

Advice to decision maker on coal mining project

IESC 2014-057: Russell Vale Colliery Underground Expansion Project (MP 09_0013; EPBC 2014/7268)

Requesting agency	The Australian Government Department of the Environment and The New South Wales Department of Planning and Environment
Date of request	12 August 2014
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Advice stage	Referral (Commonwealth Department of the Environment) Assessment (NSW Department of Planning and Environment)

Context

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) was requested by the Australian Government Department of the Environment and the NSW Department of Planning and Environment to provide advice on the Wollongong Coal Ltd Russell Vale Colliery Underground Expansion Project (the Russell Vale Expansion) in New South Wales.

This advice draws upon information in the Preferred Project Report and Residual Matters Report, together with the expert deliberations of the IESC. The project documentation and information accessed by the IESC are listed in the source documentation at the end of this advice.

The Russell Vale Expansion is proposing to use longwall mining methods to extract up to 4.7 Mt of run-of-mine coal over a five year period, at up to 3 Mtpa. The Russell Vale Expansion is located approximately 8 km north of Wollongong, NSW. The majority of the proposed project area is located within the catchment of Lake Cataract, a Sydney drinking water reservoir and also within a Sydney Catchment Authority Metropolitan Special Area, proclaimed under the NSW *Sydney Water Catchment Management Act 1998*. The proposed project area lies within the Woronora Plateau, a sandstone plateau, which is host to approximately 83% of the estimated 1003 swamps of Coastal Upland Swamp ecological communities listed (17 July 2014) as endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Approximately 78% of swamps on the Woronora Plateau are located wholly, or partially, over current mining leases, while approximately 4.7% of swamps on the Woronora Plateau are located within the proposed project area.

On 9 September 2014 the Australian Government Department of the Environment requested separate advice from the IESC in relation to a component of the Russell Vale Expansion Project, being the first 400 metres of Longwall 6, which was referred separately under the EPBC Act (EPBC 2014/7259). As

this is related to the current project but entails further information which needs to be assessed, the IESC's advice on this separate component will be expedited out of session and will be provided as soon as possible.

Key potential impacts

The key potential impacts as a result of the proposed Russell Vale Expansion include:

- Irreversible impacts to the long term viability and ecological integrity of EPBC listed Coastal Upland Swamp (swamp) ecosystems and down gradient ecosystems caused by surface and shallow cracking and subsequent loss of water holding capacity within swamps.
- Impacts to the ecological integrity of instream and riparian ecosystems caused by loss of stream flow and baseflow and increased iron seepages within Cataract Creek.
- Impacts to water storage in Cataract Reservoir caused by loss of stream flow and baseflow in its contributing catchment.
- Impacts to water storage in Cataract Reservoir caused by subsidence induced cracking within a 45 degree angle of influence from the longwall and subsequent potential connectivity and drainage between the Cataract Reservoir and mine workings.

Assessment against information guidelines

The IESC, in line with its Information Guidelines¹, has considered whether the proposed project assessment has used the following:

Relevant data and information: key conclusions

The monitoring of water level, as opposed to flow, in Cataract Creek does not enable the rainfall-runoff model to be calibrated within the subcatchment and reduces confidence in predictions.

There has been reasonable mapping of 39 upland headwater swamps. However, hydrological characterisation of all potentially impacted swamps has not been done and should include field data to inform conceptual understanding of individual swamp hydrology, determination of the distribution of perched water within swamps and all water inputs and outputs.

Application of appropriate methodologies: key conclusions

Methods for predicting subsidence in the assessment by SCT are generally appropriate. However, insufficient consideration has been given to the potential impacts of subsidence on surface water systems and upland swamps. The use of a 0.7 times depth of cover setback as a mitigation measure for protecting water storage within Cataract Reservoir needs to be justified, given the proximity to the multiple overlying extraction zones.

The applicability of the Tammetta model² to the prediction of height of fracturing and depressurisation of multi-seamed mining is not supported by evidence and may underpredict fracturing and increases in hydraulic conductivities. Predictive uncertainty analysis should include consideration of potential effects of increased and variable vertical hydraulic conductivity as a result of mine subsidence. The regional scale groundwater model does not enable prediction of impacts to swamp hydrology at a scale suitable for informing management and mitigation options.

Potential impacts to surface water in Bellambi Gully cannot be assessed as the project assessment documentation does not include an up-to-date water balance or an updated flood study. Also the proposed future mining at Wonga West has the potential to add to the cumulative impacts of mining in this region.

Reasonable values and parameters in calculation: key conclusions

The greatest uncertainties regarding the groundwater model are related to the hydraulic and spatial characteristics of the fracture zone. Calibrated hydraulic conductivity values are only partially reported and those reported for the fracture zones are lower than values measured from other studies within the southern coalfields³ potentially leading to underestimation of drawdown and loss of baseflow. In addition, the value used for evapotranspiration is significantly higher than predicted for the area by the Bureau of Meteorology, leading to potential overestimation of groundwater losses to evapotranspiration from low elevation areas within the model. Scenarios modelled for subsidence-induced surface water losses are not justified and have not been linked to the mechanisms which are likely to cause impacts. As such, there is low confidence in predicted impacts to Cataract Creek and the Reservoir.

Advice

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

The Residual Matters Report for the preferred project has identified a number of risks relating to Coastal Upland Swamps, listed as endangered under the EPBC Act.

Question 1: Do the subsidence, groundwater assessment and surface water assessments, including numerical modelling therein, provide reasonable estimations of the risk (including likelihood, extent and significance) of impacts on overlying and adjacent swamps?

Response

1. The subsidence assessment does not provide a reasonable estimation of the risk of impacts to overlying swamps as it does not take into account potential increased subsidence implications of multiple goaf strata settling after longwall extraction, and possibly underestimates the risks of cracking beneath swamps by using less stringent strain criteria than elsewhere in the Residual Matters Report.
2. The surface water assessment only predicts the area of swamps impacted by subsidence but does not assess the surface water related risks to swamps.
3. The proponent is justified in not including swamps which are known to be disconnected from the regional groundwater system, in the regional scale numerical groundwater model. However, the connectivity of all swamps to the regional groundwater system has not yet been assessed. Swamps whose hydrology is connected to, or influenced by, the regional groundwater system should be included in the regional groundwater model. Where localised perched aquifers are likely to support overlying swamps, finer scale groundwater modelling is necessary to predict the risk of impacts to swamps.

Explanation

Subsidence assessment

4. The proponent's subsidence assessment predicts fracturing of bedrock where tensile and compressive strains are greater than 1-2 mm/m and 2-3 mm/m respectively. The proponent's biodiversity assessment uses the more stringent criteria (>0.5 mm/m and >2 mm/m for tensile and compressive strains) for identification of swamps at risk of negative environmental consequences, such as bedrock cracking, as stated by the NSW Planning Assessment Commission⁴ and referenced in Conservation Advice for Coastal Upland Swamps in the Sydney Basin Bioregion⁵.

Groundwater assessment

5. The regional-scale numerical groundwater model is not constructed to assess the potential risks as a result of subsidence on localised perched aquifers. Where shallow ephemeral perched aquifers within the Hawkesbury Sandstone contribute to the water balance of swamps, there is a risk that surface cracking associated with subsidence will drain perched aquifers and reduce inflows to swamps. All sources of water, including contributions from perched aquifers and potential losses associated with surface cracking need to be considered in the assessment of risk of impacts to swamps. Finer scale models are needed to characterise the hydrology of swamps and quantify likely changes as a result of the proposed project. These models should be informed by detailed site specific studies, and include time series data and predicted changes to runoff within swamp catchments.

Biodiversity assessment

6. The initial risk assessment within the biodiversity assessment used established criteria^{4,5}, which indicated that 14 swamps are likely to experience negative environmental consequences. The final risk assessment potentially underestimates the risks to swamps from cracking by equally weighting risks to perched water and flow accumulation, resulting in the proponent's final ranking of risks as low, where there remains a high likelihood of cracking and tilting. The risks assigned to compressive tilts and strains within the final risk assessment should be considered high where they exceed established criteria^{4,5}.
7. The biodiversity assessment provides reasonable descriptions of swamp locations and ecological characteristics, however, the assessment of perched water within swamps is based on a limited number of piezometers installed in swamps, with only swamp CCUS5 having more than one installed piezometer (two). To better determine ecosystem reliance on perched water, assessment of swamp hydrology should include measurement of the distribution of perched water and soil moisture content using multiple piezometers distributed within each potentially impacted swamp, and within unimpacted control swamps.

Question 2: If not, what is a reasonable assessment of the likelihood, extent and significance of impacts on overlying and adjacent swamps?

Response

8. The likelihood that cracking and tilting will occur to the base of at least 14 swamps within the project area is considered high. While there is limited evidence available on ecological impacts on the Woronora Plateau, research from the Newnes Plateau (NSW) indicates impacts are likely to be severe and irreparable where the ecology is dependent on standing water levels; and where desiccation and induced slope are sufficient to initiate erosion⁶.
9. The hydrological and soil conditions within the swamps provide habitats for an array of threatened flora and fauna communities. Where these threatened species occur, the loss or severe decline of the swamps within the project area would be expected to negatively impact these species⁵.

Explanation

Evidence of previous impacts

10. Impacts to undermined Coastal Upland Swamps in the Sydney Basin are variable and poorly understood. Mining has occurred in the area over many years and impacts to swamps in many

cases are not apparent, however ecological change may occur over decadal timeframes. While a number of studies have assessed impacts to water-holding capacity of swamps, the IESC is not aware of any long term ecological impact studies.

11. Evidence of undermining of Swamp 12 and 15b at the adjacent Dendrobium mine presented in Appendix G of the Residual Matters Report and further evidence at Swamp 1b⁷ indicate loss of perched water and reduction in soil moisture as a result of subsidence. The ecological impacts of these changes are yet to be determined but are likely to lead to ecosystem change over extended time periods.
12. Impacts have been identified in swamp CCUS4 which overlies the proposed longwall 6. These impacts included collapse of the sandstone cliffs and fracturing within sandstone bedrock. Further fracturing has been identified on ridgelines following the extraction of longwalls 4 and 5. Fracturing is predicted to occur within shallow bedrock and may not be visible below surface soil cover within swamps.
13. The Residual Matters Report does not identify any significant impacts to swamp ecology within the project area; however this assessment does not include identification of cracks beneath swamps or a long term assessment of ecosystem change. As noted in the NSW Planning Assessment Commission (2010) report on Bulli Seam Operations *“There are compounding problems in the current lack of ability to detect and quantify all but the most obvious change and the possibility that vegetation compositional changes will take time (possibly decades). However, the bottom line appears to be if mine subsidence has the potential to impact on near surface formations to an extent that could cause changes in the hydrology of a swamp, then the swamp is at risk of serious negative environmental consequences in whole or in part”*⁴.

Subsidence

14. Changes to the slope (through subsidence induced tilt) above the established subsidence criteria^{4,5} are predicted to occur in 14 headwater swamps within the project area. Tilts are predicted to range between 19 and 32 mm/m at various points within these swamps. Tilt is predicted to be most severe where multiple underlying goaves are directly adjacent to multiple underlying chain pillars (for example, between proposed longwalls one to three and between longwall five and proposed longwalls six and seven). In these locations, changes to surface flow regimes are expected to be more severe, and therefore these localities represent a higher risk to headwater swamps.

Perched water

15. Assessment of water level responses within headwater swamps indicates short residence times for perched water within a number of headwater swamps, in some cases possibly indicating impacts due to prior subsidence. The limited number and distribution of piezometers may underestimate reliance of swamp ecosystems on standing water levels and soil moisture levels.
16. Assessment of impacts to a headwater upland swamp at the nearby Dendrobium mine indicates undermining has resulted in impacts to perched aquifer levels, soil moisture levels and flows to the down gradient tributary⁷. A reliable assessment of impacts to perched water levels, soil moisture levels and associated ecological communities needs a robust Before-After Control-Impact study design approach⁸ including assessment of the spatial and temporal distribution of standing water levels and soil moisture within each swamp.

Threatened species

17. The Coastal Upland Swamps provide important habitats for a number of threatened species, including the EPBC listed vulnerable green and gold bell frog (*Litoria aurea*) and giant burrowing

frog (*Heleioporus australiacus*). The red-crowned toadlet (*Pseudophryne australis*), which is listed as vulnerable in NSW, is also known to be present. The ecological community also provides habitat for the NSW listed endangered giant dragonfly (*Petalura gigantea*) which is now uncommon in the coastal regions of NSW⁵. The proponent's biodiversity assessment identified the giant burrowing frog (tadpoles), the red-crowned toadlet, and the giant dragonfly onsite, with suitable habitats for the stuttering frog (*Mixophyes balbus*). Where these threatened species occur, the loss or severe decline of Coastal Upland Swamps within the project area would be expected to negatively impact the reproductive cycle and thus the long term viability of these species.

Question 3: Has the proponent provided strategies to effectively avoid and mitigate, or reduce the likelihood, extent and significance of these impacts?

Response

18. While the proponent has reduced the likelihood of impacts to a number of swamps through a change of the mine plan associated with the Preferred Project Report, the mine plan still proposes to wholly or partially undermine 12 swamps, which the proponent predicts will experience fracturing within shallow bedrock at their base. No other strategies are provided that are likely to effectively avoid or mitigate impacts to swamps.

Explanation

19. The proponent has reduced the likelihood of impacts to a number of swamps through a change of the mine plan associated with the Preferred Project Report that has reduced the number of swamps that will be undermined. The redesign includes moving longwall extraction areas resulting in significantly reduced but still partial undermining of swamps CCUS1, CCUS5 and CCUS10.
20. The Residual Matters Report outlines a Biodiversity Management Plan and associated adaptive management measures. The associated measures involve identifying impacts during and post mining which may provide important information for future mining proposals in this area. However, as they do not include conditions to reduce ground movement and strains below swamps to less than the established criteria^{4,5}, these measures are considered ineffective in avoiding or mitigating impacts to swamps.
21. Triggers outlined in the Trigger Action Response Plan (TARP) for recently mined longwall 5⁹ will not determine swamp reliance on perched water, or mitigate impacts to swamps, because they occur after, not prior, to impacts. Further, the TARP does not require changes to the mine plan or cessation of mining associated with an unacceptable level of impact, therefore limiting its capacity to avoid or mitigate impacts.

Question 4: Are there any strategies available to avoid, mitigate, reduce or remediate the likelihood, extent and significance of these impacts? If so, what are these?

Response

22. The only known strategy to avoid the risk of impacts to swamps is to ensure mining does not cause ground movement and strain in excess of the established criteria^{4,5}. This strategy should also be applied to any ephemeral perched groundwater systems which contribute a significant proportion of a swamp's water balance.
23. The irreversible nature of impacts to swamps in combination with the potential delay before identification of impacts diminishes the likelihood of success of adaptive management measures.

Explanation

24. A recent evaluation of remediation techniques was not able to identify any examples of mitigation or remediation of undermined peat swamps, and in instances where impacts have occurred there have been no signs of self-amelioration in swamps impacted more than 25 years ago⁶.
25. Remediation strategies such as sealing fracture networks of exposed rock in creeks and tributaries have been found to be costly, risky and likely to have a limited lifespan⁶. The successful use of this approach is likely to be limited due to presence of overlying sediments, issues with detection of fracture networks, and potential significant impacts to swamps associated with the remediation process such as clearance of vegetation and swamp substrate to determine extent of cracking.

Question 5: Which, if any, of the strategies does the IESC recommend, and why?

Response

26. Given the variable nature of impacts to swamps and difficulties in their accurate and confident prediction, the most effective strategy to reduce the risk of impact to swamp communities within the proposed project area would be to alter the mine layout such that swamps are not undermined by longwall panels and are not subjected to strains in excess of the established criteria^{4,5}. Further, surface flows that contribute water to swamps should not be disrupted. There is no scientific evidence to demonstrate that remediation activities are able to successfully restore the hydraulic and ecological functions of these ecological communities to pre-impact condition⁶.

Question 6: The Residual Matters Report recognizes the limitations of adaptive management to address potential impacts on individual upland swamps due to the short timeframes to manage longwall retreat. What measures or triggers could be used to minimize impacts and address uncertainty in impact prediction?

Response

27. The only currently known measures to successfully minimise impacts to swamps involve modification of mine layout to prevent stresses greater than established criteria^{4,5}.
28. Adaptive management is not a suitable approach to minimise impacts to swamps due to the irreversible nature of impacts and the potential for long time delays before identification of irreversible ecological impacts.

Explanation

29. Measures to reduce uncertainty in impact prediction include:
 - a. Detailed swamp water balance studies assessing extent and temporal distribution of standing water and soil moisture within swamps, including identification of all water inputs and outputs. Assessment of water sources should consider but not be limited to potential contributions from catchment run-off and seepage from shallow perched groundwater systems.
 - b. The development of long term Before-After Control-Impact studies which enable identification and quantification of cracking and tilting, altered flowpaths and changes to water quality, subsequent erosion and ecological responses of flora and fauna.

Questions 7-12 are in respect to the preferred project's assessment of the impacts of potential groundwater and surface waters and its groundwater and surface water modelling:

Question 7: Are the groundwater and surface water models suitably robust for the quantitative predictions provided?

Response

30. No. The groundwater and surface water models are not suitably robust for the quantitative predictions provided. The key uncertainties regarding the groundwater model are related to the hydraulic and spatial characteristics of the fracture zone and its unsuitability to predict impacts at a scale relevant to swamp hydrology. The key uncertainties with the surface water model include the lack of justification for predicted streamflow loss scenarios, and lack of streamflow data for calibration in Cataract Creek.

Explanation

Groundwater

31. Quantitative predictions made using the regional groundwater model include predictions of drawdown, mine inflow and stream baseflow. There is low confidence in these predictions for the following reasons:
- a. There is a lack of long term calibration data for groundwater pressure, and no calibration data for baseflow and mine inflows resulting in low confidence in the predicted range of baseflow and mine inflow.
 - b. The calibrated hydraulic conductivity values, particularly within the impacted zone, are lower than values measured in other studies within the Southern Coalfields³. Given the low hydraulic conductivity values utilised, the groundwater model potentially underestimates drawdown, including lateral and vertical extent, as well as the quantity of mine inflows induced by the effect of multiple overlying goaves and their associated fracture network.
 - c. The Tammetta Model² used to predict subsidence effects on groundwater pressure and hydraulic conductivity is not supported by evidence from the site. Measurements of groundwater pressure and horizontal and vertical hydraulic conductivity, prior to and post undermining, would improve confidence in model representation of subsidence impacts on groundwater systems.
 - d. The predictive uncertainty analysis is limited in that it does not explore a full range of vertical and horizontal hydraulic conductivities. Confidence in the predictions of this analysis are low due to:
 - i. The limits placed on the range of randomly generated horizontal hydraulic conductivity values whereby values are centred around the calibrated value for each model layer. Uncertainty analysis should enable consideration of the effects of higher horizontal hydraulic conductivity on baseflow and mine inflow.
 - ii. The analysis not including scenarios which consider increased vertical hydraulic conductivity through the profile. Given the high likelihood of increased vertical conductivity above goaves and the potential effect this can have on reducing groundwater pressures and increasing downward flow, uncertainty analysis predictions should consider the potential effect of increased vertical hydraulic conductivity.

Surface water

32. Quantitative predictions made using the surface water model include loss of streamflow to locations along Cataract Creek, complete loss of tributaries to Cataract Creek, and loss of catchment yield to Cataract Reservoir (see paragraphs 61-64). There is low confidence in these predictions as:
- a. The model does not predict the magnitude of actual streamflow losses, or the lengths of streams likely to be impacted by subsidence; rather it assumes a range of streamflow losses, which are not supported by adequate justification.
 - b. There is no link provided between the scenarios and the physical factors influencing streambed fracturing. Predictions of streamflow losses as a result of streambed fracturing should explicitly consider mining-related factors, topographic factors, near-surface geological factors and in-situ stresses.
 - c. Streamflow loss is modelled as a constant value per day up to the total flow. Confidence in predictions would be increased by consideration of the variation of impacts: over time (cracks may develop, then fill with sediment; fracture networks may be flooded, then drain); along the length of the creek (rock bars are more susceptible to cracking, natural pools may drain more rapidly, in other areas subsidence is likely to result in ponding); and under a variety of flow conditions (losses are more likely to be significant in low flows).
 - d. Given the limited justification for the scenarios chosen, a sensitivity analysis is recommended, including: the potential for streamflow losses of greater than 0.5 ML/day to Cataract Creek; more realistic scenarios for loss of tributary flow; and a range of fracturing behaviour, including that the Bald Hill Claystone and Bulgo Sandstone fracture in the same manner as the Hawkesbury Sandstone.
 - e. There is no flow data available for calibration of the model in Cataract Creek (see recommendation in paragraph 46), despite water monitoring in pools along Cataract Creek and Cataract River since September 2009.
 - f. Daily runoff for the Cataract Creek catchment was estimated using Australian Water Balance Model (AWBM) parameters transposed from the Bellambi Creek catchment. There is low confidence in the predictions for Cataract Creek as the Bellambi Creek AWBM rainfall-runoff model:
 - i. Was calibrated with under five years of streamflow data, with significant periods of missing, or questionable data; and
 - ii. Could not replicate a number of cease to flow periods in actual streamflow data for Bellambi Creek (9% of days). The proponent states that this would be consistent with a loss of streamflow to seepage of approximately 0.3 ML/day or due to inaccuracies in the flow data.
 - g. The complete results of verification of the model against available water level data from Cataract Creek were not presented. Presentation of the performance of the model against the full period of measured data at all sites along the creek would improve confidence in predictions.

Question 8: Do the subsidence, groundwater assessment and surface water assessments provide reasonable estimations of likely impacts to water resource, with particular reference to Cataract Creek and the Cataract Reservoir?

Response

33. The subsidence, groundwater assessment and surface water assessment do not provide reasonable estimations of the combined impacts as a result of the Russell Vale Expansion to Cataract Creek and Cataract Reservoir.
- a. The proponent should quantify the potential for impacts to Cataract Creek surface water flow and quality as a result of: impacts to swamps in the headwaters; shallow subsidence effects (see also paragraphs 32, 40 & 43); deep connective cracking; and groundwater drawdown.
 - b. Assessment of impacts to water resources should include potential for impacts to all water related assets and associated ecological communities (see paragraph 45).
 - c. The mitigation measure of a lateral setback of 0.7 times the depth of cover, proposed for protecting Cataract Reservoir, requires further justification (see Question 11 for further explanation). Such a setback might not be adequate to ensure the integrity of Cataract Reservoir.

Explanation

Surface water

Swamps

34. The proponent's surface water assessment compares the relative extent (in hectares) of: swamps likely to be impacted by subsidence; swamps not predicted to be impacted by subsidence; and the remaining catchment areas of Cataract Creek, Cataract River and Bellambi Creek. The assessment has not considered:
- a. The existing contribution of each swamp to streamflow;
 - b. The extent or significance of subsidence impacts to each swamp; or
 - c. The consequential impacts to streamflow, water quality and aquatic ecosystems as a result of subsidence beneath swamps.

Shallow subsidence effects

35. There is a risk to stream flow and connectivity to Cataract Creek and its tributaries as a result of valley closure (up to 650 mm on the third order unnamed tributary above longwalls 1-3). This is likely to result in cracking of the streambed and rock bars and bed delamination, diverting flow beneath the surface and reducing pool capacity.
36. The proponent's assessments disregard the potential for significant changes to the streambed profile. Given the change in stream profile along the length of Cataract Creek, further justification is needed to support the proponent's lack of assessment of bedload transport mechanisms or afflux.

Deep connective cracking

37. The proponent suggests that impacts on surface flow will be minimal, since water lost through surface cracks (up to 15 metres deep) will flow laterally and then re-emerge downstream. The

NSW Office of Environment and Heritage, in its submission on the Preferred Project Report, showed that there is mounting evidence to suggest that water is being lost from upland swamps and streams into Southern Coalfield mines or lower aquifers due to deep connective cracking. Given this evidence and historical mining activity, deep connective cracking and its role in preventing re-emergence of surface flows should be explicitly assessed by the proponent.

Groundwater drawdown

38. The predicted reductions in baseflow to Cataract Creek (0.006-0.03 ML/day) should consider the existing temporal (baseflow is shown to vary substantially between months) and spatial (e.g. groundwater seeps at various locations) variability, which may be masked by presentation of averaged results. In particular, the potential impacts to water related assets as a result of modifying the point that Cataract Creek changes from ephemeral to perennial need to be assessed (see paragraph 45).
39. The proponent assumes that, as a result of groundwater drawdown, redirected surface flow will re-emerge down gradient within Cataract Creek or directly into Cataract Reservoir. This assumption needs to be supported by further evidence (see paragraph 47), as shallow groundwater levels associated with longwalls 4 and 5 indicate an increased downward gradient. If subsurface flows do not re-emerge, actual baseflow losses to Cataract Creek and subsequently Cataract Reservoir may be greater than predicted.

Question 9: The subsidence assessment indicates the likelihood of minor fracturing of creek beds and creek catchments with resultant diversion of stream flow and runoff. Does the Residual Matters Report provide a reasonable estimation of the potential changes in stream flow and runoff volume, and the impacts to water dependent ecosystems? Is there adequate monitoring to enable these impacts to be assessed? What measures or triggers could be used to monitor and minimise impacts into the future?

Response

40. The Residual Matters Report, particularly Appendix F, does not provide a reasonable estimation of impacts to streamflow and runoff volume as a result of subsidence. The resultant impacts on aquatic ecosystems of predicted extended cease to flow periods, or the potential draining of pools, including loss of refugial habitat and stream connectivity, are not assessed.
41. There is inadequate streamflow monitoring to enable future impacts to the flow regime to be assessed. Pool water level data along Cataract Creek and its tributaries has not been converted to flow. Converting to flow would enable characterisation of existing gaining and losing reaches, calibration of the rainfall-runoff model and verification of streamflow impacts due to mining of longwalls 4 and 5.
42. To monitor impacts in future, quantitative flow monitoring should commence and surface water quality monitoring should continue. Visual observations should also include any visible cracking in the vicinity of rock bars as well as signs of erosion or sedimentation where there are changes in stream gradient. To minimise impacts in future, mitigation measures should be applied when triggers are exceeded to avoid, restrict or isolate subsidence impacts on drainage features.

Explanation

Changes to streamflow

43. There is low confidence in the proponent's prediction of impacts to streamflow in Cataract Creek as a result of cracking, streambed fracturing and bed delamination from the Russell Vale Expansion. Predictions include:

- a. No flow in Cataract Creek midstream (monitoring station 5) 21% of the time under the maximum streamflow loss scenario (0.5 ML/day). Whilst the model predicts no cease to flow periods under existing conditions, it predicts the creek at this location could have no flow for up to 78 days per year as a result of the Russell Vale Expansion.
- b. Decrease in median streamflow in Cataract Creek downstream (monitoring station 9) by 0.9 ML/day as a result of the loss of the nine upper tributaries. The largest impact on streamflow is seen with the loss of the third order unnamed tributary 1 overlying longwalls 1-3.
- c. Estimates for impacts to runoff, baseflow and total streamflow. It is unclear how impacts to baseflow and runoff have been separated.

Impacts to ecology

44. Assessment of the likely impacts to water-related assets as a result of changes to flow predicted in Appendix F of the Residual Matters Report has not been undertaken. How the maximum predicted streamflow loss to Cataract Creek may impact on habitat connectivity and the viability of instream and riparian ecosystems is not considered. A decrease or complete loss of flow could remove refugial habitat in pools, would likely further increase iron flocculent in streams and has the potential to isolate fish or reduce ability to feed and distribute eggs as connectivity between pools is lost. The impact on listed frog species has not been considered by the proponent.
45. Further information on water-related assets needs to be provided in the Environmental Management Plan including: pre-mining condition of water related assets; the water regime required to maintain assets; impacts to the assets from Russell Vale Expansion (changes to flow regimes, water quality, habitat, channel morphology and erosion zones with consideration of seasonal variations and extreme events such as floods); monitoring requirements with measurable thresholds and triggers; and options to minimise, mitigate or avoid impacts.

Monitoring

46. Flow monitoring should be undertaken at various locations along Cataract Creek, ideally by developing height-discharge relationships for existing pool monitoring locations. Records of the existing, or subsidence-induced, subsurface or overland diversion of flow along the creek would assist the proponent in providing evidence for the existing behaviour of the stream, so that impacts as a result of the proposed Russell Vale Expansion can be assessed.
47. Installations of additional shallow piezometers along Cataract Creek, as well as the monitoring of streamflow, are needed to provide evidence to support the proponent's assertion that surface flows will re-emerge downstream.

Measures and triggers

48. Stream features particularly prone to subsidence effects should be monitored regularly. The location of all rock bars should be mapped and recorded with photos on a regular basis during mining. Similar attention should be paid to areas where ponding or erosion/sedimentation (indicated by a significant change in stream gradient) are likely.
49. The TARP for longwall 5⁹ does not require changes to mine plan or cessation of undermining associated with an unacceptable level of impact on surface water features, only a requirement to report and undertake remediation works. The effectiveness of remediation measures, such as grouting, has not been proven.
50. Mitigation measures for Cataract Creek are recommended when subsidence, surface water quality or flow triggers are exceeded. Measures should preferentially avoid (stop mining, change

mine layout) or restrict (decrease extraction height, increase pillar width) subsidence impacts on streams.

Question 10: The Residual Matters Report indicates an increase in iron rich seepage in Cataract Creek due to impacts of previous mining subsidence. Does it adequately consider the potential for further increases in iron rich discharges to creeks and the significance of any resulting impacts to water quality and the downstream environment? If not, what is the potential?

Response

51. No, the Residual Matters Report does not adequately consider the potential for further increases in iron rich discharges to creeks or its potential impact to water quality and the downstream environment. Given the high likelihood of further cracking of Cataract Creek and its tributaries and the history of related iron seepages, the potential for increased iron seepages is considered highly likely. This has the potential to impact water quality as well as instream and riparian ecological communities.

Explanation

52. The Residual Matters Report acknowledges the potential for further increases in iron rich discharges to Cataract Creek and the associated development of large quantities of iron oxidising bacteria to smother eggs of threatened fish¹⁰. However, the potential for future increases in iron oxides/hydroxides and associated water quality changes in the future has not been quantified, nor has the tolerance of aquatic biota and threatened species to changes in water quality been assessed.

53. Where there is increased subsurface flow and re-emergence resulting from cracking, impacts are likely to include increased salinity, iron, manganese and other metals, cations and anions, combined with depleted oxygen concentrations. Re-emerging water is rapidly oxidised to precipitate iron oxides/hydroxides out of solution and is more concentrated under low flow conditions where baseflow is the major flow component¹¹. Mats of bacteria commonly develop on iron oxides/hydroxides and in doing so can reduce interstitial habitat, available food, oxygen content and can negatively impact macroinvertebrate communities and smother eggs of threatened fish species. These changes have the potential to negatively impact the ecological integrity of instream and riparian systems resulting in loss of plant and animal populations.

54. Threatened fish species present within Cataract Creek include EPBC-listed macquarie perch (*Macquaria australasica*), silver perch (*Bidyanus bidyanus*) and murray cod (*Maccullochella peelii*). An assessment of potential impacts to these species from increased iron seepages and associated mats of bacteria has not been undertaken. Where it is considered possible that threatened fish species will be negatively impacted, monitoring and mitigation measures should be developed.

55. While the EPBC-listed stuttering frog (*Mixophyes balbus*) was not identified in surveys undertaken by the proponent, Cataract Creek is within its range and provides suitable habitat. As this species relies on shallow running water, it is likely to be impacted by the loss of baseflow and increased iron seepages resulting from bedrock fracturing.

Question 11: Is the information provided sufficient to predict any changes to either water quality or water quantity in the Cataract Reservoir which would arise as a result of the mining operations? What are the consequences for stored waters within Cataract Reservoir?

Response

56. The information provided is not sufficient to determine the likelihood of subsidence induced fracturing and potential drainage from Cataract Reservoir outside the proposed mitigation zone of 0.7 times the depth of cover. Considering the significant consequences should potential cracking associated with mining activities occur beneath the reservoir, even low likelihoods of fracturing and drainage equate to considerable overall risks.
57. The information provided is not sufficient to confidently predict changes to water quantity within Cataract Creek and their subsequent impacts on storage within Cataract Reservoir as a result of the proposed mining. Consequences for storage in Cataract Reservoir are presented across a large range, including very significant losses of storage in the upper range, but there is little evidence that predictions are realistic.
58. The information provided is not sufficient to predict changes to water quality in Cataract Reservoir as the proponent has not modelled the likely changes as a result of the proposed project. However based on existing water quality and flow volumes in Cataract Creek the water quality consequences for Cataract Reservoir are not likely to be significant.

Explanation

Water quality

59. Detailed assessment of the effects of potential changes in water quality in Cataract Creek on water quality in Cataract Reservoir has not been undertaken. However, the information provided in the Residual Matters Report indicates the current water quality in Cataract Creek meets Australian drinking water guidelines¹² though occasionally exceeds ANZECC and ARMCANZ¹³ South-east Australia trigger values for total nitrogen and total phosphorus and the trigger values for protection of 95% of aquatic ecosystems for zinc, copper and aluminium.

Water quantity

60. The proponent's primary measure to prevent leakage from the Cataract Reservoir through subsidence induced connective fracturing is through a lateral set back distance between the Cataract Reservoir full supply level and proposed longwalls equal to 0.7 times the depth of cover. This distance is equal to approximately 203 m at the closest point, which correlates to a 35 degree angle of draw. However it is also stated that in several places the presence of overlying historical pillar extraction areas reduces the protection afforded by the set back distance.
61. Further, there is a risk that the 0.7 times depth of cover (35 degree angle of draw) is not an adequate distance to prevent subsidence induced leakage from the Cataract Reservoir where the full supply level extends upwards along Cataract Creek and Cataract River. Evidence from the western coalfield suggests an angle of influence for impact, characterised by deformation of underlying strata, to a maximum of 45 degrees¹⁴. Evidence from the western coalfields aligns closely with observations discussed by Ouyang and Elsworth (1993)¹⁵ who identified a "probable angle of influence" of 42 degrees. In their current proposed layout, a 45 degree angle of influence for impact due to the proposed longwalls would intersect the full supply level of Cataract Reservoir. As a result, there is a risk that subsidence induced fractures will cause connectivity and leakage between the cataract reservoir and mine workings. The use of a 0.7 times depth of cover set back needs to be justified, given its proximity to the multiple overlying historical extraction zones.

62. While the existing mining voids associated with historical underground mining within the proposed project area do not appear to have induced leakage from Cataract Reservoir, the extraction of further underlying coal beneath these historical workings presents a risk of re-mobilisation of the previously collapsed overlying strata. Re-mobilisation and the resulting increased vertical subsidence are potential causes of fracturing which may result in connectivity between the reservoir, historical underground voids and the proposed longwalls. Any fracturing that results in connectivity between the existing Bulli Seam board and pillar voids (shallowest) and the Cataract Reservoir will result in connectivity to the Wongawilli longwalls of the proposed project, as the historical underground voids and the proposed longwalls are hydraulically interconnected through the collapsed goaves.
63. The maximum modelled loss in Cataract Reservoir storage as a result of subsidence impacts from the Russell Vale Expansion ranges from 550 ML (0.5 ML/day loss in yield) to greater than 10 GL (10 ML/day loss in yield). The upper prediction is reported inconsistently in Appendix F of the Residual Matters Report: 10,890 ML in the text (P51); and at least 20,000 ML in Figure 8.2 (P52). However, the reservoir is not modelled to drop below 10% storage under the historical climate record for any scenario.
64. While the range of modelled potential losses of storage in the Cataract Reservoir are significant, there is low confidence in the assumptions made in the modelling and the applicability of model results (see paragraph 32). No justification is provided for the selection of modelled losses in catchment yield. However, given the reported¹⁶ lack of measurable risk to water storage volumes from longwall mining in the Southern Coalfield, these scenarios are likely to be worst-case.

Question 12: Are the questions adequately targeted to the greatest risks of impacts to water resources for the preferred project? If not, what are the greatest foreseeable risks to water resources associated with the project and how could they be mitigated?

Response

65. The greatest immediate risks associated with the project are largely as targeted by the questions:
- a. Impacts to Coastal Upland Swamps and associated communities;
 - b. Impacts to Cataract Creek, its tributaries; and
 - c. Impacts to the integrity of Cataract Reservoir.
66. However, further risks to water resources are likely to arise from the cumulative impacts of the additional proposed mining at Wonga West, and these should be considered together with the current proposal.
67. Further, there are risks associated with mine discharges to Bellambi Gully, due to the increase in mine discharge associated with the proposed project, and a history of flooding at the site.

Explanation

68. There is no flood study yet available for the proposed project and the proponent has not evaluated the capacity of the mine water management system to handle revised groundwater inflows or discharge mine-affected water in a manner which enables water quality objectives for the Bellambi Gully to be achieved. A complete assessment of the potential impact of mine-affected discharges on water resources and water related assets as a result of the Russell Vale Expansion is needed. Discharges of water with low pH and elevated concentrations of toxicants including metals are likely to increase risks to aquatic ecosystems and other water related assets.

69. The Southern Sydney Basin, which includes the Hawkesbury-Nepean subregion, has been identified as a Bioregional Assessment priority region. Data and relevant information from the proposed project should be made accessible to this Bioregional Assessment to assist the knowledge base for regional scale assessments.

Date of advice 11 September 2014

Source documentation available to the IESC in the formulation of this advice Gujarat NRE Coking Coal Pty Ltd, 2013. Underground Expansion Project Preferred Project Report including Response to Submissions.
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