Hanson Construction Materials Pty Ltd

Level 1 Assessment - Bunyip Quarry

Existing Conditions

November 2019

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1. Introduction

1.1 Context

GHD Pty Ltd (GHD) has been engaged by Hanson Construction Materials Pty Ltd (Hanson) to undertake a Level 1 Air Quality Assessment as part of an EES for a proposed granite quarry in Bunyip North (herein after 'the Project'). One of the components of the assessment involved the deployment of an automatic weather station and air quality monitoring program at the subject site to characterise the existing environment prior to the preparation of an air quality assessment using dispersion modelling.

1.2 Purpose of this report

This report presents the results of the baseline monitoring for the purpose of characterising the existing meteorology and air quality environment at the Project Site and at surrounding sensitive land use areas. This data will inform the Air Quality Impact Assessment (AQIA) EES Chapter and supporting technical reports to this Chapter.

1.3 Limitations

This report has been prepared by GHD for Hanson Construction Materials Pty Ltd and may only be used and relied on by Hanson Construction Materials Pty Ltd for the purpose agreed between GHD and the Hanson Construction Materials Pty Ltd as set out in section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than Hanson Construction Materials Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Hanson Construction Materials Pty Ltd and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The assessments in this report are based on onsite inspections and measurements obtained by GHD between November 2018 and November 2019. Due to the nature of environmental assessments, this report cannot assert that all variations in environmental conditions of the site have been assessed and uncertainty concerning the conditions of the ambient air quality environment cannot be completely eliminated. It is neither the intention of this assessment to cover every element of the air, noise and vibration environment, but rather to conduct the assessment with consideration to the prescribed scope of work. Professional judgement must be expected in the investigation and interpretation of observations.

1.4 Assumptions

- All data used from monitoring equipment provided accurate measurements unless otherwise stated
- This report has been written based on the information on hand as of November 2018
- The selected monitoring locations are reasonably representative of the existing background environment

2. Overview of monitoring program

A component of the AQIA involved the deployment of an automatic weather station and an air quality monitoring station at the subject site (as shown in Figure 1) to characterise the local meteorology and background air quality. The monitoring program[1] was designed in accordance with the Mining Protocol for Environmental Management (Mining PEM) and was subsequently approved by EPA Victoria in April 2017[2].

Air quality and meteorological monitoring equipment was installed at the Project Site in August 2017 and decommissioned in December 2018.

The following parameters were measured as part of the monitoring programme:

- Meteorology:
  - Temperature (at 2 m and 10 m)
  - Wind speed at 10 m
  - Wind direction at 10 m
  - Rainfall
  - Relative humidity
  - Net radiation
- Air quality:
  - PM_{10} (EBAM for 24 hour averages)
  - $PM_{2.5}$ (EBAM for 24 hour averages)
  - Dust deposition for monthly (annual averaged) nuisance dust)
  - Respirable crystalline silica (RCS) in PM2.5 (ambient and in crushed granite core samples)

2.1 Engagement with EPA Victoria

Subsequent to the conclusion of the monitoring program, GHD presented the baseline meteorology and air quality results and proposed modelling methodology, using the data from the monitoring program, to EPA Victoria. The baseline monitoring results and modelling methodology was subsequently approved by EPA Victoria in February 2019[3]. In summary EPA Victoria concluded:

- The baseline data obtained is reasonably representative of the site and will be suitable for determining background conditions
- The PM_{10}, $PM_{2.5}$, dust deposition and RCS monitoring are of an acceptable quality
- The ancillary meteorological and modelling input data to be accepted and would be useful to assess any differences between site specific conditions and those at the nearest BoM site

[1] GHD letter 3134861-11711, dated 16 March 2017 (Monitoring Option 1)

[2] Email from Paula Bradshaw, Manager Major Projects EPA Victoria, dated 26 April 2017

[3] Email from Kristel Hartlief, Team Leader - Major Projects EPA Victoria, dated 15 February 2019

2.2 Modelling period and data availability

The Mining PEM requires real time continuous 24-hour PM_{10} and $PM_{2.5}$ data for a 12-month period, analysis of crystalline silica ($PM_{2.5}$ fraction) and heavy metal content (PM10) (where applicable).

Monitoring was undertaken from August 2017 until December 2018. The 12 month period with the lowest number of 24-hour averaged days missing was selected. This was determined to be between 4 November 2017 and 3 November 2018.

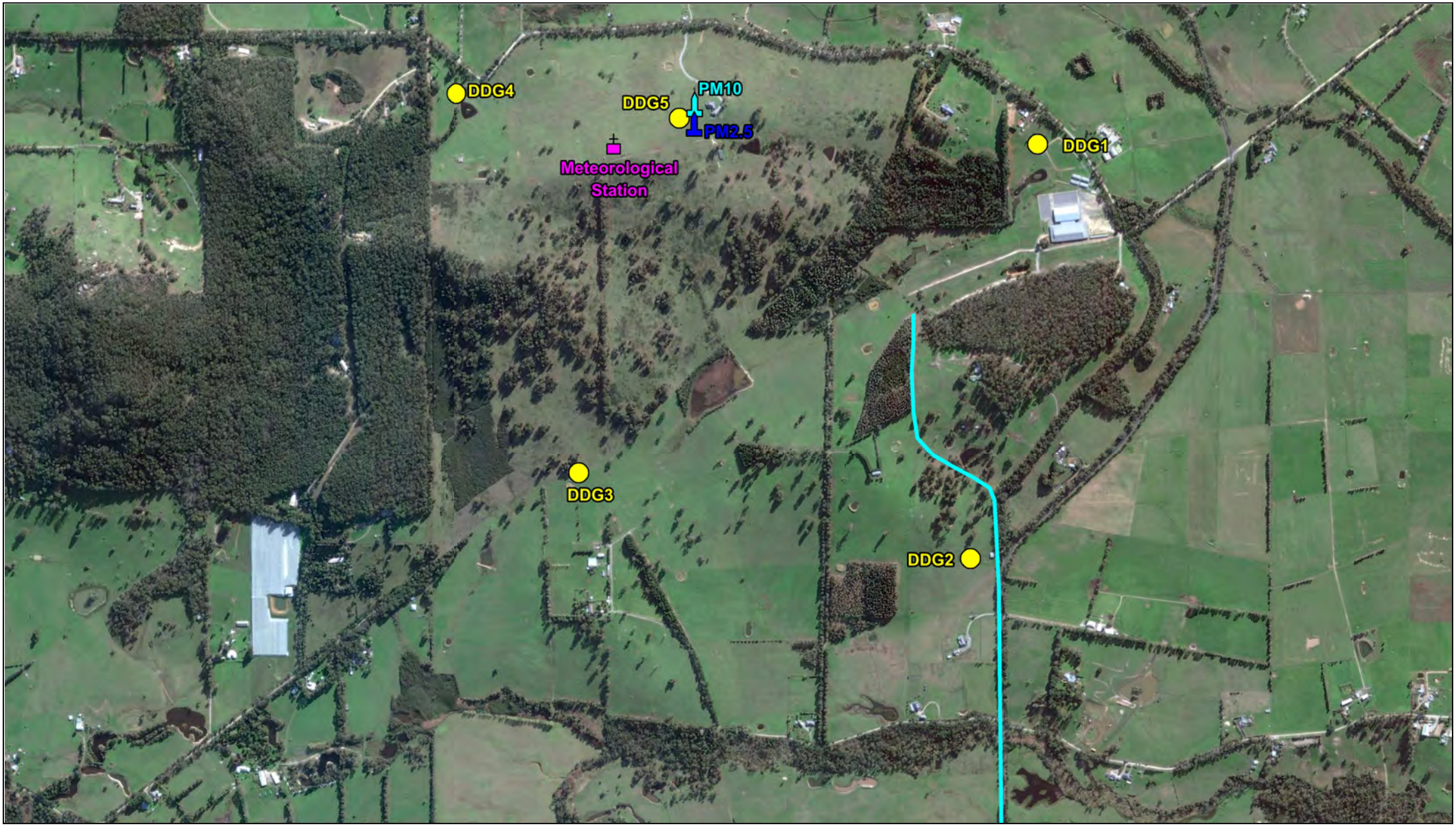
A summary of the seasonal data availability during this period is provided in Table 1. From Table 1, it can be seen that the data availability for each of the four seasons is greater than 75%, in line with standard EPA practice[4].

Table 1 Data availability for 4 November 2017 to 3 November 2018

Data availability	Data available PM_{10} (%)	Data available $PM_{2.5}$ (%)
Summer	99	90
Autumn	99	95
Winter	89	90
Spring	100	99
Total	**97**	**93**

Therefore, the air quality and meteorological data presented within this report were collected within this period.

[4] Methodology outlined in EPA Publication 1703



1:16,000

0 160 320 480

Metres (at A4)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

N

LEGEND

Meteorological Station

Haul Route

PM10

PM2.5

DDG

Hanson Construction Materials Pty Ltd
Bunyip North Quarry EES

Job Number	31-34861
Revision	A
Date	23-05-2017

GHD CLIENTS | PEOPLE | PERFORMANCE

Hanson

Monitoring equipment locations

Figure 1

G:\31\34861\GIS\Maps\Working\3134861_Garfield.WOR

8/180 Lonsdale St Melbourne VIC 3000 Australia **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com.au **W** www.ghd.com.au

Data Source: Google Earth Pro. Created by: CMcVie

3. Legislation, policy and guidelines

3.1 Protocol for Environmental Management: Mining and Extractive Industries

The Protocol for Environmental Management: Mining and Extractive Industries (Mining PEM) is an incorporated document of the State environment protection policy (Air Quality Management) 2001 (SEPP AQM). It supports the interpretation of SEPP (AQM) and sets out the statutory requirements for the management of emissions to the air environment from activities such as the Project.

3.1.1 Assessment criteria

The Mining PEM outlines specific assessment criteria that are used to evaluate the impact of any emissions from the mining or extractive industry's operation, in addition to the existing air quality. The criteria were developed for the protection of human health and that the beneficial uses outlined in the SEPP (AQM) are protected. The criteria relevant to Bunyip Quarry are reproduced in Table 2.

GHD notes that core rock samples at the subject site were analysed for arsenic and asbestos and no evidence was detected in any of the samples analysed (discussed further in section 4.1.3). Therefore, these indicators are not considered relevant for the AQIA and have not been listed in Table 2.

It is noted that the criteria outlined in Table 2 are used to assess the total concentration of background plus emissions arising from activities at the Project Site. The results presented within this report are background only (i.e. no emissions from activities at the Project Site), and therefore a comparison against these criteria has been provided for context only. An assessment against the criteria in Table 2 is provided in the AQIA.

Table 2 Mining PEM 2007 assessment criteria

Indicator	Criteria	Averaging period
PM_{10}	60 µg/m^3	24 hour average
$PM_{2.5}$	36 µg/m^3	24 hour average
Respirable crystalline silica (as $PM_{2.5}$)	3 µg/m^3	Annual average

Furthermore, with regards to the monitoring of deposited dust, the Mining PEM (ibid.) states the following:

"Results of [deposited dust] monitoring should not exceed 4g/m^2 /month (no more than 2g/m^2 /month above background) as a monthly average."

This value of 4 g/m^2/month has been adopted from the *NSW Approved Methods for the modelling and assessment of air pollutants in NSW* (NSW Approved Methods), and will be used in this report.

It is noted that TSP is not listed as an indicator in the Mining PEM and has therefore not been considered in this report.

3.1.2 Level of assessment

Section 3.4 of the Mining PEM outlines three levels (Level 1 – Level 3) when assessing the air emissions from mining and extractive industries. The levels are determined based on the size/throughput and location of the site. Table 1 in the Mining PEM tabulates the criteria for determining the level of assessment required and is reproduced in Table 3.

A Level 1 assessment has been undertaken for the Project in line with Table 3, as the Project will be a large quarry extracting greater than 500,000 tonnes per year and has rural residences within 500 m from the limit of work.

Table 3 Criteria for determining the level of assessment required (EPA Publication 1191)

	Large Mine or quarry greater than 500,000 tonnes/yr extraction	Medium Mine or quarry between 150,000 tonnes/yr and 500,000 tonnes/yr extraction	Small Mine or quarry between 50,000 tonnes/yr and 150,000 tonnes/yr extraction	Mine or quarry with yearly extraction below 50,000 tonnes/yr extraction
Urban area	Level 1	Level 1	Level 2	No assessment
Rural area close to residences (less than 500 m from the limit of work described in the approved DPI work plan or final EES)	Level 1	Level 2	Level 3	No assessment
Rural area (residences more than 500 m from the limit of work described in the approved DPI work plan or final EES)	Level 2	Level 3	No assessment	No assessment

3.1.3 Monitoring

The Mining PEM (Section 6) outlines monitoring requirements to be conducted prior to preparation of an air quality assessment, to gain an understanding of existing air quality (i.e. background) in the area. With regards to a Level 1 assessment, the following is required for air quality:

"Real time continuous 24-hour PM_{10} and $PM_{2.5}$ data for a 12-month period, analysis of crystalline silica ($PM_{2.5}$ fraction) and heavy metal content (PM_{10}) (where applicable)."

Furthermore, with regards to the monitoring of deposited dust, the Mining PEM (ibid.) states the following:

"Deposited dust should be monitored at the site boundary for most operations. Monitoring is conducted with dust deposition gauges that should be located both upwind and downwind of the site to reflect the impact of the mining or quarry operations during the most predominant wind directions."

With regards to meteorological data, the Mining PEM requires meteorological data to be collected when air quality data is being collected or developed for modelling purposes. For Level 1 assessments, it is required that data from the area where the operation is proposed needs to be collected prior to the air quality assessment commencing.

The results of the air quality and meteorological monitoring undertaken at the Project Site is presented in section 4.

4. Monitoring results

4.1 Air quality

4.1.1 PM_{10} and $PM_{2.5}$

The 24-hour average PM_{10} and $PM_{2.5}$ results for the modelling period are presented in Figure 2 and Figure 3, respectively. GHD has adopted EPA Victoria practice[5], whereby 24 hour averages have been formed only when at least 75% of the data for the day are valid. From Figure 2, it can be seen that the PM_{10} measured values remained relatively consistent throughout the modelling period, with an average recorded value of 11.9 µg/m^3. From Figure 3, it can be seen that the $PM_{2.5}$ measured values also remained relatively consistent throughout the modelling period, with an average recorded value of 2.2 µg/m^3.

A peak in both datasets was recorded in late April and early May 2018, due to smoke from controlled burning[6].

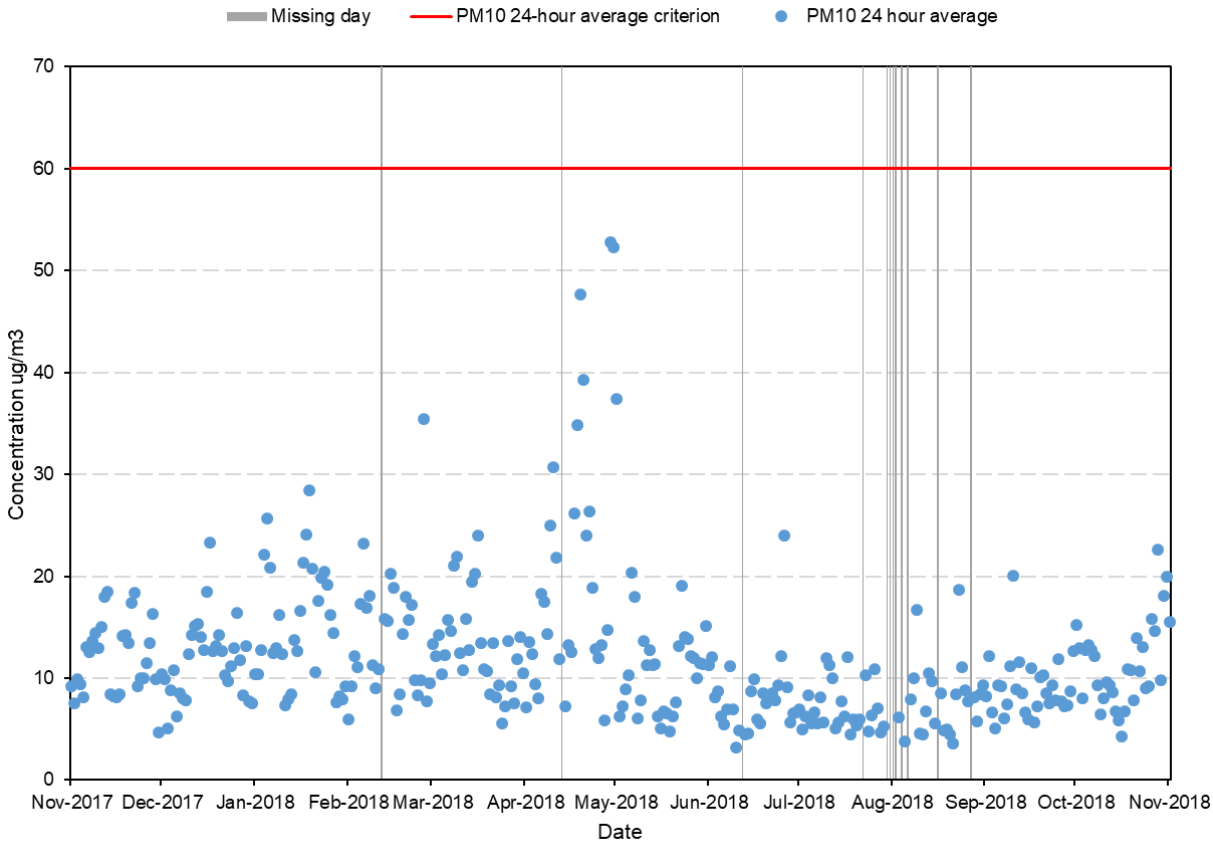


Figure 2 PM_{10} montoring results (4/11/2017 – 3/11/2018)

[5] Air monitoring report 2017 – Compliance with the National Environment Protection (Ambient Air Quality) Measure (Publication 1703) document

[6] https://www.heraldsun.com.au/news/victoria/smoke-haze-from-controlled-burns-covers-melbourne/news-story/3d927cae527abfe8c941203239570c4f

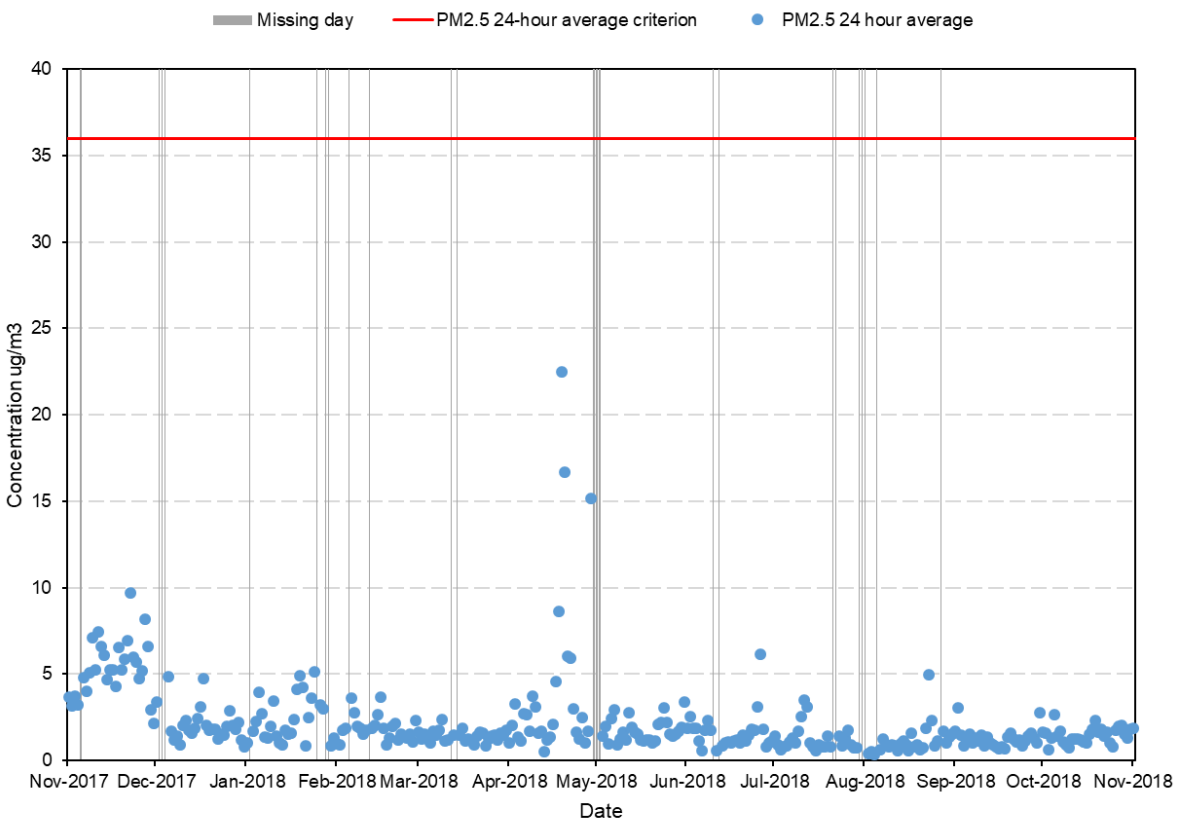


Figure 3 $PM_{2.5}$ montoring results (4/11/2017 – 3/11/2018)

4.1.2 Dust deposition

The dust deposition results presented are for the total insoluble matter collected in each dust gauge in accordance with the NSW Approved Methods, as per AS 3580.10.1 – 1991 (now superseded by AS 3580.10.1 – 2016), which describes nuisance dust as insoluble solids.

The dust deposition results for the modelling period are presented in Figure 4. From Figure 4, it can be seen that the overall deposited dust levels remain relatively constant across the monitoring period, with the exception of a peak measured DDG2 (highlighted in red) which occurred in June 2018. When a comparison is made to the remaining dust gauges, this peak is likely an anomaly and is therefore not representative of ambient conditions at the Project Site.

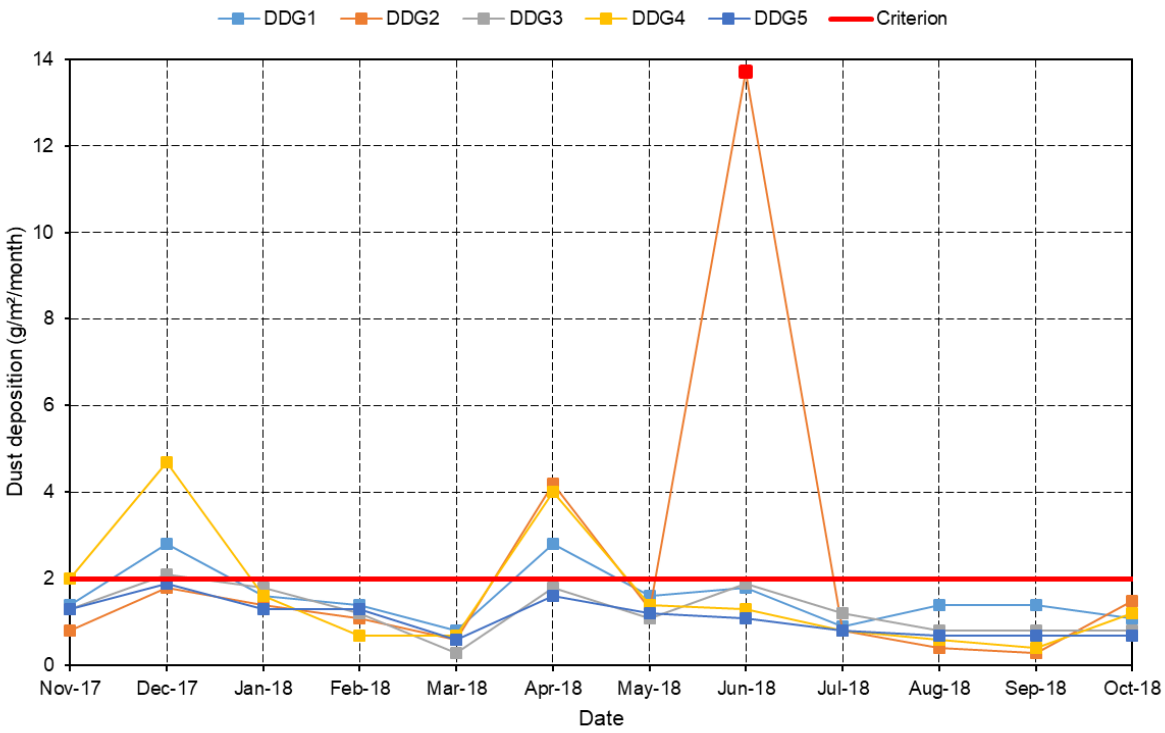


Figure 4 Dust deposition monitoring results – total insoluable matter

4.1.3 Respirable crystalline silica

Ambient air

The following is a summary of the measurements of $PM_{2.5}$ at Bunyip North conducted by Ecotech/ALS and the subsequent analysis for RCS conducted by Test Safe NSW. Two rounds of monitoring were conducted as follows:

- **7 February to 8 March 2018**: 29 samples taken with all but one taken over a 24 hour period and one taken over 48 hours.
- **6 June to 17 June 2019:** Four samples were taken with two samples taken over a 48 hour period and two samples taken over a seven day period.

The results for the monitoring for both rounds returned a non-detect for each of the two species of RCS (alpha quartz and cristobalite). The non-detect refers to the lower limit of mass detectable on the filter paper of 40 µg.

Core rock

A total of nine core rock samples were selected from exploratory drilling cores to be representative of the range of quality of granite in the resource. Samples from each of the nine core samples were crushed to a fineness level that gave a substantial portion of the fines in the sub 2.5 micron range. The samples were sent to Test Safe NSW to determine the percentage of RCS in each sample using X–ray diffraction (XRD). The results of the analysis are provided in Table 4. From Table 4, it can be seen that the crystalline fraction ranged from 13% to 20%, with a mean value of 16.3%.

Table 4 Analysis for RCS in core rock samples

Sample ID	α-Quartz (% / dust)	Cristobalite (% / dust)	RCS (α-Quartz + Cristobalite) (% / dust)
1	16	4	20
2	11	4	15
3	14	4	18
4	12	4	16
5	12	5	17
6	13	ND	13
7	11	4	15

4.1.4 Model input (background data)

PM_{10} and $PM_{2.5}$

The Mining PEM states that air dispersion modelling for a Level 1 assessment requires "time varying background files (24- hour averages)" to be included in the model for PM_{10} and $PM_{2.5}$ predictions. GHD has utilised the 24-hour values presented in Figure 2 and Figure 3 to form the time varying background files for PM_{10} and $PM_{2.5}$ respectively.

The onsite monitoring records for PM_{10} and $PM_{2.5}$ show instances of high values (likely resulting from local bushfires) that are probably unrepresentative of general site conditions. EPA Victoria have stated that it is appropriate to exclude these events from the background data, provided specific details, such as documentation including the dates/times that the bushfires were known, and any other supporting evidence (including monitoring data from EPA air quality monitoring stations (AQMS) is provided.

A summary of the excluded data and justification for exclusion is provided in Table 5.

Table 5 Summary of excluded dates

Cluster	Date	PM_{10} concentration ($\mu g/m^3$)	$PM_{2.5}$ concentration ($\mu g/m^3$)	Reason for exclusion
1	28 February 2018	35.7	N/A	"Very poor" air quality recorded at nearest EPA AQMS Dandenong during this period[7]
2	20 April 2018	35	8.6	"Very poor" air quality recorded at nearest EPA AQMS Dandenong during this period[8]
	21 April 2018	46.9	22.1	
	22 April 2018	40.8	17	
3	1 May 2018	50.1	14.4	Poor air quality across Victoria region resulting from controlled burns.[9]
	2 May 2018	53.5	N/A	
	3 May 2018	38.6	N/A	

[7] https://www.epa.vic.gov.au/our-work/monitoring-the-environment/epa-airwatch/historic-air-quality-data-table 28 February 2018 - 2:00 pm to 3:00 pm

[8] https://www.epa.vic.gov.au/our-work/monitoring-the-environment/epa-airwatch/historic-air-quality-data-table 21 April 2018 - 10:00 pm to 11:00 pm

[9] https://www.heraldsun.com.au/news/victoria/smoke-haze-from-controlled-burns-covers-melbourne/news-story/3d927cae527abfe8c941203239570c4f

Where the 24 hour averaged data for a particular day has been excluded, (either due to high values as outlined in Table 5, or due to less than 75% of the data for the day being valid), the average of the previous day and the following day, with valid data, was used. Based on the above methodology, the following time varying background files for PM_{10} and $PM_{2.5}$ were developed, as shown in Figure 5 and Figure 6 respectively.

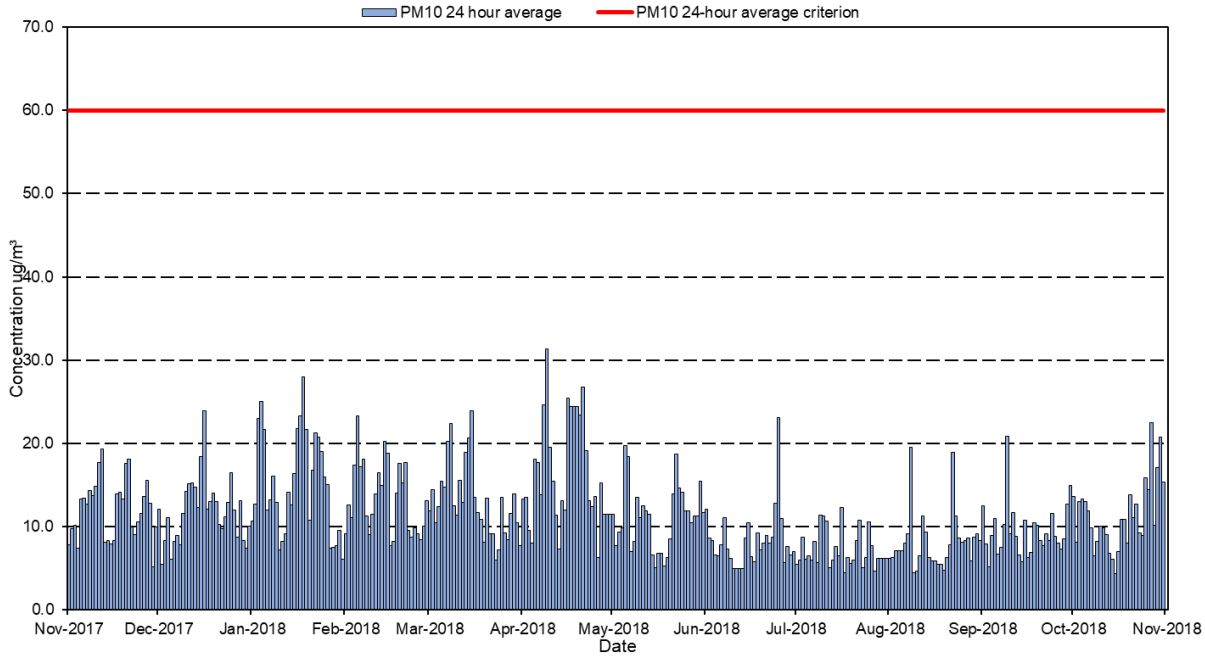


Figure 5 PM_{10} 24 hour average time varying background file

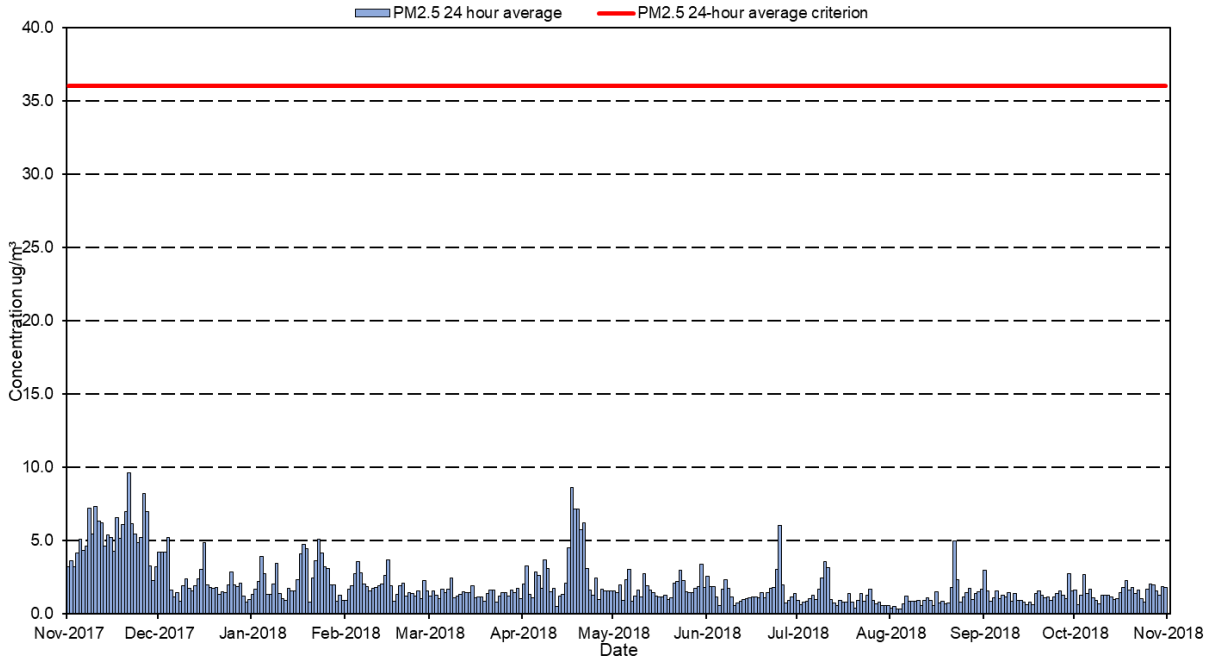


Figure 6 $PM_{2.5}$ 24 hour average time varying background file

Dust deposition

As the Mining PEM does not provide guidance on the inclusion of background values for the modelling of dust deposition, GHD has referred to the NSW Approved Methods, for guidance on the inclusion of deposited dust background values. The NSW Approved Methods states that the maximum background concentration for the averaging period should be used in the model. For deposited dust, it is stated that the relevant averaging period is annual.

Therefore, to obtain a background value, GHD has taken the average annual value (November 2017 to October 2018) based on the monthly values, for each dust gauge. The maximum (1.6 g/m^2/month) of these averages has then been selected as the background concentration. Note that the 13.7 g/m^2/month peak has been excluded from the background calculation, as it was deemed not representative of ambient conditions at the Project Site.

A summary of the annual values for each dust gauge and the background deposited dust value selected is provided in Table 6.

Table 6 Data availability for 4 November 2017 to 3 November 2018

Dust gauge	DDG1	DDG2	DDG3	DDG4	DDG5
November 2017	1.4	0.8	1.3	2.0	1.3
December 2017	2.8	1.8	2.1	4.7	1.9
January 2018	1.6	1.4	1.8	1.6	1.3
February 2018	1.4	1.1	1.2	0.7	1.3
March 2018	0.8	0.6	0.3	0.7	0.6
April 2018	2.8	4.2	1.8	4.0	1.6
May 2018	1.6	1.3	1.1	1.4	1.2
June 2018	1.8	13.7[10]	1.9	1.3	1.1
July 2018	0.9	0.8	1.2	0.8	0.8
August 2018	1.4	0.4	0.8	0.6	0.7
September 2018	1.4	0.3	0.8	0.4	0.7
October 2018	1.1	1.5	0.8	1.2	0.7
Average (g/m^2/month)	**1.6**	**1.3**	**1.3**	**1.6**	**1.1**

Respirable crystalline silica

The Mining PEM requires "crystalline silica, arsenic and other indicators that have long-term health effects" to be modelled for a Level 1 assessment. The core samples were also analysed for arsenic and asbestos and no evidence was detected in any of the samples analysed.

With regards to RCS, the Mining PEM requires annually averaged background data for RCS to be included in the model.

To determine this value for the selected period, GHD would use the ambient RCS analysis results (as discussed in section 4.1.3). However, as the analysis results have shown that no RCS was detected in any of the ambient samples, GHD has used the maximum result of the core rock sample analysis; that is assumed 20% of $PM_{2.5}$ is RCS. This is considered a conservative approach as the ambient RCS percentage is expected to be significantly less than measured in the core rock samples. This percentage was applied to the annual $PM_{2.5}$ value (2.2 µg/m^3) for the modelling period, resulting in an RCS annually averaged background value of 0.4 µg/m^3.

[10] Value excluded

4.2 Local meteorology

An analysis of the monitored meteorological parameters is provided in the following sections, for the period (4 November 2017 to 3 November 2018).

4.2.1 Wind pattern

The local meteorology largely determines the pattern of off-site dust impact. The characterisation of local wind pattern requires accurate site-representative hourly recordings of wind speed and direction over a period of at least 12 months. The wind speed and direction data availability for the selected modelling period is 97%. Therefore, this dataset has been deemed sufficient to characterise patterns in wind for the subject site.

The effect of wind on dispersion patterns can be examined using the general wind climate and atmospheric stability class distributions. The general wind climate at a site is most readily displayed by means of wind rose plots, giving the incidence of winds from different directions for various wind speed ranges.

The features of particular interest in this report are: (i) the prevailing wind directions, (ii) the relative incidence of more stable light wind conditions, and (iii) good dispersion conditions with winds over 5 m/s.

A distinction can be made for fugitive deposited dust entrained into strong winds, as opposed to dust emissions from process sources where the emission rate is independent of local wind conditions. The ‘worst case’ in the former class is wind speed greater than 5 m/s, while ‘worst case’ in the latter is light, stable winds.

Long term pattern in wind

The average wind rose for 4 November 2017 to 3 November 2018 is shown in Figure 7 and shows the following features:

- The measured average wind speed is 3.5 m/s
- The general wind pattern is from the northwesterly sector, with a portion of winds observed from the east-southeast
- Very light winds are measured from all directions, with the largest contribution from the northwest
- Strong winds are primarily from the north-northwest

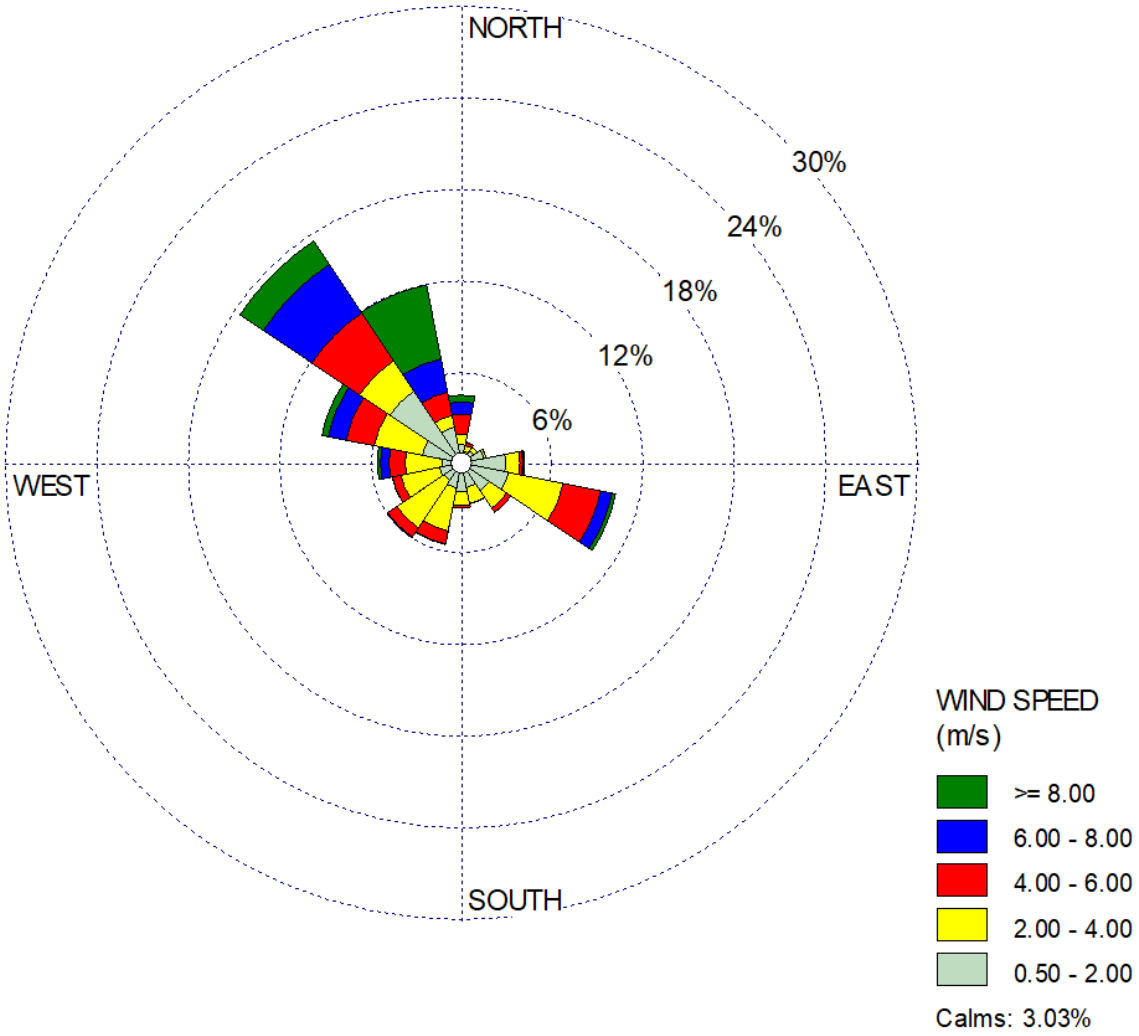


Figure 7 Wind rose for Bunyip North (4/11/2017 – 3/11/2018)

Seasonal variation in wind pattern

The seasonal wind roses for the same period are presented in Figure 8 and show that:

- During the summer, the predominant wind direction is from the east-southeast, which comprises 15% of the total winds. The summer wind rose also includes winds from the southwest and northwesterly sectors.
- During winter, northwesterly sector winds are the most dominant due to pre-frontal northerlies and cool air drainage from the surrounding hills and mountains. Northwesterly component winds comprise ~62% of all incident winds.
- Autumn and spring are transitional periods. During these months both summer and winter patterns are observed. Autumn wind patterns are characteristically similar to winter, generally consisting of north to northwesterly winds. Spring wind patterns are similar to summer wind patterns with a high incidence of east-southeasterly winds.
- The seasonal incidence of light (<2 m/s) wind speeds is greatest in summer, comprising approximately 41% of wind speeds.
- The seasonal incidence of (>5 m/s) high wind speeds is greatest in winter, comprising approximately 45% of wind speeds.
- As with the annual wind rose for the monitoring period, there is a lack of northeasterly sector winds in all observed seasons.

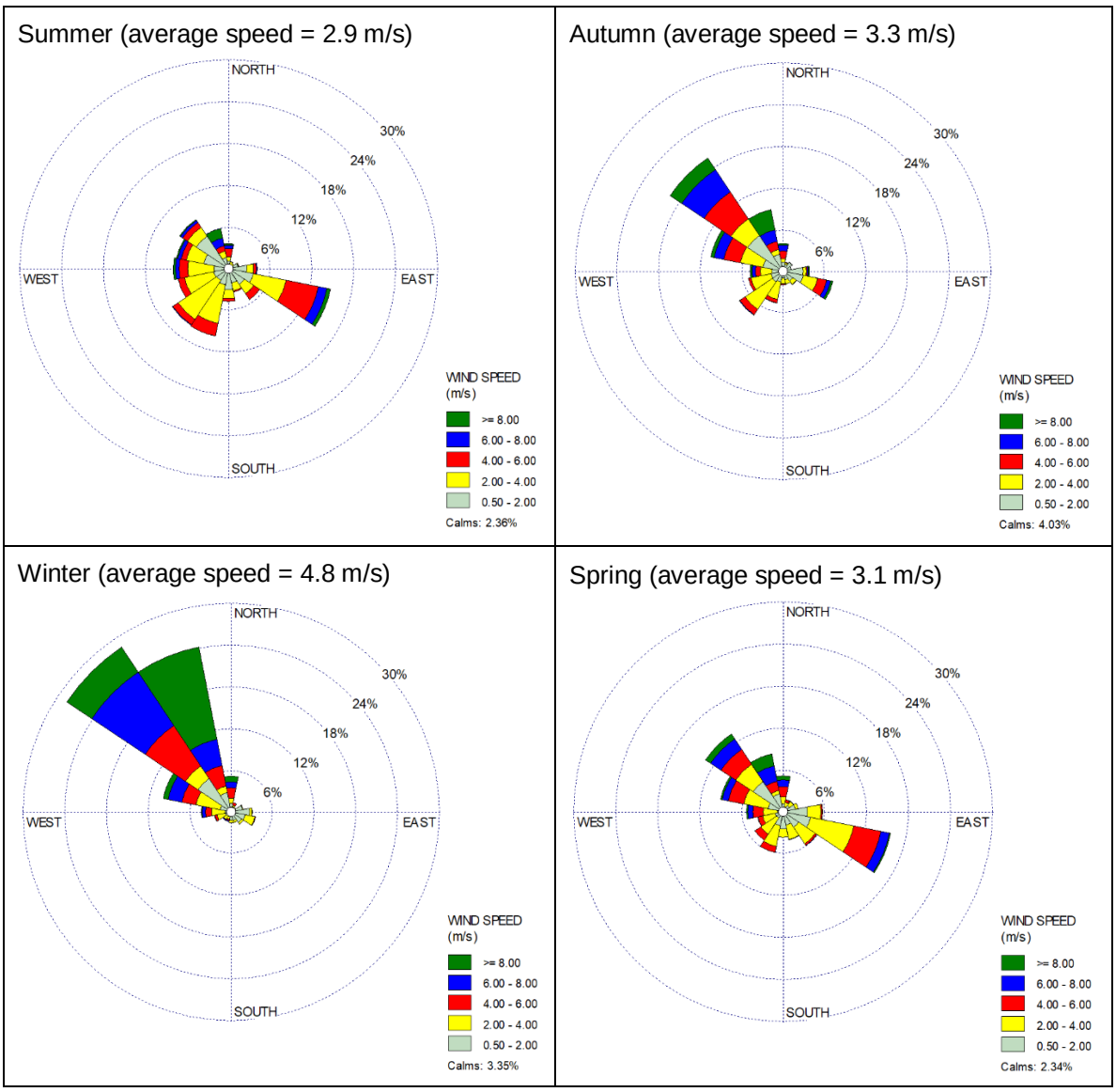


Figure 8 Seasonal wind roses (4/11/2017 – 3/11/2018) for Bunyip North

4.2.2 Temperature

Average hourly temperatures measured at 10 m and 2 m heights are plotted for the annual period 4 November 2017 to 3 November 2018 in Figure 9. Figure 9 shows that temperatures reached a minimum of approximately 0.5 °C in winter. In contrast, temperatures are occasionally above 35 °C in summer, with peaks just below 40°C.

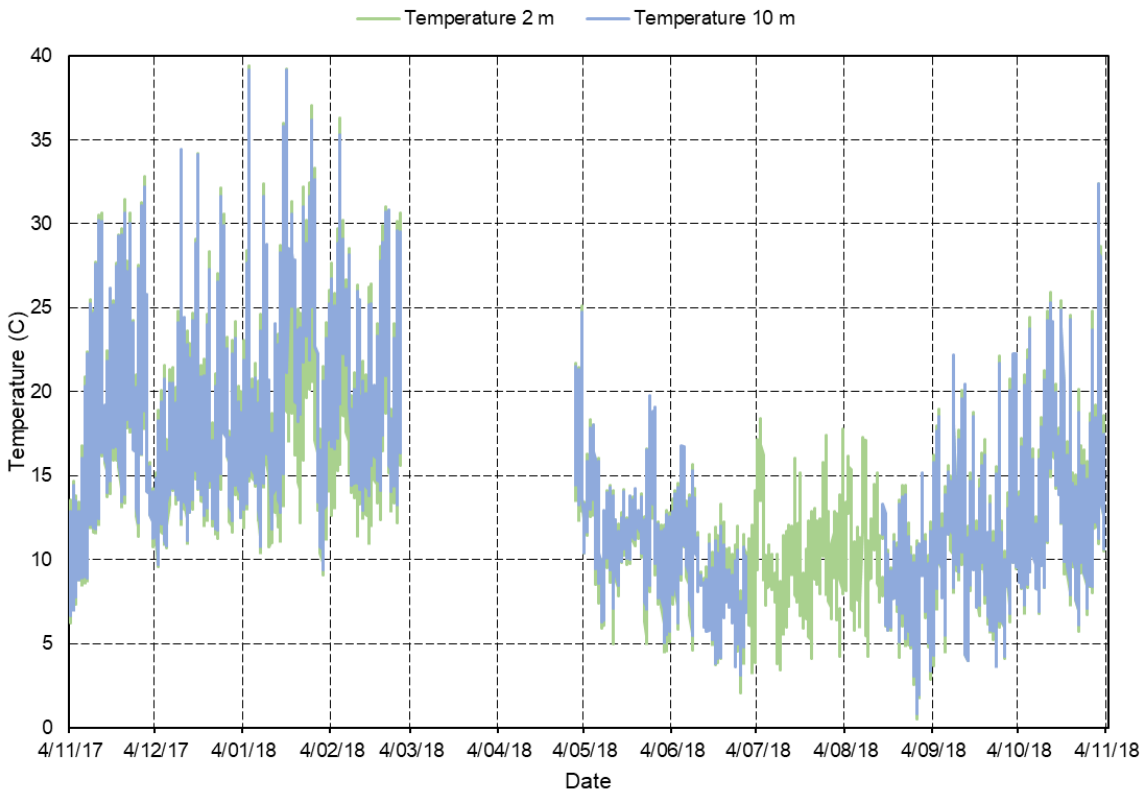


Figure 9 Average hourly temperatures for the period 4 November 2017 to 3 November 2018

It is noted that an instrument fault resulted in extended periods of no recordings (as shown in Figure 9), occurred as follows:

- 1 March 2018 to 1 May 2018 – temperature at 10 m and 2 m
- 1 July 2018 to 17 August 2018 – temperature at 10 m

EPA Victoria's *Construction of input meteorological data files for EPA Victoria's regulatory air pollution model (AERMOD)* (Publication 1550) states that hourly averaged screen level temperature is a mandatory data required for the construction of a meteorological input file.

The onsite data for the period 1 March 2018 to 1 May 2018 does not meet this requirement as temperature measurements at both heights are invalid. To overcome this, GHD utilised data from the most site-representative Bureau of Meteorology (BoM) operated automatic weather station at Nilma North (approximately 30 km east-southeast of the subject site) during this period. This approach was approved by EPA Victoria. The Nilma North temperature data substituted into the Bunyip monitoring data is shown in Figure 10.

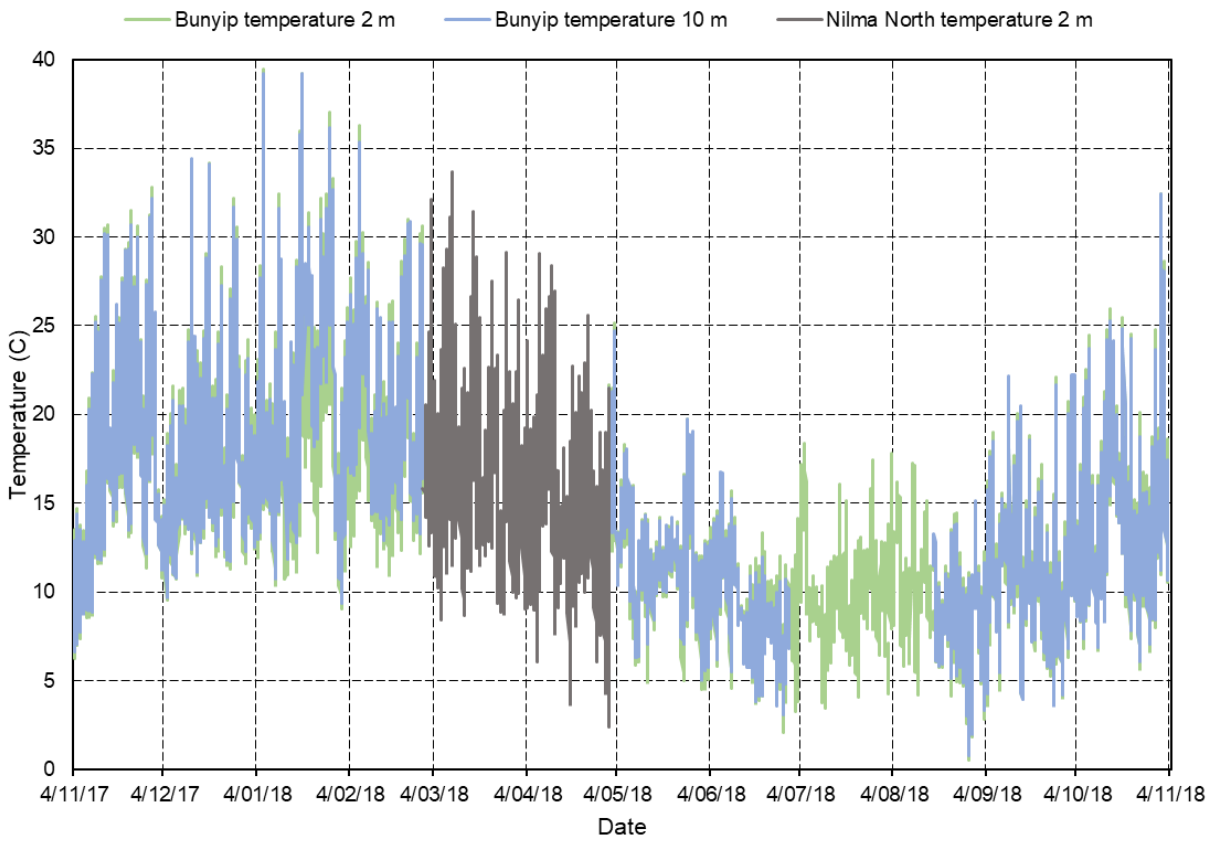


Figure 10 Average hourly temperatures for the period 4 November 2017 to 3 November 2018 – including Nilma North data

4.2.3 Relative humidity

Average hourly relative humidity is plotted for the period 4 November 2017 to 3 November 2018 in Figure 11. Figure 11 shows the relative humidity reaching a maximum close to 100% and a minimum of 13% in January. In general, lower values of relative humidity are seen throughout the summer months when it is drier.

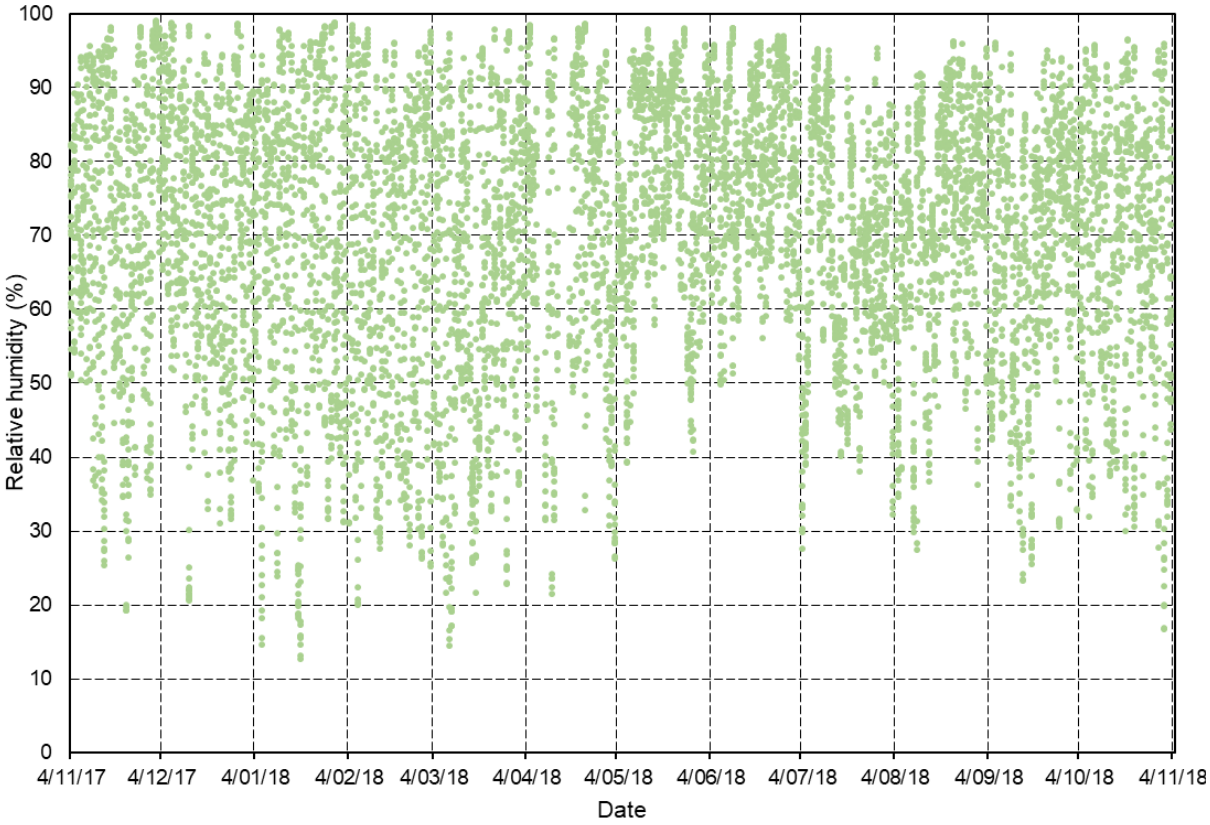


Figure 11 Average hourly relative humidity for the period 4 November 2017 to 3 November 2018

4.2.4 Net radiation

Average hourly net radiation is plotted for the period 4 November 2017 to 3 November 2018 in Figure 12. Figure 12 shows the net radiation peaks of 900 W/m^2 in daytime summer (late December), whilst lower maximum daytime values of 300 W/m^2 are seen in winter (late June/early July). Minimum night-time net radiation measurements typically reach -70 W/m^2 to -80 W/m^2.

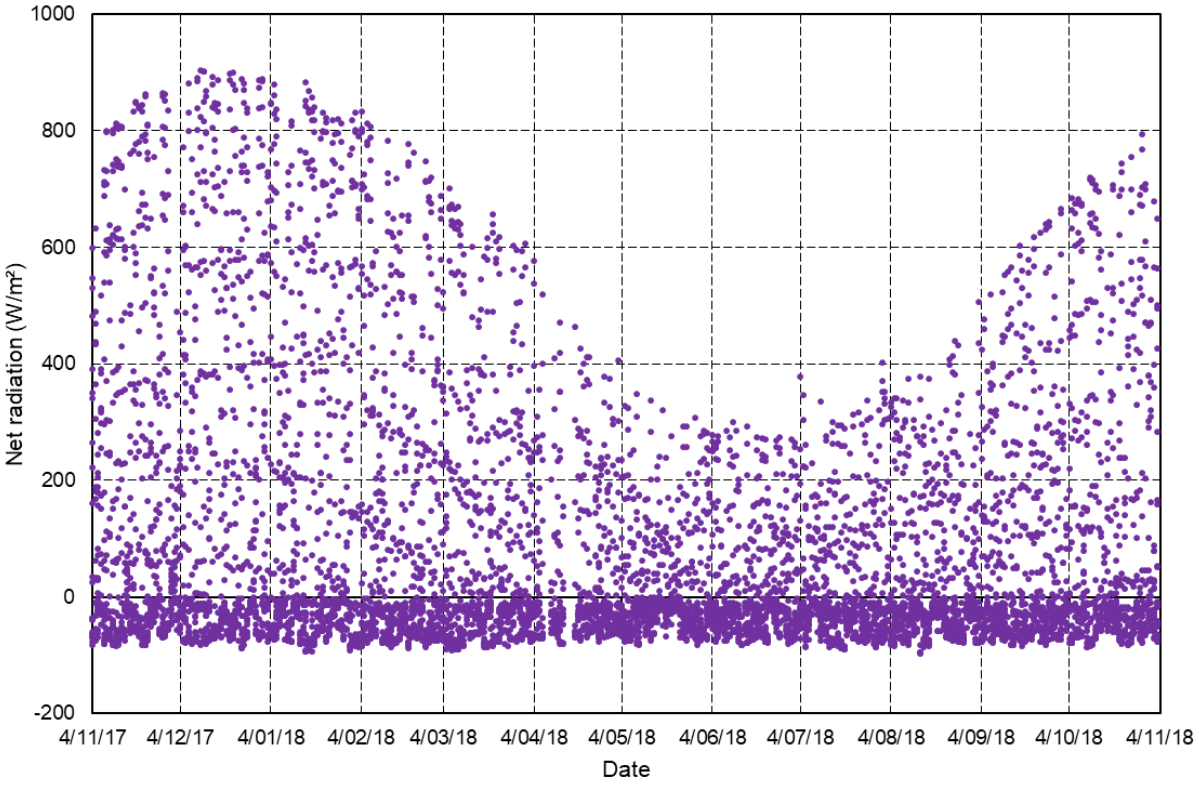


Figure 12 Average hourly net radiation for the period 4 November 2017 to 3 November 2018

4.2.5 Model input

Meteorological data file construction

A meteorological data file will be constructed for the AQIA for input into AERMET using the meteorological data measured at the Project Site. AERMET will be configured in accordance with the guidance outlined in Publication 1550 (EPA Victoria, 2013). When developing a meteorological input file, the minimum surface observation requirements to process 'onsite' data within AERMET are:

- Wind speed and wind direction
- Air temperature
- Either:
  - Cloud cover (all hours)
  - Solar/Net radiation (day time hours) and difference in temperature measurements (night time hours)

As stated in section 4.2.2, an instrument fault resulted in no difference in temperature measurements recorded during the periods 1 March 2018 to 1 May 2018 and 1 July 2018 to 17 August 2018. As a result, a combination of net radiation and difference in temperature measurements are unable to be used in the meteorological input file during these two periods.

During these periods, GHD will substitute in cloud cover measurements to be used in conjunction with the net radiation measurements (i.e. net radiation measurements used during day time hours and cloud cover measurements used only during night time hours). GHD notes that the ADJ_U* option will be used, which utilises equation (26) of Qian and Venkatram (2011) during night time hours. Equation (26) is not dependent on cloud cover and instead utilises the critical wind speed, the measured wind speed and the drag coefficient (which is dependent on the measurement height, aerodynamic roughness length and the zero-plane displacement). As such, a nominal cloud cover value will be utilised in the meteorological input file (Materia & Craggs 2019).[11]

GHD notes that EPA Victoria publication 1550 states that measured net radiation (if available for the application site) is preferred over cloud observations. Therefore, the adopted approach, whereby net radiation is used in conjunction with cloud cover measurements for periods where difference in temperature measurements are absent, is considered appropriate. A summary of the meteorological data input throughput the modelling period (with regards to net radiation, difference in temperature and cloud cover) is provided in Figure 13. In addition to these parameters, wind speed, wind direction, temperature (measured at 2 m) and relative humidity will also be included in the meteorological input file.

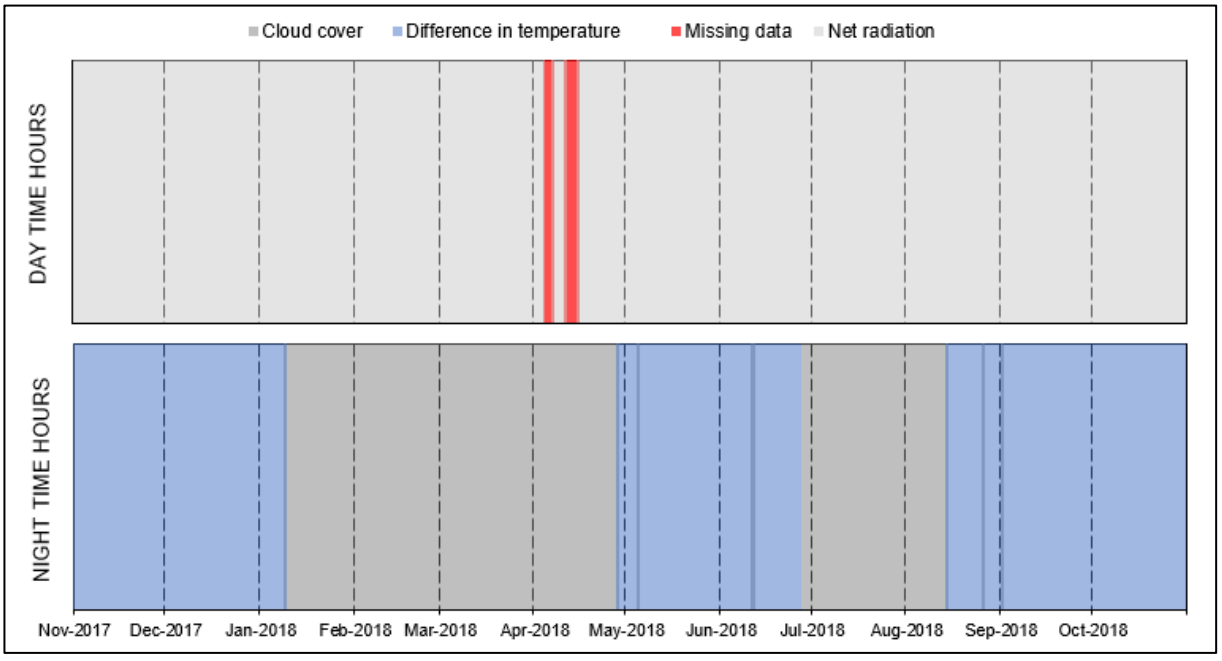


Figure 13 Meteorological input parameters

[11] Materia & Craggs, 2019, The Influence Of The ADJ_U* Option On AERMOD Dispersion Characteristics For Meteorological Data-sets, CASANZ Conference Queenstown 2019

5. Summary

Air quality and meteorological monitoring was undertaken at the proposed Bunyip North Quarry site in order to meet the monitoring requirements for a Level 1 air quality assessment as outlined in the Mining PEM.

The air quality results indicated the following:

- Ambient particulates: the overall trend of the measured PM_{10} and $PM_{2.5}$ concentrations were below the criteria, with a major peak recorded in both datasets in late April and early May 2018 due to controlled burning.
- Dust deposition: the overall deposited dust levels remained relatively constant across the monitoring period, with the exception of a peak which occurred in June 2018. It was assessed that this peaks is likely an anomaly and not representative of ambient conditions at the subject site.
- RCS: Both core rock and ambient air analysis was conducted as follows:
  - Core rock: the analysis of the rock core samples showed that the crystalline fraction ranged from 13 to 20%, with a mean value of 16.3%.
  - Ambient air: the results of the ambient air analysis showed that no RCS was detected in any of the samples.

Based on the results outlined above, the following modelling methodology, as approved by EPA Victoria in February 2019 was adopted:

- PM_{10} and $PM_{2.5}$: The 12 month period with the lowest number of 24-hour averaged days missing was selected. This was determined to be between 4 November 2017 and 3 November 2018. Time varying background files (24- hour averages) will be included in the model for PM_{10} and $PM_{2.5}$ predictions, in line with the Mining PEM.
- Dust deposition: A background value for dust deposition was selected based on the maximum background concentration for the annual averaging period (November 2017 – October 2018), in line with the NSW Approved Methods. The likely anomalies were excluded from this calculation and the background value was determined to be 1.6 g/m^2/month.
- RCS: The Mining PEM requires annually averaged background data for RCS to be included in the model. GHD has assumed 20% of $PM_{2.5}$ is RCS, based on the core rock analysis. This percentage was applied to the annual $PM_{2.5}$ value (2.2 $\mu g/m^3$) for the modelling period, resulting in an RCS annually averaged background value of 0.4 $\mu g/m^3$.

Meteorological parameters including wind speed, wind direction, temperature (at 10 m and 2 m), relative humidity and net radiation were measured at the subject site. It was determined that these parameters are valid inputs into the dispersion model, with the following alterations:

- Temperature at 2 m: It is noted that the temperature measurements during the period 1 March 2018 to 1 May 2018 are invalid and therefore cannot be input into the model. In order to overcome this, GHD will utilise data from the BOM operated Nilma North automatic weather station for this period.
- Difference in temperature: Where difference in temperature measurements are absent, GHD has utilised a nominal cloud cover value (nigh time hours) in conjunction with net radiation values (day time hours).

A summary of the baseline air quality and meteorological input parameters to be utilised in the AQIA are provided in Table 7.

Table 7 Summary of pollutant input parameters

Parameter	Averaging time	Input
Air quality		
PM_{10}	24-hour	24-hour time varying values (refer to Figure 5)
$PM_{2.5}$	24-hour	24-hour time varying values (refer to Figure 6)
RCS	Annual	0.4 µg/m^3
Deposited dust	Monthly	1.6 g/m²/month
Meteorology		
Temperature (2 m)	Hourly	Yes BoM operated automatic weather station at Nilma North used when site measurements are missing.
Difference in temperature (10 m minus 2 m)	Hourly	Yes
Wind speed	Hourly	Yes
Wind direction	Hourly	Yes
Relative humidity	Hourly	Yes
Net radiation	Hourly	Yes
Cloud cover	Hourly	Yes Only when difference in temperature measurements at the site are missing.

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