

Mod3 Appin Mine Ventilation and Access Project: Peer Review of Air Quality Assessment

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Glossary

Term	Definition
$\mu\text{g}/\text{m}^3$	micrograms per cubic metre
μm	microns
$^{\circ}\text{C}$	degrees Celsius
km	kilometre
m	metre
$\text{g}/\text{m}^2/\text{month}$	grams per metre squared per month
OU	odour units
Nomenclature	Definition
CO	carbon monoxide
H_2S	hydrogen sulfide
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
PM_{10}	particulate matter with a diameter less than 10 micrometres
$\text{PM}_{2.5}$	particulate matter with a diameter less than 2.5 micrometres
SO_2	Sulfur dioxide
TSP	total suspended particulate
VOCs	Volatile organic compounds
Abbreviations	Definition
ACGIH	American Conference of Governmental Industrial Hygienists
Approved Methods for Modelling	Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales
DPIE	Department of Planning, Industry & Environment
MOD3	Bulli Seam Operation Project – Appin Mine Ventilation and Access Modification 3 application
NSW EPA	New South Wales Environment Protection Agency
OEHHA	California Office of Environmental Health Hazard Assessment
REL	Reference Exposure Level
VS7	Downcast ventilation shaft 7
VS8	Upcast ventilation shaft 8

1. INTRODUCTION

Katestone Environmental Pty Ltd (Katestone) was engaged by the Department of Planning, Industry & Environment (DPIE) to conduct an independent peer review of the air quality assessment that was prepared as part of the modification report for the Bulli Seam Operation Project – Appin Mine Ventilation and Access Modification 3 (MOD3) application (the Project).

1.1 Scope of work

DPIE has requested that Katestone undertake the following work:

- 1) Conduct an independent peer review of the adequacy of the air quality and greenhouse gas assessment, particularly in relation to potential health related impacts to surrounding residential receivers from:
 - Contamination of drinking water due to dust particles landing on roofs of surrounding residences and settling in rainwater tanks; and
 - Pollutants from mine ventilation air emissions from the upcast Ventilation Shaft 8 (VS8), including particulate matter and gases [oxides of nitrogen (NO_x), sulphur dioxide (SO₂), carbon monoxide (CO), carbon dioxide (CO₂) and volatile organic compounds (VOCs)].
- 2) Conduct an independent peer review of the adequacy of the advice received from EMM on the potential health risks associated with windborne dust containing silica from stockpiles and bunds surrounding the site during adverse weather conditions, particularly given the material would primarily be Hawkesbury sandstone from blasting and excavation of the ventilation shafts and may be exposed for extended periods prior to revegetation.

1.2 Relevant documents

To evaluate the suitability and appropriateness of the air quality assessment, Katestone has had regard to the following documents:

- *Protection of the Environment Operations Act 1997*
- Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (NSW EPA, 2016) (Approved Methods for Modelling)
- Generic guidance and Optimum Model Setting for the CALPUFF Modeling System, for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia' (TRC Environmental Corporation 2011)
- CALPUFF Modeling System Version 6 User Instructions (EarthTec, 2011)
- TAPM v4. User Manual (CSIRO Marine and Atmospheric Research Internal Report No5, October 2008).

This peer review has considered the following information relevant to the air quality assessment:

- Air Quality and Greenhouse Gas Assessment Appin Mine Ventilation and Access Project, EMM, June 2021
- MOD 3 Appin Mine Ventilation and Access Project – response to submissions on air quality (Letter from EMM to Illawarra Metallurgical Coal dated 25 November 2021) (EMM advice on silica)

- Submissions (Attachment C – Eg submissions.pdf)
- Dispersion modelling files provided by EMM.

2. REVIEW OF AIR QUALITY ASSESSMENT

The detailed review of technical aspects of the air quality assessment is presented in Appendix A.

2.1 Project overview

The Appin Mine Ventilation and Access Project includes the development of mine access facilities, a downcast ventilation shaft (VS7), an upcast ventilation shaft (VS8), three extraction fans, ducting and evases and associated ancillary infrastructure.

The Project is located approximately 35 km northwest of Wollongong and 8 km northwest of Appin. The township of Menangle is located approximately 1.3 km to the northeast of the site. To assess potential air quality impacts across the surrounding area, residences within approximately 1.5 km of the site have been selected as discrete assessment locations.

2.2 Emissions inventory

2.2.1 Emissions sources

In the construction phase, the following potential sources of emissions were considered for the bulk earthworks and shaft sinking phases.

- Bulk earthworks (duration 9 months):
 - Vegetation and topsoil stripping
 - Loading trucks with soil
 - Hauling soil across site
 - Emplacement of soil to stockpile
 - Excavation of bulk material
 - Loading bulk material to trucks
 - Hauling soil across site
 - Emplacement of soil to stockpile
 - Dozer spreading/shaping
 - Exposed ground wind erosion
 - Onsite diesel consumption
- VS7 - main shaft sink (duration 5 months):
 - Drilling
 - Blasting
 - Material handling - spoil to surface
 - Loading trucks with spoil
 - Hauling spoil across site
 - Emplacement of spoil
 - Dozer spreading/shaping

- Exposed ground wind erosion
- Onsite diesel consumption
- VS8 - main shaft sink (duration 5 months):
 - Drilling
 - Blasting
 - Material handling - spoil to surface
 - Loading trucks with spoil
 - Hauling spoil across site
 - Emplacement of spoil
 - Dozer spreading/shaping
 - Exposed ground wind erosion
 - Onsite diesel consumption

In operations phase, the primary potential source of emissions is the ventilation of mine gas from VS8.

2.2.2 Emission rates

Emission rates of air pollutants are a critical input into a dispersion modelling study because downwind concentrations are proportional to the emission rate.

2.2.2.1 Construction

Dust (TSP, PM₁₀ and PM_{2.5}) emissions associated with construction were estimated using activity data for construction representing a nominal year when material handling is at a maximum and emission factors from the National Pollutant Inventory Estimation Handbook for Mining. Where control measures are proposed to be implemented, they have been accounted for by reductions in emissions.

The air quality assessment did not explicitly quantify emissions of metals or silica. However, silica emissions were subsequently characterised in EMM's advice on silica.

Katestone's review of construction emissions found that:

- The emissions (TSP, PM₁₀ and PM_{2.5}) may have been underestimated by about 2%. This is due EMM using a lower emission factor for haulage of material than expected based on vehicle mass and road silt content provided.
- The emission rates were reported as kg/year; however, it is relevant to note that the duration of the various phases of construction varies, with bulk earthworks anticipated to take nine months and construction of VS7 and VS8 to each take five months, with a two-month overlap.
- Bulk earthworks would occur 12 hours per day.
- Activities associated with sinking the shafts would occur 24 hours per day, with installation of surface infrastructure to occur over daytime hours; however, it is not clear which specific activities from the emissions inventory would be occurring during the night.

2.2.2.2 Operations

Emissions associated with operation of VS8 were estimated based on the average of sampling data obtained from Appin Vent 6 and fan flow rates, with the exception of odour which was based on maximum measured odour concentration. Emissions of dust (PM₁₀, PM_{2.5}, TSP), NO_x, odour and H₂S were quantified for VS8. Katestone's review of operational emissions found emission rates of dust and odour were reported and modelled correctly. Emissions of NO_x were reported incorrectly; however, were modelled correctly.

Katestone was unable to reproduce the emissions of H₂S that were presented within the EMM Report and that were modelled. Modelled emissions of H₂S were higher than those calculated using information provided within the EMM Report. Consequently, the H₂S assessment will likely overestimate the potential impact of the Project.

Emissions of silica, SO₂, CO, VOCs or metals were not quantified for operations.

2.2.3 Dispersion model release parameters

The physical attributes of emission sources (release parameters) need to be correctly characterised in the dispersion model to provide reliable predictions of potential dust levels at sensitive receptors. This section provides Katestone's review of the release parameters.

Construction sources were modelled as diffuse area and volume sources, which is consistent with standard practice. However, the parameterisation of the volume sources (haulage and truck loading and unloading) used an effective height of 0.25m and sigma z of 0.23m, which are much smaller than standard practice. Typically, activities such as haulage and loading and unloading of trucks would have an effective height of between 4 and 10m, which is representative of the initial scale of the dust plume. It is not possible to quantify the effect of this approach on the predicted ground-level concentrations of air pollutants without revising the dispersion modelling.

The emission sources that were modelled for construction used base elevations of zero rather than with base elevations that are reflective of the terrain height of the area. It is not possible to quantify the effect of this approach on the predicted ground-level concentrations of air pollutants without revising the dispersion modelling.

For operations, VS8 has been characterised as a point source with exit velocity based on fan speed and ambient temperature. This approach is correct.

2.2.4 Hours of operation of construction activities

The EMM Report specifies the hours of operation for construction activities as follows:

- Bulk earthworks would occur 12 hours per day.
- Activities associated with sinking the shafts would occur 24 hours per day, with installation of surface infrastructure to occur over daytime hours.

However, it is not clear which specific activities from the emissions inventory would be occurring during the night. The hours of operation are important for the selection of dispersion modelling scenario because dispersion is poorer at night and, consequently, air pollutant concentrations may be greater than during the day. This is discussed further in Section 2.4.

2.3 Meteorological modelling

The meteorological data used in the dispersion model is of fundamental importance as it drives the transport and dispersion of the air pollutants in the atmosphere. The most critical parameters are wind direction, which determines the initial direction of transport of pollutants from the place of emission; wind speed, which dilutes the plume as it

travels downwind and determines the travel time from source to receptor; and atmospheric turbulence, which indicates the dispersive ability of the atmosphere.

The Approved Methods for Modelling makes the following recommendations for meteorological data:

- At least one year of site-specific meteorological data is required.
- The meteorological data must be 90% complete in order to be acceptable for use.
- If site-specific meteorological data are not available, at least one year of site-representative meteorological data must be used. The site representative data should be:
 - *“...preferably collected at a meteorological monitoring station. Where measured data is unavailable or of insufficient quality for dispersion modelling purposes, a meteorological data file may be generated using a prognostic meteorological model such as TAPM...”*
 - *“...correlated against a longer-duration site-representative meteorological database of at least five years (preferably five consecutive years) to be deemed acceptable. It must be clearly established that the data adequately describes the expected meteorological patterns at the site under investigation (e.g. wind speed, wind direction, ambient temperature, atmospheric stability class, inversion conditions and katabatic drift).”*

The meteorological data that was used in the modelling was generated using a coupled approach of using the TAPM and CALMET models and observational data.

The assessment is based on dispersion modelling that includes 12 months of meteorological data that is 100% complete. Meteorological data from the Department of Environment, Energy and Science, Bureau of Meteorology, and from Appin Shaft 6 and the Appin Power Station were also included in the development of a meteorological windfield for the site.

The assessment has presented an analysis of five years of meteorology, which determined that 2018 is a representative year.

The requirements for conducting meteorological modelling are detailed in the documents listed in Section 1.2. Katestone’s review of the assessment found that the CALMET model was configured in accordance with the above guidance and the resulting analysis of meteorological parameters indicates that the meteorology is reasonable.

2.4 Dispersion modelling

The requirements for conducting dispersion modelling are detailed in the documents listed in Section 1.2. Katestone has reviewed the dispersion modelling input and output files that were generated for assessment against the requirements specified in these documents.

The CALPUFF dispersion model was used by EMM to predict ground-level concentrations of air pollutants due to construction and operation of the Project. Katestone’s review has found that the CALPUFF model was configured in general accordance with the above guidance. In particular, the following points are relevant:

- Peak to mean ratios have been applied to concentrations of H₂S in accordance with the Approved Methods for Modelling.
- The particle size, geometric mass mean diameter and geometric standard deviation for dry depletion are appropriate.

The EMM Report modelled two scenarios, namely:

- Construction – bulk earthworks
- Operation – VS8.

The key issue that has arisen from Katestone's review of the dispersion modelling is that the bulk earthworks phase of construction may not be indicative of the potential impact of the entire construction phase because operations occur for 12 hours per day, whereas construction of VS7 and VS8 will occur for 24 hours per day. Whilst emissions from the construction of VS7 and VS8 were quantified, dispersion modelling of these scenarios was not conducted because total emissions during the bulk earthworks phase were found to be slightly greater than construction of VS7 and VS8 and it was assumed that bulk earthworks would not overlap with the construction of VS7 and VS8.

However, atmospheric dispersion is much poorer during the night than during daylight hours. Consequently, for the same dust emission rate, air pollutant concentrations will be greater at night than during the day and, therefore, the dispersion modelling of the construction phase as a 12 hour per day activity, may underestimate ground-level concentrations of air pollutants. Whilst it is relevant to note that ground-level concentrations of air pollutants during the construction phase have been predicted to be relatively low, it is not possible to determine the consequence of 12 hour versus 24 hour emissions without revising the dispersion modelling.

It is also relevant to note that the EMM Report has not quantified emissions or potential impacts due to fumes associated blasting activities. The EMM Report advocates that potential impacts due to blasting can be adequately managed via a blast management plan. Katestone agrees that this is a reasonable approach.

2.5 Impact and risk assessment

2.5.1 Assessment criteria

The EMM Report utilised the impact assessment criteria specified in the Approved Methods for Modelling for dust, NO_x, H₂S and odour. The assessment criteria have been applied correctly.

The EMM Report estimated the population likely to be affected by the Project to be 125 to derive criteria for odour and H₂S. Based on this population, an odour criterion of 4OU (nose response time average, 99th percentile) and an H₂S criterion of 2.76 µg/m³ (nose response time average, 99th percentile) were adopted.

2.5.2 Impact assessment results

The dispersion modelling of construction and operational emissions found predicted concentrations of air pollutants at sensitive receptors complied with the relevant air quality impact assessment criteria.

A summary of the ground-level concentrations of air pollutants due to the construction phase is provided in Table 1. A summary of the ground-level concentrations due to the operational phase with ventilation fans running at high flowrate is provided in Table .

Whilst the assessment has indicated compliance with the relevant air quality impact assessment criteria, the cumulative assessment has demonstrated marginal compliance with the assessment criteria for 24-hour average concentrations of PM₁₀ and annual average concentrations of PM_{2.5}.

Table 1 Construction – predicted ground-level concentrations

Pollutant	Averaging period	Isolation		Cumulative		Impact assessment criterion (µg/m ³)
		Minimum concentration predicted at a receptor (µg/m ³)	Maximum concentration predicted at a receptor (µg/m ³)	Minimum concentration predicted at a receptor (µg/m ³)	Maximum concentration predicted at a receptor (µg/m ³)	
PM ₁₀	24-hour	0.4	6.1	48.5	49.1	50
	Annual	<0.1	0.7	17.7	18.3	25
PM _{2.5}	24-hour	0.2	2.1	19.6	20.4	25

Pollutant	Averaging period	Isolation		Cumulative		Impact assessment criterion ($\mu\text{g}/\text{m}^3$)
		Minimum concentration predicted at a receptor ($\mu\text{g}/\text{m}^3$)	Maximum concentration predicted at a receptor ($\mu\text{g}/\text{m}^3$)	Minimum concentration predicted at a receptor ($\mu\text{g}/\text{m}^3$)	Maximum concentration predicted at a receptor ($\mu\text{g}/\text{m}^3$)	
	Annual	<0.1	0.2	7.8	8	8
TSP	Annual	0.1	1.6	44.3	45.6	90
Dust deposition	Annual	<0.1 $\text{g}/\text{m}^2/\text{month}$	0.1 $\text{g}/\text{m}^2/\text{month}$	NA	NA	2

Table 2 Operation – predicted ground-level concentrations

Pollutant	Averaging period	Isolation		Cumulative		Impact assessment criterion ($\mu\text{g}/\text{m}^3$)
		Minimum concentration predicted at a receptor ($\mu\text{g}/\text{m}^3$)	Maximum concentration predicted at a receptor ($\mu\text{g}/\text{m}^3$)	Minimum concentration predicted at a receptor ($\mu\text{g}/\text{m}^3$)	Maximum concentration predicted at a receptor ($\mu\text{g}/\text{m}^3$)	
PM ₁₀	24-hour	0.5	6.7	48.5	49.3	50
	Annual	<0.1	0.3	17.7	18.0	25
PM _{2.5}	24-hour	0.1	1.6	19.6	19.7	25
	Annual	<0.1	0.1	7.7	7.8	8
TSP	Annual	0.1	0.6	44.3	45.6	90
Dust deposition	Annual	<0.1 $\text{g}/\text{m}^2/\text{month}$	<0.1 $\text{g}/\text{m}^2/\text{month}$	NA	NA	2 $\text{g}/\text{m}^2/\text{month}$
NO ₂	1-hour	10.7	65	68.6	95.8	246
	Annual	0.1	8	15.0	15.8	62
odour	1s nose-response	<10U	20U	NA	NA	40U
H ₂ S	1s nose-response	0.04	0.26	NA	NA	2.67

Overall, the EMM Report demonstrates that the operational phase of the Project is unlikely to cause impacts on air quality.

However, Katestone's review of the construction assessment has identified the following matters that may affect the assessment outcome:

- The construction assessment did not incorporate correct base elevations for emission sources
- The construction assessment did not incorporate source parameters that are representative of the emission sources
- The construction assessment assumed operations for 12 hours per day, whereas construction associated with VS7 and VS8 will occur for 24 hours per day.

3. RAINWATER TANKS

3.1 Background to rainwater tanks

EMM did not quantify levels of air pollutants in rainwater tanks for sensitive receptors due to the Project. EMM did not quantify concentrations of metals or VOCs due to the Project. However, it is unlikely that VOCs will be a concern in rainwater tanks. EMM concluded that the low dust deposition rates (less than 5% of the relevant criterion) associated with the project were unlikely to be an issue for rainwater tanks.

To provide DPIE with a preliminary estimate of air pollutant concentrations in rainwater, Katestone has used the method detailed in the Air Toxics Hot Spot Program Guidance Manual for Preparation of Health Risk Assessments (Office of Environmental Health Hazard Assessment, 2015) and metal speciation profiles for coal and soil from the National Pollutant Inventory Emission Estimate Technique Manual for Mining Version 3.1 (DSEWPC, 2011) along with predicted annual average dust deposition rates to estimate likely levels of metals in tank water ($\mu\text{g/L}$). Katestone has compared those estimates to the relevant Australian Drinking Water Guidelines (ADWG) 2011 (Updated January 2022).

The quantity of air pollutants that may be deposited on roofs and transferred to rainwater tanks is dependent upon:

- Amount of dust that is deposited on the roof of a sensitive receptor
- The contaminants contained in the dust
- Roof surface area feeding rainwater tank
- Rainwater tank capacity
- Annual rainfall.

3.2 Legislative framework

The Australian Drinking Water Guidelines (ADWG) 2011 (Updated January 2022) provides a framework for good management of drinking water. Whilst the ADWG are not mandatory, the ADWG provide a basis for determining the quality of water in tanks that may be affected by deposited dust.

The ADWG provide information on management and monitoring of drinking water as well as provides a list of contaminants that may exist and suitable levels for protecting health and the aesthetics of water.

3.3 Rainwater tank results

To estimate likely concentration of metals in rainwater tanks, Katestone has applied the following assumptions:

- Roof surface area of 600m²
- Rainwater tank capacity of 50,000L
- Annual rainfall of 984mm (Menangle Bridge, BoM)
- 100% of each metal leaches or dissolves in water, which, depending on the form of the metals may be unlikely.

The greatest potential impact would occur during the construction phase. Based on Katestone's analysis, lead is the metal that is likely to be highest relative to the ADWG, which has been estimated to be less than 0.43% of the ADWG for health. Consequently, Katestone is satisfied that the Project is unlikely to adversely affect tank water.

4. SILICA

Katestone's review has considered EMM's advice in the context of existing regulations and guidance documents relating to silica. Katestone's advice does not constitute medical, epidemiological or toxicological advice in relation to silica. In this regard, Katestone has relied upon the suitability of existing regulatory limits for silica.

4.1 Background to silica

Silica is a mineral that is commonly found in the earth's crust. Chemically, silica is silica dioxide (SiO₂). Silica is present in crystalline and amorphous forms in many naturally occurring and manmade materials including stone, rock, sand, gravel, clay, bricks, tiles, concrete and artificial stone benchtops.

Exposure to elevated levels of fine crystalline silica dust is associated with lung cancer, silicosis, chronic obstructive pulmonary disease and kidney disease.

The common forms of silica for health consideration are quartz, cristobalite and tridymite.

4.2 Legislative framework relevant to silica

The environmental legislation in NSW does not address silica explicitly. However, silica is implicitly captured under various aspects of the regulatory framework.

4.2.1 Protection of the Environment Operations Act 1997

The POEO Act is the key legislation in NSW for regulating industrial emissions into the environment. It provides the following:

- Licensing and imposition of licence conditions by NSW EPA in relation to activities that are defined under Schedule 1 of the POEO Act
- Development of Protection of the Environment Policies
- Definition of offences and penalties in relation to air pollution under Sections 124-129
- Definition of offences relating to licensing and conditions
- Development of regulations and guidelines that promulgate impact assessment criteria and emission standards for industry
- Provision of a mechanism for public participation in the environmental assessment of activities that may be licensed by NSW EPA, in conjunction with the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Under section 126 of the POEO Act, it is an offence to cause air pollution due to a failure to deal with materials in a proper and efficient manner. That is:

126 Dealing with materials

(1) The occupier of any premises who deals with materials in or on those premises in such a manner as to cause air pollution from those premises is guilty of an offence if the air pollution so caused, or any part of the air pollution so caused, is caused by the occupier's failure to deal with those materials in a proper and efficient manner.

(2) In this section—

deal with materials means process, handle, move, store or dispose of the materials.

materials includes raw materials, materials in the process of manufacture, manufactured materials, by-products or waste materials.

Consequently, silica emissions from the Project would need to be managed to not cause air pollution. Air quality standards and criteria, such as those specified in the Approved Methods for the Modelling are commonly used as an indicator of the potential for air pollution.

4.2.2 Approved Methods for Modelling

The Approved Methods for the Modelling does not specify impact assessment criteria for silica. The Approved Methods for Modelling does provide guidance for the use of Health Risk Assessment where toxic air pollutants are emitted. The Approved Methods for Modelling states that dose response and risk characterisation can be undertaken in accordance with the following:

- *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA 2003)*
- *Hot Spots Analysis and Reporting Program (HARP) (CARB 2003a)*
- *Hot Spots Analysis and Reporting Program – User Guide Version 1.0 (CARB 2003b).*

In NSW, as with other Australian jurisdictions, it is common to consider the impact assessment criteria adopted internationally and elsewhere in Australia where no criterion has been specified in the Approved Methods for Modelling.

4.2.3 Other jurisdictions

EnRisks (2020) completed a detailed review of toxicity reference values for respirable crystalline silica for occupational and environmental exposures for Dowe's Quarry near Tenterfield in NSW. That review considered cancer and non-cancer effects and recommended the adoption of EPA Victoria's criterion which is based on the Chronic Reference Exposure Level (Chronic REL) that was developed by the California Office of Environmental Health Hazard Assessment (OEHHA).

4.2.3.1 California OEHHA

In 2005, OEHHA adopted a Chronic REL for respirable crystalline silica of $3\mu\text{g}/\text{m}^3$.

OEHHA defines a Chronic REL as an airborne level of a chemical at or below which no adverse health effects are anticipated in individuals indefinitely exposed to that level. OEHHA states that its Chronic RELs are developed from the best available published scientific data, based solely on health considerations (OEHHA, 2005).

This Chronic REL is meant to be applied only to particles of crystalline silica (quartz, cristobalite, tridymite), of respirable size, as defined by the occupational hygiene methods described by ACGIH (2004)/ISO (1995) which has a 50% cut-point at $4\mu\text{m}$ particle aerodynamic diameter.

4.2.3.2 Victoria

EPA Victoria has adopted an assessment criterion for mining and extractive industries (EPA Victoria, 2007) for respirable crystalline silica (as $\text{PM}_{2.5}$) of $3\mu\text{g}/\text{m}^3$ based on OEHHA's Chronic REL. EPA Victoria requires the assessment of respirable crystalline silica to include background levels of silica.

Katestone notes that EPA Victoria's assessment criterion for respirable crystalline silica is applied to the crystalline silica component of PM_{2.5}, whereas the OEHHA Chronic REL is derived from concentrations of essentially PM₄. On the face of it, the EPA Victoria criterion is less stringent than the OEHHA Chronic REL. However, EnRisks (2020) notes that there is an absence of comprehensive data on the ability of particle size to induce silicosis and, hence, it is not possible to adjust the Chronic REL for different particle size distributions.

Concentrations of PM₄ are not normally determined in an air quality assessment. Given the above points, EnRisks (2020) suggests also assessing the crystalline silica component of PM₁₀ against the limit of 3 µg/m³.

4.3 EMM Advice on silica

EMM's letter in response to DPIE's request addresses three key points:

- Silica content of Hawkesbury sandstone
- Exposure criteria for silica
- Estimation of ambient concentrations of silica and assessment against criteria.

EMM agrees that Hawkesbury sandstone contains a high silica content. EMM determined from a report of Pells (2004) that the total quartz content of excavated and stockpiled material from the Project could be up to 76.4%. This quartz content has been applied to all construction related dust, which will likely overestimate emissions of respirable crystalline silica because not all of the dust emitted from the Project will be derived from Hawkesbury sandstone.

Katestone notes that the estimate of 76.4% as the quartz content of Hawkesbury sandstone is likely to be a slight overestimate based on Pells (2004), which reports two studies of Hawkesbury sandstone from 1969 and 1978. The former suggests a maximum quartz content of 74% and the latter 66.8%. EMM's value of 76.4% has been derived by adding the maximum proportion of sandstone that is quartz grains from the 1969 study to the maximum proportion that is secondary quartz from the 1978 study.

Elsewhere, Katestone is aware that practitioners have adopted a more conservative assumption that all of the PM_{2.5} that is emitted is crystalline silica. Commonly, such assumptions are adopted where the composition of materials is not well known.

EMM's silica advice estimates that the Project would contribute 5% of EPA Victoria's assessment criterion due to the Project in isolation. At the most affected sensitive receptor, the annual average concentration of PM₁₀ due to the Project in isolation is predicted by EMM to be 0.7µg/m³. If all of the dust was assumed to be crystalline silica, the Project would contribute 23% to the OEHHA Chronic REL at the most affected receptor.

EMM has not included background levels of respirable crystalline silica on the basis that levels would be minimal. EnRisks (2020) summarised respirable crystalline silica levels reported for various locations around the world and in Australia and concluded that a conservative background level would be 1.9µg/m³. Katestone agrees that this value is conservative and is likely to overestimate background levels of respirable crystalline in the vicinity of the Project. However, regardless of the conservatism, assuming the predicted concentrations of respirable crystalline silica are reliable, compliance with the EPA Victoria criterion would still be achieved if a background of 1.9µg/m³ were added to the maximum predicted concentration (as PM_{2.5} and PM₁₀) at the most affected sensitive receptor.

The potential 2% underestimate in dust emissions would not change the above results. However, the predicted annual average concentrations of PM_{2.5} for the construction phase that are relied upon in EMM's silica advice are based on the bulk earthworks phase of construction, which is proposed to occur during daylight hours for 12 hours per day, whereas some activities relating to the construction of VS7 and VS8 will occur for 24 hours per day. Dispersion of air pollutants is well known to be much poorer at night. Consequently, the predicted annual average concentrations of PM_{2.5} and PM₁₀ may not be representative of the period of construction of VS7 and VS8.

5. REVIEW OF GREENHOUSE GAS ASSESSMENT

The greenhouse gas assessment has focused on the additional greenhouse gas emissions due to the Project. That is:

- Construction
 - Diesel consumption
 - Blasting
 - Electricity use
 - Land clearing
- Operation
 - Electricity use

Fugitive emissions associated with mine ventilation were not quantified as there will not be an increase in the volume of coal produced, only a redistribution of mine ventilation air.

Fuel consumption during the operation of the mine was not quantified as there will be no change in fuel consumption during the operation of the mine as a result of the project.

Katestone's review of the greenhouse gas emissions found that they had been calculated correctly using the appropriate emission factors from the NGER Determination 2008.

Katestone agrees with EMM that the emission factor for land clearing of grassland is conservative.

6. CONCLUSIONS

Katestone was engaged by the Department of Planning, Industry & Environment (DPIE) to conduct an independent peer review of the air quality and greenhouse gas assessments that have been prepared as part of the modification report for the Bulli Seam Operation Project – Appin Mine Ventilation and Access Modification 3 (MOD3) application (the Project).

Katestone's review found that the air quality and greenhouse gas assessment has been undertaken in general accordance with industry standards and methods. The operational phase of the Project is unlikely to adversely affect air quality.

In relation to the construction phase, Katestone has identified a number of issues with the air quality assessment that should be reviewed and the dispersion modelling potentially revised to ensure that the assessment is rigorous and robust. These issues are as follows:

- Parameterisation of sources within the dispersion model. Construction sources were modelled as diffuse area and volume sources, which is consistent with standard practice. However, the parameterisation of the volume sources (haulage and truck loading and unloading) used an effective height of 0.25m and sigma z of 0.23m, which are much smaller than standard practice. Typically, activities such as haulage and loading and unloading of trucks would have an effective height of between 4 and 10m, which is representative of the initial scale of the dust plume.
- Base elevations of sources within the dispersion model. The emission sources that were modelled for construction used base elevations set to zero rather than base elevations that are reflective of the terrain height of the area.
- Hours of operation of construction works. The key issue that has arisen from Katestone's review of the dispersion modelling is that the bulk earthworks phase of construction may not be indicative of the potential impact of the entire construction phase because operations occur for 12 hours per day, whereas construction of VS7 and VS8 will occur for 24 hours per day. The hours of operation are important for the selection of dispersion modelling scenario because dispersion is poorer at night and, consequently, air pollutant concentrations may be greater than during the day.
- Potential impacts of silica. Whilst Katestone's analysis indicates that silica levels should be acceptable, the uncertainty around the modelling outcomes for this assessment based on issues with source parameterisation and hours of operation makes it difficult to determine definitively.

7. REFERENCES

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NHMRC, 2022, Australian Drinking Water Guidelines 6 2011 Version 3.7 Updated January 2022

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TRC Environmental Corporation, 2011, Generic guidance and Optimum Model Setting for the CALPUFF Modeling System, for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia'

VEPA, 2007, Protocol for Environmental Management State Environment Protection Policy (Air Quality Management) Mining and Extractive Industries.

A. REVIEW OF THE TECHNICAL AIR QUALITY AND GREENHOUSE ASSESSMENT REPORT

Table A1 Assessment against the requirements of the Approved Methods

Approved Methods		Comment
Section	Subsection	
3. Emissions inventory	3.1 Identify all sources of air pollution and potential emissions	The following stages have been identified in the EMM report: • Construction - Construction of downcast ventilation shaft (Ventilation Shaft 7) an upcast ventilation shaft (Ventilation Shaft 8), three extraction fans, ducting and evases and associated ancillary infrastructure. - Considered dust. - Site preparation, earthworks, shaft spoil handling. - Nominal year when material handling/movement is at maximum. • Operations - Considered oxides of nitrogen (NOx), H₂S, odour and particulate matter. - Fan evases for ventilation shaft 8.
	3.2 Determine source release parameters	• Construction - The construction sources have been modelled as a combination of area and volume sources. - Wind erosion of exposed areas has been parameterised as area sources with an effective height of 0.1m and sigma z of 2m. This is appropriate. - Other non wind erosion construction activities have been parameterised as volume sources with an effective height of 0.25m and sigma z of 0.23m. The effective height and sigma z values seem low given the sources are characterising haul of material, dozing, loading and unloading. - Base elevations of sources for construction were modelled with a base elevation of 0m, instead of incorporating terrain. This has the potential to affect predicted concentrations, however, the sensitivity of the results to this is unknown without revising the model. • Operation - The ventilation shaft 8 has been characterised as a point source with exit velocity based on fan speed and ambient temperature. This is appropriate.

Approved Methods		Comment
Section	Subsection	
	3.3 Estimate emission rates	• Construction - Annual emissions (kg/annum) of TSP, PM₁₀ and PM_{2.5} are presented in Table 7.1 of the EMM report for construction activities. - Emission factors and assumptions regarding control measures and activity rates are provided in Appendix D of the EMM Report. - Emission factors for the NPI and US EPA AP42 in relation to mining have been used. - Emission rates have been calculated using appropriate methodologies. - There are typographical errors in Appendix D of the EMM Report that suggests controls have been incorporated (e.g., for blasting and material handling – spoil to surface) but review of emissions and modelling indicates that these have not been included. This is appropriate as there are no controls for blasting. - Katestone's review found that the emissions (TSP, PM₁₀ and PM_{2.5}) associated with construction are underestimated by 2%. This is due EMM using a lower emission factor for haulage of material than expected based on vehicle mass and road silt content provided. - The emission rates were reported as kg/year; however, it is relevant to note that the duration of the various phases of construction varies, with bulk earthworks anticipated to take nine months and construction of VS7 and VS8 to each take five months, with a two-month overlap. - Bulk earthworks would occur 12 hours per day. - Activities associated with sinking the shafts would occur 24 hours per day, with installation of surface infrastructure to occur over daytime hours; however, it is not clear which specific activities from the emissions inventory would be occurring during the night. • Operations - Emission concentrations are presented in Table 7.2 of EMM report. - Emissions of silica, SO₂, CO, VOCs or metals were not quantified for operations. - Emission concentrations are based on sampling of other existing vents. - The average emission concentration has been used for the TSP, PM₁₀, PM_{2.5}, NO_x - The maximum emission concentration has been used for odour. - It is not clear what has been used for H₂S as these emissions could not be reproduced. - Emissions of NO_x, PM₁₀, PM_{2.5}, odour and H₂S are presented in Table 7.3 of the EMM Report for operations along with vent parameters such as flow rates and exhaust velocities.

Approved Methods		Comment
Section	Subsection	
		- There are typographical errors in Table 7.3 of the EMM Report in relation to NO_x and H₂S emission rates. However, it appears that the correct emission rates have been used in the dispersion modelling files for NO_x. - H₂S emissions were not able to be reproduced.
4. Meteorological data	4.1 Minimum data requirements	• The Approved Methods list the following requirements for meteorological data - <i>At least one year of data</i> – this has been addressed adequately - <i>At least 90% complete</i> – this has been addressed adequately - <i>Correlated against a longer-duration site-representative meteorological database of at least five years</i> • The meteorological windfield used in the modelling was generated using a coupled approach of TAPM/ CALMET models and observational data. This is appropriate. • The assessment is based on dispersion modelling that includes 12 months of meteorological data that is 100% complete. Meteorological data from the Department of Environment, Energy and Science, Bureau of Meteorology, and met from Appin Shaft 6 and the Appin Power Station was also included in the development of a meteorological windfield for the site. • The assessment has presented an analysis of five years of meteorology to determine that 2018 is a representative year. This is appropriate.
	4.2 Siting and operating meteorological monitoring equipment	• Meteorological data incorporated into the modelling was from the DEES, Bureau of Meteorology, and met from Appin Shaft 6 and the Appin Power Station. Four sites were incorporated into the CALMET grid. • BOM and DEES monitoring stations are typically sited in accordance with the Australian Standard AS/NZS 3580.1.1:2007 - Methods for sampling and analysis of ambient air - Guide to siting air monitoring equipment.
	4.5 Developing site-representative meteorological data using prognostic meteorological models	• The meteorological windfield used in the modelling was generated using a coupled approach of TAPM/ CALMET models and observational data. This is appropriate if configured appropriately. • TAPM - TAPM was configured with four grids with resolution of 30km, 10km, 3km and 1km. - Each grid had 25 x 25 grid nodes and 30 vertical levels. - Topographic files are appropriate. - Data assimilation was included using data from Ventilation Shaft 6, the Appin Power Station, Bom Camden Airport and DEES Campbelltown West • CALMET - Was run with a combination of prognostic data (TAPM) and observational data.

Approved Methods		Comment																																												
Section	Subsection																																													
		- When running in this mode, seven site-specific variables must be specified. - Key parameters used in the assessment are provided in the table below. <table> <tr> <th colspan="2">Parameter</th><th>Value</th><th>Acceptable</th></tr> <tr> <td>NSSTA</td><td>Number of surface stations</td><td>4</td><td>Yes</td></tr> <tr> <td>NPSTA</td><td>Number of upper air stations</td><td>0</td><td>Yes</td></tr> <tr> <td>ICLOUD</td><td>Cloud data</td><td>4</td><td>Yes</td></tr> <tr> <td>IEXTRP</td><td>Extrapolation of surface winds to upper layers</td><td>-4</td><td>Yes</td></tr> <tr> <td>IPROP</td><td>Gridded prognostic wind field model output as initial guess windfield</td><td>14</td><td>Yes</td></tr> <tr> <td>RMAX1</td><td>Maximum radius of influence of meteorological station over land, typically less than R1</td><td>5 km</td><td>Yes</td></tr> <tr> <td>RMAX2</td><td>Maximum radius of influence of meteorological station over land, typically less than R2</td><td>5 km</td><td>Yes</td></tr> <tr> <td>TERRAD</td><td>Influence of terrain</td><td>5 km</td><td>Yes</td></tr> <tr> <td>R1</td><td rowspan="2">Weighting parameters for Step 1 wind field versus observations</td><td>2 km</td><td>Yes</td></tr> <tr> <td>R2</td><td>2 km</td><td>Yes</td></tr> </table> • Land-use and terrain data appeared appropriate for the site. • The meteorology for the site has been reviewed and it, along with the predicted ground-level concentrations of dust appear reasonable indicating that the generated meteorology is reasonable.		Parameter		Value	Acceptable	NSSTA	Number of surface stations	4	Yes	NPSTA	Number of upper air stations	0	Yes	ICLOUD	Cloud data	4	Yes	IEXTRP	Extrapolation of surface winds to upper layers	-4	Yes	IPROP	Gridded prognostic wind field model output as initial guess windfield	14	Yes	RMAX1	Maximum radius of influence of meteorological station over land, typically less than R1	5 km	Yes	RMAX2	Maximum radius of influence of meteorological station over land, typically less than R2	5 km	Yes	TERRAD	Influence of terrain	5 km	Yes	R1	Weighting parameters for Step 1 wind field versus observations	2 km	Yes	R2	2 km	Yes
Parameter		Value	Acceptable																																											
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R1	Weighting parameters for Step 1 wind field versus observations	2 km	Yes																																											
R2		2 km	Yes																																											
5. Background air quality, terrain, sensitive receptors and building wake effects	5.1 Background air quality data	• Background air quality data was characterised from ambient monitoring data collected within the region. - PM₁₀ and PM_{2.5} data were obtained from DPIE's Camden and Campbelltown West monitoring stations and the 24-hour average data was averaged across the two site to obtain a "regional" average. - Daily varying concentrations of PM₁₀ and PM_{2.5} were included in the cumulative assessment based on the regional average. - TSP was derived using PM₁₀/TSP ratio of 0.4. - Dust deposition data as assessed in isolation against incremental criterion.																																												

Approved Methods		Comment
Section	Subsection	
		- NO₂ data were obtained from DEES's Camden and Campbelltown monitoring stations and the 1-hour average data was averaged across the two site to obtain a "regional" average. - Hourly varying concentrations of NO₂ were included in the cumulative assessment based on the regional average. • This is appropriate. • EMM's silica advice has not quantified background levels of respirable crystalline silica.
	5.2 Terrain and sensitive receptors	• Terrain - No terrain information was provided in the EMM Report; however, it was included in the meteorological and dispersion models. • Sensitive receptors - Sensitive receptors (residences) are detailed shown in Figure 3.4 of the EMM report. - This is acceptable.
	5.3 Building wakes	• Building wakes were included for the vent. This is appropriate.
6. Dispersion modelling	6.1 Dispersion models	• The CALPUFF model has been used. • This is appropriate if the model is configured appropriately. • Dry depletion for TSP, PM₁₀ and PM_{2.5} for construction and operations. • Dry depletion gas phase for NO_x, odour and H₂S. • The values for particle size, geometric mass mean diameter and geometric standard deviation that were used are appropriate. • The model configuration flags used are consistent with regulator guidance. • The EMM Report modelled two scenarios, namely: - Construction – bulk earthworks - Operation – VS8. • Bulk earthworks phase of construction may not be indicative of the potential impact of the entire construction phase because operations occur for 12 hours per day, whereas construction of VS7 and VS8 will occur for 24 hours per day. • Dispersion modelling of the bulk earthworks construction phase as a 12 hour per day activity, may underestimate ground-level concentrations of air pollutants compared with the VS7 and VS8 construction phase as a 24-hour per day activity.

Approved Methods		Comment
Section	Subsection	
		Whilst it is relevant to note that ground-level concentrations of air pollutants during the construction phase have been predicted to be relatively low, it is not possible to determine the consequence of 12 hour versus 24 hour emissions without revising the dispersion modelling.
	6.1 Dispersion models – cumulative impact	- Section 8.2 of the EMM report presents tabulated predicted concentrations of PM₁₀, PM_{2.5} and TSP for sensitive receptors in isolation and with ambient backgrounds. - Section 8.3 of the EMM report presents tabulated predicted concentrations of PM₁₀, PM_{2.5}, TSP and NO_x for sensitive receptors in isolation and with ambient backgrounds. - Odour, H₂S and deposition were assessed in isolation. - This is appropriate.
7. Interpretation of dispersion modelling results	7.1 Impact assessment criteria and 7.2 Application of impact assessment criteria	- Section 4.1 of the EMM report summarises the assessment criteria used in the assessment as follows: - Impact assessment criteria in the Approved Methods - For the population based criteria for odour and H₂S, criteria were based on population of 125 people providing an 99th 1-second nose-response odour criterion of 4OU and an H₂S criterion of 2.76µg/m³. - A discussion on relevance of criteria for particulates based on the limits specified in the current Appin Mine Approval was also provided. Criteria from the Approved Methods for Modelling are equivalent or stricter than the current Appin Mine Approval. - EMM silica advice adopts the EPA Victoria assessment criterion for respirable crystalline silica of 3µg/m³ as PM_{2.5}. This is appropriate subject to comments detailed in Section 4.
	7.3 Presentation of assessment results	- Section 8 of the EMM report presents tabulated predicted concentrations of pollutants for construction and operations. - Appendix E presents the following contours (for operations in isolation): - Construction – 24hr and annual PM₁₀, 24hr and annual PM_{2.5} - Operation - 24hr and annual PM₁₀, 24hr and annual PM_{2.5}, 1-hour NO₂ for minimum and maximum flow rates. - Predicted ground-level concentrations indicate compliance with the air quality impact criteria. - EMM silica advice presents respirable crystalline silica as PM_{2.5}. This is appropriate subject to comments detailed in Section 4.