

Advice to decision maker on coal mining project

IESC 2019-106: Mangoola Coal continued operations project (EPBC 2018/8280; SSD 8642) – Expansion

Requesting agency	The Australian Government Department of the Environment and Energy and The New South Wales Department of Planning, Industry and Environment
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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 the Environment and Energy and the New South Wales Department of Planning, Industry and Environment to provide advice on the Mangoola Continued Operations Project in New South Wales. 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 Mangoola Continued Operations Project is a proposed extension to the existing Mangoola Coal Mine. It is located approximately 20 km west of Muswellbrook in the Upper Hunter Valley of NSW. The project consists of an additional open-cut pit to the north of this site, separated from the existing open-cut operation by Big Flat Creek, and will use existing mine infrastructure. The project involves extraction of 13.6 Mt of run-of-mine coal per year and has an expected operational life of 8 years.

Key potential impacts from this project are:

- contribution to cumulative impacts on groundwater-dependent vegetation and associated biota in the vicinity of Big Flat Creek;

- presence of a final void in the rehabilitated landscape which will have impacts on water quantity and may also impact on groundwater quality;
- potential ongoing water quality issues associated with sedimentation from both the proposed infrastructure and the unquantified impacts from uncontrolled discharges from sediment dams;
- potential impacts from water discharges on erosion and water quality in Big Flat Creek; and
- drawdown in four private bores of >2 m.

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

- The assessment methods employed in the Environment Impact Statement (EIS) are unlikely to have captured all potential groundwater-dependent ecosystems (GDEs) that are present. The proponent should reassess the presence of GDEs in the vicinity of the project, as detailed in this advice. Impacts to this (likely wider) area of GDEs should then be assessed. Overlaying a map of GDEs with a 0.2 m drawdown contour (presented probabilistically) would be valuable in this assessment. The GDE impact assessment should also consider direct clearing of GDEs.
- Groundwater quality monitoring data were only provided for one month (September, 2017). All relevant data should be provided so that the potential impacts of migration of groundwater from the pit and from the final pit lakes can be assessed.
- Surface water quality and aquatic ecology monitoring data in the Hunter River, upstream and downstream of the proposed discharge location, are required to assess any potential downstream impacts.
- Given that there may be future controlled and uncontrolled discharges from the mine water storages, particularly the Pit Water Dam, on-going monitoring should include total and dissolved metals, in addition to the physico-chemical parameters identified.
- The Surface and Groundwater Response Plan for the existing Mangoola coal mine needs to be updated for the project. This plan currently does not contain specific mitigation measures for the proposed project's potential impacts. The proponent should detail specific effective and achievable mitigation measures that will be included in the revised plan.

Context

Mangoola Coal Mine is an open cut coal mine located approximately 20 km west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW. Mining commenced at the site in September 2010. The Mangoola Continued Operations Project (the project) is for an additional open-cut pit to the north of this site, separated from the existing open-cut operation by Big Flat Creek (Umwelt 2019a, pp. 29–31). The project will use existing mine infrastructure, including the coal handling and preparation plant at the current Mangoola Coal Mine. Additional infrastructure comprises: construction of a haul road overpass over Big Flat Creek and Wybong Road; establishment of two out-of-pit overburden emplacement areas, including a culvert crossing of Big Flat Creek; and realignment of a section of Wybong Post Office Road. The project involves extraction of 13.6 Mt of run-of-mine coal per year and has an expected operational life of 8 years.

Response to questions

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

General

Question 1: Do the groundwater, surface water assessments within the EIS provide adequate mapping and delineation of surface and groundwater resources?

1. The delineation and mapping of surface water and groundwater resources in the EIS are not uniformly comprehensive. Some investigations and presentation of information are thorough e.g. the assessment of the presence of stygofauna and the identified aquatic ecology in Big Flat Creek and Wybong Creek. For other resources, the investigations or presentation of information needs to be improved e.g. an aquatic ecology assessment of the proposed Hunter River receiving environment and an assessment of impacts to water quality, including from potential discharges.
2. The provision of an ecohydrological conceptual framework (Umwelt 2019e, pp. 52–67) within the EIS provides a clear framework for identifying the risks of most importance. However:
 - a. a comprehensive risk assessment for the project that included details of surface water and groundwater-related risks may have helped to ensure that all issues were appropriately addressed. A risk assessment is provided for the project (Umwelt 2019b) but this provides very limited detail of water-related risks; and
 - b. the ecohydrological model needs to be more comprehensive as, at present, while two GDEs are assessed to be potentially impacted, no attempt has been made to quantify the impacts of the predicted drawdowns on other groundwater-dependent ecosystems (GDEs). This limits the application of the model in identifying causal pathways and the likely severity of potential impacts of altered hydrology on water-dependent ecological assets. These causal pathways can then be used to guide appropriate monitoring and mitigation strategies.

Groundwater and groundwater-dependent ecosystems

3. The delineation of physical groundwater resources is generally appropriate. The proponent has characterised the local groundwater system based on an existing monitoring network, knowledge from the nearby existing Mangoola mine, and targeted investigations.
4. The proponent should provide further evidence of their description of the units described as colluvium in Big Flat Creek, as the IESC considers it more likely that this unit is alluvium, deposited under a different depositional system to the alluvium along Wybong Creek. The proponent should clarify the implications of this classification for the groundwater conceptualisation and parameterisation.
5. The assessment of the presence of stygofauna is sufficiently comprehensive (see discussion in response to question 7).
6. Investigation of local groundwater use is appropriate, though incomplete at the time the EIS was prepared as bore registration details for three bores were outstanding (AGE Consultants, p. 90). While the proponent has provided estimates of impacts to these bores, these estimates should be refined as soon as construction information is available.
7. GDEs are a matter of national environmental significance under the Commonwealth 'water trigger'. The proponent adopts a more restricted interpretation, in which it is only GDEs that host listed threatened species or are threatened ecological communities that they consider to be matters of national environmental significance (Umwelt 2019d p. 54). The only justification given for the classification of groundwater-dependence of vegetation types is their 'location... in the landscape and their floristics' (Umwelt 2019c, Appendix F, p. 34). Consequently, the proponent should provide a more detailed assessment of the local occurrence of GDEs. Their assessment is limited to areas in which groundwater was <10 m from the surface prior to groundwater drawdown from the existing mine. The proponent's justification for this is that the IESC's Explanatory Note on assessing GDEs

states that vegetation in areas with groundwater <10 m from the surface are likely to be groundwater dependent (Doody, Hancock and Pritchard 2019, p. 22). The proponent has not explained why they have not assessed GDEs against the other criteria and principles described in the Explanatory Note as being indicative of groundwater-dependence, such as vegetation communities occurring adjacent to persistent water. The proponent only considers a few of the vegetation types that occur within this area to be dependent on groundwater. It is unclear on what basis other vegetation types have been classified as having low dependence on groundwater, even where they occur in areas with a shallow water table. See further discussion at paragraph 37.

Surface water

8. The assessment of surface water resources is generally appropriate. It is notable that the proponent has established two streamflow gauging sites in addition to the one operated by the New South Wales Department of Industry, though it would be useful if the additional data required to develop robust rating curves for all sites were collected. Local climate data is being collected in addition to the available regional climate data sets, and streamflow quality is monitored at a further twenty sites. Various hydrologic and hydraulic modelling procedures have been used to supplement the available gauging information to provide information on flow regime, water management, and flood risks.
9. Water quality monitoring is currently undertaken as part of the existing coal mine's operation in accordance with the Mangoola Coal Surface Water Monitoring Plan (not provided). The surface water assessment (Appendix 11) for the proposed mine extension includes a summary of water quality data in the Wybong Creek and Big Flat Creek catchments, including physico-chemical parameters and total metals. However, no data is provided for currently monitored sites in the Hunter River e.g. SW14 (downstream of the HRSTS discharge location) or SW15 (downstream of the Sandy Creek/Hunter River confluence). This water quality data is required as controlled release from the Pit Water Dam is allowed, though has not been required to date. The IESC notes it was not clearly stated by the proponent if there had been any or no discharges into the Hunter River at the Hunter River Salinity Trading Scheme (HRSTS) discharge location or if the discharge facility has been constructed. This information is required.
10. The summary of physico-chemical water quality parameters for Wybong Creek and Big Flat Creek that is presented show that water quality is highly variable, with many exceedances of ANZECC/ARMCANZ (2000) (now ANZG, 2018) guidelines for pH, EC, turbidity and TSS. Electrical conductivity in Big Flat Creek is high, with average conductivity of 13 000 $\mu\text{S}/\text{cm}$. The proponent considers the high salinity to be naturally occurring, although they provide little justification for this. Site-specific guidelines are also presented in Table 8 (Appendix 11), however, it is not clear if these were derived only from reference sites, as downstream sites have much higher trigger values than upstream sites. This should be clarified as it is not appropriate to derive site-specific trigger values from impacted sites (see Explanatory Note on Deriving site-specific guideline values for physico-chemical parameters and toxicants (Huynh T and Hobbs D, 2019)). The proponent also records exceedances of default guideline values for aquatic ecosystem protection for aluminium, chromium, copper, lead and zinc in Big Flat Creek, both upstream and downstream. The proponent considers that the exceedances are therefore indicative of background conditions, since exceedances also occur upstream of mining. A discussion of the likely source geology of these metals and consideration of potential for anthropogenic influence would add confidence to this conclusion.
11. The proponent has appropriately assessed aquatic biota in Big Flat Creek and Wybong Creek through a program of field surveys (Umwelt 2019c, Appendix F). However, no aquatic ecology assessment of the proposed Hunter River receiving environment has been undertaken.

Surface Water

Question 2: 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 potential steam flow losses, water quality, discharges and flooding?

Question 3: Are the assumptions used in the modelling reasonable and is there sufficient data within the model to provide meaningful predictions, including worst-case impacts on surface water resources?

12. The assessment of impacts to the volume of water flow due to groundwater drawdown and reduction in catchment area is generally considered appropriate. The assessment of impacts to water quality, including from potential discharges, is incomplete. The flood modelling is considered broadly appropriate, with some outstanding issues. These themes are discussed below.

Streamflow losses

13. The proponent provides appropriate estimates of impacts from the project on streamflow in the short and long-term. The estimates take account of impacts of reduction in catchment area arising from mine works and the reduced baseflow derived from groundwater modelling. Estimates that include cumulative impacts from the existing project are provided (HEC 2019, pp 76–78). Large cumulative reductions in flow to Big Flat Creek are expected, due to the 53% reduction in the catchment area; following rehabilitation, this catchment reduction will be 14%. The proportional reductions to the downstream Wybong Creek are smaller, due to the larger catchment size. The assessment of impacts on catchment yields for Big Flat Creek are heavy reliant on streamflow gauging recorded at GS 210088 (Dart Brook), a catchment which is more than an order of magnitude larger than the relevant reach of Big Flat Creek. It would appear that streamflows have been transposed by catchment area without regard to the non-linearities involved, and thus the IESC agrees that inferences regarding baseflow conditions in Big Flat Creek are conservatively high. This approach would be expected to *over-estimate* the impacts in volumetric terms, but accordingly it would be expected that the impacts of reductions in baseflow are *under-estimated* in terms of the proportion of time that zero flows will occur. Overall, it is considered that only a low level of confidence can be given to the estimates of impacts on local surface water yields, though the assessment of a modest reduction in streamflows in Wybong Creek appears justified.

Water quality and discharges

14. Discharge locations, volumes and qualities are not clearly presented in the EIS. The proponent states that they may discharge water from the Pit Water Dam into the Hunter River, in accordance with their existing licence. Licensed discharges will occur under the provisions of the HRSTS, which will manage salinity impacts. Other than HRSTS-controlled release, the proponent has predicted discharges from sediment dams, which are intended to spill periodically during rainfall events that exceed sediment dam design capacity, in accordance with 'Blue Book' (Landcom 2004) requirements for sediment dams. No spills are predicted from any other dams. The two dams, MNSD3 and MSSD3 which are the closest to the confluence of Big Flat Creek and Wybong Creek have been simulated to have a spill volume, under the predicted 95th percentile, of over 300 ML (HEC 2019, p. 100).

15. Impacts from controlled and uncontrolled discharges are not discussed in the EIS. Any impacts from discharge into the Hunter River will be cumulative with existing impacts from agriculture and mining and these potential impacts should be discussed in the context of current and future monitoring. The IESC notes that while the HRSTS effectively manages impacts from salinity, it is not intended to manage other contaminants. The proponent should provide an assessment of all potential impacts from discharges, including from metal contaminants and cumulative impacts.

16. The northern upslope diversion on the proposed project will discharge directly into Big Flat Creek (HEC 2019, Figure 15, p. 57). The south-western diversion would include a culvert crossing under the realigned Wybong Post Office Road and a silting basin further to the south-west, with a discharge to an existing natural drainage (HEC 2019, p. 66). The northern upslope diversion discharges upstream of the project area into Big Flat Creek, which could improve the water quality, as the monitoring data has highlighted high electrical conductivity (EC) values in Big Flat Creek upstream of the project area.
17. It is not clear if the proponent has constructed the approved discharge facility under the EPL 12894 (HEC 2019, p. 88).
18. The proponent has stated that they may use dust suppressants in place of water during dry years (HEC 2019, p. 76). The proponent has not stated what chemicals these agents are, or provided any analysis of the risks to water quality from their use.
19. The proponent should provide an assessment of the impacts of water discharge that includes: expected quantity, quality and timing of discharges together with assessment of the likely impacts and any proposed mitigation measures (such as water treatment). This may present an ongoing local erosion risk, with implications for downstream water quality (see paragraph 24).
20. Flood modelling shows areas of high velocity in Big Flat Creek following infrastructure installation. This may present an erosion risk and may adversely impact on the aquatic biota from sediment deposition.

Flooding

21. The project will involve changes to the catchment and building of infrastructure that will alter surface water flow, including during floods. The assessment of impacts on flood regime are made using simulation models of hydrologic and hydraulic behaviour that are widely adopted and well proven, and the adopted approaches to characterise flood risk appear consistent with current guidelines. It is not clear how the parameters of the models have been identified and verified, and thus there is a low level of confidence in the *absolute* estimates of flood risk. However, given the nature of the adopted approaches, a good level of confidence can be given to estimates of the *relative* impacts of the proposed mining works on flood risk compared to existing conditions.
22. The proponent believes that due to the location of the existing Mangoola project site and proposed site, there is little effect on flood levels in Big Flat Creek 1.3 km upstream from the confluence with Wybong Creek. As noted in above, conclusions regarding such relative impacts are considered reasonable.
23. The placement of the flood levee could potentially protect the water storage facilities, (MNSD1 and MNSD2) as part of the proposed project, although this issue is not discussed in the EIS. As elevations of these two water storage sites are not provided, it is difficult to assess the risk of impacts from overflow events.
24. Big Flat Creek has highly incised channels downstream from the proposed haul road crossing with high banks in areas ranging from 2.5 to 4 m high (HEC 2019, Attachment A, p. A28-A32). Potential channel stability issues and changes in the velocity in Big Flat Creek have been considered by the proponent, using the 1:20 AEP (greatest peak flow rate) (HEC 2019, p. 67). Results from the TUFLOW modelling predicted that the proposed works would increase flow velocities upstream of the proposed haul crossing. However, the simulated distribution of 1:20 AEP peak flow velocities in Big Flat Creek for a fully developed project shows velocity readings of 3-4 m/s in the areas where there are high banks and highly incised channels downstream of the proposed haul crossing (HEC 2019, Figure 25, p. 72). The higher velocity in this area could also be due to the outlets of the culverts. The proponent should clarify the cause of this area of high velocity and whether any mitigation measures can be provided to avoid erosion impacts.

Groundwater

Question 4: To what extent can decision makers have confidence in the predictions of potential impacts on groundwater resources provided in the EIS, including in regard to groundwater inflows, potential impacts on private bores, change in flux to Wybong Creek Alluvium and salt balance?

Question 5: Are the assumptions and the range of scenarios applied in the groundwater modelling reasonable and is there sufficient data within the model to provide meaningful predictions, including worst-case impacts on groundwater resources?

Question 6: Does the EIS provide an adequate assessment of cumulative impacts to water resources?

25. The numerical groundwater model makes good use of available data and incorporates thorough (Monte Carlo-based) uncertainty analysis. The results from the uncertainty analysis are presented in a clear format and should be a useful tool for decision-makers. The inclusion of parameter identifiability values goes beyond standard practice and provides useful information on model performance. The features of the groundwater modelling described below help to provide further confidence in model predictions.
26. The model provides a clear indication of cumulative impacts (see further discussion at paragraphs 30–31).
- The proponent presents good arguments that the Mount Ogilvie Fault is unlikely to have any material effect on model predictions. Little drawdown is predicted to extend as far as this fault. Additionally, the proponent provides additional model scenarios including the fault in the model with two different sets of hydraulic parameters. This showed negligible influence on model predictions.
 - There is a relatively good dataset for calibration of the model for hydraulic conductivity across most of the area of interest; however, the calculated recharge values require further explanation. Groundwater monitoring for the existing mine provides a reasonable spatial coverage except to the northwest of the project. The monitoring of the existing mine's drawdown provides a considered analogue for the response of the groundwater system to the perturbation that will be induced by the project.
 - The model shows reasonable calibration performance. The root mean square error for groundwater heads was 6.06 m, with a scaled root mean square error of 4.9% (AGE Consultants 2019, Appendix A, p. 21). For comparison, the Australian Groundwater Modelling Guidelines, (Barnett et al. 2012), suggest this should be <10%. Additionally, inflows to the existing mine were within 25% of values estimated from sump pumping and a water balance (AGE Consultants 2019, Appendix A, p. 33). Given that there is considerable uncertainty in the groundwater inflow values, the IESC agrees with the proponent's assessment that this represents an acceptable agreement.
 - There is general agreement between calibrated hydraulic conductivity values and those estimated from site investigations (compare AGE Consultants 2019, pp. 71–77 and AGE Consultants 2019, Appendix A, p. 27). The site investigations included several rounds of testing and included slug, packer and core testing.
27. Some additional information that could help to further increase confidence in groundwater model predictions is suggested below. These would particularly add confidence that modelling and associated uncertainty analysis captures worst-case scenarios.
- The proponent maps a number of faults in the project area. These faults are considered in the groundwater assessment as being unlikely to affect groundwater flow, given the small cross-

sections of the fault damage zones and potential for fault gouge sediment to seal the faults. No information on fault throw or type is provided. Additional justification should be provided for the assumed behaviour of faults in the project area, particularly Big Flat Creek Fault. Given that Big Flat Creek appears to be partially controlled by this fault, further information of this fault's geological and hydrogeological characteristics is important, particularly in regard to future impacts on baseflow. This discussion should address the potential for the fault to provide a pathway for baseflow in the creek or for leakage to deeper aquifers. Additional groundwater sensitivity scenarios, similar to that conducted for the Mount Ogilvie Fault, may also help to justify the conceptualisation of faults within the project area.

- b. The proponent estimated storage parameters (specific yield and specific storage) from Young's Modulus and porosity, rather than from more traditional methods such as pump tests. This approach is a reasonable first approximation if based on several rock core measurements.
 - i. *In situ* measurement of storage and geomechanical properties for each hydrostratigraphic unit could be obtained from advanced analysis of high frequency groundwater level data (McMillan et al 2019). This approach could be considered for inclusion in ongoing updates to the model over the life of the mine.
- c. Geological cross-sections, that are drawn to scale, should be provided to support the geological conceptualisation. The outline of geology includes two cross-sections that are labelled 'conceptual interpretation – not drawn to scale' (AGE Consultants 2019, pp. 30–31). The IESC does not consider a conceptual cross-section to be a suitable basis for environmental impact assessment.
- d. There are only two bores to the northwest of the project area, with one no longer monitored (AGE Consultants, Appendix A, p. 19). This means that confidence in predictions is lower in this area. This shortcoming does not have major consequences for confidence in the model's predictions, as the most likely receptors to be impacted are not in this direction, but rather to the southeast and southwest of the project area.

28. Additionally, some information in the groundwater assessment should be more clearly presented.

- a. Maps of groundwater drawdown should be provided for the 0.2m contour, since small changes in groundwater levels may impact some GDEs, especially from a 'worst-case' impact perspective. These maps should also show uncertainty bounds for this contour. The EIS only presents drawdown to 1 m (Umwelt 2019c, pp. 42–43) and the uncertainty analysis reports confidence intervals for 2 m of drawdown (AGE Consultants 2019, Appendix A, pp. 53–54).

29. The proponent only provides groundwater quality monitoring data for one month – September, 2017. The IESC cannot determine whether these data are typical of the groundwater quality. These data show exceedances of water quality guideline values for several metals in at least some of the bores – zinc, copper and aluminium at the majority of monitored sites; antimony, arsenic, chromium, lead, manganese, molybdenum, nickel and selenium at some locations (AGE Consultants 2019, Appendix D). This suggests that water from the pit water dam may add metal contaminants to the Hunter River, if not treated prior to discharge. For nutrients, there were exceedances for ammonia and nitrite against aquatic ecosystem protection guidelines, as well as total nitrogen and total phosphorus exceedances against long term irrigation guidelines. The implications for these exceedances were not discussed.

Cumulative impact assessment

30. The numerical groundwater model includes both the existing coal mine and the project. The IESC agrees that it is unlikely that the extent of groundwater drawdown for the project will overlap with that of other existing mines and that this approach is appropriate. The results of the groundwater model

are presented for two scenarios: the cumulative scenario, with the existing coal mine plus the project; and the incremental scenario, with cumulative impacts less those attributable to the existing coal mine. This presentation of results allows the reader to appropriately assess both cumulative and incremental impacts.

31. Greater contextual information on historical cumulative impacts to the groundwater resource, and to GDEs, would provide useful background to understand the setting of the project's cumulative impacts. Information would ideally be provided on the likely former extent of locally-occurring GDEs and on regional historical impacts to the groundwater regime (including surface water-groundwater interactions), groundwater quantity and water quality, including the ongoing extensive mining and agricultural activity.

Water-dependent Ecosystems

Question 7: Have the impacts of the project on surface water and groundwater dependent ecosystems (including stygofauna) been adequately described and assessed?

32. The documentation includes useful information for the assessment of potential impacts to water-dependent ecosystems. However, the information is not well integrated and there are major gaps in some areas. This means that some potential impacts are likely to be incompletely described or understated. More detail is provided below in paragraphs 37–39.

Surface water impacts

33. Changes to the local surface water regime are expected to impact on water-dependent species. As discussed in response to question 2, comprehensive information on planned water discharges has not been provided, so the IESC cannot assess the potential impacts on the downstream environment.
34. There is the potential for the final landform to cause impacts via altered surface runoff. This is discussed further in response to question 8. The IESC notes that there will be a discharge point with the drainage channel in the northern part of the final landform into Big Flat Creek, and the implications of this discharge point on the water quality, biota and ecological processes downstream should be fully assessed.
35. Further information on impacts on streamflow is provided in paragraph 13.
36. The magnitude of incremental impacts predicted to aquatic ecological systems is not large and these may be managed by appropriate monitoring and adaptive management. Further consideration of these changes to the catchment area during operational stages of the proposed project could be included in the ecohydrological conceptual model. Illustrating potential causal pathways and mechanisms of effects of altered surface flows, groundwater exchanges and in-stream water quality would help the proponent justify strategies proposed to manage and mitigate potential impacts (also see response to question 8).

Groundwater-dependent vegetation

37. While the proponent has undertaken aspects of a GDE assessment, there are gaps that mean that impacts may be underestimated. As described in response to question 1, the IESC considers that the proponent has likely underestimated the area of vegetation in the vicinity of the project that is potentially groundwater-dependent. This affects all estimations of likely impacts. The proponent maps vegetation that they classify as groundwater-dependent, overlain with the predicted extent of the 1 m water table drawdown contour. This provides an indication of the extent of potential impacts. However, this initial assessment is not conservative. Sensitive GDEs (especially seedlings and

juveniles with shallow roots) could be impacted by drawdown in the water table of <1 m (see paragraph 28). Additionally, this overlay is only provided for the basecase groundwater model predictions. The proponent should provide an overlay of vegetation types together with the 0.2 m water table drawdown contour for both the basecase and uncertainty scenarios (cumulative and project only). This would provide a good basis for further analysis of the potential risks to GDEs.

38. The proponent has not described the impacts of direct clearing on groundwater-dependent vegetation. This should also be included as part of the assessment to GDEs.
39. The IESC notes that impacts to GDEs will be cumulative within the region of the existing mine. Groundwater modelling indicates that the majority of groundwater drawdown in the vicinity of Big Flat Creek is attributable to the existing mine. The project will cause some increase in the total area of impact. Moreover, GDEs that are still present are likely to have been stressed by the existing drawdown.

Stygofauna

40. The proponent has adequately assessed stygofauna, consisting of:
 - a. a field-based stygofauna assessment, in which 11 bores were sampled. No stygofauna taxa were identified. Two taxa, not considered to be stygofauna were identified in four bores. These were Oligochaeta (worms) and Oribatida (soil mites), both of which are considered to have an association with soil habitats rather than aquatic systems (Eco Logical Australia 2019); and
 - b. a risk assessment of impacts to stygofauna (Eco Logical Australia 2019, section 7). The proponent also considers that local groundwater conditions, within the colluvium near the project area are considered to be poor habitat for stygofauna because they lack permanent water. The proponent notes that the Wybong Creek alluvium could contain stygofauna originating in the Goulburn Creek alluvium (though the two bores sampled in this area did not reveal any stygofauna). However, the alluvium in this area closest to the project is thin, and the project contributes relatively little to the cumulative 1 m of drawdown predicted in this area.

Avoidance, Mitigation and Monitoring

Question 8: Are there any additional mitigation, monitoring, management or offsetting measures that should be considered by decision makers to address the residual impacts of the project on water resources in conditions of consent?

41. The proponent proposes that management and mitigation will be achieved through a *Surface Water and Groundwater Response Plan*. A flow-chart of the trigger-action-response plan (TARP) is provided in AGE (2019, pp. 134–36). The plan is for the existing coal mine, but it will be updated for the project. However, it is unclear whether any changes other than an expansion of the monitoring network are proposed. Under the current plan, trigger exceedances lead to investigations to confirm whether the exceedance is mining-related and has caused environmental harm. If these conditions are met, unspecified mitigation measures will be implemented. The full plans for the existing coal mine (not included in the EIS: Glencore 2014) also fail to list specific mitigation measures that may be employed. To provide confidence in the ability of this plan to guide the reduction of impacts, the proponent should propose and commit to specific effective and practicable mitigation measures (and provide evidence (data or literature) to support these suggested strategies).

Groundwater

42. Additional information should be provided on the existing and proposed groundwater monitoring network. To assist with assessment of coverage of the monitoring network, a map should be provided that shows all bores coded by target aquifer. Details of bore construction should be included in the assessment documentation. The IESC notes that the groundwater monitoring plan for the existing project (Glencore 2014), although not part of the assessment documentation, does include target aquifers but not full construction details.
43. The proponent proposes four additional monitoring bores along Wybong Creek. This increase in coverage is commended, but without details of the target aquifers it is difficult to evaluate how effective this will be at detecting impacts. Ideally, bores would be nested, with groundwater measurement in deeper aquifers providing warning of potential future impact to the water table.
44. As discussed in paragraph 29, the proponent has only undertaken one round of groundwater monitoring (September 2017) that includes a broad suite of metal and nutrient analytes, and these were measured at only 8 sites. The results are presented (AGE Consultants 2019, Appendix D), but not discussed in the assessment documentation. A discussion of the implications of these results should be provided. The proponent indicates an intention to introduce monitoring of a broad suite of metals in groundwater, but has not specified to which bores this new monitoring will apply (AGE Consultants 2019, p. 131). Recent monitoring has identified several metals with concentrations above default guideline values (zinc, copper and aluminium at most sites; antimony, arsenic, chromium, copper, lead, manganese, molybdenum, nickel and selenium at some sites). Given this, it is important that sufficient bores are monitored for groundwater quality to identify causes and trends in groundwater quality. Baseline data must be collected to enable impacts from the project to be identified. It is also not clear why the proponent proposes to assess groundwater quality against recreational water quality guidelines (AGE Consultants 2019, p. 131).

Surface water

45. The proponent, while stating that the average annual reduction of 320 ML in flow represents a small and indiscernible impact to the flow in Wybong creek, suggests a possible mitigation option of a permanent retirement of this volume of water access licences from the Wybong Creek Water source within the Hunter Unregulated and Alluvial Water Sources (HEC 2019, p. 77). This would likely be an effective mitigation measure for ecological impacts to Wybong Creek. It would not mitigate impacts to Big Flat Creek and will permanently reduce the number of licences available for other uses.
46. The proponent intends to monitor surface water quality, channel stability, the water management system and discharge water in accordance with their existing surface water monitoring plan, which they will update to include the proposed project (HEC 2019, p. 106). This document was not provided as part of the EIS. Details of how this plan will be updated for the project have not been provided. The proponent also states that they intend to produce a construction phase Erosion and Sediment Control Plan to manage the construction works adjacent to the Big Flat Creek. These details should be provided so that their likely benefits can be assessed.
47. It is unclear from the assessment documentation whether the proponent plans to continue monitoring the stream biota as has been undertaken for the existing mine. This stream monitoring program, including judiciously chosen control sites, presented in Umwelt (2019c, Appendix F) is well designed to detect impacts and to distinguish these from natural variability. The IESC recommends that this monitoring should be continued for the project, and that refinement of site-specific guideline values and appropriate mitigation strategies be incorporated in the routine assessment of results after each sampling round.

48. As discussed in response to questions 2 and 3, the proponent has not clearly identified expected discharge quality (particularly in relation to metal contaminants). This lack of provided information limits the IESC's capacity to critically appraise the appropriateness of the proposed mitigation or monitoring. IESC notes that aluminium is not included in the proposed monitoring suite of parameters for surface water monitoring sites (Table 28, Appendix 11). Given the frequent exceedances for aluminium both upstream and downstream, aluminium should be included. In addition, the proposed monitoring of the water management dams on site (Table 28, Appendix 11) does not include any monitoring of metals. Metals (both total and dissolved) should be included, as these storages, especially the Pit Water Dam, may discharge to the Hunter River in future.
49. As discussed in response to questions 2 and 3, local groundwater is of poor quality (high salinity, and several nutrient and metal concentrations above guideline values). This may necessitate treatment of water prior to discharge to mitigate impacts to the water quality and biota of the downstream environment. The timing of discharges should be limited to times that minimise impact to the receiving environment. Streambed and bank armouring may be required to prevent localised erosion. Appropriately-designed monitoring, including water quality monitoring, should be undertaken to confirm that water quality and erosion management measures are effective.
50. The proponent suggests (HEC 2019, p. 74) that armouring may be required to mitigate erosion in Big Flat Creek associated with infrastructure installation. The nature of this armouring and the circumstances in which it would be installed should be explicitly described.

Final landform

51. The final landform may alter runoff to adjacent areas with potential impacts on critically endangered species. There are known occurrences of the critically endangered orchid *Prasophyllum* sp. Wybong near the final landform, particularly to the southwest. The pattern of runoff from the proposed (conceptual) final landform is not entirely clear from the information presented in the assessment documentation (HEC 2019, pp. 64–65). To avoid impacts to these orchids, the final landform should be designed to avoid runoff changes to these sensitive receptors. The IESC also notes that, as it is difficult to identify orchids other than when they are in flower, their distribution may be underestimated. Therefore, additional *Prasophyllum* sp. Wybong may be identified prior to construction of the final landform and, if so, should be taken into account in the landform's design.
52. In the geochemical assessment, the proponent concludes that most of the tailings are likely to be non-acid forming, with elevated salinity and moderate alkalinity. There are likely to be localised occurrences of potentially-acid-forming material close to outflow points. The alkalinity in the surrounding material is expected, in general, to neutralise the small amounts of acid. The proponent does, however, caution that acid and salinity may have local impacts on the rehabilitated landform and its vegetation (conceptual plan suggests ≥ 3 m cover above tailings) in the absence of appropriate controls, and recommends that this be considered further during detailed design (EGI 2019, pp. 36–37). The IESC agrees that this should be an important aspect of final landform design.

Date of advice	4 October 2019
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Source documentation provided to the IESC for the formulation of this advice	Umwelt 2019a. <i>Mangoola Coal Continued Operations Project Environmental Impact Statement</i> , prepared on behalf of Mangoola Coal Operations Pty Ltd. July 2019. Available [online]: https://www.planningportal.nsw.gov.au/major-projects/project/10131 .
	Cited appendices are listed below.

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