Steve O'Donoghue
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Energy and Resource Assessments Division

By email:
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10 December 2021

Dear Steve,

**Subject: Advice in relation to Narrabri Underground Mine Stage 3 Extension Project, Predicted Greenhouse Gas Emissions**

We provide advice in relation to the greenhouse gas emissions assessment for the Narrabri Underground Mine Stage 3 Extension Project. We have undertaken a high-level review of the key documents provided for consideration. Our findings and recommendations follow.

**Technical review of estimated greenhouse gas Scope 1, 2 and 3 emission calculations**

For the Environmental Impact Statement (EIS) a greenhouse gas (GHG) assessment was initially prepared by Jacobs (24 August 2020).[1] This addressed the relevant emission sources and scopes. Emission estimates were consistent with contemporary practice and emission factors and appear to be adequately calculated, with the following exceptions:

1) The Method 1 approach applied to calculate emissions was consistent with National Greenhouse and Energy Reporting Scheme (NGER) Technical Guidance, however global warming potentials (GWPs) from the International Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) rather than the Fourth Assessment Report (AR4) should be applied.
2) In the amended GHG assessment (Jacobs, 31 May 2021, refer the Amendment Report below), the proponent considers the impact of abatement through flaring on total scope 1 emissions for the Project. The proponent should also present the Project fugitive emissions with and without flaring for transparency. This would exclude post-mining emissions.
3) Fugitive emissions from post-mining activities were correctly calculated based on a factor applicable for gassy mines. Clarification is sought about why post-mining fugitives were not currently reported for existing mining activities at the site under the NGER requirements.
4) Emissions were not estimated for the entire life of the project, with emissions from the decommissioned mine not reported. Emissions factors for these estimates are available in the NGER technical guidelines (Div 3.2.4).
5) Other Scope 1 emissions were estimated satisfactorily however there is benefit in specifying the emission factors used in calculations for traceability.
6) The proponent has not compared the project emissions against current best practice emissions for underground coal mines in NSW. Electricity consumption at the site equates to an average of 13.3 kWh/t ROM coal. This should be compared to current best practice for energy efficiency of underground mining operations in NSW.
7) The proponent should discuss its liabilities under the Commonwealth's Safeguard Mechanism.

On 12 December 2020, the Planning and Assessments Group (the PAG) in DPIE requested the proponent respond to further information requests from various stakeholders. In response, the proponent prepared a Submissions Report that was publicly exhibited on 2 June 2021.[2] Section 4.2.10 of the report discusses the proponent's response to questions about the impacts of pre-drainage, drainage of goaf gas and flaring gases with low concentrations of methane.

An amendment to the GHG assessment[3] was provided by Jacobs (31 May 2021; ref. 3, Appendix C). This amendment did not address the exceptions noted above, but it did consider the impacts of methane flaring as an abatement measure. The report references the Palaris Report (WHC 5824-06) "Narrabri Underground Mine Stage 3 Extension Project GHG Emission Forecast", May 2021 (ref. 3, Appendix B).

This Palaris Report is important as it provides a highly detailed calculation of the fugitive emissions from the Project, split between four phases: pre-drainage, development (mining of roadways), longwall (gas from goaf drainage and mine ventilation) and outbye longwall (gas emissions from completed sealed longwalls and outbye areas). The Palaris report also indicated which phase of mining is amenable to methane flaring. The impacts of all abatement measures are discussed below in relation to the review of GHG mitigation measures.

A concern with the earlier Jacobs (2020) GHG assessment is that it did not provide sufficient resolution of the fugitive methane calculations for the Project and inconsistencies were identified in the calculation of fugitives from venting and gas drainage. Palaris Report WHC 5824-06 addresses these concerns.

The proponent provided a second Palaris report: "Narrabri Underground Mine Stage 3 Extension Project – Abatement Technology Assessment", WHC5827-01, 25 May 2021. This provided cost profiles of three abatement technologies (discussed below).

On 22 September 2021, the DPIE PAG requested further information on the feasibility of flaring low methane gas and the technologies that could be employed, including methane enrichment technologies. The proponent on 15 October 2021 provided a response[4] that included a third Palaris report: "Narrabri Underground Stage 3 Extension Project GHG Abatement Benchmarking", WHC5976-01, 14 October 2021.

**Consistency with DPIE modelling for Net Zero Stage 1: 2020-2030 Implementation Update**

The Narrabri Underground Mine Stage 3 Extension Project was accounted for in DPIE NZEM's emission projections. The emission projections were however far lower than those reported in the GHG Assessment, despite the run-of-mine (ROM) coal projections being comparable over the duration of mining. The DPIE NZEM's modelling was completed in May 2021 prior to the proponent's detailed fugitive emissions being made public on 2 June 2021.

Over 2032−2043, the GHG assessments (Jacobs2021 and Palaris WHC 5824-06) report ROM coal production of 102.6 million tonnes (Mt) with Scope 1 fugitive emissions of 16.98 million tonnes $CO_2$-e (Mt $CO_2$-e) with no pre-drainage gas flaring assumed. Post-mining fugitives are estimated to contribute a further 0.15 Mt $CO_2$-e per year on average.

DPIE NZEM modelling over the same period assumes 94 Mt ROM coal production (based on DRNSW Mineral, Exploration and Geoscience central estimates) with scope 1 fugitive emissions estimated to be 6.4 Mt $CO_2$-e. The difference in fugitive emissions is due to:

- The Project accessing the gassier Hoskissons coal seams whereas the modelling assumed the fugitive emissions characteristics of the existing mine. The existing mine ROM intensity was fixed at 0.07 t $CO_2$-e/t ROM. The Project ROM intensity varied from

approximately 0.08 to 0.20 t $CO_2$-e/t ROM (refer detailed calculations in Palaris WHC 5824-06, May 2021).

- Post-mining fugitives not being accounted for within the DPIE projections given these were based on the emission intensity of the current mining operations, as reported under NGER, and post-mining emissions are currently not reported for this facility.

DPIE NZEM projected base case emissions from all forecast underground coal mining in NSW to be 10.97 Mt $CO_2$-e in 2030. It was assumed that assistance for abatement projects under the *Net Zero Industries and Innovation Program* will deliver abatement of 2.8 Mt $CO_2$-e from coal mines in 2030. Of that abatement figure, about 0.9 Mt $CO_2$-e is assumed to come from Ventilation Air Methane destruction technology. Other measures such as goaf drainage with power generation, goaf drainage with flaring, pre-drainage with power generation, pre-drainage with flaring are assumed to make up the balance of the abatement.

**Review of the Proposed GHG Mitigation Measures**

We were requested to consider measures to minimise the Scope 1 and 2 emissions of the project and any additional measures that could be implemented to mitigate Scope 1 and 2 emissions to the greatest extent practicable over the life of the project. A synthesis of our review is at Attachment 1, and our recommendations as follows:

- A more detailed study of gas management options is required, which should draw on the two Palaris abatement technology reports (see below). This should further inform gas flows and composition to enable, as a minimum, pre-drainage gas flaring. A combination of pre-drainage and goaf gas could be undertaken where feasible. We note the goaf gas is diluted by mine ventilation air which introduces oxygen into the mixture creating a potential explosive hazard. This aspect would require very detailed gas analysis. The results of current continuous monitoring of methane and oxygen in the goaf should be used to inform such a study.
- As noted in the Palaris abatement benchmarking report (report WHC5976-01, 14 October 2021), flaring pre-drainage gas is existing practice at several underground coal mines in Australia.
- The study should consider whether the gas vented at the existing mine can be mitigated.
- Further study of the permeability and gas saturation characteristics of the Hoskissons seam is needed to inform the optimisation of gas drainage as noted by Palaris (report WHC5976-01). This should include optimal drill patterns and options analysis for pre-drainage.
- Palaris (report WHC5827-01) considered CAPEX and OPEX for VAM destruction using Regenerative Thermal Oxidizer (RTO) technology, methane enrichment with flaring, and low methane concentration power generation using gas-fired generators. This did not include the membrane separation technology discussed in the latter report.
- Palaris (report WHC5976-01) conducted a qualitative assessment of methane enrichment technologies with the most appropriate option being identified as membrane separation technology. Although this is not current practice in Australian coal mines, the report indicated it could be used in combination with the extant mobile gas extraction units. A more detailed study of the membrane separation concept plan should be undertaken to determine cost and viability and options for handling the higher methane content gas produced should be investigated.
- The outcomes from the two Palaris reports should be synthesised and expanded to inform a broader and deeper assessment of mine gas abatement.

- The proponent should discuss its liabilities under the Safeguard Mechanism (with mention of its emission cap) and investigate the feasibility of offsetting the residual emissions beyond the requirements of the Safeguard Mechanism.

In short, the proponent should prepare a more detailed gas management plan to assist in minimising Scope 1 emissions from the project.

Yours sincerely,

Matthew Riley

Director Climate and Atmospheric Science

Environment Energy and Science

## Appendix 1 – Overview of Greenhouse Gas Mitigation Information received

A brief section on mitigation of greenhouse gases in provided in Section 9.3 of the GHG Assessment (Jacobs, 2020). The proponent has also prepared in the past a Greenhouse Gas Minimisation Plan (SLR, 2012) and an Energy Saving Action Plan (Advitech, 2014) (not provided to DPIE EES as part of the review). Actions mentioned explicitly in the GHG Assessment included reducing fuel usage in mobile plant, regular plant maintenance, selecting energy efficient plant, staff training on energy efficiency and monitoring fuel, electricity, methane and sulfur hexafluoride emissions.

The GHG Assessment states that gas composition and volumes will be monitored, and that the proponent would continue to investigate developments in flaring technology to determine whether flaring is a viable option to abate Scope 1 greenhouse gas emissions associated with Project fugitive emissions.

In the more recent Submissions Report in section 4.2.10 the proponent proposes to flare pre-drainage gas for the Project. In the existing mine, the current methane content of the gas is of the order of 5%, making flaring unviable with the gas being vented to the atmosphere.

As described in Section 2.6.7 of the EIS,[5] gas extracted from the Hoskissons Coal Seam associated with the Project is expected to have a higher methane content than the approved mine area, but a lower volume than the existing mine. Further analysis showed that there are parts of the Stage 3 area where gas with a 30% methane content and sufficient gas flowrate is expected (i.e. sections of Longwalls 204 to 209) and flaring of pre-drainage gas is proposed to be conducted. Approximately three flaring units would be in operation at any one time.

The abatement from flaring was reported in the amended GHG assessment by Jacobs (2021). The proponent estimates that flaring is expected to provide approximately 0.6% of total Scope 1 abatement over the project lifetime.

In the Amendment Report (31 May 2020),[3] the Proponent provided a cost analysis and emissions abatement report (Palaris, WHC5827-01, 25 May 2021) for three technologies in response to information requests from stakeholders regarding abatement beyond flaring pre-drainage gas.

The report considered abatement by Ventilation Air Methane (VAM) destruction, (full and partial flow), low gas concentration power generation and methane gas enrichment (i.e. increasing the proportion of methane in the flaring stream). The gas enrichment technology was based on standard amine gas sweetening technology used in the oil and gas industry.

In Section 3.3.2 of the Amendment Report, the proponent considered the feasibility of the options.

The full flow VAM option (abating 500 $m^3/s$) requires CAPEX of $190M for two VAM units and $76M in annual OPEX over 7 years. This would achieve 3 Mt $CO_2$-e abatement over the project lifetime or 9.6% of total scope 1 emissions. The proponent ruled this option out due to high costs and relatively low abatement.

The partial flow option (abating 125 $m^3/s$) requires CAPEX of $64M for two VAM units and $24M in annual OPEX over 7 years. This would achieve 0.76 Mt $CO_2$-e abatement over the project lifetime or 2.2% of total scope 1 emissions. The proponent also ruled this option out due to high costs and relatively low abatement.

The gas enrichment option diverts more methane to flaring – the total CAPEX was $15M including the flares, with annual OPEX at $2M. The proponent will review this option as it is currently not standard practice in Australian coal mining.

For low gas concentration power generation, the proponent considered that the period of time of mining where the gas content is suitable for gas generation (above 25% methane) is too short.

Therefore, the costs associated with a power station would not be viable in consideration of the potential payback benefit.

In Section 3.3.3 the proponent proposed a Research Program to consider methane enrichment in relation to flaring, low methane content power generation, use of VAM to destroy low (0.2% - 0.5%) methane in VAM and other abatement options.

On 29 September 2021, the DPIE PAG requested more detailed consideration of methane abatement beyond the very limited opportunity to flare pre-drainage gases in the Project area as described in the Amendment Report.

The proponent indicated that flaring during development, longwall and post-mining goaf gas drainage was not feasible due to high dilution by the mine ventilation air (MVA). In the case of the post-mining goaf gas drainage, the methane percentage is higher, but the mine gas is still diluted by MVA which is introduced to the goaf behind the longwall equipment. This introduces oxygen to the gas mixture in the goaf and therefore a potential safety hazard.

A response was provided on 15 October 2021.[4] The proponent provided a high-level assessment report by Palaris entitled "Narrabri Underground Stage 3 Extension Project GHG Abatement Benchmarking" (dated 14 October 2021, WHC5976-01).

This Palaris report discusses various aspects of flaring low methane content gas, enhanced gas recovery, and methane enrichment of the gas pre-flaring using e.g. membrane separation technology, amine sweetening and pressure swing absorption methods. Palaris considered that "…membrane separation appears most compatible with Narrabri Mine surface gas plant infrastructure and the need for modular units."

Palaris also provided a concept plan to use existing gas extraction equipment in combination with gas compression/separation units for enrichment, mobile flares and diesel gensets.

Given all of the above information, the proponent should develop a more detailed gas management strategy that assesses the lowest cost technologies in more detail (e.g. at pre-feasibility level). Especially the recently suggested membrane separation technology. The proponent should further assess the use of methane-enriched gas for power generation or to supplement VAM destruction with commercially available regenerative thermal oxidation (RTO) technology.

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[1] Narrabri Underground Mine Stage 3 Extension Project Environmental Impact Statement, Appendix I, Air Quality and Greenhouse Gas Assessment, Jacobs Group (Australia) Pty Limited, 24 August 2020
https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021207.795%20GMT

[2] Narrabri Underground Mine Stage 3 Extension Project Submissions Report, 2 June 2021.
https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=EXH-10425089%2120210531T070053.430%20GMT

[3] Narrabri Underground Mine Stage 3 Extension Project Amendment Report, Sections 3.3.2 - 3.3.3 and Appendices B-D
https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120210531T065545.008%20GMT

[4] re: Narrabri Underground Mine Stage 3 Extension Project – Greenhouse Gas Additional Information
https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=RFI-28578842%2120211015T030000.474%20GMT

[5] Narrabri Underground Mine Stage 3 Extension Project Environmental Impact Statement (EIS), Section 2 Project Description.
https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021126.211%20GMT