter functions applied in the model for hydraulic conductivity and specific storage, particularly around longwall panels.
 - d. Noting some of the rapid depressurisation of groundwater resources predicted in the EIS groundwater assessment, the groundwater model should be bi-annually updated as works progress at the site. More extensive regional monitoring of the Purlawaugh, Napperby and Digby

Formations along with the Garrawilla Volcanics would provide a better indication of hydrostratigraphic unit interaction, and provide the evidence required to explain why the proponent has observed depressurisation in many of these groundwater sources. Updating of the model based on further monitoring of groundwater levels in the area above the longwalls would refine the assessment of the impact on regional groundwater fluxes caused by the increasing vertical hydraulic conductivity in that area (Paragraphs 12, 22).

- e. The Groundwater Assessment (AGE, 2020) in the EIS acknowledges the information gaps regarding surface water and groundwater interactions at creeks and springs present at the project site. AGE (2020, p. 146) recommends expansion of the monitoring network to include monitoring bores at these sites. The IESC agrees that the proponent should install these suggested monitoring bores and incorporate their data into the model and update predictions before this project (Stage 3) progresses (see Paragraphs 15, 22).
4. Although the documentation states that there is a current groundwater quality monitoring program, (which includes monthly monitoring of pH and EC, and annual monitoring of major ions, alkalinity, total P and some metals), no data (apart from salinity) are included in the EIS. Additional information on the aquifers monitored and the frequency of monitoring is required, as well as actual data for a wider range of parameters, including the soluble metals identified in the geochemical assessment (antimony, arsenic, cobalt, molybdenum, selenium).

GDEs

5. The IESC is not confident that the proponent has adequately assessed potential impacts on GDEs, especially springs (Paragraph 8, 14) and stygofauna (Paragraph 16). For groundwater-dependent vegetation, these impacts may include a combination of groundwater drawdown and disruptions to the root systems (e.g. shearing) caused by subsidence (see Paragraphs 30, 31). Distressed or dead trees have been recorded in areas of subsidence over completed mining longwalls (Resource Strategies 2020, p. 100). Despite this information, the proponent states that there will be minimal impacts to the vegetation as changes will happen gradually. Subsidence of up to 3 m and the formation of cracks larger than 0.5 m are highly likely to significantly disrupt root systems of overlying vegetation. Although risks to GDEs have been assessed, the risk matrix contains conflicting information and should be reviewed. For example, the proponent claims that the risk to springs and GDEs due to groundwater drawdown is 'low' whilst according to the matrix values of likelihood (rated 'unlikely') and consequence (rated 'catastrophic'), the risk should be classified as 'high' (Operational Risk Mentoring 2020, p. 15).
6. The effects of drawdown on vegetation are dismissed as 'minor impacts' (Resource Strategies 2020, p. 103), despite drawdown in many areas being predicted to be 10-20 m. Even in areas where the water is only 2 m below ground level before drawdown, this amount of drawdown is likely to severely impact groundwater-dependent vegetation. Such impacts potentially disrupt vegetated corridors and impair or remove vital habitat for native fauna and flora. The claim that mining-induced changes in groundwater level will be gradual and lie within predicted ranges does not preclude the likelihood that the rates of drawdown will be greater than the ability of the root systems to maintain contact with the water table. Further, when drawdown peaks (estimated as some 150 years post-mining), groundwater levels below many of these terrestrial GDEs may be too low to ameliorate the effects of other stressors such as prolonged drought and dieback.
7. Confidence concerning the impacts to terrestrial GDEs needs to be increased by obtaining field measurements of groundwater use by vegetation (Doody et al. 2019), especially for species overlying the longwalls and in areas where the predicted drawdown is > 5-10 m. Facultative GDEs may largely rely on groundwater during periods of prolonged drought when they are under severe stress. Loss of or decline in the condition of this vegetation is likely to impact on arboreal species such as Squirrel Gliders (*Petaurus norfolcensis*) and Koalas (*Phascolarctos cinereus*) that inhabit

these trees and are listed as Vulnerable under the *Biodiversity Conservation Act 2016* (BC) and/or the EPBC Act.

8. Three springs (Mayfield, Hardys and Eather) are identified as GDEs within and near the project area. Few details are provided about them apart from claims that they are all highly modified and that anecdotal evidence indicates spring flows have declined in the last ten years. However, these still qualify as GDEs and are crucial sources of water in a semi-arid environment. Detailed information on the ecohydrology of all three springs is required, including discharge and recharge rates, water quality and assessments of the diversity and condition of aquatic and semi-aquatic species present (Doody et al. 2019). This information will enable more accurate assessment of likely impacts of drawdown on these GDEs and their biodiversity.

Question 3: Are the arguments to include only the Narrabri Gas Project, and not the open cut coal mines located to south west (Maules/ Boggabri/ Tarrawonga/ Vickery Extension) in the cumulative impact assessment reasonable, given the distance and geology?

9. The IESC notes that the proponent has incorporated impacts associated with the Narrabri Gas Project, using Santos' 'base case' scenario, into the cumulative impact predictions of the groundwater modelling. The IESC considers that this is an acceptable approach to assessing potential cumulative groundwater impacts at the site, noting the comments in Paragraph 3b.
10. Considering the significant distances (ca. 30-50 km) to the nearest open cut coal mines in the area, and the justification provided for selecting groundwater model boundaries, it is reasonable for the proponent to exclude the potential cumulative impacts of mines located to the south-west of the project area. Additionally, the geological characteristics of the Boggabri Ridge separating the Mulley sub-basin from the Maules Creek sub-basin justify not including these other open cut mines in the cumulative impact assessment.

Question 4: Noting that brine re-injection into the underground goaf area is permitted for the approved Narrabri Mine, are the assumptions and assessment of brine re-injection on long term groundwater quality reasonable?

11. The proponent has not commented on the likely composition of brine and its potential impacts on groundwater quality when re-injected. No information on the current groundwater quality in the various aquifers, apart from salinity, has been provided by the proponent preventing the IESC from assessing the likely future impacts of brine reinjection on groundwater quality. Assumptions and assessment of brine re-injection on long-term groundwater quality require further justification.
12. Long-term impacts of brine re-injection require further justification which consider the recovery of groundwater levels and change in groundwater flux. The extensive fracturing caused by subsidence provides conduits for brine to migrate widely, including lateral extension contamination, potentially impacting local and adjacent GDEs, water bore resources and local aquifers. Despite hydraulic gradients increasing towards the goafs (i.e. the groundwater flow gradients will act like a sink towards the mine), the increase in hydraulic connectivity above the goafs coupled with the already saline groundwater present in the lower hydrostratigraphic units may have impacts on the groundwater quality long-term. These impacts will see an increase in the EC of water above the goafs. Preferential flow pathways may cause the more saline groundwater to be transported to the Pilliga Sandstone and Namoi River Alluvium present within or near the project area. The proponent should monitor hydraulic interactions above the current goafs present at the mine and trial the injection of harmless tracer-fluids into these goafs to model the flow pathways in the system above the goafs.

13. The proponent has not assessed the likely impacts of brine re-injection on GDEs, especially in combination with the effects of drawdown and altered groundwater flux. Given the need to more fully assess GDEs and, in some cases, their level of groundwater dependence (Paragraphs 15), the potential impacts of altered groundwater quality as a result of brine injection are needed.

Question 5: Have the surface and groundwater impacts of the Project on the local and regional aquatic ecological values (aquatic biota and riparian habitat) and groundwater dependent ecosystems (including groundwater dependent vegetation and stygofauna) been adequately described and assessed?

14. The terrestrial vegetation and fauna of the project site have been thoroughly surveyed by the proponent over multiple years. Desktop and survey data indicate the presence of biodiverse communities that include several species listed by the BC and/or EPBC Acts as Vulnerable (e.g. Large-eared Pied Bat (*Chalinolobus dwyeri*), Koala, Squirrel Glider, Pilliga Mouse (*Pseudomys pilligaensis*), Corben's Long-eared Bat (*Nyctophilus corbeni*)). Many of the faunal species are likely to rely on surface water when it is available as well as using riparian and other vegetation for habitat and food. The proponent does not provide detailed assessments of how potential habitat alterations by the project might directly or indirectly affect each of these species during and after mining. Some of the vegetation is likely to be groundwater-dependent and may be adversely affected by drawdown (and possibly brine injection, see Paragraph 11,13) although the extent of the vegetation's dependence on groundwater in the project area is unknown (Paragraph 7, 15). Although springs within and near the project area have been altered, they still have local and regional aquatic values that have not been adequately described and assessed by the proponent (Paragraph 8). Similarly, stygofauna (an obligate GDE) in the zone of predicted drawdown have not been surveyed and are assumed to be unlikely to occur despite other literature describing stygofauna collected along the Namoi River and its tributaries (see Paragraph 16). Watercourses draining the project area are ephemeral and their flow regimes, to which local fauna and vegetation are adapted, are likely to be altered by subsidence that changes patterns of runoff and causes ponding. However, the potential effects of these changes in stream flow regimes on aquatic biota and riparian zone vegetation have not been adequately described and assessed (see Paragraph 17).
15. Although the proponent has done an extensive desktop survey of potential GDEs, few of these have been verified by ground-truthing (AGE 2020, App. B, p. 142). 'High priority' terrestrial GDEs in, and near, the project area have also been identified based on satellite image analysis with limited ground-truthing (AGE 2020, App. B, p. 122). Some of these potential GDEs occur in areas where drawdown is predicted but these assessments are severely hampered by the paucity of data on groundwater dynamics near these GDEs and uncertainty about the degree of groundwater-dependence of the vegetation. It is recommended that monitoring bores be installed near patches of 'high priority' GDEs in areas where drawdown is predicted so that changes in groundwater levels can be monitored before, during and after mining. Further, the proponent should assess the level of groundwater-dependence (Doody et al. 2019) to confirm that these are indeed GDEs and, if so, the proponent should explain the likely effects of drawdown (and possibly brine injection, see Paragraph 13) on their condition, recruitment and persistence. This is especially relevant for those GDEs where drawdown is predicted to exceed thresholds defined by the Aquifer Interference Policy (AGE 2020, App. B, Table 7.6, p. 124-125). However, potential impacts of drawdown on all GDEs (not just 'high priority' ones) should be assessed by the proponent because they are all defined as Matters of National Environmental Significance (MNES) under the 'water trigger' and have ecological values in this semi-arid landscape, especially where they provide habitat, food or both for EPBC Act-listed species. These GDEs include those along watercourses and on alluvial flats where drawdown is predicted.

16. The proponent asserts that stygofauna are unlikely to occur along Kurrajong Creek or other watercourses within the project area because there is no mapped alluvium along these creeks which are also highly ephemeral and either entirely or usually disconnected from the Namoi Alluvium (AGE 2020, App. B, p. 77). However, it is acknowledged that stygofauna might occur in the alluvium of Tulla Mullen Creek and the adjacent Namoi River. Furthermore, stygofauna have been collected from the alluvium of the Namoi River (Korbel et al. 2017) and several sites along nearby Maules Creek (Andersen et al. 2016). The IESC recommends that the proponent test their assumptions about the occurrence of stygofauna by sampling bores along creeks traversing the project area, in the vicinity of the springs that occur in the headwaters of Kurrajong (Mayfield) and Tulla Mullen (Hardys and Eather) creeks, and in the alluvium of the lower Tulla Mullen Creek where drawdown is predicted (AGE 2020, App. B, Fig. 7.24, p. 128). If stygofauna are found, the proponent should assess the likely impacts of the predicted drawdown, especially where groundwater habitats may be isolated from the Namoi Alluvium and other potential sources of colonists. Potential impacts of brine injection on stygofauna (Paragraph 13) should also be assessed.
17. Although the creeks draining the project area are ephemeral, they still have significant ecological values (Datry et al. 2017), are MNES under the 'water trigger', and comprise part of *The Lowland Darling River aquatic ecological community* which is listed as an endangered ecological community (NSW DPI, 2007). Their flow regimes, including ecologically important flow components (such as low-flow spells and number of zero-flow days), are likely to be substantially altered by subsidence-induced changes to catchment topography and runoff, the instream profile (including areas of ponding) and areas where streambed cracking may occur. The proponent does not provide adequate detail of the likely impacts of these changes in flow regimes and their components upon aquatic or semi-aquatic biota and riparian zone vegetation of the undermined creeks. The listing of *The Lowland Darling River aquatic ecological community* has given all native fish and other aquatic animal life within its boundaries the status of endangered species (NSW DPI 2007, p. 2) and therefore this aspect deserves detailed attention. There should also be an assessment of the collective downstream effects on the flow regime caused by the altered stream flows of Kurrajong Creek and the tributaries of Tulla Mullen Creek that will be undermined.

Question 6: To what extent can decision makers have confidence in the predictions of potential impacts on surface water resources provided in the EIS, including in regard to subsidence impacts on surface water features, hydrology and water quality, discharges of treated water to the Namoi River and discharges from sediment dams from the mine infrastructure area?

18. There is a low level of confidence in predictions of potential impacts to surface water resources, especially undermined tributaries of Tulla Mullen and Kurrajong creeks, as no explicit account has been given to subsidence and mining-induced fracturing.
- The proposed operations at the site will likely result in substantial cracking and subsidence above all goafs including to the surface (Paragraph 3c). As far as the IESC can discern, the likely impacts of subsidence and cracking have not been adequately outlined in the surface water assessment of the site. The proponent should demonstrate consideration of the impacts of substantial fracturing on rates of recharge and reliability of baseflow of the ephemeral tributaries, and on the potential for increased losses from the 40 farm dams that are potentially impacted by subsidence. Furthermore, modelling of erosion to tributaries along fractures between LW101 and LW111 will assist in determining potential impacts to other tributaries in the area.
 - The proponent states that additional surface depressions (ponding) are not expected to impact on the low and medium flows or flow regime of the watercourses as the watercourses are highly ephemeral with no baseflow observed under existing conditions. Although the waterways within

the project area are ephemeral, surface water modelling informed by baseline stream gauging is still required to assess water loss from surface waters due to groundwater drawdown and from cracking and ponding, and potential changes in runoff generation processes due to increased surface depressions, under a range of climatic scenarios.

19. The assessment of potential impacts on surface water flows was undertaken assuming that the future climate will be the same as current, an approach which was justified on the basis that climate change impacts are projected to be minimal over the project's life (i.e. to 2044). However, climate change impacts beyond the life of the project were not considered as the available climate projections were deemed inconsistent (WRM 2020, p. 89). While the assumptions made are largely appropriate to the assessment of the water management system over the duration of the Project, they do not provide an adequate understanding of the possible range of hydroclimatic conditions in the longer term. Current science (Grose et al. 2020) indicates likely reductions of 10% to 20% in the austral winter and spring by 2090, and it is reasonable to expect that the low flow regime in the Namoi River will be materially different in the year 2240, which is when the peak baseflow reductions in the Namoi River are expected to occur. Such assessments should consider a range of projected changes based on the distribution of climate model results as their impacts on streamflow regime are highly non-linear.
20. It is unclear how the mine-affected water will be treated (filtered?) prior to release. While there have been no controlled releases of mine-affected water into the Namoi River during operations to date, a number of water quality values, including EC, for "filtered" water exceeded the trigger values outlined in Table 4.5 of WRM 2020 (p. 43). Only physico-chemical parameters have been measured and reported in various on-site water storages, so additional monitoring data on other parameters (e.g. soluble metals identified in the geochemical assessment (antimony, arsenic, cobalt, molybdenum, selenium)) should be obtained, especially as there may be uncontrolled releases from sediment dams into Kurrajong Creek.
21. No data are presented in the EIS for other water quality parameters in the receiving waters e.g. metals, except for mention of one sampling event in January 2020, in which dissolved metals concentrations exceeded the Namoi River Water Quality Objectives for iron, chromium, copper and zinc at more than half the monitoring sites. Additional surface water quality monitoring is needed, including a wider suite of parameters to develop more robust site-specific water quality guidelines (Huynh and Hobbs, 2019).

Question 7: Does the EIS provide reasonable strategies to effectively avoid, mitigate or minimise the likelihood, extent and significance of impacts, including cumulative impacts to significant water-related resources? Could the IESC list additional mitigation, monitoring and management measures?

22. Although the proponent describes some aspects of monitoring (AGE 2020, p. 145-146), mitigation measures are not presented in detail. Additional suggestions to improve the monitoring follow.
 - a. Ground-truthing of regional-scale geological mapping and hydraulic parameterisation near the Namoi River could provide more confidence in the lithological boundary between alluvium and porous rock aquifers that result in a steep gradient in modelled watertable drawdown. To support this mapping and parameterisation, geophysical surveys and monitoring bores for in-situ testing of hydraulic parameters will provide greater confidence in the extent and magnitude of predicted watertable drawdown within alluvium near the Namoi River.

- b. Ditton details a number of monitoring and mitigation recommendations which are supported by the IESC (DGS 2020, p. E7, 27, 34, 59, 78, 82, 96-97, 102) and the IESC considers that all of these recommendations must be implemented. The current monitoring program should be updated to reflect these recommendations. Further, the spatial coverage of the groundwater monitoring network should be expanded to where there are currently no monitoring bores to the west and south of the proposed project, as discussed in the previous advice (IESC 2019-102, Paragraphs 3-5).
 - c. Additional monitoring with multi-level VWP's above the centreline of the first new longwall panels (similar to the VWP's in borehole 57 above LW108) is required. IESC agrees with the recommendation of the peer reviewer (Jacobs, 2020) that this additional monitoring is essential to improve the local database of subsidence effects and impacts. Site-specific data should be used to justify the parameter functions applied in the groundwater model for hydraulic conductivity and specific storage, particularly above and near longwall panels.
23. While the groundwater quality monitoring plan indicates that pH and EC are monitored monthly, and additional parameters are monitored annually (including major ions, alkalinity, total phosphorus and some metals), none of these data (except salinity) is presented in the EIS. The limited data provided are compared to NEPM guideline values for stock watering, as well as site-specific trigger values. However, these site-specific trigger values are not shown, making it difficult for the IESC to determine if the monitoring or guidelines are appropriate to protect groundwater systems. No monitoring of shallow groundwater (Quaternary Alluvium) is undertaken currently.
24. The proponent still does not appear to have sufficient licences for predicted take from the NSW Gunnedah Oxley Basin water source. Notably, the peak volumes requiring licencing exceed current licensing by 1,089 ML/ year. Prudent management of this water resource would dictate licenses should be obtained before operations commence.

Surface water

25. There is little to no confidence in the predictions of the lack of baseflow in the ephemeral tributaries as no modelling or monitoring has been completed or planned to be completed.
- a. Clarification is required to determine if streams are predominately gaining or losing to determine their groundwater dependence (OWS 2020, p. 6-7).
 - b. The proponent does not consider potential impacts of subsidence on the local waterways of the proposed project, where it might be expected that changes in surface depressions (and ponding) will change the proportion of rainfall that appears as surface runoff. Installing stream gauges was a recommendation from the last IESC Advice (IESC 2019, p. 2), and installing gauges (for example, along the mid-reaches of Kurrajong Creek, a location on Tulla Mullen Creek downstream of the project area, or at a point below their confluence above the Namoi River) could be used in combination with existing gauges to assess impacts over time.
26. The proponent's mitigation strategy to manage the cracks due to subsidence is for them to fill naturally or for the larger cracks to manually fill them in with machinery. Due to the possible magnitude of these cracks, this is an unreasonable and impractical strategy as well as potentially unsafe. The cracks have been previously mentioned in the advice (IESC 2019-102, Paragraph 10b) and much of this does not appear to have been addressed.
27. Background physico-chemical and chemical parameters for the Namoi River (particularly EC values) which may receive controlled releases, as well as Kurrajong Creek which may receive overflows from sediment dams, are required.

28. No Trigger Action Response Plan (TARP) for the existing mine was provided. Clarification is required as to whether baseline values for water quality (physico-chemical parameters and contaminants) have been established for the existing mine which gained approval in 2011.
29. As the IESC specified in the previous advice (IESC 2019-102, Paragraph 17), a surface water assessment is needed which:
 - b. uses appropriate surface water quality data consistent with the ANZG (2018) guidelines for aquatic ecosystem protection to inform impacts and risks;
 - c. includes baseline and event-based monitoring of water quality parameters over a sufficient time period to enable the derivation of appropriate site-specific water quality guideline values (Huynh and Hobbs, 2019). The parameters monitored, frequency of monitoring and actual monitoring data should be included;
 - d. uses a risk-based approach to identify key surface waters that might be impacted (e.g. through direct and indirect discharges, subsidence fracturing, ponding or erosion), and considers how the proposal may alter the number of low- and zero-flow days and potentially impact on instream biota. The proposed development area is drained by ephemeral streams whose flow regime is likely to be altered by subsidence and, potentially, groundwater drawdown. Altered flow regimes will affect the capacity of these ephemeral streams to provide habitat for aquatic species (WRM 2020, p. 9) or support the important ecosystem services provided by these types of surface waters (WRM 2020, p. 9);
 - e. identifies the existing (baseline) hydrological regimes of all watercourses, including into the Namoi within the potential zone of hydrological impacts based on selected site-specific monitoring, and how these translate into the flow regime of the creek entering the Namoi River; and
 - f. informs appropriate mitigation strategies (e.g. timing and methods for re-establishing drainage lines to minimise erosion, and actions to be taken when there is a suspected exceedance of a guideline value).

GDEs

30. The proponent is commended for efforts to redesign the mine's layout to avoid or minimise subsidence-related impacts on, for example, Bulga Hill which is habitat for the EPBC Act-listed Large-eared Pied Bat although it is noted that other rocky outcrops, also used as habitat, will be undermined. However, avoiding or mitigating drawdown and subsidence-related impacts on watercourses, riparian zone vegetation and GDEs is much more challenging. It is unlikely that any mitigation of subsidence-related effects on streamflow regimes (Paragraph 17, 29d) is possible. The proponent should monitor aquatic values (e.g. aquatic macroinvertebrates, amphibians) of the undermined watercourses before, during and after mining so that predictions about the potential impacts of subsidence can be tested as well as the effectiveness of filling and repairing cracks in the streambed. Similarly, ponding and root shearing may adversely affect some riparian zone vegetation along the undermined watercourses. Monitoring of riparian zone vegetation condition and cover should be done sufficiently often to detect any changes associated with mining and to trigger rehabilitation actions such as replanting.
31. When the proponent has established the degree of groundwater-dependence of terrestrial GDEs, including those not rated as 'high priority' (Paragraph 15), monitoring will be required to detect whether drawdown (potentially combined with subsidence) is having an impact. There are few if any feasible mitigation measures to rectify the impacts of groundwater drawdown on GDEs. In some instances, drawdown may coincide with subsidence-related impacts such as root shearing that may impact groundwater-dependent vegetation. Although there is no evidence that vegetation surrounding the existing Narrabri Mine has experienced any groundwater drawdown-related

impacts (Resource Strategies 2020, p. 118), the extent of this drawdown may not yet have peaked. To get a clearer perspective on how drawdown and subsidence may affect undermined groundwater-dependent vegetation, the proponent could monitor groundwater use by vegetation overlying proposed longwalls (especially in areas where the watertable is < 10 m) during and after mining, matching this with measures of vegetation condition and recruitment. The effectiveness of any mitigation strategies could then be assessed.

32. The proponent also needs to ascertain whether stygofauna occur in the area of predicted drawdown (Paragraph 16) and, if so, whether there is a risk that assemblages may be lost or isolated from sources of potential colonists. Although predicted drawdown is < 2 m in much of the alluvium where stygofauna are likely to be found, this limited drawdown in areas where alluvial sediments are only shallow may be enough to isolate stygofaunal assemblages. There may also be impacts on ecosystem services provided by groundwater microbes that are stranded or killed by drawdown in shallow alluvial sediments. Again, mitigation measures to prevent or ameliorate this drawdown are unlikely to be feasible.

Date of advice	15 th December
Source documentation provided to the IESC for the formulation of this advice	AGE 2020. Narrabri Underground Mine Stage 3 Extension Project - Groundwater Assessment, Appendix B of the Environmental Impact Statement, Dated:12 October 2020. Version 6.02. DGS 2020. Mine Subsidence Assessment for the Narrabri Underground Mine Stage 3 Extension Project, Appendix A of the Environmental Impact Statement, Dated 5 July 2020. Document No. NAR-005/2. GEM 2020. Environmental Geochemistry Assessment for the Narrabri Underground Mine stage 3 extension project, Appendix N of the Environmental Impact Statement, Dated August 2020. Hebblewhite B.K 2020. Narrabri Stage 3 Extension Project Subsidence Assessment – Peer Review, Attachment 6 of the Environmental Impact Statement, Dated 12 August 2020. Jacobs 2020. Groundwater Assessment Review of Narrabri Underground Mine - Stage 3 Extension Project, Attachment 6 of the Environmental Impact Statement, Dated 13 October 2020. Project No. IS343800. Narrabri Coal Operations Pty Ltd (NCOPL) 2020. Narrabri Underground Mine Stage 3 Extension Project, Environmental Impact Statement, Executive Summary. Whitehaven Coal, Australia. Resource Strategies, 2020. Narrabri Underground Mine Stage 3 Extension Project – Biodiversity Development Assessment Report, Appendix D of the Environmental Impact Statement, Dated: October 2020. Document No. 01054663. Whitehaven Coal 2020a. Narrabri Underground Mine Stage 3 Extension Project, Environmental Impact Statement-Executive Summary. Whitehaven Coal 2020b. Narrabri Underground Mine Stage 3 Extension Project, Environmental Impact Statement-Project Description, Section 2. WRM 2020. Narrabri Underground Mine Stage 3 Extension Project – Surface Water Assessment, Appendix C of the Environmental Impact Statement, Dated: 06 October 2020. Version 0189-13-E9.
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Aspect Type	Risk Description	Ranking Basis/Loss Scenarios		
		P ¹	C ²	R ³
Water	Impacts to Namoi Alluvium resulting from dewatering of mine and extraction from the Namoi Zone 5 groundwater bore.		A 1	Moderate
Water	Dewatering of porous rock aquifers adjacent to coal seam.		A 1	Moderate
Water	Impacts to springs and groundwater dependent ecosystems due to groundwater drawdown.		D 5	Low

Risk ranking basis: Near source drawdown anticipated, with no material impacts to the Namoi Alluvium. Minor loss of the resource.

Planned controls: Integrated⁴ groundwater and surface water assessment; acquisition of sufficient water licences; and groundwater and surface water monitoring programmes.

Risk ranking basis: Significant depressurisation to porous rock aquifers expected. Impacts on springs and groundwater dependent ecosystems are not expected due to porous rock impacts.

Planned controls: Integrated⁴ groundwater and surface water assessment; acquisition of sufficient water licences; and groundwater and surface water monitoring programmes.

Risk ranking basis: Potential terrestrial groundwater dependent ecosystems have been mapped in the Project area and some potential springs occur in the Project area and nearby. Groundwater modelling indicates that groundwater depressurisation in the vicinity of these features is generally limited.

Planned controls: Characterisation of potentially impacted groundwater dependent ecosystems and springs; integrated⁴ groundwater and surface water assessment; validation of groundwater model and groundwater and surface water monitoring programmes.

Appendix B

Level	Description	Environment	Economics
5	Catastrophic	Unconfined detrimental impact requiring long term recovery leaving major residual damage (typically years)	>\$50M
4	Major	Unconfined detrimental impact requiring medium term recovery leaving residual damage (typically months)	\$10M - \$50M
3	Medium	Near source confined detrimental impact requiring medium term recovery (typically months) Unconfined detrimental impact requiring short term recovery (typically weeks)	\$2M - \$10M
2	Minor	Near source confined reversible impact requiring short term recovery (typically a week)	\$100K - \$2M
1	Insignificant	Near source confined negligible or temporary impact (typically a shift)	<\$100K

Source: Whitehaven (2019).

Table 5 – Risk Ranking Matrix

Likelihood	Consequence level					
		Insignificant (1)	Minor (2)	Medium (3)	Major (4)	Catastrophic (5)
	Almost Certain (A)	Moderate	High	High	Critical	Critical
	Likely (B)	Moderate	Moderate	High	High	Critical
	Occasional (C)	Low	Moderate	High	High	High
	Unlikely (D)	Low	Low	Moderate	Moderate	High
	Rare (E)	Low	Low	Moderate	Moderate	High

Legend – Risk Levels:

Risk	Critical	Risks that significantly exceed the risk acceptance threshold. Immediate attention needed, stop the job.
	High	Risks that exceed the risk acceptance threshold. Additional risk control measures required. If further risk control measures are not practicable the responsible Manager must sign off.
	Moderate	Risks acceptance threshold. Additional control measures could be implemented to control risks further. Active monitoring of risk control measures required.
	Low	Risks that are below the risk acceptance threshold. No additional control measures required. Monitoring of risks may be needed.