

Advice to decision maker on coal mining project

IESC 2020-113: Angus Place Mine Extension Project (EPBC 2013/6889 and SSD 5602) – Expansion

Requesting agency	The Australian Government Department of Agriculture, Water and the Environment 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 Agriculture, Water and the Environment and the New South Wales Department of Planning, Industry and Environment to provide advice on Centennial Angus Place Pty Limited's Angus Place Mine Extension 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 Angus Place Mine Extension Project is a proposed extension of longwall mining at the existing Angus Place Colliery. It is located in the Lithgow region of New South Wales and underlies the Newnes Plateau. The project will mainly use existing infrastructure located at the Angus Place Colliery and the adjacent Springvale Mine (also owned by Centennial Coal). Additional ventilation shafts and dewatering infrastructure will be constructed on the Newnes Plateau. Coal production will be increased to approximately 4.5 million tonnes (Mt) run-of-mine (ROM) thermal coal per year, extracting it from 15 longwall panels. Tri Star Swamp and Twin Gully Swamp are two Temperate Highland Peat Swamps on Sandstone (THPSS), an ecological community listed as endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), that will be directly undermined. Mining will also

occur within 600 m of a further four THPPS: Japan (Trail Six) Swamp, Birds Rock Swamp, Crocodile Swamp and Wolgan River Upper Swamp. These swamps are also state-listed endangered ecological communities of Newnes Plateau Shrub Swamp (NPSS) in the Sydney Basin Bioregion. An unspecified number of hanging swamps (also EPBC Act-listed) and approximately 38 km of watercourses will also be directly undermined. The project site lies within Sydney's drinking water supply catchment and includes creeks that drain into the nearby Gardens of Stone National Park and the Greater Blue Mountains World Heritage Area.

Key potential impacts from this project have changed little from those of the original proposal reviewed by the IESC in 2014 and are:

- The severe and irreversible loss of EPBC Act-listed Tri Star Swamp, Twin Gully Swamp and Japan (Trail Six) Swamp due to mining-associated ground movements. These movements will cause the swamps to dry, in turn, adversely affecting their ecological components and processes, habitat values and capacity to form peat.
- Partial drying of EPBC Act-listed Crocodile Swamp and Birds Rock Swamp and likely partial drying of the EPBC Act-listed Wolgan River Swamp and Wolgan River Upper Swamp through mining-associated ground movements. Drying of part of a swamp typically results in serious irreversible damage to the ecological condition of the entire swamp and not just the parts that dried. It also renders them highly vulnerable to severe damage by wildfire.
- The severe and irreversible loss and/or hydrological alteration of an unquantified number of hanging swamps (also included in the EPBC Act-listing of THPSS) that will be directly undermined and experience up to 2,250 mm of total vertical subsidence with likely cracking of the swamp base.
- Cracking of the streambed along 38 km of watercourses that will be directly undermined by the project. This will result in potentially long-term changes to their hydrology, aquatic ecology and riparian vegetation. Cracking could also occur in the Wolgan River as parts of the river are located as close as 180 m to proposed longwall panels, and subsidence impacts are likely to be propagated along lineaments.
- The loss of THPSS will affect multiple threatened species that rely on this habitat such as Deane's Boronia (*Boronia deanei*), the Blue Mountains Water Skink (*Eulamprus leuraensis*) and the Giant Dragonfly (*Petalura gigantea*). These species have recently had large swathes of their habitat severely impacted by bushfire.
- Long-term reductions in surface water flows due to the combined effects of groundwater drawdown and streambed cracking. These reductions will further impact THPSS ecological communities as well as adversely affecting aquatic and riparian ecosystems, including the streams that flow into the Greater Blue Mountains World Heritage Area as well as Warragamba Dam, Sydney's drinking water supply.

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

- The proponent needs to reconsider the proposed mine layout and other options to reduce impacts, particularly to THPSS and their upstream tributaries. These options include changes to longwall extraction heights, panel widths and panel lengths. The IESC strongly believes that because no remediation options exist, adaptive management will not prevent irreversible damage to or loss of THPSS once monitoring detects adverse impacts. The only approach that will avoid most key potential impacts is to redesign the mine layout as suggested in Paragraph 13.

- Further analysis of potential impact pathways for THPSS and streamflows is required. The current assessments focus on the groundwater impact pathway and do not adequately consider possible changes to surface water flows and upstream hydrological alterations. Appropriate mitigation and management measures cannot be identified without a clear understanding of all potential impact pathways.
- Several refinements to the groundwater model are suggested to improve confidence in the impact predictions (see Paragraphs 5 and 15 below). In addition, the effects of the adopted model design, its parameterisation, and lack of data on the predictive uncertainty should be quantified.
- Further site-specific data is required to parameterise and calibrate the groundwater model (see Paragraphs 3 and 15 below).
- Further effort is required to improve the defensibility and predictive performance of the catchment runoff (i.e. Australian Water Balance Model) component of the Springvale Angus Place Swamp Water Balance Model, with particular attention given to improving simulation of the low-flow regime.
- Additional consideration and risk assessment of spatially local impacts are required. Many potential impacts are assessed by the proponent as insignificant at the regional scale but the IESC considers that this assessment is inadequate given the importance of local conditions to individual THPSS and their inhabitants. For example, the Blue Mountains Water Skink has only a limited ability to disperse and colonise new habitat when their existing habitat is adversely impacted and so the risk of local extinctions of this endangered species is high.
- Assuming the mine layout is modified as strongly recommended by the IESC (see Paragraph 13 below), further work on proposed monitoring and management plans is needed. This work is needed because adaptive management approaches are not feasible as damage to THPSS is irreversible.

Context

The Angus Place Mine Extension Project (the 'project') is a proposed extension of the existing Angus Place Colliery located 15 km northwest of Lithgow and 120 km west-northwest of Sydney in New South Wales. An expansion of the Angus Place Colliery was originally proposed in 2013 at which time it was reviewed by the IESC (IESC 2014-053). In 2015, the Angus Place Colliery was placed into care and maintenance and the original expansion did not progress. The proponent has amended the original proposed expansion, and now proposes to mine 15 longwall panels to the east of existing mining at Angus Place Colliery and to the north of the Springvale Mine (also owned by Centennial Coal). The project would extract up to 55.2 Mt ROM thermal coal by late 2053.

The project is located within Sydney's drinking water supply catchment and is adjacent to the Greater Blue Mountains World Heritage Area and the Gardens of Stone and Wollemi National Parks. Mining will occur beneath the Newnes Plateau, the only location where the state-listed endangered ecological community Newnes Plateau Shrub Swamps (NPSS) occurs. NPSS are part of the Temperate Highland Peat Swamps on Sandstone (THPSS), an ecological community listed as endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Combined, the Springvale Mine and Angus Place Colliery cover approximately 15% of the known extent of the NPSS ecological community (RPS 2019, App. D, p. 10). Several THPSS have already been irreversibly impacted by mining in this region. Recent bushfires have also impacted a number of THPSS, with impacts being especially severe on swamps already damaged by mining.

The recent 2019/20 catastrophic fire season in Australia provides an insight into likely future climate scenarios that will affect the forested regions of eastern Australia, including the Greater Blue Mountains

World Heritage Area and adjoining areas. Swamps such as Carne West Swamp and Gang Gang West Swamp, already drier as a result of mining-induced changes in their hydrology, are extremely vulnerable to further extended dry periods (droughts) and fire. As a unique wetland type, these swamps require the highest level of protection and management.

Response to questions

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

Question 1: Does the IESC consider its previous concerns as documented in IESC 2014-053 have been adequately addressed?

1. Many key issues raised in the previous IESC advice (IESC 2014-053) for this project remain unaddressed, and aspects of the revised mine design (e.g. extending a longwall to now undermine Twin Gully Swamp) in this current proposal have raised or exacerbated other issues.

Subsidence

2. The previous IESC advice (IESC 2014, Paragraph 8) noted that the simplified approach to prediction of subsidence impacts near lineaments (i.e. increasing predictions obtained from the Incremental Profile Method by 25%) was insufficient. It appears that this approach continues to be used (MSEC 2019, p. 29). As discussed in Paragraphs 4 and 27 below, mining-induced ground movements associated with lineaments (especially those of Types 1 and 2) have impacted swamps. The ability to reliably quantify these potential impacts is crucial, especially as the interaction of subsidence and lineaments can cause non-conventional ground movements that exceed conventional subsidence movements.

Groundwater

3. The 2014 IESC advice (Paragraph 34a) recommended that the proponent undertake further hydrogeological testing to provide data with which the groundwater model could be parameterised. This was particularly the case for the Mt York Claystone. It is unclear whether this has occurred and if site-specific data has been used to parameterise the current groundwater model, (e.g. the hydrographs in Figure 4.23 (Jacobs 2019b, App. H, p. 69) do not have a clear time scale).
4. Lineaments are noted to influence and often exacerbate subsidence-related movements and increase impacts to THPSS where they intersect a swamp or its recharge source (IESC 2014, Paragraphs 7 and 15; MSEC 2019, p. 37). The previous IESC advice noted that these features should be better represented in the groundwater model (IESC 2014, Paragraph 9). Clearer explanation of the implementation of lineaments in the current groundwater model and in the uncertainty analysis is still needed, especially for the characterisation of the different types of lineaments.
5. Significant subsidence (up to 2,250 mm) is predicted to occur in the project. Subsidence, changes in hydrogeological properties and, in turn, changes in groundwater behaviour are coupled processes. Mining-induced changes in the overburden (e.g. subsidence) lead to changes in the hydrogeological properties of soil and rock. These changes in hydrogeological properties change groundwater behaviour. These coupled groundwater-geomechanical processes have not been adequately quantified by the proponent. An assessment of potential impacts to both surface water and groundwater behaviour due to the project is recommended using an approach that considers stress and strain changes in the overburden due to longwall mining and the changes in the hydrogeological properties of the rock and soil (e.g. Newman et al. 2017; UDEC modelling <https://www.itascacg.com/software/udec>)

Surface water

6. The surface water seasonal flow regime and potential changes in baseflow due to the project were not documented (IESC 2014, p. 2). For the current project, only annual changes have been assessed. The combined (seasonal and annual) changes due to groundwater drawdown, reductions in outflows from THPSS and potential streamflow losses caused by streambed cracking and flow reductions are still not clearly articulated. As flow has been lost through stream diversion previously, sometimes substantially (e.g. the diversion of mine discharge from the Springvale Mine at East Wolgan Swamp) and with the destination of the diverted surface water unclear, these should be fully considered for each water course. Additionally, hydrological connectivity between water courses, their alluvium and the underlying mine-impacted hydrogeological units has not been adequately discussed yet this was previously sought by the IESC (IESC 2014, Paragraph 34c).
7. The IESC (IESC 2014, Paragraphs 35, 39 and 42) recommended that more information be provided on predicted surface water quality changes due to the proposed project. The proponent is no longer going to discharge mine-affected water at LDP001; instead, it will be transferred to the Springvale Water Treatment Plant. However, site run-off and water from the “dirty water” storages (Jacobs 2019a, Figure 5.3, p. 52) will still be discharged at LDP002 into Cocks River, with possibly only sediment settlement occurring before discharge. The Cocks River flows into Warragamba Dam, the major source of Sydney’s drinking water. It is unclear if, and which, water quality parameters will be measured within the receiving environment of the Cocks River. Limits for oil and grease, pH and total suspended solids under low-flow conditions at LDP002 are currently specified in the site’s Environment Protection Licence, but no instream water quality monitoring data has been presented (see Paragraph 25 below).

Groundwater-dependent ecosystems (GDEs)

8. The current proposal still includes direct undermining of THPSS and their upstream tributaries. The potential for severe and irreparable impacts to THPSS was emphasised in the previous advice (IESC 2014, p. 2), and the IESC strongly recommended not undermining THPSS. Those recommendations still apply to the current proposal.
9. The IESC previously noted that adaptive management approaches and the use of trigger action response plans (TARPs) are generally unlikely to be successful for mitigating and managing impacts to THPSS (IESC 2014, Paragraph 31). There is no evidence that the proponent has taken account of this advice. Adaptive management approaches and use of triggers are generally discussed (e.g. RPS 2019, App. B) for managing potential ecological impacts but this presupposes (i) the capacity to detect changes before they affect the ecological integrity of a given THPSS and (ii) that, if any impact occurs, it can be remediated and reversed. No remediation options for damaged THPSS or fractured streambeds have been shown to be completely successful (Commonwealth of Australia 2014a). Details of the current proposed management options are limited, and no evidence has been provided supporting their likely efficacy. The IESC reiterates that adaptive management approaches are not applicable to undermined or impacted THPSS, and that redesigning the mine plan (see Paragraph 13 below) to avoid such impacts is the only feasible option.
10. Although some additional data and information for some THPSS have been provided in the current documentation, the IESC notes that this is still not sufficient to characterise the surface water, groundwater and ecological components of each potentially impacted THPSS (IESC 2014, Paragraph 10). Data has only been provided for some THPSS and the temporal coverage is not enough to adequately capture seasonal or inter-annual variability. No individual detailed swamp water balance models have been provided and THPSS have not been individually conceptualised as recommended by the IESC (2014, Paragraph 11). Additionally, as the full extent of maximum groundwater drawdown due to the project has not been defined (see Paragraph 16 below), it is

unknown whether all potentially impacted THPSS and other GDEs have been identified, including those outside the project area and especially to the east where extensive drawdown is predicted.

11. The previous IESC advice noted that the coarse scale of the groundwater model did not allow reliable prediction of potential impacts at small localised features such as individual THPSS (IESC 2014, p. 2, and Paragraphs 1, 4 and 33). The scale of the current groundwater model, which uses a variable grid discretisation, is still large compared to these small localised features, although the IESC appreciates the pragmatic considerations which limit the minimum grid discretisation size. The proponent has assessed impacts to THPSS using a water balance modelling approach. The Springvale Angus Place Swamp Water Balance Model (SAPSWBM) is not directly coupled with the groundwater model; however, it utilises the predictions and outputs of that model. The adequacy of this approach to predicting changes to swamp hydrological regimes is unclear as:
 - a. the approach appears to focus on changes in swamp outflows arising from changes to groundwater discharges at the swamp. It is unclear whether other potential impact pathways, such as changes to surface water flows occurring upstream of the swamp through groundwater drawdown and/or surface water losses, are fully included in the assessment; and,
 - b. the history-match (calibration) of the SAPSWBM is not adequately discussed. A reasonable match was obtained at the river gauges; however, the match was poorer for the swamps discussed. Generally, the SAPSWBM appears to systematically over-predict streamflows (Jacobs 2019a, App. E, pp. 42-43) which will tend to lead to the under-prediction of the potential impacts.

Question 2: Does the IESC have any further advice or recommendations on the Amended project?

12. Given that no proven remediation options exist for impacted THPSS, the IESC strongly advises that the proponent redesign the mine layout as recommended in Paragraph 13 below. This suggested redesign of the mine layout should prevent or minimise irreversible damage to THPSS as has already happened from previous mining in this region (e.g. Carne West Swamp, Gang Gang East Swamp, Gang Gang West Swamp). To confirm that this redesigned mine layout (i.e. not the Amended project as currently proposed) is successfully protecting THPSS and other water resources, monitoring will be required and the IESC has made some further recommendations about this in Paragraphs 14, 19, 20, 25, 33 and 34 below. Other advice and recommendations are also detailed below.

Subsidence

13. As previously highlighted by the IESC, the only way to prevent impacts to THPSS is to avoid direct undermining of swamps and their supply aquifers. Tensile and compressive strains should remain below 0.5 mm/m and 2 mm/m respectively, as there are no known peer-reviewed studies of successful remediation (Commonwealth of Australia 2014a; 2014b). Currently these strains are predicted to be exceeded at Tri Star Swamp, Twin Gully Swamp and Japan (Trail Six) Swamp as well as an unspecified number of hanging swamps. The proponent needs to consider and discuss the feasibility of changes to the mine layout including:
 - a. decreasing the height of extraction and/or the width of panels (currently planned to be 360 m) particularly when panels are located within 600 m of THPSS (or within 2,250 m when coincident with a lineament (see Paragraphs 4 and 27 of this advice)) to minimise the risk of cracking to the surface beneath these swamps;
 - b. decreasing the lengths of longwall panels LW1004, LW1005, LW1009 and LW1010 to avoid directly undermining Tri Star Swamp and Twin Gully Swamp, and decreasing the lengths of LW1014 and LW1015 to increase the distance between Japan (Trail Six) Swamp and the proposed longwall panels;

- c. decreasing the lengths of longwall panels LW1001-LW1007 to increase the distance between the project and swamps such as Birds Rock Swamp, Crocodile Swamp, Wolgan River Swamp and Wolgan River Upper Swamp;
 - d. not undermining the Type 2 lineament below Tri Star Swamp; and,
 - e. not causing drawdown of the Burrell Formation, which is a key water source for many NPSS, THPSS and hanging swamps on Newnes Plateau (McHugh 2014, pp. 14-18).
14. The proponent has identified that non-conventional ground movements are likely and could result in elevated tilts and curvatures which may exceed those predicted to occur from conventional ground movements (MSEC 2019, p. 60). Although it is difficult to predict the location and magnitude of non-conventional ground movements, the possible impacts of these require consideration especially for understanding potential worst-case scenarios. Further discussion of possible worst-case scenarios for sensitive receptors (e.g. THPSS, Wolgan River) from the combined effects of conventional and non-conventional ground movements should be provided, and may indicate the need for further redesign of the mine layout to minimise risks of irreversible harm to THPSS and surface streams from these combined effects. Monitoring for non-conventional movements at sensitive receptors should be undertaken.

Groundwater

15. The IESC notes that the current groundwater model is large and complex. It attempts to incorporate many processes and predict a range of potential impacts. Several components require further discussion and possible refinement to improve confidence in the predictive ability of the model.
- a. The proponent needs to describe how the (Bayesian) prior parameter distribution used in the uncertainty analysis for the groundwater model was derived from the site-specific hydraulic parameter data and adjusted for the adopted parameterisation.
 - b. The peer review noted that several parameters are unusually high in order to achieve a history-match (Jacobs 2019b, App. H within App. G, p. 6). A full discussion should be provided of these parameter values and the potential effects on impact predictions of the high parameter values implemented.
 - c. The provided history-matching results are mixed with some poor matches, including at swamps (e.g. Japan (Trail Six) Swamp, Jacobs 2019b, App. G, Figure 4.32, p. 81). While this misfit appears consistent with the sparse distribution of pilot point parameters, there is no discussion of how these residuals between the measured data and corresponding modelled outputs are considered in the uncertainty analysis.
 - d. History-matching used super-parameters and pilot points (Jacobs 2019b, p. 78). Further consideration of the influence and potential bias of the sparseness of this parameterisation on impact predictions should be provided.
 - e. The proponent has noted issues with implementing underground roadways in the model (Jacobs 2019b, App. G, p. 54). These issues should be explained further in the context of any potential effects on impact predictions.
 - f. Further discussion on how the effects of subsidence are considered in the groundwater model should be provided (e.g. Newman et al. 2017), including calculations of the height of cracking based on both the Tammetta and Ditton methods and the suitability of these methods for the project conditions.

- g. Although a detailed uncertainty analysis was undertaken, the presentation of the results could be improved. Maps of drawdown extent (with the locations of all swamps (including hanging ones) and streams clearly identified and including the 0.5-m contour) which include levels of uncertainty, and plots of mine inflows or baseflow losses including levels of uncertainty could be used to summarise key results clearly. Assessment of the likely effects of the fixed parameters and the sparse parameterisation on the reported uncertainty analysis are required for confidence in the predictive uncertainty analysis.
 - h. No plan for model updates was clearly articulated. This should be included in the groundwater management plan. The model should be updated every two to five years. However, if observations do not reasonably match predictions, a model review should be commenced sooner.
16. No predictions of the maximum extent and magnitude of drawdown are provided. Drawdown predictions at 38 years post-mining show the spatial extent of drawdown continuing to increase and it is unclear whether the maximum magnitude of drawdown has occurred at all locations at this time.
- a. Further post-processing of the existing modelling files, and possibly additional modelling, is required to identify the likely maximum extent and magnitude of drawdown in all potentially impacted aquifers.
 - b. The IESC notes that the spatial extent of the groundwater model should be increased as drawdown extends beyond the current eastern model boundary at 38 years post-mining, meaning that the model boundary is constraining and potentially distorting the predictions. The location and type of boundary condition could be further assessed through sensitivity analysis to understand this impact which would likely entail extending the boundary condition further east.
 - c. The reported significant decreases in groundwater levels within THPSS that would not recover within the 50-year post mining prediction period give cause for serious concern, particularly when considering the impact of climate change superimposed on these drawdown impacts. The proponent needs to consider the impacts of climate change on the drawdown predictions.
 - d. Modelling should be completed during impact assessment and not left until closure planning as currently suggested by the proponent (Jacobs 2019b, p. 91). This will enable informed decision-making, including the decision to alter longwall dimensions and mine layout to avoid impacts that cannot be remediated or compensated for by using offsets.
17. Predictions of drawdown are provided for what is described as the 'uppermost watertable aquifer'. Further context on what the uppermost watertable aquifer corresponds to should be provided. Also, the spatially discontinuous nature of the drawdown predictions within this aquifer (Jacobs 2019b, Figure 5.11, p. 86) should be explained.
18. The proponent states that surface water takes will increase post-mining (Jacobs 2019a, p. 77), but considers that post-mining streamflow loss predictions are likely to be considerably overestimated by current modelling due to the implementation of subsidence-induced changes to hydrogeological properties in the groundwater model (Jacobs 2019b, App. G, p. 192). However, the IESC also notes that the pilot point parameterisation adopted in the groundwater model was sparse due to the computational burden of long model run times. A consideration of whether this sparse parameterisation may cause a systematic bias resulting in underestimated stream baseflow predictions is required. Additional modelling should be undertaken to characterise the predicted take and its impact on the reliability of downstream water extractions, especially for Sydney's drinking water supply.
19. The proponent does not present plans to expand the current groundwater monitoring network. To the east, north and northwest of the project, monitoring is limited and mainly uses vibrating wire

piezometers (VWP) (Jacobs 2019b, Figure 4.1, p. 46). Additional monitoring infrastructure should be installed considering:

- a. VWP do not allow actual measurements of water levels, have a limited lifespan and are not generally replaced, and cannot be used to sample water quality; and,
 - b. predicted drawdown, particularly within the Lithgow Seam, is expected to extend a considerable distance (greater than 15 km at the end of mining, Jacobs 2019b, Figure 5.9, p. 85) to the east. The current monitoring network will not allow the extent of drawdown to be fully monitored. Given predicted drawdown will extend into the Greater Blue Mountains World Heritage Area, the Gardens of Stone National Park and beneath THPSS that are proposed to be used as reference swamps, it is important that drawdown is accurately monitored and that impact predictions are verified after the mine layout has been revised as recommended in Paragraph 13.
20. The proponent has noted that post-mining, the mine portals will be sealed at Angus Place Colliery and Springvale Mine. Groundwater levels will recover to a point at which seepage will occur from these portals and is likely to continue in perpetuity. Additionally, the proponent notes that the seepage may be acidic (Jacobs 2019b, p. 109). The volume of this seepage has only been approximated and further modelling to characterise the seepage is not planned until the closure planning stage.
- a. The volume of seepage requires quantification during the impact assessment phase. This impact will be ongoing and require long-term management. Consequently, a detailed understanding of the magnitude and extent of the impact is needed to identify and implement appropriate mitigation and management measures.
 - b. Further characterisation of the water quality of the seepage, the mechanism by which it may become acidic, whether such acidity may mobilise contaminants, and how the potentially contaminated discharge could impact the receiving environment including any downstream THPSS is also needed.
 - c. Monitoring of groundwater quality is needed to determine a baseline against which future monitoring results can be compared to identify whether predicted impacts are occurring. Monitoring should include a broad range of analytes (including metals and metalloids) and be informed by the work suggested in Paragraph 20b above.

Surface water

21. Potential surface water flow losses due to groundwater drawdown and streambed cracking, have not been quantified. Although the proponent is not predicting streambed cracking in the larger streams, the IESC notes that cracking could occur in the Wolgan River given its proximity to mining (as close as 180 m) and the likelihood of mining-related ground movements propagated along Type 1 and 2 lineaments. Streambed cracking is likely to occur in lower-order streams located above the longwall panels. These streams are headwater streams, particularly for Carne Creek which then flows into the Gardens of Stone National Park. Loss of flow from several streams in the same catchment is likely to have a cumulative impact on downstream in-stream and riparian biota and ecological processes, especially in protected areas such as Sydney's drinking water catchment, the Gardens of Stone National Park and the Greater Blue Mountains World Heritage Area. Potential impacts on ecologically important flow components and water supply reliability need to be described using appropriate metrics (see Paragraph 35 below).
22. The proponent has stated that flow diversions are likely to only be temporary if the depth of cover is greater than 150 m (Cardno 2019, p. 7). Data to support this claim should be provided.
23. Although stream power changes were assessed, the proponent did not provide actual values but only ranges of change (Jacobs 2019a, App. F, Table 6.2, p. 42). This makes it difficult to verify the

proponent's conclusions that changes to stream power will not be significant. Changes to stream power need to be further assessed with consideration given to the proximity of swamps to the identified areas of change as this might alter rates and amounts of sedimentation and erosion in individual THPSS. Eight of the ten locations where stream power is predicted to increase by more than 50% are located upstream of THPSS (Jacobs 2019a, App. F, Figure 6.1, p. 41). This further assessment should also consider a greater range of flow events, particularly for locations upstream of THPSS, and then predict how the altered hydrology may affect receiving waters and their biota.

24. Although the proponent states that sufficient water allocation licenses are held for the predicted takes (Jacobs 2019a, p. 77), further contextualisation of the takes and cumulative takes should be provided to understand the significance of these takes relative to system flows.
25. The current surface water monitoring network requires expansion (Jacobs 2019a, Figure 4.1, p. 36). Monitoring sites to the east of the proposed longwalls on Carne Creek are required to monitor potential impacts, especially given that many of the streams that will be undermined by the project drain to Carne Creek. Monitoring should also be implemented in the lower-order streams, particularly those with permanent pools. Monitoring sites should also be re-established in Coxs River, given that sediment dam discharges and site run off will continue to be discharged at LDP002. Detailed information of the location of additional monitoring sites, the timing of monitoring and the intended suite of analytes should be provided in an updated management plan.

GDEs

26. Drawdown depths at Tri Star Swamp, Twin Gully Swamp, Japan (Trail Six) Swamp, Birds Rock Swamp and Crocodile Swamp at the 10th percentile are predicted to be up to 5-10 m (RPS 2019, pp. 53-54). At the 90th percentile, predicted drawdown will be at least 0.5-5 m. The IESC notes that this predicted drawdown will dewater parts of all these swamps. Drying, even of only a portion of a swamp, typically results in adverse and irreparable impacts on swamp processes and associated biota such as the Blue Mountains Water Skink (Gorissen et al. 2017). In addition to these named THPSS, an unspecified number of hanging swamps will be directly impacted by altered hydrology due to subsidence-related movements (MSEC 2019, p. 89) including vertical subsidence (up to 2,250 mm), tensile strains (up to 5 mm/m) and compressive strains (up to 6mm/m) that are likely to result in irreversible ecological impacts.
27. The proponent has identified that the maximum distance from a longwall at which a THPSS experienced long-term impacts was 1,620 m (ERM 2019, p. 48). Based on information provided by the proponent, changes in swamps have been observed when mining was 2,250 m distant along strike (ERM 2019, p. 48). Swamps located above lineaments should be assessed for both long-term and temporary impacts up to at least 2,250 m from the nearest longwall. Similarly, risks of these impacts should also be assessed where lineaments (especially Types 1 and 2) that may interact with mining-induced ground movements coincide with aquifers (e.g. the Burrell Formation, McHugh 2014) supplying groundwater to THPSS, including hanging swamps.
28. Several listed threatened species are known to have a close association with THPSS, and include Deane's Boronia (*Boronia deanei*), Swamp Everlasting (*Xerochrysum palustre*), Klaphake's Sedge (*Carex klaphakei*), Blue Mountains Water Skink, Giant Dragonfly and Red Crowned Toadlet (*Pseudophryne australis*) (ERM 2019, p. 76). All these species are likely to be adversely impacted if the ecological condition of THPSS declines. The Blue Mountains Water Skink is of particular concern as this species has only a limited ability to colonise new areas or disperse when their habitat is impacted (Gorissen et al. 2017). Additionally, this species has had a considerable amount (currently estimated at 50-79%) of its habitat extent impacted by recent bushfires (DAWE 2020). Potential impacts to the habitat of this species should be minimised and carefully managed.

29. Swamps that have been previously impacted resulting in changed hydrology and drier conditions (e.g. Carne West Swamp, Gang Gang West Swamp) are also more vulnerable to future changes especially from fire. Fire can destroy the peat layer within swamps, stopping or delaying future peat formation and destroying the seed bank within the peat layer which impairs vegetation recruitment. The destruction of peat will also result in further swamp drying and further loss of critical habitat. Recent fires in this region have impacted many swamps, meaning that the remaining swamps will be important refuges for biota and critical to preserve.
30. The IESC notes that, combined, the Angus Place Colliery and Springvale Mine have directly undermined 39 THPSS (ERM 2019, p. 46). The impacts at some of these THPSS are considered serious and likely irreversible. The mining leases cover approximately 15% of all NPSS (RPS 2019, App. D, p. 10). Given the limited range of this listed threatened ecological community, further impacts and potential losses should be minimised whenever possible, and this is likely to be only achievable by altering longwall dimensions and the mine layout (see Paragraph 13 above).
31. The proponent should consider how changes to groundwater levels and saturation in swamps could impact water quality within and downstream of swamps. Many biogeochemical processes occur within the saturated zone of swamps. Changes to drying and wetting of this zone are likely to dramatically change water quality, particularly if interstitial conditions alternate between an oxidising and a reducing environment.
32. The proponent has predicted potential impacts to riparian vegetation including dieback arising from flow diversion, drainage of pools and rockfalls (ERM 2019, p. 86). Assessment of impacts on riparian vegetation should also consider that total vertical subsidence is predicted to be up to 2,200 mm for some drainage lines (MSEC 2019, Table 5.5, p. 71), substantially altering local hydraulics, erosion and sedimentation rates, soil moisture and other factors that influence riparian ecosystem processes and assemblages of native plants and animals. Finally, the potential downstream influences of riparian dieback, especially if it coincides with reduced flows and enhanced sedimentation, should also be fully assessed because streams draining the project area enter Sydney's drinking water supply and a World Heritage Area.
33. Additional monitoring of THPSS is proposed by the proponent (Jacobs 2019b, p. 109); however, limited details of this monitoring have been provided. Further information on the location and purpose of the monitoring regime including parameters and timing should be provided. Justification for each parameter is needed so that the likely mechanism of effect is made clear.
34. Assuming the proponent changes the mining layout as suggested in Paragraph 13 above, a swamp monitoring program using several reference swamps would be required to monitor the success of this strategy. Three reference swamps have been identified by the proponent: Best Swamp, Barrier Swamp and Fire Tail Swamp (Jacobs 2019b, p. 43). Further information is needed on these swamps to confirm that they are appropriate to be used as reference swamps. This information should also be provided for the additional proposed reference swamps (RPS 2019, App. B, p. 18), and should include the following:
 - a. the proximity to previous or planned future mining. Barrier Swamp appears to be located less than 2 km from Springvale Mine. It is therefore unclear whether subsidence-related ground movements may occur at this swamp, compromising its value as a reference swamp;
 - b. predicted drawdown at reference swamps, at any time in the future, from this project and other mines; and,
 - c. the natural spatial and temporal variation among the proposed reference swamps and whether this is comparable with the variability observed among impacted swamps. To discriminate natural changes from mining-induced impacts, natural variation among swamps must be clearly identified

and characterised. Variations in swamp characteristics such as swamp size, orientation and hydrological regime can all influence ecological condition and must be considered when selecting appropriate reference swamps.

35. The general conclusions drawn from the surface water modelling (Jacobs 2019b, App. E, Section 4) are that the project is likely to lead to a decrease in flow into Tri-Star Swamp, Twin Gully Swamp, Birds Rock Swamp and Japan (Trail Six) Swamp. The significance of the impacts is based on a simple assessment of the predicted changes to *median* flow conditions. Such a metric is only of general relevance to water availability; it does not provide any information on the impacts of the changes on the reliability of flows for downstream licensed water users, nor does it provide any indication of the materiality of the impacts on ecologically important flow components. For example, the upper impact on Birds Rock Swamp of a 13% decline in median flow is characterised as being “moderate” (Jacobs 2019b, App. E, p. 99); however it is seen from Figure 4.64 (Jacobs 2019b, App. E, p. 95) that this change doubles the period of time that the swamp is stressed by low flows (exceeded 90% of the time). Applying the definitions adopted by the proponent (Jacobs 2019b, App. E, p. viii) suggests that a more appropriate assessment of the likely ecological impacts on Birds Rock Swamp is “large” not “moderate”. The adoption of appropriate metrics would result in similarly large differences in assessments for Tri Star Swamp, Twin Gully Swamp and Japan (Trail Six) Swamp.

Offsets

36. The proponent currently plans to use the THPSS within the Newnes State Forest to meet their offset obligations (RPS 2019, App. D, p. 13). This plan requires further discussion on the following points:
- whether any of the THPSS within the Newnes State Forest have already been or are likely to be impacted (e.g. by drawdown);
 - the likelihood of getting the Newnes State Forest changed to a State Conservation Area (SCA) as currently proposed; and,
 - whether a SCA will provide a sufficient level of protection from threats to THPSS such as impacts from four-wheel driving and future mining.
37. The IESC notes that the proponent is proposing to finalise their offset obligations including for THPSS after the project has commenced (ERM 2019, p. 81). Given the limited number of unimpacted THPSS available to use as offsets, that the proponent has identified potential issues with meeting the requirements of the NSW Biodiversity Offsets Policy (RPS 2019, App. D, p. 10) and that irreversible adverse impacts to swamps will occur once the project commences, there is a high risk that offset requirements (in terms of like-for-like offsets) will not be able to be met if offsets are not secured before mining commences. Assuming that offsets can be secured, the IESC notes that it would be preferable, and consistent with current offset policies, if impacts to swamps were avoided by redesigning the mine layout and longwall dimensions instead.

Date of advice 12 May 2020

Source documentation provided to the IESC for the formulation of this advice ERM 2019. Amendment Report. Angus Place Extension Project. 6 December 2019. Project No.:0511056. Available [online]: <https://www.planningportal.nsw.gov.au/major-projects/project/12641> accessed May 2020.

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