Bayswater Water and Other Associated Operational Works Project

Appendix F – Air Quality Impact Assessment

Bayswater Water and Other Associated Works Project

AGL Macquarie Pty Ltd

Air Quality Impact Assessment

F0 | v2

4 December 2019

JACOBS

Bayswater Water and Other Associated Works

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Document history and status

Revision	Date	Description	By	Review	Approved
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D1v1	20/11/2019	Update following client review	LS	SL	KF
F0v1	20/11/2019	Final following client review	LS	KF	KF
F0v2	04/12/2019	Final following second client review	LS	KF	KF

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Executive Summary

Background

AGL Macquarie Pty Ltd is planning to undertake water and other associated works activities at Bayswater Power Station (the Project). The works are intended to improve the management of ancillary processes at the site. The primary air quality issue associated with the Project was identified to be dust (that is, particulate matter in the form of Total Suspended Particles (TSP), deposited dust, and fine particles (particles with an aerodynamic diameter less than 10 and 2.5 microns [PM_{10} and $PM_{2.5}$]). Consistent with the *Secretary's Environmental Assessment Requirements* (SEARs), an assessment was completed to identify and evaluate the potential for dust-related impacts from the proposed activities, including the development of feasible mitigation and management measures.

Policy setting and key features of the existing environment

Statutes, policies and guidelines were reviewed to identify a suitable approach and criteria for assessing potential impacts. From the Environment Protection Authority's (EPA's) 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW' (2016) and consistent with the SEARs, it was confirmed that impacts were to be assessed quantitatively, and suitable assessment criteria were therefore established.

Quantitative modelling assessments require an understanding of key features of the existing environment including the presence and location of sensitive receivers, local meteorological conditions, and existing background pollutant concentrations. Data from local government and private meteorological and air quality monitoring stations were reviewed to establish local conditions around the Project, and aerial imagery was used to identify surrounding sensitive receivers.

Quantification of emissions to air

Total dust emissions were estimated by analysing details of the Project and identifying the location and intensity of dust generating activities (such as ash transport activities). Emissions were quantified using emissions factors developed locally and by the United States Environmental Protection Agency (US EPA). Emissions were estimated for two scenarios; peak operations and post-completion during rehabilitation. For the peak operations scenario, it was conservatively considered that all four clay borrow pits were opened, with the largest (clay borrow pit 4) being actively used to generate materials for the ash dam augmentation and salt cake landfill facility. The full footprint of the ash dam was also conservatively considered as a source of emissions. Twenty percent of the salt cake landfill facility was considered to be opened and exposed, consistent with the program of use of the facility.

Assessment of impacts

The computer-based air dispersion model, known as CALPUFF, was used to predict the potential air quality impacts of the Project. The dispersion modelling accounted for meteorological conditions, land use and terrain information and used the dust emission estimates to predict changes in local air quality.

The main conclusions of the assessment for each key pollutant and assessable averaging time were:

- TSP and $PM_{2.5}$: Contributions from the Project would not result in exceedance of the EPA's relevant impact assessment criteria at any of the nearest sensitive receivers;
- 24-hour averaged PM_{10}: Background concentrations in the Hunter Valley have exceeded the EPA's 50 µg/m^3 assessment criterion however no additional exceedances of the impact assessment criteria were predicted as a result of the Project at all sensitive receivers;
- Annual PM_{10}: Negligible contributions (less than 1%) were predicted from the Project, resulting in concentrations less than the 25 µg/m^3 assessment criterion at all representative receiver locations assessed except one location (RR04) where background levels already exceeded the criterion; and

- Annual deposited dust: Negligible contributions (less than 0.35%) were predicted from the Project, resulting in concentrations less than the 4 g/m^2/month assessment criterion at all representative receiver locations assessed except two locations (RR03 and RR04) where background levels already exceeded the criterion.

Conclusion and recommended safeguards

The assessment found that the Project would not result in unacceptable changes in local air quality, based on predicted contributions that would not cause exceedances of relevant assessment criteria. Measures were however recommended to mitigate and effectively manage emissions to air. These included the watering of haulage routes, progressive rehabilitation and active management measures. Real-time monitoring and forecasting systems were also reviewed, in the context of the potential impacts, given that best practice approaches to minimise dust generation and potential impacts include these measures. However, these measures have not been explicitly included as recommended measures since the modelling showed that the change in ambient air quality at the nearest private sensitive receivers would not lead to exceedances of criteria.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to quantify the potential air quality impacts for the Bayswater Water and Other Associated Works activities in accordance with the scope of services set out in the contract between Jacobs and AGL Macquarie Pty Ltd (AGL Macquarie). That scope of services, as described in this report, was developed with AGL Macquarie.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by AGL Macquarie and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

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1. Introduction

Bayswater Power Station (Bayswater) is located on the New England Highway within the Muswellbrook Local Government Area (LGA) and Singleton LGA. The facility is operated by operated by AGL Macquarie Pty Ltd (AGL Macquarie). AGL Macquarie is planning to undertake water and other associated works activities (the Project) and have engaged Jacobs Group Australia Pty Ltd (Jacobs) to complete an Environmental Impact Statement (EIS) to assess these works. The *Secretary's Environmental Assessment Requirements* (SEARs) (No. SSD 9697 issued November 2018) for the Project identify the key environmental matters requiring assessment as part of the EIS. Dust and other emissions to air associated with construction and operations is identified as a key issue. The requirements for air quality assessment from the SEARs is the subject of this Air Quality Impact Assessment (AQIA) report. These requirements, including where they are addressed in the AQIA are reproduced below:

Table 1-1 SEARs and where they are addressed in the AQIA

Requirements of SEARs and submissions	Where addressed in this report
SEARs (No. SSD 9697 issued November 2018)	
Air – including a quantitative assessment of potential: - Construction and operational air quality impacts with a particular focus on dust emissions including $PM_{2.5}$ and PM_{10} emissions and dust generation from ash transport.	**Section 7**
- Reasonable and feasible mitigation measures to minimise dust emissions, including evidence that there are no other available measures.	**Section 8**
- Monitoring and best practice management measures, in particular real-time air quality monitoring.	**Section 8**

In meeting these requirements, the objectives of this assessment were to:

- Describe the Project setting, proposed activities and potential air quality issues (**Section 2**)
- Establish suitable air quality assessment criteria (**Section 3**);
- Describe the existing environment including surrounding receivers, terrain, meteorology and ambient air quality conditions (**Section 4**);
- Estimate emissions to air associated with the Project (**Section 5**);
- Explain the methods used to predict potential air quality impacts (**Section 6**);
- Present and discuss predicted potential impacts (**Section 7**); and
- Recommend mitigation and management measures (**Section 8**).

2. Project overview

2.1 Site and surrounds

Bayswater is located approximately 15 kilometres (km) south-east of Muswellbrook, 25 km north-west of Singleton, and approximately 165 km west north west of Sydney in NSW. The total area of the AGL Macquarie landholding is approximately 10,000 hectares, including Liddell Power Station (Liddell), the Ravensworth rehabilitation area, Lake Liddell and surrounding buffer lands. Bayswater's operational area occupies approximately 300 hectares. The location of Bayswater is shown in **Figure 2-1**. The majority of works associated with the Project would be within Bayswater, with a component of works extending to the Ravensworth rehabilitation area.

Existing development neighbouring Bayswater includes the former Drayton Mine, Liddell Coal Mine, as well as Liddell and the Main Northern Railway Line. The New England Highway runs parallel to Bayswater, with access from the highway provided by means of a dedicated road network designed to service the power stations. Agricultural clearing for the purposes of grazing is also present within and surrounding the AGL Macquarie landholding. The closest residential area is the Antiene subdivision, which is located behind a ridge line around 5 km north of the Project.

Data sources

Jacobs 2019,
AGL 2019,
NSW Spatial Services 2019

GDA94 MGA56

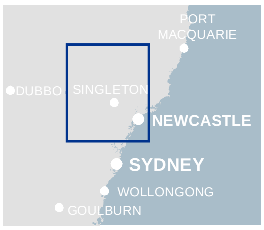

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Figure 2 - 1 Project location

2.2 Project description

Bayswater was commissioned in 1985 to utility standards of the time and has a current technical life up to 2035. Bayswater has a current generation capacity of 2640 megawatts (MW) and approval for efficiency upgrades that will increase capacity to 2740 MW. Bayswater employs technology common to other NSW coal-fired power stations using the following general process:

- Coal is burned in the boiler furnace producing heat for the boiler;
- Water is circulated through the boiler and heated by the boiler furnace to produce steam;
- High pressure steam from the boiler enters the turbine trains within the generating units;
- The turbines drive the generator rotor which produces electricity; and
- The electricity produced by the generator is transformed to system voltage and fed to the interconnected transmission system via the station switchyard.

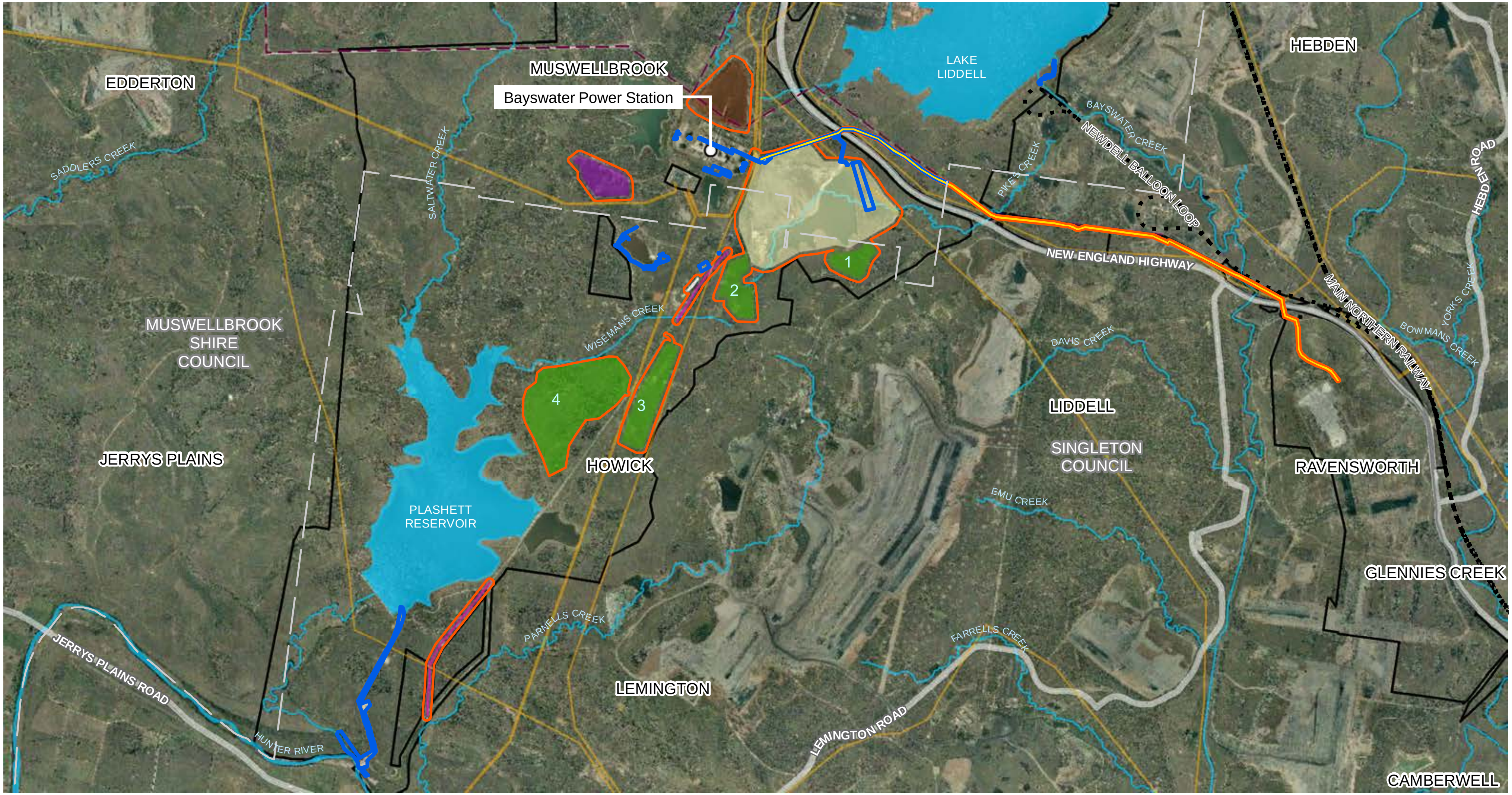
Ancillary activities arising out of coal fired power generation at Bayswater include:

- Receipt, storage and transfer of coal within the coal handling plant area;
- Pumping of water from the Hunter River under existing water entitlements and storage and treatment of this water, including the management of salt and other impurities, to supply boilers and for cooling purposes; and
- The management of incombustible coal residue, in the form of bottom ash and fly ash, which is collected and transported to ash disposal areas.

The purpose of the Project is to improve the management of these ancillary processes over the remaining operating life of Bayswater. This would involve:

- Optimizing and improving ash management including augmenting the existing ash disposal area, and plans for its closure and rehabilitation;
- Creation of a salt cake disposal landfill to complete the alternative process for managing water impurities and reduce the reliance on the Hunter River Salinity Trading Scheme; and
- Improvements to water management around the coal handling plant area.

Figure 2-2 below identifies the location of the Project, including where key elements are proposed.

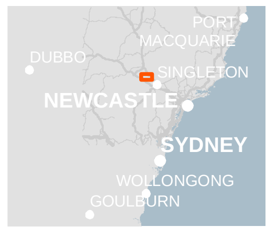


Study area
Local Government Area boundary
Footprints of approvals to be surrendered
AGL owned land
Railway
Electricity transmission line
Coal supply conveyor

Project elements:

Ash Dam Augmentation, Ash Harvesting and Water Management Works
Ravensworth Ash Line
Coal Handling Plant Water and Wastewater Infrastructure Upgrades
HP Pipe Clearing
LSP Sludge Line Clearing
Clay Borrow Pits
Salt Cake Landfill

0 2 4 km
1:78,000 at A4



Data sources
Jacobs 2019
AGL 2019
NSW Spatial Services 2019

GDA94 MGA56

Figure 2 - 2 AGL Site Plan and Project Elements

Date: 21/05/2020 Path: J:\IE\Projects\04_Eastern\IA215400\22_Spatial\GIS\Directory\Templates\Figures\WOAOW_EIS\IA215400_GIS_EIS_F002_r1v1_AGLSitePlanAndProjectElements.mxd
Created by : XX | QA by : XX

2.3 Primary air quality-related risks

Air quality issues can arise when emissions from an industry or activity lead to a deterioration in the ambient air quality. Potential air quality issues have been identified from a review of the activities and upgrades planned as part of the Project. This identification process has considered the types and quantum of potential emissions to air, as well as the proximity of these emission sources to sensitive receivers.

There is the potential for emission to air from a range of different sources during the Project:

- Ash management optimisation and improvements:
    - Construction of the augmentation works, and the operation and subsequent decommissioning of the augmented ash dam;
    - Construction and operational activities associated with the additional coal ash recycling and fly ash harvesting upgrades including the use of additional materials handling plant and equipment, a new diesel fuel storage area, new vehicle internal access routes, additional traffic movements, and upgrades to the fly ash harvesting plant; and
    - Construction of new ash pipelines from Bayswater to Ravensworth Void number 3.
- Salt cake landfill facility:
    - Construction and operation of the new facility, including the salt cake emplacement area.
- Borrow pits:
    - Construction and operation of up to four borrow pit sites which would be excavated to provide material for the Project and for other suitable projects such as subsequent land forming and rehabilitation at Bayswater and Liddell. It is expected that material from these borrow pit sites would be used for future ash dam augmentation works, in the salt cake landfill and in other areas of AGL Macquarie land as required.
- Coal handling plant and wastewater infrastructure upgrades:
    - Minor civil works and plant modifications to the coal handling plant (CHP) and existing wastewater infrastructure during construction, as well as minor changes during operations.
- Ancillary Works:
    - Routine vegetation clearing works along the alignments of the LSP Sludge Line and HP Pipeline to facilitate pipeline maintenance and replacement.

Emissions from these sources would occur as a result of the extraction, transport and handling of dispersive materials, as well as from wind erosion of stored materials and exposed surfaces. These emissions would mainly comprise of particulate matter in the form of Total Suspended Particles (TSP), particulate matter with equivalent aerodynamic diameter of 10 microns or less (PM_{10}) and particulate matter with equivalent aerodynamic diametre of 2.5 microns or less ($PM_{2.5}$).

There would also be relatively minor emissions from machinery exhausts such as carbon monoxide (CO), oxides of nitrogen (NO_x) and particulate matter.

As identified in the SEARs, the primary air quality issue associated with the Project is expected to be dust (that is, particulate matter in the form of TSP, deposited dust, PM_{10} or $PM_{2.5}$). This issue is the focus of this AQIA. Computer-based air dispersion modelling was used to predict whether there would be unacceptable changes in local air quality.

3. Policy setting and assessment criteria

Typically, air quality is quantified by the concentrations of air pollutants in the ambient air. Air pollution occurs when the concentration (or some other measure of intensity) of substances known to cause health, nuisance and/or environmental effects, exceeds a certain level. With regard to human health and nuisance effects, the air pollutants most relevant to the Project are particulate matter emissions from excavation works and material handling, transport and processing activities; as well as from wind erosion of stored materials and exposed surfaces.

There are various classifications of particulate matter and the Environment Protection Authority (EPA) has developed assessment criteria for:

- TSP, to protect against nuisance amenity impacts;
- PM_{10}, to protect against health impacts;
- $PM_{2.5}$, to protect against health impacts; and
- Deposited dust, to protect against nuisance amenity impacts.

Most of the EPA criteria are drawn from national standards for air quality set by the National Environmental Protection Council of Australia (NEPC) as part of the National Environment Protection Measures (NEPM). To measure compliance with ambient air quality criteria, the former Office of Environment and Heritage (OEH) (now Department of Planning, Industry and Environment [**DPIE**]) has established a network of monitoring stations across the State and up-to-date records are published on DPIE's website.

Air quality impacts from a project are determined by the level of compliance with the air quality criteria set by the EPA as part of their 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW' (Approved Methods), (EPA, 2016). These criteria are outlined in **Table 3-1** and apply to existing and potential sensitive receivers such as such as residences, schools and hospitals.

Table 3-1 EPA Impact assessment criteria

Substance	Averaging time	Criterion	Source
Particulate matter (PM_{10})	24-hour	50 µg/m^3	EPA (2016) / DoE (2016)
	Annual	25 µg/m^3	EPA (2016) / DoE (2016)
Particulate matter ($PM_{2.5}$)	24-hour	25 µg/m^3	EPA (2016) / DoE (2016)
	Annual	8 µg/m^3	EPA (2016) / DoE (2016)
Particulate matter (TSP)	Annual	90 µg/m^3	EPA (2016) / NHMRC (1996)
Deposited dust	Annual (maximum increase)	2 g/m^2/month	EPA (2016) / NERDDC (1998)
	Annual (maximum total)	4 g/m^2/month	EPA (2016) / NERDDC (1998)

The EPA air quality assessment criteria relate to the total concentration of air pollutant in the air (that is, cumulative) and not just the contribution from project-specific sources. Therefore, some consideration of background levels needs to be made when using these criteria to assess the potential impacts. Further discussion of background levels in the study area is provided in **Section 4.4**.

In situations where background levels are elevated, the proponent must "demonstrate that no additional exceedances of the impact assessment criteria will occur as a result of the proposed activity and that best management practices will be implemented to minimise emissions of air pollutants as far as is practical" (EPA, 2016).

4. Existing environment

4.1 Surrounding land use and receivers

Figure 4-1 displays land uses around the Project, including the location of nearby sensitive receiver locations and nearby meteorological and ambient air quality monitoring stations.

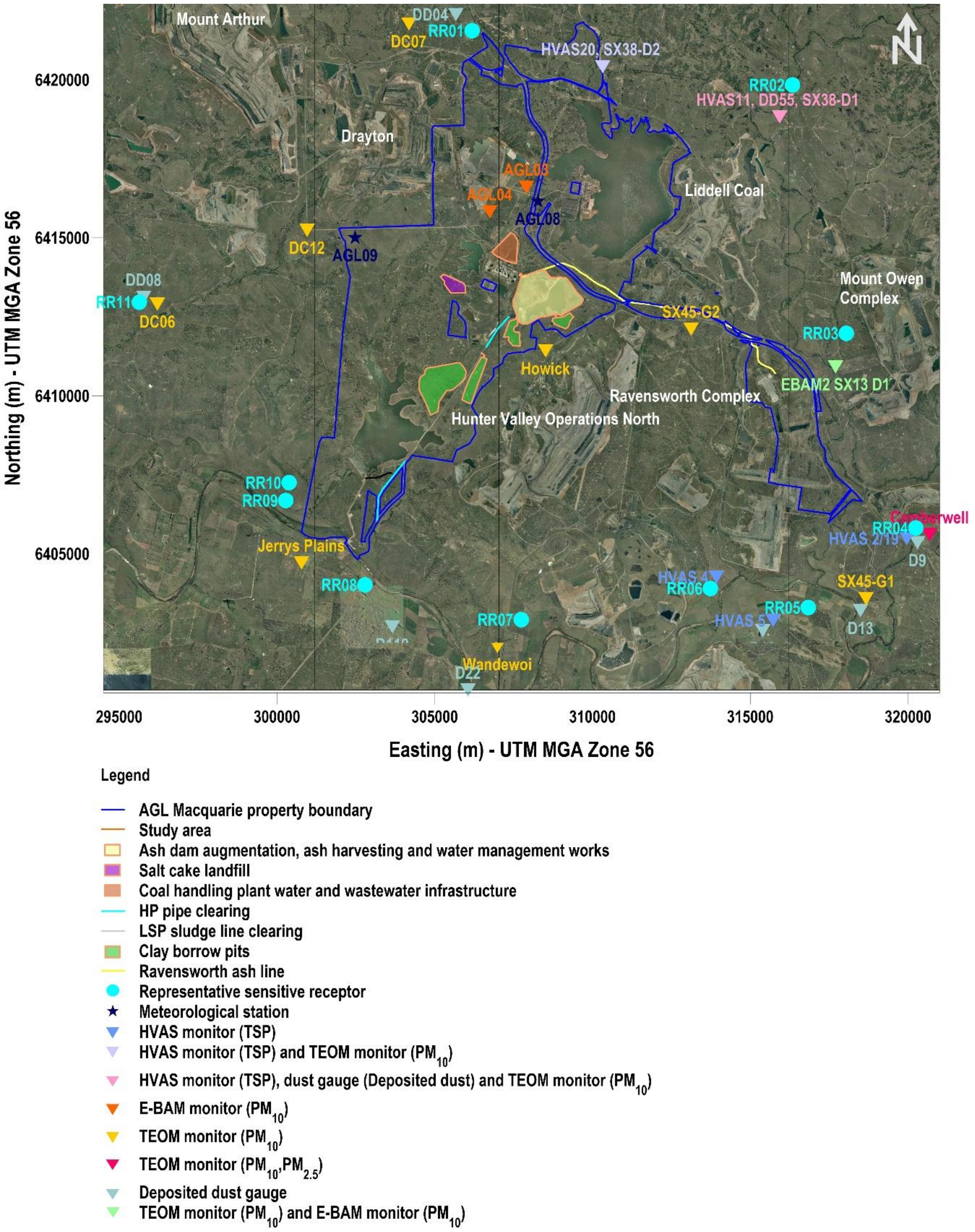


Figure 4-1 Project setting

As shown in **Figure 4-1**, sensitive receiver areas are located in all directions from the Project. Eleven (11) representative receiver locations were established, which denote the nearest sensitive receiver locations in different directions from the Project. Details of these locations are listed below.

Table 4-1 Surrounding representative receivers

Receiver ID	X co-ordinate (UTM MGA Zone 56)	Y co-ordinate (UTM MGA Zone 56)	Approximate orientation from the Project	Approximate distance from the Project (metres)
RR01	306177	6421554	North	6,400 m
RR02	316337	6419837	Northeast	9,300 m
RR03	318041	6411978	East	8,500 m
RR04	320245	6405818	East southeast	12,500 m
RR05	316832	6403296	Southeast	11,500 m
RR06	313729	6403903	South southeast	9,000 m
RR07	307735	6402915	South	4,900 m
RR08	302782	6404017	South southwest	1,800 m
RR09	300275	6406687	Southwest	2,600 m
RR10	300383	6407252	Southwest	2,500 m
RR11	295636	6412963	West	9,000 m

4.2 Terrain

A three-dimensional schematic of terrain features around the Project is shown below in **Figure 4-2**. As displayed, elevations within approximately 10 km of the Project range from around 100 to 500 metres above sea level. The key project areas (ash dam augmentation area, borrow pits, coal handling plant and salt cake landfill) are set at elevations between 150 and 190 metres above sea level. Representative receiver RR01 is located above the Project areas at an elevation of approximately 210 metres. The other ten representative receiver locations identified in **Figure 4-1** are located at similar or lower elevations than the key Project areas.

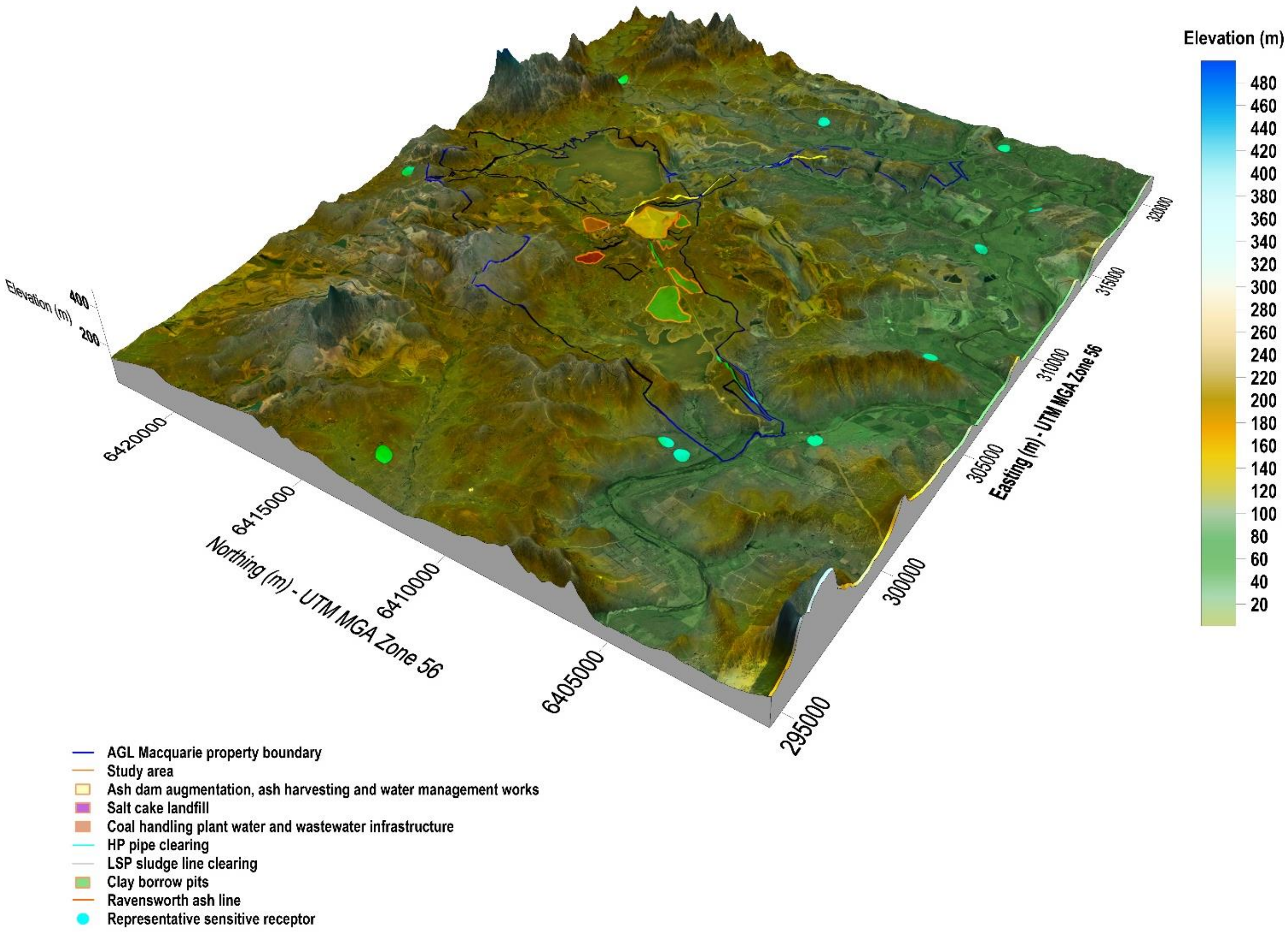


Figure 4-2 Three-dimensional schematic of Project setting

4.3 Meteorology

Meteorological conditions are important for determining the direction and rate at which emissions from a source will disperse. The key meteorological requirements of air dispersion models are, typically, hourly records of wind speed, wind direction, temperature, atmospheric stability class and mixing layer height. For air quality assessments, a minimum one year of hourly data is usually required, which means that almost all possible meteorological conditions, including seasonal variations, are considered in the model simulations.

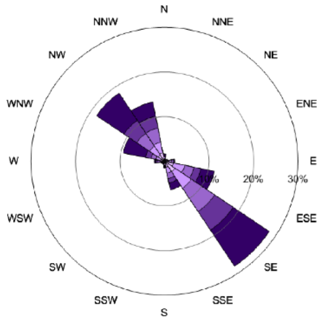
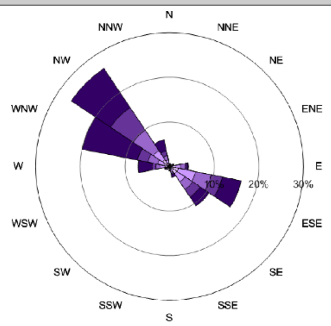
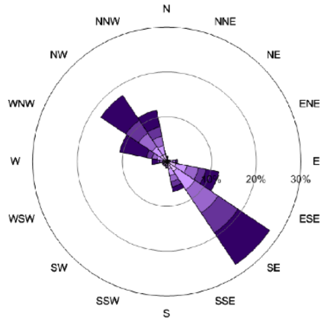
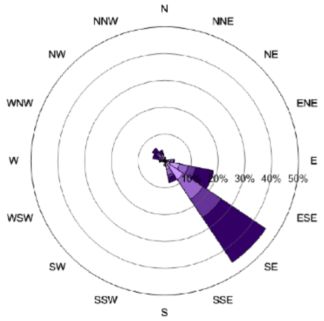
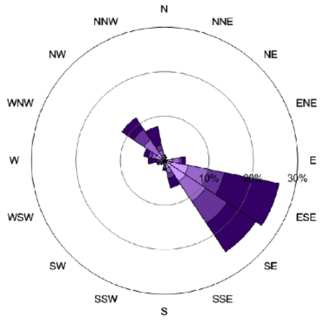
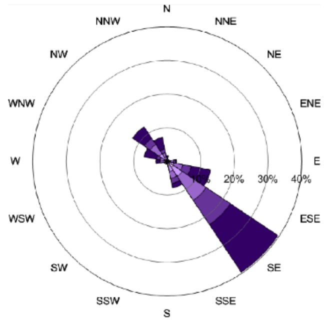
AGL Macquarie operates two meteorological stations, referred to as AGL08 and AGL 09. AGL08 is located to the north of the ash dam augmentation area at an elevation similar to the key Project areas of approximately 150 m AHD. AGL09 is located on Savoy Hill to the west of the ash dam augmentation area, at an elevation of circa 300 m above sea level.

Meteorological data from four recent years (1 Jan 2015 to 6 Jun 2018) have been analysed to identify trends from year-to-year and also to identify a representative year for use in the dispersion modelling. As outlined above, a minimum of one year of data is generally required for dispersion modelling assessments, and so data from the years' 2015 to 2018 were reviewed to determine a suitable year for the assessment. **Table 4-2** shows the statistics reviewed as part of this analysis from the data collected at AGL08 and AGL09.

Table 4-2 Annual statistics from meteorological data collected at AGL08 and AGL09 meteorological stations (2015 to 2018)

Statistic	2015	2016	2017	2018
AGL08 (Liddell meteorological station)				
Percent complete (%)	53	100	100	41
Mean wind speed (m/s)	2.4	2.4	2.7	2.4
Percentage of calms (%)	3.7	4.3	4.5	4.7
AGL09 (Bayswater meteorological station)				
Percent complete (%)	100	78	86	43
Mean wind speed (m/s)	6.2	6.8	6.3	6.5
Percentage of calms (%)	0.8	0.4	0.1	0.4

As displayed in **Table 4-2**, over the years reviewed, the mean speed has ranged from 2.4 to 2.7 m/s at AGL08 and from 6.2 to 6.8 m/s at AGL09. This difference is largely explained by the different elevations of the two monitoring sites, with AGL09 being located on a hill approximately 150 m higher than AGL08 and the key project areas. The wind sensors at AGL08 are at approximately 158 m AHD and the wind sensors at AGL09 are at approximately 310 m AHD. Meteorological conditions in 2015, 2016 and 2017 were further analysed to identify representative year for modelling. Annual and seasonal wind roses were developed for these years. These are displayed below in **Figure 4-3**. It is noted that 2018 was excluded owing to the limited measurement data available.

2015	2016	2017
Annual		
		
Calms: 0.8%	Calms: 0.4%	Calms: 0.1%
Summer		
		
Calms: 0.8%	Calms: 1.0%	Calms: 0.2%
Autumn		

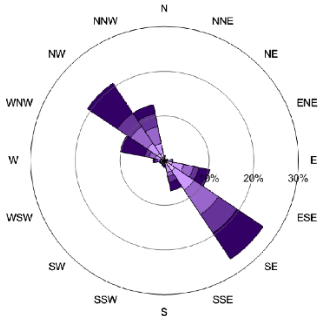
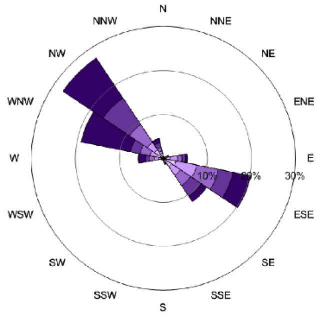
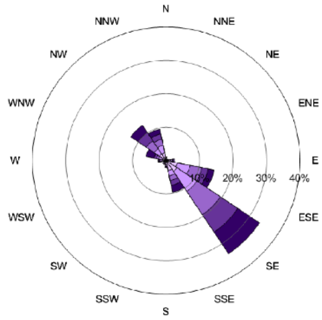
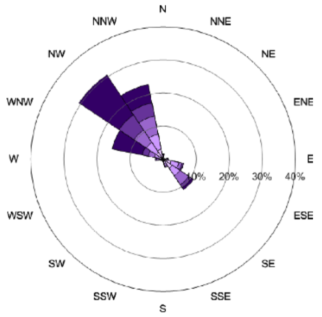
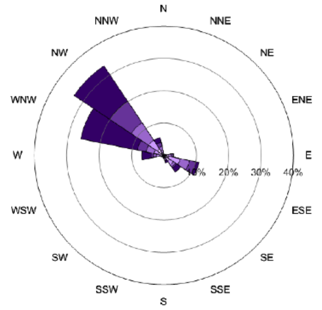
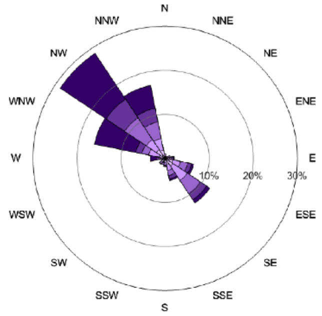
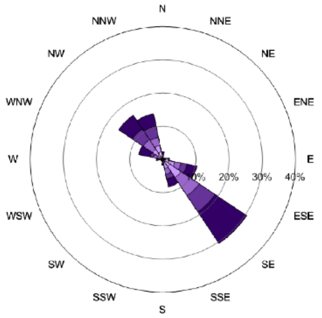
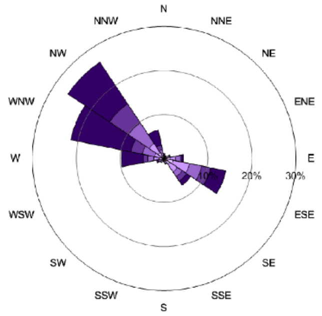
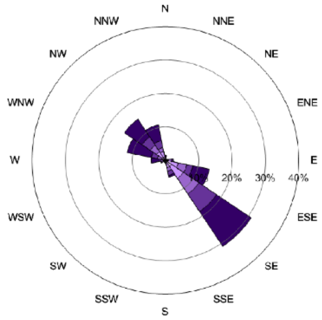
2015	2016	2017
 Calms: 0.2%	 Calms: 0.2%	 Calms: 0.3%
Winter		
 Calms: 1.4%	 Calms: 0.3%	 Calms: 0.0%
Spring		
 Calms: 0.9%	 Calms: 0.2%	 Calms: 0.0%
Legend		
Wind speed (m/s) >0.5 - 1.5 >1.5 - 3 >3 - 4.5 >4.5 - 6 >6 - 7.5 >7.5		

Figure 4-3 Annual and seasonal wind roses, Bayswater meteorological station AGL09

The 2017 calendar year was selected as the meteorological modelling year. The reasoning for this selection was as follows:

- 2017 had a higher data capture rate compared with 2018, 2016 and 2015; and

- Contemporaneous background data is available for 2017, to allow a more detailed review of changes in the number of exceedances. Further detail of this is provided below in **Section 4.4**.

4.4 Background air quality

4.4.1 Overview

To fully assess impacts against the relevant air quality criteria (see **Section 3**), it is necessary to have information or estimates of the existing air quality conditions. This section provides a description of the existing air quality.

As shown in **Figure 4-1**, there are several ambient air quality monitors within the vicinity of the Project. These are operated by a number of parties including AGL Macquarie, Glencore (Liddell Coal Operations [**LCO**], Glencore Ravensworth Complex [**RC**], Glencore Mount Owen Complex (**MOC**), Yancoal Hunter Valley Operations (**HVO**), Peabody Wambo Open-Cut Mine [**PW**], BHP Mount Arthur Coal [**MAC**], and DPIE]). Details of these stations are listed below in **Table 4-3**.

Table 4-3 Summary of nearby air quality monitoring stations

Station	Type	Pollutant(s) monitored	Operated by
AGL03	E-BAM	PM_{10}	AGL Macquarie
AGL04	E-BAM	PM_{10}	AGL Macquarie
HVAS20, SX38-D2	HVAS, TEOM	TSP, PM_{10}	LCO
HVAS11, DG 55, SX38-D1	HVAS, Deposited dust gauge and TEOM	TSP, deposited dust and PM_{10}	LCO
SX45-G1	TEOM	PM_{10}	RC
SX45-G2	TEOM	PM_{10}	RC
HVAS 4	HVAS	TSP	RC
HVAS 5	HVAS	TSP	RC
HVAS 2/19	HVAS	TSP	RC
DD9	Deposited dust gauge	Deposited dust	RC
DD12	Deposited dust gauge	Deposited dust	RC
DD13	Deposited dust gauge	Deposited dust	RC
Howick	TEOM	PM_{10}	HVO
Wandewoi	TEOM	PM_{10}	HVO
D119	Deposited dust gauge	Deposited dust	HVO
DD04	Deposited dust gauge	Deposited dust	MAC
DC06	TEOM	PM_{10}	MAC
DC07	TEOM	PM_{10}	MAC
DD08	Deposited dust gauge	Deposited dust	MAC
DC12	TEOM	PM_{10}	MAC
Jerrys Plains	TEOM	PM_{10}	DPIE
Camberwell	TEOM	PM_{10},	DPIE
D22	Deposited dust gauge	Deposited dust	PW
EBAM2, SX13 D1	E-BAM and TEOM	PM_{10}	MOC

E-BAM – Electronic beta attenuation monitor; HVAS – High volume air sampler; and TEOM – Tapered element oscillating microbalance

Background air quality data collected at these monitoring stations is discussed by classification of particulate matter in the following subsections.

4.4.2 Total suspended particulates (TSP)

TSP is monitored at HVAS20 and HVAS11 for Glencore's LCO, as well as at HVAS 4, HVAS 5 and HVAS 2/19 for Glencore's RC. Results collected are presented in Glencore's Annual Environmental Management Review (**AEMR**) reporting (available at http://www.liddellcoal.com.au/en/Publications/Pages/annual-reports.aspx for LCO and http://www.ravensworthoperations.com.au/en/publications/Pages/AEMR.aspx for RC). These are summarised below in **Table 4-4**.

Table 4-4 Glencore LCO and RC TSP monitoring results, 2015 to 2018

Year	Measured annual TSP (µg/m³)					Criterion (µg/m³)
	Glencore LCO HVAS20	Glencore LCO HVAS11	Glencore RC HVAS 4	Glencore RC HVAS 5	Glencore RC HVAS 2/19	
2018	59	44	84	71	80	90
2017	33	45	68	59	68	
2016	47	31	59	54	62	
2015	44	29	62	55	57	

As displayed, for 2015 to 2018 inclusive, annually measured TSP at Glencore LCO's HVAS20 and HVAS 11 varied between 32% and 66% of the NSW EPA's 90 µg/m³. At Glencore RC's HVAS 4, HVAS 5 and HVAS 2/19 measured values ranged from 60% to 93% of the criterion.

4.4.3 Particulate matter (as PM_{10})

Table 4-3 lists several nearby locations where PM_{10} concentrations are measured. These measurements are discussed by operator below.

AGL Macquarie

Continuous PM_{10} measurements are collected at AGL Macquarie's AGL03 and AGL04 e-sampler (E-BAM) air quality monitoring stations. **Figure 4-4** shows the measured 24-hour average PM_{10} concentrations from each monitoring site for data collected between 2015 and 2018. The EPA's air quality assessment criteria for PM_{10} (50 µg/m³) has also been shown on these graphs.

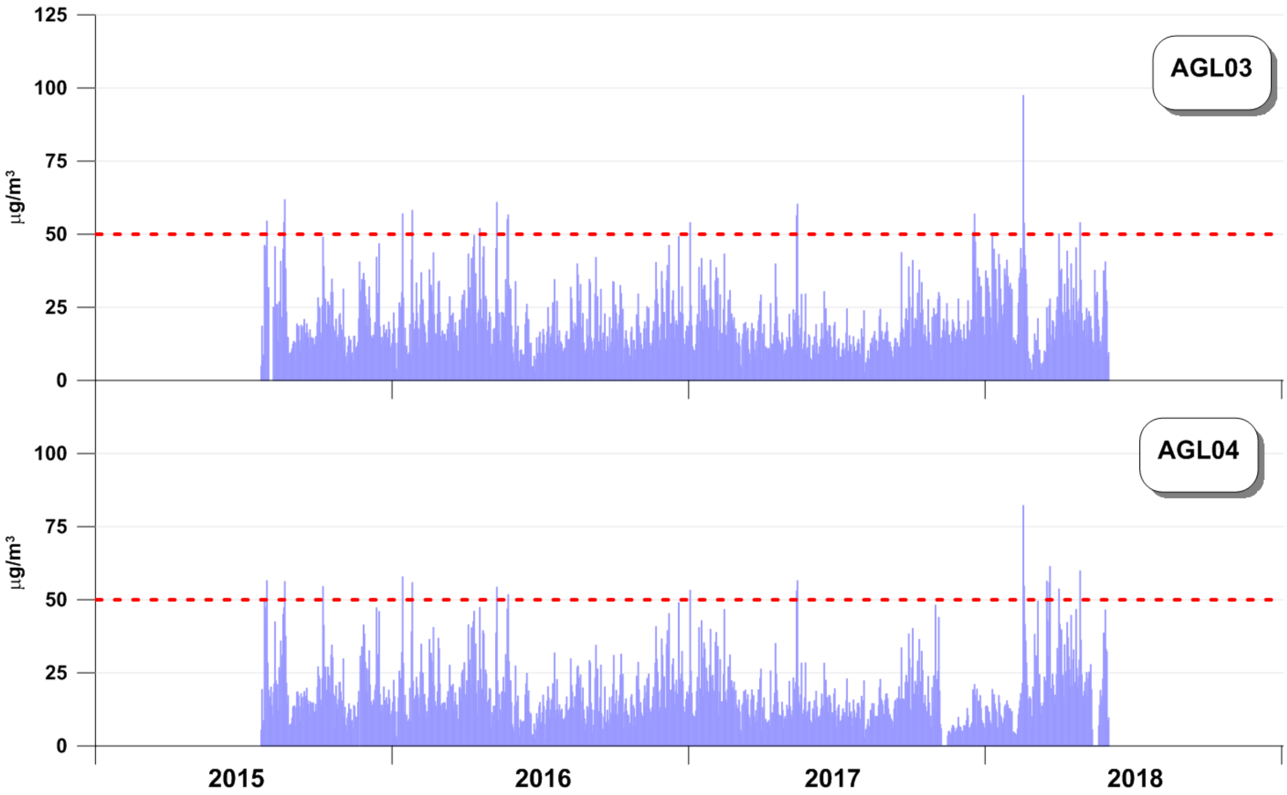


Figure 4-4 Measured 24-hour average PM_{10} concentrations AGL03 and AGL04, 2015 to 2018

It can be seen from **Figure 4-4** that both sites recorded at least one day above the 50 µg/m³ criterion in each of the past four years. **Table 4-5** summarises these results. Annual concentrations at both stations remained below the 25 µg/m³ criterion.

Table 4-5 Summary of measured PM_{10} concentrations at AGL Macquarie monitoring locations

Year	AGL03	AGL04	Criterion
Maximum 24-hour average in µg/m³			
2018	97*	82*	50
2017	60	57	
2016	61	58	
2015	62*	57*	
Number of days above 24-hour average criteria (50 µg/m³)			
2018	4*	7*	0
2017	5	3	
2016	6	4	
2015	3*	4*	
Annual average in µg/m³			
2018	24*	21*	25 (only applicable from 20 Jan 2017 onwards)
2017	17	15	
2016	20	18	
2015	20*	20*	

** Not a full year of data.*

Glencore LCO

Glencore LCO operate several TEOMs including SX38-D1 and SX38-D2 which continuously measure PM_{10} at locations around the LCO (refer to **Figure 4-1**). **Figure 4-5** shows the measured 24-hour average PM_{10} concentrations from each monitoring site for data collected in 2017 and 2018.

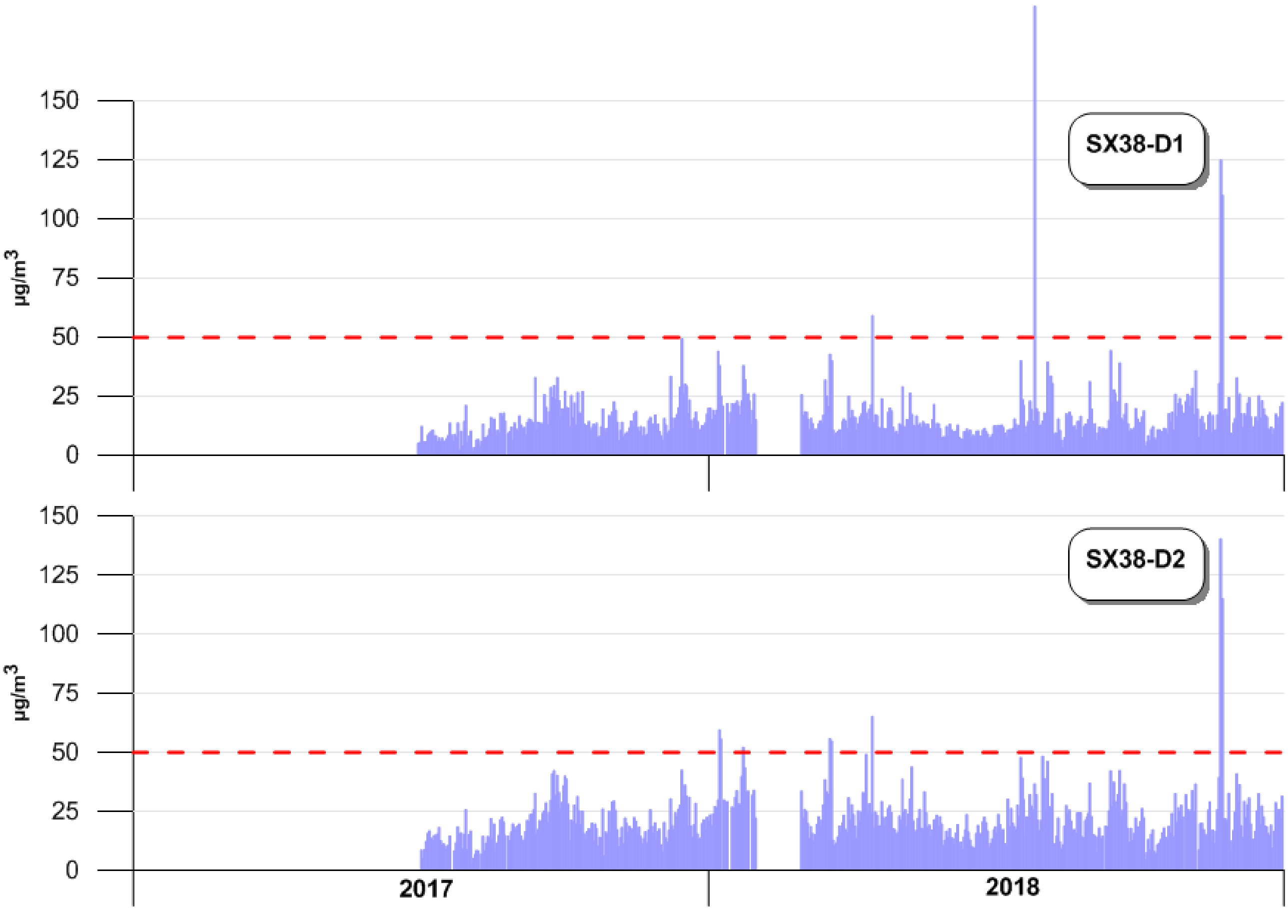


Figure 4-5 Measured 24-hour average PM_{10} concentrations at SX38-D1 and SX38-D2, 2017 to 2018

As displayed, both sites recorded at least one day above the 50 µg/m³ criterion over the period available. **Table 4-6** summarises these results.

Table 4-6 Summary of measured PM_{10} concentrations at Glencore LCO monitoring locations

Year	SX38-D1	SX38-D2	Criterion
Maximum 24-hour average in µg/m³			
2018	130	146	50
2017	49*	42*	
Number of days above 24-hour average criteria (50 µg/m³)			
2018	4	11	0
2017	0*	0*	
Annual average in µg/m³			
2018	17	23	

Year	SX38-D1	SX38-D2	Criterion
2017	13*	18*	25 (only applicable from 20 Jan 2017 onwards)

** Not a full year of data*

As displayed, at least one day above the 50 µg/m³ criterion was recorded at both sites in 2018. Annual concentrations remained below the 25 µg/m³ criterion that became applicable from 20 January 2017 onwards.

Glencore RC

Two TEOMs at Ravensworth Coal, SX45-G1 and SX45-G2 are located near receivers surrounding AGL Macquarie. Due to the formatting of the data in the Ravensworth Monthly Reports and Annual Reviews, graphing the 24-hour PM_{10} levels was not possible. However, the annual statistics for the TEOMs are listed in **Table 4-7** below. While the annual average and number of exceedances at SX45-G2 was reported in the annual monitoring reports, it is noted that the maximum 24-hour PM_{10} at SX45-G2 in 2015 and 2016 were not reported.

Table 4-7 Summary of measured PM_{10} concentrations at Glencore RC monitoring locations

Year	SX45-G1	SX45-G2	Criterion
Maximum 24-hour average in µg/m³			
2018	154	140	50
2017	55	71	
2016	49	-	
2015	64	-	
Number of days above 24-hour average criteria (50 µg/m³)			
2018	17	15	0
2017	3	5	
2016	0	1	
2015	6	21	
Annual average in µg/m³			
2018	25	24	25 (only applicable from 20 Jan 2017 onwards)
2017	21	17	
2016	22	17	
2015	20	16	

Glencore MOC

Glencore operates two air quality stations (EBAM2 and SX13 D1) near representative receiver RR03 monitoring PM_{10}. **Table 4-8** below summarises data reported between 2015 and 2018.

Table 4-8 Summary of measured PM_{10} concentrations at Glencore MOC EBAM2

Year	EBAM2	SX13 D1	Criterion
Maximum 24-hour average in µg/m³			
2018	60	144	50
2017	44*	63	
2016	-	56	
2015	-	71	

Year	EBAM2	SX13 D1	Criterion
Number of days above 24-hour average criteria (50 µg/m³)			
2018	6	10	0
2017	0*	15	
2016	-	5	
2015	-	6	
Annual average in µg/m³			
2018	18	23	25 (only applicable from 20 Jan 2017 onwards)
2017	15*	20	
2016	--	20	
2015		18	

As listed, several days were recorded where concentrations exceeded the 50 µg/m³, although annual concentration remained below the EPA criterion. Owing to the presentation of these data in reporting, it was not possible to produce time series plots.

HVO

Hunter Valley Operations Mine (**HVO**) operates a number of TEOMs at their, including Howick and Wandewoi which continuously measure PM_{10} (refer to **Figure 4-1**). **Figure 4-6** shows the measured 24-hour average PM_{10} concentrations from each monitoring site for data collected between 2017 and 2018.

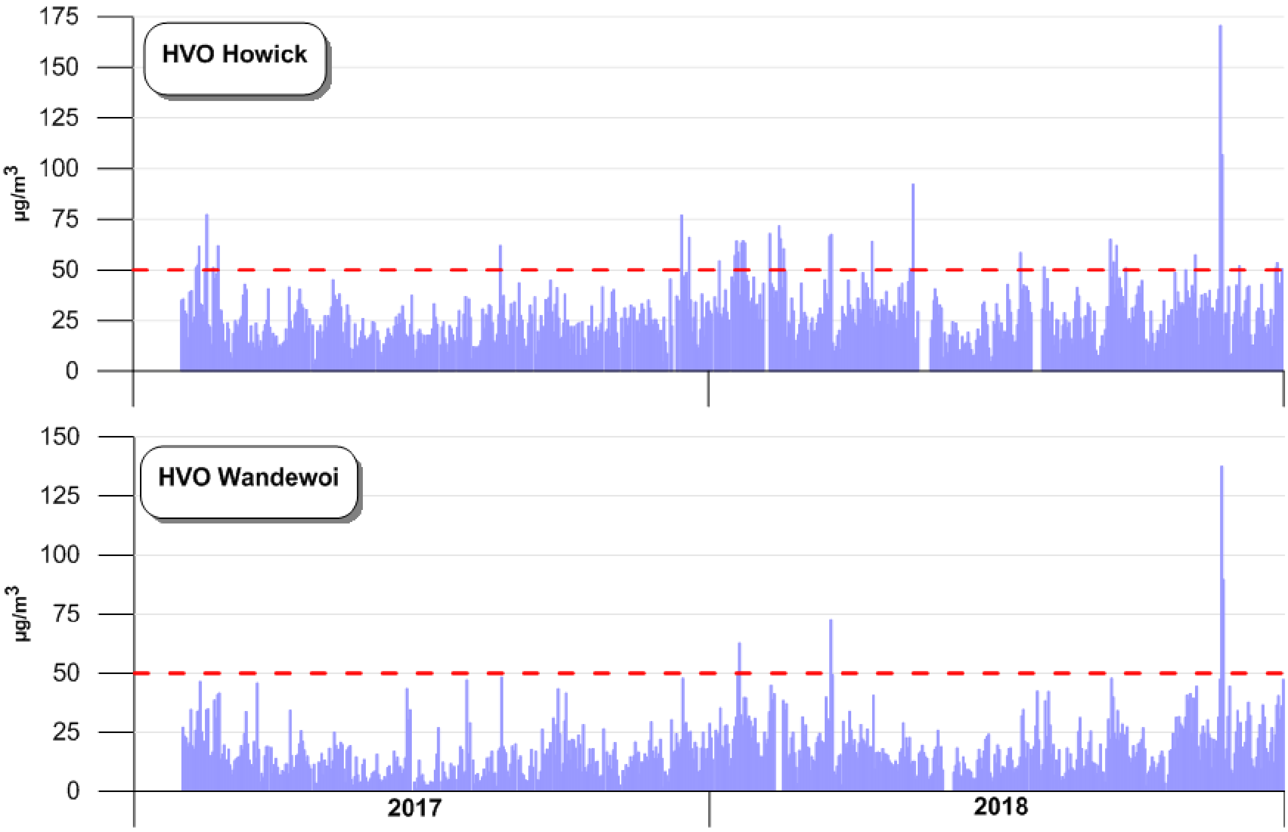


Figure 4-6 Measured 24-hour average PM_{10} concentrations at Howick and Wandewoi, 2017 to 2018

As displayed in **Figure 4-6** in 2017 Howick recorded 24 days over the 50 µg/m³ criterion, while there were no exceedances recorded at Wandewoi. In 2018, these numbers increased to 30 at Howick and 4 at Wandewoi. As displayed in **Figure 4-1**, the Howick station is located just to the north of Hunter Valley Operations Mine near AGL Macquarie's site boundary. The annual EPA criterion of 25 µg/m³ was reported as being exceeded at Howick in 2018. Annual concentrations remained below this criterion at Howick in 2017, and over both years of available data at Wandewoi. **Table 4-9** summarises these results.

Table 4-9 Summary of measured PM_{10} concentrations at Yancoal HVO monitoring locations

Year	Howick	Wandewoi	Criterion
Maximum 24-hour average in µg/m³			
2018	171	138	50
2017	77*	48*	
Number of days above 24-hour average criteria (50 µg/m³)			
2018	30	4	0
2017	24*	0*	
Annual average in µg/m³			
2018	31	20	25 (only applicable from 20 Jan 2017 onwards)
2017	24*	15*	

** Not a full year of data. Data only spanned February – December.*

BHP MAC

BHP operates several TEOMs including DC06, DC07 and DC12 which monitor PM_{10} around Mt Arthur Coal (refer to **Figure 4-1**). **Figure 4-7** shows the measured 24-hour average PM_{10} concentrations from DC06 for data collected between 2016 and 2018. Reported data for DC07 and DC12 was not available in a format suitable for graphing.

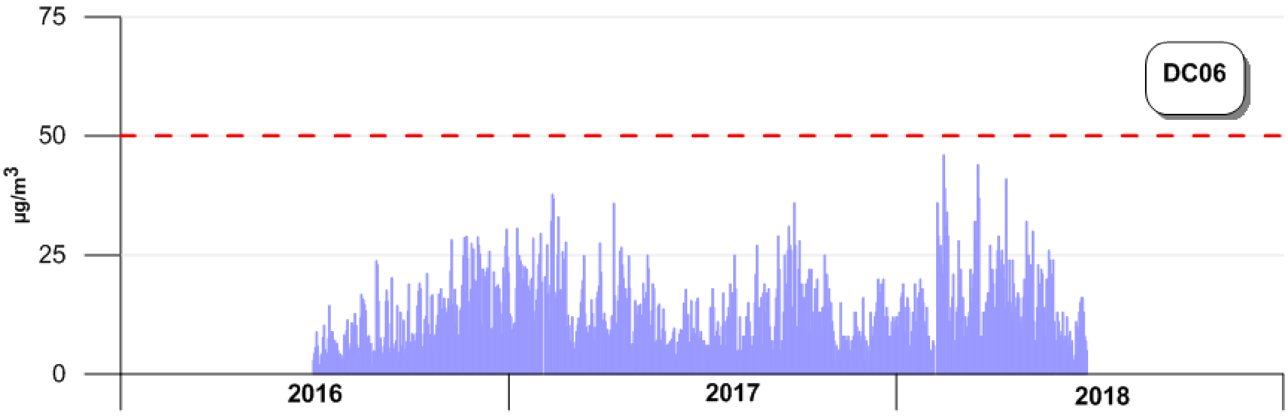


Figure 4-7 Measured 24-hour average PM_{10} concentrations at DC06, 2016 to 2018

It can be seen in **Figure 4-7** that for the recorded period there were no exceedances of the 50 µg/m³ criterion at DC06. A summary of the measured data for all three stations is list in **Table 4-10** below.

Table 4-10 Summary of measured PM_{10} concentrations at BHP MAC monitoring locations

Year	DC06	DC07	DC12	Criterion
Maximum 24-hour average in µg/m³				
2018	46*	-	249*	50
2017	38	42*	129*	
2016	37*	41	-	

Year	DC06	DC07	DC12	Criterion
2015	50*	-	-	
Number of days above 24-hour average criteria (50 µg/m³)				
2018	0	-	-	0
2017	0	0	-	
2016	0	0	-	
2015	0	-	-	
Annual average in µg/m³				
2018	14*	-	45*	25 (only applicable from 20 Jan 2017 onwards)
2017	13	14*	44*	
2016	12*	14	-	
2015	15*	-	-	

** Not a full year of data.*

DPIE

DPIE operates a number of air quality monitoring stations across NSW, with two located near AGL Macquarie at Jerrys Plains and Camberwell (refer to **Figure 4-1**). **Figure 4-8** shows the measured 24-hour average PM_{10} concentrations from each location between 2015 and 2018.

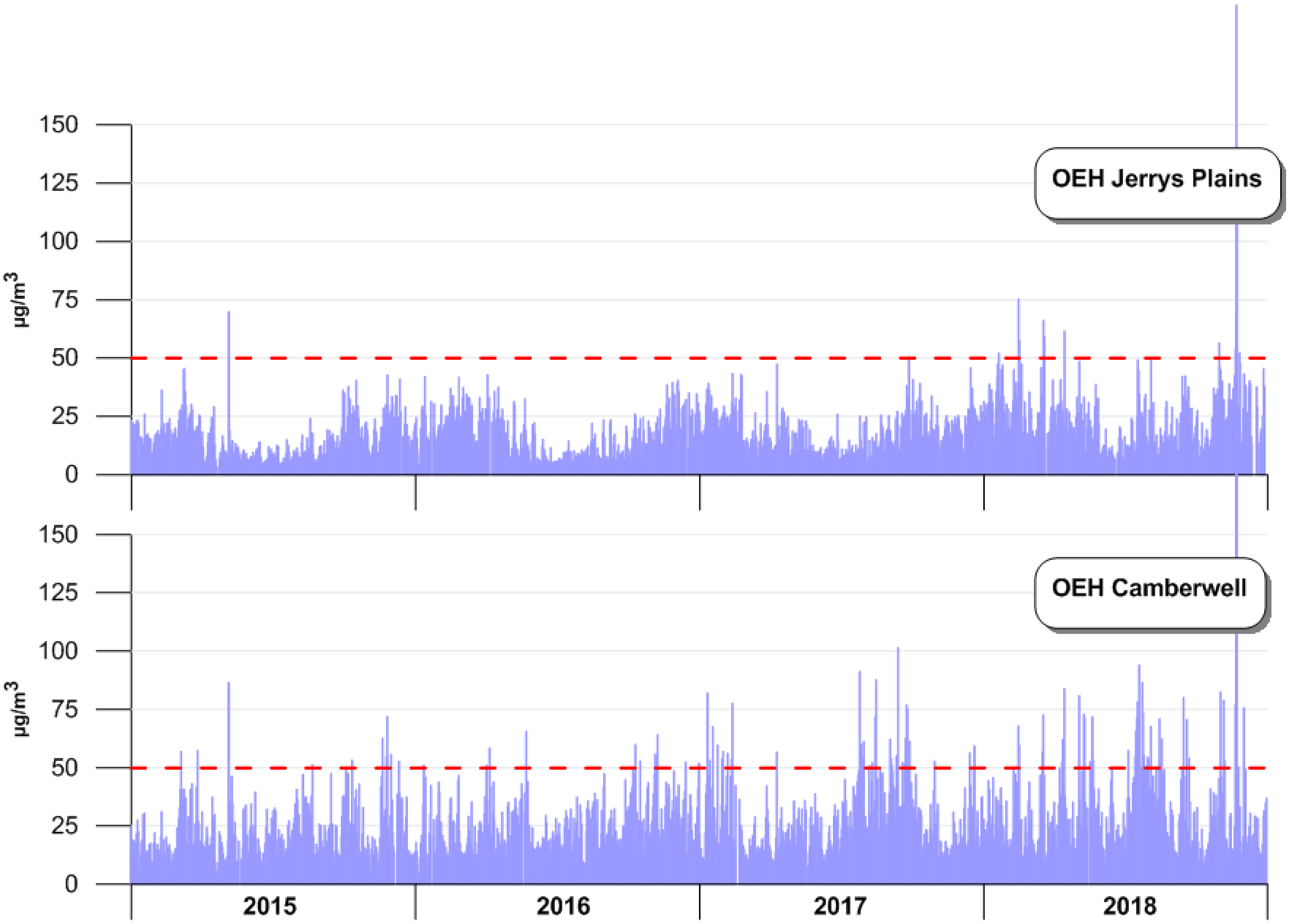


Figure 4-8 Measured 24-hour average PM_{10} concentrations at OEH stations at Jerrys Plains and Camberwell, 2015 to 2018

As **Figure 4-8** shows, Camberwell experienced a notable number of exceedances over the past four years compared to Jerrys Plains, though both locations recorded a significant increase in exceedances in 2018. This outcome has been influenced by drought conditions across NSW. Annual data is summarised in **Table 4-11** below.

Table 4-11 Summary of measured PM_{10} concentrations at DPIE monitoring stations

Year	DPIE Jerrys Plains	DPIE Camberwell	Criterion
Maximum 24-hour average in µg/m^3			
2018	201	244	50
2017	51	102	
2016	43	66	
2015	70	87	
Number of days above 24-hour average criteria (50 µg/m^3)			
2018	11	44	0
2017	1	33	
2016	0	11	
2015	1	11	
Annual average in µg/m^3			
2018	24	31	

Year	DPIE Jerrys Plains	DPIE Camberwell	Criterion
2017	17	27	25 (only applicable from 20 Juan 2017 onwards)
2016	18	25	
2015	24	22	

4.4.4 Particulate matter (as $PM_{2.5}$)

$PM_{2.5}$ is monitored at the DPIE's Camberwell air quality monitoring station (refer to **Figure 4-1** for location). **Figure 4-9** shows the 24-hour $PM_{2.5}$ averages for the last four years at Camberwell.

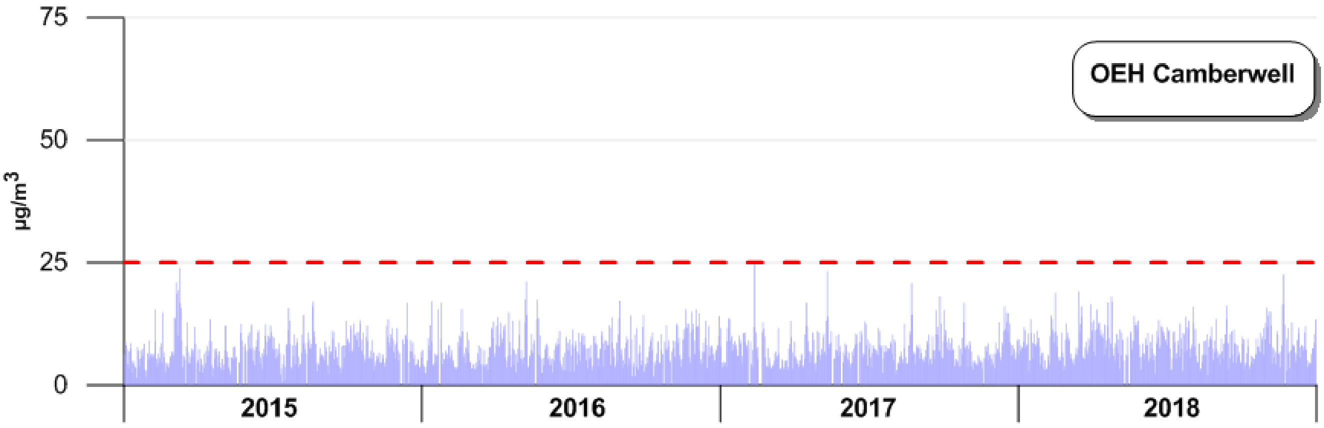


Figure 4-9 Measured 24-hour average $PM_{2.5}$ concentrations at OEH station at Camberwell, 2015 to 2018

As **Figure 4-9** shows, there were no exceedances of the daily $PM_{2.5}$ 25 µg/m³ criterion in the past four years. The monitoring data recorded over this period is summarised in **Table 4-12** below. Annual concentrations remained below the EPA's 8 µg/m³ criterion in 2015, 2016 and 2017 but was exceeded in 2018.

Table 4-12 Summary of measured $PM_{2.5}$ concentrations at OEH monitoring stations

Year	OEH Camberwell	Criterion
Maximum 24-hour average in µg/m³		
2018	22.6	25 (only applicable from 20 Jan 2017 onwards)
2017	24.7	
2016	21.1	
2015	23.9	
Number of days above 24-hour average criteria (25 µg/m³)		
2018	0	-
2017	0	
2016	0	
2015	0	
Annual average in µg/m³		
2018	8.4	8 (only applicable from 20 Jan 2017 onwards)
2017	7.4	
2016	7.5	
2015	7.2	

4.4.5 Deposited dust (DD)

Deposited dust is monitored at several gauges around AGL Macquarie. The data from these gauges are summarised below in **Table 4-13**.

Table 4-13. Glencore LCO, Yancoal HVO and BHP MAC DD monitoring results, 2015 to 2018

Year	Measured annual DD (g/m^2/month)								Criterion (g/m^2/month)
	Glencore LCO DG55	Peabody Wambo D22	BHP MAC DD04	BHP MAC DD08	Glencore RC D9	Glencore RC D12	Glencore RC D13	Yancoal HVO D119	
2018	1.5	3.2	-	1.4	3.6	2.3	2.5	N/A*	4
2017	2.3	2.3	2.3#	1.4	4.1	2.9	2.4	2.0	
2016	2.1	3.9	2.3	1.6	2.6	2	2.5	1.7	
2015	1.6	1.8	-	1.1	2.3	2.1	2.4	2.8	

** Not able to be extracted from monthly monitoring reports (results displayed graphically); # incomplete year*

As displayed, for 2015 to 2018 inclusive, all values remained below the EPA's g/m^2/month except in 2017 at Glencore RC's D9 deposited dust gauge.

4.4.6 Summary

The monitoring data from the various stations around the Project indicate that the EPA's daily impact assessment criterion were occasionally being exceeded around the nearby representative receiver locations. Annual PM_{10} and $PM_{2.5}$ concentrations and deposited dust levels were also exceeded in some years at some stations.

Background concentrations for the purpose of assessing cumulative pollutant concentrations and levels were estimated using the 2017 concentration (year of modelling) measured at the nearest station or otherwise most conservative (i.e. highest recorded) value. **Table 4-14** summarises the station data adopted at each representative receiver location. Data from DPIE's Camberwell and Jerrys Plains stations were considered where further analysis was required.

Table 4-14 Adopted representative background monitoring stations

Representative receiver	Particulate matter (TSP)	Particulate matter (PM_{10})	Particulate matter ($PM_{2.5}$)	Deposited dust
RR01	HVAS20	DC07	Camberwell	DD04
RR02	HVAS11	SX38-D1		DD55
RR03	HVAS 2/19	SX13 D1		D9
RR04	HVAS 2/19	Camberwell		D9
RR05	HVAS 5	SX45-G1		D12
RR06	HVAS 4			D12
RR07	HVAS 4	Wandewoi		D22
RR08	HVAS 4	Jerrys Plains		D119
RR09	HVAS 4			D119
RR10	HVAS 4			D119
RR11	HVAS 4	DC06		DD08

5. Emissions to air

As identified in **Section 2.3**, the most significant emission to air from the Project will be dust (particulate matter) due to material excavation, handling, transport and placement; and wind erosion of stored and exposed surfaces. Estimates of these emissions are required by the dispersion model. Total dust emissions have been estimated by analysing details of the Project and identifying the location and intensity of dust generating activities. Operational parameters have been combined with emissions factors developed both locally and by the United States Environmental Protection Agency (US EPA).

The emission factors used for this assessment have been drawn largely from the following sources:

- *Emission Estimation Technique Manual for Mining* (NPI, 2012); and
- AP 42 (US EPA, 1985 and updates).

Dust emission inventories were developed for two scenarios, namely:

- Peak operations; and
- Post-completion during rehabilitation.

For the peak operations scenario, it was conservatively considered that all four clay borrow pits would be opened, with the largest (clay borrow pit 4) being actively used to generate materials for the ash dam augmentation and salt cake landfill facility. The full footprint of the ash dam was also conservatively considered as a source of emissions. Twenty percent (20%) of the salt cake landfill facility was considered to be opened and exposed, consistent with the program of use of the facility. Emissions associated with the transport of fly ash were also included.

Table 5-1 and **Table 5-2** below summarise the estimated annual TSP, PM_{10} and $PM_{2.5}$ emissions (in kg/y) for the two assessment scenarios. **Appendix A** provides details of the dust emission calculations, including assumptions, emission controls and allocation of emissions to modelled locations. Only emissions from activities and sources associated with the Project have been modelled, with the contribution of emissions from existing operations at AGL Macquarie already considered to be present in the monitored background data discussed above in **Section 4.4**.

Table 5-1 Estimated emissions, peak operations

Activity	Estimated annual emissions (kg/y)		
	TSP	PM_{10}	$PM_{2.5}$
Ash Dam (AD) augmentation - Excavators on augmentation materials	192	91	10
AD augmentation - Trucks unloading augmentation materials	11,761	4,214	588
AD - Wind erosion ash and augmentation materials	146,378	73,189	10,978
Salt Cake Landfill Facility (SCLF) - Scrappers removing topsoil	3,786	953	191
SCLF - Dozers ripping materials	3,739	710	35
SCLF - Wind erosion from landfill area	19,062	9,531	1,430
SCLF - Wind erosion from stockpiled materials	953	477	71
SCLF - Excavators on materials	4	2	0
SCLF - Hauling SC product	62,202	16,046	1,605
Clay Borrow Pit (CBP) 1 - Scrappers removing topsoil	2,522	635	127

Activity	Estimated annual emissions (kg/y)		
	TSP	PM_{10}	$PM_{2.5}$
CBP 1 - Wind erosion from pit 1	15,870	7,935	1,190
CBP 2 - Scrappers removing topsoil	3,681	927	185
CBP 2 - Wind erosion from pit 2	23,165	11,583	1,737
CBP 3 - Scrappers removing topsoil	5,983	1,506	301
CBP 3 - Wind erosion from pit 3	37,652	18,826	2,824
CBP 4 - Scrappers removing topsoil	19,041	4,793	959
CBP 4 - Dozers ripping materials	3,739	710	35
CBP 4 - Wind erosion from pit 4	119,828	59,914	8,987
CBP 4 - Wind erosion from stockpiled materials	876	438	66
CBP 4 - Excavators loading materials	48	23	3
Haulage CBP 4 - Ash Dam	203,202	52,420	5,242
Haulage CBP 4 - SCLF	58,058	14,977	1,498
Haulage Fly Ash	44,725	8,585	2,077
Haulage Rehabilitation works	25	5	1
Total	**786,492**	**288,489**	**40,141**

Table 5-2 Estimated emissions, post-completion during rehabilitation

Activity	Estimated annual emissions (kg/y)		
	TSP	PM_{10}	$PM_{2.5}$
AMD - Wind erosion, Ash Dam	146,378	73,189	10,978
SCF - Wind erosion from landfill area	66,717	33,359	5,004
CBP1 - Wind erosion from pit 1	11,109	5,554	833
CBP2 - Wind erosion from pit 2	16,216	8,108	1,216
CBP3 - Wind erosion from pit 3	26,357	13,178	1,977
CBP4 - Wind erosion from pit 4	83,880	41,940	6,291
Total	**350,656**	**175,328**	**26,299**

The main intent of the inventories is to capture the most significant emission sources that may affect off-site air quality. Not every source will be captured. However, the contribution of emissions from sources not identified will be captured in the assumed background levels and these data have been added to the predicted contributions.

The following emission controls were assumed to be applicable to the Project and included in the inventories:

- Watering of unsealed access roads (leading to a 50% control on emissions); and
- Partial revegetation of the salt cake landfill facility and borrow pit areas (leading to a 30% control on emissions in the rehabilitation scenario).

6. Approach to assessment

6.1 Overview

This assessment has followed the EPA's Approved Methods which specifies how assessments based on the use of air dispersion models should be undertaken. The Approved Methods include guidelines for the preparation of meteorological data, reporting requirements and air quality assessment criteria to assess the significance of dispersion model predictions.

The CALPUFF computer-based air dispersion model has been used to predict ground-level concentrations and deposition levels due to the identified emission sources, and the model predictions have been compared with relevant air quality criteria. The choice of model has considered the expected transport distances for the emissions, as well as the potential for temporally and spatially varying flow fields due to influences of the locally complex terrain, non-uniform land use, and potential for stagnation conditions characterised by calm or very low wind speeds with variable wind directions.

The CALPUFF model, through the CALMET meteorological pre-processor, simulates complex meteorological patterns that exist in a particular region. The effects of local topography and changes in land surface characteristics are accounted for by this model. The model comprises meteorological modelling as well as dispersion modelling, both of which are described below.

6.2 Meteorological modelling

The air dispersion model used for this assessment, CALPUFF, requires information on the meteorological conditions in the modelled region. This information is typically generated by the meteorological pre-processor, CALMET, using surface observation data from local weather stations and upper air data from radio-sondes or numerical models, such as the CSIRO's prognostic model known as TAPM (The Air Pollution Model). CALMET also requires information on the local land-use and terrain. The result of a CALMET simulation is a year-long, three-dimensional output of meteorological conditions that can be used as input to the CALPUFF air dispersion model.

Meteorological data collected in 2017 from AGL Macquarie's AGL08 and AGL09 surface stations and upper air data generated by TAPM were used to initialise the CALMET model. CALMET was then set up with two surface observation stations (AGL08 and AGL09) and one upper air station (AGL08), based on TAPM output at AGL09. The meteorological modelling followed the guidance of TRC (2011) and adopted the "observations" mode. Key setup details for TAPM and CALMET are listed in **Table 6-1** and **Table 6-2** respectively.

Table 6-1 TAPM setup details

Parametre	Value(s)
Model version	4.0.5
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	35 x 35 x 25
Year(s) of analysis	2017, with one "spin-up" day.
Centre of analysis	Bayswater Power Station (32º24' S, 150º57' E)
Terrain data source	Shuttle Research Topography Mission (SRTM), 30 m resolution
Land use data source	Default
Meteorological data assimilation	Bayswater meteorological stations AGL08 and AGL09 Radius of influence = 10 km. Number of vertical levels for assimilation = 4. Quality factor = 1

Table 6-2 CALMET setup details

Parametre	Value(s)
Model version	6.334
Run mode	“observations” mode
Terrain data source(s)	NASA SRTM1 30 metre resolution dataset
Land-use data source(s)	Digitized from aerial imagery and classified as ‘water’, ‘barren’ or ‘agricultural’ categories specified in “CALPUFF Modeling System Version 6 User Instructions”, (TRC, 2011). This is displayed in **Appendix B**.
Meteorological grid domain	26.2 km x 21.8 km
Meteorological grid resolution	0.2 km
Meteorological grid dimensions	131 x 109 x 11
Meteorological grid origin	294900 mE, 6400500 mN. MGA Zone 56
Surface meteorological inputs	AGL08 and AGL09 for observations of wind speed and wind direction. TAPM for temperature, relative humidity, air pressure, ceiling height and cloud cover.
Upper air meteorological inputs	Upper air data file for the location of AGL08 derived by TAPM Biased towards surface observations (-1, -0.8, -0.8, -0.4, -0.2, 0, 1, 1, 1, 1, 1)
Simulation length	8760 hours (1 Jan 2017 to 31 Dec 2017)
R1, R2	0.1, 0.5
RMAX1, RMAX2	5, 20
TERRAD	3

6.3 Dispersion modelling

Ground-level concentration and deposition levels due to the identified emission sources have been predicted using the air dispersion model known as CALPUFF (Version 6.42). CALPUFF is a Lagrangian dispersion model that simulates the dispersion of pollutants within a turbulent atmosphere by representing emissions as a series of puffs emitted sequentially. Provided the rate at which the puffs are emitted is sufficiently rapid, the puffs overlap, and the serial release is representative of a continuous release.

The CALPUFF model differs from traditional Gaussian plume models (such as AUSPLUME and ISCST3) in that it can model spatially varying wind and turbulence fields that are important in complex terrain, long-range transport and near calm conditions. CALPUFF has the ability to model the effect of emissions entrained into the thermal internal boundary layer that forms over land, both through fumigation and plume trapping. CALPUFF is an air dispersion model which has been approved by the EPA for these types of assessments (EPA, 2016).

The modelling was performed using the emission estimates from **Section 5** and using the meteorological information provided by the CALMET model, described in **Section 6.2**. Predictions were made at 639 discrete receivers (including the 11 nearby sensitive receivers shown in **Figure 4-1**) to allow for contouring of results. The locations of the model receivers are shown in **Appendix C**.

Operations listed above in **Table 5-1** and **Table 5-2** were represented by a series of volume sources. These sources were positioned at the locations shown in **Figure 6-1** as identified below in **Table 6-3** and **Table 6-4** for the respective peak and rehabilitation scenarios.

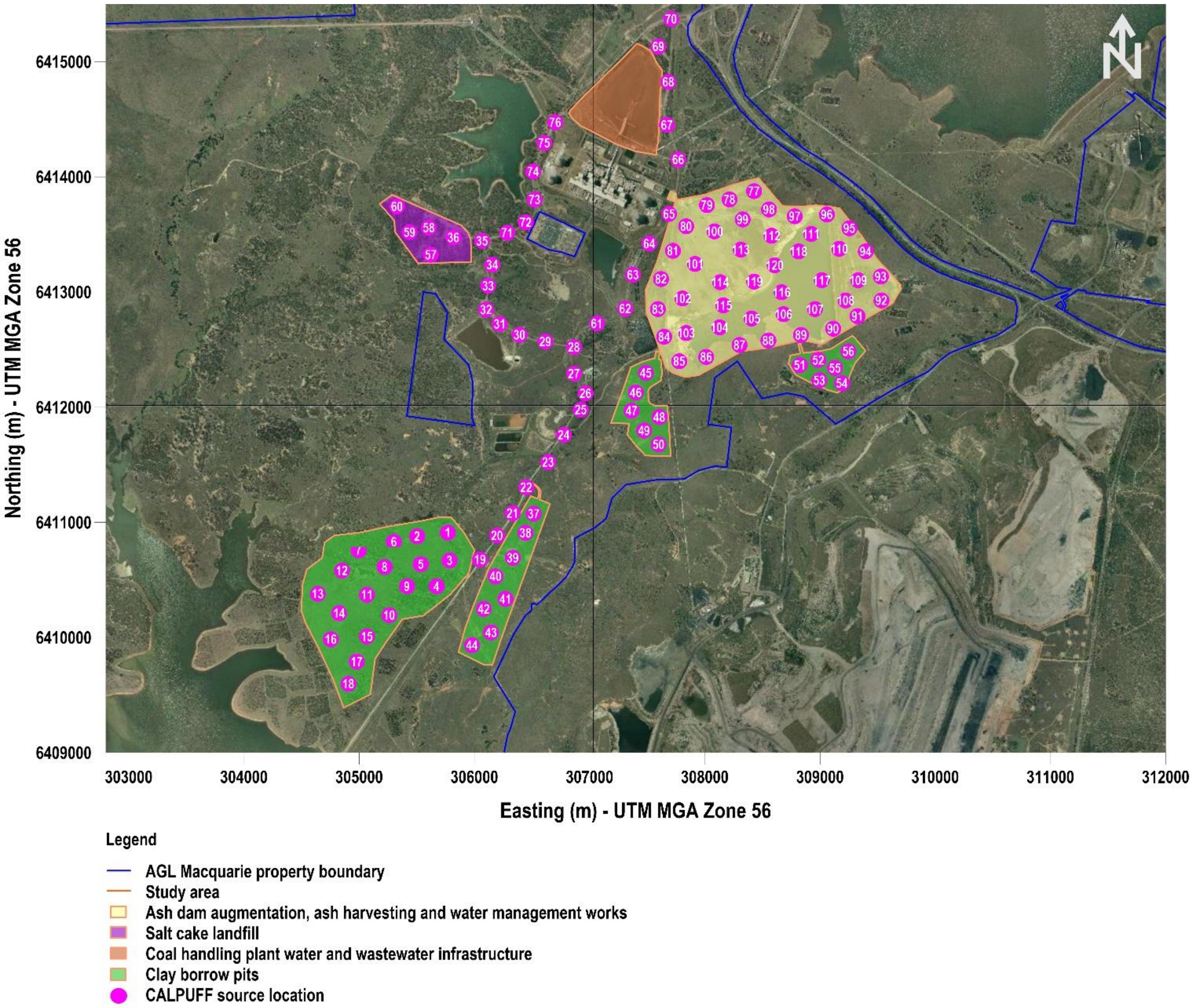


Figure 6-1 CALPUFF modelling source locations

Table 6-3 Allocation, peak operations

Activity	Assumed source locations where activities will take place
Ash Dam (AD) - Excavators on materials	77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119 and 120
AD - Trucks unloading materials	77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119 and 120
AD - Wind erosion	77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119 and 120
Salt Cake Landfill Facility (SCLF) - Scrappers removing topsoil	36, 57, 58, 59 and 60
SCLF - Dozers ripping materials	36, 57, 58, 59 and 60

Activity	Assumed source locations where activities will take place
SCLF - Wind erosion from landfill area	36, 57, 58, 59 and 60
SCLF - Wind erosion from stockpiled materials	36, 57, 58, 59 and 60
SCLF - Excavators on materials	36, 57, 58, 59 and 60
SCLF - Hauling SC product	35, 71, 72, 73, 74, 75 and 76
Clay Borrow Pit (CBP) 1 - Scrappers removing topsoil	51, 52, 53, 54, 55 and 56
CBP 1 - Wind erosion from pit 1	51, 52, 53, 54, 55 and 56
CBP 2 - Scrappers removing topsoil	45, 46, 47, 48, 49 and 50
CBP 2 - Wind erosion from pit 2	45, 46, 47, 48, 49 and 50
CBP 3 - Scrappers removing topsoil	37, 38, 39, 40, 41, 42, 43 and 44
CBP 3 - Wind erosion from pit 3	37, 38, 39, 40, 41, 42, 43 and 44
CBP 4 - Scrappers removing topsoil	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18
CBP 4 - Dozers ripping materials	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18
CBP 4 - Wind erosion from pit 4	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18
CBP 4 - Wind erosion from stockpiled materials	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18
CBP 4 - Excavators loading materials	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18
Haulage CBP 4 - Ash Dam	19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 61, 62, 63, 64 and 65
Haulage CBP 4 - SCLF	19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34 and 35
Haulage Fly Ash	65, 66, 67, 68, 69 and 70
Haulage Rehabilitation works	65, 66, 67, 68, 69 and 70

Table 6-4 Allocation, rehabilitation

Activity	Assumed source locations where activities will take place
AMD - Wind erosion, Ash Dam	77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119 and 120
SCF - Wind erosion from landfill area	36, 57, 58, 59 and 60
CBP1 - Wind erosion from pit 1	51, 52, 53, 54, 55 and 56
CBP2 - Wind erosion from pit 2	45, 46, 47, 48, 49 and 50
CBP3 - Wind erosion from pit 3	37, 38, 39, 40, 41, 42, 43 and 44
CBP4 - Wind erosion from pit 4	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18

Dust emissions for all modelled sources have been considered to fit into one of three categories, as follows:

- Wind insensitive sources, where emissions are relatively insensitive to wind speed (for example, dozers);
- Wind sensitive sources, where emissions vary with the hourly wind speed, raised to the power of 1.3, a generic relationship published by the US EPA (1987). This relationship has been applied to sources such as loading and unloading of materials to/from trucks and results in increased emissions with increased wind speed; and
- Wind sensitive sources, where emissions also vary with the hourly wind speed, but raised to the power of 3, a generic relationship published by Skidmore (1998). This relationship has been applied to sources including wind erosion from stockpiles, exposed areas or active pits, and results in increased emissions with increased wind speed.

Emissions from each volume source were developed on an hourly time step, taking into account the level of activity at that location and, in some cases, the hourly wind speed. This approach ensured that light winds corresponded with lower dust generation and higher winds, with higher dust generation. Full details of this is provided in **Appendix A**.

7. Assessment of impacts

7.1 Total suspended particulates (TSP)

Table 7-1 summarises predicted TSP contributions and cumulative concentrations at the 11 representative receiver locations identified in **Figure 4-1**. Background concentrations were estimated using the 2017 annual concentration (year of modelling) measured at the nearest station or otherwise most conservative (i.e. highest recorded) value. As displayed, the highest contribution at an off-site sensitive receiver location was predicted to be 0.14 µg/m^3 and resulting cumulative concentration was predicted to remain more than 21 µg/m^3 below the 90 µg/m^3 criterion.

Table 7-1 Predicted results, TSP

Location	Peak operations: incremental contribution (µg/m^3)	Rehabilitation: incremental contribution (µg/m^3)	Background concentration (µg/m^3)	Peak operations: cumulative concentration (µg/m^3)	Rehabilitation: incremental contribution (µg/m^3)	Criterion (µg/m^3)
RR01	0.01	<0.01	33	<34	<34	90
RR02	<0.01	<0.01	45	<46	<46	
RR03	0.05	0.02	68	<69	<69	
RR04	0.08	0.04	68	<69	<69	
RR05	0.13	0.05	59	<60	<60	
RR06	0.14	0.05	68	<69	<69	
RR07	0.02	0.01	68	<69	<69	
RR08	0.01	<0.01	68	<69	<69	
RR09	0.01	<0.01	68	<69	<69	
RR10	0.01	<0.01	68	<69	<69	
RR11	0.02	0.01	68	<69	<69	

Predicted contributions from the Project at all locations across the modelling domain (refer to map in **Appendix B**) are shown as contour plots in **Appendix D**.

7.2 Particulate matter (PM_{10})

Predicted 24-hour and annually averaged PM_{10} contributions and cumulative concentrations at the 11 representative receiver locations (see **Figure 4-1**) are listed below in **Table 7-2** and **Table 7-4** respectively. As for TSP, background concentrations were estimated using the 2017 measured at the nearest station or otherwise most conservative (i.e. highest recorded) value.

Table 7-2 Predicted results, 24-hour averaged PM_{10}

Location	Peak operations: incremental contribution (µg/m³)	Rehabilitation: incremental contribution (µg/m³)	Maximum 24-hour background concentration (µg/m³)	Peak operations: cumulative concentration (µg/m³)	Rehabilitation: incremental contribution (µg/m³)	Criterion (µg/m³)
RR01	0.56	0.24	42	<42	<42	50
RR02	0.21	0.07	49	<49	<49	
RR03	0.74	0.71	**63**	**<63**	**<63**	
RR04	0.43	0.39	**104**	**<104**	**<104**	
RR05	0.51	0.43	**55**	**<56**	**<56**	
RR06	0.65	0.55	**55**	**<56**	**<56**	
RR07	0.50	0.44	48	<49	<49	
RR08	0.27	0.23	**51**	**<52**	**<52**	
RR09	0.30	0.06	**51**	**<52**	**<52**	
RR10	0.43	0.05	**51**	**<52**	**<52**	
RR11	0.30	0.20	38	<39	<39	

Regarding 24-hour averaged PM_{10}, maximum daily background concentrations above the EPA's 50 µg/m³ criterion were recorded at stations used to characterise conditions around representative receivers RR03, RR04, RR05, RR05, RR06, RR08, RR09 and RR10 (see bolded background concentration values in **Table 7-2**). As such, cumulative concentrations were predicted to exceed 50 µg/m³ at these locations so it was necessary to determine if the Project would be the cause of additional exceedances. The highest contribution from the proposed operations compared with existing background sources was approximately 1.2%. Still, consistent with the Approved Methods, further assessment was completed to determine whether additional exceedances of the impact assessment criteria would occur as a result of the Project. This type of analysis requires daily background concentrations so that they can be added to the daily predicted PM_{10} contributions to determine whether additional exceedances have the potential to occur. This data was not available for SX13-D1 and SX45-G1 was used above for RR03 and RR05 and RR06 respectively. Thus, for this analysis at these locations, 2017 daily data measured at DPIE's Camberwell station was used. This is considered conservative, noting the higher 2017 24-hour maximum and annual average measured at Camberwell compared with SX13-D1 and SX45-G1. Daily data collected at Camberwell were also applied at RR04, with 2017 daily data from DPIE's Jerrys Plains station used for RR08, RR09 and RR10.

Table 7-3 summarises the results of this review, with time series of daily cumulative and incremental PM_{10} concentrations at RR03, RR04, RR05, RR06, RR08, RR09 and RR10 displayed in **Figure 7-1** and **Figure 7-2**.

Table 7-3 Review of changes in the number of PM_{10} exceedances at RR03, RR04, RR05, RR06, RR08, RR09 and RR10

Location	Number of exceedances (background)	Number of exceedances (Background + contributions from Project)	Change in number of exceedances per year
RR03	33	33	0
RR04	33	33	0
RR05	33	33	0
RR06	33	33	0
RR08	1	1	0
RR09	1	1	0
RR10	1	1	0

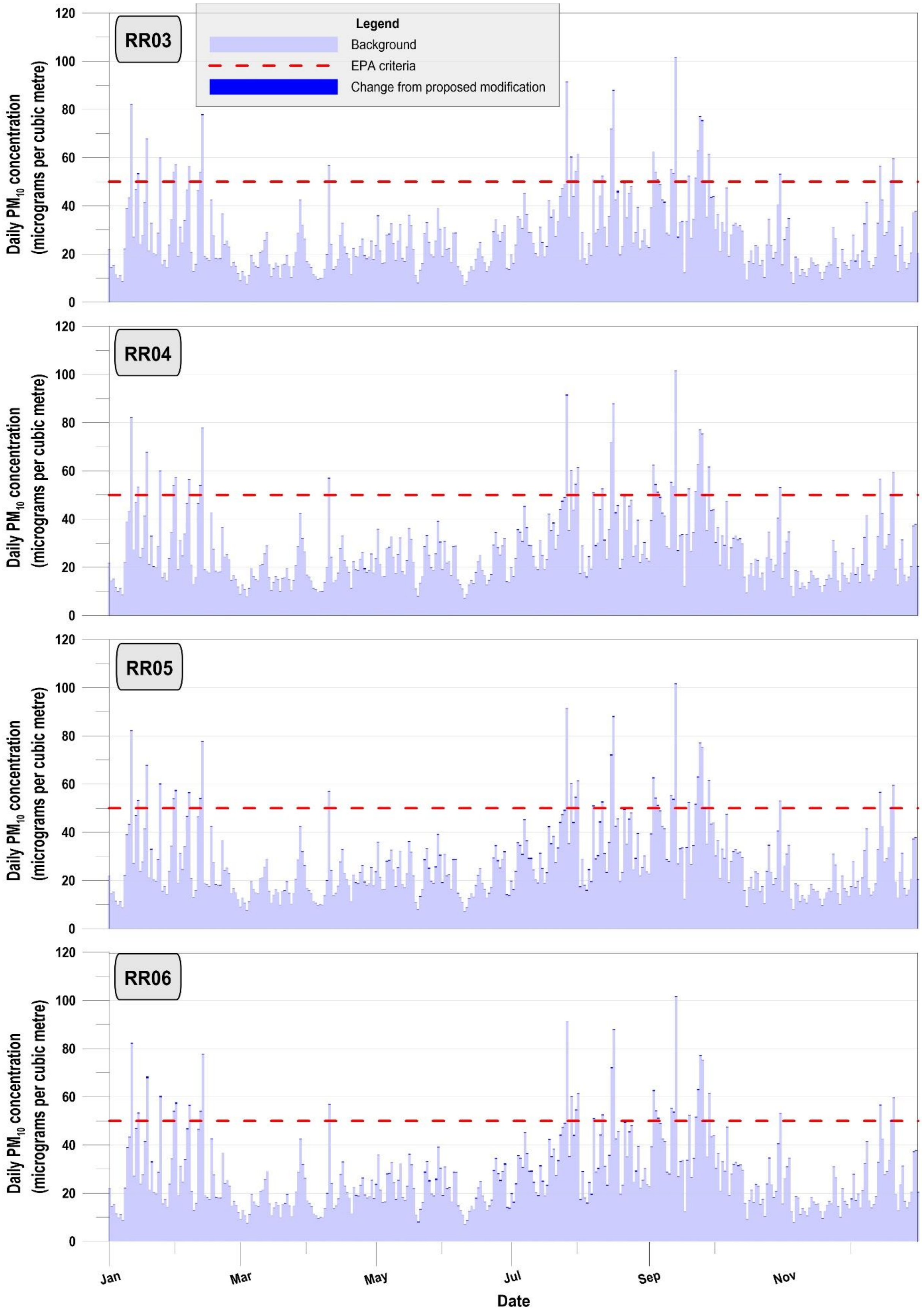


Figure 7-1 Timeseries of daily PM_{10} concentrations at RR03, RR04, RR05 and RR06

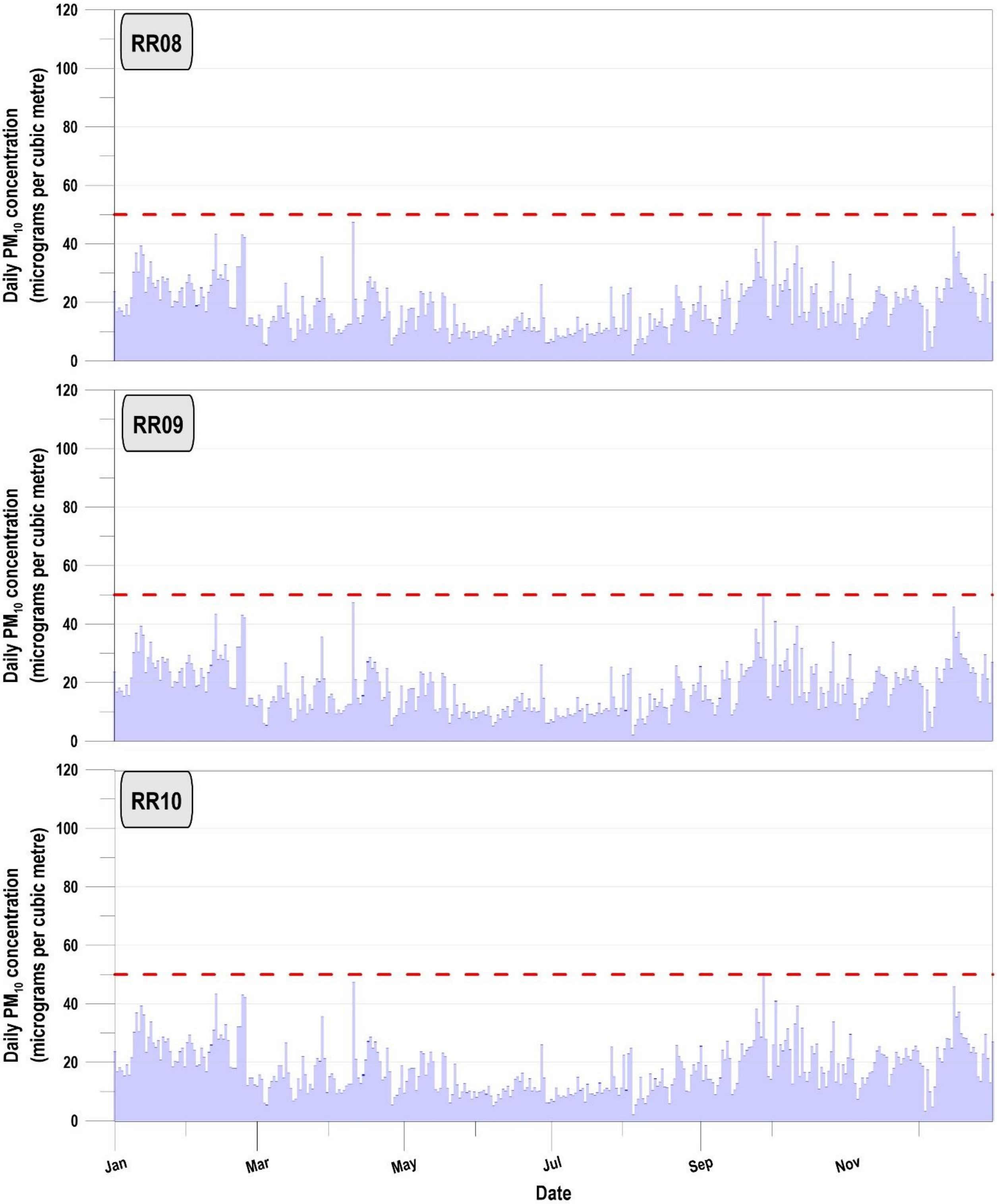


Figure 7-2 Timeseries of daily PM_{10} concentrations at RR08, RR09 and RR10

As listed and displayed, contributions from the Project were not predicted to result in any additional exceedances of the EPA's daily PM_{10} criterion at these representative receiver locations.

As listed in **Table 7-4**, annual PM_{10} contributions at the surrounding representative receivers were predicted to be negligible (i.e. less than 1%) compared with existing background sources. Cumulative concentrations were predicted to remain below the EPA's 25 µg/m^3 impact assessment criterion, except at RR04 where the 2017 background concentration already exceeded this limit.

Table 7-4 Predicted results, annually averaged PM_{10}

Location	Peak operations: incremental contribution (µg/m³)	Rehabilitation: incremental contribution (µg/m³)	Background concentration (µg/m³)	Peak operations: cumulative concentration (µg/m³)	Rehabilitation: incremental contribution (µg/m³)	Criterion (µg/m³)
RR01	0.02	0.01	14	<15	<15	25
RR02	<0.01	<0.01	13	<14	<14	
RR03	0.03	0.02	20	<21	<21	
RR04	0.06	0.03	**27**	<28	<28	
RR05	0.11	0.06	21	<22	<22	
RR06	0.12	0.05	21	<22	<22	
RR07	0.02	0.01	15	<16	<16	
RR08	0.01	<0.01	17	<18	<18	
RR09	0.01	<0.01	17	<18	<18	
RR10	0.01	<0.01	17	<18	<18	
RR11	0.02	0.01	13	<14	<14	

Predicted maximum 24-hour and annual PM_{10} contributions from the Project at all locations across the modelling domain (refer to map in **Appendix B**) are shown as contour plots in **Appendix D**.

7.3 Particulate matter ($PM_{2.5}$)

24-hour and annual $PM_{2.5}$ incremental and cumulative predictions at the representative receiver locations are summarised below in **Table 7-5** and **Table 7-6**. Background concentrations were estimated using the 2017 (year of modelling) data monitored at DPIE's station at Camberwell. As **Table 7-5** lists the highest daily cumulative concentration was predicted to be 24.8 µg/m³, below the EPA's 25 µg/m³ criterion. Existing background sources were estimated to contribute 99.4% of the predicted highest daily cumulative concentration.

Table 7-5 Predicted results, 24-hour averaged $PM_{2.5}$

Location	Peak operations: incremental contribution (µg/m³)	Rehabilitation: incremental contribution (µg/m³)	Maximum 24-hour background concentration (µg/m³)	Peak operations: cumulative concentration (µg/m³)	Rehabilitation: incremental contribution (µg/m³)	Criterion (µg/m³)
RR01	0.09	0.05	24.7	<24.8	<24.8	25
RR02	0.05	0.01		<24.8	<24.8	
RR03	0.16	0.15		<24.9	<24.9	
RR04	0.09	0.08		<24.8	<24.8	
RR05	0.10	0.10		<24.9	<24.9	
RR06	0.12	0.10		<24.9	<24.9	
RR07	0.09	0.08		<24.8	<24.8	
RR08	0.05	0.04		<24.8	<24.8	
RR09	0.04	0.01		<24.8	<24.8	
RR10	0.06	0.01		<24.8	<24.8	
RR11	0.06	0.04		<24.8	<24.8	

Regarding annually averaged $PM_{2.5}$, cumulative concentrations were predicted to remain below the 8 µg/m³ impact assessment criterion.

Table 7-6 Predicted results, annually averaged $PM_{2.5}$

Location	Peak operations: incremental contribution (µg/m³)	Rehabilitation: incremental contribution (µg/m³)	Background concentration (µg/m³)	Peak operations: cumulative concentration (µg/m³)	Rehabilitation: incremental contribution (µg/m³)	Criterion (µg/m³)
RR01	<0.01	<0.01	7.4	<7.5	<7.5	8
RR02	<0.01	<0.01		<7.5	<7.5	
RR03	0.01	<0.01		<7.5	<7.5	
RR04	0.01	0.01		<7.5	<7.5	
RR05	0.02	0.01		<7.5	<7.5	
RR06	0.02	<0.01		<7.5	<7.5	
RR07	<0.01	<0.01		<7.5	<7.5	
RR08	<0.01	<0.01		<7.5	<7.5	
RR09	<0.01	<0.01		<7.5	<7.5	
RR10	<0.01	<0.01		<7.5	<7.5	
RR11	<0.01	<0.01		<7.5	<7.5	

Predicted maximum 24-hour and annual $PM_{2.5}$ contributions from the Project at all locations across the modelling domain (see **Appendix B**) are shown as contour plots in **Appendix D**.

7.4 Deposited dust

Predicted incremental and cumulative levels of annually deposited dust at the surrounding representative receiver locations are summarised in **Table 7-7**. Cumulative levels were predicted to remain below the 4 g/m²/month impact assessment criterion at all representative receivers except RR03 and RR04 where 2017 background concentrations were already measured above 4 g/m²/month (see **bolded** values). The highest contribution from the modified operations at these receivers was 0.014 4 g/m²/month, or less than 0.35% of background contributions. In 2018, the annual deposited dust level at Glencore RC's D9 used to characterise background levels at RR03 and RR04 was 3.6 g/m²/month.

Table 7-7 Predicted results, deposited dust

Location	Peak operations: incremental contribution (g/m²/month)	Rehabilitation: incremental contribution (g/m²/month)	Background concentration (g/m²/month)	Peak operations: cumulative concentration (g/m²/month)	Rehabilitation: incremental contribution (g/m²/month)	Criterion (g/m²/month)
RR01	0.001	0.001	2.3	<2.31	<2.31	4
RR02	<0.001	<0.001	2.3	<2.31	<2.31	
RR03	0.008	0.005	**4.1**	**<4.11**	**<4.11**	
RR04	0.014	0.007	**4.1**	**<4.12**	**<4.11**	
RR05	0.022	0.010	2.9	<2.93	<2.92	
RR06	0.023	0.009	2.9	<2.93	<2.92	
RR07	0.002	0.001	2.3	<2.31	<2.31	
RR08	0.001	<0.001	2.0	<2.01	<2.01	

Location	Peak operations: incremental contribution (g/m^2/month)	Rehabilitation: incremental contribution (g/m^2/month)	Background concentration (g/m^2/month)	Peak operations: cumulative concentration (g/m^2/month)	Rehabilitation: incremental contribution (g/m^2/month)	Criterion (g/m^2/month)
RR09	0.001	<0.001	2.0	<2.01	<2.01	
RR10	0.001	<0.001	2.0	<2.01	<2.01	
RR11	0.004	0.001	1.4	<1.41	<1.41	

Contour plots of annual deposited dust are displayed in **Appendix D**.

7.5 Summary and interpretation

In summary, the following changes in local air quality as a result of the Project were predicted:

- TSP and $PM_{2.5}$: Changes would not result in exceedance of the EPA’s relevant impact assessment criteria at any of the nearest sensitive receivers;
- 24-hour averaged PM_{10}: Compliance with the EPA’s 50 µg/m^3 assessment criterion at representative receivers RR01, RR02, RR07 and RR11. No additional exceedances of the impact assessment criteria were predicted as a result of the Project at receivers where background conditions were already elevated (RR03, RR04, RR05, RR06, RR08, RR09 and RR10);
- Annual PM_{10}: Negligible contributions (less than 1%) were predicted from the Project, resulting in concentrations less than the 25 µg/m^3 assessment criterion at all representative receiver locations assessed except RR04 where background levels already exceeded this value; and
- Annual deposited dust: Negligible contributions (less than 0.35%) were predicted from the Project, resulting in concentrations less than the 4 g/m^2/month assessment criterion at all representative receiver locations assessed except RR03 and RR04 where background levels already exceeded this value.

Noting the conservatism of the assessment approach (i.e. all key work areas were assessed as concurrent emitting sources, with the full areas of the ash dam and clay borrow pits applied in developing emission factors, as well as for all hours), the results indicate that the Project would not result in unacceptable changes in local air quality.

8. Safeguards and monitoring

8.1 Recommended measures

As presented above, the assessment indicated that EPA impact assessment criteria for TSP and $PM_{2.5}$ would be met at surrounding sensitive receivers, with no additional exceedances of 24-hour averaged PM_{10} predicted. Negligible (less than 1%) contributions of annually averaged PM_{10} and deposited dust were predicted, although levels were noted to be already elevated above criteria at some receiver locations. Therefore, the assumed mitigation measures in the modelling have been determined to be appropriate to minimise impacts. Specifically, to limit potential emissions to air during the Project from dust-generating activities (i.e. extraction, transport and handling of dispersive materials and from wind erosion of stored materials and exposed surfaces), the following control measures would be required:

- Watering of all unsealed trafficked haulage routes to minimise visible dust emissions;
- Timely revegetation of rehabilitation areas at decommissioning.

In addition, and for consistency with Section 8.3 of 'Bayswater Ash Dam Augmentation Design Report' (Aurecon, 2019), the following measures should also be implemented:

- Conduct routine inspections of the ash dam to identify whether cenospheres (floating ash) have accumulated in dry areas beyond the decant pond;
- Where identified promptly bury, harvest or move dried cenospheres into the decant pond;
- Where feasible, use less dispersive bottom ash to 'cap fly' ash deposits in the ash dam before they dry out;
- As possible, restrict discharge from fly ash pipelines to one cell at a time, and utilise bottom ash to 'cap' before moving to the next cell;
- Where feasible utilise temporary 'flooding' of individual ash dam cells prior to unfavourable meteorological conditions; and
- As applicable make use of new access track to apply water or dust suppressing agents.

The following standard measures are also recommended to limit dust generation:

- Where possible, limit the extent of exposed areas and quantity of stockpiled dispersible materials;
- Apply watering to activities involving the loading and unloading, compaction and handling of soil materials as required; and
- Imposing suitable speed limits on site haulage routes.

These measures should be incorporated into an Air Quality Management Plan (AQMP) within the Operational Environmental Management Plan (OEMP) being prepared for the Project.

8.2 Best-practice measures

Although the assessment found that unacceptable changes in local air quality were not expected as a result of the Project, the SEARs require that all reasonable and feasible measures to minimise dust are implemented, and that monitoring and best practice management measures, in particular real-time air quality monitoring is considered. The recommended measures above have been identified as commensurate with the potential air quality impact of the Project. Best-practice measures may also include real-time monitoring and forecasting systems and further details of both these management options are provided below.

8.2.1 Real-time monitoring

Real-time monitoring involves the use of monitoring equipment capable of real-time (e.g. hourly or better resolution) measurement and reporting (e.g. E-BAM) usually at the nearest sensitive receivers. Multiple monitors are often used and configured around key emission sources at suitable 'upwind' and 'downwind' locations based on prevailing local wind conditions. Considering the prevailing annual meteorological trends displayed in **Figure 4-3**, monitors placed to the northwest and southeast of the ash dam (representing the largest Project source) would be most suitable. Locations would need to meet exposure guidelines from Australian Standards for siting air monitoring equipment. Suitable meteorological data would also be necessary for the interpretation of results. As the modelling showed that the change in ambient air quality at the nearest private sensitive receivers would not lead to exceedances of criteria, real-time monitoring has not been identified as a recommended measure.

8.2.2 Forecasting systems

There are various forecasting tools available that may assist with proactive management of dust emissions. These tools can be categorised into three main types:

- General weather information;
- Regional wind predictions; and
- Site specific wind and dust predictions.

General weather forecasts and five to seven-day outlooks can assist with identifying potentially high-risk days for dust, based on consideration of expected hot, dry and / or windy conditions. These forecasts are available from the Bureau of Meteorology website (www.bom.gov.au).

Regional five-day wind predictions for the Muswellbrook region are also available. The predictions are typically based on extraction of synoptic-scale forecasts from the Global Forecast System for various regions. The predictions can assist with identifying potentially high-risk times of days for dust, based on consideration of expected wind conditions.

Finally, site-specific dust and meteorological forecasting systems exist which can use local information to identify times and locations of increased dust risk, based on automated, daily dispersion modelling of emissions from identified sources. The forecasts can be used for discussion at pre-shift meetings and to assist with planning of daily operations to proactively manage air quality. As the modelling showed that the change in ambient air quality at the nearest private sensitive receivers would not lead to exceedances of criteria, predictive air quality forecasting has not been identified as a recommended measure

8.2.3 Summary

Real-time monitoring and forecasting systems can allow emissions to air to be actively managed so that potential issues are identified early. Both methods form part of best practice approaches to minimise dust generation and potential impacts however these have not been explicitly included as recommended measures since the modelling showed that the change in ambient air quality at the nearest private sensitive receivers would not lead to exceedances of criteria.

9. Conclusion

An assessment was completed to evaluate potential air quality impacts associated with the Project at Bayswater. This assessment was undertaken to meet the requirements for assessment listed in the SEARs and associated submissions.

The primary air quality issue associated with the Project was identified to be dust (that is, particulate matter in the form of TSP, deposited dust, PM_{10} or $PM_{2.5}$).

Statutes, policies and guidelines were reviewed to identify a suitable approach and criteria for assessing potential impacts from the Project. From the EPA's Approved Methods and consistent with the SEARs it was confirmed that impacts were to be assessed quantitatively, and suitable criteria were established.

The assessment required an understanding of key features of the existing environment including the presence and location of sensitive receivers; local meteorological conditions; and existing background pollutant concentrations. Nearby sensitive receivers around the site were identified by reviewing aerial imagery.

The computer-based dispersion model known as CALPUFF was used to predict the potential air quality impacts of the Project. The dispersion modelling accounted for meteorological conditions, land use and terrain information and used dust emission estimates to predict the off-site air quality impacts. A conservative approach was adopted which was based on adding maximum background levels for the modelling year (2017) to the maximum predicted contributions from the Project. Where impact assessment criteria were found to be exceeded, further analysis was performed consistent with the Approved Methods to determine the potential for additional instances of levels exceeding impact assessment criteria.

The model predictions showed that the Project would not have a significant contribution to local air quality. Predicted TSP and $PM_{2.5}$ concentrations were below the relevant EPA assessment criteria at the nearest sensitive receivers, including with the contributions from other activities at AGL Macquarie, and other local sources of emissions. In terms of 24-hour averaged PM_{10}, elevated existing background concentrations were found at some receiver locations. Modelling showed that the Project would not result in any additional exceedances at these locations. Negligible (less than 1%) contributions of annually averaged PM_{10} and deposited dust from the Project were predicted, although levels were noted to be already elevated above criteria at some receiver locations.

Although the assessment found that Project would not result in unacceptable changes in local air quality, measures were still recommended to mitigate and effectively manage emissions to air. These included the watering of haulage routes, progressive rehabilitation and active management measures. Real-time monitoring and forecasting systems were also discussed, which are best practice approaches to minimise dust generation and potential impacts, however these have not been explicitly included as recommended measures since the modelling showed that the change in ambient air quality at the nearest private sensitive receivers would not lead to exceedances of criteria.

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Appendix A. Emissions calculations

Emission estimates, controls factors, emission factors and input variables

Peak operations:

Emission calculations																						
Bayswater - Peak																						
	Annual emissions (kg/y)						TSP		PM10		PM2.5		Variables									
Activity	TSP	PM10	PM2.5	Control (%)	Intensity	Units	Factor	Units	Factor	Units	Factor	Units	Area (m2)	(ws/2.2)^1.3	Moisture (%)	k	kg/VKT	t/truck	km/trip	Silt (%)	Total average weight (t)	Bulk Density (t/m3)
AMD - Excavators on materials	192	91	10	0	980047	t/y	0.00020	kg/t	9.3E-05	kg/t	0.000	kg/t	-	1.13	7.9	-	-	-	-	-	-	1.6
AMD - Trucks unloading materials	11761	4214	588	0	980047	t/y	0.01200	kg/t	0.0043	kg/t	0.001	kg/t	-	-	-	-	-	-	-	-	-	-
AMD - Wind erosion, Ash Dam	146378	73189	10978	0	167.098	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	1670982	-	-	-	-	-	-	-	-	
SCF - Scrappers removing topsoil	3786	953	191	0	130562	t	0.029	kg/t	0.0073	kg/t	0.00146	kg/t	272005	-	-	-	-	-	-	-	-	1.6
SCF - Dozers ripping materials	3739	710	35	0	2080	h/y	1.79753	kg/h/v	0.34125	kg/h/v	0.01706	kg/h/v	-	-	7.9	-	-	-	-	6.9	-	-
SCF - Wind erosion from landfill area	19062	9531	1430	0	5.4401	ha	3504.0	kg/ha/y	1752.0	kg/ha/y	262.8	kg/ha/y	54401	-	-	-	-	-	-	-	-	-
SCF - Wind erosion from stockpiled materials	953	477	71	0	1.08802	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	10880.2	-	-	-	-	-	-	-	-	-
SCF - Excavators on materials	4	2	0	0	20000	t/y	0.00020	kg/t	9.3E-05	kg/t	0.000	kg/t	-	1.13	7.9	-	-	-	-	-	-	-
SCF - Hauling SC product	62202	16046	1605	50	60000	VKT/y	2.07339	kg/VKT	0.53488	kg/VKT	0.05349	kg/VKT	-	-	-	-	-	28	3	5.1	-	-
CBP1 - Scrappers removing topsoil	2522	635	127	0	86957.3	t	0.029	kg/t	0.0073	kg/t	0.00146	kg/t	181161	-	-	-	-	-	-	-	-	1.6
CBP1 - Wind erosion from pit 1	15870	7935	1190	0	18.1161	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	181161	-	-	-	-	-	-	-	-	-
CBP2 - Scrappers removing topsoil	3681	927	185	0	126932	t	0.029	kg/t	0.0073	kg/t	0.00146	kg/t	264442	-	-	-	-	-	-	-	-	1.6
CBP2 - Wind erosion from pit 2	23165	11583	1737	0	26.4442	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	264442	-	-	-	-	-	-	-	-	-
CBP3 - Scrappers removing topsoil	5983	1506	301	0	206314	t	0.029	kg/t	0.0073	kg/t	0.00146	kg/t	429821	-	-	-	-	-	-	-	-	1.6
CBP3 - Wind erosion from pit 3	37652	18826	2824	0	42.9821	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	429821	-	-	-	-	-	-	-	-	-
CBP4 - Scrappers removing topsoil	19041	4793	959	0	656593	t	0.029	kg/t	0.0073	kg/t	0.00146	kg/t	1367903	-	-	-	-	-	-	-	-	1.6
CBP4 - Dozers ripping materials	3739	710	35	0	2080	h/y	1.79753	kg/h/v	0.34125	kg/h/v	0.01706	kg/h/v	-	-	7.9	-	-	-	-	6.9	-	-
CBP4 - Wind erosion from pit 4	119828	59914	8987	0	136.79	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	1367903	-	-	-	-	-	-	-	-	-
CBP4 - Wind erosion from stockpiled materials	876	438	66	0	1	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	10000	-	-	-	-	-	-	-	-	-
CBP4 - Excavators loading materials	48	23	3	0	245012	t/y	0.00020	kg/t	9.3E-05	kg/t	0.000	kg/t	-	1.13	7.9	-	-	-	-	-	-	-
Haulage CBP4 - Ash Dam	203202	52420	5242	50	196009	VKT/y	2.07339	kg/VKT	0.53488	kg/VKT	0.05349	kg/VKT	-	-	-	-	-	28	7	5.1	-	-
Haulage CBP4 - SCF	58058	14977	1498	50	56003	VKT/y	2.07339	kg/VKT	0.53488	kg/VKT	0.05349	kg/VKT	-	-	-	-	-	28	8	5.1	-	-
Haulage FAH	44725	8585	2077	50	166667	VKT/y	0.53670	kg/VKT	0.10302	kg/VKT	0.02492	kg/VKT	-	-	-	-	-	24	4	8.2	23	-
Haulage Rehabilitation works	25	5	1	50	60	VKT/y	0.82361	kg/VKT	0.15809	kg/VKT	0.03825	kg/VKT	-	-	-	-	-	24	4	8.2	35	-
kg/yr	**786492**	**288489**	**40141**																			

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--------------------------------      15-Oct-2019 13:52
  DUST EMISSION CALCULATIONS XL1
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 Meteorological file    : NA
 Number of dust sources : 120
 Number of activities   : 24

  -----ACTIVITY SUMMARY-----
 ACTIVITY NAME : AMD - Excavators on materials
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 192 kg/y TSP  91 kg/y PM10  10 kg/y PM2.5
 FROM SOURCES  : 44
77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116
117 118 119 120
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : AMD - Trucks unloading materials
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 11761 kg/y TSP  4214 kg/y PM10  588 kg/y PM2.5
 FROM SOURCES  : 44
77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116
117 118 119 120
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : AMD - Wind erosion, additional areas Ash Dam
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 146378 kg/y TSP  73189 kg/y PM10  10978 kg/y PM2.5
 FROM SOURCES  : 44
77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116
117 118 119 120
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : SCF - Scrappers removing topsoil
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 3786 kg/y TSP  953 kg/y PM10  191 kg/y PM2.5
 FROM SOURCES  : 5
36 57 58 59 60
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : SCF - Dozers ripping materials
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 3739 kg/y TSP  710 kg/y PM10  35 kg/y PM2.5
 FROM SOURCES  : 5
36 57 58 59 60
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : SCF - Wind erosion from landfill area
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 19062 kg/y TSP  9531 kg/y PM10  1430 kg/y PM2.5
 FROM SOURCES  : 5
36 57 58 59 60
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : SCF - Wind erosion from stockpiled materials
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 953 kg/y TSP  477 kg/y PM10  71 kg/y PM2.5
 FROM SOURCES  : 5
36 57 58 59 60
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : SCF - Excavators on materials
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 4 kg/y TSP  2 kg/y PM10  0 kg/y PM2.5
 FROM SOURCES  : 5
36 57 58 59 60
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : SCF - Hauling SC product
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 62202 kg/y TSP  16046 kg/y PM10  1605 kg/y PM2.5
 FROM SOURCES  : 7
35 71 72 73 74 75 76
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : CBP1 - Scrappers removing topsoil
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 2522 kg/y TSP  635 kg/y PM10  127 kg/y PM2.5
 FROM SOURCES  : 6
51 52 53 54 55 56
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : CBP1 - Wind erosion from pit 1
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 15870 kg/y TSP  7935 kg/y PM10  1190 kg/y PM2.5
 FROM SOURCES  : 6
51 52 53 54 55 56
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : CBP2 - Scrappers removing topsoil
```

```
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 3681 kg/y TSP  927 kg/y PM10  185 kg/y PM2.5
 FROM SOURCES  : 6
45 46 47 48 49 50
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : CBP2 - Wind erosion from pit 1
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 23165 kg/y TSP  11583 kg/y PM10  1737 kg/y PM2.5
 FROM SOURCES  : 6
45 46 47 48 49 50
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : CBP3 - Scrappers removing topsoil
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 5983 kg/y TSP  1506 kg/y PM10  301 kg/y PM2.5
 FROM SOURCES  : 8
37 38 39 40 41 42 43 44
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : CBP3 - Wind erosion from pit 1
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 37652 kg/y TSP  18826 kg/y PM10  2824 kg/y PM2.5
 FROM SOURCES  : 8
37 38 39 40 41 42 43 44
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : CBP4 - Scrappers removing topsoil
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 19041 kg/y TSP  4793 kg/y PM10  959 kg/y PM2.5
 FROM SOURCES  : 18
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : CBP4 - Dozers ripping materials
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 3739 kg/y TSP  710 kg/y PM10  35 kg/y PM2.5
 FROM SOURCES  : 18
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : CBP4 - Wind erosion from pit 1
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 119828 kg/y TSP  59914 kg/y PM10  8987 kg/y PM2.5
 FROM SOURCES  : 18
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : CBP4 - Wind erosion from stockpiled materials
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 876 kg/y TSP  438 kg/y PM10  66 kg/y PM2.5
 FROM SOURCES  : 18
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : CBP4 - Excavators loading materials
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 48 kg/y TSP  23 kg/y PM10  3 kg/y PM2.5
 FROM SOURCES  : 18
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Haulage CBP4 - Ash Dam
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 203202 kg/y TSP  52420 kg/y PM10  5242 kg/y PM2.5
 FROM SOURCES  : 15
19 20 21 22 23 24 25 26 27 28 61 62 63 64 65
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Haulage CBP4 - SCF
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 58058 kg/y TSP  14977 kg/y PM10  1498 kg/y PM2.5
 FROM SOURCES  : 17
19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Haulage FAH
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 44725 kg/y TSP  8585 kg/y PM10  2077 kg/y PM2.5
 FROM SOURCES  : 6
65 66 67 68 69 70
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Haulage Rehabilitation works
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 25 kg/y TSP  5 kg/y PM10  1 kg/y PM2.5
 FROM SOURCES  : 6
65 66 67 68 69 70
 HOURS OF DAY  : 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
```

Rehabilitation:

Emission calculations																						
Bayswater - Rehabilitation																						
	Annual emissions (kg/y)						TSP		PM10		PM2.5		Variables									
Activity	TSP	PM10	PM2.5	Control (%)	Intensity	Units	Factor	Units	Factor	Units	Factor	Units	Area (m2)	(ws/2.2)^1.3	Moisture (%)	k	kg/VKT	t/truck	km/trip	Silt (%)	Total average weight (t)	Bulk Density (t/m3)
AMD - Wind erosion, Ash Dam	146378	73189	10978	0	167.098	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	1670982	-	-	-	-	-	-	-	-	
SCF - Wind erosion from landfill area	66717	33359	5004	30	27.2005	ha	3504.0	kg/ha/y	1752.0	kg/ha/y	262.8	kg/ha/y	272005	-	-	-	-	-	-	-	-	-
CBP1 - Wind erosion from pit 1	11109	5554	833	30	18.1161	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	181161	-	-	-	-	-	-	-	-	-
CBP2 - Wind erosion from pit 2	16216	8108	1216	30	26.4442	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	264442	-	-	-	-	-	-	-	-	-
CBP3 - Wind erosion from pit 3	26357	13178	1977	30	42.9821	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	429821	-	-	-	-	-	-	-	-	-
CBP4 - Wind erosion from pit 4	83880	41940	6291	30	136.79	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	1367903	-	-	-	-	-	-	-	-	-
kg/yr	**350656**	**175328**	**26299**																			

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--------------------------------      15-Oct-2019 17:16
  DUST EMISSION CALCULATIONS XL1
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 Meteorological file    : NA
 Number of dust sources : 120
 Number of activities   : 6

  -----ACTIVITY SUMMARY-----
 ACTIVITY NAME : AMD - Wind erosion, Ash Dam
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 146378 kg/y TSP  73189 kg/y PM10  10978 kg/y PM2.5
 FROM SOURCES  : 44
77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116
117 118 119 120
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : SCF - Wind erosion from landfill area
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 66717 kg/y TSP  33359 kg/y PM10  5004 kg/y PM2.5
 FROM SOURCES  : 5
36 57 58 59 60
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : CBP1 - Wind erosion from pit 1
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 11109 kg/y TSP  5554 kg/y PM10  833 kg/y PM2.5
 FROM SOURCES  : 6
51 52 53 54 55 56
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : CBP2 - Wind erosion from pit 2
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 16216 kg/y TSP  8108 kg/y PM10  1216 kg/y PM2.5
 FROM SOURCES  : 6
45 46 47 48 49 50
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : CBP3 - Wind erosion from pit 3
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 26357 kg/y TSP  13178 kg/y PM10  1977 kg/y PM2.5
 FROM SOURCES  : 8
37 38 39 40 41 42 43 44
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : CBP4 - Wind erosion from pit 4
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 83880 kg/y TSP  41940 kg/y PM10  6291 kg/y PM2.5
 FROM SOURCES  : 18
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```
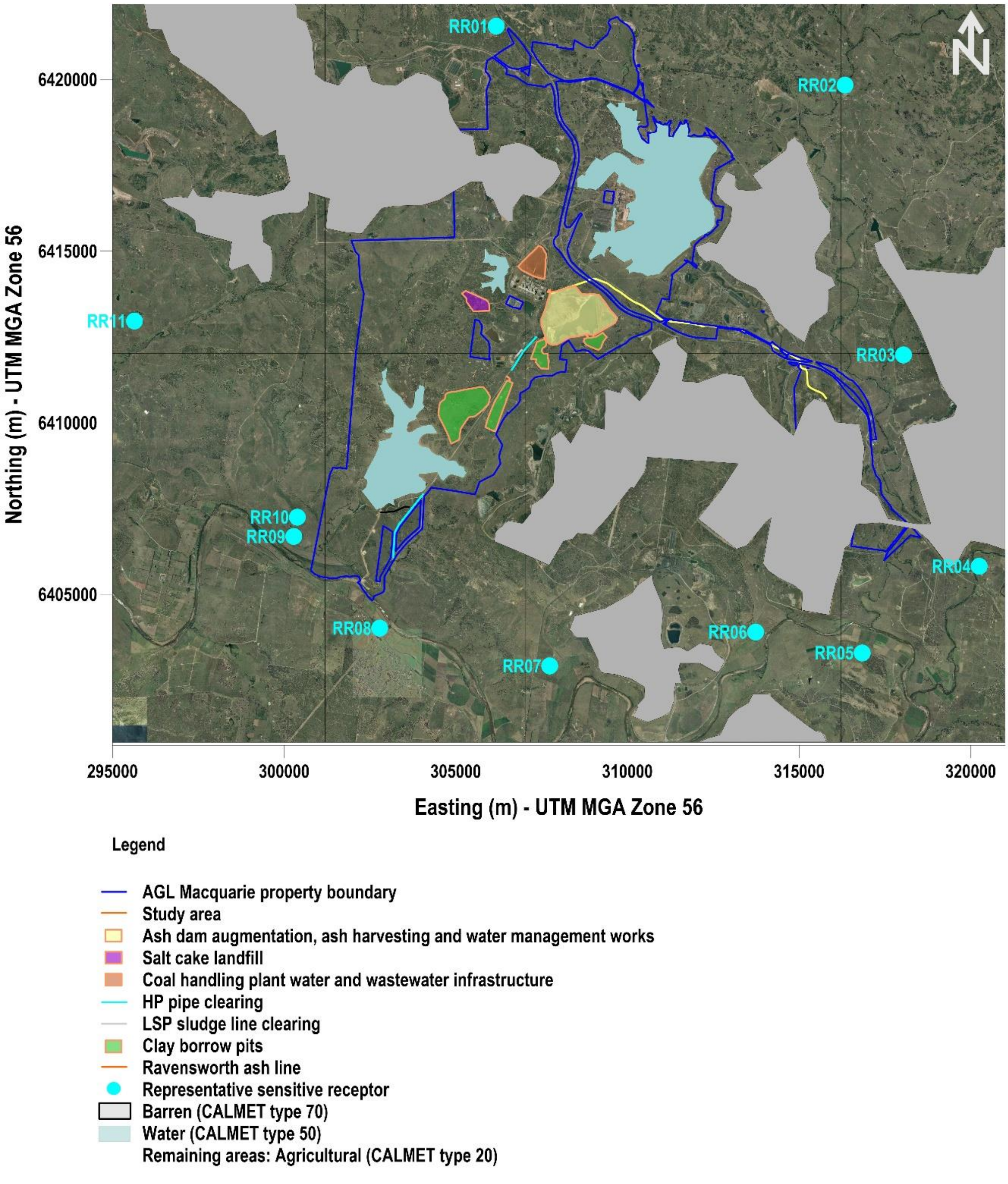
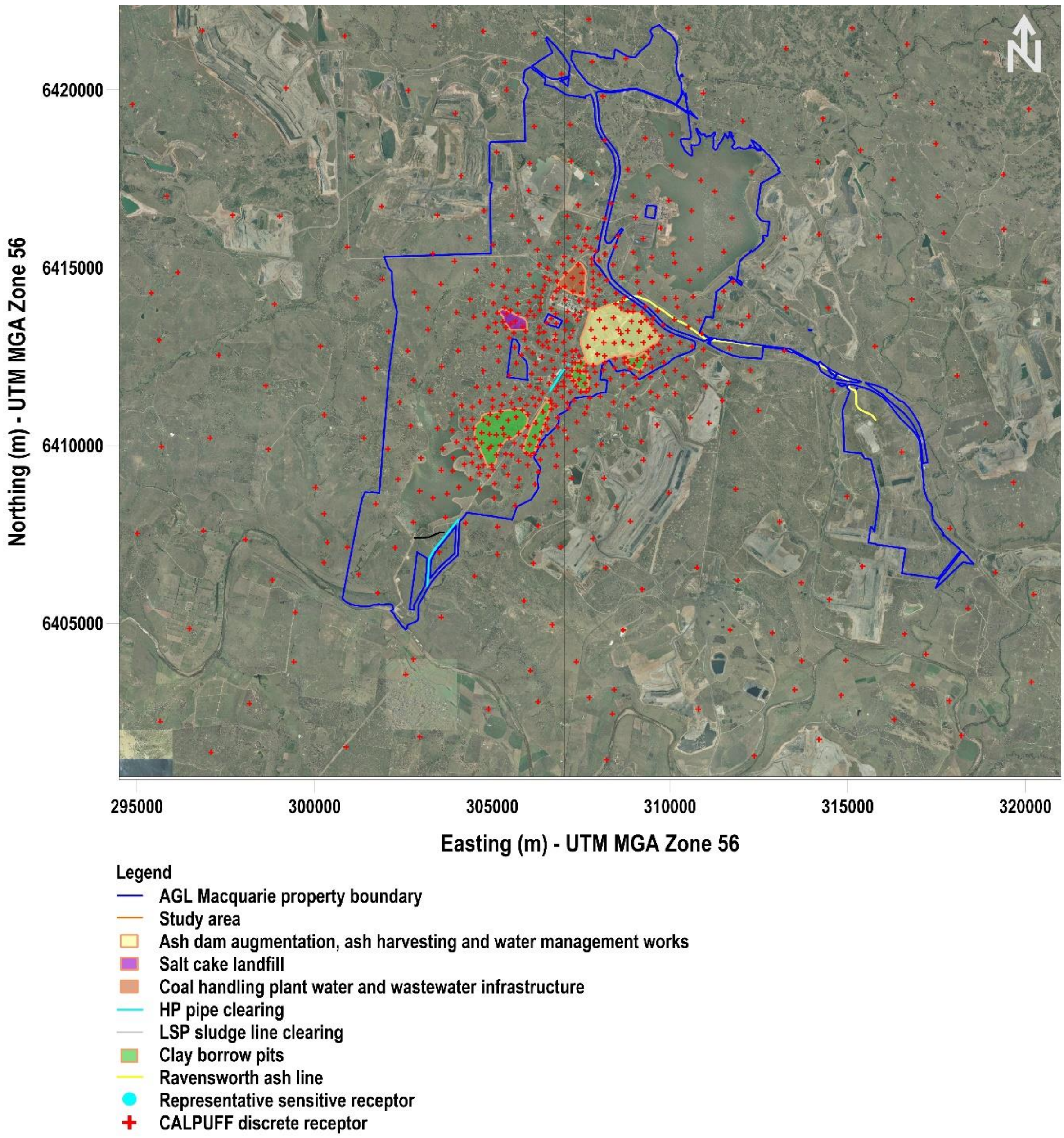

Appendix B. CALMET land use classifications



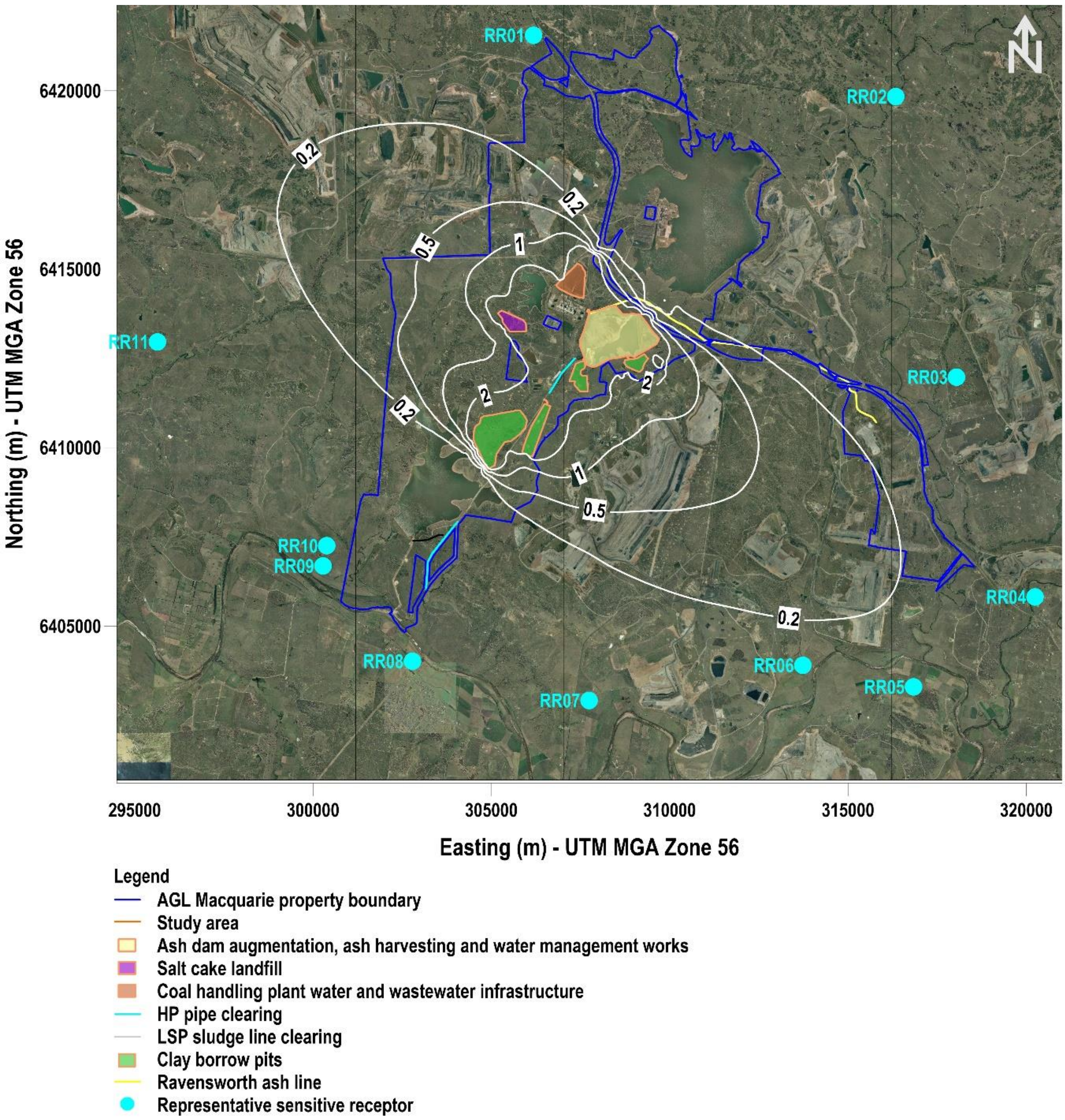
Appendix C. CALPUFF discrete receiver locations



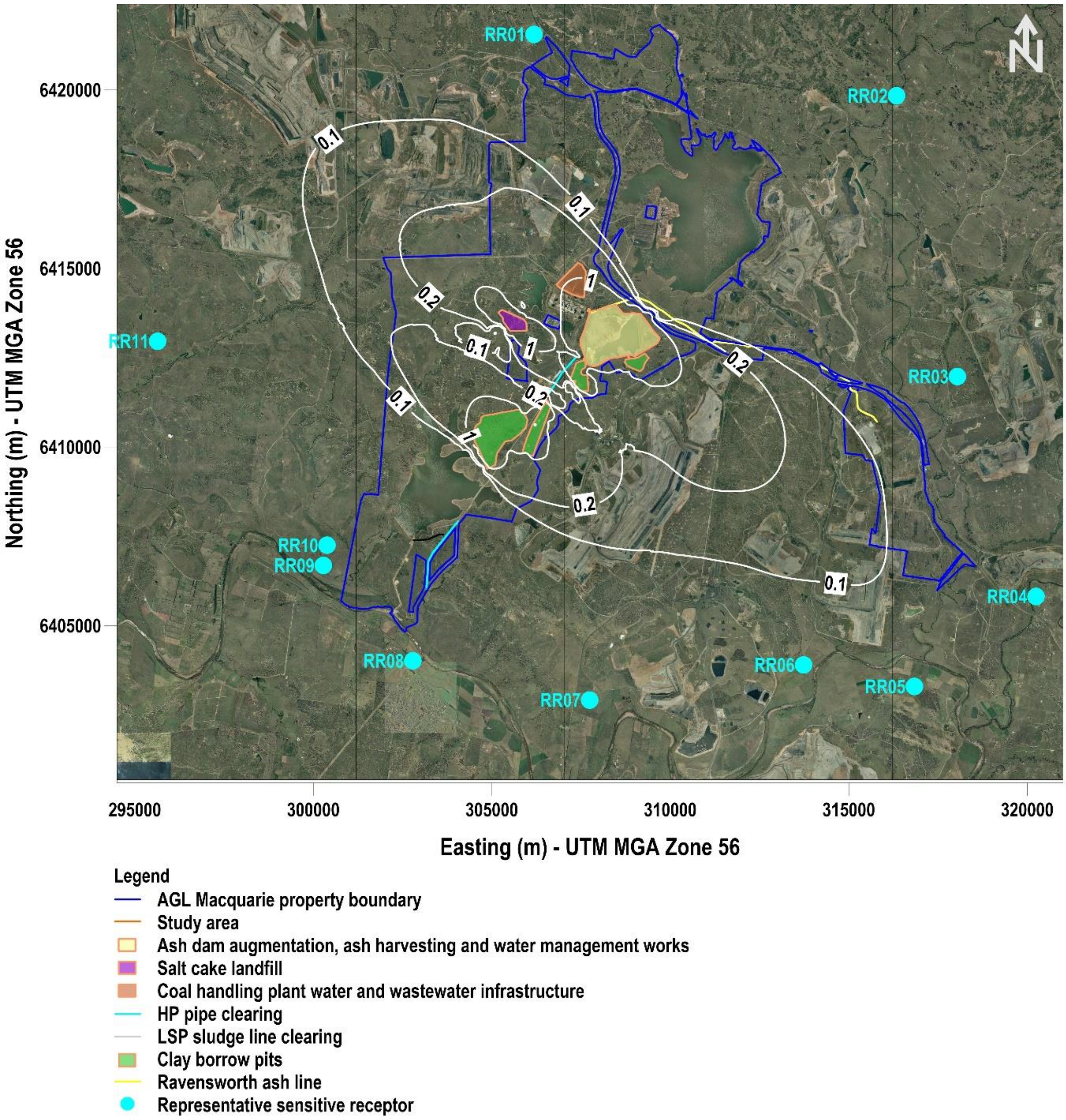
Appendix D. Contour plots

D.1 Total suspended particulates (TSP)

Peak operations: Annually averaged TSP, µg/m³, modified operations only

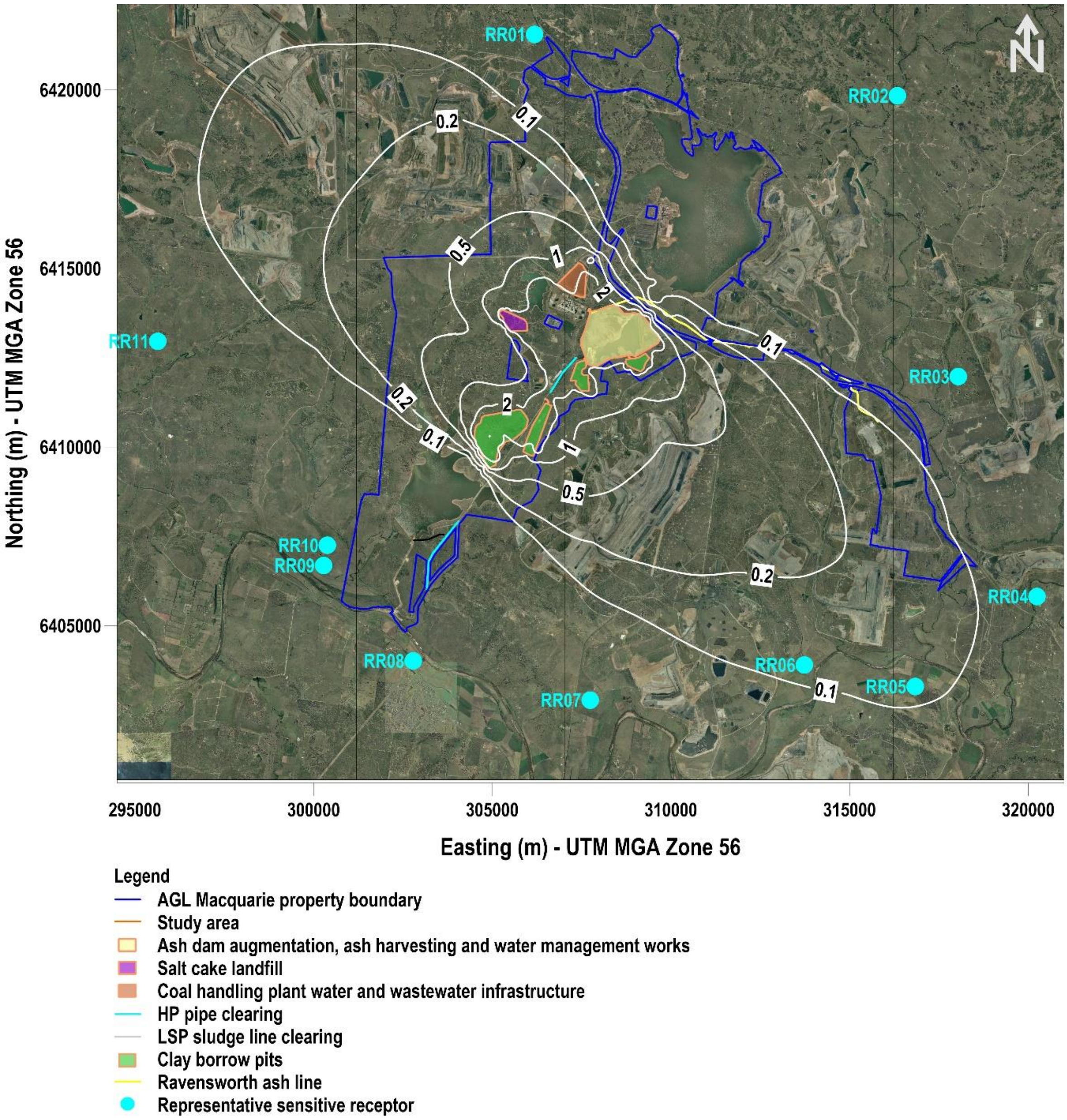


Rehabilitation: Annually averaged TSP, µg/m^3, modified operations only

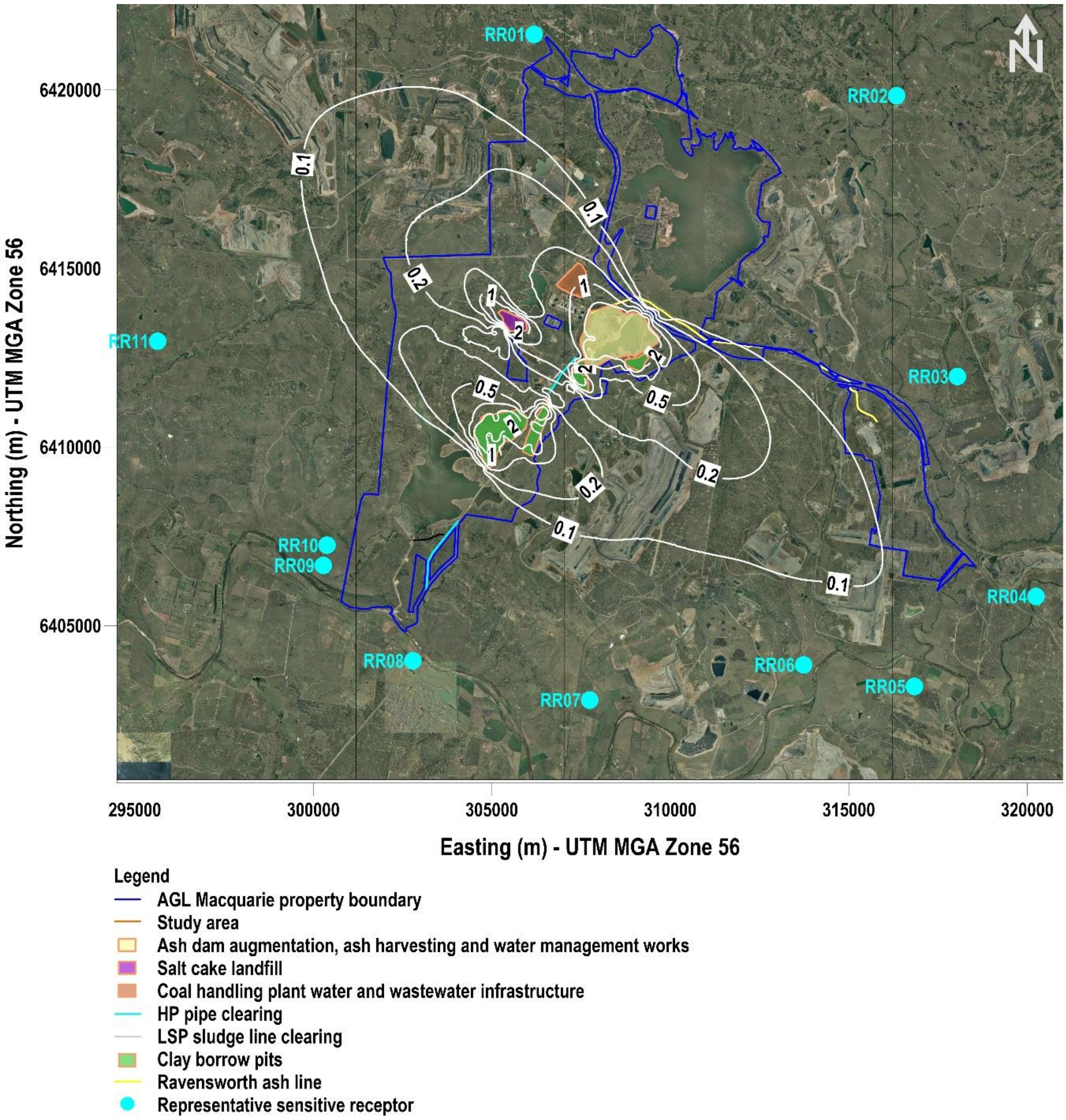


D.2 Particulate matter (PM_{10})

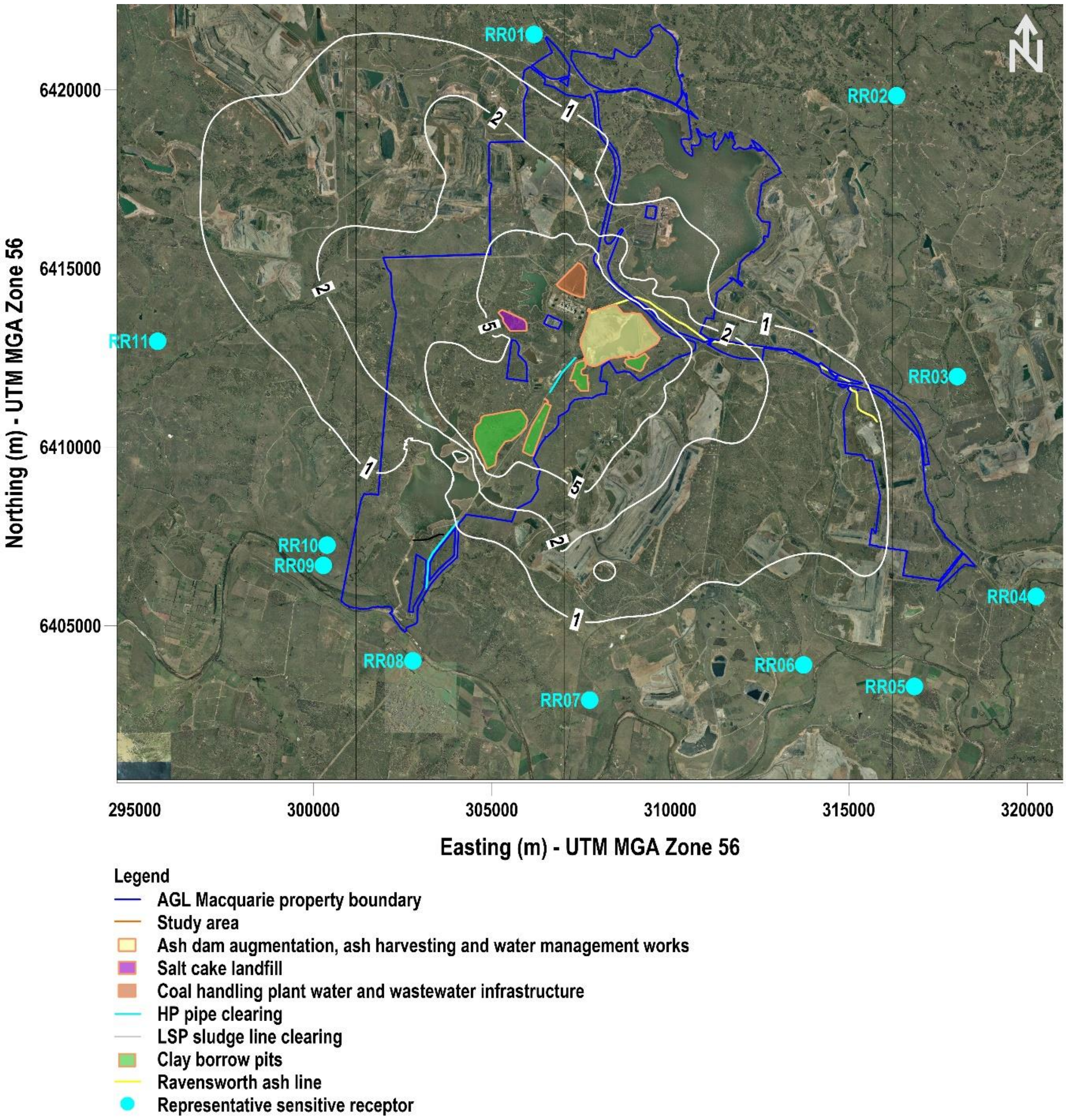
Peak operations: Annually averaged PM_{10}, µg/m^3, modified operations only



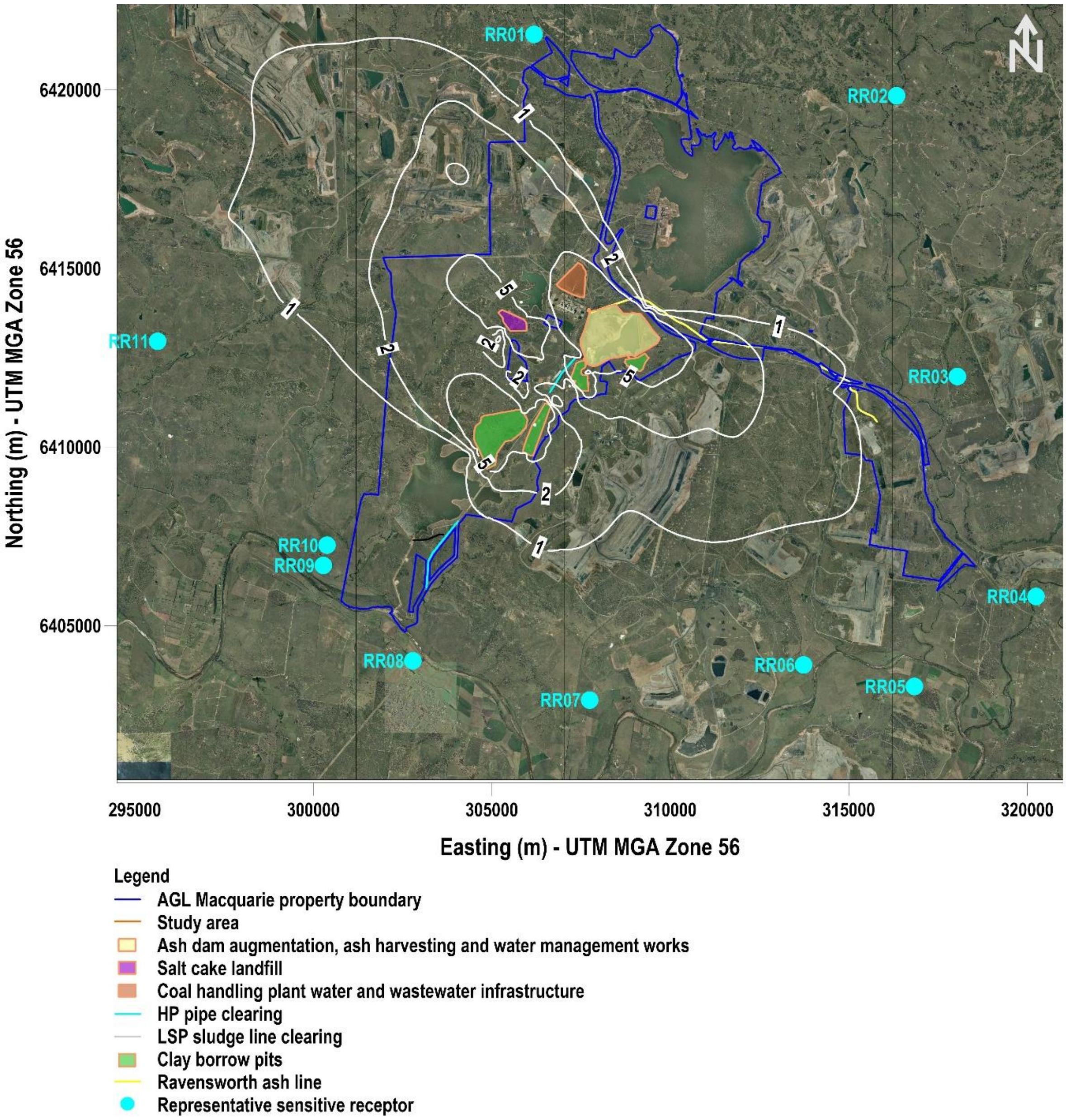
Rehabilitation: Annually averaged PM_{10}, µg/m³, modified operations only



Peak operations: Maximum 24-hour averaged PM_{10}, µg/m³, modified operations only

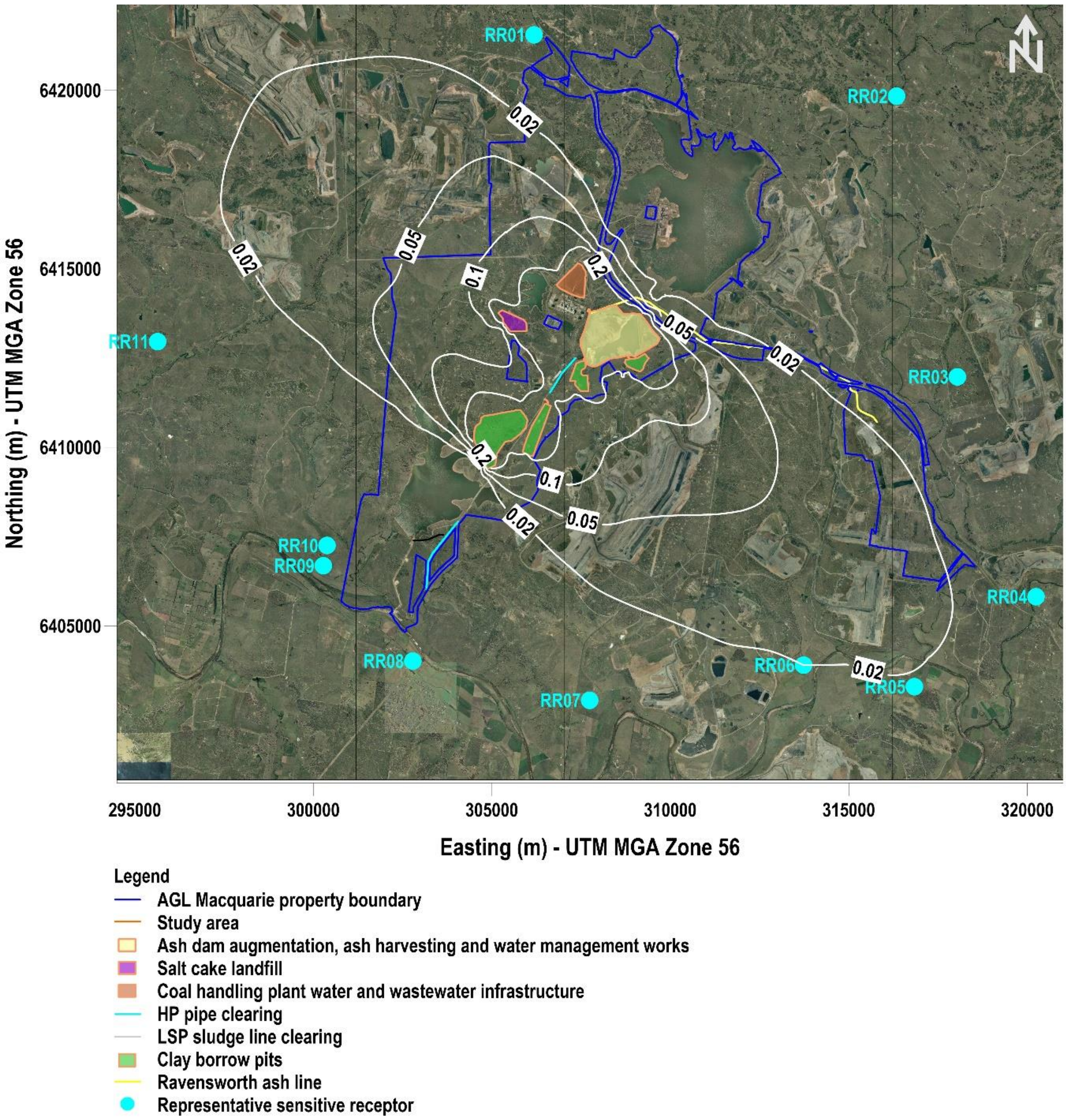


Rehabilitation: Maximum 24-hour averaged PM_{10}, µg/m^3, modified operations only

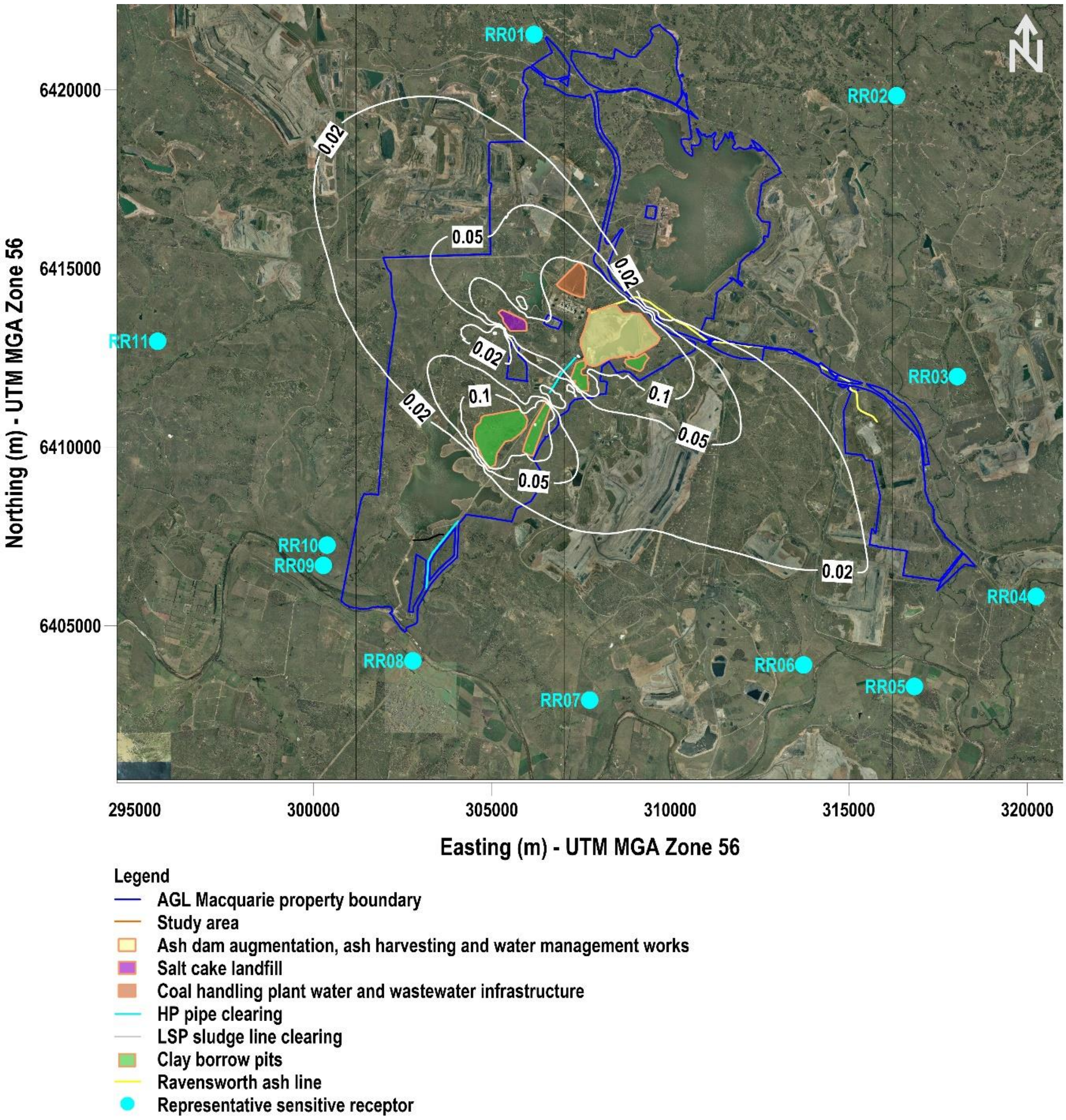


D.3 Particulate matter ($PM_{2.5}$)

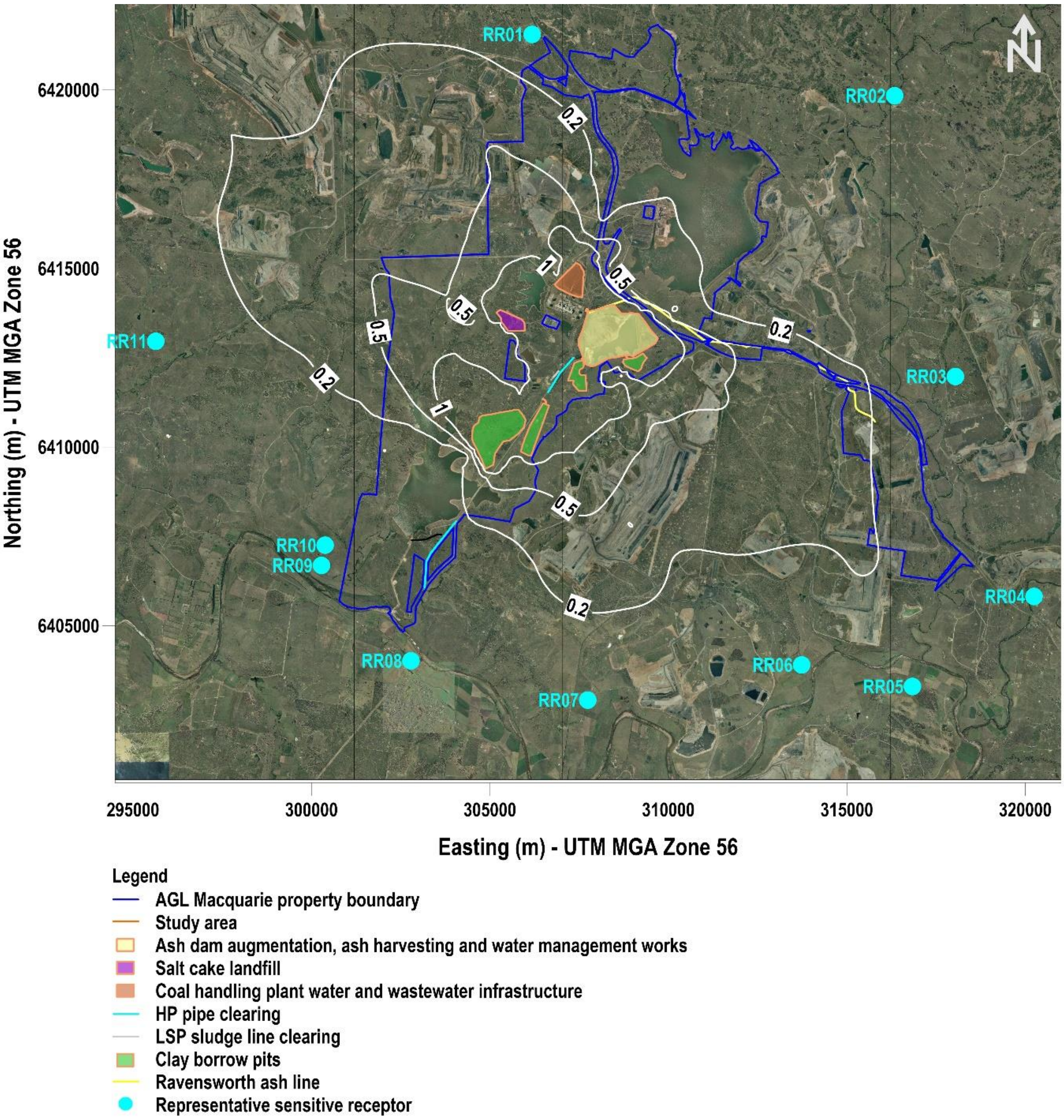
Peak operations: Annually averaged $PM_{2.5}$, µg/m^3, modified operations only



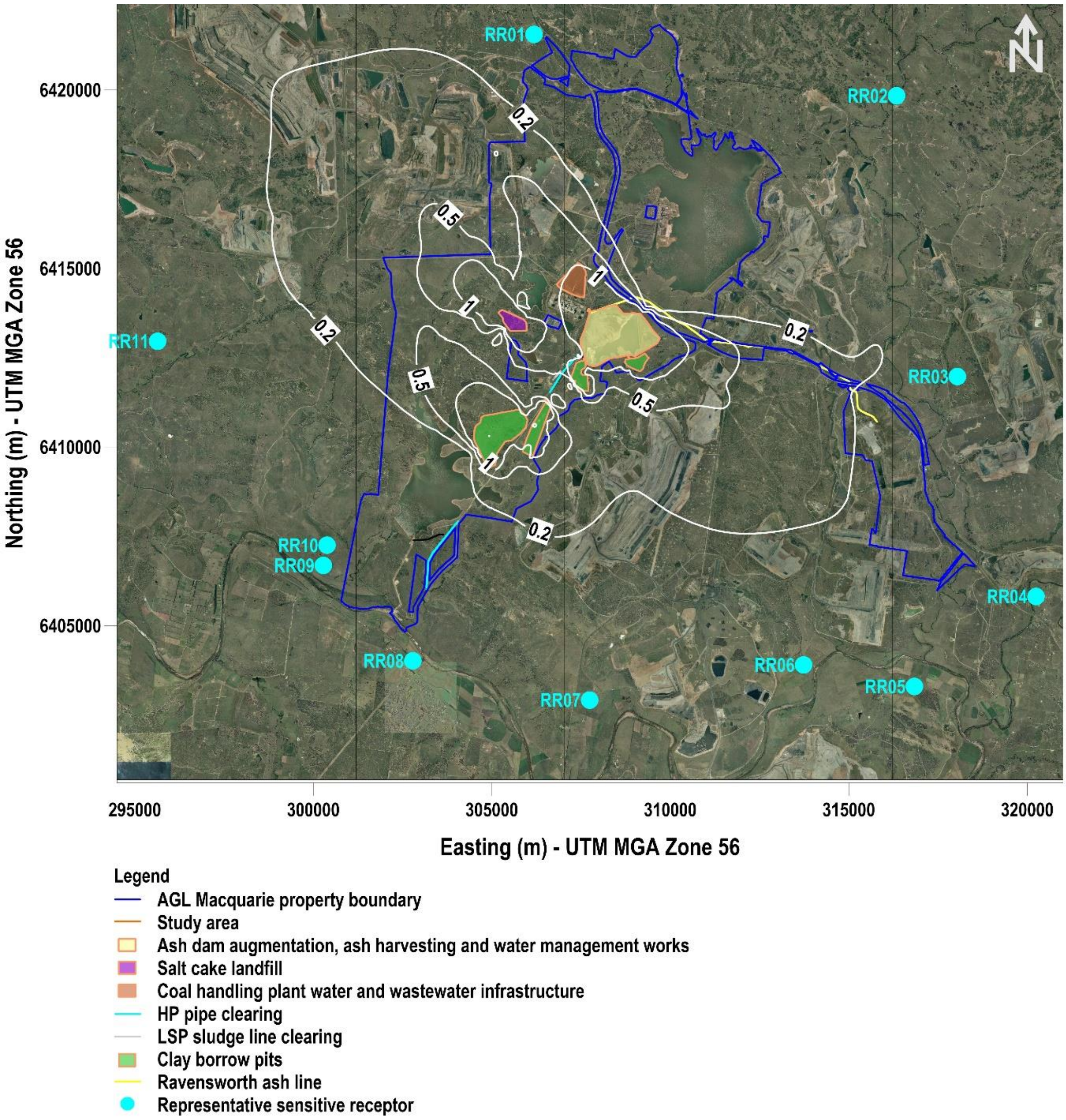
Rehabilitation: Annually averaged $PM_{2.5}$, µg/m^3, modified operations only



Peak operations: Maximum 24-hour averaged $PM_{2.5}$, µg/m^3, modified operations only

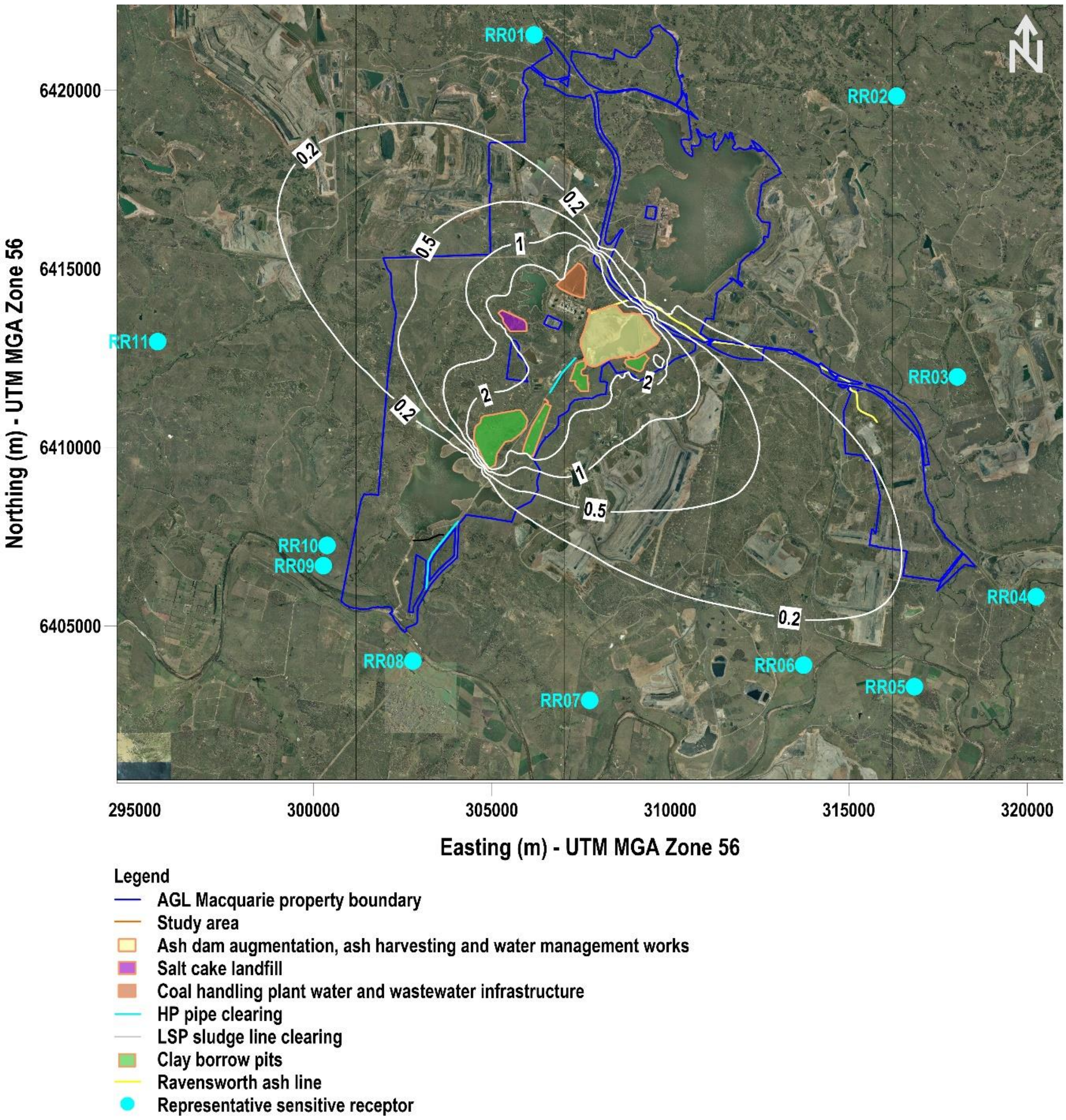


Rehabilitation: Maximum 24-hour averaged $PM_{2.5}$, µg/m^3, modified operations only



D.4 Deposited dust

Peak operations: Annually averaged maximum deposited dust (g/m^2/month), modified operations only



Rehabilitation: Annually averaged maximum deposited dust (g/m^2/month), modified operations only