Appendix E

Air quality impact assessment

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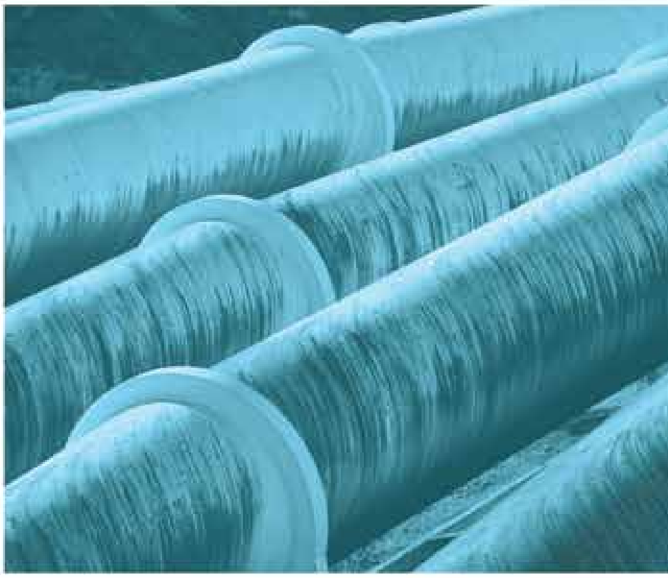
Cowal Gold Operations Underground Development

Air quality and greenhouse gas assessment to support SSD application and Modification 16

Prepared for Evolution Mining (Cowal) Pty Limited
August 2020

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Cowal Gold Operations Underground Development

Air quality and greenhouse gas assessment to support SSD application and Modification 16

Report Number

J190140 RP17

Client

Evolution Mining (Cowal) Pty Limited

Date

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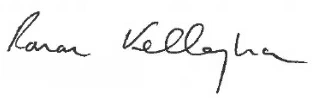
Version

Final

Prepared by



Ronan Kellaghan

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27 August 2020

Approved by

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27 August 2020

Executive Summary

This air quality impact assessment (AQIA) supports the application for the Cowal Gold Operations (CGO) Underground Development. Air quality and greenhouse gas (GHG) impacts are assessed concurrently to support two separate approval pathways; the underground development State significant development (SSD) and the surface changes modification (Mod 16), collectively referred to as 'the project'. Impacts are assessed concurrently as the project components are linked (the underground development cannot proceed without the surface changes modification) and cannot be separated for an assessment of cumulative impacts.

The AQIA documents the existing air quality and meteorological environment, applicable impact assessment criteria, air pollutant emission calculations, dispersion modelling of calculated emissions and provides an assessment of predicted impacts relative to criteria. The AQIA has been prepared in general accordance with the guidelines specified by the NSW Environment Protection Authority (EPA) in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (EPA 2016).

Meteorological conditions were described and characterised using data from the CGO on-site meteorological station. Existing air quality was characterised using data from the on-site monitoring network, supported with data from rural monitoring sites operated by DPIE.

Emissions estimation and dispersion modelling was completed for a single operational scenario which includes existing (approved) open cut operations and proposed underground development, for a scenario that corresponds to the maximum combined total movement of ore and waste (nominal mining year 2022). Emissions of total suspended particulates (TSP), particulate matter less than 10 micrometres (µm) in aerodynamic diameter (PM_{10}), particulate matter less than 2.5 µm in aerodynamic diameter and ($PM_{2.5}$) were estimated and modelled, using the AERMOD model.

The results of the modelling show that the predicted concentrations and deposition rates for incremental particulate matter (TSP, PM_{10}, $PM_{2.5}$ and dust deposition) are below the applicable impact assessment criteria at all assessment locations. For all pollutants and averaging periods, the project alone (underground development and associated surface changes), represents a minor change from the existing open cut operations.

When background concentrations are added, the cumulative annual average concentrations for all pollutants were predicted to be below the relevant impact assessment criteria. However, the predicted cumulative 24-hour average PM_{10} is greater than the impact assessment criterion (50 µg/m³) at a number of private receptors. The maximum number of additional days above 50 µg/m at a private receptors is two. Additional cumulative analysis is presented with an extended background dataset, for the receptors with the highest predictions. This analysis showed that the probability of days above 50 µg/m³ was low, with less than 1 additional day predicted for each receptor. The maximum predicted 24-hour $PM_{2.5}$ concentrations were below the impact assessment criterion at all assessment locations. There are no private residences where the VLAMP criteria are triggered.

A greenhouse gas (GHG) assessment was also undertaken for the project. Annual average total GHG emissions (Scope 1 and 2) generated by the project represent approximately 0.04% of total GHG emissions for NSW and 0.01% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2017.

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Tables

Figures

1 Introduction

Evolution Mining (Cowal) Pty Limited (Evolution Mining) is the owner and operator of the Cowal Gold Operations (CGO) located approximately 38 kilometres (km) north-east of West Wyalong, New South Wales (NSW) (see Figure 1.1).

CGO is an existing open cut mine site which has been operational since commencement in 2005 and has approvals in place to continue processing at a rate of 9.8 million tonnes of ore per annum (Mtpa) until 2032. The existing mine site is located immediately adjacent to the ephemeral Lake Cowal. The area of land to which the CGO's Development Consent (DA 14/98) is relevant includes Mining Lease (ML) 1535, ML 1791 and the CGO's water supply pipeline and Bland Creek Palaeochannel Borefield. Open pit mining operations are currently undertaken within ML 1535, which encompasses approximately 2,636 hectares (ha).

Evolution Mining seeks to extend mining operations at the CGO by way of an underground development, which would be wholly contained within ML 1535. The underground development proposal seeks to introduce an underground mine using stope mining practices, in addition to the existing open cut mine, to exploit an identified ore deposit in proximity to the current E42 pit. It is anticipated that this development will extend the mine life to the end of 2040.

1.1 Overview of assessment

This air quality impact assessment (AQIA) and greenhouse gas (GHG) assessment has been prepared by EMM Consulting Pty Limited (EMM) to assess potential air quality and GHG emissions and impacts associated with the underground development on the surrounding environment.

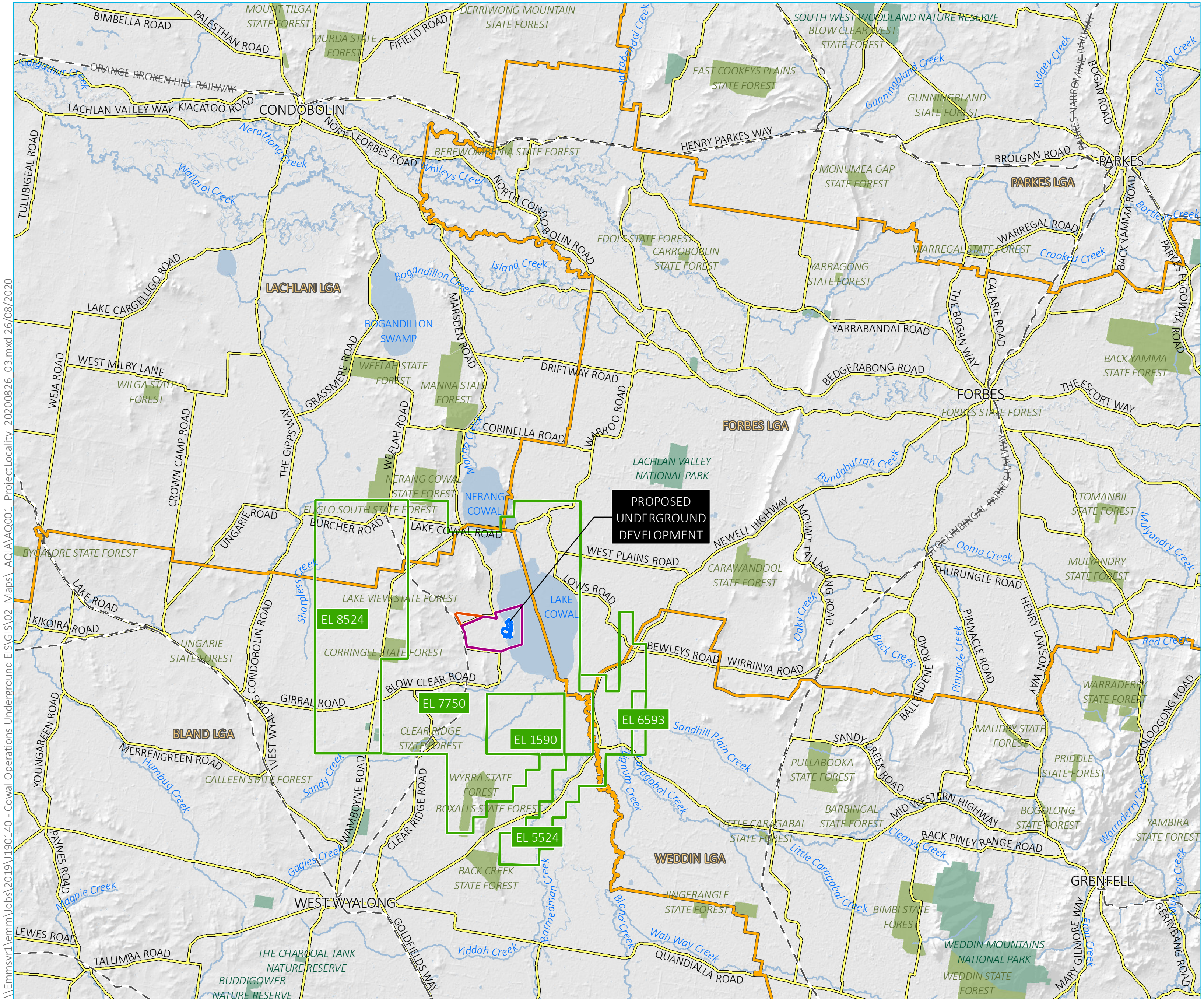
The air quality and greenhouse gas assessment is guided by the Department of Planning, Industry and Environment (DPIE) Secretary's Environmental Assessment Requirements (SEARs) (refer Section 1.2) and is prepared in accordance with the guidelines specified by the NSW Environment Protection Authority (EPA) in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (EPA 2016), referred to in this report as 'the Approved Methods for Modelling'.

Air quality and GHG impacts are assessed concurrently to support two separate approval pathways, as follows:

- Underground workings EIS – State Significant Development (SSD) application to extend mining operations at the CGO by way of an underground development, to exploit an identified ore deposit in proximity to the current E42 pit; and

- Surface changes modification – Modification (Mod 16) to surface operations required for the CGO Underground Development, including modifications to the existing processing plant and changes to the integrated waste landform (IWL).

For the purposes of this report, the underground development and the surface changes modification are collectively referred to as 'the Project'. Impacts are assessed concurrently as the project components are linked (the underground development cannot proceed without the surface changes modification) and cannot be separated for an assessment of cumulative impacts.



KEY

- Proposed underground development
- Mining lease (ML1535)
- Mining lease (ML1791)
- Exploration licence (EL)
- Rail line
- Main road
- Named watercourse
- Waterbody
- Local government area
- NPWS reserve
- State forest

Source: EMM (2020); Evolution (2020); DFSI (2017); GA (2011); ASGC (2006)

0 10 20 km

GDA 1994 MGA Zone 55

Project location in a regional context

Evolution Mining
Cowal Gold Operations
Air quality impact assessment
Figure 1.1

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1.2 Assessment requirements

This AQIA addresses the SEARs issued for the Underground Development SSD on 27 September 2019, and comments from the Environment Protection Authority in relation to Modification (16). The relevant SEARs, and how they are addressed, are outlined in Table 1.1. Agency requirements, where relevant, are also listed in Table 1.1.

Table 1.1 Air quality assessment requirements

Agency	Requirement	How this is addressed
DPIE	An assessment of the likely air quality impacts of the development in accordance with the Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW.	The assessment and report are prepared in accordance with the Approved Methods for Modelling.
	An assessment of the likely greenhouse gas impacts of the development.	Refer to Section 8
NSW EPA	The goals of the project in relation to air quality should be to ensure sensitive receptors are protected from adverse impacts from odour and dust.	The objective of CGO's existing air quality management plan and monitoring programme is to protect sensitive receptors from adverse impacts. The existing air quality management plan and monitoring programme will be reviewed and updated, as required, for the project (refer to Section 10)
	Details would need to be provided on the proposed measures to manage odour and dust from all sources.	Refer to Section 10 for proposed measures to manage dust. No significant sources of odour are identified for the project (refer Section 3.5).
	Measures to prevent or control the emission of odour from the composting activities must be detailed based on the outcome of an air quality impact assessment undertaken in accordance with the Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Wales (EPA, 2016)[1].	The assessment and report are prepared in accordance with the Approved Methods for Modelling.
	All potentially impacted residential or sensitive premises likely to be impacted by the development must be identified and included in the assessment.	Refer to Section 2.5
	The EIS should identify any other existing impacts on air quality within the area and if necessary provide an assessment and commentary on the predicted cumulative impacts that may arise.	Cumulative impacts are assessed in Section 7
	Emissions from any plant must meet the design criteria detailed in the Protection of the Environment Operations (Clean Air) Regulation 2010. Details need to be provided on the proposed air pollution control techniques from any air emission points, including proposed measures to manage and monitor efficiency and performance.	Refer to Section 3.8.
	The EIS must outline the proposed monitoring regime to be implemented in relation to the following potential impacts, where relevant. • Odour and particulate matter	Refer to Section 10 for existing and proposed monitoring regime.

1 Reference to composting in the EPA's response is assumed to be a typographical error as it is not relevant to the proposed works.

2 Project overview and local setting

2.1 Proposed Underground Development scope

The underground development proposal seeks to introduce an underground mine using stope mining practices, including an underground access decline, access tunnels, mine ventilation system and dewatering infrastructure. The application also seeks to backfill the extracted stopes using a paste made from tailings and waste rock. The underground mine would produce approximately 1.8 Mtpa of ore over a life of 20 years.

The key components associated with the underground mine are:

- development of a box-cut entry to the underground mine;
- development of an underground haulage decline from the box-cut, for men and materials access, and to bring ore and waste to the surface;
- development of several other access points to the underground mine;
- a network of underground tunnels, to access the ore, transport ore to the surface and to ventilate the mine;
- use of stope mining methods to extract ore;
- production of up to 27 Mt of ore at a rate of 1.8 Mtpa;
- production of approximately 5.74 Mt of waste rock;
- delivery of extracted ore to the surface by truck;
- developing a paste fill plant to produce paste fill to backfill underground stopes;
- delivery of paste fill via a borehole and the backfilling underground stopes with the paste; and
- development of ancillary underground infrastructure to support the underground operation, including dewatering infrastructure, air ventilation system, electrical reticulation.

2.2 Proposed Modification 16 scope

The underground development project would require additional infrastructure to be developed at the surface. Several changes to existing site infrastructure would also be required to support the underground operations. These changes are being considered under a modification to the existing CGO development consent.

The key components associated with the proposed modification are:

- developing a box-cut, to provide access to the underground mine for workers, materials, maintenance and haulage vehicles;
- making changes to the processing facility to upgrade it to process higher grade ore;
- transporting the additional 27 Mt of ore to the processing facility by truck;
- processing this additional ore at the processing facility;

- moving around 5.74 Mt of waste rock extracted from the underground mine to the existing waste rock emplacement areas;
- continued emplacement of tailings at the IWL and increasing the final height of the IWL by one metre;
- developing other minor ancillary supporting infrastructure at the site to manage site operations, including administrative facilities, bathhouse, access tracks and telecommunications equipment;
- extending the life of the surface operations to align with the life of proposed underground mining and ore processing requirements (ie to the end of 2040); and
- producing an additional 1.8 million ounces of gold (Moz).

The key components associated with the underground development and surface changes modification are shown in Figure 2.1.

2.3 Proposed mining schedule

The proposed mining schedule for the underground development is shown in Table 2.1, along with the approved material movement for the open-cut pit. The total material movement for the underground development peaks in financial year 2024 (FY24); however, when the underground development is combined with the open cut production schedule, the year with the maximum combined total movement of ore and waste at the site is FY22. This year is therefore selected as the modelled emissions scenario. Further discussion on this is presented in Section 6.

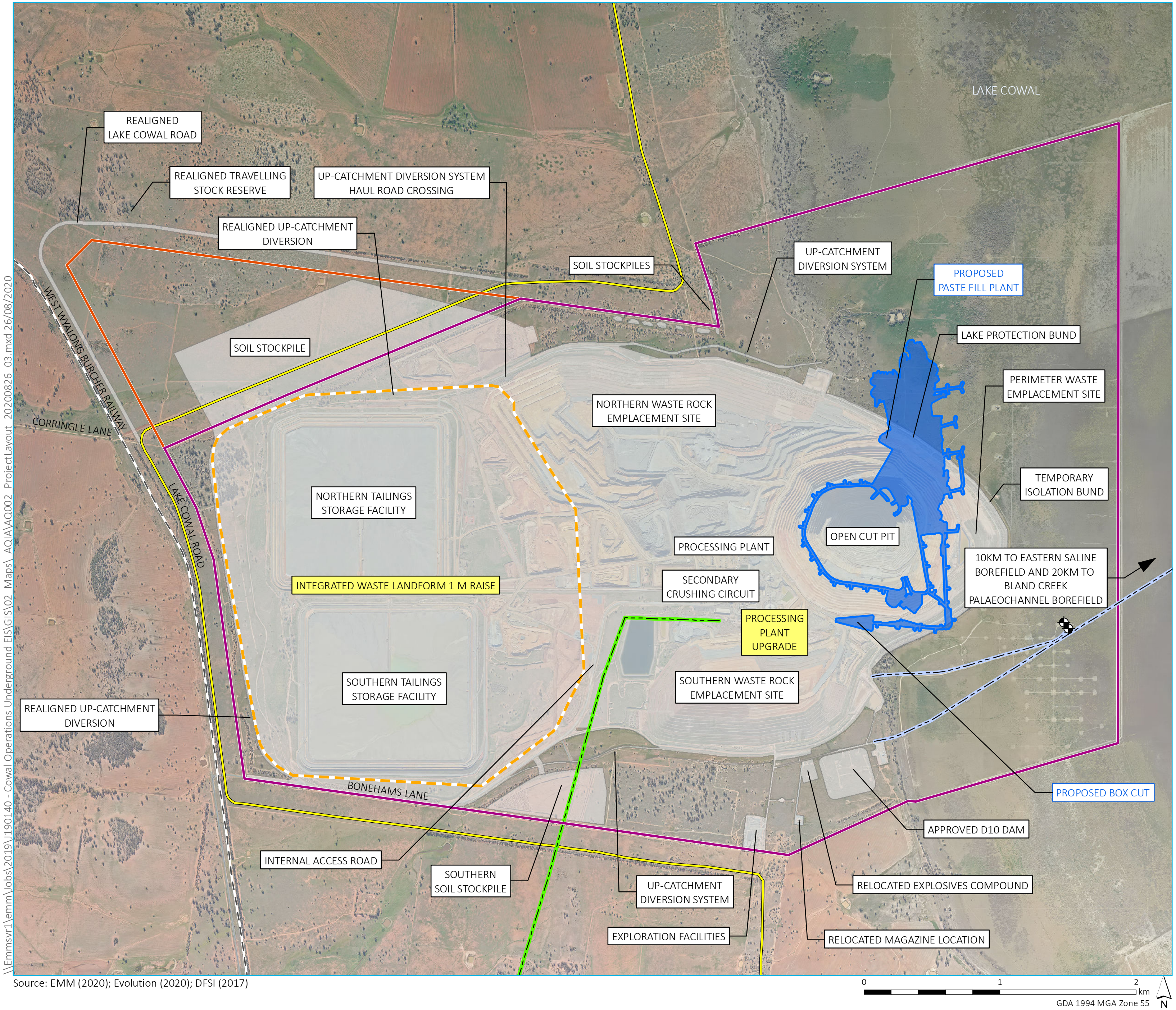
Table 2.1 Proposed mining schedule for the project

Year	Underground (UG) material movement (t)			Open Cut (OC) approved material movement			UG+OC
	Ore	Waste	Total	Ore	Waste	Total	Total
FY21	2,619	1,630,415 [1]	1,633,034	11,600,000	12,100,000	23,700,000	25,333,034
FY22	**71,158**	**488,190**	**559,348**	**18,200,000**	**7,300,000**	**25,500,000**	**26,059,348**
FY23	627,288	869,792	1,497,080	11,000,000	2,400,000	13,400,000	14,897,080
FY24	669,085	709,523	1,378,608	12,800,000	600,000	13,400,000	14,778,608
FY25	1,676,207	729,586	2,405,793	1,400,000	0	1,400,000	3,805,793
FY26	1,801,531	692,980	2,494,511	0	0	0	2,494,511
FY27	1,795,495	624,846	2,420,340	0	0	0	2,420,340
FY28	1,801,111	396,998	2,198,109	0	0	0	2,198,109
FY29	1,803,377	349,116	2,152,494	0	0	0	2,152,494
FY30	1,795,511	317,438	2,112,949	0	0	0	2,112,949
FY31	1,800,630	76,713	1,877,343	0	0	0	1,877,343
FY32	1,802,862	86,819	1,889,681	0	0	0	1,889,681
FY33	1,796,504	109,432	1,905,936	0	0	0	1,905,936
FY34	1,801,604	68,412	1,870,016	0	0	0	1,870,016
FY35	1,795,163	1,690	1,796,853	0	0	0	1,796,853
FY36	1,805,188	0	1,805,188	0	0	0	1,805,188

Table 2.1 Proposed mining schedule for the project

Year	Underground (UG) material movement (t)			Open Cut (OC) approved material movement			UG+OC
	Ore	Waste	Total	Ore	Waste	Total	Total
FY37	1,801,447	0	1,801,447	0	0	0	1,801,447
FY38	1,655,334	0	1,655,334	0	0	0	1,655,334
FY39	406,927	0	406,927	0	0	0	406,927

Note [1] includes material movement during development of the box-cut



Source: EMM (2020); Evolution (2020); DFSI (2017)

KEY
- Proposed underground development
- Mining lease (ML1535)
- Mining lease (ML1791)
- DA14/98 approved surface disturbance
- Indicative integrated waste landform perimeter
- Electricity transmission line
- Water supply pipeline
- Saline groundwater supply bore
- Rail line
- Main road
- xxx Underground development elements
- xxx Mod 16 surface elements
- xxx Approved surface elements

Project layout

Evolution Mining
Cowal Gold Operations
Air quality impact statement
Figure 2.1

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2.4 Local setting, land use and topography

The project is located approximately 38 km to the north-east of West Wyalong in NSW immediately adjacent to Lake Cowal in the Lachlan Catchment, an ephemeral inland wetland system.

The current CGO development area includes the underlying ML 1535, ML 1791, CGO water supply pipeline to the Bland Creek Palaeochannel Borefield, and associated infrastructure. The proposed Underground Development works are located within and adjacent to the existing operational open cut pit, and are wholly contained within ML 1535.

The area surrounding the CGO is characterised by relatively flat terrain consisting predominantly of agricultural land uses. Elevation in the study area ranges from approximately 203 m AHD to 260 m AHD. A three-dimensional representation of the local topography is presented in Figure 2.2.

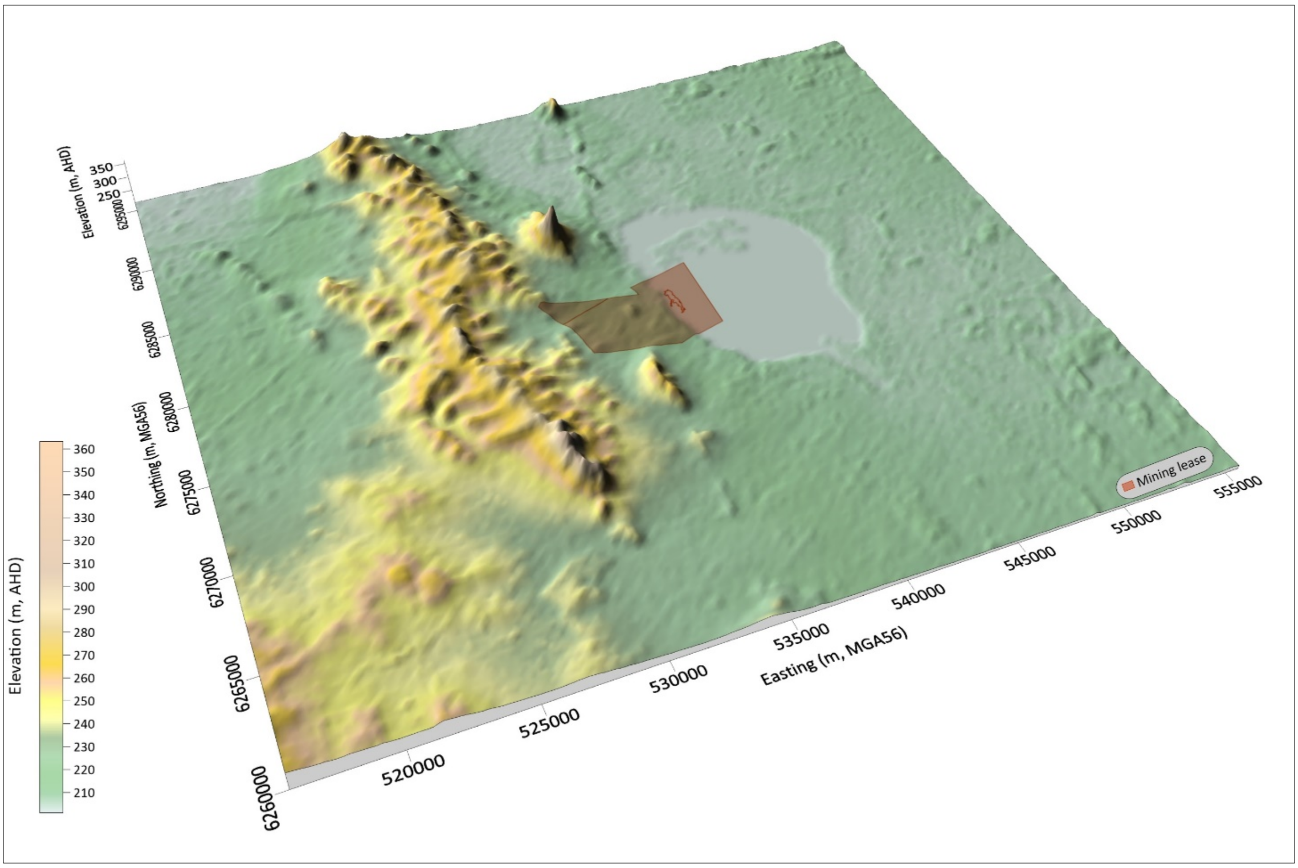


Figure 2.2 3-dimensional topography of the Project site and surrounding area

Source: NASA Shuttle Radar Topography Mission data

2.5 Assessment locations

The area surrounding the Project includes rural residential properties, with the closest located approximately 2.3 km south-west of the CGO. In order to comprehensively assess potential air quality impacts across the surrounding area, residences within a 15 km radius of the project have been selected as discrete model prediction locations. Details are provided in Table 2.2 and their locations are shown in Figure 2.3.

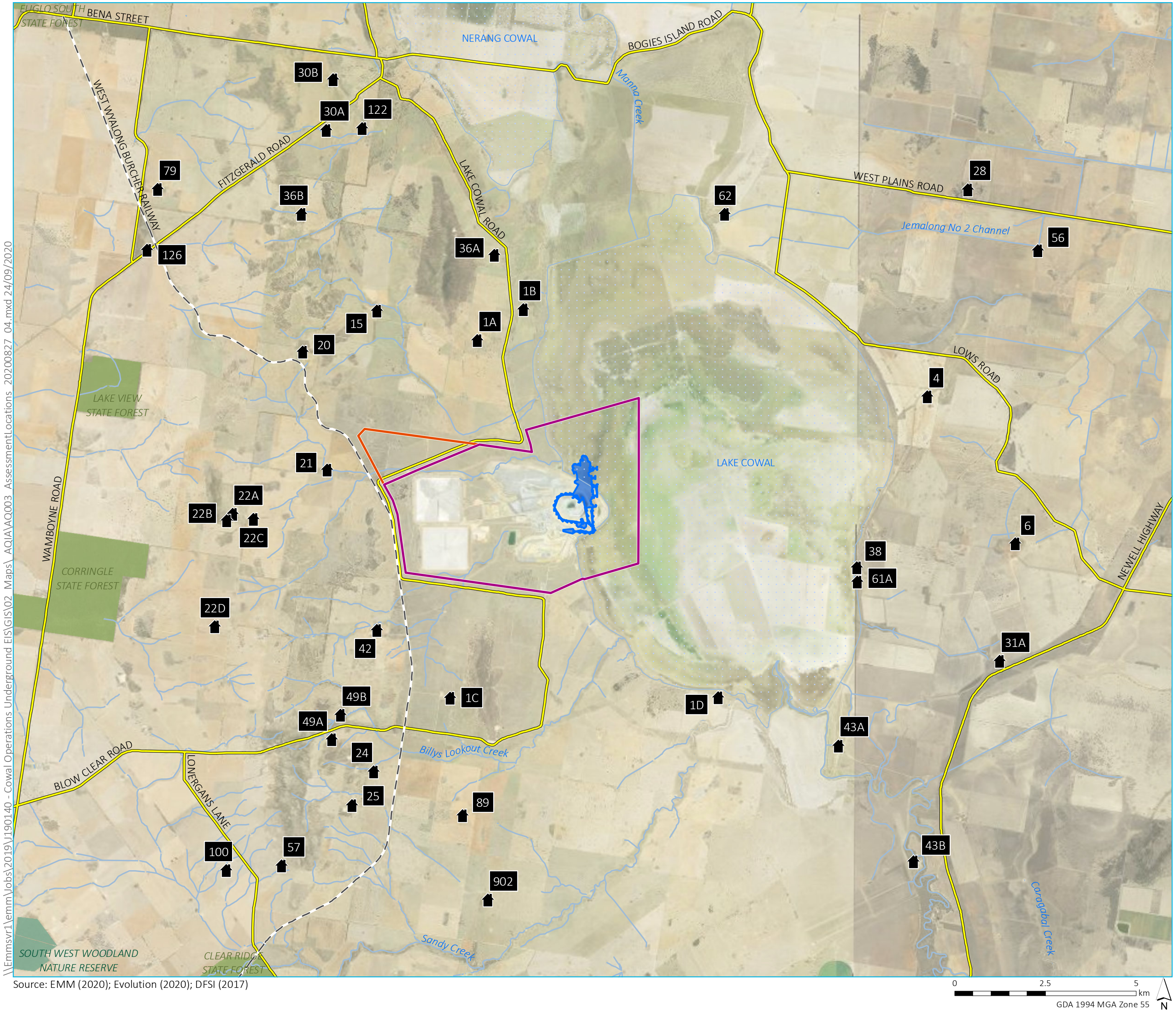
The selected residences are referred to in this report as assessment locations. Assessment locations 1a to 1d are classified as mine-owned residences, while the remaining are classified as private residences.

Table 2.2 Air quality assessment locations

Figure ID	Assessment location type	Easting	Northing
1a	Residential (mine-owned)	535153	6282548
1b	Residential (mine-owned)	536424	6283400
1c	Residential (mine-owned)	534407	6272697
1d	Residential (mine-owned)	541794	6272704
4	Residential	547567	6281001
6	Residential	549989	6276946
15	Residential	532378	6283364
20	Residential	530337	6282231
21	Residential	531013	6278985
22a	Residential	528402	6277761
22b	Residential	528249	6277583
22c	Residential	528976	6277626
22d	Residential	527918	6274662
24	Residential	532297	6270665
25	Residential	531695	6269734
28	Residential	548681	6286710
30a	Residential	530989	6288345
30b	Residential	531171	6289740
31a	Residential	549554	6273711
36a	Residential	535625	6284898
36b	Residential	530297	6286030
38	Residential	545613	6276295
42	Residential	532383	6274566
43a	Residential	545105	6271379
43b	Residential	547179	6268189
49a	Residential	531145	6271554
49b	Residential	531386	6272221

Table 2.2 Air quality assessment locations

Figure ID	Assessment location type	Easting	Northing
56	Residential	550605	6285032
57	Residential	529760	6268071
61a	Residential	545627	6275893
62	Residential	541979	6286026
79	Residential	526342	6286717
89	Residential	534740	6269452
902	Residential	535441	6267131
100	Residential	528226	6267940
122	Residential	531978	6288396
126	Residential	526050	6285038



Source: EMM (2020); Evolution (2020); DFSI (2017)

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Air quality assessment locations

Evolution Mining
Cowal Gold Operations
Air quality impact assessment
Figure 2.3

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3 Pollutants and assessment criteria

3.1 Potential air pollutants

The operation of the project has the potential to generate emissions of various air pollutants to the atmosphere. Project emission sources will include a mixture of the following:

- fugitive dust/particulate matter from ore and waste extraction, handling and processing, movement of mobile plant and equipment, and wind erosion of exposed surfaces;
- fugitive gaseous releases from the processing plant and surface of active Integrated Waste Landform (IWL);
- combustion sources, such as exhaust emissions from site equipment fleet; and
- emissions from underground ventilation portals/shafts.

A detailed description of emission sources associated with the project is presented in Section 6. Air pollutants emitted by the project will comprise of:

- particulate matter (PM), specifically:
  - total suspended particulate matter (TSP);
  - particulate matter less than 10 micrometres (µm) in aerodynamic diameter (PM_{10}); and
  - particulate matter less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$).
- oxides of nitrogen (NO_x)[2], including nitrogen dioxide (NO_2);
- sulphur dioxide (SO_2);
- carbon monoxide (CO);
- volatile organic compounds (VOCs); and
- hydrogen cyanide (HCN).

3.2 Emissions from the combustion of diesel fuel

The combustion of diesel in mining equipment results in combustion-related emissions, including $PM_{2.5}$, NO_x, SO_2, CO, carbon dioxide (CO_2) and VOCs. Gaseous combustion emissions from mining equipment does not generally result in significant off-site concentrations and are unlikely to compromise ambient air quality goals. Furthermore, the underground development will result in a relatively small increase in diesel usage. Accordingly, with the exception of PM, combustion emissions have not been quantitatively assessed.

2 By convention, NOx = Nitrous oxide (NO) + NO_2.

The US EPA AP-42 emission factors developed for mining emission inventories do not separate PM emissions from mechanical processes (i.e. crustal material) and diesel exhaust (combustion). Accordingly, the emissions of PM_{10} and $PM_{2.5}$ presented in Section 6 are assumed to include the contribution from diesel combustion in mining equipment.

However, the emissions controls applied are often only relevant to the crustal fraction of total PM, for example the watering of haul roads does not control the diesel component of the emissions (US EPA 1998). Adjustments to the emission inventories have been made to account for this and discussed further in Section 6.

Greenhouse gas emissions from diesel combustion are considered in Section 8.

3.3 Blast fume

Blast fume is the result of a less than optimal chemical reaction of ammonium nitrate explosives during the open cut blasting process, resulting in the release of nitric oxide and NO_2. Potential adverse impacts from blast fume can be effectively managed through good practice blast management.

CGO operate under an existing approved Blast Management Plan, which includes blast fume prevention measures, developed in accordance with the *Code of Good Practice: Prevention and Management of Blast Generated NO_x Gases in Surface Blasting* (Code of Practice) (Australian Explosives Industry and Safety Group Inc., 2011).

The underground mine will result in a relatively small increase in explosive usage at CGO in the early years and therefore no change is anticipated to the blast fume management measures currently in place. No further assessment of blast fume is therefore presented in this report, noting that dust emissions from blasting are included in the emission inventories presented in Section 6.

3.4 Hydrogen cyanide

Cyanide (CN) is used as a reagent in the processing plant and can lead to small amounts of fugitive emissions of hydrogen cyanide (HCN) through volatilisation from storage tanks and the IWL. CGO operates under an existing approved Cyanide Management Plan. The site uses a cyanide destruction process before discharge to the IWL and undertakes twice daily cyanide monitoring. There have been no exceedances of the approved cyanide concentrations under the existing development consent. The underground development will result in a relatively small increase in cyanide usage and therefore no change is anticipated to the management measures currently in place. No further assessment of HCN is therefore presented in this report.

3.5 Odour

There are no significant sources of odour identified for the project. The processing plant may use small quantities of potassium amyl xanthate (PAX), which has a pungent odour, however off-site odour impacts from its use do not currently occur (a review of the complaint register indicates that no odour complaints have been received from surrounding residences). There would be no significant increase in usage of PAX from the project and therefore no further assessment of odour is presented in this report.

3.6 Impact assessment criteria

Consistent with AQIA for modification 14 at CGO, this assessment will focus on emissions and impacts from particulate matter (TSP, PM_{10} and $PM_{2.5}$) only. Impact assessment criteria applicable to particulate matter is presented in the following sections as defined in the Approved Methods for Modelling (EPA 2016). The impact assessment criteria are designed to maintain ambient air quality that allows for the adequate protection of human health and well-being.

3.6.1 Particulate matter

The NSW EPA's impact assessment criteria for particulate matter, as documented in Section 7 of the Approved Methods for Modelling, are presented in Table 3.1. The assessment criteria for PM_{10} and $PM_{2.5}$ are consistent with the national air quality standards that are defined in the *National Environment Protection (Ambient Air Quality) Measure* (AAQ NEPM) (Department of the Environment 2016).

TSP, which relates to airborne particles less than around 50 µm in diameter, is used as a metric for assessing amenity impacts (reduction in visibility, dust deposition and soiling of buildings and surfaces) rather than health impacts (NSW EPA 2013). Particles less than 10 µm in diameter, accounted for in this assessment by PM_{10} and $PM_{2.5}$, are a subset of TSP and are fine enough to enter the human respiratory system and can therefore lead to adverse human health impacts. The NSW EPA impact assessment criteria for PM_{10} and $PM_{2.5}$ are therefore used to assess the potential impacts of airborne particulate matter on human health.

The Approved Methods for Modelling classifies TSP, PM_{10}, $PM_{2.5}$ and dust deposition as 'criteria pollutants'. The impact assessment criteria for criteria pollutants are applied at the nearest existing or likely future off-site sensitive receptors[3], and compared against the 100th percentile (ie the highest) dispersion modelling prediction for the relevant averaging. Both the incremental (project only) and cumulative (project + background) impacts need to be presented, with the latter requiring consideration of the existing ambient background concentrations.

For dust deposition, the NSW EPA (2016) specifies criteria for the project-only increment and cumulative dust deposition levels. Dust deposition impacts are derived from TSP emission rates and particle deposition calculations in the dispersion modelling process.

Table 3.1 Impact assessment criteria for particulate matter

PM metric	Averaging period	Impact assessment criterion
TSP	Annual	90 µg/m^3
PM_{10}	24 hour	50 µg/m^3
	Annual	25 µg/m^3
$PM_{2.5}$	24 hour	25 µg/m^3
	Annual	8 µg/m^3
Dust deposition	Annual	2 g/m^2/month (project increment only)
		4 g/m^2/month (cumulative)

Notes: µg/m^3: micrograms per cubic meter; g/m^2/month: grams per square metre per month

[3] NSW EPA (2016) defines a sensitive receptor as a location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area.

3.7 Voluntary land acquisition and mitigation policy

In September 2018, the DPE released the *Voluntary Land Acquisition and Mitigation Policy (VLAMP) for State Significant Mining, Petroleum and Extractive Industry Developments*. The VLAMP describes the voluntary mitigation and land acquisition policy to address dust and noise impacts, and outlines mitigation and acquisition criteria for particulate matter. Under the VLAMP, if a development cannot comply with the relevant impact assessment criteria, or if the mitigation or acquisition criteria may be exceeded, the applicant should consider a negotiated agreement with the affected landowner or acquire the land. In doing so, the land is then no longer subject to the impact assessment, mitigation or acquisition criteria, although provisions do apply to the "use of the acquired land", primarily related to informing and protecting existing or prospective tenants.

In relation to dust, voluntary mitigation and acquisition rights apply when a development contributes to exceedances of the criteria set out in Table 3.2. The criteria for voluntary mitigation and acquisition are the same, except for the number of days the short-term impact assessment criteria for PM_{10} and $PM_{2.5}$ can be exceeded, which is zero for mitigation and five for acquisition. Voluntary mitigation rights apply to any residence on privately-owned land or any workplace on privately-owned land where the consequences of the exceedance, in the opinion of the consent authority, are unreasonably deleterious to worker health or the carrying out of business. Voluntary acquisition rights also apply to any residence or any workplace on privately-owned land, but also apply when an exceedance occurs across more than 25% of any privately-owned land where there is an existing dwelling or where a dwelling could be built under existing planning controls.

Table 3.2 VLAMP mitigation and acquisition criteria

Pollutant	Averaging period	Criterion	Basis	Allowable exceedances over life of development	Impact type
PM_{10}	24-hour	50 µg/m³	Project only	None for voluntary mitigation Five for voluntary acquisition	Human health
	Annual	25 µg/m³	Cumulative	NA	Human health
$PM_{2.5}$	24-hour	25 µg/m³	Project only	None for voluntary mitigation Five for voluntary acquisition	Human health
	Annual	8 µg/m³	Cumulative	NA	Human health
TSP	Annual	90 µg/m³	Cumulative	NA	Amenity
Deposited dust	Annual	2 g/m²/month	Project only	NA	Amenity
		4 g/m²/month	Cumulative	NA	

3.8 POEO (Clean Air) Regulation

The statutory framework for managing air emissions in NSW is provided in the *Protection of the Environment Operations Act*[4] *1997* (POEO Act) and the primary regulation for air quality made under the POEO Act is the Protection of the Environment Operations (Clean Air) Regulation 2010[5] (POEO Regulation). As a scheduled activity under the POEO Regulation, the Project will operate under an environment protection licence (EPL) and will comply with the associated requirements, including emission limits, monitoring and pollution reduction programs (PRPs).

[4] http://www.legislation.nsw.gov.au/maintop/view/inforce/act+156+1997+cd+0+N

[5] http://www.legislation.nsw.gov.au/maintop/view/inforce/subordleg+428+2010+cd+0+N

4 Meteorology and climate

4.1 Overview

A description of the prevailing meteorology for the local area is based on the CGO meteorological station, installed near the southern boundary of ML 1535. Further analysis of long-term climatic trends is made based on data from the closest Bureau of Meteorology (BoM) monitoring sites at Wyalong Post Office, located approximately 30 km south-west of the site. The location of the CGO meteorological station is shown in Figure 4.1.

4.1.1 Prevailing winds

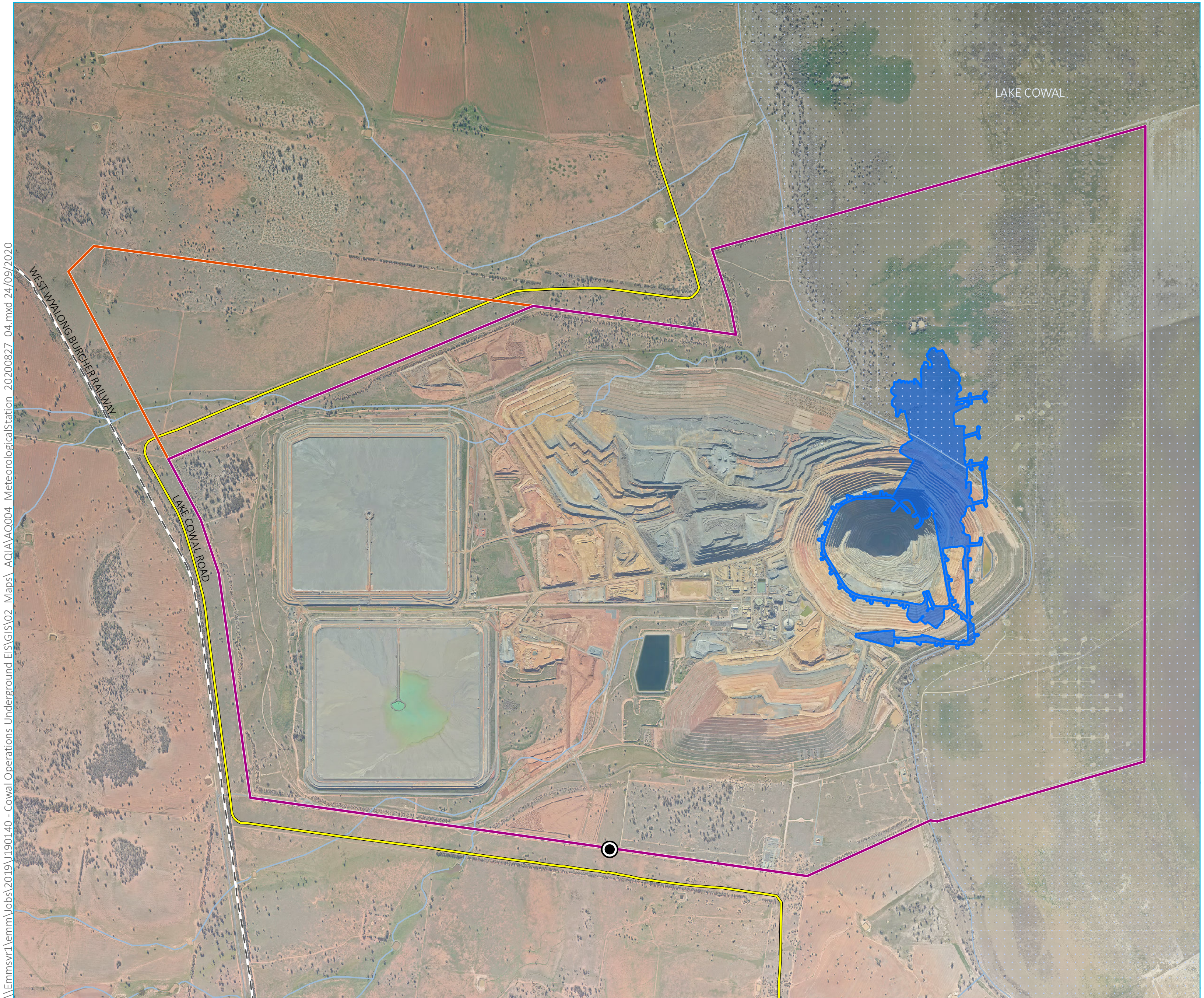
Six years of hourly data from the CGO meteorological station were reviewed and annual wind roses for the period 2013 to 2018 are presented in Figure 4.2. The analysis shows consistency in wind direction, average wind speed and percentage occurrence of calm winds (less than or equal to 0.5 m/s). Winds are recorded from all directions for all years, with a slightly higher frequency of occurrence from the south-west.

The high degree of consistency in winds across all years indicates that each calendar year would be suitable for modelling. The period of January to December 2018 was selected for modelling, being the most complete calendar year available at the time of modelling.

Seasonal and diurnal wind patterns are presented as wind rose in Appendix A. The recorded wind speed and direction profile is comparable across all years with winds present from all directions. A dominant south-easterly wind is seen in all years. Average wind speeds and percentage of calms are consistent for each year with wind speeds ranging from 3.0 m/s to 3.2 m/s and calms ranging from 2.2 m/s and 3.6 m/s.

4.1.2 Ambient temperature

The inter-annual variation in temperature for Lake Cowal is presented as a box and whisker plot in Figure 4.3 (individual years) and Figure 4.4 (all years grouped in one plot). The plots show that the monthly median temperature (lines) and the monthly quantile ranges (5/95 and 25/75). The plots demonstrate that temperatures measured across the modelled year (2018) are consistent and therefore representative when compared with the most recent six-year period of measurements.



Source: EMM (2020); Evolution (2020); DFSI (2017)

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KEY

- Cowal meteorological station
- Proposed underground development
- Mining lease (ML1535)
- Mining lease (ML1791)
- Rail line
- Main road
- Watercourse/drainage line
- Waterbody

Location of meteorological station

Evolution Mining
Cowal Gold Operations
Air quality impact assessment
Figure 4.1

EMM
creating opportunities

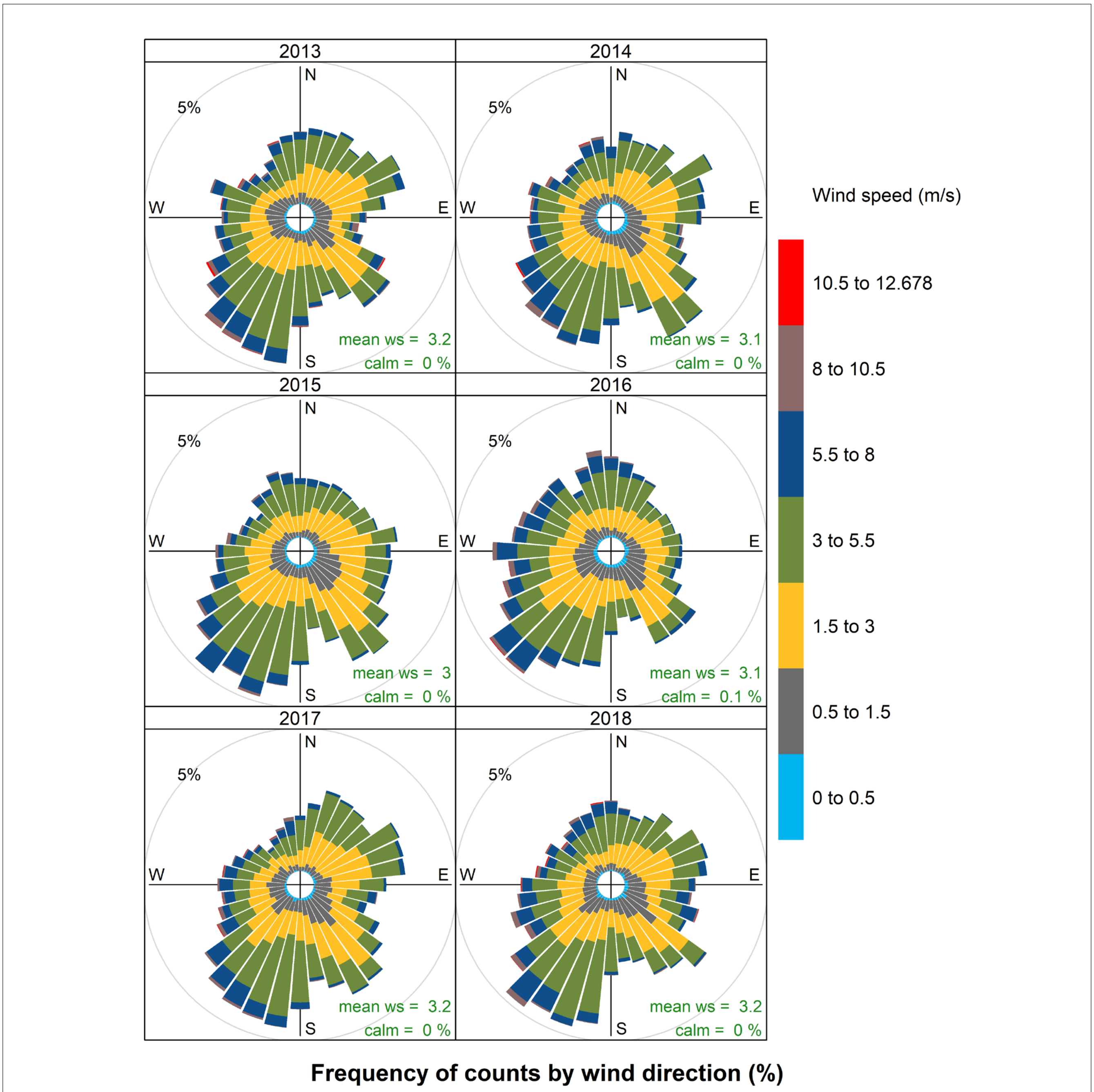


Figure 4.2 Annual wind roses for CGO meteorological station – 2013-2018

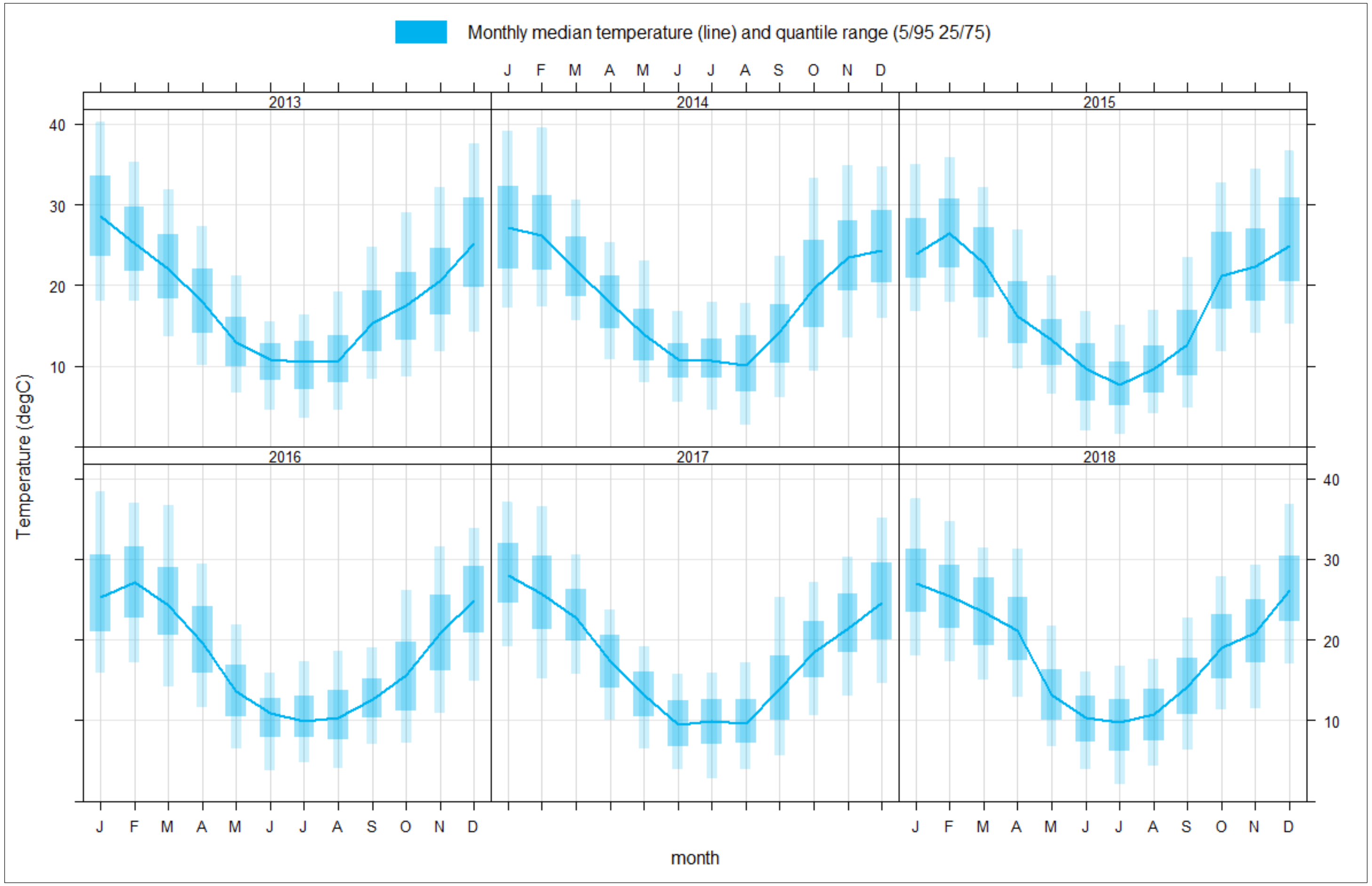


Figure 4.3 Box and whisker plot of temperature for CGO meteorological station – 2013-2018

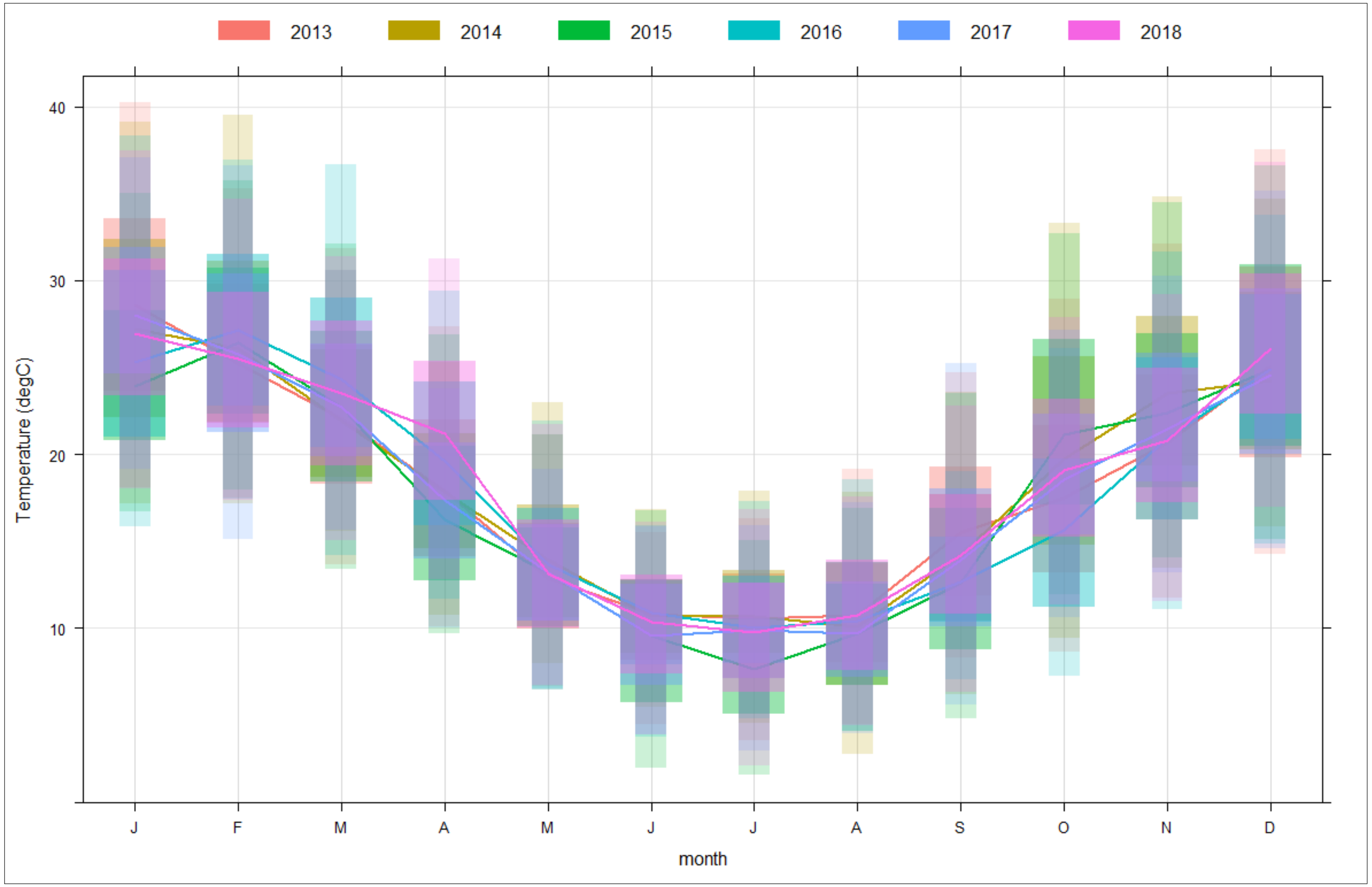


Figure 4.4 Box and whisker plot of temperature for CGO meteorological station – 2013-2018 (grouped)

4.1.3 Rainfall

Figure 4.5 compares the long term monthly mean rainfall at West Wyalong with the monthly rainfall for 2018 (at West Wyalong and from the CGO station).

Based on historical data recorded at West Wyalong, rainfall for the region is considered low, with a long-term annual rainfall of 479 mm. Analysis of the CGO data for the period 2013-2018 shows that the average annual rainfall over the last six years (535 mm) is similar to the long-term average for West Wyalong. The annual rainfall for the modelling period 2018 is the lowest for the past six years (246 mm). It is noted that 2018 was dominated by very dry conditions and was the driest year in NSW since 2002[6].

To provide a conservative (upper bound) estimate of the PM concentrations, wet deposition (removal of particles from the air by rainfall) was excluded from the dispersion modelling simulations undertaken in this report. Furthermore, the emission inventories developed for this study have not applied a natural mitigation factor[7] for rainfall and are therefore more conservative (higher) than if rainfall was incorporated.

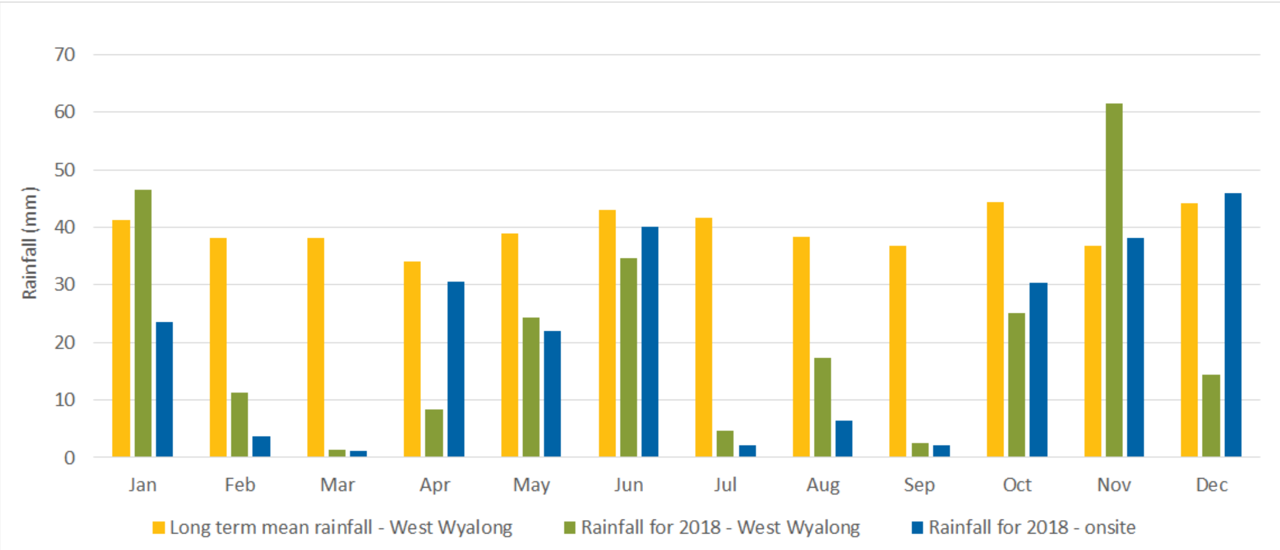


Figure 4.5 Monthly rainfall for West Wyalong and the onsite station

[6] http://www.bom.gov.au/climate/current/annual/nsw/summary.shtml

[7] The US EPA AP-42 emission factor documentation for unsealed roads (Chapter 13.2.2) describes a 'natural mitigation' factor, which can be applied for rainfall and other precipitation, based on the assumption that annual emissions are inversely proportional to the number of days with measurable rain, defined as the number of days with greater than 0.25 mm recorded.

4.2 Meteorological modelling

Atmospheric dispersion modelling for this assessment has been completed using the AMS[8]/USEPA[9] regulatory model (AERMOD) (model version v18081). The meteorological inputs for AERMOD were generated using the AERMET meteorological processor using local surface observations and upper air profiles generated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) TAPM meteorological modelling module.

Hourly average meteorological data from the CGO meteorological station was used as observations in the TAPM and AERMET modelling. Further details of the TAPM meteorological modelling and AERMET data processing completed to prepare the inputs for AERMOD are documented in Appendix A.

4.2.1 Atmospheric stability and mixing depth

Atmospheric stability refers to the degree of turbulence or mixing that occurs within the atmosphere and is a controlling factor in the rate of atmospheric dispersion of pollutants.

The Monin-Obukhov length (L) provides a measure of the stability of the surface layer (ie the layer above the ground in which vertical variation of heat and momentum flux is negligible; typically about 10% of the mixing height). Negative L values correspond to unstable atmospheric conditions, while positive L values correspond to stable atmospheric conditions. Very large positive or negative L values correspond to neutral atmospheric conditions.

Figure 4.6 illustrates the overall diurnal variation of atmospheric stability derived from the Monin-Obukhov length calculated by AERMET based on observations collected at the on-site meteorological station in 2018. The diurnal profile shows that atmospheric instability increases during the daylight hours as the sun generated convective energy increases, whereas stable atmospheric conditions prevail during the night-time. This profile indicates that the potential for effective atmospheric dispersion of emissions would be greatest during day time hours and lowest during evening through to early morning hours.

Mixing depth refers to the height of the atmosphere above ground level within which the dispersion of air pollution can be dispersed. The mixing depth of the atmosphere is influenced by mechanical (associated with wind speed) and thermal (associated with solar radiation) turbulence. Similar to the Monin-Obukhov length analysis above, higher daytime wind speeds and the onset of incoming solar radiation increases the amount of mechanical and convective turbulence in the atmosphere. As turbulence increases, so too does the depth of the boundary layer, generally contributing to higher mixing depths and greater potential for the atmospheric dispersion of pollutants.

Hourly-varying atmospheric boundary layer depths were generated by AERMET, the meteorological processor for the AERMOD dispersion model. The variation in AERMET-calculated boundary layer depth by hour of the day is illustrated in Figure 4.7. Greater boundary layer depths occur during the daytime hours, peaking in the mid to late afternoon.

8 AMS - American Meteorological Society

9 USEPA - United States Environmental Protection Agency

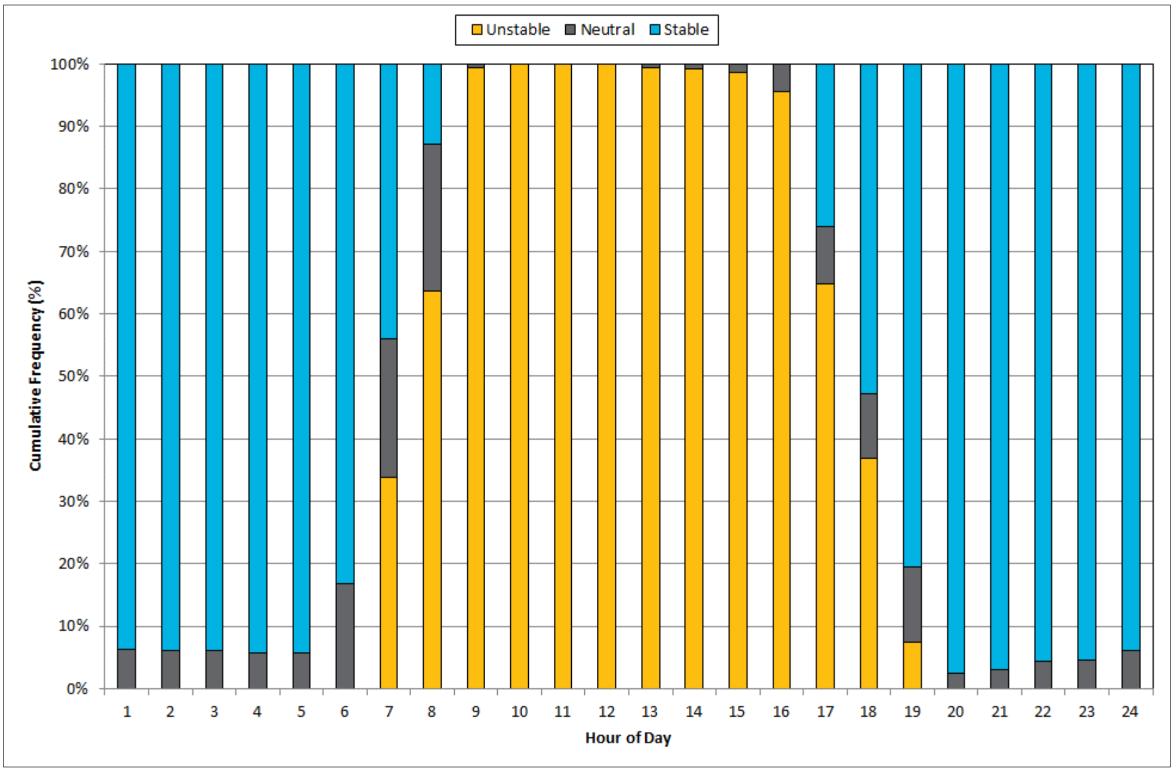


Figure 4.6 Diurnal variations in AERMET-generated atmospheric stability

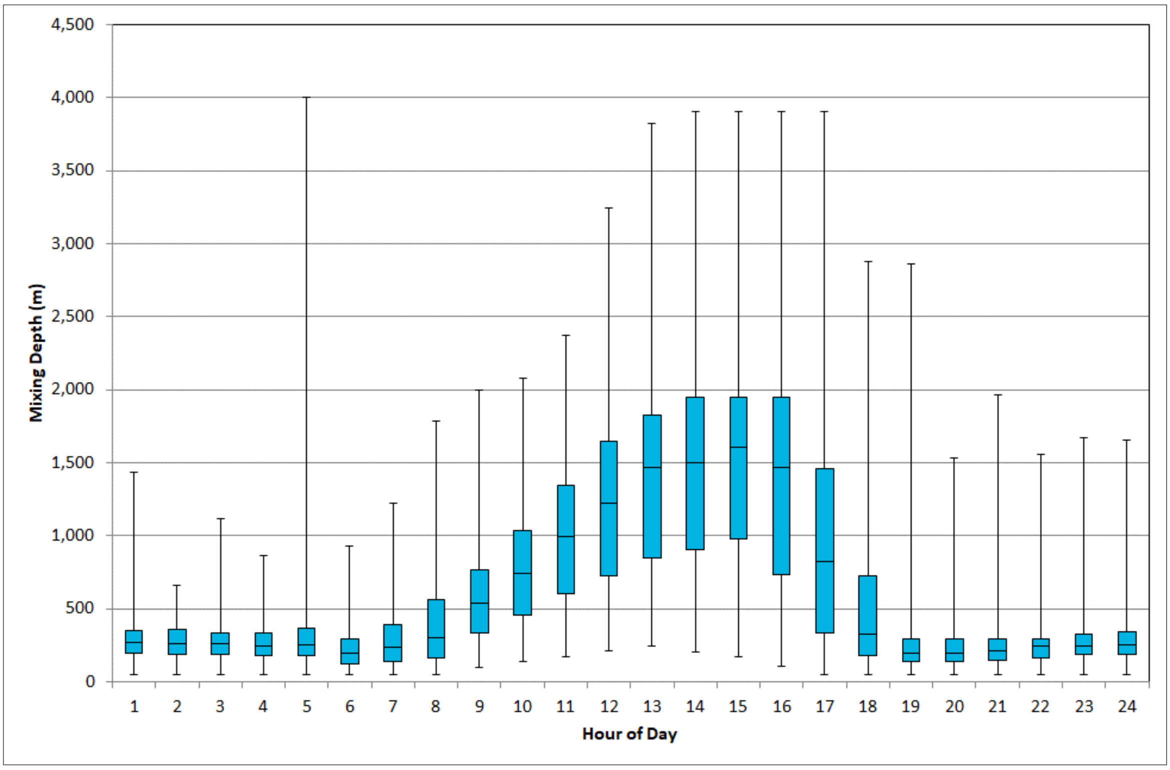


Figure 4.7 Diurnal variation in AERMET generated mixing heights

5 Existing ambient air quality

5.1 Overview

Cumulative impacts are assessed by combining the existing ambient air quality environment and the emissions contribution from the project. Characterising the existing ambient air quality environment is primarily based on an air quality monitoring program for CGO, which includes a network of 12 dust deposition gauges (DDGs) and one High Volume Air Sampler (HVAS) (measuring TSP). The monitoring program is described in the CGO Air Quality Management Plan (AQMP) (February 2015). Environmental monitoring data are published monthly, in accordance with its EPL and summarised in the CGO Annual Review, in accordance with its development consent (DA 14/98).

Recent additions to the air quality monitoring program include two new sites with continuous monitoring for PM_{10} and $PM_{2.5}$.

The locations of the air quality monitoring stations used in the assessment are shown in Figure 5.1.

5.2 Total Suspended Particulates and derived PM_{10}

TSP concentrations are measured using a HVAS at a residence location approximately 3 km to the north of the CGO (receptor 1a from Table 2.2 and Figure 2.3).

PM_{10} is not measured but instead is inferred from TSP, based on the assumption that 40% of TSP falls within the PM_{10} size fraction. This assumption is consistent with how PM_{10} concentrations have been reported through the Annual Review process and assessed in air quality assessment for prior modifications.

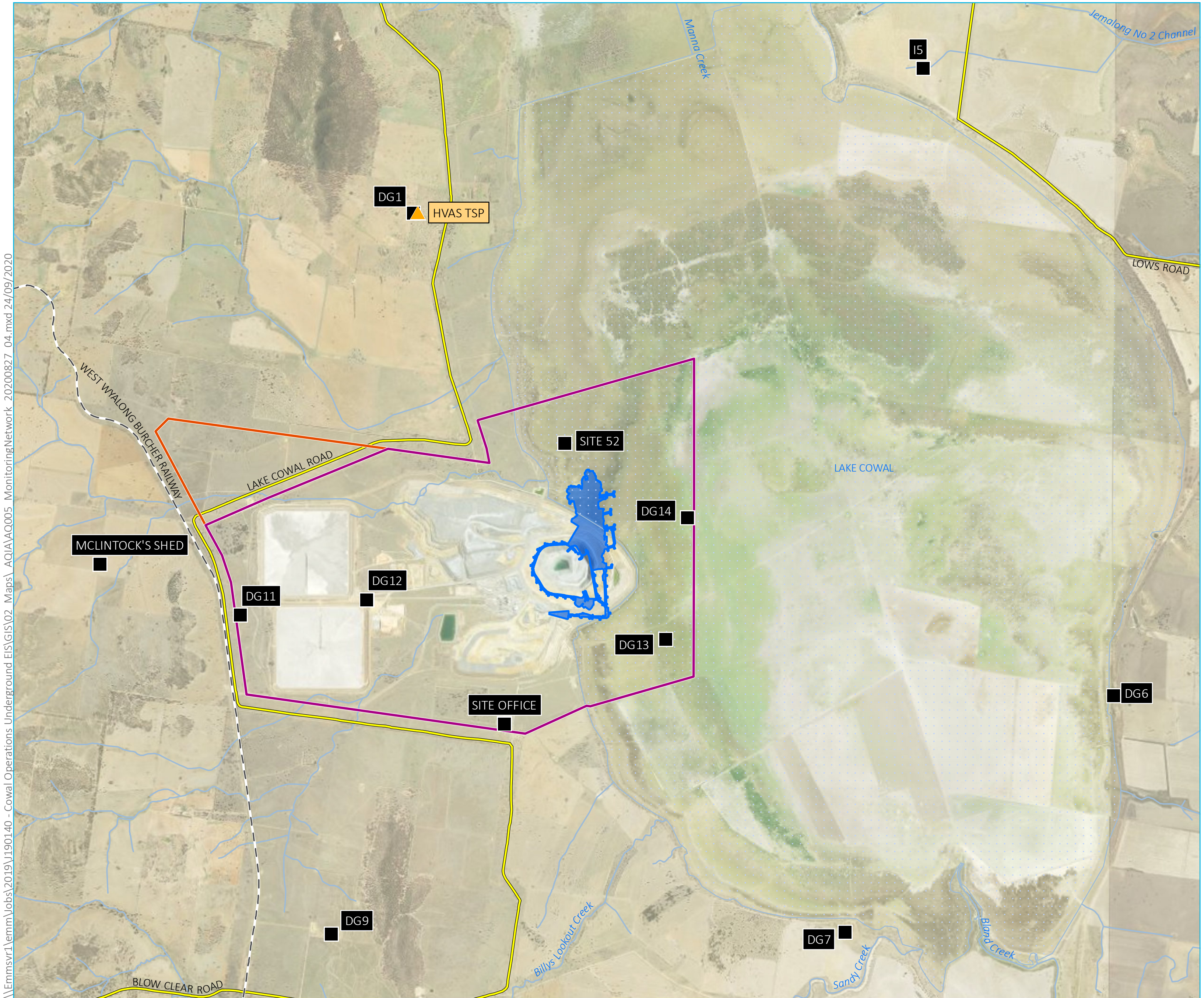
The annual average TSP and PM_{10} concentrations and the daily maximum PM_{10} concentrations for 2010 to 2018 are presented in Table 5.1. Also shown are the number of days over the 24-hour average impact assessment criterion for PM_{10}. It is noted that HVAS are run on a campaign basis (for a continuous 24-hour period every sixth day). The monitoring results therefore do not represent a true indication of the daily maximum PM_{10} or number of days over the impact assessment criterion.

The results in Table 5.1 show that annual average TSP concentrations have not exceeded the impact assessment criterion of 90 $\mu g/m^3$ in the past eight years. Similarly, the inferred PM_{10} concentrations have not exceeded the impact assessment criterion of 25 $\mu g/m^3$ between 2010 to 2017; however, in 2018, the inferred annual average PM_{10} concentration was 25.7 $\mu g/m^3$, marginally above the impact assessment criterion.

It is noted that during 2018 there were a number of dust storms that resulted in higher than usual daily concentrations, which in turn has influenced the annual average. For HVAS measurements, a few high daily values can disproportionately influence the annual average concentrations, as there are less 'normal day' values to smooth out the effect of these peak events.

Generally, based on measurements over the past eight years, annual average PM_{10} concentrations are well below the impact assessment criterion.

Daily maximum PM_{10} concentrations are also inferred from the TSP measurements. Concentrations above 50 $\mu g/m^3$ are recorded in most years, noting that HVAS does not capture every day of the year and therefore some peak days may have been missed.



Source: EMM (2020); Evolution (2020); DFSI (2017)

KEY
- Dust gauge
- High volume air sampler
- Proposed underground development
- Mining lease (ML1535)
- Mining lease (ML1791)
- Rail line
- Main road
- Watercourse/drainage line
- Waterbody

Location of air quality monitoring network

Evolution Mining
Cowal Gold Operations
Air quality impact assessment
Figure 5.1

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Table 5.1 TSP and PM_{10} monitoring summary for the CGO

Year	Average TSP (µg/m³)	Average PM_{10} (µg/m³)	Maximum daily PM_{10} (µg/m³)	Days over 50 µg/m³
2010	38.8	15.5	51.6	1
2011	28.6	11.4	23.5	0
2012	35.0	14.0	34.9	0
2013	44.2	17.7	61.6	2
2014	45.3	18.1	68.8	2
2015	43.0	17.2	46.4	0
2016	32.3	12.9	34.6	0
2017	27.5	11.0	21.3	0
2018	64.2	**25.7**	82.8	6

5.3 Continuous monitoring of PM_{10} and $PM_{2.5}$ concentrations

In November 2019, CGO installed three additional continuous monitoring sites for PM_{10}. A full year of continuous monitoring data is not yet available from these stations and therefore they cannot be used directly for derivation of background air quality. Also, the period between November 2019 and January 2020 was significantly influenced by bushfire activity and this period is not representative of typical background concentrations.

To supplement the onsite data, reference is made to the closest publicly available monitoring data for PM_{10} and $PM_{2.5}$, operated by DPIE at Bathurst, located approximately 200 km east[10]. Summary statistics for the Bathurst monitoring site for 2018 (the modelled year) are presented in Table 5.2.

Table 5.2 Summary statistics for PM_{10} and $PM_{2.5}$ concentrations (µg/m³) at Bathurst (2018)

Size fraction	Annual mean	Criteria	Max 24-hour average	Criteria	Days at or above the criteria	Highest 24-hour average concentration not at or above the criteria
PM_{10}	18.8	25	274.1	50	9	49.2
$PM_{2.5}$	7.0	8	40.5	25	2	22.1

10 20122013The Orange monitoring site was only added recently (no data exist for 2018) and the Wagga Wagga monitoring site is generally considered unsuitable for describing baseline air quality for other rural areas of NSW, due to the influence of specific sources at this site.

The annual average PM_{10} concentration for 2018 at Bathurst is significantly less than the PM_{10} concentration inferred from the CGO HVAS. However, as discussed previously, a few high daily values can disproportionately influence the annual average concentrations recorded by HVAS. In other years, the annual average PM_{10} concentrations at Bathurst are much more closely aligned with the CGO HVAS data (refer Table 5.3).

Table 5.3 Annual mean PM_{10} concentrations (µg/m^3) at Bathurst and the CGO HVAS

Year	CGO HVAS	Bathurst
2010	15.5	9.4
2011	11.4	11.0
2012	14.0	13.4
2013	17.7	15.1
2014	18.1	14.6
2015	17.2	13.4
2016	12.9	13.3
2017	11.0	14.1
2018	**25.7**	18.8

During 2018, the number of days above 50 µg/m^3 are similar at Bathurst (9) and the CGO HVAS (8). The 24-hour average PM_{10} concentrations measured at Bathurst are compared with the inferred CGO HVAS data in Figure 5.2 for the period 2009 to 2018. Since 2009, there are a few periods when the 24-hour average PM_{10} concentrations at the CGO HVAS are higher than at Bathurst, however, in general, the time series for both sites follow the same general trend.

A similar analysis is presented in Figure 5.3, comparing the continuous PM_{10} monitoring station recently installed at the Coniston residence with the Bathurst monitoring data for the post bushfire period (March to June 2020). Similar to the longer term comparison presented in Figure 5.2, there are a few periods when the 24-hour average PM_{10} concentrations differ, but in general the time series for both sites follow a similar trend.

In the absence of continuous monitoring data at CGO, the Bathurst monitoring data is accordingly considered a suitable background dataset for cumulative assessment.

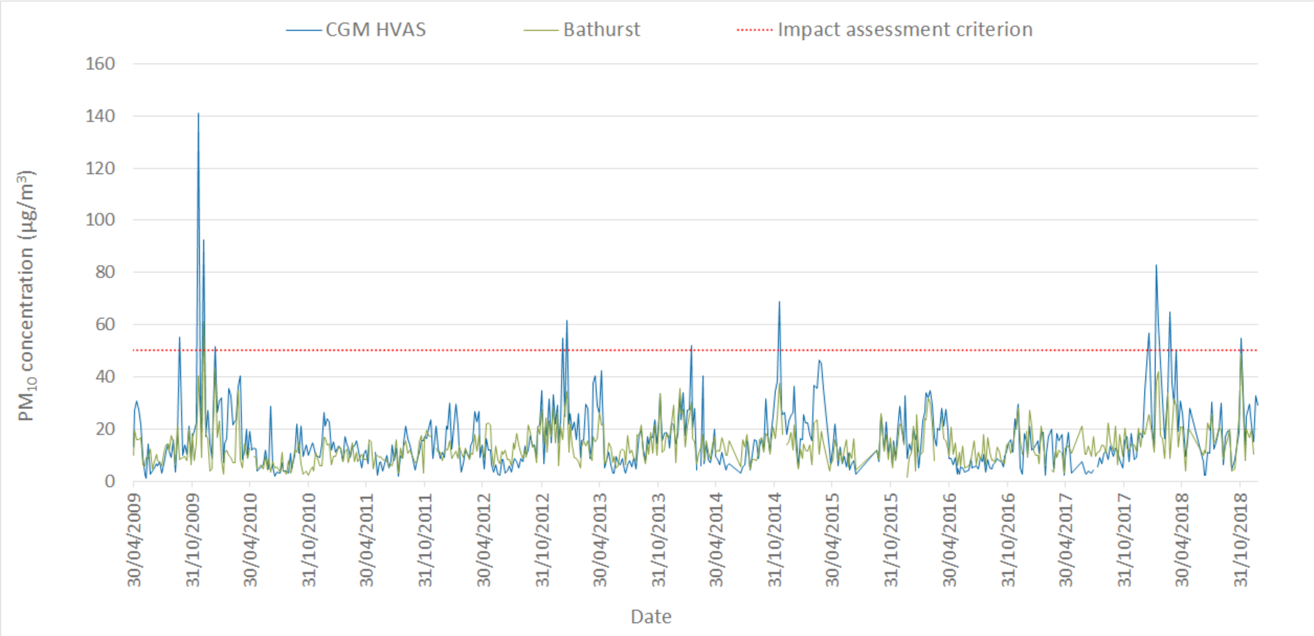


Figure 5.2 Periods of coincidental 24-hr average PM_{10} concentration – Bathurst and CGO HVAS

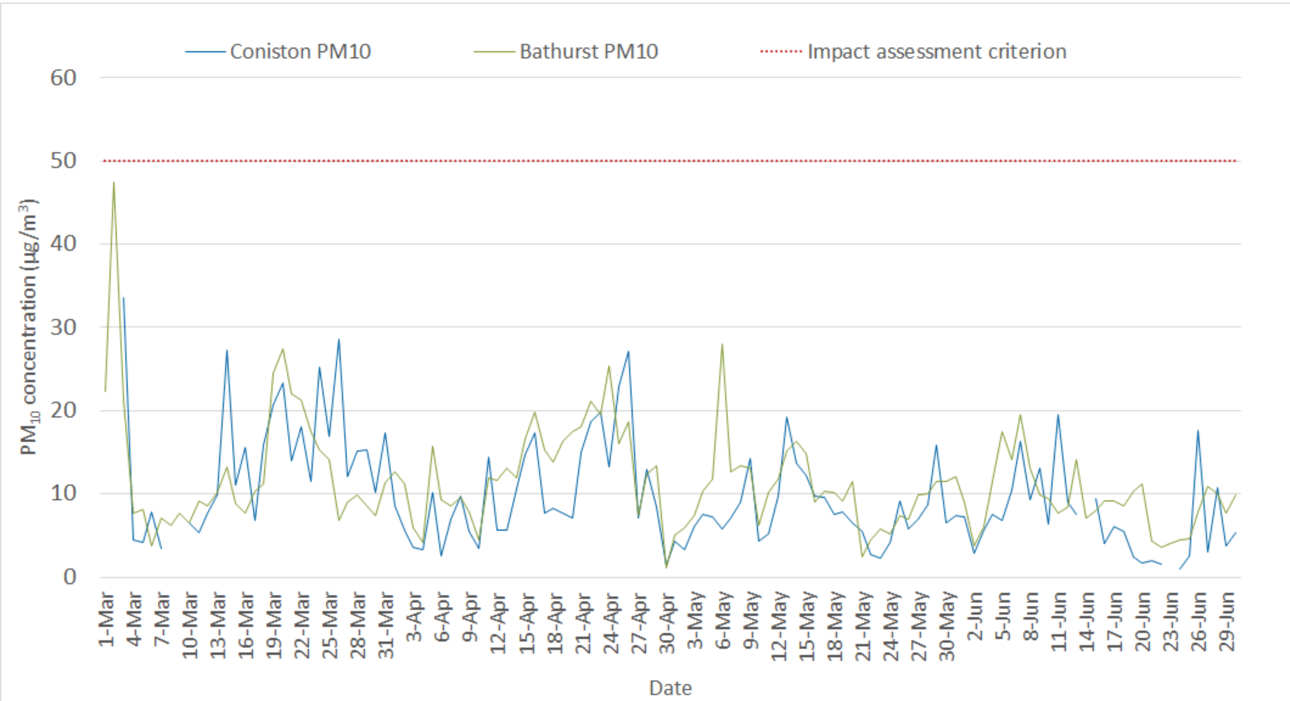


Figure 5.3 Periods of coincidental 24-hr average PM_{10} concentration – March – June 2010 for Bathurst and Coniston

5.4 Dust deposition

The annual average dust deposition levels for 2012 to 2018 are presented in Figure 5.4. Sites that are located within the mining lease are not shown, rather, our analysis focuses on sites that are representative of surrounding residential receptors. The analysis shows that dust deposition levels greater than that impact assessment criterion (4 g/m^2/month) occur in most years, but not necessarily at the same locations.

Across all sites and years, the annual average dust deposition levels ranged from 1.0 g/m^2/month to 6.7 g/m^2/month (average of 3.4 g/m^2/month). During 2018, annual average dust deposition levels range from 1.7 g/m^2/month to 6.5 g/m^2/month (average of 4.1 g/m^2/month) across all sites.

Given the consistency in wind patterns demonstrated in Figure 4.2, the contribution of CGO operations to annual dust levels should be relatively consistent year to year. For example, during drier years the contribution would be higher than during high rainfall years, but the relative change from a dry year to a wet year may be consistent across the same locations.

There will be operational changes at CGO from year to year (both in intensity and location) which would also affect how the relative contribution would change. Notwithstanding, the variation seen in Figure 5.4 suggests that there are other external sources that strongly influence whether dust deposition levels are above the impact assessment criterion at the receptor locations.

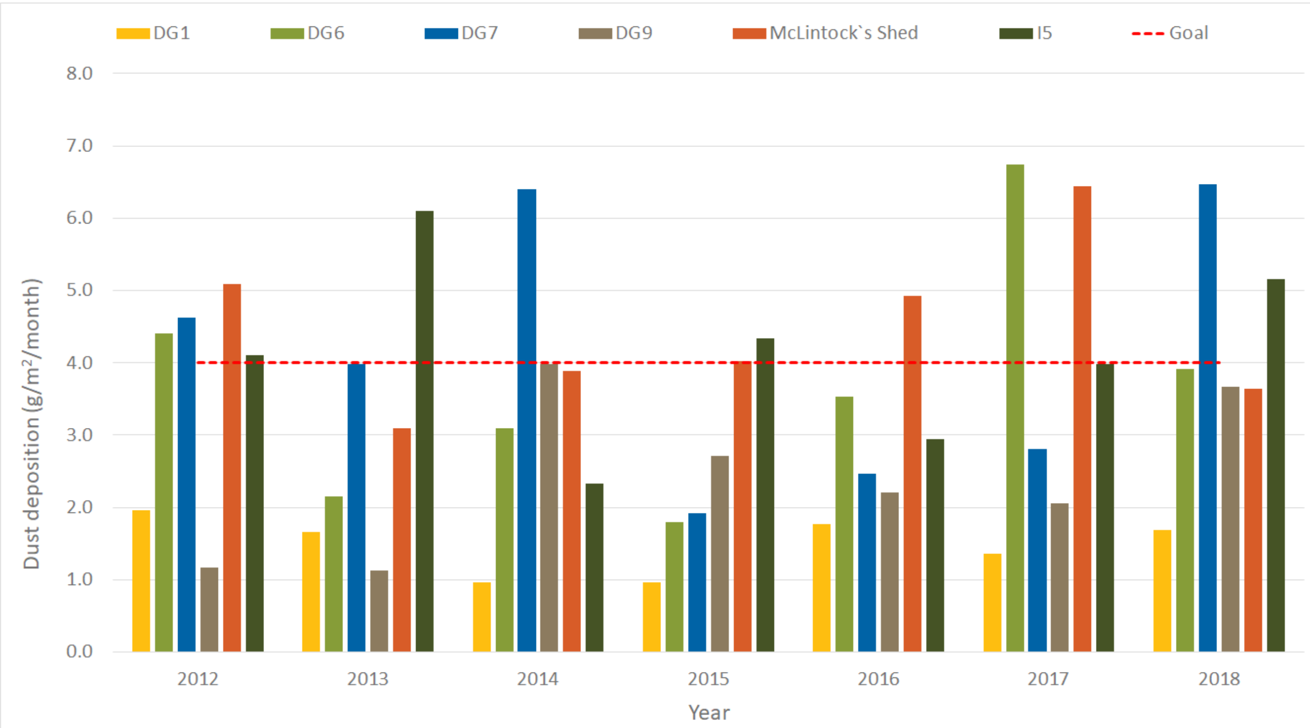


Figure 5.4 Annual average dust deposition for sites representative of residences

5.5 Adopted background for cumulative assessment

In the absence of continuous monitoring data at CGO, the Bathurst 2018 dataset is considered a suitable representative background for cumulative assessment of PM_{10} and $PM_{2.5}$. For short term (24-hour average) cumulative assessment, there are existing days when the background measurement is already above the impact assessment criteria and the assessment therefore focuses on the number of additional days above the impact assessment criteria. This approach is consistent with the guidance provided in Section 5.1.3 of the Approved Methods for Modelling for dealing with elevated background concentrations.

For 24-hour average PM_{10}, cumulative assessment is presented in two ways:

- using a paired in time approach, combining daily modelling predictions with a corresponding daily background taken from the closest suitable continuous monitoring station at Bathurst; and
- a frequency analysis of days above the impact assessment, whereby multiple years of data (from the CGO HVAS and from Bathurst) are combined with each daily modelling prediction and expressed as a probability or likelihood of days above the impact assessment criterion.

For annual average TSP and dust deposition, there are sufficient data measured in the vicinity of the CGO for use as a background for cumulative assessment, however these data will result in an element of double counting, as they measure existing operations at CGO.

In summary, the following background values are adopted for cumulative assessment:

- 24-hour PM_{10} concentration – daily varying;
- annual average PM_{10} concentration – 18.8 µg/m^3;
- 24-hour $PM_{2.5}$ concentration – daily varying;
- annual average $PM_{2.5}$ concentration – 7.0 µg/m^3;
- annual average TSP concentration – 64.2 µg/m^3; and
- annual average dust deposition – 3.4 g/m^2/month.

6 Emissions inventory

6.1 Emissions scenario

An emissions inventory has been developed for a single representative mining year, selected to assess the air quality impact of worst-case operational conditions. The emissions inventory includes existing (approved) open cut operations, as well as operations at the proposed underground development and surface changes modification.

It is noted that existing (approved) operations is defined as the modelled emissions scenario presented in the 2018 modification (Mod 14), which corresponds to a nominal mining year of 2020 (PEL 2018). The Mod 14 emissions scenario has been updated to reflect the 2022 open cut production schedule and incorporate the 2022 underground development production schedule, to develop an emission scenario that corresponds to the maximum combined total movement of ore and waste at the site.

6.2 Emissions estimates

Fugitive dust sources associated with the operations of the Project were quantified through the application of US-EPA AP-42 emission factor equations. Particulate matter emissions were quantified for the three size fractions identified in Section 3, with the TSP fraction also used to model dust deposition. Emission rates for coarse particles (PM_{10}) and fine particles ($PM_{2.5}$) were estimated using ratios for the different particle size fractions available in the literature (principally the US-EPA AP-42).

A detailed description of the assumptions and emission factors adopted in the development of the emissions inventory are provided in Appendix B. The modelled source locations are shown in Figure 6.1.

6.2.1 Emissions summary

The proposed underground mine would be accessed via a box-cut and decline from the surface. The box-cut would be located adjacent to the southern boundary of the open-cut pit. There are three primary access points and three secondary access points proposed for the underground mine, and each has its own associated underground tunnel system. The primary access points are used where regular worker and/or vehicle access is required, and include the Main Portal, the Fresh Air Intake/Haulage Decline Portal and the Box-cut. The secondary access points are used for mine ventilation, and include the Fresh Air Intake Adit 1, the Fresh Air Intake Adit 2 and the Exhaust Adit.

In addition to the emission estimates for existing (approved) operations, the following activities are considered in the dust emission estimates for the underground development and surface changes modification.

Underground development

- development of a box-cut entry to the underground workings;
- additional blasting required to develop the underground stopes;
- mining (extraction) of material from underground workings; and
- trucking of ore and waste to the surface; and
- development of a paste fill plant, and the delivery of paste fill via a borehole and the backfilling underground stopes with the paste.

Emissions for these underground mining activities are modelled as a release from the Exhaust Adit point.

Surface changes modification

- hauling underground ore to the processing plant and waste and to the waste rock emplacements;
- unloading ore at the processing plant and waste at the waste rock dump;
- rehandle ore to the crusher and processing of ore (crushing/screening); and
- loading the coarse ore stockpile.

Minor changes to the IWL height associated with the surface changes modification are considered negligible from an air quality perspective, however activities at the IWL are included as an emission source for existing operations.

Material movement during development of the box cut is included in FY21 mining schedule, and is less than material movement during the modelled scenario (FY22). Therefore, an additional modelling scenario for the development of the box cut was not considered necessary. Activities associated with producing the cement paste to backfill the mined underground stopes are not considered as significant dust sources.

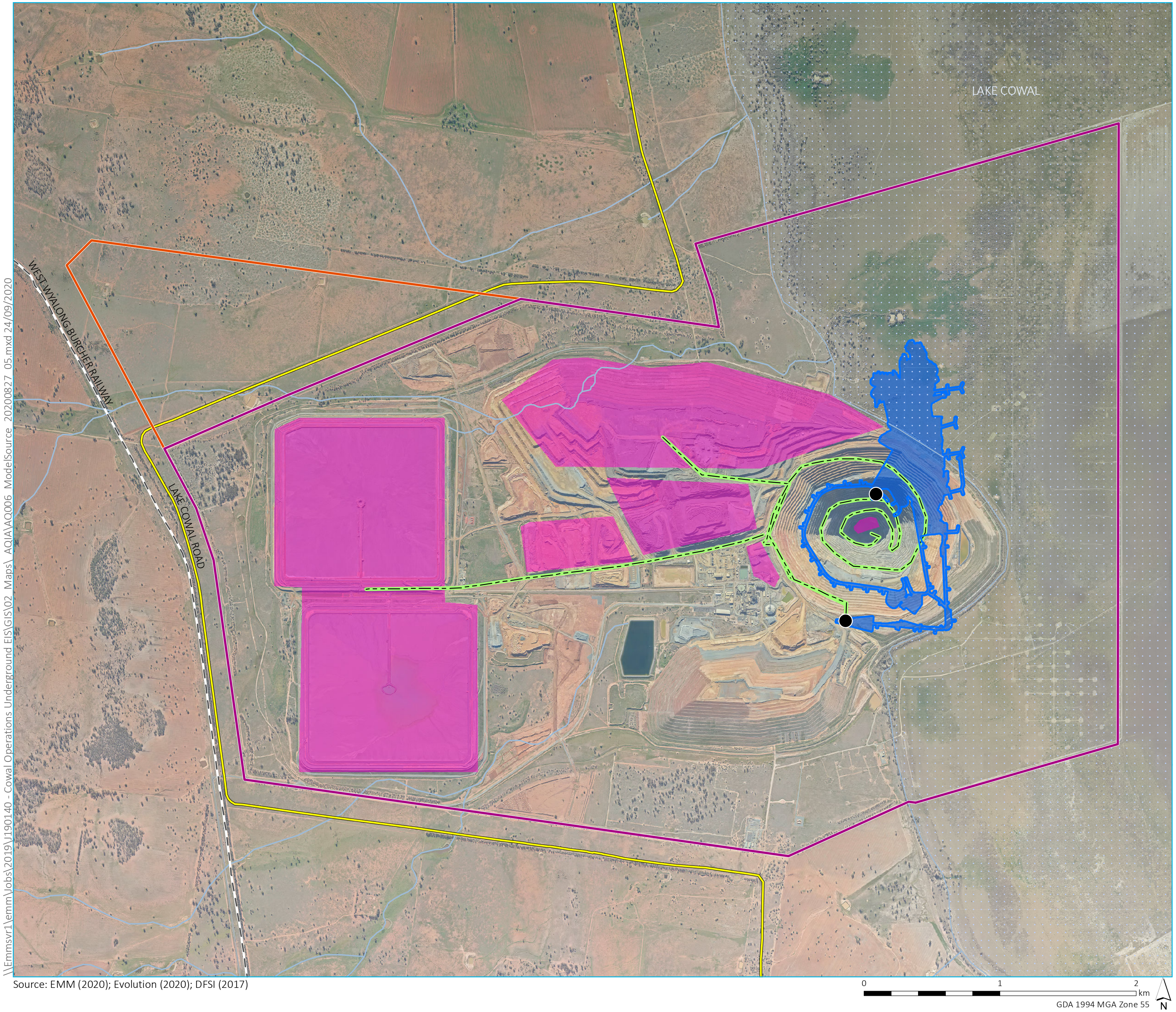
A summary of the Project's contribution to annual dust emissions by source type is provided in Figure 6.2. Calculated annual emissions by emissions source is presented in Table 6.1. Emissions are presented separately for existing (approved operations) and the underground development (including surface changes and underground sources).

Particulate matter control measures, as documented in Section 6.3, are accounted for in these emission totals.

From the data presented in Figure 6.2 and Table 6.1, the most significant source of particulate matter emissions from the operation of the Project is associated with hauling of materials and wind erosion. This is typical for facilities involving open cut mining operations.

Further details regarding emission estimation factors and assumptions are provided in Appendix B.

A comparison of the estimated emissions from the approved open cut operations (Mod 14), the surface changes due to the underground development (Mod 16) and the underground workings (the SSD) is shown in Figure 6.3. Table 6.2 provides the same comparison in tabular form. The emissions data show that the Mod 16 surface changes makes up approximately 1% of the already approved open cut operations while the proposed underground workings makes up approximately 3% to 4% of the already approved open cut operations.



KEY

- Proposed underground development
- Mining lease (ML1535)
- Mining lease (ML1791)
- Rail line
- Main road
- Watercourse/drainage line
- Waterbody

Model source

- Exhaust adit
- Haul route
- Stockpile and waste rock emplacement area

Source: EMM (2020); Evolution (2020); DFSI (2017)

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Model source locations

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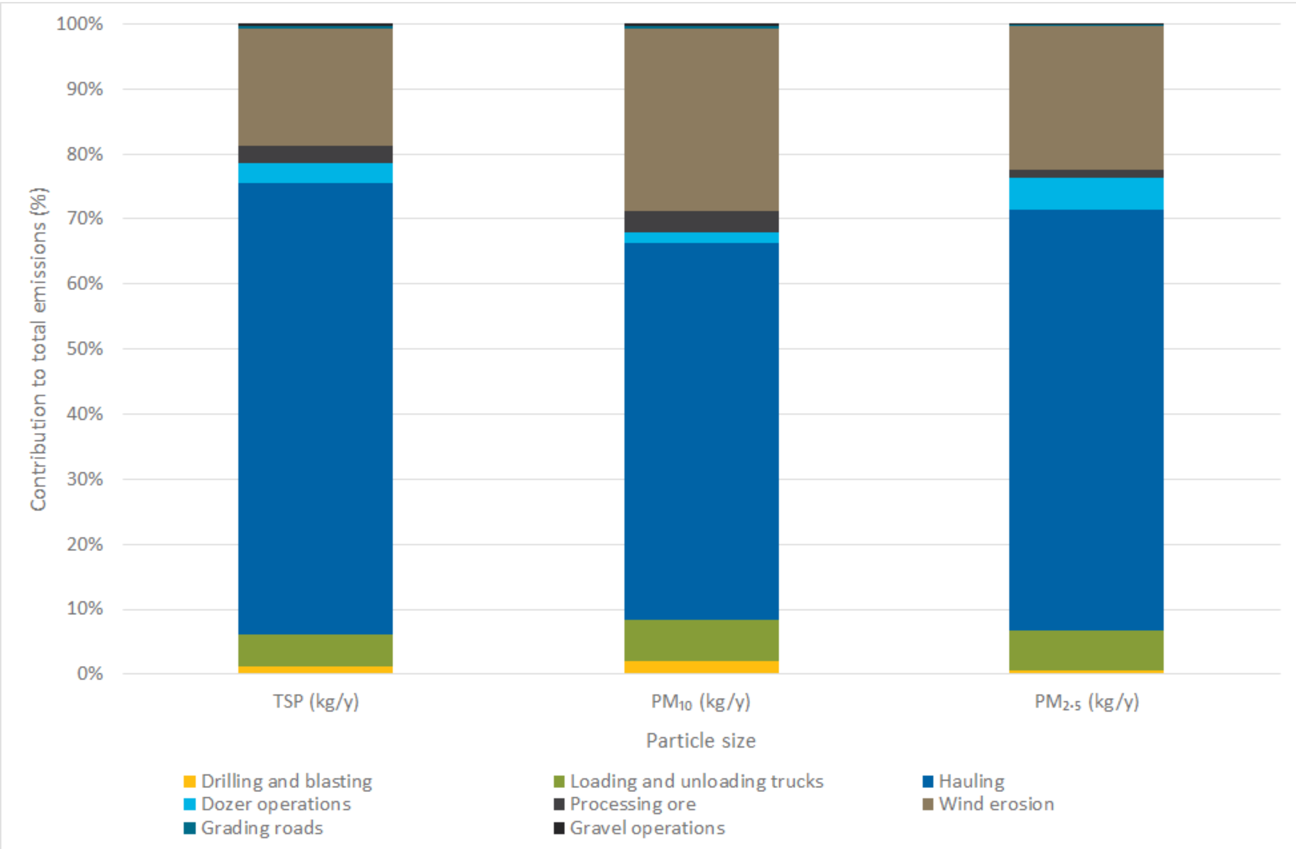


Figure 6.2 Contribution to annual emissions by emissions source type and particle size

Table 6.1 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM_{10}	$PM_{2.5}$
Approved Open Cut Operations (as per Mod 14)			
Waste rock extraction, loading, hauling and unloading			
Drilling	8,098	4,211	243
Blasting	28,808	14,980	864
Waste - Excavators loading haul trucks	14,068	6,654	1,008
Waste - Hauling to northern waste dump	494,830	163,212	33,054
Waste - Unloading at northern waste dump	14,068	6,654	1,008
Waste - Loading trucks with clay at Hardstand area for IWL	1,927	911	138
Waste - Hauling clay from Hardstand to IWL construction area	110,425	30,266	5,319
Waste - Unloading clay at IWL construction area	1,927	911	138
Waste - Dozers in pit	20,819	4,086	2,186
Waste - Dozers on IWL construction area	34,922	6,855	3,667
Waste - Dozers on STSF area	34,922	6,855	3,667
Ore extraction, loading, hauling and processing			
Ore - Loading mineral waste ore to haul trucks	16,958	8,021	1,215
Ore - Hauling mineral waste ore to northern dump	726,677	180,343	38,205
Ore - Unloading mineral waste ore to northern dump	16,958	8,021	1,215
Ore - Loading ore to haul trucks	18,114	8,568	1,297
Ore - Hauling ore to ROM pad	707,834	171,552	38,701
Ore - Unloading ore to ROM pad	18,114	8,568	1,297
Ore - Rehandling ore	10,869	5,141	778
Ore - Crushing	12,690	5,640	1,044
Ore - Screening	58,750	20,210	118
Ore - Loading to coarse ore stockpile	18,114	8,568	1,297
Gravel - loading to trucks in pit	289	137	21
Gravel - Hauling from pit to mobile crusher	10,913	2,692	269
Gravel - unloading at crusher	289	137	21
Gravel - crushing	203	90	17
Grading roads	10,783	3,768	334
Wind erosion			
Wind erosion - Open pit	93,500	46,750	7,013
Wind erosion - Northern dump	76,500	38,250	5,738
Wind erosion - Stockpiles and exposed areas	65,450	32,725	4,909
Wind erosion - Northern stockpiles	85,000	42,500	6,375

Table 6.1 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM_{10}	$PM_{2.5}$
Wind erosion - Dry TSF and IWL area construction	232,050	116,025	17,404
CGO Underground Development			
Modification 16 surface changes			
Waste - hauling from box cut portal to northern waste dump	25,258	7,414	1,860
Waste - unloading at northern waste dump	941	445	67
Ore - hauling from box cut to temporary stockpile	1,505	521	215
Ore - unloading ore to temporary stockpile	137	65	9.8
Ore - rehandle at crusher/ROM pad	137	65	9.8
Ore - Crushing	96	43	7.9
Ore - Screening	445	153	0.9
Ore - Loading to coarse ore stockpile	137	65	9.8
Wind erosion - increase in area of IWL (considered negligible)	0	0	0
Underground workings SSD (emissions released from Exhaust Adit point)			
Additional blasting for UG development	1,430	744	43
Mining of material (underground)	25,525	5,010	2,680
Waste and ore – trucking to surface	58,919	15,139	3,535
Total	**3,059,399**	**982,961**	**186,997**

Note: Emission totals incorporate particulate matter management measures (refer Section 6.3).

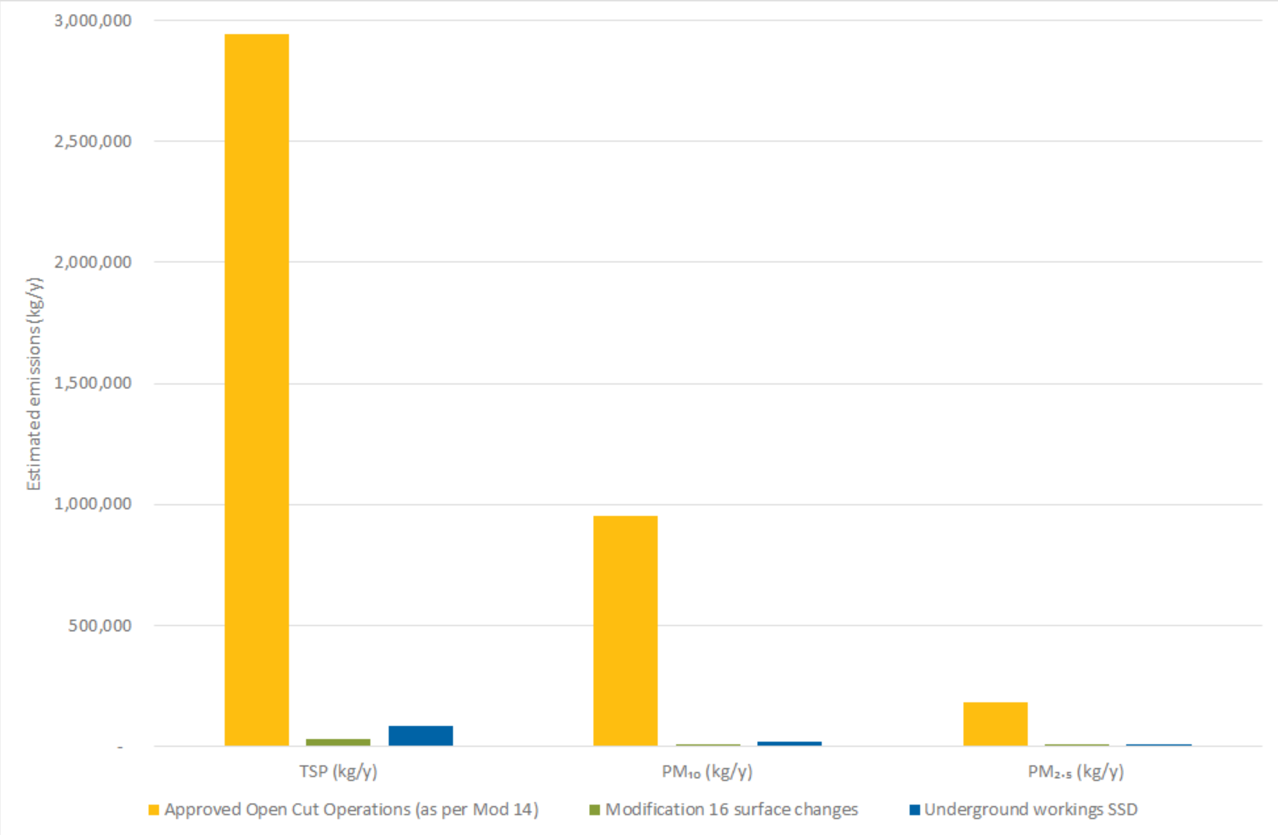


Figure 6.3 Comparison of estimated TSP, PM_{10} and $PM_{2.5}$ emissions for the approved open cut, the underground workings SSD and Mod 16 surface changes

Table 6.2 Estimated TSP, PM_{10} and $PM_{2.5}$ emissions for CGO open cut operations, the underground workings and SSD Mod 16 surface changes

Operation	TSP (kg/y)	PM_{10} (kg/y)	$PM_{2.5}$ (kg/y)
Approved Open Cut Operations (Mod 14)	2,944,869	953,297	178,557
Modification 16 surface changes	28,656	8,771	2,181
Underground workings SSD	85,874	20,893	6,258

6.3 Management measures

CGO currently implement a range of particulate matter emission controls at the site. Table 6.3 presents the dust management measures and the corresponding particulate matter emission reduction factor applied for the emissions inventory. Further discussion on dust controls is provided in Section 10.

Table 6.3 Control measures applied in the assessment

Control measure	Control applied in emissions inventory	Control source
Water injection while drilling	70%	NPI 2012
Watering/suppressants on unpaved haul roads	80%	NPI 2012
Watering during crushing and screening	50%	NPI 2012
Watering graded roads	50%	NPI 2012

6.4 Diesel emissions

As discussed in Section 3, emissions of PM_{10} and $PM_{2.5}$ from diesel combustion in mining equipment are assumed to be included in the total emissions for each relevant source and are not explicitly modelled as a separate emission source. However, adjustments have been made to account for the fact that emission reductions applied to the inventory (i.e. watering) are not relevant to the control of diesel exhaust emissions.

Diesel consumption has been estimated for each project component and diesel emissions are estimated using the NSW fleet average $PM_{2.5}$ emission factor of 1.39 kg/kL, as reported in the NSW EPA's benchmarking study[11]. PM_{10} emissions are estimated based on the assumption that $PM_{2.5}$ emissions are 97% of PM_{10} emissions (NSW EPA, 2012).

The estimated diesel emissions for hauling are subtracted from the uncontrolled haul road emissions to derive the wheel-generated component of emissions for each haul road. The control for watering is then applied to the wheel-generated component only, and the diesel emissions are then added back to derive the final emission estimate from haul trucks.

[11] Based on total $PM_{2.5}$ emissions (1,298 tonnes per annum) and diesel combustion (936,440 kilolitres per annum)

7 Dispersion modelling

7.1 Dispersion model selection and configuration

The atmospheric dispersion modelling completed for this assessment used the AERMOD dispersion model (version v18081). AERMOD is designed to handle a variety of pollutant source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain. Specific activities (listed in Table 6.1) were represented by line-volume, volume and area sources which were located according to the layout of the project. The modelled source locations are shown in Figure 6.1.

In addition to the 37 individual assessment locations (documented in Section 2.5), air pollutant concentrations were predicted over a 29.5 km by 29.5 km domain with a 500 m resolution) and used to generate concentration isopleth plots (Appendix C). The predicted project-only and cumulative concentrations and deposition levels are presented in subsequent sections.

Project-only predictions are presented as follows:

- for the underground development and associated surface changes (the Project); and
- for the total combined site operations (including the existing approved open-cut).

Cumulative modelling predictions are presented for the total combined site operations, in two ways:

- using a paired in time approach, combining daily modelling predictions with a corresponding daily background taken from the closest suitable continuous monitoring station at Bathurst; and
- a frequency analysis of days above the impact assessment, whereby multiple years of data (from CGO HVAS and Bathurst) are combined with each daily modelling prediction and expressed as a probability or likelihood of days above the impact assessment criterion.

7.2 Project-only modelling results

Modelling results are presented in Table 7.1 and show:

- for the underground development and associated surface changes, the highest predicted increment in annual average PM_{10} at a private receptor is less than 0.1 µg/m³ and the highest predicted increment in 24-hour average PM_{10} at a private receptor is 0.5 µg/m³. Comparing this to the modelling results for the total combined site operations, the highest predicted increment in annual average PM_{10} at a private receptor is 2.0 µg/m³ and the highest predicted increment in 24-hour average PM_{10} at a private receptor is 15.0 µg/m³;
- for the underground development and associated surface changes, the highest predicted increment in annual average $PM_{2.5}$ at a private receptor is <0.1 µg/m³ and the highest predicted increment in 24-hour average $PM_{2.5}$ at a private receptor is 0.1 µg/m³. Comparing this to the modelling results for the total combined site operations, the highest the highest predicted increment in annual average $PM_{2.5}$ at a private receptor is 0.4 µg/m³ and the highest predicted increment in 24-hour average $PM_{2.5}$ at a private receptor is 3.0 µg/m;
- for the underground development and associated surface changes, the highest predicted increment in annual average TSP at a private receptor is 0.1 µg/m³. Comparing this to the modelling results for the total combined site operations, the highest predicted increment in annual average TSP at a private receptor is 2.0 µg/m³; and

- for the underground development and associated surface changes, the highest predicted increment in annual average dust deposition at a private receptor is <0.1 g/m^2/month. Comparing this to the modelling results for the total combined site operations, the highest predicted increment in annual average dust deposition at a private receptor is 0.1 g/m^2/month.

There are no private residences where the short-term VLAMP criteria are triggered.

Table 7.1 Incremental (project only) modelling predictions

Assessment location ID	Underground development and surface changes						Total site (including existing open cut operations)					
	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		TSP (µg/m³)	Dust Dep (g/m²/month)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		TSP (µg/m³)	Dust Dep (g/m²/month)
	24-hour maximum	Annual average	24-hour maximum	Annual average	Annual average	Annual average	24-hour maximum	Annual average	24-hour maximum	Annual average	Annual average	Annual average
Criterion	**50**	**25**	**25**	**8**	**90**	**2**	**50**	**25**	**25**	**8**	**90**	**2**
1a	0.7	<0.1	0.2	<0.1	0.2	<0.1	16.8	2.6	3.3	0.5	3.0	0.1
1b	0.3	<0.1	<0.1	<0.1	0.1	<0.1	11.7	1.9	2.4	0.4	2.2	0.1
1c	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	6.4	0.9	1.2	0.2	1.3	0.1
1d	0.4	<0.1	0.1	<0.1	<0.1	<0.1	6.7	0.6	1.4	0.1	0.8	<0.1
4	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	7.5	0.6	1.6	0.1	0.6	<0.1
6	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	6.0	0.4	1.3	0.1	0.4	<0.1
15	0.5	<0.1	0.1	<0.1	0.1	<0.1	15.0	1.7	3.0	0.4	2.0	0.1
20	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	7.3	0.9	1.7	0.2	1.3	<0.1
21	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	10.8	1.4	2.5	0.3	1.9	0.1
22a	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	5.6	0.6	1.3	0.1	0.9	<0.1
22b	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	4.8	0.6	1.1	0.1	0.8	<0.1
22c	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	6.2	0.7	1.4	0.2	1.0	0.1
22d	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.3	0.5	0.8	0.1	0.7	<0.1
24	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.8	0.5	0.8	0.1	0.7	<0.1
25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.9	0.4	0.6	0.1	0.5	<0.1
28	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.1	0.5	0.9	0.1	0.5	<0.1

Table 7.1 Incremental (project only) modelling predictions

Assessment location ID	Underground development and surface changes						Total site (including existing open cut operations)					
	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		TSP (µg/m³)	Dust Dep (g/m²/month)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		TSP (µg/m³)	Dust Dep (g/m²/month)
	24-hour maximum	Annual average	24-hour maximum	Annual average	Annual average	Annual average	24-hour maximum	Annual average	24-hour maximum	Annual average	Annual average	Annual average
Criterion	**50**	**25**	**25**	**8**	**90**	**2**	**50**	**25**	**25**	**8**	**90**	**2**
30a	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	6.4	0.6	1.4	0.1	0.7	<0.1
30b	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	5.0	0.5	1.1	0.1	0.6	<0.1
31a	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.9	0.3	1.0	0.1	0.4	<0.1
36a	0.4	<0.1	0.1	<0.1	<0.1	<0.1	9.7	1.3	1.9	0.3	1.4	<0.1
36b	0.4	<0.1	0.1	<0.1	<0.1	<0.1	9.0	0.8	1.9	0.2	0.9	<0.1
38	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	9.1	0.6	1.9	0.1	0.7	<0.1
42	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	7.7	1.0	1.6	0.2	1.5	0.1
43a	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	4.6	0.3	0.9	0.1	0.4	<0.1
43b	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.8	0.2	0.7	0.1	0.3	<0.1
49a	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.9	0.4	0.8	0.1	0.6	<0.1
49b	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	4.9	0.5	1.0	0.1	0.7	<0.1
56	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.1	0.3	0.7	0.1	0.4	<0.1
57	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.0	0.3	0.6	0.1	0.4	<0.1
61a	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	7.2	0.6	1.6	0.1	0.7	<0.1
62	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	8.7	1.0	2.1	0.2	1.2	0.1
79	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	4.9	0.6	1.1	0.1	0.7	<0.1

Table 7.1 Incremental (project only) modelling predictions

Assessment location ID	Underground development and surface changes						Total site (including existing open cut operations)					
	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		TSP (µg/m³)	Dust Dep (g/m²/month)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		TSP (µg/m³)	Dust Dep (g/m²/month)
	24-hour maximum	Annual average	24-hour maximum	Annual average	Annual average	Annual average	24-hour maximum	Annual average	24-hour maximum	Annual average	Annual average	Annual average
Criterion	**50**	**25**	**25**	**8**	**90**	**2**	**50**	**25**	**25**	**8**	**90**	**2**
89	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	6.1	0.5	1.1	0.1	0.7	<0.1
902	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	6.6	0.4	1.3	0.1	0.5	<0.1
100	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.5	0.3	0.5	0.1	0.4	<0.1
122	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	6.0	0.7	1.3	0.1	0.7	<0.1
126	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	4.4	0.6	1.0	0.1	0.6	<0.1

In summary, for all pollutants and averaging periods, the project alone (underground development and associated surface changes), represents a minor change from the existing open cut operations. This is illustrated in Figure 7.1 and which compares the 24-hour average PM_{10} modelled increment for the underground development with the modelling results for the total combined site operations.

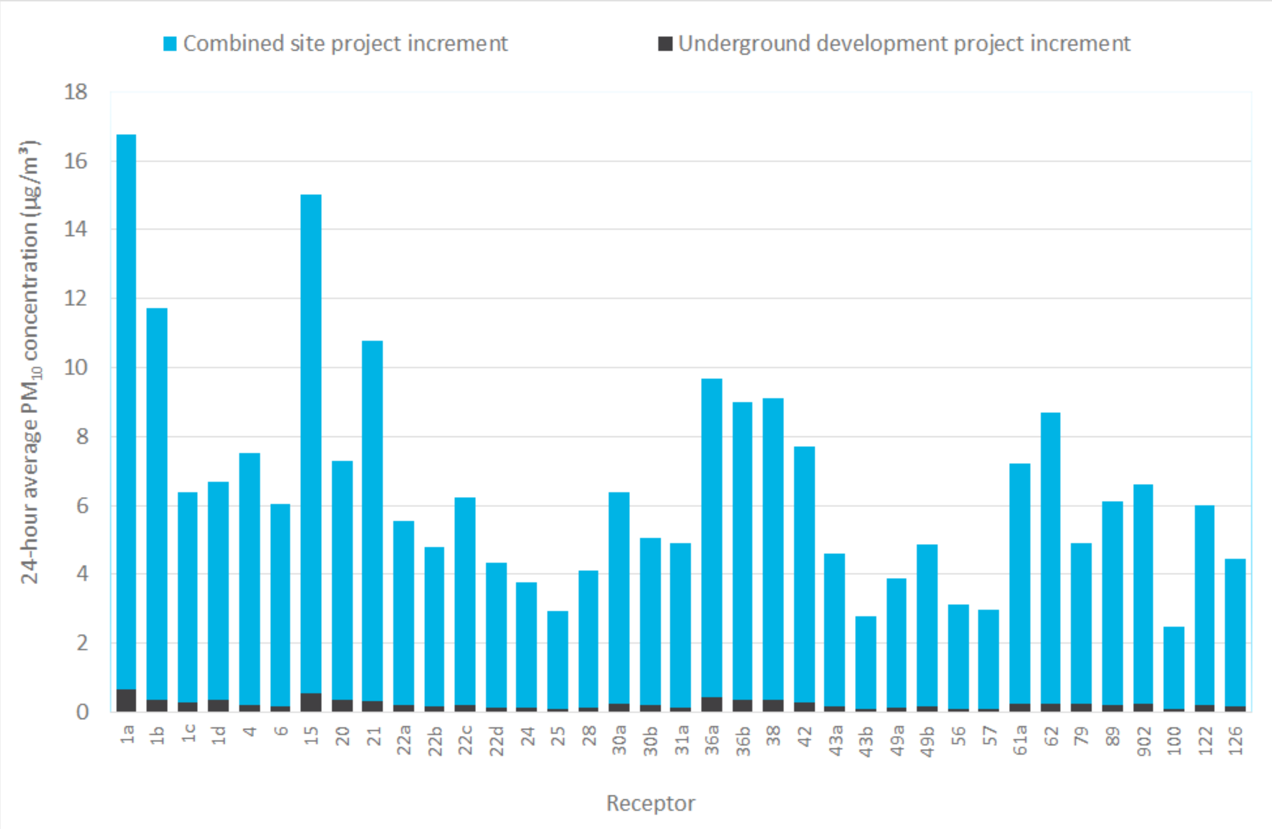


Figure 7.1 **Comparison of project increment for underground development with the combined site (open cut and underground development) for 24-hour average PM_{10}**

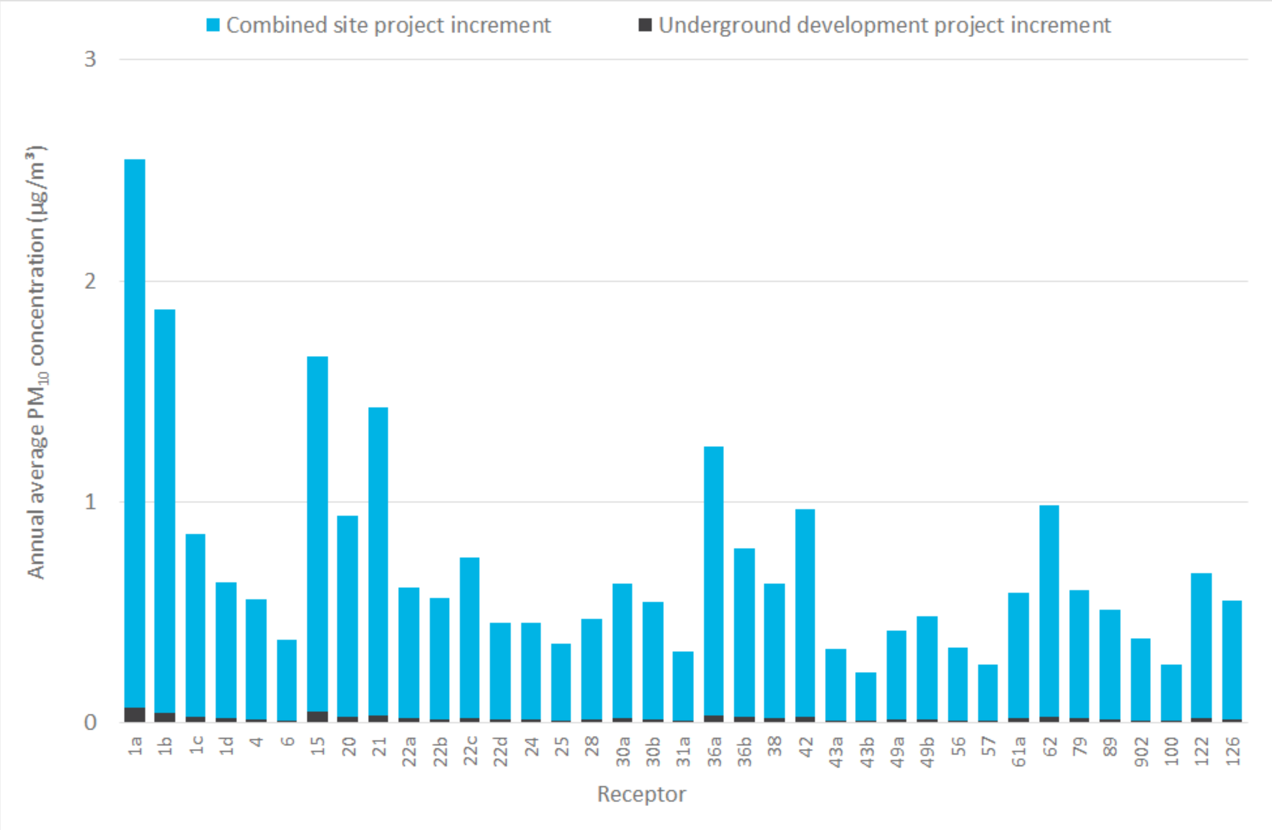


Figure 7.2 **Comparison of project increment for underground development with the combined site (open cut and underground development) for annual average PM_{10}**

7.3 Cumulative annual average modelling results

Cumulative modelling results are presented for the total combined site operations (underground development and open cut) plus the existing background described in Section 5. Cumulative annual average modelling results are presented in Table 7.2 and show:

- the highest predicted cumulative annual average PM_{10} at a private residence is 20.5 µg/m³;
- the highest predicted cumulative annual average $PM_{2.5}$ at a private residence is 7.3 µg/m³;
- the highest predicted cumulative annual average TSP at a private residence is 66.2 µg/m³; and
- the highest predicted cumulative annual average dust deposition at a private residence is 3.5 g/m²/month.

There are no assessment locations (mine-owned or private) where the cumulative annual average concentration and deposition levels exceed the impact assessment criteria. Similarly, VLAMP criteria are not triggered at any location.

Table 7.2 Predicted cumulative annual average modelling results

Assessment location ID	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	TSP (µg/m³)	Dust Dep (g/m²/month)
Criterion	**25**	**8**	**90**	**4**
1a	21.4	7.5	67.2	3.5
1b	20.7	7.4	66.4	3.5
1c	19.7	7.2	65.5	3.5
1d	19.5	7.1	65.0	3.4
4	19.4	7.1	64.8	3.4
6	19.2	7.1	64.6	3.4
15	20.5	7.3	66.2	3.4
20	19.8	7.2	65.5	3.4
21	20.3	7.3	66.1	3.5
22a	19.5	7.1	65.1	3.4
22b	19.4	7.1	65.0	3.4
22c	19.6	7.2	65.2	3.4
22d	19.3	7.1	64.9	3.4
24	19.3	7.1	64.9	3.4
25	19.2	7.1	64.7	3.4
28	19.3	7.1	64.7	3.4
30a	19.5	7.1	64.9	3.4
30b	19.4	7.1	64.8	3.4
31a	19.2	7.1	64.6	3.4
36a	20.1	7.3	65.6	3.4
36b	19.6	7.2	65.1	3.4
38	19.5	7.1	64.9	3.4
42	19.8	7.2	65.7	3.5
43a	19.2	7.1	64.6	3.4
43b	19.1	7.0	64.5	3.4
49a	19.3	7.1	64.8	3.4
49b	19.3	7.1	64.9	3.4
56	19.2	7.1	64.6	3.4
57	19.1	7.0	64.6	3.4
61a	19.4	7.1	64.9	3.4
62	19.8	7.2	65.4	3.4
79	19.4	7.1	64.9	3.4
89	19.4	7.1	64.9	3.4
902	19.2	7.1	64.7	3.4

Table 7.2 Predicted cumulative annual average modelling results

Assessment location ID	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	TSP (µg/m³)	Dust Dep (g/m²/month)
Criterion	**25**	**8**	**90**	**4**
100	19.1	7.0	64.6	3.4
122	19.5	7.1	64.9	3.4
126	19.4	7.1	64.8	3.4

7.4 Cumulative 24-hour average modelling results

7.4.1 Paired-in-time analysis

The predicted cumulative maximum 24-hour average and PM_{10} and $PM_{2.5}$ concentrations for assessment locations are presented in Table 7.3. Cumulative modelling results are presented for the total combined site operations (underground development and open cut).

When background concentrations are added, the predicted cumulative 24-hour average PM_{10} is greater than the impact assessment criterion (50 µg/m³) at a number of private receptors. Also shown are the number of additional days above 50 µg/m³, predicted as a result of the project[12]. The maximum number of additional days above 50 µg/m³ at any private receptor is two (2).

The CGO HVAS (located at receptor 1a) recorded eight days above 50 µg/m³ in 2018[13]. The cumulative modelling prediction for 1a predicts four (4) additional days above 50 µg/m³ (ie less than what was measured for approved operations in 2018). This indicates that the addition of the proposed underground development is unlikely to result in additional exceedances, beyond what would already occur for private receptors in the vicinity of CGO.

It is noted that the short-term VLAMP criteria are applied to the incremental impact from the project alone, therefore there are no exceedances of the VLAMP criteria for 24-hour PM_{10}.

The highest predicted cumulative 24-hour average $PM_{2.5}$ is 23.0 µg/m³. There are no assessment locations (mine-owned or private) where the cumulative 24-hour average $PM_{2.5}$ concentration is greater than the impact assessment criterion (25 µg/m³).

12 It is noted that 'additional days' refers to additional days beyond what occurs in the background dataset, which, in this case, is 2018 monitoring data from Bathurst.

13 It is noted that this is inferred from the HVAS TSP measurements and also does not represent every day of the year. Therefore, the number of days above 50 µg/m³ may have been higher.

Table 7.3 Predicted cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentration

Assessment location ID	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)
	Maximum 24-hour average	Additional days over the impact assessment criterion	Maximum 24-hour average
Criterion	**50**	**NA**	**25**
1a	52.7	4	21.4
1b	51.8	2	20.7
1c	50.7	1	19.7
1d	54.9	2	19.5
4	49.9	0	19.4
6	51.2	2	19.2
15	50.9	1	20.5
20	50.5	1	19.8
21	50.5	1	20.3
22a	49.9	0	19.5
22b	49.8	0	19.4
22c	49.9	0	19.6
22d	49.8	0	19.3
24	50.0	1	19.3
25	49.9	0	19.2
28	49.8	0	19.3
30a	50.1	1	19.5
30b	50.1	1	19.4
31a	50.3	1	19.2
36a	51.9	2	20.1
36b	49.9	0	19.6
38	54.0	2	19.5
42	50.1	1	19.8
43a	50.1	1	19.2
43b	50.0	1	19.1
49a	49.8	0	19.3
49b	49.9	0	19.3
56	49.8	0	19.2
57	49.8	0	19.1
61a	52.4	2	19.4
62	51.9	1	19.8

Table 7.3 Predicted cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentration

Assessment location ID	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)
	Maximum 24-hour average	Additional days over the impact assessment criterion	Maximum 24-hour average
Criterion	**50**	**NA**	**25**
79	52.0	1	19.4
89	51.1	1	19.4
902	51.8	1	19.2
100	49.8	0	19.1
122	50.1	1	19.5
126	50.6	1	19.4

7.4.2 Additional probability analysis

Further cumulative analysis for 24-hour PM_{10} is presented in Figure 7.3, for the receptors with the highest incremental predictions (15 and 21) and the receptors with highest number of additional days over (6, 36a, 38, 61a).

An extended background dataset is collated, which combines 10 years of CGO HVAS data with 10 years of data at Bathurst and calculates the percentage occurrence of days above 50 µg/m³. This is then multiplied by 365 to normalise the annual number of days above 50 µg/m³ (3.6) that would occur for this extended background dataset.

These daily background values are combined with each daily modelling predictions and used to calculate the probability of additional days above 50 µg/m³. Using the extended background dataset, the analysis shows that the likelihood of additional days above 50 µg/m³ is low, with less than one additional day predicted for each receptor.

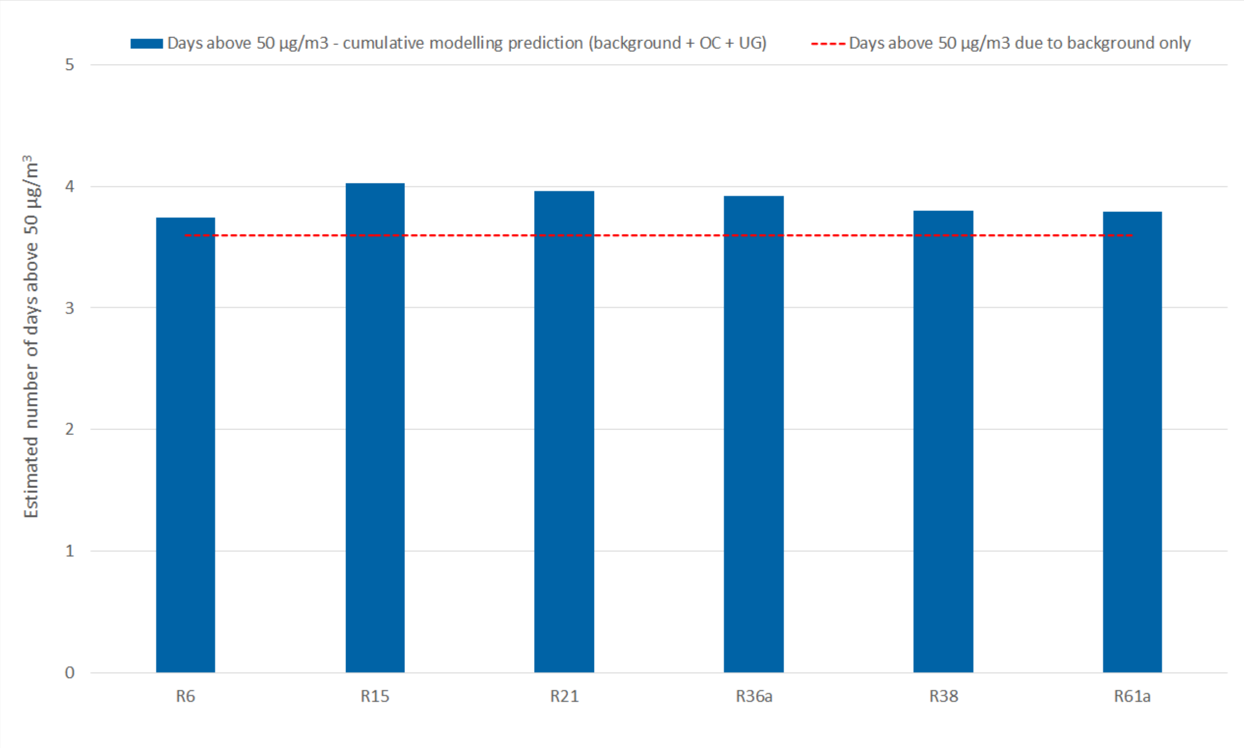


Figure 7.3 **Estimated number of days over 50 µg/m^3 for extended background and cumulative modelling predictions**

8 Construction phase impacts

The proposed underground mining operations would require a range of supporting surface infrastructure. Much of this infrastructure is already in place at CGO, in terms of ore stockpiling and processing, internal transportation systems, water management and the emplacement of tailings and waste rock.

The existing infrastructure would however be required to be augmented, in order to handle and process the higher grade ore from the underground mine, and to emplace additional tailings and waste rock. New infrastructure would also be required at the surface, to gain access to the underground mine and to produce cemented paste fill to put back into the extracted underground stopes to stabilise the workings.

Key surface infrastructure will be required to support the underground development, including:

- developing a box-cut, to provide access to the underground mine for workers, materials, maintenance vehicles and haul trucks;
- making changes to the processing facility to upgrade it to process higher grade ore;
- developing a paste fill plant to produce paste fill to backfill underground stopes;
- continued emplacement of tailings at the IWL and increasing the final height of the IWL by one metre; and
- developing other minor ancillary supporting infrastructure at the site to manage site operations, including administrative facilities, bathhouse, access tracks and telecommunications equipment.

Material movement during development of the box cut is included in FY21 mining schedule and is less than material movement during the modelled scenario (FY22). Therefore, an additional modelling scenario for the development of the box cut was not considered necessary. The air quality impacts associated with additional construction activities would be relatively minor when compared to the modelled scenario of open cut mining operations and proposed underground development. Consequently, construction phase emissions are not inventoried or modelled. In comparison to mining operations, construction activities are short in duration and relatively easy to manage through commonly applied dust control measures. Procedures for controlling dust impacts during construction would be consistent with measures outlined in the Air Quality Management Plan.

The air quality impacts of the construction of the accommodation camp will be considered in a separate development application/environmental impact assessment.

9 Greenhouse gas assessment

9.1 Introduction

The estimation of GHG emissions for the project was based on the former Australian Government Department of the Environment and Energy (DoEE) National Greenhouse Accounts Factors (NGAF) workbook (DoEE 2019). The methodologies in the NGAF workbook follow a simplified approach, equivalent to the 'Method 1' approach outlined in the National Greenhouse and Energy Reporting (Measurement) Technical Guidelines (DoE 2014). The Technical Guidelines are used for the purpose of reporting under the National Greenhouse and Energy Reporting Act 2007 (the NGER Act).

For accounting and reporting purposes, GHG emissions are defined as 'direct' and 'indirect' emissions. Direct emissions (also referred to as Scope 1 emissions) occur within the boundary of an organisation and as a result of that organisation's activities. Indirect emissions are generated as a consequence of an organisation's activities but are physically produced by the activities of another organisation (DoEE 2019). Indirect emissions are further defined as Scope 2 and Scope 3 emissions. Scope 2 emissions occur from the generation of the electricity purchased and consumed by an organisation. Scope 3 emissions occur from all other upstream and downstream activities, for example the downstream extraction and production of raw materials or the upstream use of products and services.

Scope 3 is an optional reporting category (Bhatia et al 2010) and should not be used to make comparisons between organisations, for example in benchmarking GHG intensity of products or services. Typically, only major sources of Scope 3 emissions are accounted and reported by organisations. Specific Scope 3 emission factors are provided in the NGAF workbook for the consumption of fossil fuels and purchased electricity, making it straightforward for these sources to be included in a GHG inventory, even though they are a relatively minor source.

9.2 Emission sources

The GHG emission sources included in this assessment are listed in Table 9.1, representing the most significant sources associated with the project. Emissions of GHGs have been quantified for the project on an annual basis, based on energy data and explosives usage provided by Evolution Mining.

GHG emissions from the project are estimated using the methodologies outlined in the NGAF workbook, using fuel energy contents and scope 1, 2 and 3 emission factors for diesel, ULP, LPG, explosives and electricity use in NSW.

Table 9.1 Scope 1, 2 and 3 emission sources

Scope 1	Scope 2	Scope 3
Direct emissions from fuel combustion (diesel) by onsite plant and equipment	Indirect emissions associated with the consumption of purchased electricity	Indirect upstream emissions from the extraction, production and transport of diesel used for onsite plant and equipment and employee travel
Direct emissions associated with explosives use (ANFO)		Indirect upstream emissions from electricity lost in delivery in the transmission and distribution network

9.3 Activity data

Estimates of annual diesel consumption and explosive usage associated with the project have been provided by Evolution Mining. The additional electricity consumption for the project has been estimated by scaling CGO's 2018 electricity consumption (as reported under NGERs) pro-rata based on the additional ore processed for the project.

A summary of estimated annual energy consumption is presented in Table 9.2. It is noted that Year 2020 of the project represent construction activities.

Table 9.2 Project annual energy consumption

Year	Estimated additional diesel consumption (kL)	Estimated additional electricity consumption (kWh)	Estimated additional explosive usage (t)
Construction	11,070		86
2021	5.9	91,822	179
2022	161.6	2,494,785	244
2023	1,425	21,992,603	982
2024	1,520	23,458,011	1,323
2025	3,807	58,767,516	1,767
2026	4,092	63,161,349	1,854
2027	4,078	62,949,713	1,733
2028	4,091	63,146,635	1,614
2029	4,096	63,226,072	1,507
2030	4,078	62,950,292	1,520
2031	4,090	63,129,755	1,537
2032	4,095	63,208,007	1,544
2033	4,081	62,985,083	1,385
2034	4,092	63,163,891	1,328
2035	4,078	62,938,080	1,049
2036	4,100	63,289,550	693
2037	4,092	63,158,413	355
2038	3,760	58,035,696	6
2039	924.3	14,266,770	

9.4 Emission estimates

The following emission factors have been used to estimate GHG emissions from the project:

- diesel consumption on-site (Scope 1) – diesel oil factors from Table 3 of the NGAF workbook (2019);
- electricity consumption (Scope 2) – NSW Scope 2 emission factor from Table 5 of the NGAF workbook (2019); and
- explosives use (Scope 1) - emission factor from the NGAF workbook (2008).

The estimated annual GHG emissions for each emission source are presented in Table 9.3. The average annual GHG emissions for the project are compared against CGO reported NGERs data for existing open cut operations in FY2019 (also shown in Table 9.3). The comparison shows that the underground development is estimated to increase Scope 1 and Scope 2 GHG emissions by approximately 19% annually.

The significance of project GHG emissions relative to state and national GHG emissions is made by comparing annual average GHG emissions against the most recent available total GHG emissions inventories (calendar year 2017[14]) for NSW (128,780.2 kt CO_2-e) and Australia (530,840.9 kt CO_2-e).

Annual average GHG emissions (Scope 1 and 2) generated by the project represent approximately 0.04% of total GHG emissions for NSW and 0.01% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2017. The Project's contribution to projected climate change, and the associated environmental impacts, would be in proportion with its contribution to global greenhouse gas emissions.

Table 9.3 Estimated annual GHG emissions during operations

Project year	Scope 1 (t CO_2-e/year)		Scope 2 (t CO_2-e/year)	Scope 3 (t CO_2-e/year)	
	Diesel	Explosives	Electricity	Diesel	Electricity
2020 (construction)	29,997	14.3		1,538	
2021	231	30.0	74.4	12	8.3
2022	6,287	40.7	2,021	322	225
2023	10,045	164.0	17,814	515	1,979
2024	11,159	220.9	19,001	572	2,111
2025	13,064	295.0	47,602	670	5,289
2026	14,016	309.7	51,161	719	5,685
2027	14,016	289.4	50,989	719	5,665
2028	14,209	269.5	51,149	729	5,683
2029	15,031	251.7	51,213	771	5,690
2030	15,031	253.9	50,990	771	5,666
2031	14,692	256.6	51,135	753	5,682
2032	14,467	257.8	51,198	742	5,689
2033	14,692	231.3	51,018	753	5,669
2034	14,467	221.8	51,163	742	5,685

[14] http://ageis.climatechange.gov.au/

Table 9.3 Estimated annual GHG emissions during operations

Project year	Scope 1 (t CO_2-e/year)		Scope 2 (t CO_2-e/year)	Scope 3 (t CO_2-e/year)	
	Diesel	Explosives	Electricity	Diesel	Electricity
2035	13,707	175.3	50,980	703	5,664
2036	13,707	115.7	51,265	703	5,696
2037	13,707	59.2	51,158	703	5,684
2038	13,707	1.0	47,009	703	5,223
2039	12,948		11,556	664	1,284
Annual average	**13,459**	**192**	**37,925**	**690**	**4,436**
FY2019 NGERs data	**70,741**		**202,168**	**NA**	
Annual average increase	**19%**		**19%**	**NA**	

9.5 Emission management

GHG emissions from the project are principally associated with on-site energy consumption, specifically diesel combustion and consumption of purchased electricity. The proposed mining development features conventional drill, blast and haul techniques, which is largely dependent on the use of diesel-powered equipment.

Ultimately, measures and practices designed to improve energy efficiency, will assist with the management of project GHG emissions.

The CGO operates under an Air Quality Management Plan (AQMP)[15] developed for approved operations at the site. The AQMP includes GHG management measures implemented at the CGO. These include:

- regular maintenance of plant and equipment to minimise fuel consumption;
- efficient mine planning (eg minimising rehandling and haulage of materials) to minimise fuel consumption;
- consideration of energy efficiency in the plant equipment selection phase; and
- implementation of a biodiversity offset program.

Opportunities to improve energy efficiency will be investigated on an ongoing basis throughout the life of the project.

The calculated annual Scope 1 and 2 emissions from the project are greater than the NGER Scheme facility reporting threshold of 25,000 tpa CO_2-e. Consequently, Evolution Mining will measure energy consumption, and calculate and report Scope 1 and 2 GHG emissions in accordance with the requirements of the NGER Act.

[15] https://evolutionmining.com.au/wp-content/uploads/2016/02/Air-Quality-Management-Plan-2.pdf

10 Management and monitoring

10.1 Management measures

The CGP Air Quality Management Plan AQMP has been developed for approved operations at the site. The dust management measures applied to the emission estimates for the Modification are consistent with the AQMP and are outlined in Section 6.3. Other control measures adopted at the CGO, while not explicitly applied as reduction factors in the emission calculations, are provided in Table 10.1 below.

Table 10.1 Air quality management measures listed in the CGO AQMP

Source	Management measure
Haul road	• Routes to be clearly marked • Obsolete roads will be ripped and re-vegetated
Minor roads	• Minor road development will be limited, and the locations will be defined and within approved surface disturbance areas • Obsolete roads will be ripped and re-vegetated
Materials handling	• Prevention of truck overloading to reduce spillage during ore loading/unloading and hauling • Freefall height during ore/waste stockpiling will be limited
Soil stripping	• Soil stripping will be limited to areas required for mining operations
Drilling	• Dust aprons will be lowered during drilling for collection of fine dust
Blasting	• Fine material collected during drilling will not be used for blast stemming • Adequate stemming will be used at all times • Blasting will only occur following an assessment of weather conditions by the Environmental Manager to ensure that wind speed and direction will not result in excess dust emissions from the site towards adjacent residences (see the blasting Management Plan for further details)
Equipment maintenance	• Emissions from mobile equipment exhausts will be minimised by the implementation of a maintenance programme to service equipment in accordance with the equipment manufacturer specifications
General areas disturbed by mining	• Only the minimum area necessary for mining will be disturbed • Exposed areas will be reshaped, topsoiled and revegetation as soon as practicable
Waste emplacement areas	• Exposed active work areas on waste emplacement surfaces will be watered to supress dust where practicable • Rehabilitation (ie reshaping, topsoil placement and revegetation) will be conducted progressively, as soon as practicable
Tailings Storage Facility	• During non-operational periods, dust suppression measures will be undertaken to minimise dust emissions from dry exposed areas on the
Soil stockpiles	• Long-term stockpiles will be revegetated with a cover crop.
Material handling and ore stockpiles	• Prevention of truck overloading to reduce spillage during ore loading/unloading and hauling • The coarse stockpile will be protected by a hood to prevent wind erosion • The surface of all stockpiles will be sufficiently treated to minimise dust emissions. Treatment may include application of a dust suppressant, regular dust suppression watering or establishment of vegetation on longer term stockpiles (eg the low-grade ore stockpile)
General exposed areas	• Increased watering of exposed surfaces via water trucks or other methods as required

Table 10.1 Air quality management measures listed in the CGO AQMP

Source	Management measure
Ancillary activities	• Temporary cessation of ancillary or non-essential on-site dust generating activities (eg soil stripping)
Gold room doré melt furnace	• Use of a baghouse and associated collection hood/ducting to remove dust particles

10.2 Monitoring

The air quality monitoring network for the CGO is described Section 5 and in the AQMP for CGO. The network consists of a meteorological monitoring station, 12 dust deposition gauges and a TSP HVAS. Recent additions to the air quality monitoring program include three new sites with continuous monitoring for PM_{10}.

The addition of these continuous monitoring sites will provide upwind downwind measurements of PM_{10} and will allow the site to better monitoring and manage dust emissions from the site.

There have never been any odour complaints from the site, therefore odour monitoring is not considered necessary.

11 Conclusion

Atmospheric dispersion modelling was undertaken using the US-EPA regulatory model, AERMOD. Hourly meteorological observations from 2018, collected primarily by the onsite meteorological station, were used as inputs into the dispersion modelling process.

The results of the modelling show that the predicted concentrations and deposition rates for incremental particulate matter (TSP, PM_{10}, $PM_{2.5}$ and dust deposition) are below the applicable impact assessment criteria at all assessment locations. For all pollutants and averaging periods, the project alone (underground development and associated surface changes), represents a minor change from the existing open cut operations.

When background concentrations are added, the cumulative annual average concentrations for all pollutants were predicted to be below the relevant impact assessment criteria. However, the predicted cumulative 24-hour average PM_{10} is greater than the impact assessment criterion (50 $\mu g/m^3$) at a number of private receptors. The maximum number of additional days above 50 µg/m was two. Additional cumulative analysis was presented with an extended background dataset, for the receptors with the highest predictions. This analysis showed that the probability of days above 50 $\mu g/m^3$ is low, with less than one additional day predicted for each receptor. The maximum predicted 24-hour $PM_{2.5}$ concentrations were below the impact assessment criterion at all assessment locations. There are no private residences where the VLAMP criteria are triggered.

A GHG assessment was also undertaken for the Project. Annual average GHG emissions (Scope 1 and 2) generated by the project represent approximately 0.04% of total GHG emissions for NSW and 0.01% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2017.

References

AEGIS 2015, Australian Greenhouse Emissions Information System – http://ageis.climatechange.gov.au/ - Accessed January 2019.

AEISG 2011, *Code of Practice: Prevention and management of blast generated NO_x gases in surface blasting, edition 2*, prepared by AEISG, August 2011.

Bhatia, P, Cummis, C, Brown, A, Rich, D, Draucker, L & Lahd, H 2010, Greenhouse Gas Protocol. *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*. Supplement to the GHG Protocol Corporate Accounting and Reporting Standard, World Resources Institute & World Business Council for Sustainable Development.

Bureau of Meteorology 2019, observations from the West Wyalong Airport AWS (Station Number 050017).

Cowal Gold Operations 2015, *Cowal Gold Operations: Air Quality Management Plan,* prepared by Evolution Mining, February 2015.

DoE 2014, *National Greenhouse and Energy Reporting (Measurement) Technical Guidelines.*

DoE 2016, National Environment Protection (Ambient Air Quality) Measure.

DoEE 2019, National Greenhouse Accounts Factors, August 2019.

NPI 2012, *Emission Estimation Technique Manual for Mining.*

NSW EPA 2013, *Air Emissions in My Community web tool Substance information*, NSW EPA

NSW EPA 2016, *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*. New South Wales Environment Protection Authority, Sydney.

Oke T.T 2003, *Boundary Layer Climates*, Second Edition, Routledge, London and New York.

Pacific Environment 2018, *Cowal Gold Operations Modification 14 – Air Quality & Greenhouse Gas Assessment*, prepared for Evolution Mining (Cowal) Pty Limited, March 2018.

Stull R. B. 1997, *An Introduction to Boundary Layer Meteorology*, Kluwer Academic Publishers, London.

US-EPA 1982, AP-42 Chapter 11.24 – *Metallic Minerals Processing*

US-EPA 1998, AP-42 Chapter 11.9 – *Western surface coal mining*

US-EPA 2006a, AP-42 Chapter 13.2.2 – *Unpaved roads*

US-EPA 2006b, AP-42 Chapter 13.2.4 – *Aggregate Handling and Storage Piles*

Abbreviations

AERMET	AMS/US-EPA regulatory model
AERMOD	AMS/US-EPA regulatory model
AHD	Australian height datum
Approved Methods for Modelling	*Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*
AWS	automatic weather station
BoM	Bureau of Meteorology
CGO	Cowal Gold Operations
CO	carbon monoxide
CO_2-e	carbon dioxide equivalent
DoEE	Department of the Environment and Energy
DPIE	Department of Planning, Industry and Environment
EPA	Environment Protection Authority
EPL	environment protection licence
GHG	greenhouse gas
HCN	hydrogen cyanide
HVAS	High volume air sampler
IWL	integrated waste landform
kW	kilowatt
ML	Mining Lease
Mtpa	million tonnes per annum
NGAF	National Greenhouse Accounts Factors
NO_x	oxides of nitrogen
NPI	National Pollution Inventory
PM_{10}	particulate matter less than 10 microns in aerodynamic diameter
$PM_{2.5}$	particulate matter less than 2.5 microns in aerodynamic diameter
POEO	Protection of the Environment Operations
SEARs	Secretary's Environmental Assessment Requirements
SSD	State Significant Development
SO_2	sulphur dioxide

TAPM	The Air Pollution Model
TSF	Tailings storage facility
US-EPA	United States Environmental Protection Agency
VOCs	volatile organic compounds


Appendix A

Meteorological modelling and processing




A.1 Data availability

A summary of data availability for the on-site meteorological station dataset for the period between 2014 and 2018 is provided in Figure A.1. The following points are noted:

- data completeness is between 92% and 100% for all parameters between 2014 and 2018. Therefore, all years meet the minimum 90% data completeness requirements for all parameters specified with Section 4.1 of the Approved Methods for Modelling (EPA 2016); and

- being the most recent and available year of data, 2018 was chosen for assessment. It was also deemed representative of meteorological conditions at this location over the period of data analysed. This is further analysed below.

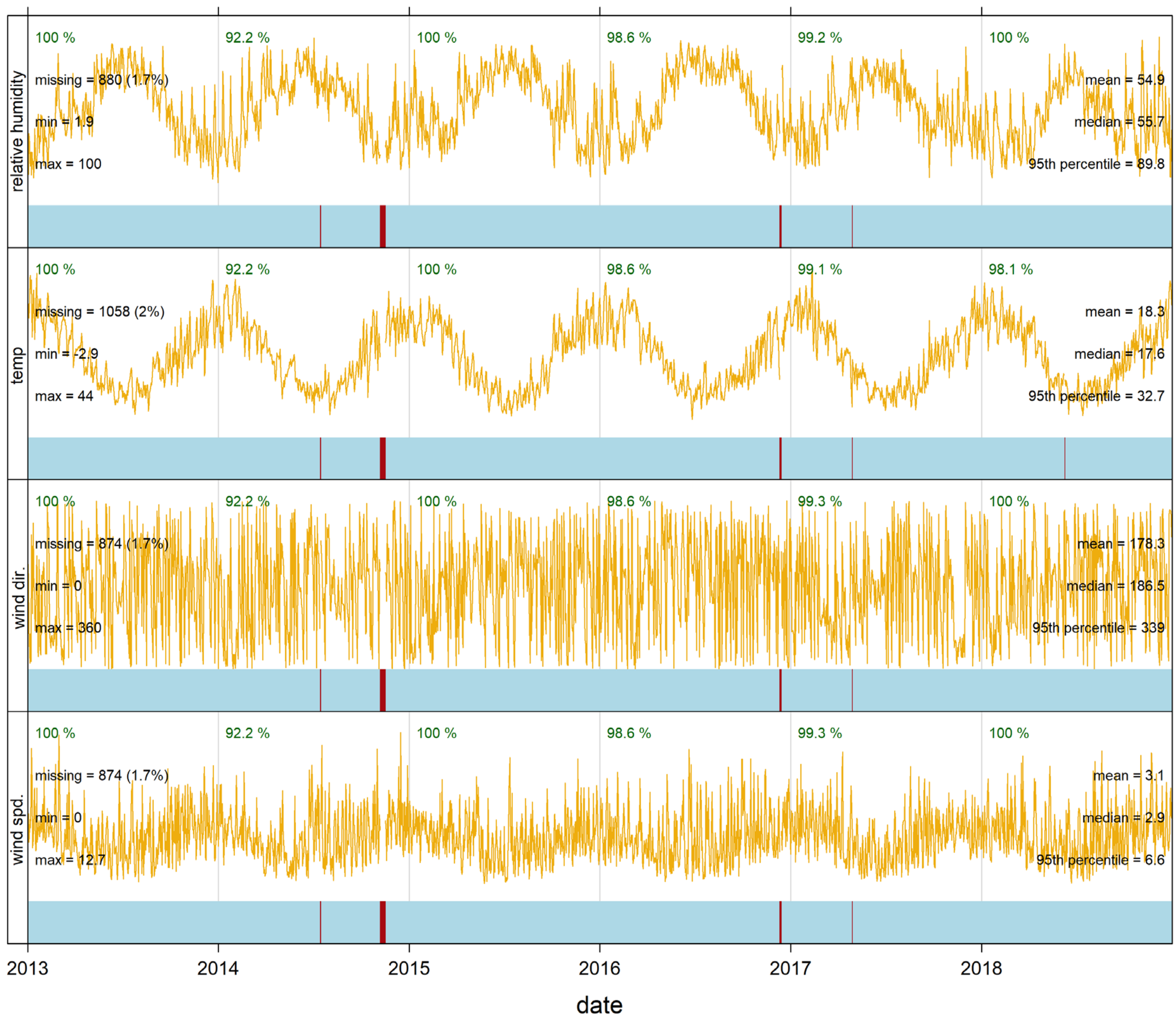


Figure A.1 Five-year data completeness analysis plot – on-site meteorological station – 2014 to 2018

A.2 Selection of a representative year

While 2018 was the most recent and complete year of monitoring data from the on-site meteorological station, in order to determine the most representative year of data for modelling an analysis of inter-annual trends was conducted. Inter-annual wind roses for 2014 to 2018 were shown in Figure 4.2. Seasonal and diurnal wind roses are presented in Figure A.2 below. The diurnal distribution of wind speed (Figure A.3), wind direction (Figure A.4), temperature (Figure A.5) and relative humidity (Figure A.6) recorded between 2014 and 2018 are also analysed.

The following points are noted from these figures:

- The recorded wind speed and direction profile is comparable across all years with winds present from all directions. A dominant south-easterly wind is seen in all year.
- Average wind speeds and percentage of calms are consistent for each year with wind speeds ranging from 3.0 m/s to 3.2 m/s and calms ranging from 2.2 m/s and 3.6 m/s.
- Afternoon to night-time air temperatures (midday to midnight) were typically higher during 2018 relative to the previous four years of data. This is indicative of the drought conditions experienced in 2018.
- Relative humidity was typically lowest during 2018 also considered to be a reflection of drought conditions.

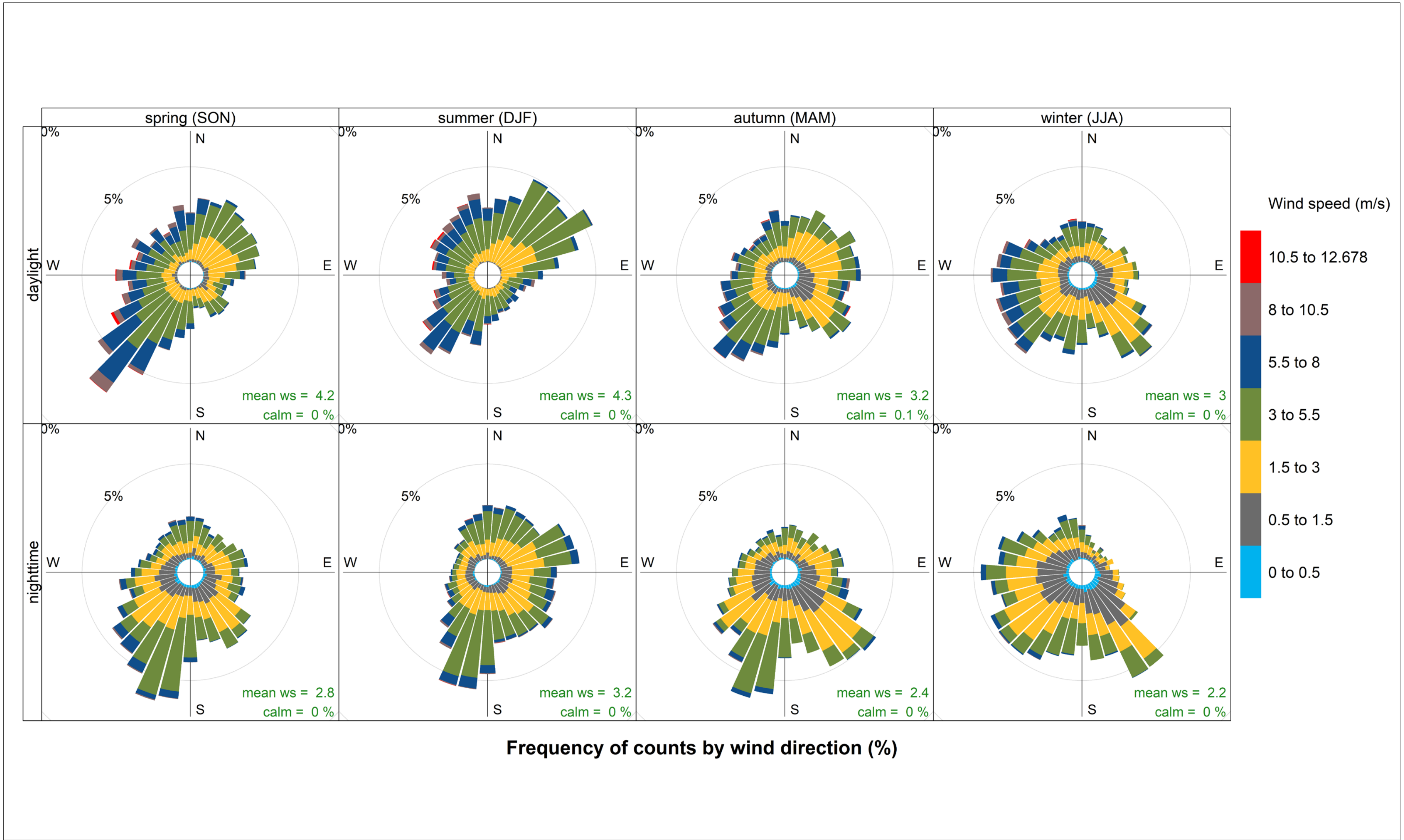


Figure A.2 Seasonal and diurnal wind roses – CGO meteorological station – 2014 to 2018

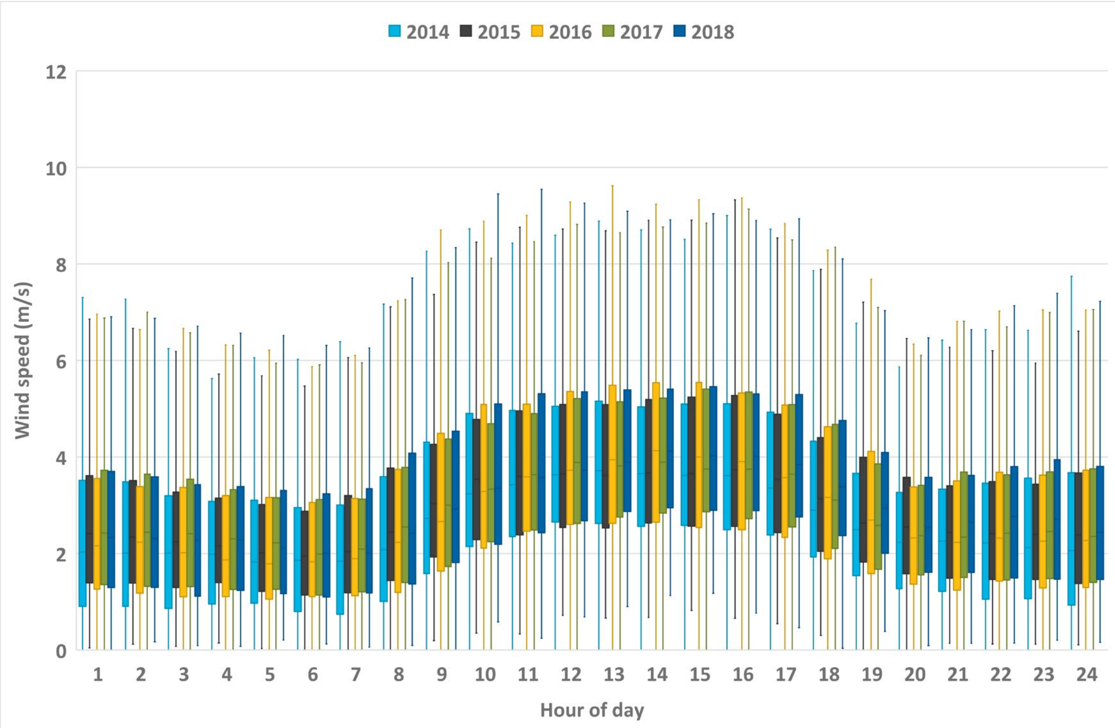


Figure A.3 Inter-annual variability in diurnal wind speed – on-site meteorological station – 2014 to 2018

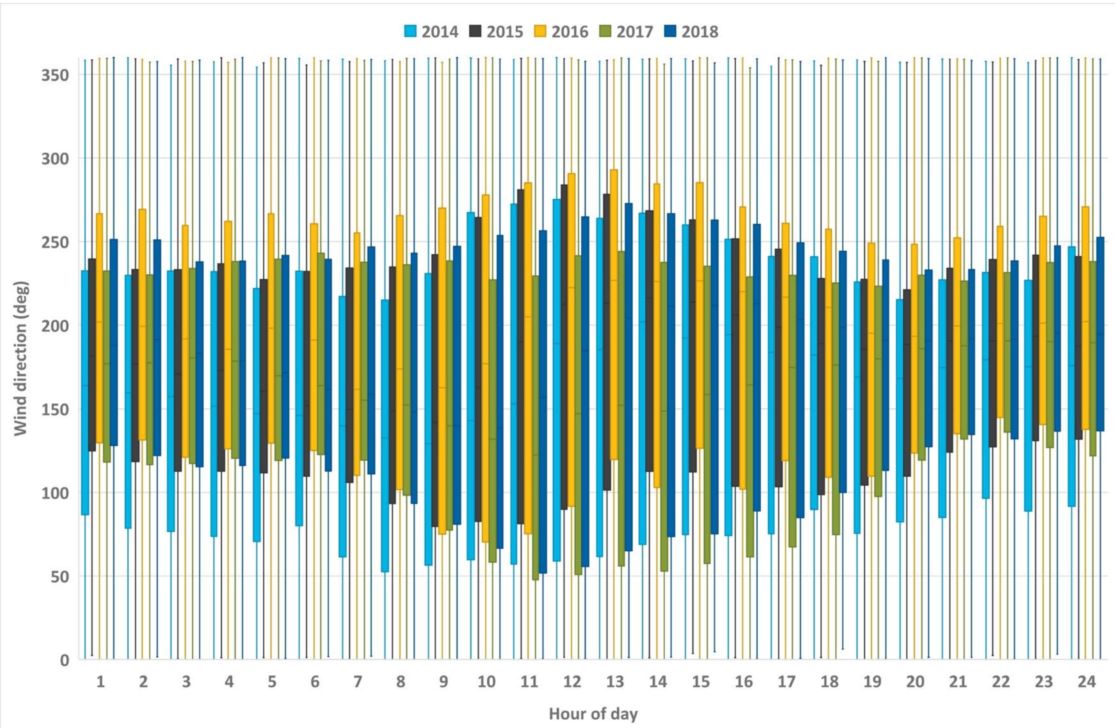


Figure A.4 Inter-annual variability in diurnal wind direction – on-site meteorological station – 2014 to 2018

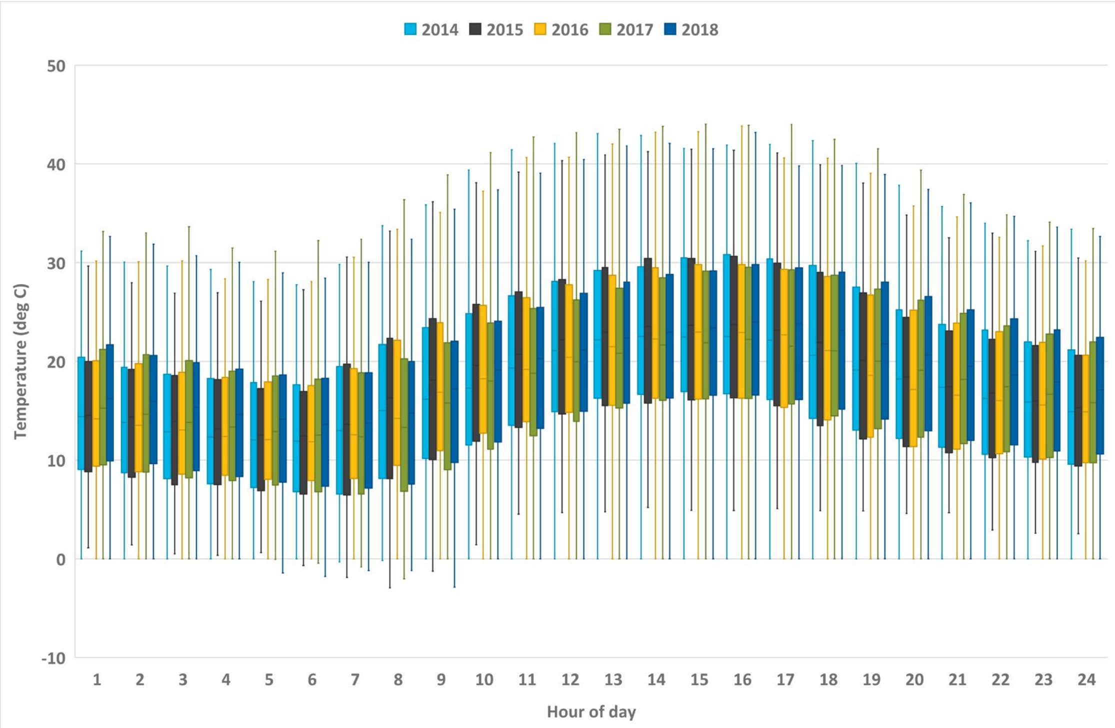


Figure A.5 **Inter-annual variability in diurnal air temperature – on-site meteorological station – 2014 to 2018**

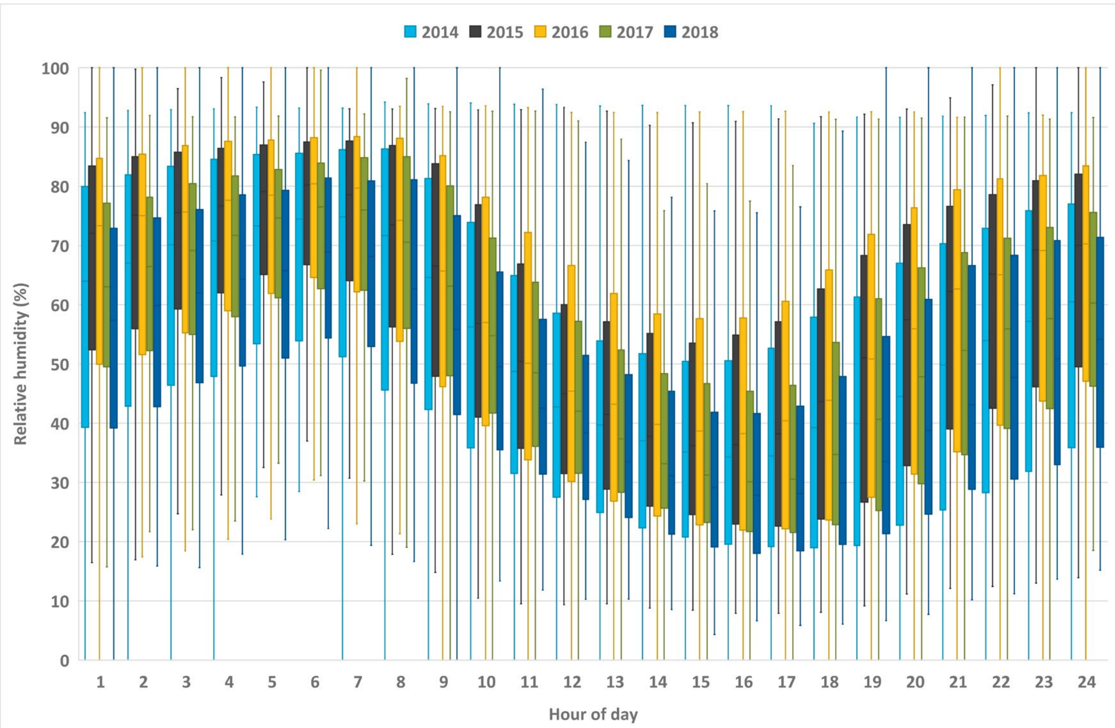


Figure A.6 **Inter-annual variability in diurnal relative humidity – on-site meteorological station – 2014 to 2018**

A.3 TAPM modelling

To supplement the meteorological monitoring datasets adopted for this assessment, the Commonwealth Scientific and Industry Research Organisation (CSIRO) prognostic meteorological model The Air Pollution Model (TAPM) was used to generate required parameters that are not routinely measured, specifically mixing height and vertical wind/temperature profile.

TAPM was configured and run in accordance with the Section 4.5 of the Approved Methods for Modelling as follows:

- TAPM version 4.0.5;
- inclusion of high resolution (90 m) regional topography (improvement over default 250 m resolution data);
- Grid domains with cell resolutions of 30 km, 10 km, 3 km and 1 km. Each grid domain features 25 x 25 horizontal grid points and 25 vertical levels;
- TAPM default databases for land use, synoptic analyses and sea surface temperature; and
- TAPM defaults for advanced meteorological inputs.

A.4 AERMET meteorological processing

The meteorological inputs for AERMOD were generated using the AERMET meteorological processor. The following sections provide an overview of meteorological processing completed for this assessment.

A.4.1 Surface characteristics

Prior to processing meteorological data, the surface characteristics of the area surrounding the adopted monitoring station require parameterisation. The following surface parameters are required by AERMET:

- surface roughness length;
- albedo; and
- Bowen ratio.

As detailed by USEPA (2013), the surface roughness length is related to the height of obstacles to the wind flow (eg vegetation, built environment) and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

The land cover of the 10 km by 10 km area surrounding the Project was mapped (see Figure A.7). Using the AERSURFACE tool and following the associated guidance of USEPA (2013), surface roughness was determined for 12 (30 degree) sectors grouped by similar land use types within a 1 km radius around the on-site meteorological station, while the Bowen ratio and albedo were determined for the total area. Monthly-varying values for surface roughness, Bowen ratio and albedo were allocated to each sector based on the values prescribed by USEPA (2013).

It is noted that Lake Cowal was assigned a landuse type of 'Scrubland' (not open water) and the mine site was assigned a landuse type 'Bare rock / Sand/ Clay".

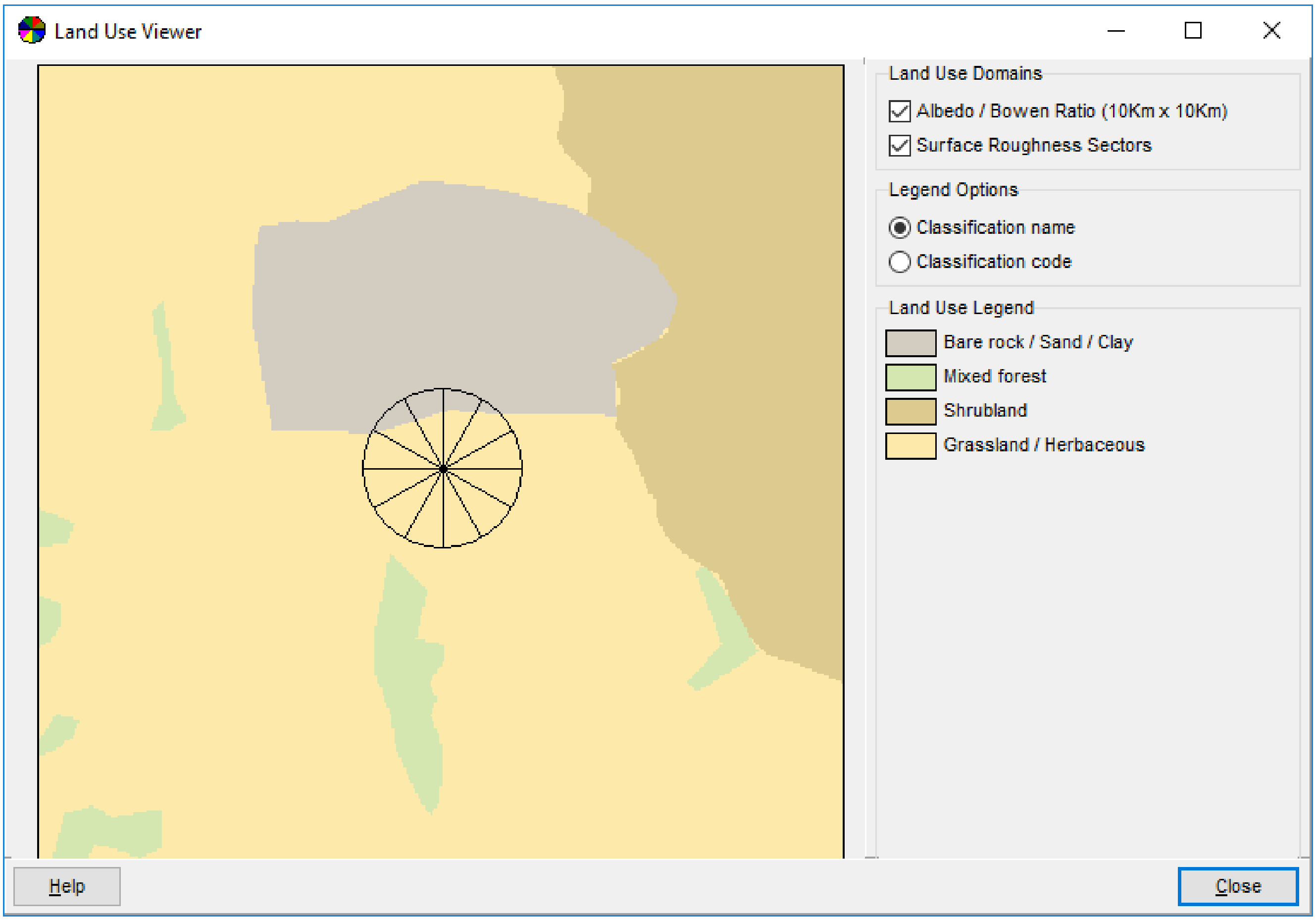


Figure A.7 Land use map for AERSURFACE processing – on-site meteorological station

Note: Marked in figure are the 1 km radius for surface roughness (12 sectors defined) and 10 km x 10 km for albedo/bowen ratio (total image shown)

A.4.2 Meteorological inputs

Monitoring data from the on-site meteorological station at CGO were combined with TAPM meteorological modelling outputs for input to AERMET. The following parameters were input as on-site data to AERMET:

- wind speed and direction – on-site;
- sigma-theta (standard deviation of wind direction) - on-site;
- temperature (heights of 2 m and 10 m) - on-site;
- relative humidity - on-site;
- station level pressure – on-site;
- cloud cover - Orange Airport;
- solar insolation - on-site; and
- mixing depth – TAPM at on-site station.

The period of meteorological data input to AERMET was 1 January 2018 to 31 December 2018.

A.4.3 Upper air profile

Due to the absence of necessary local upper air meteorological measurements, the hourly profile file generated by TAPM at the on-site meteorological station location was adopted. Using the temperature difference between levels, the TAPM-generated vertical temperature profile for each hour was adjusted relative to the hourly surface (10m) temperature observations from the on-site station.


Appendix B

Emissions inventory background




B.1 Introduction

Particulate matter emissions from the Project were quantified through the application of accepted published emission estimation factors, collated from a combination of United States Environmental Protection Agency (US-EPA) AP-42 Air Pollutant Emission Factors and NPI emission estimation manuals, including the following:

- US-EPA AP-42 Chapter 11.9 – Western surface coal mining (US-EPA 1998);
- US-EPA AP-42 Chapter 11.24 – Metallic minerals processing (US-EPA 1982);
- US-EPA AP-42 Chapter 13.2.4 – Aggregate handling and storage piles (US-EPA 2006a); and
- US-EPA AP-42 Chapter 13.2.4 – Industrial wind erosion (US-EPA 2006b).

Particulate releases were quantified for TSP, PM_{10} and $PM_{2.5}$ as documented in subsequent sections.

B.2 Sources of particulate matter emissions

Sources of particulate matter emissions associated with the Project include:

- drilling and blasting;
- hauling ore and gravel;
- loading ore and gravel to trucks;
- bulldozers working on waste;
- processing ore and gravel (crushing, screening and handling);
- wind erosion from open pit dumps, stockpiles and the TSF;
- grading roads; and
- upcast ventilation shaft.

B.3 Particulate matter emissions inventory

Emissions inventories of TSP, PM_{10} and $PM_{2.5}$ developed for the operations at the Project is presented in Table B.1, Table B.2 and Table B.3.

Table B.1 TSP emissions inventory

Type	Activity	Emission estimate (kg/year) - controlled	Intensity	Units	Emission Factor	Units	Variable 1		Variable 2		Variable 3		Variable 4		Variable 5		Control %	Control
Approved Open Cut Operations (as per Mod 14)																		
Waste rock extraction, loading, hauling and unloading																		
WI	Drilling	8,098	45,750	holes/y	0.59	kg/hole											70	wet suppression
WI	Blasting	28,808	183	blast/y	157.4191856	kg/blast	8000	Area of blast (m2)										
WS	Waste - Excavators loading haul trucks	14,068	7,300,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - Hauling to northern waste dump	494,830	7,300,000	t/y	0.3262	kg/t	184	t/load	225	Ave trip vehicle gross mass (t)	11.0	km/return trip	5.5	kg/VKT	5.0	% silt content	80	watering and/or suppressants
WS	Waste - Unloading at northern waste dump	14,068	7,300,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Waste - Loading trucks with clay at Hardstand area for IWL	1,927	1,000,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - Hauling clay from Hardstand to IWL construction area	110,425	1,000,000	t/y	0.5394	kg/t	45	t/load	52	Ave trip vehicle gross mass (t)	8.6	km/return trip	2.8	kg/VKT	5.0	% silt content	80	watering and/or suppressants
WS	Waste - Unloading clay at IWL construction area	1,927	1,000,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - Dozers in pit	20,819	5,716	h/y	7.3	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
WI	Waste - Dozers on IWL construction area	34,922	9,588	h/y	7.3	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
WI	Waste - Dozers on STSF area	34,922	9,588	h/y	7.3	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
Ore extraction, loading, hauling and processing																		
WS	Ore - Loading mineral waste ore to haul trucks	16,958	8,800,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Hauling mineral waste ore to northern dump	726,677	8,800,000	t/y	0.4002	kg/t	136	t/load	181	Ave trip vehicle gross mass (t)	11.0	km/return trip	4.9	kg/VKT	5.0	% silt content	80	watering and/or suppressants
WS	Ore - Unloading mineral waste ore to northern dump	16,958	8,800,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Ore - Loading ore to haul trucks	18,114	9,400,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Hauling ore to ROM pad	707,834	9,400,000	t/y	0.3638	kg/t	136	t/load	181	Ave trip vehicle gross mass (t)	10.0	km/return trip	4.9	kg/VKT	5.0	% silt content	80	watering and/or suppressants
WS	Ore - Unloading ore to ROM pad	18,114	9,400,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Ore - Rehandling ore	10,869	5,640,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Crushing	12,690	9,400,000	t/y	0.0027	kg/t											50	watering
WI	Ore - Screening	58,750	9,400,000	t/y	0.0125	kg/t											50	watering
WS	Ore - Loading to coarse ore stockpile	18,114	9,400,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Gravel - loading to trucks in pit	289	150,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Gravel - Hauling from pit to mobile crusher	10,913	150,000	t/y	0.3638	kg/t	136	t/load	181	Ave trip vehicle gross mass (t)	10.0	km/return trip	4.9	kg/VKT	5.0	% silt content	80	watering and/or suppressants
WS	Gravel - unloading at crusher	289	150,000	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Gravel - crushing	203	150,000	t/y	0.0027	kg/t											50	watering
WI	Grading roads	10,783	35,040	km/y	0.6155	kg/km	8	speed of graders in km/h	4380	grader hours							50	watering
Wind erosion																		
WE	Wind erosion - Open pit	93,500	110	ha	850	kg/ha/yr												
WE	Wind erosion - Northern dump	76,500	90	ha	850	kg/ha/yr												
WE	Wind erosion - Stockpiles and exposed areas	65,450	77	ha	850	kg/ha/yr												
WE	Wind erosion - Northern stockpiles	85,000	100	ha	850	kg/ha/yr								400				
WE	Wind erosion - Dry TSF and IWL construction area	232,050	273	ha	850	kg/ha/yr												
Total		**2,944,869**																
CGO Underground Development																		
Modification 16 surface changes																		
WS	Waste and ore - unloading from conveyor	0		t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Waste and ore - rehandle to trucks	0		t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - hauling from conveyor to northern waste dump	25,258	488,190	t/y	0.2460	kg/t	63	t/load	75	Ave trip vehicle gross mass (t)	4.7	km/return trip	3.3	kg/VKT	5.0	% silt content	80	watering and/or suppressants
WS	Waste - unloading at northern waste dump	941	488,190	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - hauling from conveyor to temporary stockpile	1,505	71,158	t/y	0.0930	kg/t	63	t/load	75	Ave trip vehicle gross mass (t)	1.8	km/return trip	3.3	kg/VKT	5.0	% silt content	80	watering and/or suppressants
WS	Ore - unloading ore to temporary stockpile	137	71,158	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Ore - rehandle to crusher	137	71,158	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Crushing	96	71,158	t/y	0.0027	kg/t											50	watering
WI	Ore - Screening	445	71,158	t/y	0.0125	kg/t											50	watering
WS	Ore - Loading to coarse ore stockpile	137	71,158	t/y	0.0019	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WE	Wind erosion - increase in area of IWL (considered negligible)	0	0	ha	850	kg/ha/yr												
Total		**28,656**																
Underground workings SSD																		
WI	Additional blasting for UG development	1,430	52	blast/y	27.5	kg/blast	2500	Area of blast (m2)										
WI	Mining of material (underground)	25,525	7,008	h/y	7.3	kg/h	2.0	moisture content in %	5.0	silt content in %							50	watering
WI	Waste and ore - hauling (underground)	58,919	559,348	t/y	0.1053	kg/t	63	t/load	75	Ave trip vehicle gross mass (t)	2.0	km/return trip	3.3	kg/VKT	5.0	% silt content		
Total		**85,874**																

Table B.2 PM$_{10}$ emissions inventory

Type	Activity	Emission estimate (kg/year) - controlled	Intensity	Units	Emission Factor	Units	Variable 1		Variable 2		Variable 3		Variable 4		Variable 5		Control %	Control
Approved Open Cut Operations (as per Mod 14)																		
Waste rock extraction, loading, hauling and unloading																		
WI	Drilling	4,211	45,750	holes/y	0.3	kg/hole											70	wet suppression
WI	Blasting	14,980	183	blast/y	81.9	kg/blast	8000	Area of blast (m2)										
WS	Waste - Excavators loading haul trucks	6,654	7,300,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - Hauling to northern waste dump	163,212	7,300,000	t/y	0.0991	kg/t	184	t/load	225	Ave trip vehicle gross mass (t)	13.0	km/return trip	1.4	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Waste - Unloading at northern waste dump	6,654	7,300,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Waste - Loading trucks with clay at Hardstand area for IWL	911	1,000,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - Hauling clay from Hardstand to IWL construction area	30,266	1,000,000	t/y	0.1386	kg/t	45	t/load	52	Ave trip vehicle gross mass (t)	8.6	km/return trip	0.7	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Waste - Unloading clay at IWL construction area	911	1,000,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - Dozers in pit	4,086	5,716	h/y	1.4	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
WI	Waste - Dozers on IWL construction area	6,855	9,588	h/y	1.4	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
WI	Waste - Dozers on STSF area	6,855	9,588	h/y	1.4	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
Ore extraction, loading, hauling and processing																		
WS	Ore - Loading mineral waste ore to haul trucks	8,021	8,800,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Hauling mineral waste ore to northern dump	180,343	8,800,000	t/y	0.0897	kg/t	136	t/load	181	Ave trip vehicle gross mass (t)	9.6	km/return trip	1.3	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Ore - Unloading mineral waste ore to northern dump	8,021	8,800,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Ore - Loading ore to haul trucks	8,568	9,400,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Hauling ore to ROM pad	171,552	9,400,000	t/y	0.0785	kg/t	136	t/load	181	Ave trip vehicle gross mass (t)	8.4	km/return trip	1.3	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Ore - Unloading ore to ROM pad	8,568	9,400,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Ore - Rehandling ore	5,141	5,640,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Crushing	5,640	9,400,000	t/y	0.0012	kg/t											50	watering
WI	Ore - Screening	20,210	9,400,000	t/y	0.0043	kg/t											50	watering
WS	Ore - Loading to coarse ore stockpile	8,568	9,400,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Gravel - loading to trucks in pit	137	150,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Gravel - Hauling from pit to mobile crusher	2,692	150,000	t/y	0.0897	kg/t	136	t/load	181	Ave trip vehicle gross mass (t)	9.6	km/return trip	1.3	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Gravel - unloading at crusher	137	150,000	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Gravel - crushing	90	150,000	t/y	0.0012	kg/t											50	watering
WI	Grading roads	3,768	35,040	km/y	0.2150	kg/km	8	speed of graders in km/h	4380	grader hours							50	watering
Wind erosion																		
WE	Wind erosion - Open pit	46,750	110	ha	425	kg/ha/yr												
WE	Wind erosion - Northern dump	38,250	90	ha	425	kg/ha/yr												
WE	Wind erosion - Stockpiles and exposed areas	32,725	77	ha	425	kg/ha/yr												
WE	Wind erosion - Northern stockpiles	42,500	100	ha	425	kg/ha/yr												
WE	Wind erosion - Dry TSF and IWL construction area	116,025	273	ha	425	kg/ha/yr												
Total		**953,297**																
CGO Underground Development																		
Modification 16 surface changes																		
WS	Waste and ore - unloading from conveyor	0		t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Waste and ore - rehandle to trucks	0		t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - hauling from conveyor to northern waste dump	7,414	488,190	t/y	0.0632	kg/t	63	t/load	75	Ave trip vehicle gross mass (t)	4.7	km/return trip	0.9	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Waste - unloading at northern waste dump	445	488,190	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - hauling from conveyor to temporary stockpile	521	71,158	t/y	0.0239	kg/t	63	t/load	75	Ave trip vehicle gross mass (t)	1.8	km/return trip	0.9	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Ore - unloading ore to temporary stockpile	65	71,158	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Ore - rehandle at crusher/ROM pad	65	71,158	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Crushing	43	71,158	t/y	0.0012	kg/t											50	watering
WI	Ore - Screening	153	71,158	t/y	0.0043	kg/t											50	watering
WS	Ore - Loading to coarse ore stockpile	65	71,158	t/y	0.0009	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WE	Wind erosion - increase in area of IWL (considered negligible)	0	0	ha	425	kg/ha/yr												
Total		**8,771**																
Underground workings SSD																		
WI	Additional blasting for UG development	744	52	blast/y	14.3	kg/blast	2500	Area of blast (m2)										
WI	Mining of material (underground)	5,010	7,008	h/y	1.4	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
WI	Waste and ore - hauling (underground)	15,139	559,348	t/y	0.0271	kg/t	63	t/load	75	Ave trip vehicle gross mass (t)	2.0	km/return trip	0.9	kg/VKT	5.0	% silt content		
Total		**20,893**																
Overall Total		**982,961**																

Table B.3 PM2.5 emissions inventory

Type	Activity	Emission estimate (kg/year) - controlled	Intensity	Units	Emission Factor	Units	Variable 1		Variable 2		Variable 3		Variable 4		Variable 5		Control %	Control
Approved Open Cut Operations (as per Mod 14)																		
Waste rock extraction, loading, hauling and unloading																		
WI	Drilling	243	45,750	holes/y	0.02	kg/hole											70	wet suppression
WI	Blasting	864	183	blast/y	4.7	kg/blast	8000	Area of blast (m2)										
WS	Waste - Excavators loading haul trucks	1,008	7,300,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - Hauling to northern waste dump	33,054	7,300,000	t/y	0.0099	kg/t	184	t/load	225	Ave trip vehicle gross mass (t)	13.0	km/return trip	0.14	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Waste - Unloading at northern waste dump	1,008	7,300,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Waste - Loading trucks with clay at Hardstand area for IWL	138	1,000,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - Hauling clay from Hardstand to IWL construction area	5,319	1,000,000	t/y	0.0139	kg/t	45	t/load	52	Ave trip vehicle gross mass (t)	8.6	km/return trip	0.07	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Waste - Unloading clay at IWL construction area	138	1,000,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - Dozers in pit	2,186	5,716	h/y	0.8	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
WI	Waste - Dozers on IWL construction area	3,667	9,588	h/y	0.8	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
WI	Waste - Dozers on STSF area	3,667	9,588	h/y	0.8	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
Ore extraction, loading, hauling and processing																		
WS	Ore - Loading mineral waste ore to haul trucks	1,215	8,800,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Hauling mineral waste ore to northern dump	38,205	8,800,000	t/y	0.0090	kg/t	136	t/load	181	Ave trip vehicle gross mass (t)	9.6	km/return trip	0.13	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Ore - Unloading mineral waste ore to northern dump	1,215	8,800,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Ore - Loading ore to haul trucks	1,297	9,400,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Hauling ore to ROM pad	38,701	9,400,000	t/y	0.0079	kg/t	136	t/load	181	Ave trip vehicle gross mass (t)	8.4	km/return trip	0.13	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Ore - Unloading ore to ROM pad	1,297	9,400,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Ore - Rehandling ore	778	5,640,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Crushing	1,044	9,400,000	t/y	0.00022	kg/t											50	watering
WI	Ore - Screening	118	9,400,000	t/y	0.00003	kg/t											50	watering
WS	Ore - Loading to coarse ore stockpile	1,297	9,400,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Gravel - loading to trucks in pit	21	150,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Gravel - Hauling from pit to mobile crusher	269	150,000	t/y	0.0090	kg/t	136	t/load	181	Ave trip vehicle gross mass (t)	9.6	km/return trip	0.13	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Gravel - unloading at crusher	21	150,000	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Gravel - crushing	17	150,000	t/y	0.00022	kg/t											50	watering
WI	Grading roads	334	35,040	km/y	0.01908	kg/km	8	speed of graders in km/h	4380	grader hours							50	watering
Wind erosion																		
WE	Wind erosion - Open pit	7,013	110	ha	64	kg/ha/yr												
WE	Wind erosion - Northern dump	5,738	90	ha	64	kg/ha/yr												
WE	Wind erosion - Stockpiles and exposed areas	4,909	77	ha	64	kg/ha/yr												
WE	Wind erosion - Northern stockpiles	6,375	100	ha	64	kg/ha/yr												
WE	Wind erosion - Dry TSF and IWL construction area	17,404	273	ha	64	kg/ha/yr												
Total		**178,557**																
CGO Underground Development																		
Modification 16 surface changes																		
WS	Waste and ore - unloading from conveyor	0	0	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Waste and ore - rehandle to trucks	0	0	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Waste - hauling from conveyor to northern waste dump	1,860	488,190	t/y	0.0063	kg/t	63	t/load	75	Ave trip vehicle gross mass (t)	4.7	km/return trip	0.09	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Waste - unloading at northern waste dump	67	488,190	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - hauling from conveyor to temporary stockpile	215	71,158	t/y	0.0024	kg/t	63	t/load	75	Ave trip vehicle gross mass (t)	1.8	km/return trip	0.09	kg/VKT	5.0	% silt cont	80	watering and/or suppressants
WS	Ore - unloading ore to temporary stockpile	9.8	71,158	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WS	Ore - rehandle at crusher/ROM pad	9.8	71,158	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WI	Ore - Crushing	7.9	71,158	t/y	0.00022	kg/t											50	watering
WI	Ore - Screening	0.9	71,158	t/y	0.00003	kg/t											50	watering
WS	Ore - Loading to coarse ore stockpile	9.8	71,158	t/y	0.0001	kg/t	2.0	moisture content in %	1.6	(wind speed/2.2)^1.3								
WE	Wind erosion - increase in area of IWL (considered negligible)	0.0	0	ha	64	kg/ha/yr												
Total		**2,181**																
Underground workings SSD																		
WI	Additional blasting for UG development	43	52	blast/y	0.8	kg/blast	2500	Area of blast (m2)										
WI	Mining of material (underground)	2,680	7,008	h/y	0.8	kg/h	2.0	moisture content in %	5.0	silt content in %							50	
WI	Waste and ore - hauling (underground)	3,535	559,348	t/y	0.0063	kg/t	63	t/load	75	Ave trip vehicle gross mass (t)	4.7	km/return trip	0.09	kg/VKT	5.0	% silt content		
Total		**6,258**																
Overall Total		**186,997**																

B.4 Project-related input data used for particulate matter emission estimates

The material property inputs used in the emission estimates are summarised in Table B.4.

Table B.4 Material property inputs for emission estimation

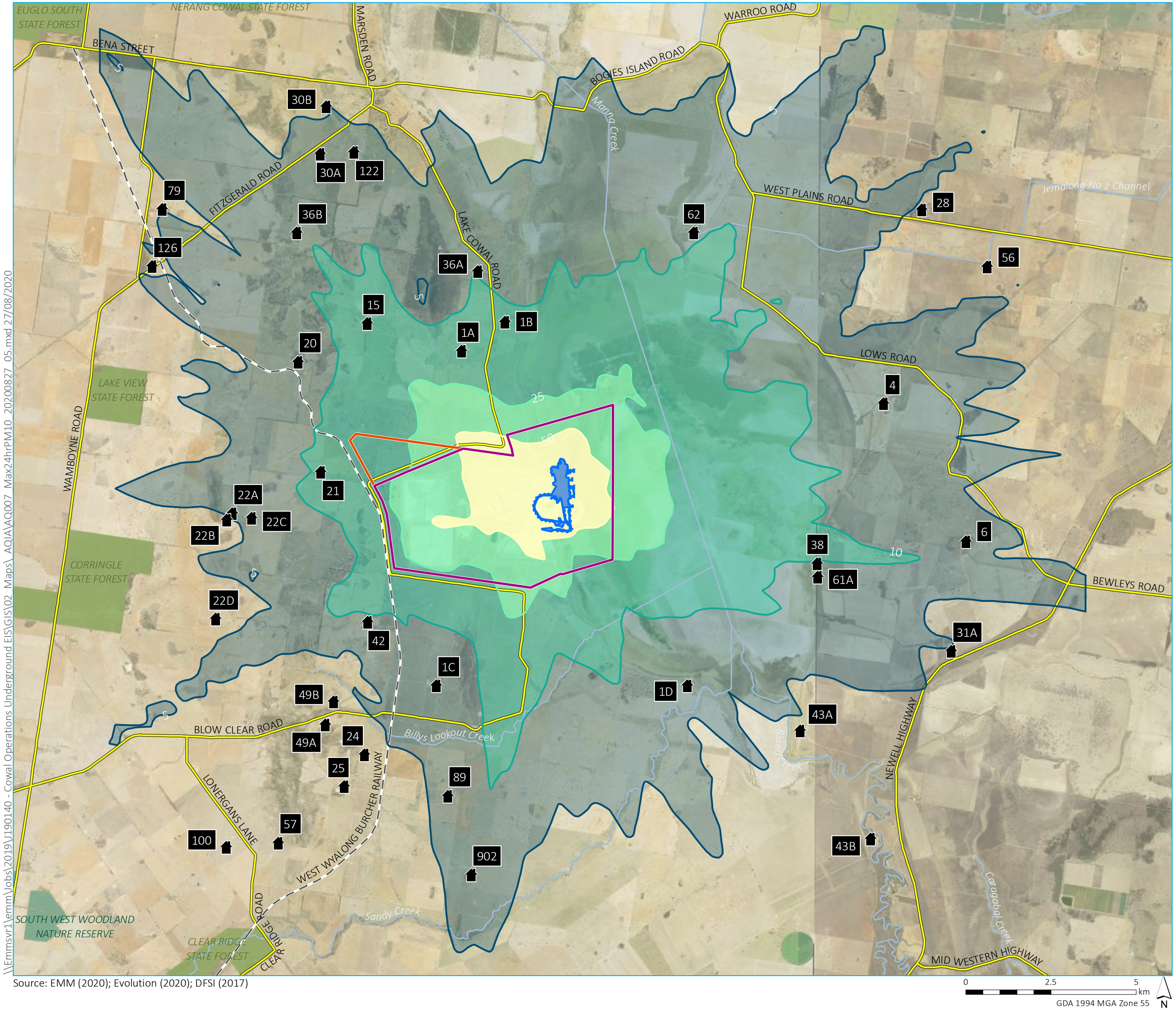
Material properties	Value	Source of information
Unpaved road silt content (%)	5	PEL 2018
Waste moisture (%)	2	PEL 2018
Ore moisture (%)	2	PEL 2018


Appendix C

Predicted incremental isopleth contours




\\Emmsvr1\emm\Jobs\2019\J190140 - Cowal Operations Underground EIS\GIS\02_Maps_AQIA\AQ007_Max24hrPM10_20200827_05.mxd 27/08/2020



Source: EMM (2020); Evolution (2020); DFSI (2017)

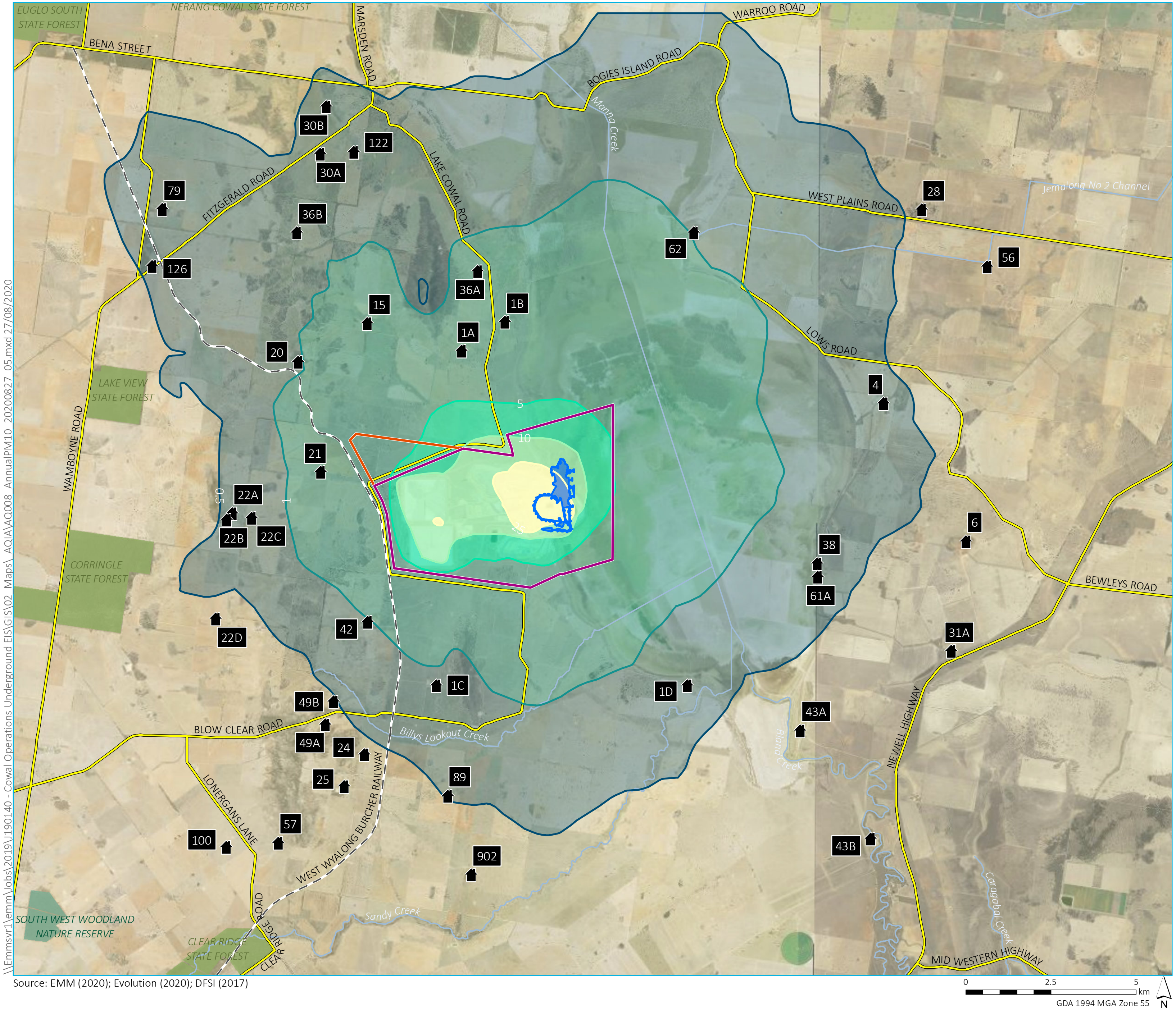
KEY
- Receptor location
- Proposed underground development
- Mining lease (ML1535)
- Mining lease (ML1791)
- Rail line
- Main road
- Named watercourse
- NPWS reserve
- State forest

PM_{10} concentration ($\mu g/m^3$)
- 5
- 10
- 25
- 50

Maximum predicted 24-hour average PM_{10} concentrations - project only

Evolution Mining
Cowal Gold Operations
Air quality impact assessment
Figure C.1

EMM
creating opportunities



\\Emmsvr1\emm\Jobs\2019\J190140 - Cowal Operations Underground EIS\GIS\02_Maps_AQIA\AQ008_AnnualPM10_20200827_05.mxd 27/08/2020

Source: EMM (2020); Evolution (2020); DFSI (2017)

KEY

- Receptor location
- Proposed underground development
- Mining lease (ML1535)
- Mining lease (ML1791)
- Rail line
- Main road
- Named watercourse
- NPWS reserve
- State forest

PM_{10} concentration ($\mu g/m^3$)

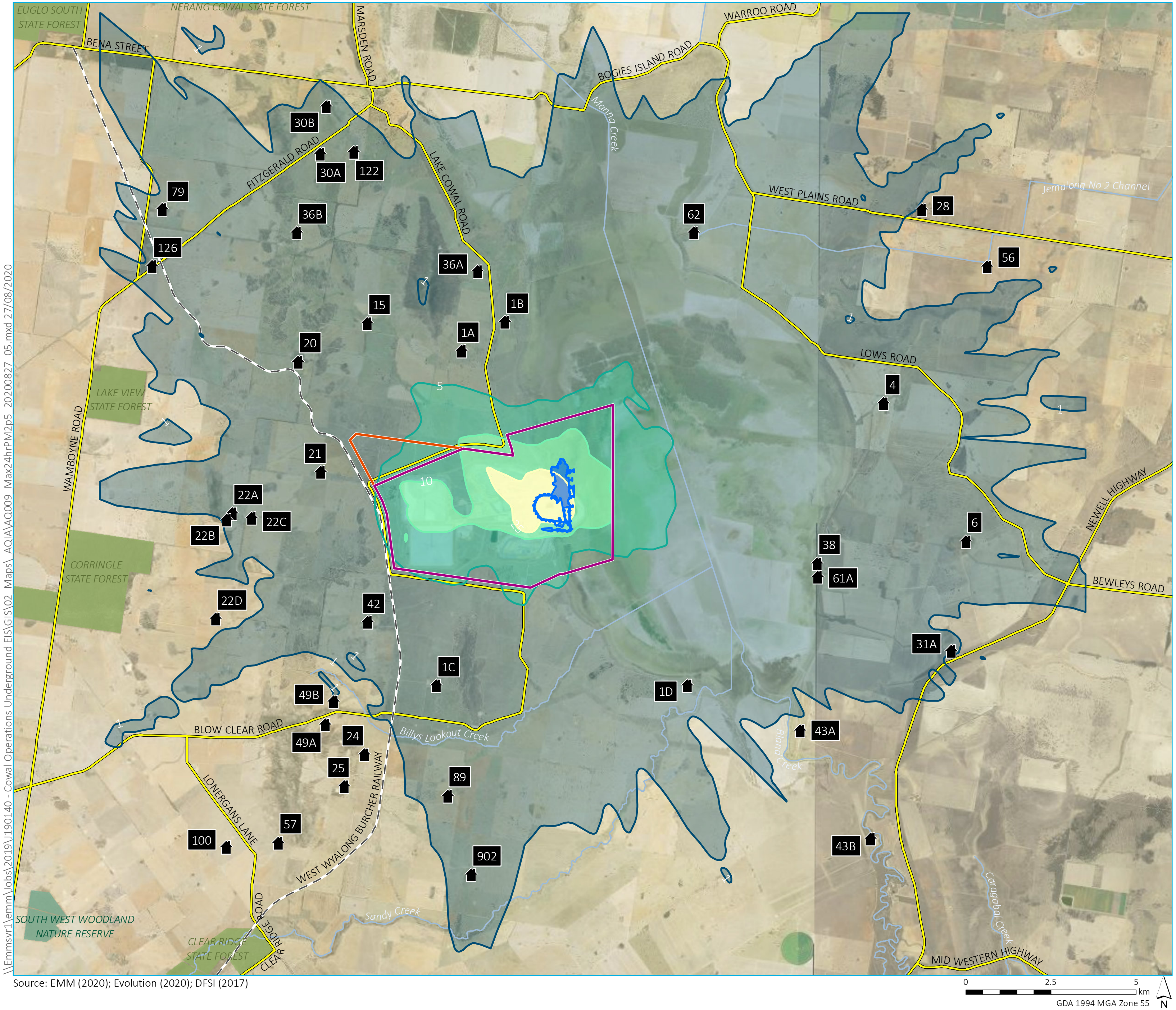
- 0.5
- 1
- 5
- 10
- 25

DRAFT

Predicted annual average PM_{10} concentrations - project only

Evolution Mining
Cowal Gold Operations
Air quality impact assessment
Figure C.2

EMM creating opportunities



KEY

- Receptor location
- Proposed underground development
- Mining lease (ML1535)
- Mining lease (ML1791)
- Rail line
- Main road
- Named watercourse
- NPWS reserve
- State forest

$PM_{2.5}$ concentration (µg/m^3)

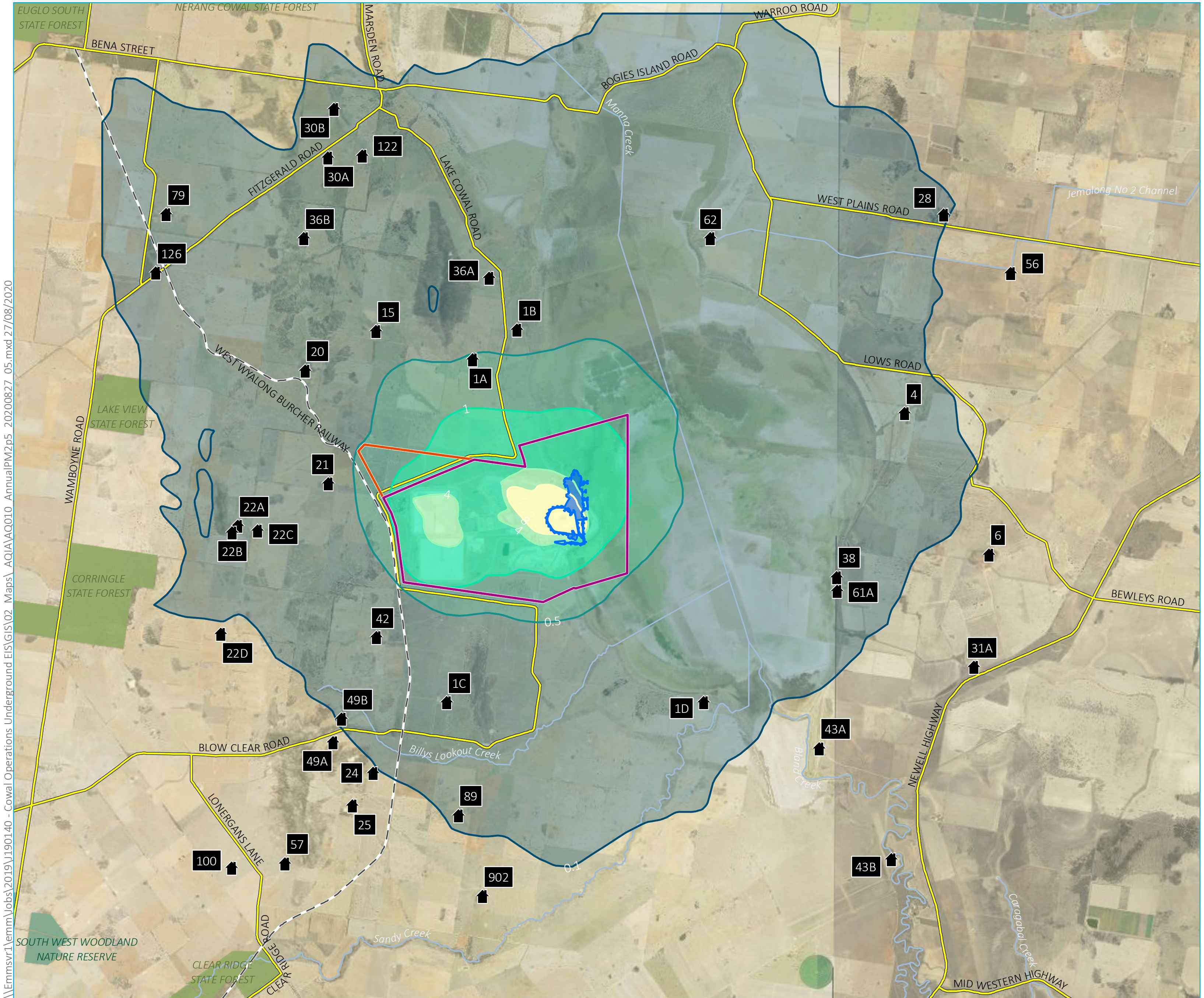
- 1
- 5
- 10
- 25

Source: EMM (2020); Evolution (2020); DFSI (2017)

Maximum predicted 24-hour average $PM_{2.5}$ concentrations - project only

Evolution Mining
Cowal Gold Operations
Air quality impact assessment
Figure C.3

EMM creating opportunities



Source: EMM (2020); Evolution (2020); DFSI (2017)

0 2.5 5 km
GDA 1994 MGA Zone 55
N

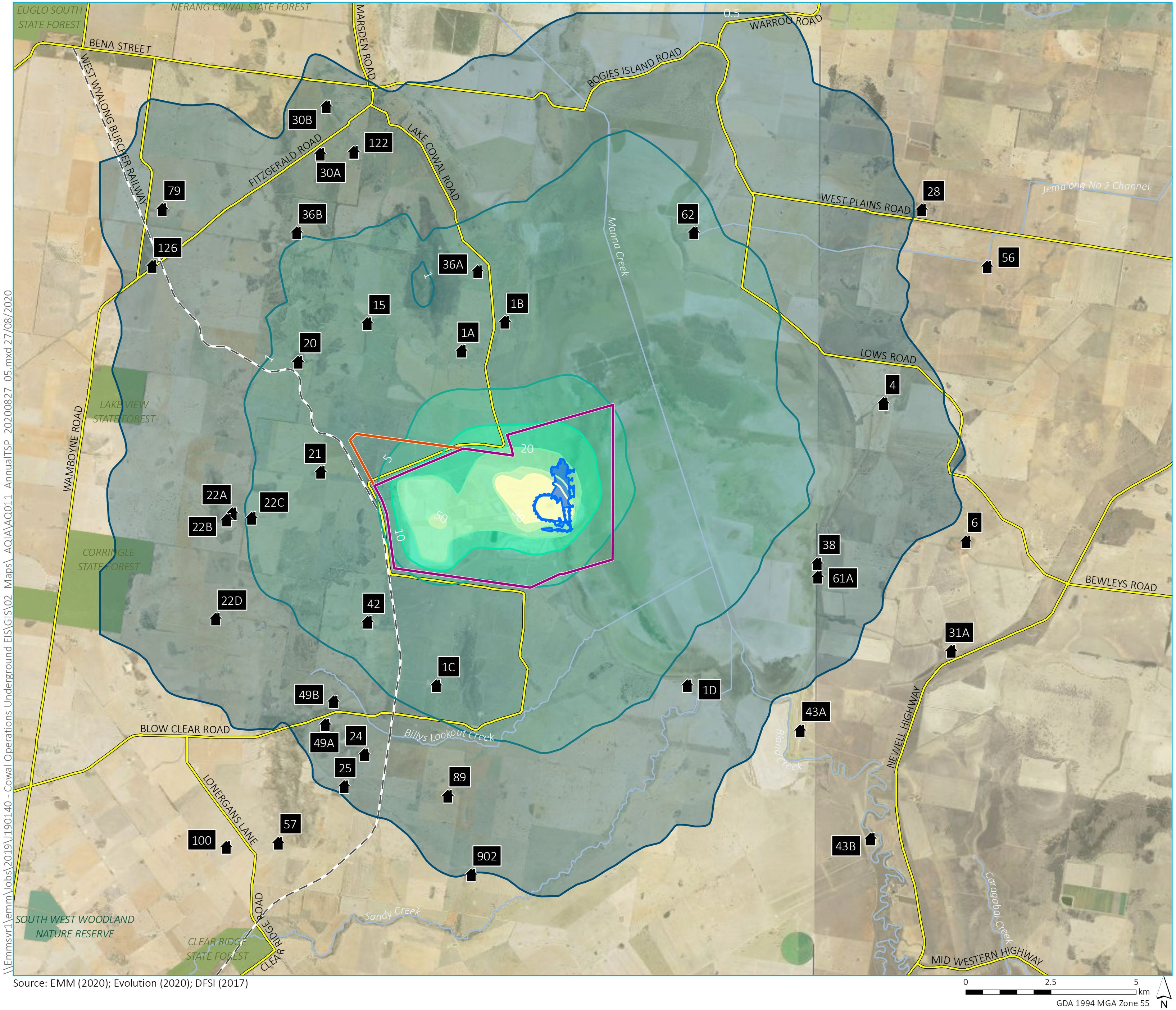
KEY
Receptor location
Proposed underground development
Mining lease (ML1535)
Mining lease (ML1791)
Rail line
Main road
Named watercourse
NPWS reserve
State forest
$PM_{2.5}$ concentration (µg/m^3)
0.1
0.5
1
4
8

Predicted annual average $PM_{2.5}$ concentrations - project only

Evolution Mining
Cowal Gold Operations
Air quality impact assessment
Figure C.4

EMM creating opportunities

\\Emmsvr1\emm\Jobs\2019\J190140 - Cowal Operations Underground EIS\GIS\02_Maps_AQIA\AQ010_AnnualPM2p5_20200827_05.mxd 27/08/2020



\\Emmsvr1\emm\Jobs\2019\J190140 - Cowal Operations Underground EIS\GIS\02_Maps_AQIA\AQ011_AnnualTSP_20200827_05.mxd 27/08/2020

Source: EMM (2020); Evolution (2020); DFSI (2017)

KEY

- Receptor location
- Proposed underground development
- Mining lease (ML1535)
- Mining lease (ML1791)
- Rail line
- Main road
- Named watercourse
- NPWS reserve
- State forest

TSP concentration (µg/m^3)

- 0.5
- 1
- 5
- 10
- 20
- 50
- 90

Predicted annual average TSP concentrations - project only

Evolution Mining
Cowal Gold Operations
Air quality impact assessment
Figure C.5

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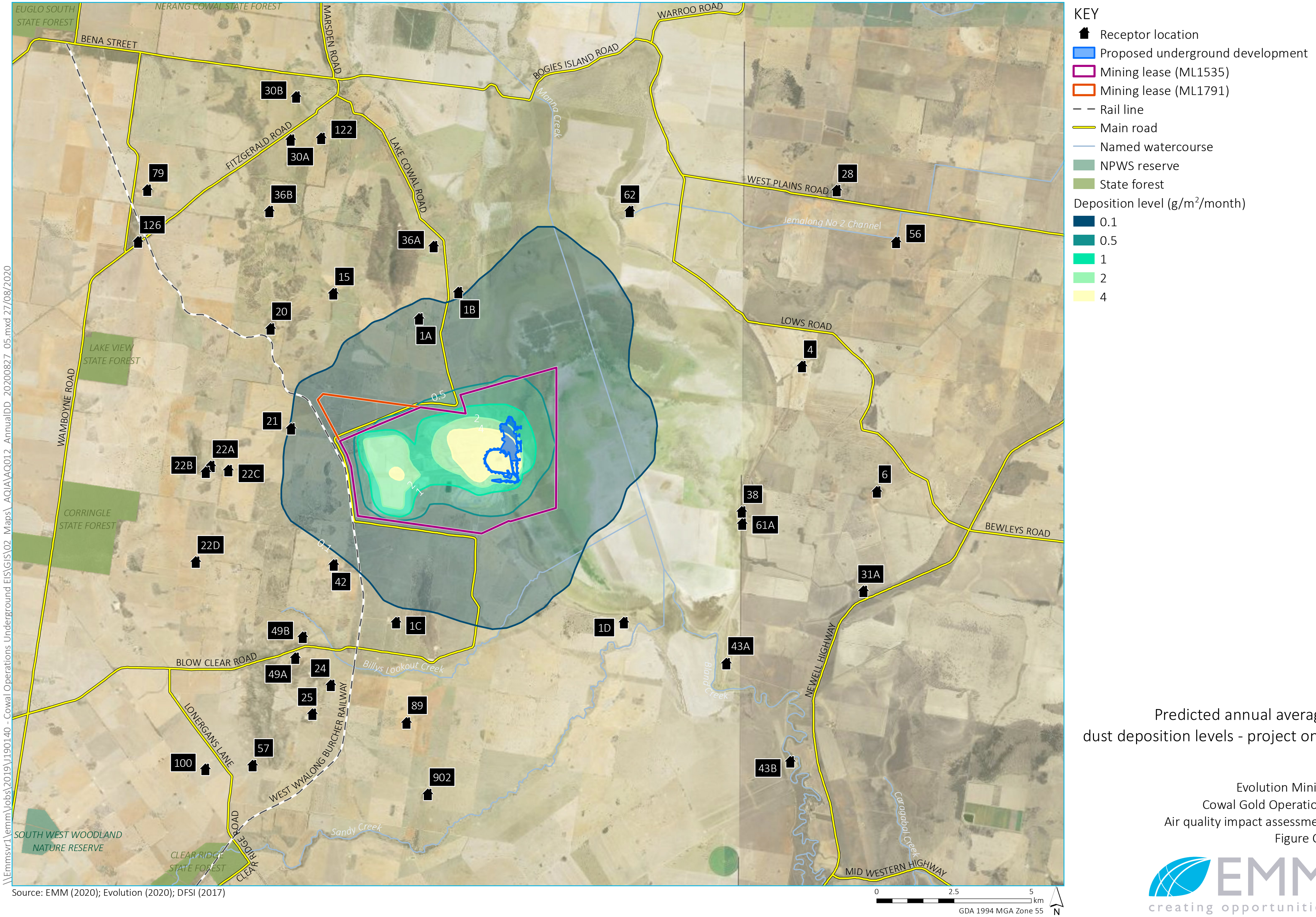
creating opportunities



Source: EMM (2020); Evolution (2020); DFSI (2017)

\\Emmsvr1\emm\Jobs\2019\J190140 - Cowal Operations Underground EIS\GIS\02_Maps_AQIA\AQ012_AnnualDD_20200827_05.mxd 27/08/2020

Predicted annual average dust deposition levels - project only

Evolution Mining
Cowal Gold Operations
Air quality impact assessment
Figure C.6

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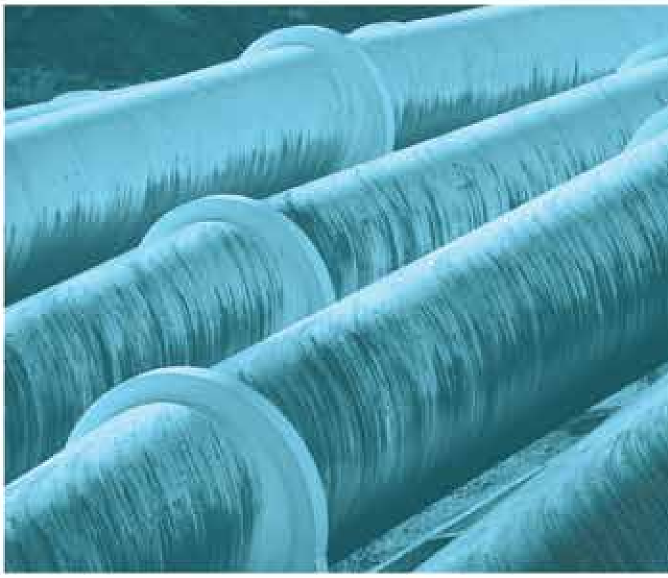

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