Appendix A

Air Quality

QUEENSLAND
PACIFIC METALS

EMM
creating opportunities

QPM Energy Project

Air Quality Technical Report

Prepared for QPM Energy

September 2022

QPM Energy Project

Air Quality Technical Report

QPM Energy

E210671 RP#

September 2022

Version	Date	Prepared by	Approved by	Comments
v1	1 September 2022	Francine Manansala	Paul Boulter	
V2	9 September 2022	Francine Manansala	Paul Boulter	
V3	4 October 2022	Francine Manansala	Paul Boulter	

Approved by

Paul Boulter
Associate Director
4 October 2022

Ground floor 20 Chandos Street
St Leonards NSW 2065
PO Box 21
St Leonards NSW 1590

Abbreviations

Table 1 Abbreviations

Abbreviation	Term
AHD	Australian Height Datum
AQIA	air quality impact assessment
AQMS	air quality monitoring station
AWS	automatic weather station
BoM	Bureau of Meteorology
CEMP	Construction Environment Management Plan
CO	carbon monoxide
CSIRO	Commonwealth Scientific and Industry Research Organisation
DES	Department of Environment and Science
EA	Environmental Authority
EAR	Environmental Assessment Report
EMM	EMM Consulting
EPP	Environmental Protection Policy
GCF	gas compression facility
ha	hectare
IAQM	(UK) Institute of Air Quality Management
km	kilometres
NEPC	National Environment Protection Council
NEPM	National Environment Protection (Ambient Air Quality) Measure
NGCM AQIA	North Goonyella Coal Mine AQIA
NO_x	oxides of nitrogen
NO_2	nitrogen dioxide
NQGP	North Queensland Gas Pipeline
OLM	ozone limiting method
O_3	ozone
PM_{10}	particulate matter less than 10 micrometres in aerodynamic diameter
$PM_{2.5}$	particulate matter less than 2.5 micrometres in aerodynamic diameter
QPM Energy	Queensland Pacific Metals Energy
SO_2	sulfur dioxide
TAPM	The Air Pollution Model

Table 1 Abbreviations

Abbreviation	Term
TECH	Townsville Energy Chemicals Hub Project
TSP	total suspended particulate matter
US-EPA	United States Environmental Protection Agency
VOCs	volatile organic compounds

TABLE OF CONTENTS

Annexures

Tables

Figures

1 Introduction

1.1 Project overview

The QPM Energy Project (the Project) involves the design, construction and operation of a gas compression facility (GCF) and a high-pressure pipeline that links the proposed GCF to the nearby existing and operational North Queensland Gas Pipeline (NQGP).

The Project proposes to collect waste coal mine gas at the proposed GCF via waste gathering lines from existing coal mines located adjacent to the proposed site. At the GCF, waste coal mine gas will be dehydrated and filtered, with the remaining clean gas then compressed and transported via high-pressure pipeline to the existing and operational NQGP. The NQGP will then transport the compressed gas north to Townsville, where in turn it will be depressurised and distributed, by a third party, to industrial users, including the QPM Townsville Energy Chemicals Hub (TECH) Project.

The Project is located approximately 43 kilometres (km) north of Moranbah.

1.2 Purpose of this report

This air quality impact assessment (AQIA) has been prepared by EMM Consulting Limited (EMM) on behalf of QPM Energy in support of an application for a new Environmental Authority (EA) for a resource activity, as part of the Project.

The purpose of this document is to provide sufficient detail to support an application for a site-specific EA. The key objectives of this AQIA are to:

- describe the local setting and surrounds of the Project;
- detail the pollutants which are relevant to the assessment, and the applicable impact assessment criteria;
- describe the existing environment, specifically:
  - the meteorology and climate; and
  - the existing air quality environment;
- complete an air pollutant emission inventory for the Project;
- complete atmospheric dispersion modelling for the quantified emissions, including an analysis of Project-only and cumulative impacts accounting for baseline air quality; and
- provide an overview of mitigation measures proposed to be employed at the Project.

The AQIA has been conducted in accordance with the guideline *Application requirements for activities with impacts to air* (DES 2021).

1.3 Project footprint and study area

The Project footprint is comprised of the following components and land areas:

- Gas Compression Facility (GCF) – 200 m by 300 m, an area of 6 ha;
- pipeline – easement initially a 30 m wide construction right of way (an area of 51 ha) which reduces to a 15 m wide operating easement (an area of 25 ha) after the first 3.2 km from the GCF;
- access road – 8 ha being a 30 m wide easement from Red Hill Road to the GCF – a distance of 2.8 km; and
- other incidental/ancillary activities, within the above footprint.

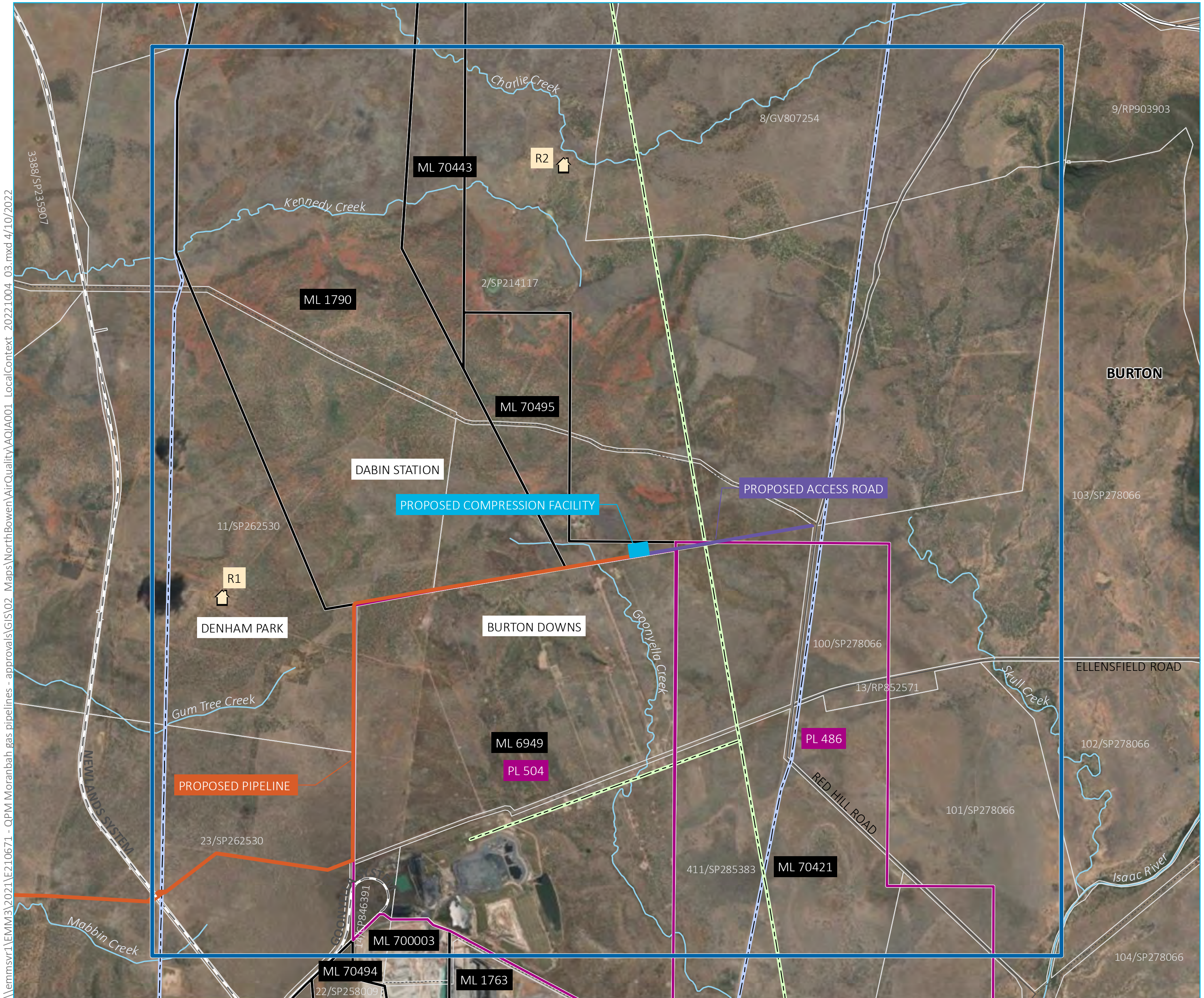
A detailed project description is provided in Section 3 of the Environment Assessment Report (EAR).

For the purposes of the AQIA, the study area is defined as the dispersion model domain. The Project footprint, study area and assessment locations (discussed in Section 2.4) are shown on Figure 1.1.

The land surrounding the Project is predominantly vacant with no industrial or agricultural industry in proximity. The land surrounding the Project is predominantly rural. There are two homesteads within 7 km of the Project.

The North Goonyella Coal Mine (previously Eaglefield Coal Mine) is approximately 6 km south of the Project. The open-cut coal mine spans approximately 20 km of terrain and is currently operational. Alongside fugitive methane emissions and flaring of gas, the main source of pollutants from the mine are particulate matter in the form of PM_{10} and $PM_{2.5}$ from activities typical to open-cut coal mining such as drill and blast, the movement of overburden and coal, hauling on unsealed surfaces, processing, and wind erosion (Noise Mapping Australia 2010). Potential impacts from both operations have been considered.

The terrain immediately surrounding the Project is relatively flat with few distinguishing features. The elevation ranges from approximately 280 m Australian Height Datum (AHD) to 350 m AHD within approximately 5 km of the Project. A three-dimensional representation of the local topography is shown in Figure 1.2.



KEY

- Assessment location
- Study area
- Gas compression facility
- Pipeline
- Access road
- Mining lease
- Petroleum lease
- Electrical transmission line
- Water pipeline
- Rail line
- Major road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary

INSET KEY

- Main road
- National park
- State forest

Source: EMM (2022); DNRME (2021); DES (2021); ESRI (2022); GA (2011); ASGC (2006)

0 2.5 5 km

GDA 1994 MGA Zone 55

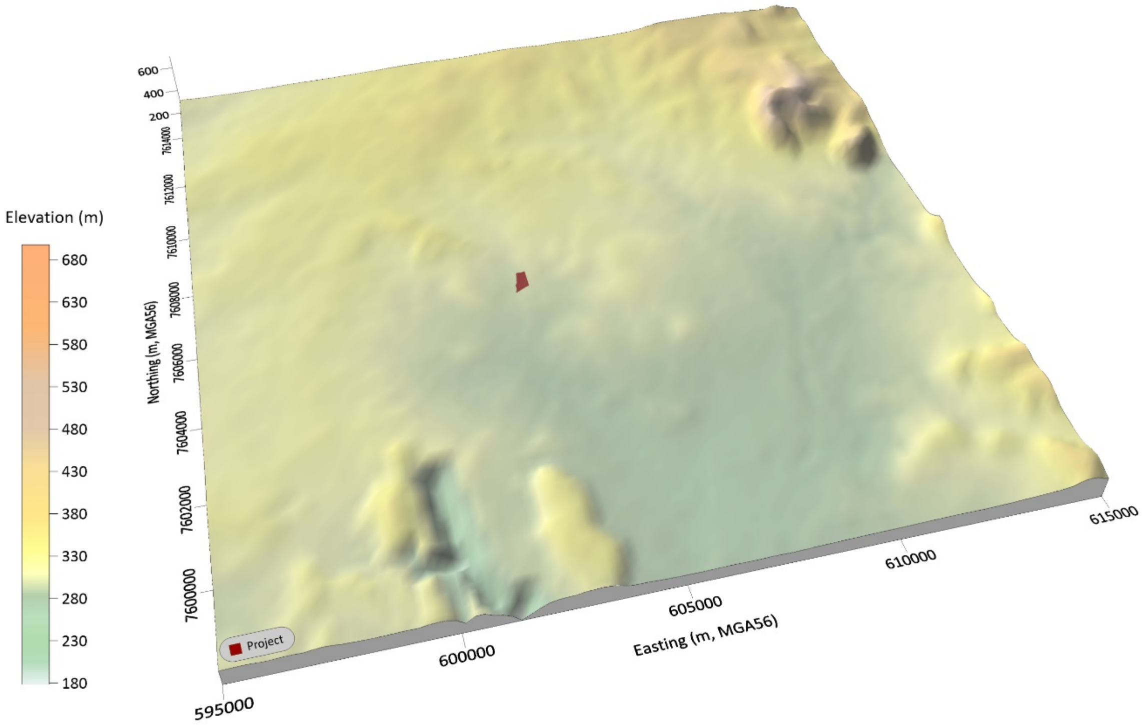
N

Local context

QPM Energy Project
Air
Figure 1.1

EMM
creating opportunities

\\emmsvr1\EMM3\2021\E210671 - QPM Moranbah gas pipelines - approvals\GIS\02_Maps\NorthBowen\AirQuality\AQIA001_LocalContext_20221004_03.mxd 4/10/2022



Source: NASA Shuttle Radar Topography Mission data

Figure 1.2 3-dimensional topography surrounding the Project

2 Project description

2.1 Overview

The Project involves the design, construction, and operation of a GCF and a high-pressure pipeline that links the proposed GCF to the nearby existing and operational NQGP.

The Project proposes to collect waste coal mine gas at the proposed GCF via waste gathering lines located at adjacent coal mines. At the GCF, waste coal mine gas will be dehydrated and filtered, with the remaining clean gas then compressed and transported via high-pressure pipeline to the existing and operational NQGP. The NQGP will then transport the compressed gas north to Townsville, where in turn it will be depressurised and distributed, by a third party, to industrial users, including QPM's TECH Project.

Access to the GCF will be provided via the construction of a 2.8 km all-weather access road from Red Hill Road.

Ancillary activities will also occur within the defined Project footprint.

The Project is proposed 43 km north of Moranbah.

It should be noted that the Project involves capturing and converting methane in waste coal mine gas (a greenhouse gas) into carbon dioxide that would otherwise be released into the atmosphere by the relevant coal mining operator. The Project proposes to capture and convert waste coal mine gas through a process of filtration to remove water slugs and fine coal dust, compression, dehydration to remove water vapour, and flaring, in the event of a shutdown. It does not involve refining natural gas or coal seam methane gas.

For further detail on the Project description refer to Section 3 of the Environmental Assessment Report. The Project will be staged, with an initial installation of four compressors, associated compressor engines and ancillary facilities and plant. The following two stages will incorporate an additional four compressors each to an ultimate capacity of twelve compressors. This AQIA addresses the ultimate capacity at Stage 3 of the Project.

2.2 Key project components

Table 2.1 summarises the key components of the Project.

Table 2.1 Project components

Component	Description
Gas Compression Facility	• Captures and converts waste coal mine gas to clean gas which is then compressed to 15.3 megapascal for transport within the high pressure gas pipeline. • Proposed to be located at Dabin Station on the southern boundary of Lot 2 SP214117 and 2.8 km west of the Red Hill Road reserve. • Sited on a 200 m by 300 m pad. • 6 ha disturbance footprint.
High-pressure pipeline	• High-pressure pipeline to transport clean compressed gas from the GCF to the NQGP. • 16.8 km in length, running along fence lines and property boundaries. • During construction, a 30 m wide construction right of way (disturbance area of 51 ha). • During operations, a 15 m wide operating easement (disturbance area of 25 ha) after the first 3.2 km.
Access road	• Road to provide all-weather access to the GCF from Red Hill Road reserve. • 2.8 km long and 30 m wide. • 8 ha disturbance footprint.

A detailed project description is provided in Section 3 of the EAR.

2.3 Project description influencing air quality matters

The key emissions sources and pollutants applicable to the construction of the Project include:

- fugitive dust from clearing, excavation, material handling, movement of plant and equipment, and wind erosion of exposed surfaces, comprising:
  - 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 ($PM_{2.5}$);
- diesel exhaust emissions from construction equipment, comprising:
  - $PM_{2.5}$;
  - oxides of nitrogen (NO_x)[1], including nitrogen dioxide (NO_2);
  - sulphur dioxide (SO_2);
  - carbon monoxide (CO); and
  - volatile organic compounds (VOCs).

For the operational phase, the key pollutants associated with the combustion of coal mine waste gas are oxides of nitrogen (NO_x), carbon monoxide (CO), and volatile organic compounds (VOCs). Operational emissions would be emitted from the following sources anticipated to be operational during Stage 3 of the Project:

- compressor stacks (12);
- reboiler stacks (2);
- gas generators (2);
- backup diesel generator (1); and
- flares (2).

2.4 Assessment locations

The land surrounding the Project is predominantly rural. There are two isolated homesteads within 7 km of the Project. The nearest homestead is located 6.2 km to the north.

The nearest representative sensitive locations to the Project have been identified for the purpose of assessing potential air quality impacts from the Project. These are referred to as 'assessment locations' throughout this report. Details are provided in Table 2.2 and their locations are shown in Figure 1.1.

[1] By convention, NO_x = Nitrous oxide (NO) + NO_2.

Table 2.2 Assessment locations

Assessment location ID	Address	Type	Coordinates (MGA 55)		Distance to the Project
			Easting	Northing	
R1	'Old Denham Park' 535 Mabbin Road, Moranbah (11SP262530)	Residential	596292	7608543	6.6 km to the west
R2	'Wards Well' 8595 Suttor Development Road, Burton (2SP214117)	Residential	601805	7615530	6.2 km to the north

3 Legislation, policies, standards and guidelines

Legislation and guidelines relevant to this AQIA assessment are provided in Table 3.1.

Table 3.1 Relevant legislation, policies, standards and guidelines to the AQIA

Document	Relevance to the assessment
Legislation	
QLD Environmental Protection (Air) Policy 2019 (EPP (Air))	Provides air quality objectives to be applied in the AQIA.
Policies, standards, guidelines	
Application requirements for activities with impacts to air (ESR/2015/1840)	DES (2021) *Application requirements for activities with impacts to air guideline* seeks to assist both regulators and operators of an environmentally relevant activity (ERA) to identify, quantify and evaluate the impacts that air emissions may have on environmental values (EV) and to manage these in a way that achieves a balance between the social benefits of development and maintaining the EVs of the receiving environment.

The Queensland Department of Environment and Science (DES) specifies air quality objectives for a wide range of pollutants in Schedule 1 of the Environmental Protection (Air) Policy 2019 (EPP (Air)). The air quality objectives specified in the EPP (Air) relevant to the assessment of operational emission from the Project are presented in Table 3.2. Benzene, formaldehyde, toluene and xylene were assessed as individual toxic VOCs.

Table 3.2 Ambient air quality objectives relevant to the Project as per the EPP Air 2019

Pollutant	Averaging period	Air quality objective	Units
NO_2	1 hour Annual	250 62	µg/m^3
PM_{10}	24 hour Annual	50 25	µg/m^3
$PM_{2.5}$	24 hour Annual	25 8	µg/m^3
CO	8 hour	11	mg/m^3
SO_2	1 hour 24 hour Annual	570 229 57	µg/m^3
Benzene	Annual	5.4	µg/m^3
Formaldehyde	24 hour	54	µg/m^3
Toluene	24 hour Annual	4.1 400	mg/m^3 µg/m^3
Xylene	24 hour Annual	1.2 950	mg/m^3 µg/m^3

In April 2021, the National Environment Protection Council (NEPC) approved a variation to the National Environment Protection (Ambient Air Quality) Measure (NEPM) standards for ozone (O_3), NO_2 and SO_2. Whilst the Queensland Government has not officially adopted these new standards in the EPP Air, the standards relevant to this assessment (NO_2 and SO_2) are provided below and have also been compared against the predictions in this report (see Chapter 8). It is noted that the revised NEPM standards are significantly lower (ie more stringent) than the corresponding EPP Air objectives for NO_2 and SO_2.

Table 3.3 Updated Air Quality NEPM standards for NO_2 and SO_2

Pollutant	Averaging period	Air quality standards	Units
NO_2	1 hour Annual	164 31	µg/m^3
SO_2	1 hour 24 hour Annual	286 57 No annual standards proposed	µg/m^3

4 Assessment methodology

The assessment methodology generally follows the guidance provided in DES (2021) *Application requirements for activities with impacts to air guideline*.

The risk of dust impacts during the construction of the Project was assessed using the *Guidance on the Assessment of Dust from Demolition and Construction* published by the Institute of Air Quality Management in the United Kingdom (IAQM 2014).

Operational impacts were assessed using emissions estimation of key sources of pollutants from the Project and dispersion modelling to predict ground-level concentrations at nearby assessment locations and across a cartesian grid to produce contour plots.

Meteorological modelling conducted for this assessment was based on The Air Pollution Model (TAPM) and AERMET models. The modelling system works as follows:

- TAPM is a prognostic meteorological model that generates gridded three-dimensional meteorological data for each hour of the model run period.
- AERMET is the meteorological pre-processor to AERMOD.

Additional information relating to the TAPM and AERMET configuration for meteorological modelling is detailed in Annexure A.

This AQIA assesses two operational scenarios:

- Scenario 1: normal operations for Stage 3 of the Project (all stacks except flares); and
- Scenario 2: as above with the inclusion of flares.

The inventories represent worst-case operations developed to quantify particulate matter and gaseous pollutant emissions from the Project. The scenarios are considered highly conservative as in reality, not all stacks would be operating simultaneously and not for all hours of the year (as assumed in the modelling).

Stack parameters and emissions data were developed based on information provided by QPM Energy.

Atmospheric dispersion modelling for this assessment was completed using the AMS[2]/USEPA[3] regulatory model (AERMOD) (release date 22 April 2022). 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's (CSIRO) TAPM (version 4.0.4) meteorological model. Spatially varying land use and terrain data were included in the model.

Each emission source has been represented in the modelling as a point source. Details of the emissions estimation and dispersion modelling are provided in Chapter 6.

2 AMS - American Meteorological Society

3 USEPA - United States Environmental Protection Agency

5 Existing environment

5.1 Meteorology

5.1.1 Introduction

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. To adequately characterise the dispersion meteorology of a region, information is needed on the prevailing wind regime, ambient temperature, rainfall, relative humidity, mixing depth and atmospheric stability.

There are no meteorological stations in the vicinity of the Project. The closest meteorological stations to the Project are:

- Moranbah (Utah Drive) operated by QLD DES since 2011 – approximately 43 km south of the Project;
- Moranbah (Cunningham Way) operated by QLD DES since 2020 – approximately 44 km south of the Project; and
- Moranbah Airport operated by the Bureau of Meteorology (BoM) since 2012 – approximately 50 km south of the Project.

Due to data availability and distance from the Project, the QLD DES Moranbah (Utah Drive) meteorological station was chosen to represent meteorological conditions at the Project site.

5.1.2 Prevailing winds and selection of a representative year

Meteorological data available for the period between 2017 and 2021 were analysed for the purposes of characterising the existing environment and selecting a representative year for dispersion modelling. Table 5.1 provides a summary of the annual average wind speed, percentage of calms (wind speeds <0.5 metres per second (m/s)), and data recovery for each year.

The statistics in Table 5.1 show that there was a general inter-annual consistency in the recorded annual average wind speed and annual percentage of calms at each station. There was also a high percentage of data recovery at each station.

Table 5.1 Summary of average wind speed, percentage calms and data recovery for QLD DES Moranbah (Utah Drive)

Year	Average wind speed (m/s)	Calms (%)	Data recovery (%)*
2017	1.7	13.4	99.4
2018	2.0	9.7	99.4
2019	2.0	8.3	100.0
2020	1.9	7.1	99.9
2021	1.9	8.1	99.8

* Note: Base on availability of wind speed data.

Inter-annual profiles for wind speed, wind direction and air temperature by hour of the day were also analysed for the QLD DES Moranbah (Utah Drive) air quality monitoring station (AQMS) (see Annexure A, Figure A.1 to Figure A.3). Data for years 2017 to 2020 are considered generally comparable between years for all parameters. The 2021 data appear to be inconsistent with the data from the previous years. For example, in 2021 wind speed appears to be higher in the night-time and lower during the daytime than in previous years. Hourly temperature in 2021 is also higher in the night-time and lower during the daytime than in previous years. Wind direction for 2021 also shows noticeable hourly variation when compared with the previous years.

Annual, seasonal and diurnal wind roses created from wind speed and direction data collected at the QLD DES Moranbah (Utah Drive) AQMS are presented in Annexure A, Figure A.4 to Figure A.6. Annually, the winds recorded by the QLD DES Moranbah (Utah Drive) AQMS show a similarity across years for both wind speed and wind direction. Winds were predominately from the south-east. On a seasonal basis, winds are also generally from the south-east but are most prominent in autumn and winter. Diurnally, the dominant winds are again from the south-east both during the day and night-time. Average wind speeds were higher during the day and the percentage of calms was higher at night-time.

As a result of the analysis provided above, the 2020 calendar year was adopted as the 12-month modelling period for the purpose of this AQIA. The modelling year was also chosen with regard to background air quality which is discussed in Section 5.2.

The annual wind rose for the QLD DES Moranbah (Utah Drive) AQMS for 2020 is shown in Figure 5.1. The wind rose displays the characteristics described above, being dominated by winds from the south-east.

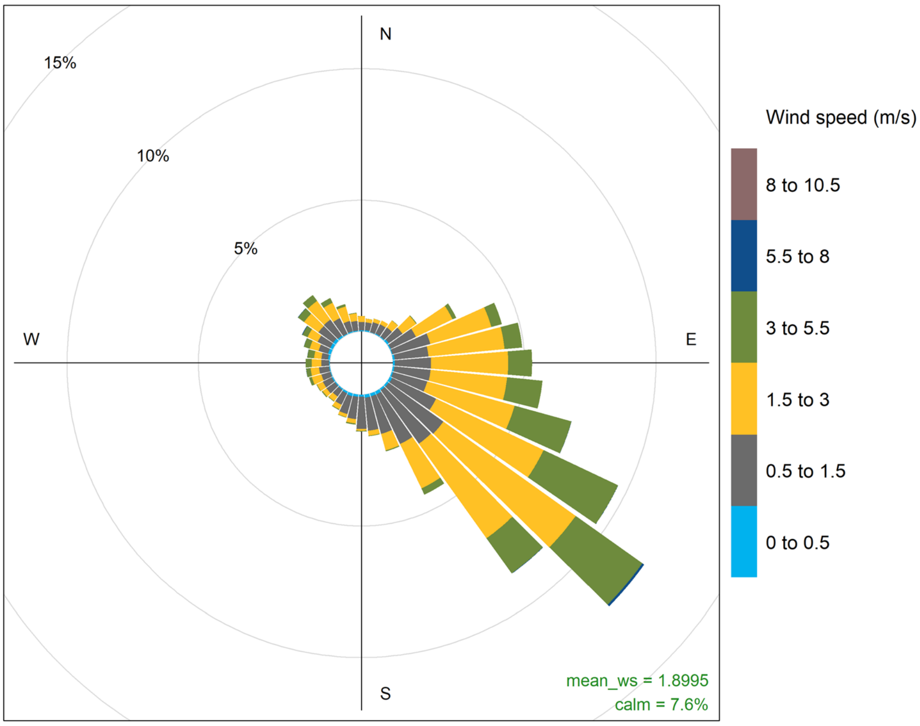


Figure 5.1 Recorded wind speed and direction – QLD DES Moranbah (Utah Drive), 2020

5.1.3 Meteorological modelling

i Overview

Atmospheric dispersion modelling for this assessment has been completed using the AERMET and TAPM meteorological models as previously described.

Hourly average meteorological data from the QLD DES Moranbah (Utah Drive) AQMS were used as observations in the TAPM and AERMET modelling.

Further details of the TAPM and AERMET meteorological modelling is presented in Annexure A.

ii Atmospheric stability and mixing depth

Atmospheric stability refers to the degree of turbulence or mixing that occurs in 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 5.2 illustrates the diurnal variation of atmospheric stability, derived from the Monin-Obukhov length calculated by AERMET at the QLD DES Moranbah (Utah Drive) AQMS. 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 will be greatest during daytime hours and lowest during evening through to early morning hours.

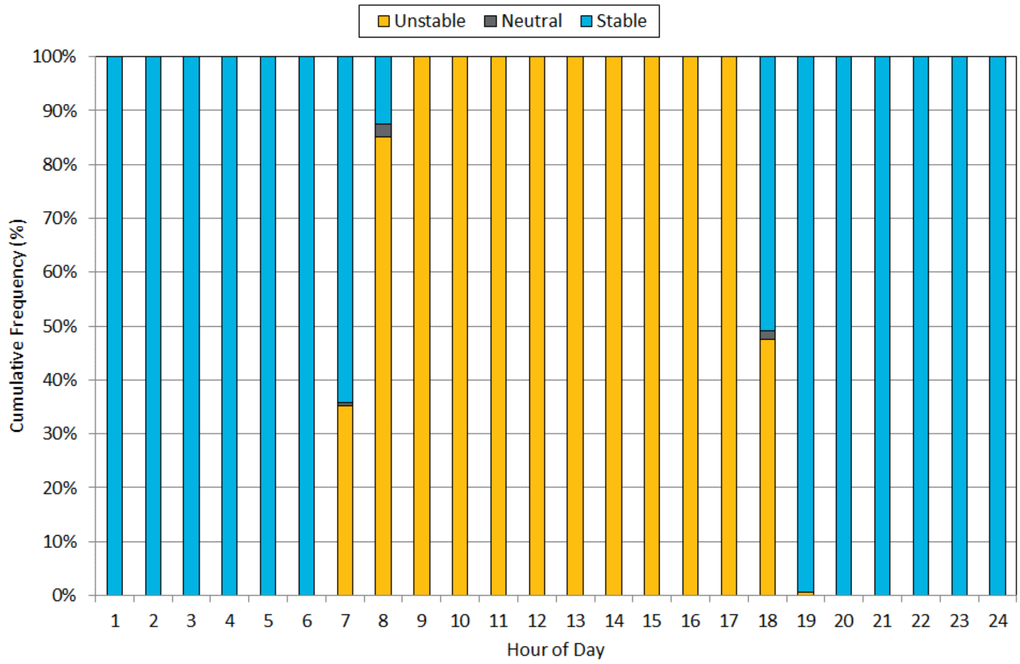


Figure 5.2 AERMOD-calculated diurnal variation in atmospheric stability – QLD DES Moranbah (Utah Drive) AQMS

Mixing depth refers to the height of the atmosphere above ground level within which 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 increase 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.

Figure 5.3 presents the hourly-varying atmospheric boundary layer depths generated by AERMET. Greater boundary layer depths occur during the daytime hours, peaking in the mid to late afternoon.

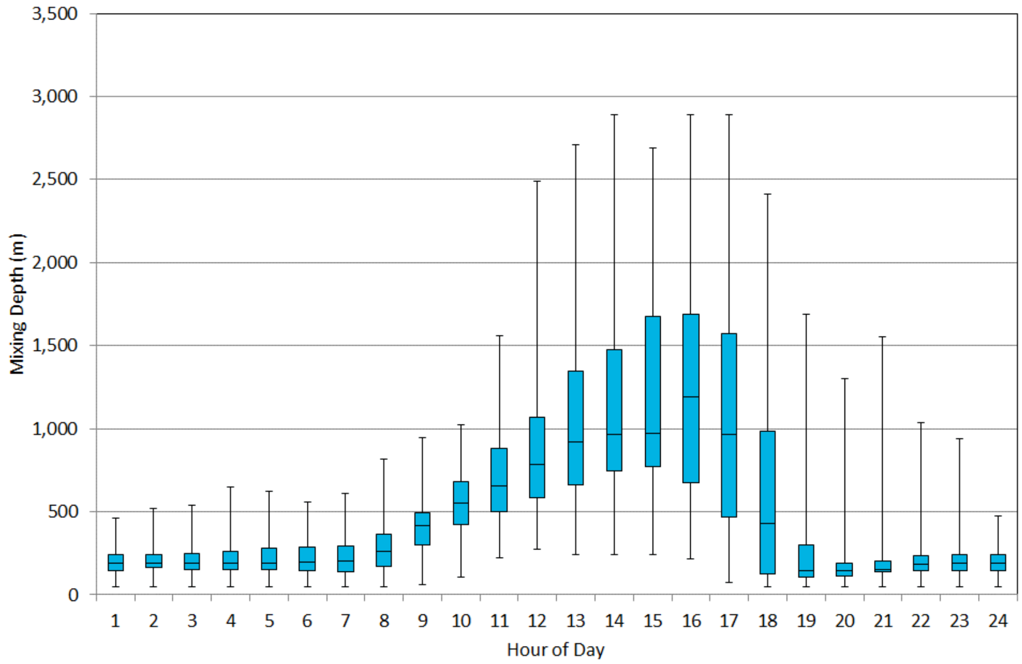


Figure 5.3 AERMOD-calculated diurnal variation in atmospheric mixing depth – QLD DES Moranbah (Utah Drive) AQMS

5.2 Baseline air quality

5.2.1 Introduction

Apart from the Project itself, air quality in the local airshed will also be influenced by:

- agricultural practices on adjacent properties;
- wind generated dust from exposed areas;
- dust entrainment and exhaust emissions from vehicle movements along unsealed and sealed roads;
- seasonal emissions from household wood heaters; and
- long-range transport of fine particles into the region.

Exceptional events which contribute episodically to suspended particulate matter in the region include dust storms and bushfires. The North Goonyella Coal Mine is also located approximately 6 km south of the Project. Potential emissions from this source are discussed in Section 5.2.4.

5.2.2 Air monitoring data resources

Similar to meteorological monitoring, no ambient air quality monitoring is currently conducted at the Project site.

The closest ambient air quality monitoring station to the Project is the QLD DES Moranbah (Utah Drive) AQMS approximately 43 km south of the Project. In terms of ambient air quality data, the station measures long-term PM_{10} concentrations and began monitoring $PM_{2.5}$ concentrations in October 2019.

For the key pollutants associated with the operational phase (NO_x, CO, SO_2 and VOCs) there are no significant local sources that would contribute to background air quality in the vicinity of the Project, other than minor contributions from traffic. On this basis, the ambient background for these pollutants can be assumed to be very low or negligible.

5.2.3 Background air quality

i PM_{10} and $PM_{2.5}$

A summary of key statistics for the five years of analysed PM_{10} data from the QLD DES Moranbah (Utah Drive) station is presented in Table 5.2. Exceedances of the 24 hour average air quality objective of 50 µg/m³ were recorded in every year between 2017 and 2021. Concentrations were elevated in 2019 due to extreme drought conditions, and the extensive bushfires during November and December around Eastern Australia. As a result, 2019 was not considered representative of the local area for use in describing background air quality.

A time series of 24 hour average PM_{10} concentrations at the QLD DES Moranbah (Utah Drive) AQMS is presented in Figure 5.4. The recorded 24 hour average PM_{10} concentrations fluctuated throughout the period. However, there was a clear upward trend of concentrations towards 2018 and 2019 attributed to dry conditions and bushfires as previously described.

Table 5.2 PM_{10} concentration data collected at QLD DES Moranbah (Utah Drive) – 2017 to 2021

Year	Maximum 24 hour average concentration (µg/m³)	Annual average concentration (µg/m³)	Number of days greater than 50 µg/m³	Data recovery (%)
2017	68.8	25.6	7	98.9
2018	113.6	30.0	19	99.5
2019	217.8	31.3	34	97.5
2020	89.8	21.1	5	100.0
2021	57.3	20.5	4	100.0

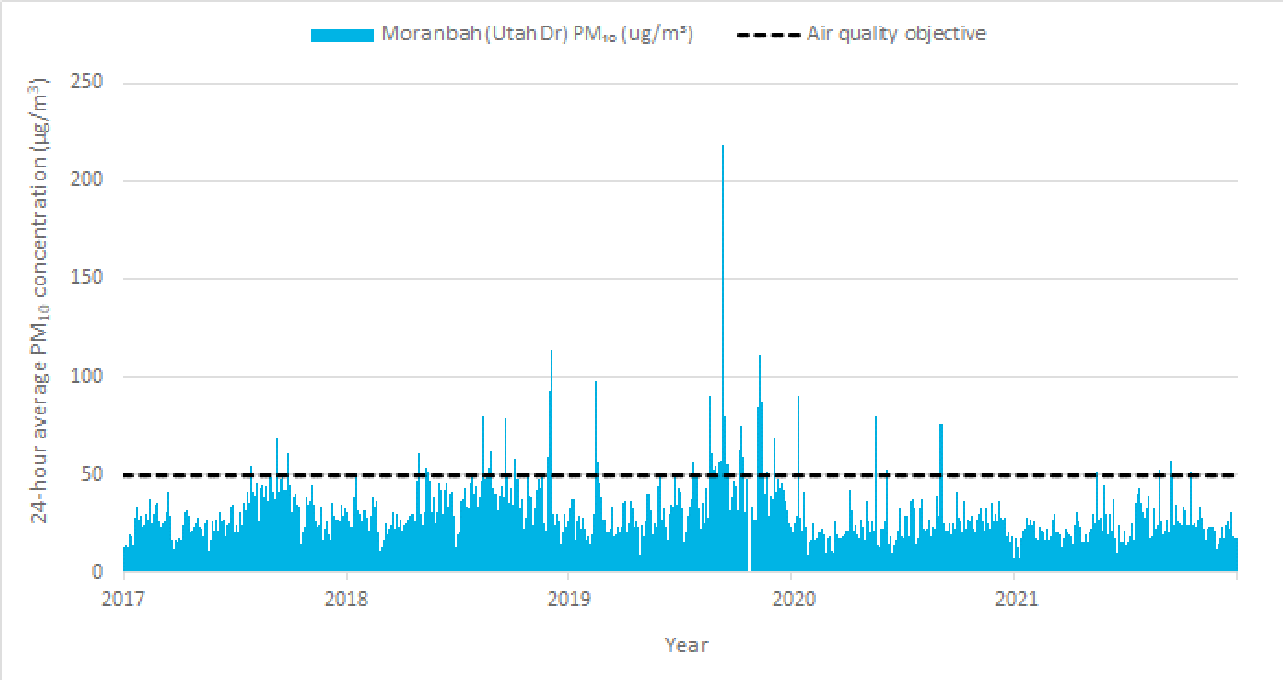


Figure 5.4 **Time series of 24 hour average PM_{10} concentrations recorded at QLD DES Moranbah (Utah Drive) AQMS – 2017 to 2021**

A summary of key statistics for the five years of analysed $PM_{2.5}$ data from the QLD DES Moranbah (Utah Drive) station is presented in Table 5.3. Exceedances of the 24 hour average air quality objective of 25 µg/m³ were recorded in both years. Concentrations were elevated in 2019 due to extreme drought conditions, and the extensive bushfires during November and December around Eastern Australia.

A time series of recorded 24 hour average $PM_{2.5}$ concentrations at the QLD DES Moranbah (Utah Drive) AQMS is presented in Figure 5.5. Recorded $PM_{2.5}$ concentrations were reasonably consistent throughout the period however with a few elevated concentrations measured in 2020.

Table 5.3 **$PM_{2.5}$ concentration data collected at QLD DES Moranbah (Utah Drive) – 2020 to 2021**

Year	Maximum 24 hour average concentration (µg/m³)	Annual average concentration (µg/m³)	Number of days greater than 25 µg/m³	Data recovery (%)
2020	53.9	6.4	4	100.0
2021	11.6	5.6	0	100.0

* Note: From October only.

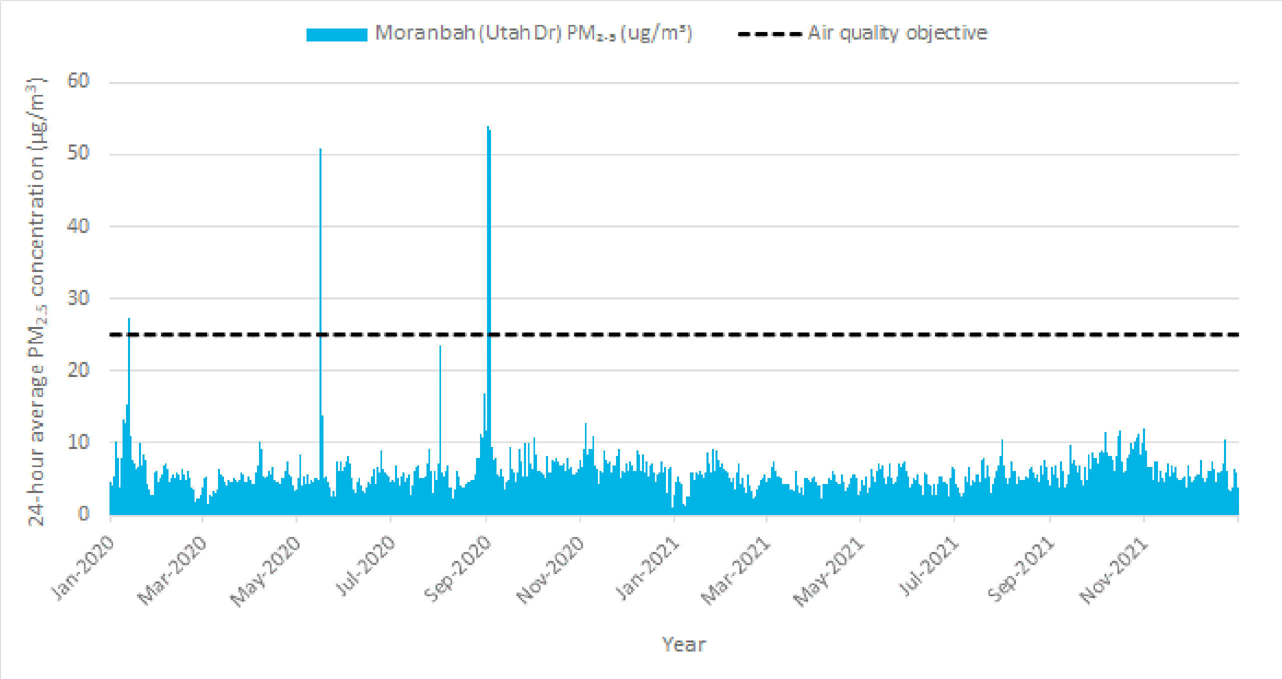


Figure 5.5 Time series of 24-hour average $PM_{2.5}$ concentrations recorded at QLD DES Moranbah (Utah Drive) AQMS – 2019 to 2021

Due to the analysis provided above, data from 2020 was used to define background concentrations of PM_{10} and $PM_{2.5}$ for this assessment.

ii NO2 and O3

The ozone limiting method (OLM) for converting modelled NO_x concentrations to NO_2 concentrations, requires a record of 1-hour NO_2 and O_3 concentrations over a year. There are no AQMSs in the vicinity of the Project that record 1-hour NO_2 and O_3 concentrations. The closest station recording these pollutants (Pimlico AQMS) is located near the Port of Townsville approximately 287 km north-west of the Project. As the Pimlico monitoring station was decommissioned in 2016, the last full year of monitoring data were 2015. The 2015 data were therefore used in the OLM. This is noted as a limitation of the calculations, as the model predictions (and meteorology) for the assessment were for a different year (2018). Further details are provided in Annexure B.

The average and maximum 1 hour NO_2 concentrations in the 2015 Pimlico data were 7.8 µg/m^3 and 80.0 µg/m^3, respectively. For O_3, the average and maximum 1-hour concentrations were 40.8 µg/m^3 and 109.2 µg/m^3, respectively.

5.2.4 Assumed background concentrations

The background pollutant values adopted for cumulative assessment, based on the analysis presented in the preceding sections, are as follows:

- 24 hour PM_{10} concentration – daily varying concentrations from the QLD DES Moranbah (Utah Drive) AQMS 2020 dataset. Concentrations range from 3.0 µg/m^3 to 89.8 µg/m^3;
- annual average PM_{10} concentration – 21.1 µg/m^3 from the QLD DES Moranbah (Utah Drive) AQMS 2020 dataset;
- 24 hour $PM_{2.5}$ concentration – daily varying concentrations from the QLD DES Moranbah (Utah Drive) AQMS 2020 dataset. Concentrations range from 1.1 µg/m^3 to 53.9 µg/m^3;

- annual average $PM_{2.5}$ concentration – 6.4 µg/m^3 from the QLD DES Moranbah (Utah Drive) AQMS 2020 dataset; and
- 1 hour and annual NO_2 concentrations – hourly varying concentrations of NO_x converted to NO_2 using NO_2 and ozone (O^3) from the QLD DES Pimlico 2015 dataset.

Due to the rural nature of the Project, it is assumed that existing ambient concentrations of CO, SO_2 and VOCs are negligible. There are also no monitoring data available for these pollutants in the vicinity of the Project.

As previously discussed, the North Goonyella Coal Mine is approximately 6 km south of the Project, and the main pollutants from the mine are PM_{10} and $PM_{2.5}$. There will be relatively minor contributions of CO, NO_x, SO_2 and VOCs as a result of methane emissions and flaring, fuel combustion from vehicles and potentially plant equipment. Given the distance of the mine from the Project (6 km), it is not anticipated that there would be significant combined impacts with the Project's contribution at assessment locations R1 and R2. As a result, emissions from the coal mine have not been included in the assumed background concentrations for this assessment. However, a semi-quantitative assessment of cumulative PM_{10} and $PM_{2.5}$ concentrations with the Project has been provided in Section 8.4.

6 Emissions inventory

6.1 Introduction

Inventories have been developed to quantify emissions of the various pollutants resulting from the operation of the Project. The main sources of pollutants are:

- compressor stacks (12);
- reboiler stacks (2);
- gas generators (2);
- backup diesel generator (1); and
- flares (2).

Flaring is expected to occur for a maximum of 24 hours in a year. It is anticipated that there will be one flare in the initial stages of the Project and two flares by Stage 3.

This AQIA assesses two scenarios:

- Scenario 1: normal operations for Stage 3 of the Project (all stacks except flares); and
- Scenario 2: as above with the inclusion of flares.

Each activity has been represented in the modelling as a point source. The modelled source locations are shown in Figure 6.1.

KEY

- Model source location
- Project footprint
- Proposed disturbance footprint
- Proposed gas compression facility layout

Source: EMM (2022); QPM (2022); DNRME (2021); ESRI (2022)

0 50 100 m

GDA 1994 MGA Zone 55

N

\\emmsvr1\EMM3\2021\E210671 - QPM Moranbah gas pipelines - approvals\GIS\02_Maps\NorthBowen\AirQuality\AQIA002_ModelSources_20221004_05.mxd 4/10/2022

Model source locations

QPM Energy Project

Air

Figure 6.1

EMM creating opportunities

6.2 Emissions estimates

Stack locations and parameters were provided by QPM Energy and are presented in Table 6.1.

Stack emissions rates (g/s) for the flares, reboiler stacks, gas generators and the backup diesel generator were also provided by QPM Energy. The flare emission rates were calculated using the US-EPA's AP-42 *Industrial Flares* document (US-EPA 2018). For Scenario 2, although flares will only operate for an expected maximum of 24 hours in a year, emissions were modelled for every hour of the year to capture worst-case meteorological conditions. All stacks have also been assumed to operate simultaneously however, this would not occur in reality.

Emission rates for the compressor stacks were calculated using compressor engine specifications provided by QPM Energy (for Waukesha VHP Series Five L7044GSI S5 compressor engines).

VOC speciation was determined using the US-EPA's speciation profiles from their 'Speciate' database[4] for natural gas combustion as follows:

- benzene = 0.11%;
- formaldehyde = 0.81%;
- toluene = 0.04%; and
- isomers of xylene = 0.02%.

It is noted that the flare exit velocity is 267 m/s. QPM Energy has confirmed this rate and has provided the following context regarding the design of the flares:

> The flare header is designed to API 521 with a high exit velocity (267m/s) to shift the flame epicentre away from the ground level (ie minimise personnel exposure). The maximum exit velocity is based on the maximum field to flare rate (46.1 TJ/d). Based on a 10" header, velocity is Mach 0.68 which is considered acceptable by design standards.

4 https://www.epa.gov/air-emissions-modeling/speciate-0

Table 6.1 Stack parameters and emission rates per stack

Parameter	Source				
	Compressors	Reboiler stacks	Gas generators	Backup diesel generator	Flares
Source type	Point	Point	Point	Point	Point
Operating load (%)	100%	100%	100%	100%	100%
Coordinates (MGA)	1: 602926, 7609265	1: 602990,7609304	1: 603062, 7609317	1: 603060, 7609326	1: 602964, 7609368
	2: 602941, 7609268	2: 602978,7609302	2: 603062, 7609321		2: 602905, 7609357
	3: 602957, 7609270				
	4: 602971, 7609273				
	5: 602997, 7609277				
	6: 603011, 7609280				
	7: 603027, 7609282				
	8: 603042, 7609285				
	9: 603058, 7609288				
	10: 602921, 7609295				
	11: 602936, 7609297				
	12: 602947, 7609299				
Stack height (m)	8	5	4.5	2	15
Stack diameter (m)	0.25	0.19	0.20	0.07	0.30
Exit velocity (m/s)	60	15	37.2	35.6	267
Temp (K)	871	423	825	755	303

Table 6.1 Stack parameters and emission rates per stack

Parameter	Source				
	Compressors	Reboiler stacks	Gas generators	Backup diesel generator	Flares
NO_x emission rate (g/s)	5.75	0.0067	0.416	0.111	15.6
PM_{10} emission rate (g/s)	N/A	0.0005	N/A	N/A	N/A
$PM_{2.5}$ emission rate (g/s)	N/A	0.0005	N/A	N/A	N/A
CO emission rate (g/s)	4.86	0.0056	0.194	0.015	84.8
SO_2 emission rate (g/s)	N/A	0.0000	N/A	0.026	N/A
VOC emission rate (g/s)	0.21	0.0004	0.162	N/A	151.3

Notes:

1. N/A = not applicable

7 Construction dust risk assessment

7.1 Overview

The risk of dust impacts during the construction of the Project was assessed using the *Guidance on the Assessment of Dust from Demolition and Construction* published by the Institute of Air Quality Management in the United Kingdom (IAQM 2014).

The main air pollution and amenity issues[5] at construction sites are:

- annoyance due to dust deposition (soiling of surfaces) and visible dust plumes;
- contamination of pipelines and requirement for dust removal;
- elevated concentrations of airborne particulate matter less than 10 micrometres (µm) in aerodynamic diameter (PM_{10}) due to dust-generating activities; and
- exhaust emissions from diesel-powered construction equipment[6].

Dust emissions can occur during the preparation of the land (eg demolition and earthmoving) and during construction itself. They can vary substantially from day to day depending on the level of activity, the specific operations being undertaken, and the weather conditions. The risk of dust impacts from a construction site is also influenced by factors such the meteorological conditions, the proximity of receptors to the activities, and the sensitivity of the receptors to dust. However, any effects of construction on air pollution and amenity are generally temporary and relatively short-lived. Moreover, mitigation should be straightforward, as most of the necessary measures are routinely employed as 'good practice' on construction sites. The IAQM approach therefore aims to identify risks and to recommend mitigation measures that are appropriate to the activities and location.

7.2 Details of construction

The construction footprint for the Project is shown on Figure 1.1.

The main construction activities of relevance to air quality will include:

- site clearing and vegetation removal;
- establishment of access roads;
- site mobilisation;
- vehicle movements;
- bulk earthworks and soil movement; and
- excavation work, including ground preparation.

5 There are other potential impacts, such as the release of heavy metals, asbestos fibres or other pollutants during the demolition of certain buildings. These issues need to be considered on a site by site basis (IAQM 2014).

6 Exhaust emissions from on-site plant and site traffic are unlikely to have a significant impact on local air quality, and in the majority of cases they will not need to be quantitatively assessed (IAQM 2014).

The majority of construction activities will take place between 7.00 am and 6.00 pm, seven days per week. During the commissioning phase, activities will also take place between 7.00 am and 6.00 pm, seven days per week, however for the final two weeks, commissioning activities will be 24 hours per day.

7.3 Risk assessment procedure

In the IAQM procedure, activities at construction sites are divided into four types: demolition, earthworks, construction and track-out (the transport of dust by vehicles from the construction site onto public roads).

The assessment method considers three separate dust impacts:

- annoyance due to dust soiling;
- the risk of health effects due to an increase in exposure to PM_{10}; and
- harm to ecological receptors.

The key steps in the IAQM procedure are:

- Step 1 – a screening requirement for a detailed assessment based on the proximity of surrounding receptors;
- Step 2 – an assessment of the risk of dust impacts and the sensitivity of surrounding receptors;
- Step 3 – a determination of site-specific mitigation;
- Step 4 – consideration of residual effects and significance; and
- Step 5 – an assessment report.

7.4 Risk assessment for Project

In Step 1 of the procedure, the IAQM guidance specifies that a detailed construction dust assessment should be undertaken if:

- a human receptor[7] is located within 350 m of the site boundary;
- an ecological receptor[8] is located within 50 m of the site boundary; or
- a human/ecological receptor is within 50 m of a route used by construction vehicles up to 500 m from a site entrance.

This step is deliberately designed to be conservative.

The results of Step 1 for the Project are summarised in Table 7.1. The Project is located in an area of low population density. There were no human receptors within 350 m of the boundary of the premises and within 50 m of construction routes, and no ecological receptors within 50 m of the boundary of the premises.

[7] A 'human receptor' refers to any location where a person or property may experience the adverse effects of airborne dust or dust soiling, or exposure to PM_{10} over a time period relevant to air quality standards and goals. In terms of annoyance effects, this will most commonly relate to dwellings, but may also refer to other premises such as museums, galleries, vehicle showrooms, food manufacturers, electronics manufacturers, amenity areas and horticultural operations.

[8] An 'ecological receptor' refers to any sensitive habitat affected by dust soiling. This includes the direct impacts on vegetation or aquatic ecosystems of dust deposition, and the indirect impacts on fauna (eg on foraging habitats).

Consequently, the proposed construction activities did not trigger a detailed assessment of construction impacts. Where the need for a more detailed assessment is screened out, as in this case, it can be concluded that the level of risk is ‘negligible’, and any effects will not be significant.

Human receptors		**Ecological receptors**		**Detailed assessment required**
Within 350 m of site boundary	**Within 50 m of route used by construction vehicles**	**Within 50 m of site boundary**	**Within 50 m of route used by construction vehicles**	
No	No	No	No	No

8 Operational assessment

8.1 Dispersion model selection and configuration

Atmospheric dispersion modelling for this assessment was completed using AERMOD.

Each emission source has been represented in the modelling as a point source. Details of the emissions estimation and dispersion modelling are provided in Chapter 6.

In addition to the two individual assessment locations (documented in Section 2.4), air pollutant concentrations were predicted over a 20 km (x axis) by 20 km domain (y axis) with 200 m resolution.

The modelled source locations are shown in Figure 6.1. Simulations were undertaken for the 12 month period of 2020.

8.2 NO_x to NO_2 conversion

The dispersion model was used to predict NO_x concentrations due to the Project's operations. These concentrations were then converted to NO_2 using the OLM as described in Annexure B.

8.3 Incremental results

8.3.1 Scenario 1

The predicted incremental concentrations of PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2 and specific VOCs as a result of the Project's operation in Scenario 1 are presented in Table 8.1, Table 8.2 and Table 8.3.

The predicted concentrations for all pollutants and averaging periods are below the applicable EPP (Air) air quality objectives at both assessment locations. The air quality objectives listed are applicable to cumulative concentrations and are only included here for reference purposes. An analysis of cumulative impacts is presented in Section 8.4.

The results for NO_2 and SO_2 are also below the more stringent, revised NEPM standards (as discussed in Section 2.4).

The results for Scenario 1 are considered conservative because the diesel generator is anticipated to operate sporadically for up to two weeks in total across the year but has been modelled for every hour of the year.

Contour plots, illustrating spatial variations in incremental NO_2 concentrations are provided in Annexure C. As the predicted concentrations of particulate matter, CO, SO_2 and VOCs were very low for the assessment locations, these have not been plotted as contours. The contour plots for the maximum 1-hour average NO_2 concentrations do not represent a particular hour, but rather the maximum concentration at each grid point in any hour of the year.

Table 8.1 Scenario 1 – incremental concentration results for PM_{10} and $PM_{2.5}$

Assessment location ID	Predicted incremental concentration (µg/m³)			
	PM_{10}		$PM_{2.5}$	
	Maximum 24-hour average	Annual average	Maximum 24-hour average	Annual average
Air quality objective	**50**	**25**	**25**	**8**
R1	0.03	0.0027	0.03	0.0025
R2	0.02	0.0005	0.02	0.0004

Table 8.2 Scenario 1 – incremental concentration results for CO, NO_2 and SO_2

Assessment location ID	Predicted incremental concentration					
	CO (mg/m³)	NO_2 (µg/m³)		SO_2 (µg/m³)		
	Maximum 8-hour average	Maximum 1-hour average	Annual average	Maximum 1-hour average	Maximum 24-hour average	Annual average
Air quality objective	**11**	**250**	**62**	**570**	**229**	**57**
R1	0.1	123.4	5.8	0.7	0.09	0.008
R2	0.1	96.5	0.9	0.5	0.07	0.001

Table 8.3 Scenario 1 – incremental concentration results for VOCs

Assessment location ID	Predicted incremental concentration					
	Benzene	Formaldehyde	Toluene		Xylenes	
	Annual average (µg/m³)	Annual average (µg/m³)	Maximum 24-hour average (mg/m³)	Annual average (µg/m³)	Maximum 24-hour average (mg/m³)	Annual average (µg/m³)
Air quality objective	**5.4**	**54**	**4.1**	**400**	**229**	**57**
R1	0.00050	0.0037	0.0000011	0.00018	0.0006	0.00009
R2	0.00007	0.0005	0.0000010	0.00003	0.0005	0.00001

8.3.2 Scenario 2

The predicted incremental concentrations of PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2 and specific VOCs as a result of the Project's operations in Scenario 2 are presented in Table 8.4 to Table 8.6.

Scenario 2 includes the same sources as Scenario 1, plus flares. The pollutants relevant to flares are NO_2, CO and VOCs. Therefore, the Scenario 2 results for PM_{10}, $PM_{2.5}$ and SO_2 remain unchanged from Scenario 1 but have been replicated in this section for completeness.

The predicted concentrations for all pollutants and averaging periods are below the applicable EPP (Air) air quality objectives at both assessment locations.

The results for NO_2 and SO_2 are also below the more stringent, revised NEPM standards.

The results for Scenario 2 are considered conservative because the diesel generator is anticipated to operate for two weeks in the year, and the two flares are expected to be operational for a maximum of 24 hours in a year and spread across multiple occasions. Both sources have been modelled for every hour of the year. This means that all meteorological conditions will be combined with the input emission rates (which would not happen in reality), and therefore the predicted annual average concentrations will be over-predicted. As noted above, even with a high level of conservatism assumed, the predicted results are well below the relevant air quality objectives for all pollutants at both assessment locations.

Contour plots, illustrating spatial variations in incremental NO_2 concentrations are provided in Annexure C.

Table 8.4 Scenario 2 – incremental concentration results for PM_{10} and $PM_{2.5}$

Assessment location ID	Predicted incremental concentration (µg/m³)			
	PM_{10}		$PM_{2.5}$	
	Maximum 24-hour average	Annual average	Maximum 24-hour average	Annual average
Air quality objective	**50**	**25**	**25**	**8**
R1	0.03	0.0027	0.03	0.0025
R2	0.02	0.0005	0.02	0.0004

Table 8.5 Scenario 2 – incremental concentration results for CO, NO_2 and SO_2

Assessment location ID	Predicted incremental concentration					
	CO (mg/m³)	NO_2 (µg/m³)		SO_2 (µg/m³)		
	Maximum 8-hour average	Maximum 1-hour average	Annual average	Maximum 1-hour average	Maximum 24-hour average	Annual average
Air quality objective	**11**	**250**	**62**	**570**	**229**	**57**
R1	0.6	140.2	5.3	0.7	0.09	0.008
R2	0.6	107.3	1.0	0.5	0.07	0.001

Table 8.6 Scenario 2 – incremental concentration results for VOCs

Assessment location ID	Predicted incremental concentration					
	Benzene	Formaldehyde	Toluene		Xylenes	
	Annual average (µg/m³)	Annual average (µg/m³)	Maximum 24-hour average (mg/m³)	Annual average (µg/m³)	Maximum 24-hour average (mg/m³)	Annual average (µg/m³)
Air quality objective	**5.4**	**54**	**4.1**	**400**	**229**	**57**
R1	0.05	0.36	0.0001	0.018	0.05	0.009
R2	0.01	0.06	0.0001	0.003	0.06	0.001

8.4 Cumulative results

Cumulative impacts (ie the Project plus background) at each assessment location have been assessed in the following way:

- for 24 hour average concentrations – each predicted 24-hour average concentration for PM_{10}, $PM_{2.5}$ from the Project has been combined with the corresponding concentrations from the 2020 background concentration datasets (Section 5.2.3); and
- for annual average concentrations – the predicted annual average concentrations have been paired with the corresponding background annual average concentration (Section 5.2.3).

As described in Section 5.2.4, due to the rural nature of the Project, it is assumed that existing ambient concentrations of CO, SO_2 and VOCs are negligible. On this basis, the ambient background for these pollutants can be assumed to be very low and compliance with the impact assessment criteria can be inferred based on the Project increment. There are also no monitoring data available for these pollutants in the vicinity of the Project.

The predicted cumulative PM_{10} and $PM_{2.5}$ concentrations as a result of the Project's operations are presented in Table 8.7. Table 8.7 shows that the results for PM_{10} and $PM_{2.5}$ are below the applicable EPP (Air) air quality objectives at both assessment locations.

Table 8.7 Scenario 1 and 2 – cumulative concentration results for PM_{10} and $PM_{2.5}$

Assessment location ID	Predicted cumulative concentration (µg/m³)			
	PM_{10}		$PM_{2.5}$	
	Maximum 24-hour average	Annual average	Maximum 24-hour average	Annual average
Air quality objective	**50**	**25**	**25**	**8**
R1	42.0	21.1	23.5	6.4
R2	42.0	21.1	23.5	6.4

8.5 Influence of North Goonyella Coal Mine

The North Goonyella Coal Mine is approximately 6 km south of the Project and the main source of pollutants from the mine are particulate matter in the form of PM_{10} and $PM_{2.5}$. There will be relatively minor contributions of CO, NO_x, SO_2 and VOCs as a result of fugitive gas emissions and flaring and fuel combustion from vehicles and potentially plant equipment. Given the distance of the mine from the Project (6 km), it is not anticipated that there would be significant combined impacts with the Project's contribution at assessment locations R1 and R2. However, a semi-quantitative assessment of cumulative PM_{10} and $PM_{2.5}$ concentrations with the Project is provided here.

An AQIA for the Goonyella Coal Mine completed in 2010 (hereafter referred to as the NGCM AQIA) predicted PM_{10} and $PM_{2.5}$ concentrations at the two assessment locations included in this report (Noise Mapping Australia 2010). The results presented in the NGCM AQIA were cumulative only (ie Incremental results were not shown). The NGCM AQIA predicted results for three operational scenarios (Cases 1 to 3). The predicted PM_{10} and $PM_{2.5}$ concentrations for the worst-case scenario (Case 3) are shown in Table 8.8.

When the predicted maximum 24 hour PM_{10} concentration from the Project is added to the values shown in Table 8.8, the results remain unchanged from the NGCM AQIA (given the low incremental contribution from the project) and therefore under the air quality objectives when the Goonyella Coal Mine is considered. It is noted that as the NGCM AQIA results included background which may vary to that assumed in this AQIA. However, the increment predicted from the Project is minor in comparison (0.03 $\mu g/m^3$ and 0.02 $\mu g/m^3$ for 24 hour PM_{10} and $PM_{2.5}$ respectively), and therefore there is no material change to the results predicted in the NGCM AQIA. As a result, predictions at R1 and R2 would still be under the air quality objectives for particulate matter when the NGCM is considered.

Table 8.8 Goonyella Coal Mine AQIA particulate matter results for Case 3 (Noise Mapping Australia 2010)

Assessment location ID	Predicted incremental concentration ($\mu g/m^3$)	
	PM_{10}	$PM_{2.5}$
	Maximum 24-hour average	Maximum 24-hour average
Air quality objective	**50**	**25**
Denham Park (old) Homestead (R1 in this report)	43	10
Dabin Station Homestead (R2 in this report)	24	7

9 Mitigation

QPM has committed to a range of mitigation measures and management practices to minimise pollutant emissions from the Project's construction and operation. These are detailed below.

9.1 Mitigation measures - construction

The Project would be constructed according to conventional methods and would be guided by a Construction Environmental Management Plan (CEMP) to effectively manage environmental impacts.

According to the IAQM guidance:

> for those cases where the risk is assigned as 'negligible', no mitigation measures beyond those required by legislation are required. However, additional mitigation measures ... may be applied as part of good practice.

The Project would be constructed according to conventional methods and would be guided by a CEMP to effectively manage environmental impacts. The CEMP may include (but will not be limited to) the mitigation measures listed below:

- maintain a logbook throughout the construction phase, to include:
  - any complaints relating to dust, and where a dust complaint is received the response actions;
  - any exceptional incidents that cause dust and/or air emissions, either on- or off-site, and the response actions; and
  - the results of site inspections (see below);
- limit the extent of clearing of vegetation and topsoil to the designated footprint for construction;
- erect cloth barriers around potentially dusty activities such as trench excavations and material stockpiles where practicable;
- erect bunds around the site perimeter to a minimum height of 4 m;
- avoid dry sweeping of large areas;
- provide an adequate water supply on the construction site for effective dust suppression/mitigation, including:
  - keeping site fencing and barriers clean using wet methods;
  - deploying water carts to ensure that exposed areas and topsoils/subsoil are kept moist; and
  - washing vehicle wheels prior to on-site movement and exit onto public roads;
- seal all road surfaces to minimise the potential for dust release and/or use of water carts to prevent dust;
- impose a maximum-speed-limit of 20 km/h on all internal roads and work areas during construction;
- ensure proper maintenance and tuning of all equipment engines;

- limit construction activity during periods of adverse weather (hot, dry and windy conditions) and when dust is seen leaving the site;
- minimise drop heights from loading or handling equipment;
- ensure vehicle loads entering and leaving sites are covered to prevent escape of materials during transport;
- control (reduce) trips and trip distances where possible, such as by coordinating delivery and removal of materials; and
- re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.

Visual monitoring by construction personnel will represent an effective means of dust monitoring during construction. Visual monitoring should comprise of the following:

- Undertaking daily on-site and off-site inspections to monitor dust. The inspection results should be recorded in a specific log. Inspection should include regular dust soiling checks of surfaces such as street furniture and cars.
- At the commencement of each day's activities, the local meteorological forecast should be reviewed, including the timing of notable increases in wind speed and/or temperature. Appropriate increased intensity or additional mitigation measures should be planned for the day based on this forecast review. The likely meteorological conditions and implications for dust emissions and impacts should be discussed at the morning toolbox meeting.
- Increasing the frequency of site inspections when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions. Should notable visual dust emissions be observed leaving the site boundary, increased intensity or additional mitigation measures should be deployed.

For almost all construction activities the aim should be to prevent significant effects on receptors through effective mitigation. Experience shows that this is normally possible. Hence the residual effect will normally be 'not significant' (IAQM 2014).

9.2 Mitigation measures - operations

QPM Energy has committed to implementing a range of specific mitigation measures for each proposed stack to be used during the Project's operations (see Table 9.1).

Table 9.1 Proposed mitigation measures

Stacks	QPM proposed mitigation measure
Compressors	Use of low NO_X engines or catalytic convertors.
Reboiler stacks	Minimise the use of stripping gas as far as practicable.
Gas generators	Use of low NO_X engines or catalytic convertors.
Backup diesel generator	Minimise the use of diesel generators as far as practicable (noting they are only used as backup).
Flares	Minimise the use of flares as far as practicable.

10 Conclusion

Dispersion modelling has been completed for two operational scenarios for the proposed GCF at Wards Well using the AERMET/AERMOD system. Hourly meteorological observations from 2020, measured at the QLD DES Moranbah (Utah Drive) air quality monitoring station were used as input to the dispersion modelling. Concentrations were predicted for two assessment locations.

The results of the modelling show that the predicted concentrations for PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2, and individual VOC concentrations were below the EPP (Air) air quality objectives at both assessment locations.

Cumulative impacts for particulate matter were assessed by combining the incremental concentrations for the Project with background concentrations. The cumulative results showed that compliance with applicable EPP (Air) impact assessment criteria was predicted at both assessment locations.

The modelling assessment for the Project is considered to be conservative, as it assumes that all sources are operating for every hour of the year. In reality, sources such as the diesel generator and the flares (included in Scenario 2) would operate for less than two weeks of the year.

References

Bureau of Meteorology (BoM) 2022, observations from Moranbah Airport AWS (Station Number 034035).

DES 2019, *Environmental Protection (Air) Policy 2019*.

DES 2021, Application requirements for activities with impacts to air.

IAQM 2014, Guidance on the assessment of dust from demolition and construction, Version 1.1, Institute of Air Quality Management, London, www.iaqm.co.uk/text/guidance/construction-dust-2014.pdf.

Noise Mapping Australia (2010), Eaglefield Expansion Project: Environmental Impact Statement, Appendix F6 of the EIS, prepared by Noise Mapping Australia for MET Serve, December 2010.

NSW EPA 2017, Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, Environment Protection Authority, January 2017.

QLD DES 2022, observations from Moranbah (Utah Drive) AQMS.

US-EPA 2013, AERSURFACE User's Guide.

US-EPA 2018, Industrial Flares, final section, February 2018.

Annexure A

Meteorological processing and modelling

EMM
creating opportunities

A.1 Meteorological data analysis

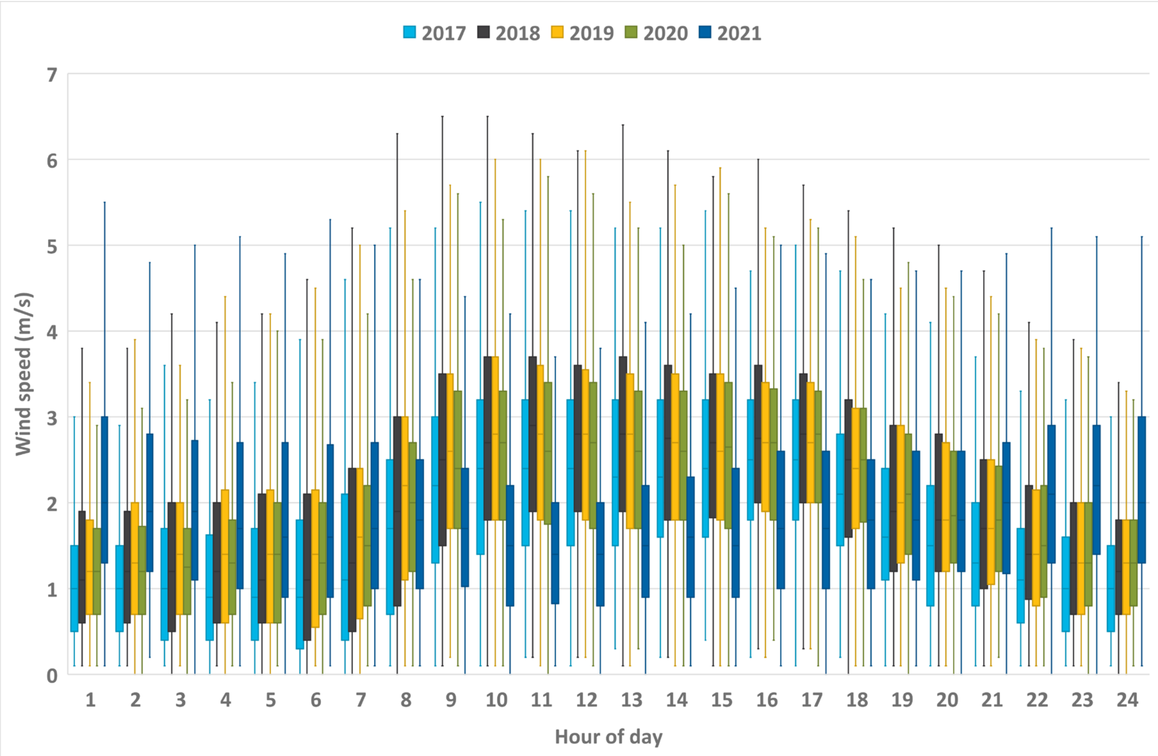


Figure A.1 Inter-annual variability in diurnal wind speed – QLD DES Moranbah (Utah Drive) – 2017 to 2021

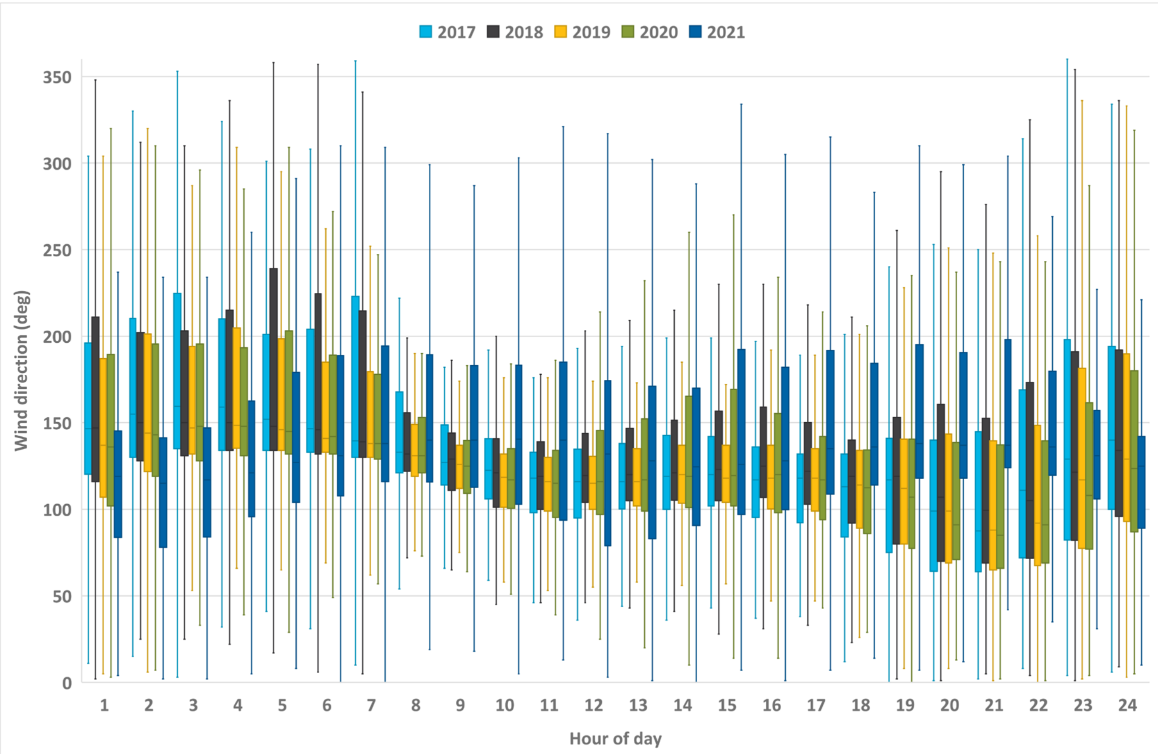


Figure A.2 Inter-annual variability in diurnal wind direction – QLD DES Moranbah (Utah Drive) – 2017 to 2021

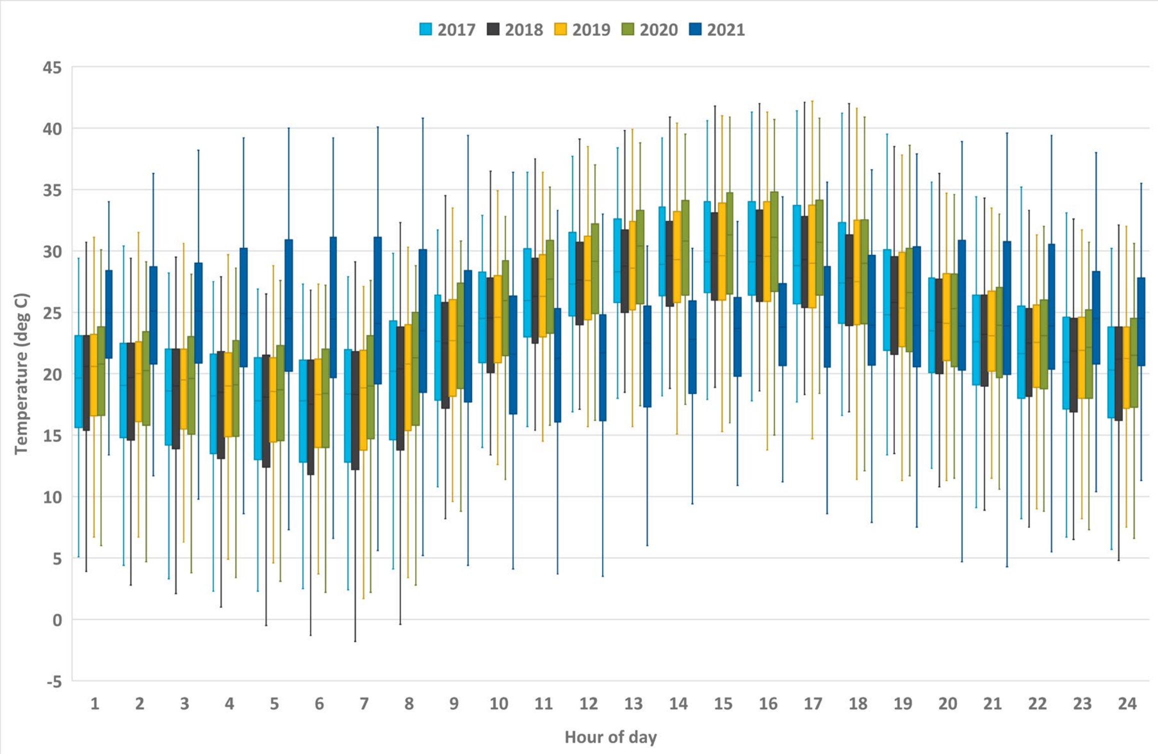


Figure A.3 Inter-annual variability in diurnal air temperature – QLD DES Moranbah (Utah Drive) – 2017 to 2021

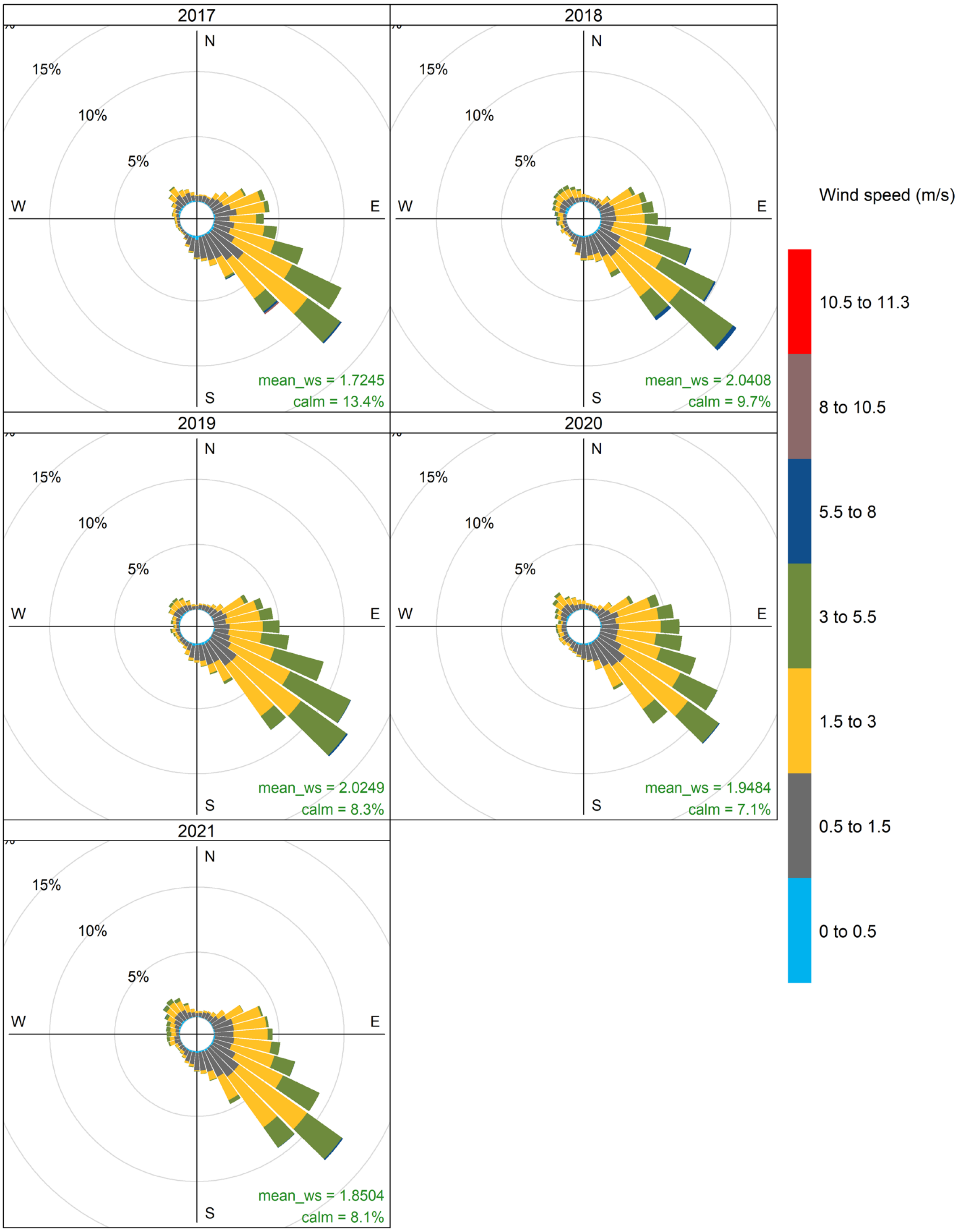


Figure A.4 Annual wind roses for QLD DES Moranbah (Utah Drive), 2017 – 2021

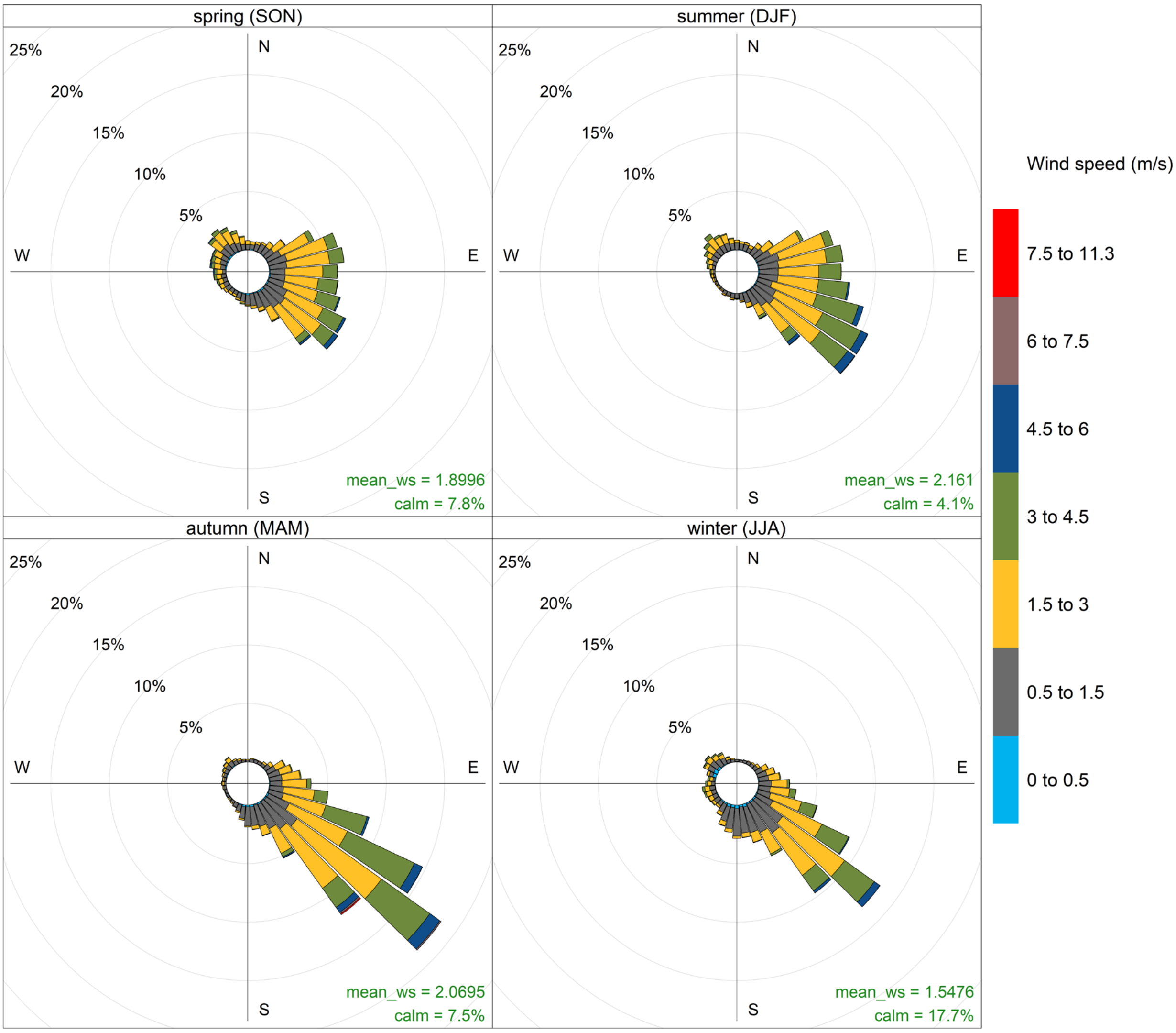


Figure A.5 Seasonal wind roses for QLD DES Moranbah (Utah Drive), 2017 – 2021

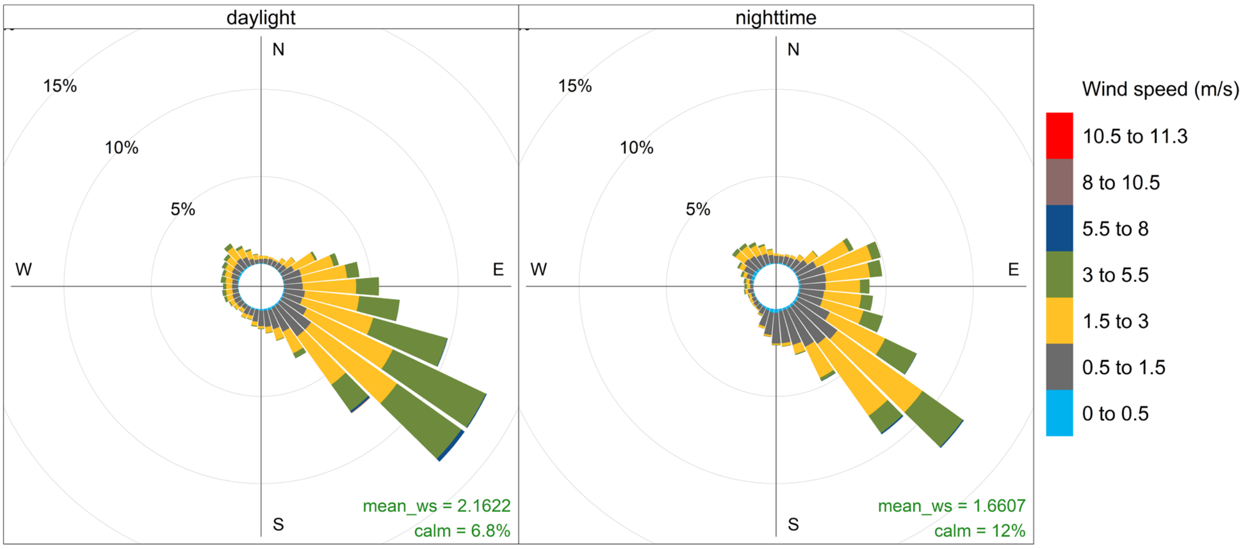


Figure A.6 Diurnal wind roses for QLD DES Moranbah (Utah Drive), 2017 – 2021

A.2 Meteorological modelling

i TAPM modelling

To supplement the meteorological monitoring datasets adopted for this assessment, the 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 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 and 3 km. Each grid domain features 25 x 25 horizontal grid points and 35 vertical levels;
- TAPM default databases for land use, synoptic analyses and sea surface temperature;
- TAPM defaults for advanced meteorological inputs; and
- two 'spin-up' days allowed at the beginning and end of the run.

A.3 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.3.1 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.

Land cover over an area of approximately 10 km (y axis) and 10 km (x axis) surrounding the Project was mapped using aerial photography and specific land-use codes in AERMET. The AERSURFACE tool then determined the appropriate surface roughness, albedo and Bowen ratio values using the resultant land-use file and internal algorithms. Land use types in the area surrounding the Project include shrubland, and strip mining (to represent the North Goonyella Coal Mine).

Meteorological data from the QLD DES Moranbah (Utah Drive) AQMS were combined with TAPM meteorological modelling outputs for input to AERMET. Cloud data were sourced from the Moranbah Airport AWS operated by BoM.

The following parameters were input as on-site data to AERMET:

- wind speed and direction;
- temperature (10 m);
- cloud cover; and
- mixing depth – TAPM at the location of the project.

The period of meteorological data input to AERMET was 1 January 2020 to 31 December 2020.

A.3.2 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 (10 m) temperature observations from the QLD DES Moranbah (Utah Drive) AQMS.

Annexure B

NO_x to NO_2 conversion methodology

B.1 Background

The estimation of NO_2 concentrations is not straightforward. One reason for this is that the conversion of NO to NO_2 occurs in the atmosphere following release from the source, and is dependent on the local atmospheric conditions, including the amount of ozone available. For this assessment, NO_2 concentrations were estimated using the ozone limiting method (OLM), as defined in the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA 2017). The same overall approach was applied to both discrete receptors and gridded receptors (for contour plots).

B.2 Ozone limiting method

The OLM uses a simple approach to the reaction chemistry of nitric oxide (NO) and O_3 in order to estimate NO_2 concentrations. It is assumed that all the available O_3 in the atmosphere will react with the NO from the source until either all the O_3 is consumed.

The OLM is represented by the following equation (NSW EPA 2017):

$$[NO_2]_{total} = \{0.1 \times [NO_X]_{pred}\} + MIN\ \{(0.9) \times [NO_X]_{pred} \text{ or } (46/48) \times [O_3]_{bgd}\} + [NO_2]_{bgd}$$

Where:

$[NO_2]_{total}$	=	predicted concentration of NO_2 in µg/m^3
$[NOX]_{pred}$	=	dispersion model prediction of NO_X in µg/m^3
MIN	=	minimum of the two quantities within the braces
$[O_3]_{bgd}$	=	background ambient O_3 concentration in µg/m^3
(46/48)	=	molecular weight of NO_2 divided by the molecular weight of O_3 in µg/m^3
$[NO_2]_{bgd}$	=	background ambient NO_2 concentration in µg/m^3

The OLM – in the above form – is based on the assumption that 10% of the initial NO_X emissions are NO_2. The emitted NO reacts with ambient ozone to form additional NO_2. If the ozone concentration is greater than 90% of the predicted NO_X concentration, all the NO_X is assumed to be converted to NO_2. Otherwise, NO_2 concentrations are calculated on the assumption of total conversion of the ozone. The predicted NO_2 concentration is then added to the background NO_2 concentration.

Continuous 1-hour average background concentrations of NO_2 and O_3 are (ideally) obtained for the same period as the dispersion modelling predictions over one year. The value of $[NO_2]_{total}$ is then calculated for every hour of the dispersion model simulation by substituting the hourly values of $[NO_X]_{pred}$, $[NO_2]_{bgd}$ and $[O_3]_{bgd}$ into the above equation.

The OLM yields various statistics for NO_2, including:

- the annual mean concentration (based on the 1-hour predictions for a year);
- the maximum concentration;
- percentile concentration values; and
- the frequency with which the 1-hour NO_2 criterion is exceeded.

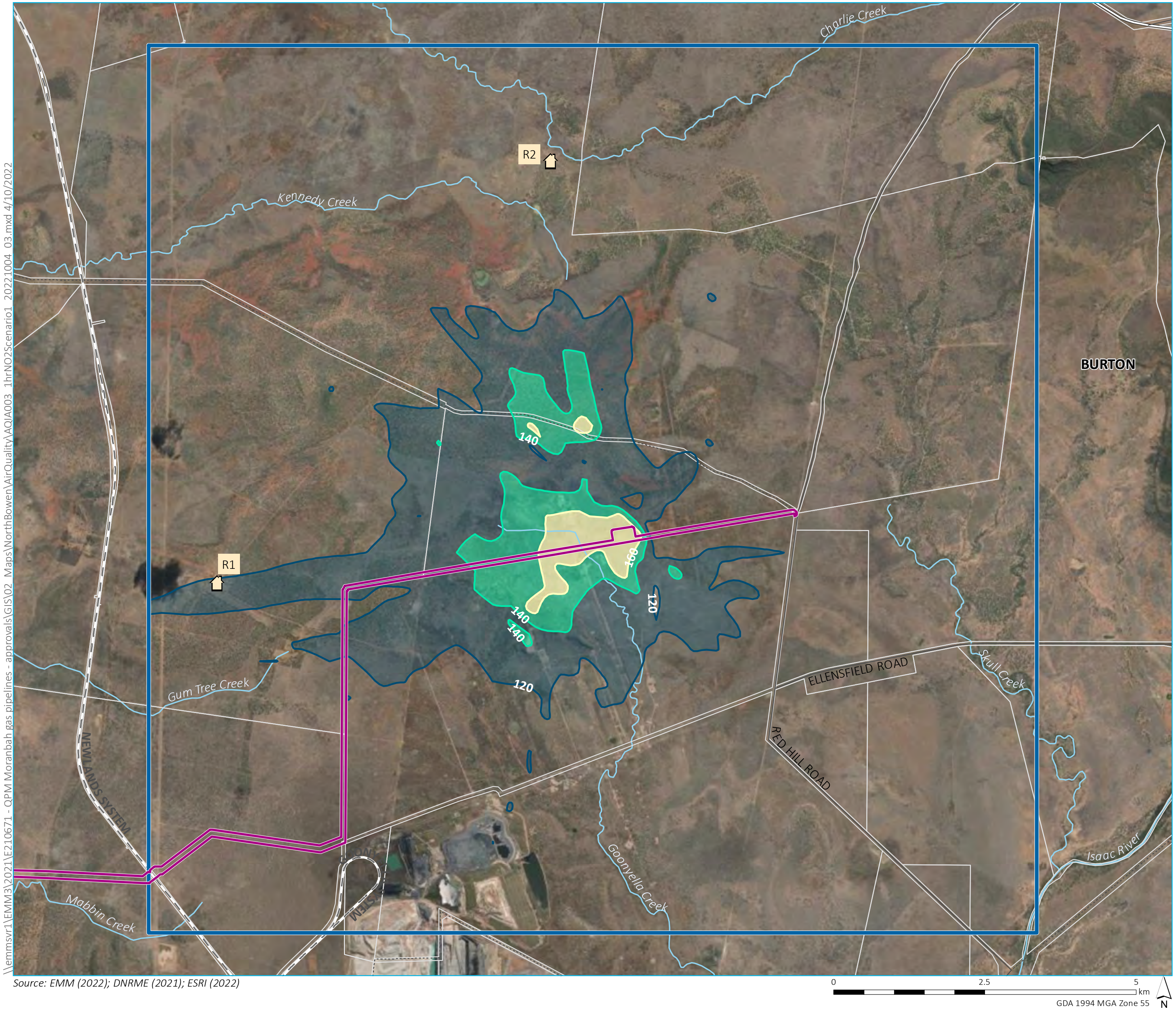
B.3 Monitoring data

The OLM requires a record of 1 hour NO_2 and O_3 concentrations over a year. There are no AQMSs in the vicinity of the Project that record 1 hour NO_2 and O_3 concentrations. The closest station recording these data (Pimlico AQMS) is located near the Port of Townsville approximately 287 km north-west of the Project. As the Pimlico monitoring station was decommissioned in 2016, the last full year of monitoring data were 2015. The 2015 data were therefore used in the OLM. This is noted as a limitation of the calculations, as the model predictions (and meteorology) for the assessment were for a different year (2020).

The Pimlico 2015 dataset had a high data capture rate for both O_3 and NO_2 (around 95%), with the missing periods generally being the hours for automatic instrument calibration. When applying the OLM, it is important to have a complete set of hourly measurements for the year. The concentrations for the calibration hours were mostly filled using interpolation, based on the previous and subsequent hours or, in the few instances where the gaps were larger, using the data from the previous day. For one six-day period there were O_3 data but no NO_2 data. For this period, NO_2 concentrations were estimated from the O_3 concentrations based on a polynomial regression model derived from the concentrations in the whole of 2015.

Annexure C
Contour plots

EMM
creating opportunities



Source: EMM (2022); DNRME (2021); ESRI (2022)

\\emmsvr1\EMM3\2021\E210671 - QPM Moranbah gas pipelines - approvals\GIS\02_Maps\NorthBowen\AirQuality\AQIA003_1hrNO2Scenario1_20221004_03.mxd 4/10/2022

KEY

- Assessment location
- Study area
- Project footprint
- Rail line
- Major road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary

NO_2 concentration (µg/m^3)

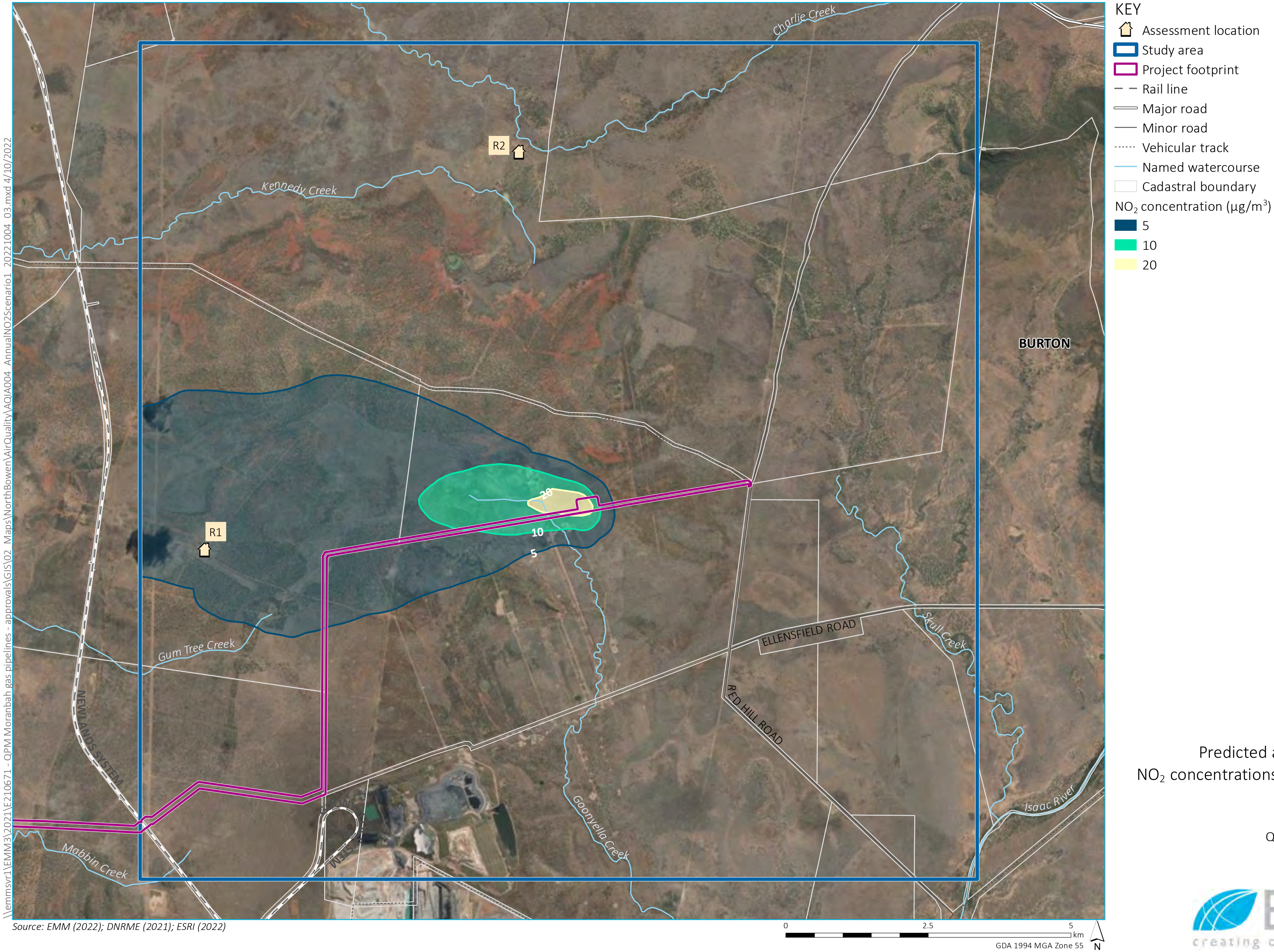
- 120
- 140
- 160

Predicted maximum 1-hour average NO_2 concentrations – project only (Scenario 1)

QPM Energy Project

Air

Figure C.1

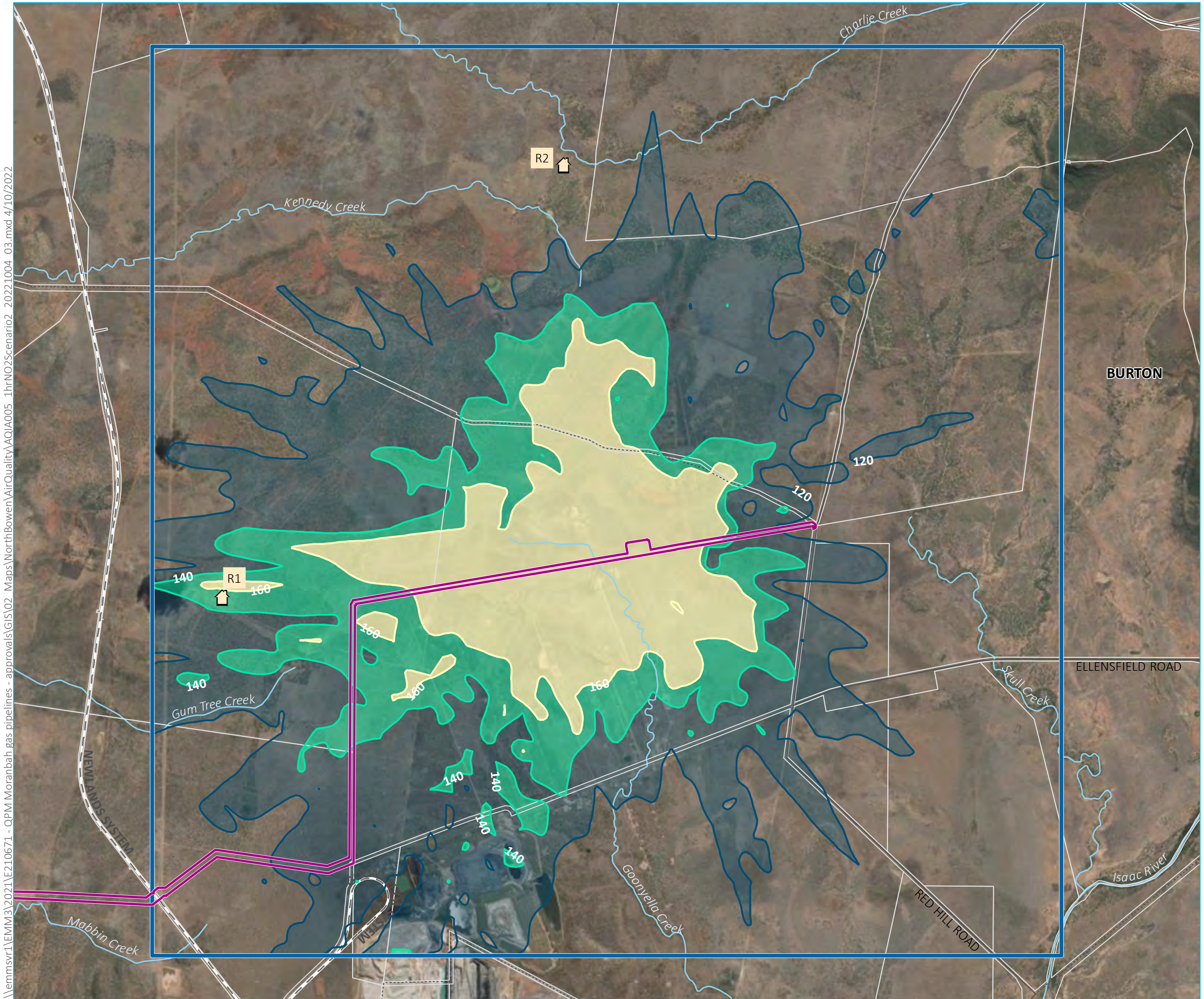


Source: EMM (2022); DNRME (2021); ESRI (2022)

Predicted annual average NO_2 concentrations – project only (Scenario 1)

QPM Energy Project
Air
Figure C.2

EMM creating opportunities



KEY

- Assessment location
- Study area
- Project footprint
- Rail line
- Major road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary

NO_2 concentration (µg/m^3)

- 120
- 140
- 160

Source: EMM (2022); DNRME (2021); ESRI (2022)

0 2.5 5 km

GDA 1994 MGA Zone 55

N

\\emmsvr1\EMM3\2021\E210671 - QPM Moranbah gas pipelines - approvals\GIS\02_Maps\NorthBowen\AirQuality\AQIA005_1hrNO2Scenario2_20221004_03.mxd 4/10/2022

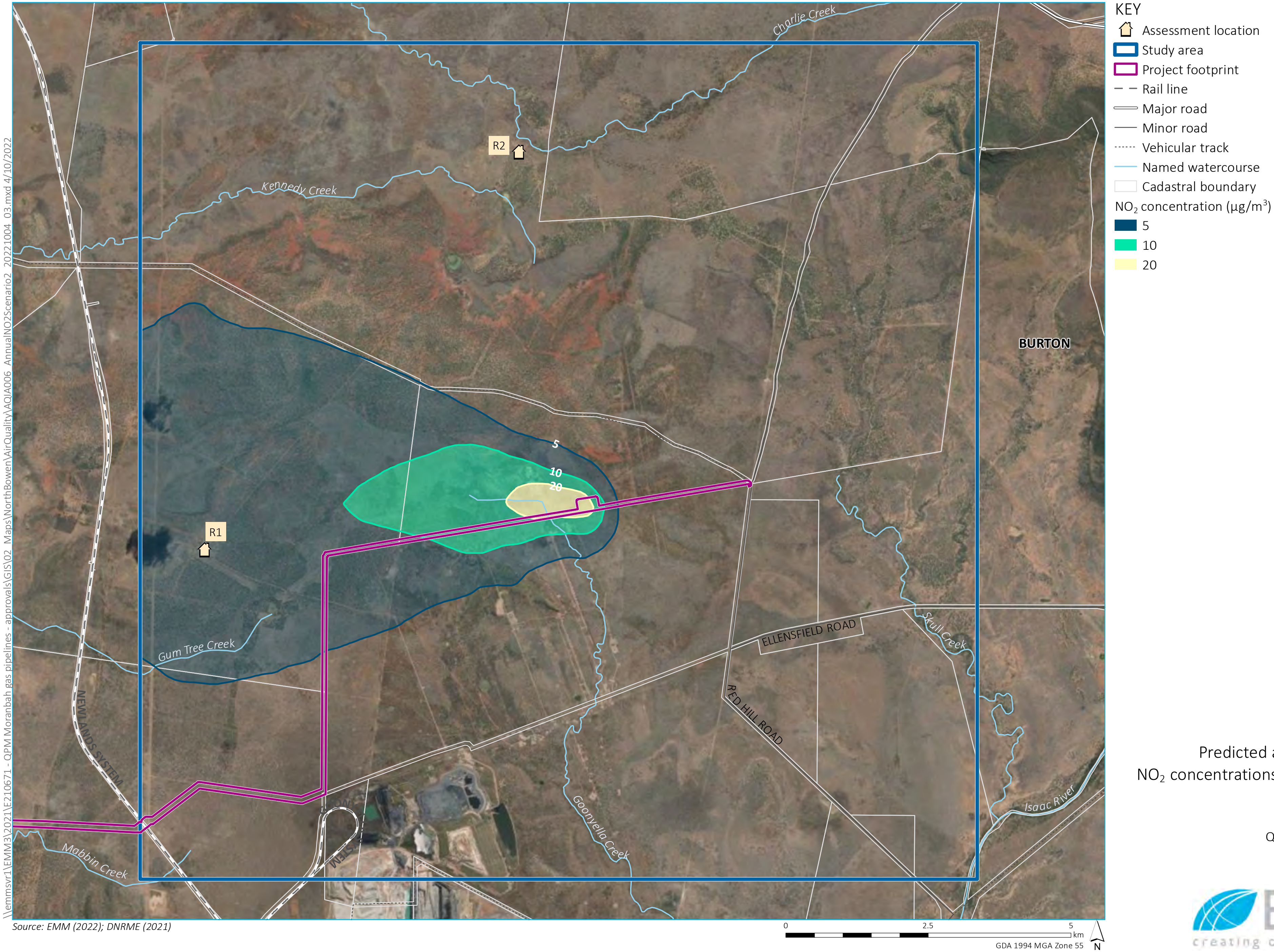
Predicted maximum 1-hour average NO_2 concentrations – project only (Scenario 2)

QPM Energy Project

Air

Figure C.3

EMM creating opportunities



Source: EMM (2022); DNRME (2021)

\\emmsvr1\EMM3\2021\E210671 - QPM Moranbah gas pipelines - approvals\GIS\02_Maps\NorthBowen\AirQuality\AQIA006_AnnualNO2Scenario2_20221004_03.mxd 4/10/2022

Predicted annual average NO_2 concentrations – project only (Scenario 2)

QPM Energy Project

Air

Figure C.4

Australia

SYDNEY
Ground floor 20 Chandos Street
St Leonards NSW 2065
T 02 9493 9500

NEWCASTLE
Level 3 175 Scott Street
Newcastle NSW 2300
T 02 4907 4800

BRISBANE
Level 1 87 Wickham Terrace
Spring Hill QLD 4000
T 07 3648 1200

CANBERRA
Level 2 Suite 2.04
15 London Circuit
Canberra City ACT 2601

ADELAIDE
Level 4 74 Pirie Street
Adelaide SA 5000
T 08 8232 2253

MELBOURNE
Suite 8.03 Level 8
454 Collins Street
Melbourne VIC 3000
T 03 9993 1900

PERTH
Suite 9.02 Level 9
109 St Georges Terrace
Perth WA 6000

Canada

TORONTO
2345 Younge Street Suite 300
Toronto ON M4P 2E5

VANCOUVER
60 W 6th Ave Suite 200
Vancouver BC V5Y 1K1

linkedin.com/company/emm-consulting-pty-limited
emmconsulting.com.au