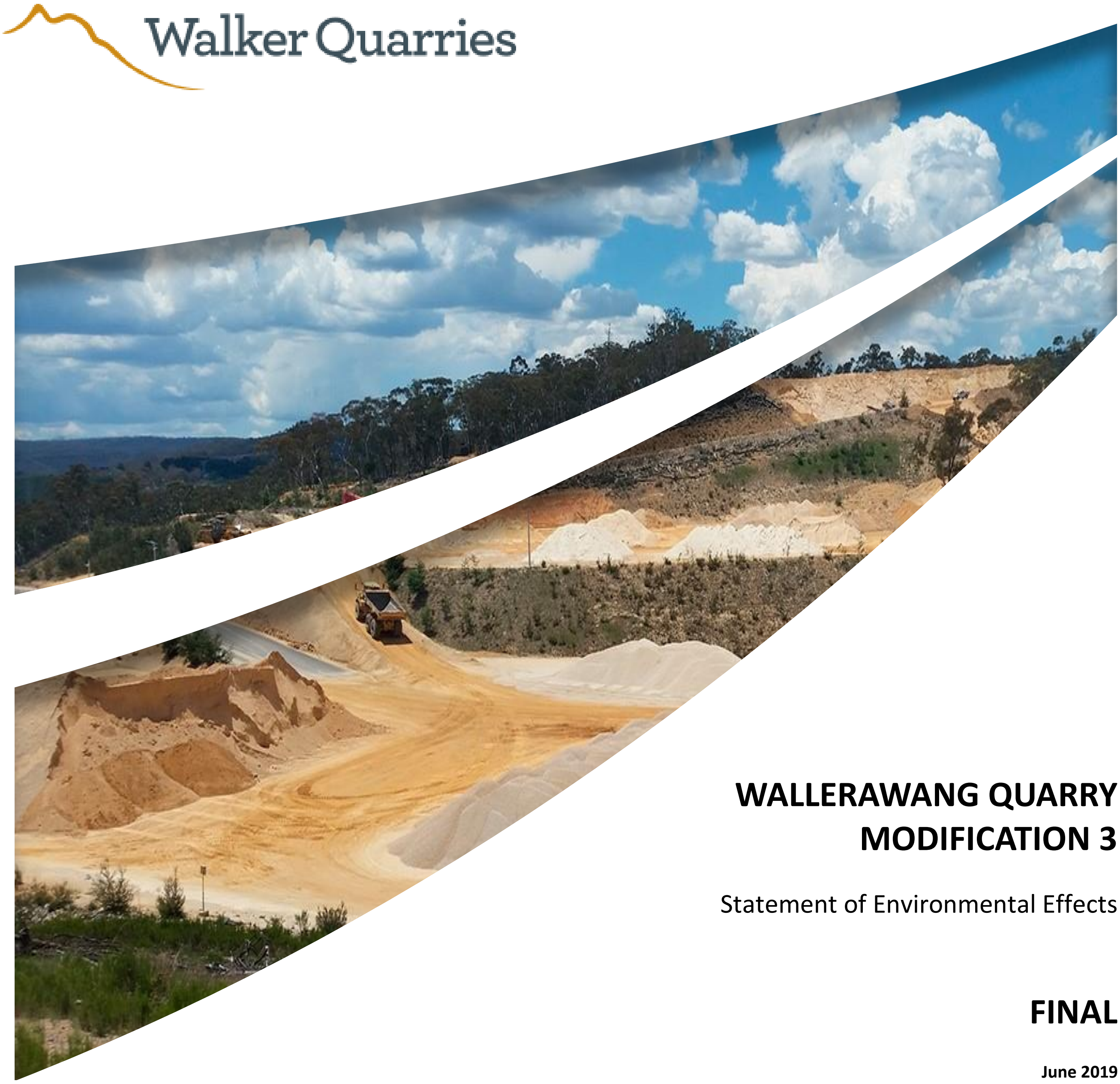
Walker Quarries



WALLERAWANG QUARRY MODIFICATION 3

Statement of Environmental Effects

FINAL

June 2019

APPENDIX 9

Surface Water Impact Assessment

Environmental & Social Consultants

Walker Quarries

SURFACE WATER IMPACT ASSESSMENT

Wallerawang Quarry Modification 3

June 2019

SURFACE WATER IMPACT ASSESSMENT

Wallerawang Quarry Modification 3

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Walker Quarries Pty Ltd

Report No. 4433/R11
Date: June 2019

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Final	Chris Bonomini	20 June 2019	Alex Irwin	20 June 2019

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1.0 Introduction

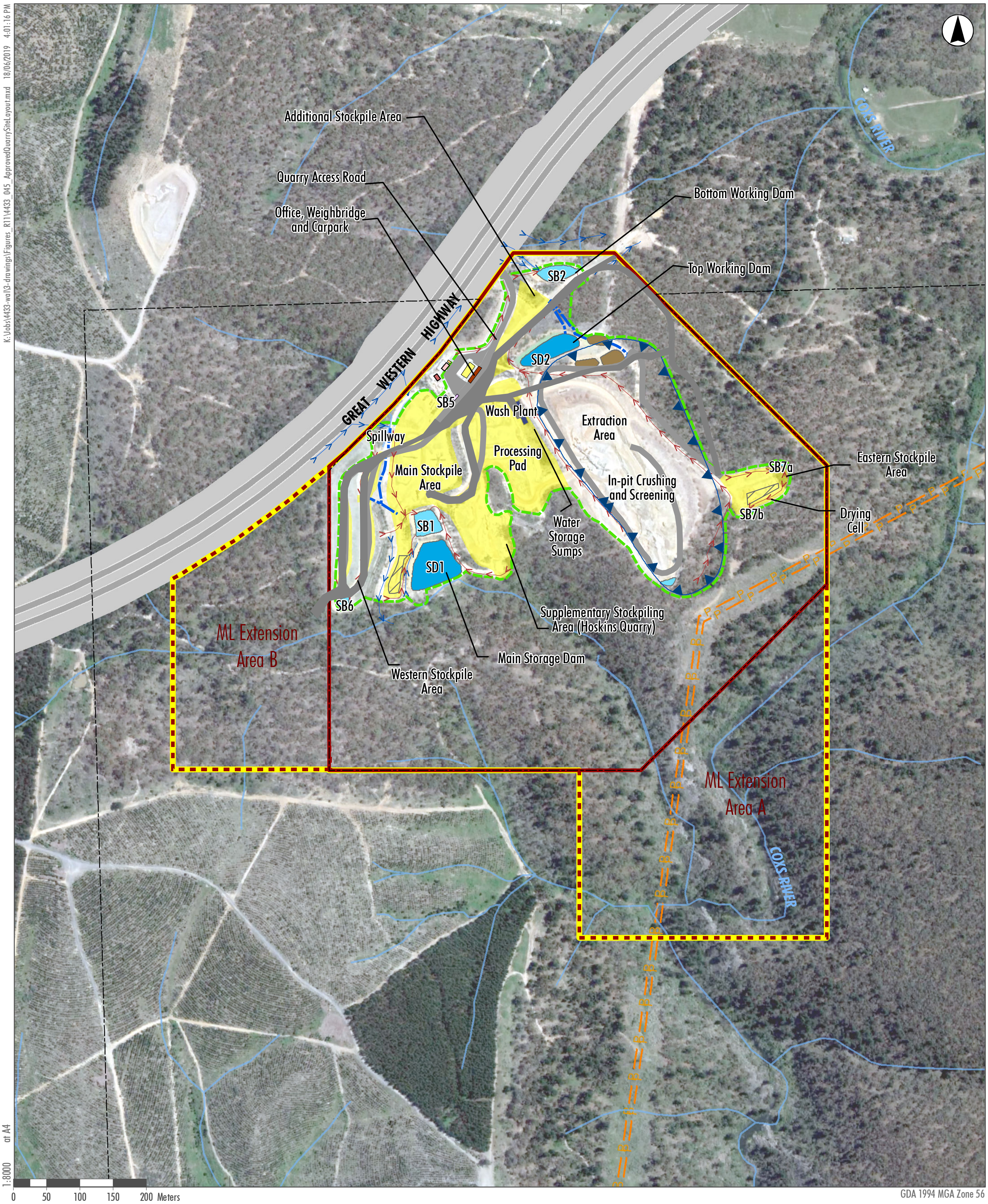
1.1 Overview of the Modification

The Wallerawang Quarry ("the Quarry") is located on land adjoining the Great Western Highway to the south of Wallerawang, approximately 8 kilometres (km) northwest of Lithgow. Development consent DA 344-11-2004 for Wallerawang Quarry (the Quarry) was issued to Sitegoal Pty Ltd on 19 October 2004 by the then Minister of Planning & Infrastructure. No activities were undertaken under DA 344-11-2001 until 2014 when an intersection with the Great Western Highway was constructed. Mining activities commenced in late 2014 with the Quarry now producing a range of quartzite aggregates, pebbles and sand. Notably, the range of products now produced at the Quarry is more extensive than envisaged by the original development application which nominated quartzite and rock aggregates only.

Since 2004, two modifications to DA 344-11-2001 have been approved. The current proposal to modify DA 344-11-2004 ("the Proposed Modification") includes the following components.

- An extension to the current limit on Quarry operations from July 2020 to July 2050.
- An extension of both the approved extraction area, from 6.5 ha to 13.3 ha, and the extraction depth, from 930 mAHD to 860 mAHD, to enable greater recovery of quartzite and additional resources. The additional resources include hornfels, sandstone and cobble conglomerate and will enable the production of a wider variety of Quarry products.
- An extension to the stockpile area at the Quarry Site to accommodate the increased storage requirement for Quarry products. The extended stockpile areas will be constructed using overburden removed from the extraction area.
- Modifications to the Quarry's approved water management system to accommodate the modified stockpile area construction. This would include:
    - the construction of additional sediment basins and erosion and sediment controls to manage potential water quality impacts
    - the extension and burial of the central pipeline to transfer clean water runoff from the Great Western Highway to the south of the main stockpile area
    - the diversion of ephemeral, second order drainage lines around the extended stockpile areas
    - the construction of an additional water storage dam for the harvesting and storage of water (required for processing and dust suppression).

The approved layout of the current Quarry Site, which is concurrent with the boundary of Mining Lease (ML) 1633 is displayed on **Figure 1.1** and the proposed Quarry Layout, including the proposed extensions to ML 1633 which form the larger Project Site, identifying these key modifications is provided as **Figure 1.2**.



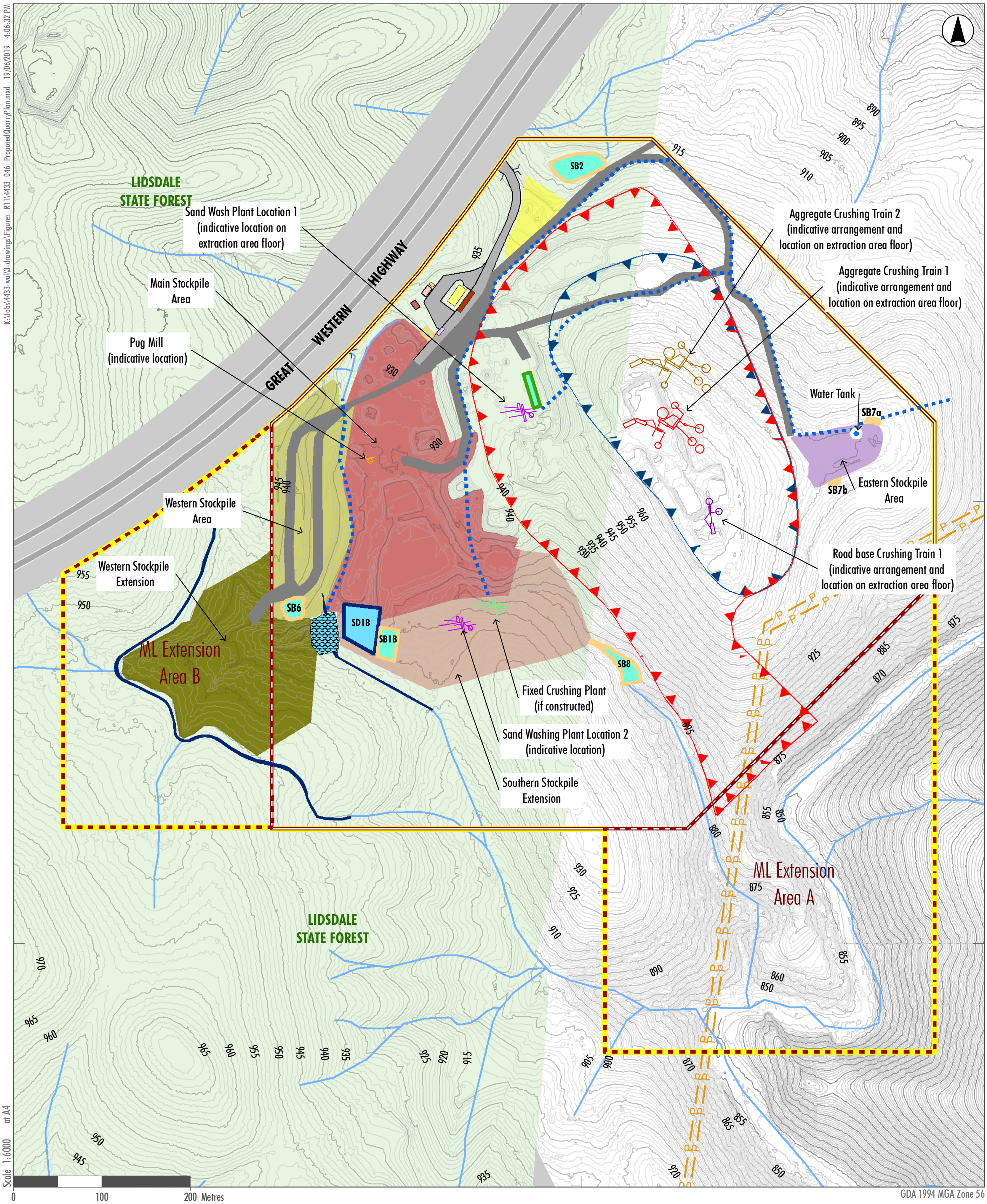
Legend

- Project Site
- Quarry Site - ML1633
- Quarry Site Extension
- EL 4473
- Approved Extraction Area
- Approved Area of Disturbance
- Drying Cell
- Indicative Internal Roads
- Stockpile Area
- Sediment Basin
- Silt Cell
- Storage Dam
- Water Storage Sumps
- Clean Water Drain
- Dirty water drain
- Haul Road
- Water Pipeline
- Electricity Transmission Lines

FIGURE 1.1

Existing Quarry Plan

Image Source: Google Earth (2016) Data source: Walker Quarries (2019); Umwelt (2019); NSW LPI DTDB (2019); CEH Survey (November 2016)



Legend

- Project Site
- Quarry Site (ML1633)
- Quarry Site Extension
- Clean Water Drainage
- State Forest

Indicative Plant Infrastructure Locations

- Aggregate Crushing Train 1
- Aggregate Crushing Train 2
- Fixed Crushing Plant (if constructed)
- Pug Mill
- Road base Crushing Train 1
- Sand Wash Plant

Approved & Proposed Quarry Layout

- Approved Extraction Area
- Proposed Extraction Area
- Main Stockpile Area (935m AHD)
- Southern Stockpile Area (935m AHD)
- Western Stockpile Area
- Western Stockpile Extension (940m AHD)
- Eastern Stockpile Area

Water Management Infrastructure (Proposed)

- Clean Water Diversion
- Sediment Basins
- Settlement Ponds
- Water Tank
- Water Pipeline (Indicative)
- Clean Water Drainage

FIGURE 1.2

Proposed Quarry Plan

Image Source: Data source: Walker Quarries (2019) ; NSW LPI DTDB (2019)

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1.1.1 Modification EARs and Agency Submissions

This SWIA has been prepared to address the Environmental Assessment Requirements (EARs) issued for the Proposed Modification and associated agency submissions relating to surface water. **Table 1.1** presents the EARS issued for the Proposed Modification and where each element is addressed in this SWIA report.

Table 1.1 Environmental Assessment Requirements

Agency	Requirement	Section
Resources Regulator – NSW Department of Planning and Environment	(m) Where a void is proposed to remain as part of the final landform, include:	-
	(iii) outcomes of the surface and groundwater assessments in relation to the likely final water level in the void. This should include an assessment of the potential for fill and spill along with measures required to be implemented to minimise associated impacts to the environment and downstream water users.	**Section 5.1**
Department of Industry (DoI) - Water	The PEA (Preliminary Environmental Assessment) should address the following in accordance with the detailed comments in Attachment A:	-
	• Water Supply and Licensing	-
	○ Annual volumes of surface water and groundwater proposed to be taken by the activity (including through inflow and seepage) from each surface and groundwater source as defined by the relevant water sharing plan.	**Section 4.2.2.2**
	Assessment of any volumetric water licensing requirements (including those for ongoing water take following completion of the project).	**Section 6.1.2**
	○ The identification of an adequate and secure water supply for the life of the project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased.	**Section 4.0**
	○ A detailed and consolidated site water balance.	**Section 4.0**
	• Water impact assessment, monitoring and management	-
	○ Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	**Section 5.0** Note: Groundwater not considered in this assessment
	○ Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.	**Section 5.2**
	○ Details of the final landform of the site, including final void management (where relevant) and rehabilitation measures.	Refer to Statement of Environmental Effects (SEE)

Agency	Requirement	Section
	○ Full technical details and data of all surface and groundwater modelling, and an independent peer review.	Surface water modelling not required for this assessment Note: Groundwater not considered in this assessment
	○ Proposed surface and groundwater monitoring activities and methodologies.	**Section 6.2** Note: Groundwater not considered in this assessment
	○ Proposed management and disposal of produced or incidental water.	**Section 4.2.2.3**
	• Relevant policies and guidelines	-
	○ Consideration of relevant policies and guidelines.	**Section 2.1**
	○ A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI Water's assessment framework	Note: Groundwater not considered in this assessment
	A statement of where each element of the SEARs is addressed in the PEA (i.e. in the form of a table).	This table
DoI – Crown Lands and Water Division	4. No development drainage, overflow or contaminated waste (contaminated runoff) shall impact negatively on the Crown Land or waterway.	**Section 5.0**
	6. Appropriate erosion and sediment controls would be installed to prevent sediment laden water impacting upon crown land.	**Section 3.2.1.3**
	7. Controls would be in accordance with the technical document Landcom (2006) Edition 4 'Managing Urban Stormwater: Soils & Construction'. These controls would be installed prior to the commencement of works.	**Section 3.2.1.3**
	8. The Department should be notified of any sedimentation events that flow into the Crown waterway, Coxs River Creek, or any encroachment of the earthworks into the Crown waterway by email to orange.crownlands@crownland.nsw.gov.au	**Section 6.3**
Office of Environment and Heritage (OEH)	Water and Soils	-
	10. The Environmental Impact Statement (EIS)) must map the following features relevant to water and soils including:	-
	a. Acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soils Planning Map)	Not relevant to this assessment
	b. Rivers, streams, wetlands, estuaries (as described in s4.2 of the Biodiversity Assessment Method)	**Section 2.2.1**
	c. Wetlands as described in s4.2 of the Biodiversity Assessment Method	**Section 2.2.1**
	d. Groundwater	Refer to Jacobs (2019)
	e. Groundwater dependent ecosystems.	Refer to Jacobs (2019)
	f. Proposed intake and discharge locations.	**Section 4.2.3.3**

Agency	Requirement	Section
	11. The EIS must describe background conditions for any new water resource likely to be affected by the development, including:	-
	a. Existing surface and groundwater.	**Section 2.3** Note: groundwater not considered in this assessment.
	b. Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations.	**Section 4.2.3.3**
	c. Water Quality Objectives (as endorsed by the NSW Government http://www.environment.nsw.gov.au/ieo/index.htm) including groundwater as appropriate that represent the community's uses and values for the receiving waters.	**Section 2.3.1**
	d. Indicators and trigger values/criteria for the environmental values identified at (c) in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	**Section 2.3.1**
	e. Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning decisions http://www.environment.nsw.gov.au/research-and-publications/publications-search/risk-based-framework-for-considering-waterway-health-outcomes-in-strategic-land-use-planning	This Surface Water Impact Assessment addresses the five nominated steps of the Framework 1. Establish context (**Section 2.0**) 2. Effects-based assessment (**Sections 1.1.2, 2.2, 2.3, 2.4 and 3.1**) 3. Compare against waterway objectives (**Section 2.3**) 4. Strategic impact assessment (**Section 5.0**) 5. Design and implementation (**Sections 3.2, 5.3 and 6.0**)
	12. The EIS must assess the impacts of the development on water quality, including:	-

Agency	Requirement	Section
	a. The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction.	**Section 5.1.1**
	b. Identification of proposed monitoring of water quality.	**Section 6.2**
	c. Consistency with any relevant certified Coastal Management Program (or Coastal Zone Management Plan).	Not assessed within this report
	13. The EIS must assess the impact of the development on hydrology, including:	-
	a. Water balance including quantity, quality and source.	**Section 4.0**
	b. Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas.	**Section 5.0**
	c. Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems.	Not assessed within this report – refer to SEE
	d. Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (e.g. river benches).	Not assessed within this report – refer to SEE
	e. Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water.	**Sections 5.1.2** and **5.2**
	f. Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options.	**Section 5.3**
	g. Identification of proposed monitoring of hydrological attributes.	**Section 6.2**
	Flooding and Coastal Hazards	**Section 1.1.2.1**

1.1.2 Potential Surface Water Impacts

The proposed modification has the potential to have the following impacts on surface water resources.

- Capture of runoff from additional undisturbed catchments as a result of the interception of ephemeral creeks that drain through the proposed modification to the Coxs River.
- Degradation of downstream water quality as a result of:
  - ground disturbing activities leading to erosion and transport of sediment to downstream water users and water courses including the Coxs River
  - additional volumes of water being discharged from the licensed discharge points (refer to **Section 5.1.2**) to the downstream water users and water courses including the Coxs River
  - potential spills of hydrocarbons and other chemicals.
- Increased water imports from alternate water sources to meet the increased operational demands.

The potential surface water impacts listed are assessed in **Sections 5.0**. Proposed controls and mitigation measures to manage the impacts of the Proposed Modification are detailed in **Section 5.3**.

1.1.2.1 Flooding

Additional local provision 7.2 of the Lithgow Local Environmental Plan (LEP) (2014) has the noted objectives to:

a) minimise the flood risk to life and property associated with the use of land;

b) allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change; and

c) avoid significant adverse impact on flood behaviour and the environment.

A review of Lithgow LEP 2014 Flood Planning Map Sheet FLD_002 confirms that the Quarry Site is not located within the nominated flood planning area. There is no catchment based flood mapping for the Coxs River in the vicinity of the Quarry Site, however, the following provides context to the location of the Quarry Site with respect to the channel of the Coxs River:

- The proposed extensions to the extraction area and stockpile area would remain at least 30 metres above the Coxs River .
- The bridge of the Great Western Highway traverses the Coxs River between 870 mAHD and 880 mAHD, i.e. at an equivalent elevation to the lowest area of the extraction boundary of the Quarry Site.

On the basis of the above, the Quarry Site disturbance is likely to remain above the 1:100 average recurrence interval (ARI) flood level. A detailed flood impact assessment to address the requirements of Clause 7.1(3) is therefore not required.

2.0 Surface Water Context

2.1 Regulatory Framework

The Quarry exists within a regulated system that has been designed to provide for the sustainable management of the State's water resources. This includes licensing of allowable water take with consideration of environmental flow requirements of watercourses and the needs of other water users; control of water pollution; and guidelines that govern the appropriate design of water management systems for extractive industries to manage water quality in accordance with Environment Protection Licence (EPL) requirements.

2.1.1 Water Extraction

2.1.1.1 Regulation

Extraction of water in NSW is managed under two legislative acts: *Water Act 1912* and *Water Management Act 2000*.

The objective of the *Water Management Act 2000* is the sustainable and integrated management of water in NSW and is based on the concept of ecologically sustainable development by defining water access and water sharing strategies within NSW. The *Water Management Act 2000* supersedes the provisions of the *Water Act 1912* in regard to water take when a Water Sharing Plan (WSP) is in place and in regards to works adjacent to or within watercourses. Where WSPs have not commenced the provisions of the *Water Act 1912* continue to apply.

WSPs have been developed across NSW to protect the fundamental environmental health of water sources, whilst at the same time securing sustainable access to water for all users in the long-term. The WSPs specify maximum water extractions and allocations and provide water users with a clear picture of when and how water will be available for extraction.

The Quarry lies within the area regulated by the WSP for the Greater Metropolitan Region Unregulated River Water Sources 2011 and is located in the Wywandy water source. Water use from surface and alluvial waters in and adjacent to the Quarry is therefore governed by the *Water Management Act 2000*.

2.1.1.2 Licensing of Extraction

All water extraction in NSW (apart from some exemptions for government authorities and basic landholder rights extractions) must be authorised by a water licence. Harvestable rights, which are a basic landholder right under the *Water Management Act 2000*, allow a landholder to capture and use up to 10 per cent of the average regional runoff from a landholding. Basic landholder rights are exempt from volumetric licensing requirements however water extracted under basic landholder rights must be taken into consideration when assessing licensing requirements.

Each water licence, referred to under the WSP system as a Water Access Licence (WAL), specifies a share component. The share components of specific purpose licences such as local water utility, major utility and domestic and stock are expressed as a number in megalitres (ML) per year. The share components of high security, general security and supplementary WALs are expressed as a number of unit shares for the water source. The value of each unit share is subject to Available Water Determinations (AWDs) as specified by Department of Industry – Water (DoI Water).

The Quarry presently holds one surface WAL (WAL 41884) within the Upper Nepean and Upstream Warragamba water source, however WAL 41884 has a 0 ML/year share component. As such, the Quarry would be required to purchase entitlement from other WAL licence holders in the water source to allow for surface water take in excess the Quarry's harvestable right.

2.1.2 Environment Protection Licences and Discharges

The *Protection of the Environment Operations Act 1997* (POEO Act) is the key piece of environment protection legislation in NSW. Scheduled activities or other activities that do or may lead to pollution of waters in NSW are required to be licensed under the POEO Act and are regulated by the NSW Environment Protection Authority EPA. Where discharge of waters is permitted, it is strictly controlled by licence conditions such that discharges do not result in significant impacts on water resources.

Under Section 120 of the POEO Act, it is an offence to pollute waters or cause harm unless licensed to do so. Pollution in NSW is regulated by the POEO Act with discharges from water management systems requiring licensing by an Environment Protection Licence (EPL) if the discharge would otherwise constitute a pollution of waters (Section 120 of the POEO Act).

Mining for minerals, which includes the Quarry as the quartzite is identified as a mineral under Schedule 1 of the Mining Regulation 2016, is listed in Schedule 1 of the POEO Act and the Quarry is therefore required to hold an EPL for the operation. The Quarry holds EPL 13172 which licenses the operational activities, including the two existing water licensed discharge points (LDPs). Further details regarding the EPL and LDPs are included in **Section 6.1.1**.

2.2 Catchments

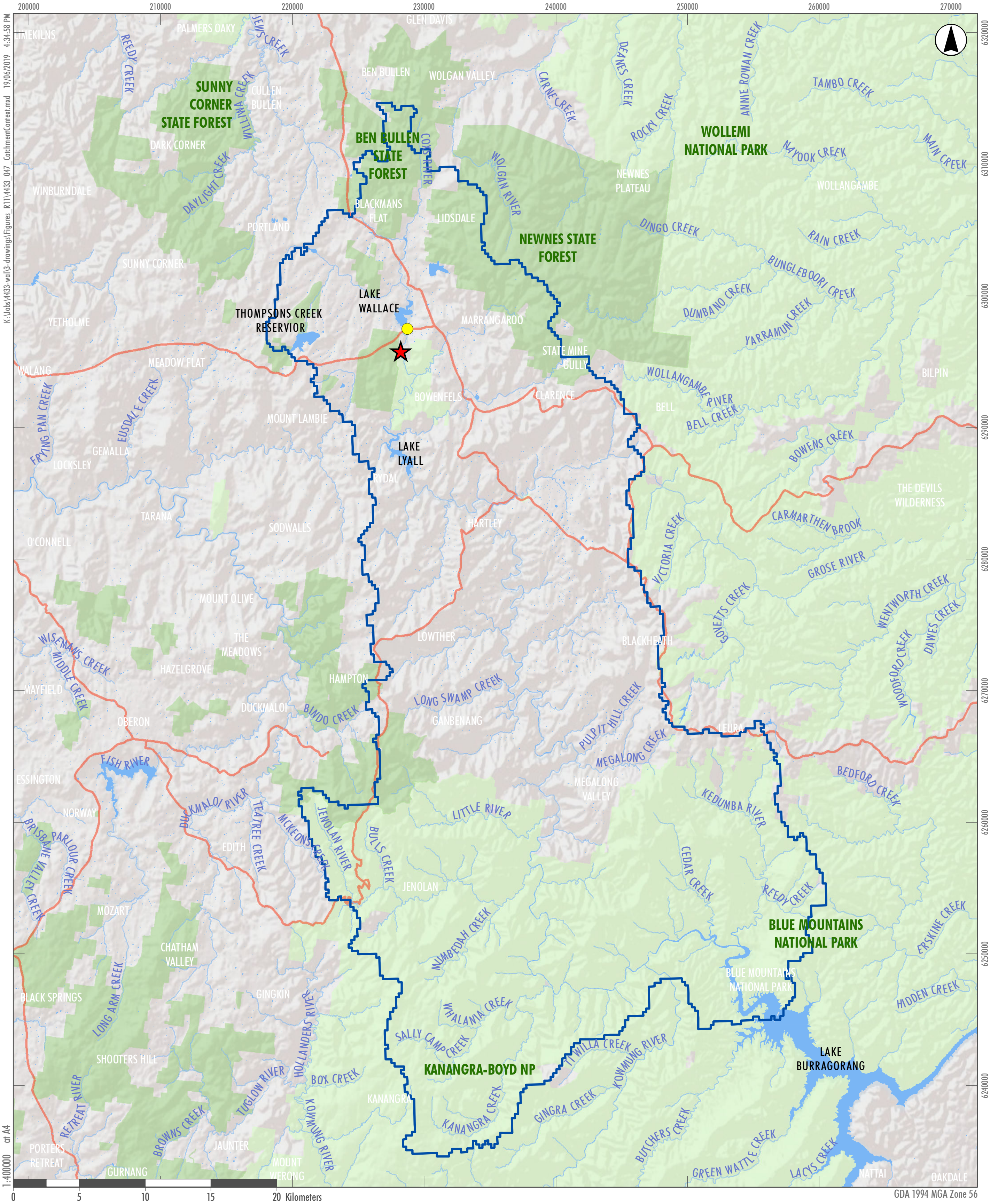
2.2.1 Surface Hydrology

The Quarry is located within the Coxs River catchment which has a total area of 1,700 km^2 (NSW Office of Water 2011) and is a sub catchment of the Hawkesbury-Nepean catchment (see **Figure 2.1**). The headwaters of the Coxs River originate in Ben Bullen State Forest at an elevation of approximately 1,000 m above the Australian height datum (mAHD). The river flows 130 km along its course across dams at Lake Wallace and at Lake Lyell down to an elevation of 120m AHD where it flows into Lake Burragorang, the main water source for greater Metropolitan Sydney.

The Quarry is located approximately 1 km downstream from Lake Wallace and 11 km upstream from Lake Lyell. The existing south-eastern boundary of the site is approximately 50 metres from the top of bank of the Coxs River. Flow monitoring of Coxs River occurs at a station 0.5 km upstream adjacent to the Great Western Highway and gives a mean annual flow volume of 21,077 ML (recorded for the period 1951 to 2016) (WaterNSW 2019).

Runoff from undisturbed upslope catchment areas to the northwest of the Quarry are diverted around disturbance areas, and eventually discharge to Coxs River via second order drainage channels at two locations (see **Figure 1.1**).

Currently, runoff within the Quarry Site is divided into nine separate catchments by site topography and water management infrastructure (such as drainage bunds). Water is discharged from the Quarry Site via two licensed discharge points, Main Storage Dam (SD1) and Sediment Basin 2, into Coxs River catchment.



Legend

- Quarry Location
- Coxs River Flow Monitoring Location
- Coxs River Catchment
- State Forest
- NPWS Estate

FIGURE 2.1

Catchment Context

Image Source: Copyright:(c) 2014 Esri Data source: NSW LPI (2019)

2.2.2 Climate

The Quarry lies within a cool-temperate climatic zone and is characterised by mild summers and cold winters. The local climate is largely influenced by factors such as topography, altitude, aspect and exposure.

Three long-term Bureau of Meteorology (BoM) rainfall stations lie within a 12 km radius of the Quarry: Station 63132 Lidsdale (6.1 km north); Station 63226 Lithgow (7 km south-east); and Station 63071 Portland (11.9 km north-east). Of these three BoM rainfall stations, Lidsdale is considered most representative of rainfall conditions at the Quarry due to its topographical location and the completeness of the data set. The BoM station nearest to the Quarry recording evaporation is the Bathurst Agricultural Station (Station 63005).

Daily rainfall has been recorded at Lidsdale (Station 63132) since 1960. Rainfall is generally spread evenly across the year, with slightly higher falls in late spring and summer and lower falls in autumn. **Table 2.1** presents the rainfall statistics recorded at the Lidsdale BoM station. **Chart 2.1** presents a plot of average monthly rainfall data recorded at the Lidsdale BoM station and the average monthly evaporation recorded at the Bathurst Agricultural Station.

Table 2.1 Lidsdale Rainfall Statistics 1960 – 2018 (BoM Station 63132)

Statistic	Rainfall (mm)
Minimum	329.8
10th %ile	517.74
50th %ile	755.4
90th %ile	927.1
Maximum	1171

Source: Bureau of Meteorology, 2019

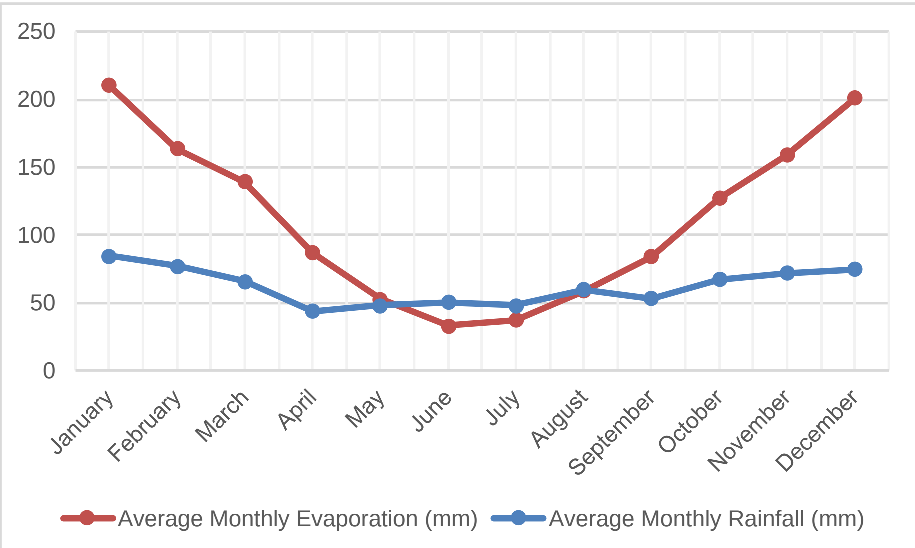


Chart 2.1 Average Monthly Lidsdale Rainfall (BoM Station 63132) and Bathurst Evaporation Data (BoM Station 63005)

2.2.3 Topography, Geology and Soils

The Quarry is located on undulating terrain to the north of the Coxs River which flows at an elevation of between 845 mAHD and 855 mAHD in the vicinity of the Quarry. The approved extraction area includes a local hilltop between elevations of approximately 930 mAHD to 970 mAHD. The remaining Quarry infrastructure, including processing and stockpile areas, occurs between elevations of 925 and 940 mAHD. Average slopes are approximately 8%, increasing to 25% approaching the hilltop in the eastern portion of the site and becoming steeper in areas adjacent the Coxs River.

The Quarry Site is located within two soil landscapes – the Cullen Bullen Soil Landscape and the Mount Walker Soil Landscape. The Cullen Bullen Soil Landscape is characterised as having hardsetting topsoils, high water erosion hazard, and shallow to moderately deep soils. The Mount Walker Soil Landscape is characterised as having an extreme soil erosion hazard, steep slopes, and shallow soils.

RME (2018) describes the basement geology of the Quarry Site and surrounds as being of the Carboniferous Bathurst Batholith with the granite of this basement formation outcropping to the east of the Quarry Site. Overlying the Bathurst Batholith are variably metamorphosed and silicified sandstones, siltstones, limestones and volcanoclastic rocks of the Late Devonian Lambie Group. These rocks, which include interbedded quartzite, hornfels and sandstone, dip to the west at an angle of between 50° and 60° and outcrop across the Quarry Site. Unconformably overlying the Lambie Group and the Carboniferous granite are the irregular and discontinuous deposits of relatively flat-lying pebble to cobble conglomerates of the Permian Shoalhaven Group (Snapper Point Formation – formerly Megalong Conglomerate), the lowest part of the Sydney Basin sequence. The Snapper Point Formation is well exposed in a roadside cutting of the Great Western Highway adjacent to the quarry, and has been mapped in the north-eastern section of the Quarry Site.

Soil surveys conducted in preparation for the EIS in July 1999 identified two soil types at the Quarry Site; a yellow uniform Lithosol soil (Um1.21) and an orange duplex Podzolic soil (Dr3.11). The uniform Lithosol contained a large percentage of gavel and rock fragments and was found to occur across the extent of the Quarry Site, with average depth ranging from 0.60 m at the eastern boundary to 0.05 m on the hillcrest with an average depth of 0.1 m (Pacrim, 2001). NSW Office of Environment and Heritage (OEH) online soil and land mapping tool, eSPADE, classifies this soil to have high to very high erosion hazard when exposed to concentrated flows. The Podzolic soil was comprised two distinct horizons, horizon A being a fine siliceous sandy material and horizon B being a heavy read clay. Approximate depths for the two horizons were 0.2 m for horizon A and 0.4 m for horizon B (Pacrim, 2001). eSPADE classifies this soil as having a high to extreme erosion hazard when exposed to concentrated flows.

2.3 Water Quality

2.3.1 NSW Water Quality Objectives

NSW Water Quality Objectives (WQOs) are agreed environmental values and long-term goals for NSW's surface waters used across NSW to guide catchment management. To date, no WQOs have been specified by NSW Office of Environment and Heritage (OEH) for the Hawkesbury-Nepean catchment. In the absence of WQOs, default trigger values for slightly disturbed ecosystems in south-east Australia from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council (ANZECC), 2000) may be used to assess the baseline receiving water condition downstream of the quarry. **Table 2.2**, presents the Upland River (for rivers systems > 150 m Australian Height Datum (mAHD)) default trigger values for slightly disturbed ecosystems in south-east Australia from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).

Table 2.2 Default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems ANZECC (2000)

Parameter	Units	Trigger Value
pH	-	6.5 – 8.0
Electrical Conductivity	µS/cm[1]	125 – 350
Turbidity	NTU[2]	2 - 25

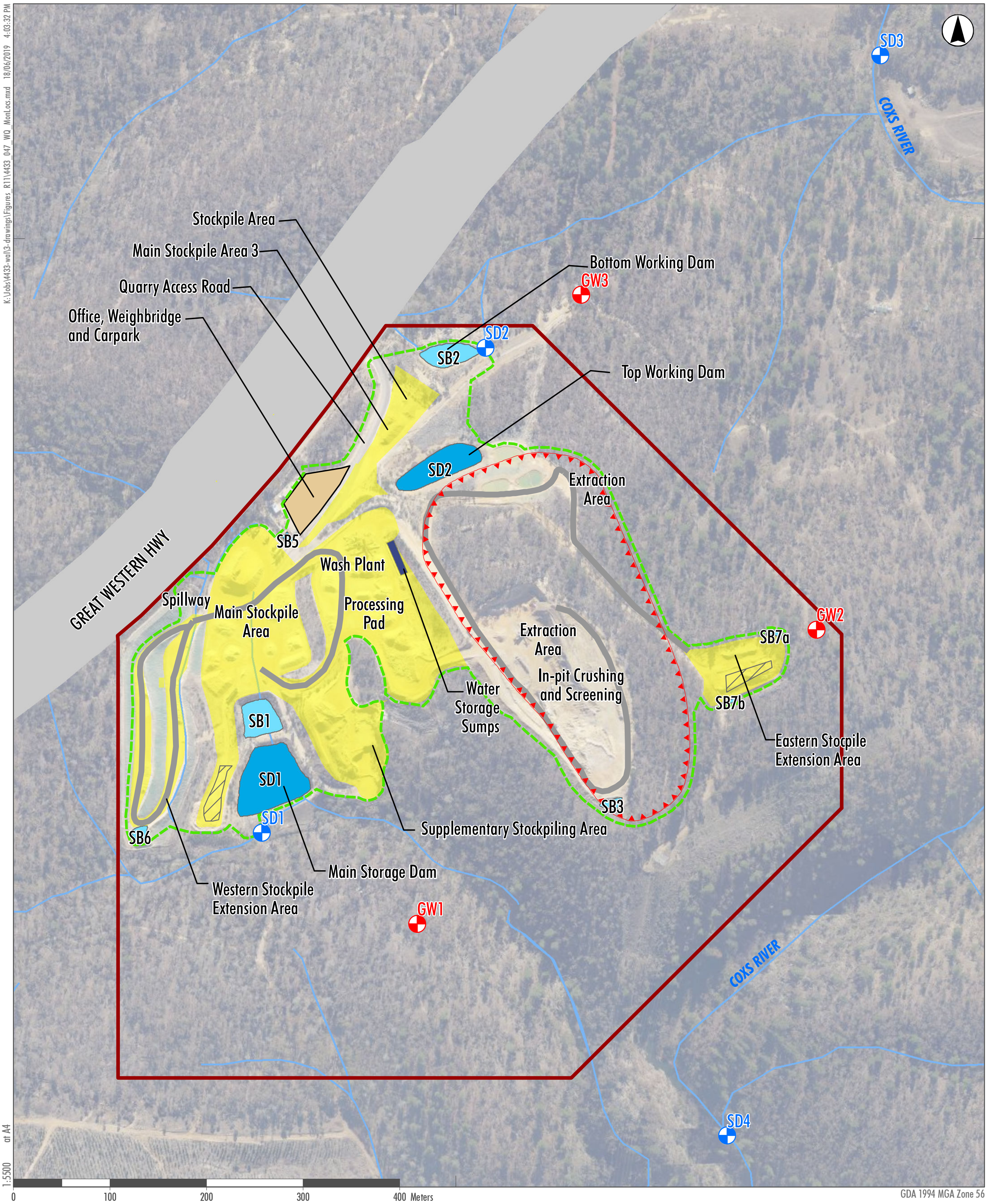
Notes

1. Conductivity of an electrolyte solution is measured in µS/cm: Microsiemens per centimetre. Conductivity is indicative of the concentration of total dissolved salts (TDS).
2. Turbidity is measured in NTU: Nephelometric Turbidity Units. The instrument used for measuring it is called nephelometer or turbidimeter.

2.3.2 Receiving Water Quality

The Quarry completed baseline water quality monitoring in the Coxs River in 2016 at locations considered to be upstream (RW1) and downstream (RW2) of any potential Quarry impacts (refer to **Figure** 2.2). **Table** 2.3 and **Table 2.4** present a summary water quality results for the Coxs River Upstream and Downstream monitoring locations respectively. The Quarry has recently reinstated Coxs Rover water sampling and analysis (on an Annual basis) as part of a recently modified Soil and Water Management Plan (SWMP) (Umwelt, 2019).

The baseline water quality results presented in **Table 2.3** and **Table 2.4** indicate that the ANZECC 2000 default trigger values for pH and EC are not representative of Coxs River water quality. As such, specific trigger values should be developed to identify any potential Quarry for the Coxs River using upstream Coxs River water quality monitoring data. The trigger values, for pH, EC and TSS, should be developed in accordance with ANZECC 2000 based on the 80th percentile (and/or 20th percentile for lower limit trigger values) result from 24 months of contiguous water quality monitoring results at the Coxs River Upstream monitoring location. Trigger Action Response Plan's (TARPs) should also be developed and incorporated into the Quarry SWMP that provide clear guidance for Quarry personnel to respond to any Coxs River water quality deviations outside of the site specific trigger values.



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Legend

- Quarry Site - ML1633
- Approved Extraction Area
- Approved Area of Disturbance
- Office, Weighbridge and Carpark
- Drying Cell
- Stockpile Area
- Sediment Basin
- Silt Cell
- Storage Dam
- Water Storage Sumps
- Haul Road
- Surface Water Monitoring Location
- Groundwater Bore Location
- Watercourses

FIGURE 2.2

Water Quality Monitoring Locations

Image Source: ESRI World Imagery (2019) Data source: Walker Quarries (2019); Umwelt (2019); NSW LPI DTDB (2019); CEH Survey (November 2016)

Table 2.3 Coxs River Water Quality - Upstream

Parameter	Units	Number of Results	Minimum	20th Percentile	Average	80th Percentile	Maximum	Trigger Value/Range
Oil and Grease (O&G)	mg/L	7	<5		<5		<5	-
pH	-	7	7.5	7.8	8.4	8.8	8.9	6.5 – 8.0
Sulphate (SO_4)	mg/L	7	111	121	142	148	208	-
Total Suspended Solids (TSS)	mg/L	7	<5		<5		<5	-
Electrical Conductivity (EC)	µS/cm	7	597	659	976	1,202	1,229	125 - 350

Table 2.4 Coxs River Water Quality - Downstream

Parameter	Units	Number of Results	Minimum	20th Percentile	Average	80th Percentile	Maximum	Trigger Value/Range
O&G	mg/L	7	<5	<5	<5	<5	<5	-
pH	-	7	8.1	8.2	8.6	8.9	9.0	6.5 – 8.0
SO_4	mg/L	7	91	115	138	142	206	-
TSS	mg/L	7	<5	<5	<5	<5	<5	-
EC	µS/cm	7	513	601	949	1,197	1,226	125 - 350

2.3.3 Discharge Water Quality

Under EPL 13172, the Quarry is required to monitor discharge water quality. Since the commencement of Quarry operations there have been three discharges from the Main Storage Dam (SD1) and one discharge from the SB2 as indicated in **Table 2.5**.

Table 2.5 Discharge Water Quality

Discharge Date	Discharge Location	pH	EC (µS/cm)	TSS (mg/L)	O&G (mg/L)	SO_4 (mg/L)
June 2016	SD1	5.72	94	75	<5	10
September 2016	SD1	7.81	73	115	<5	4
March 2017	SD1	8.53	46	120	<5	1
March 2017	SB2	8.34	19	58	<5	1
EPL 100^{th} Percentile Limit	**SD1 and SD2**	**6.5 – 8.5**	**-**	**30**	**10**	**250**

The O&G and SO_4 concentrations of all discharges were within the EPL concentration limit conditions. However, two pH results (SD1 in June and March 2017) were outside of the EPL limits and TSS concentrations for all discharges were the EPL concentration limit conditions. All discharges were the result of dam spills during rainfall events rather than controlled discharges. Site rainfall data for the five days preceding the March 2017 discharges from SD1 and SB2 shows that the total rainfall exceeded the five day 95^{th} percentile rainfall depth for Lithgow of 56 mm. Both SD1 and SD2 are designed to contain the five day 95^{th} percentile rainfall depth for Lithgow of 56 mm. As such, spills during five day rainfall events greater than 56.4 mm are expected and the most recent version of EPL 13172 allows for discharges outside of EPL limit conditions as a result of rainfall events that exceed the design capacity of SD1 and SB2 (refer to **Section 6.1.1**). Site rainfall data was not available for the discharges in 2016.

2.4 Water Users

A search of the NSW Water Register for WALs in the Upper Nepean and Upstream Warragamba Water Source indicates that the primary water users are major and local water utilities and rural licence holders extracting water for domestic and stock watering purposes. The Upper Nepean and Upstream Warragamba Water Source is within the broader Sydney drinking water catchment. There are 411 WALs with a total share component equivalent to approximately 669 GL/year as of June 2019 in the water source. A further search for individual WALs and woks approvals to a point approximately 8 km downstream of the Quarry at Lake Lyell based on Lot and DP numbers did not identify and licensed users in the water source. In the vicinity of the Quarry (the Coxs River and Lake Lyell), other water uses include general recreational use (particularly in Lake Lyell) and recreational fishing.

3.0 Water Management

3.1 Existing Water Management

The existing quarry Water Management System is designed to maximise opportunities for reuse and recycling and minimise the possibility of uncontrolled discharge. The existing site water management system has been developed in a manner that aims to enable:

- efficient recovery and use of natural resources
- effective management of available storage volumes that prevents uncontrolled discharge to receiving environments
- effective water quality management strategies that prevent discharge of impacted water to receiving environments.

The existing WMS is divided into nine catchments by site topography, drainage infrastructure or drainage bunds (refer to **Figure 3.1**). **Table 3.1** identifies and describes the details of each catchment for the existing WMS.

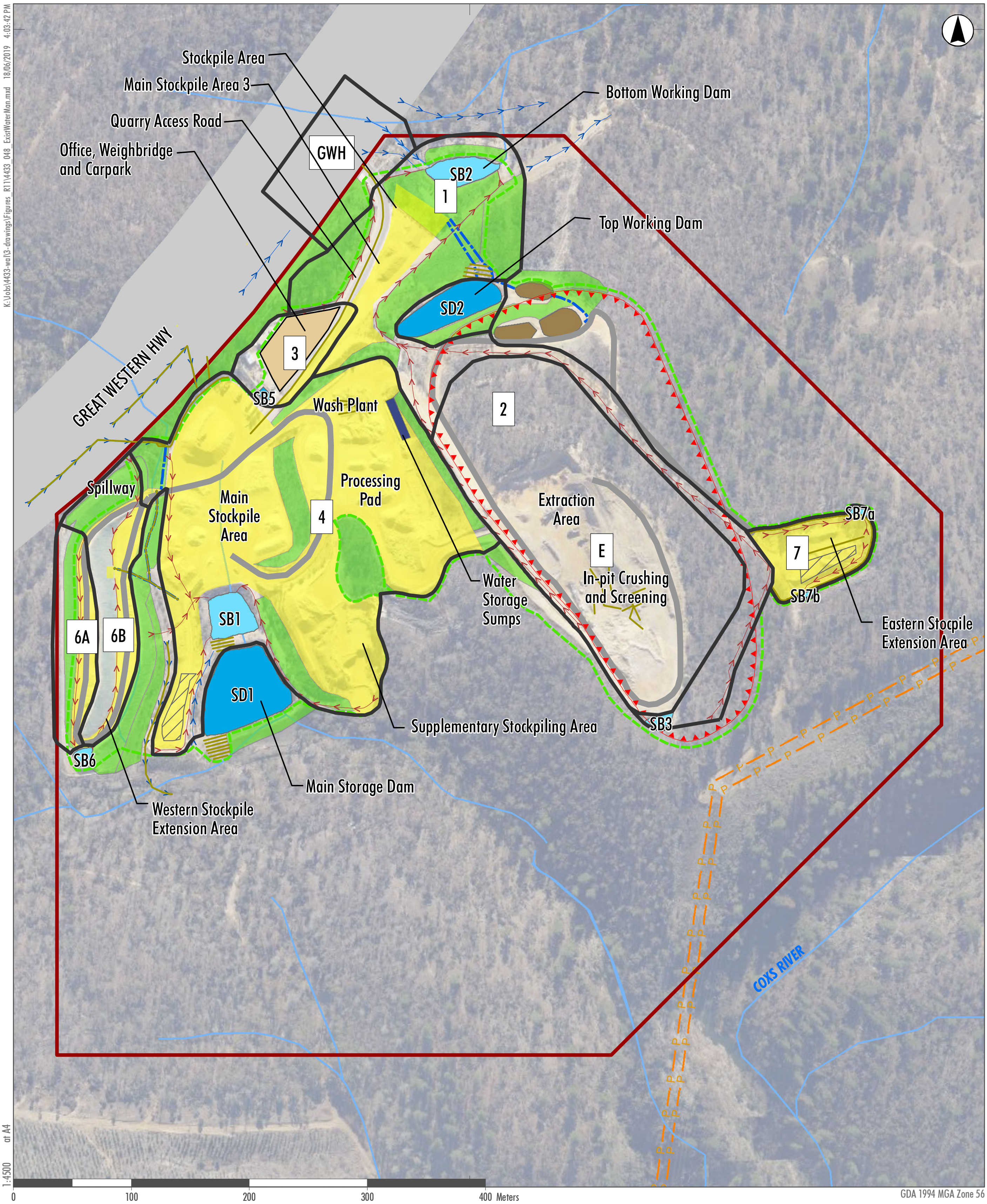
Table 3.1 Existing WMS Catchment Areas

Name	Area (ha)	Runoff Type	Description	Drains to (Storage)	Volume
1	3.4	Combined	Entrance road, west facing slope of the extraction area, haul road and miscellaneous disturbance.	Bottom Working Dam (SB2)	2.8
GWH	1.0	Clean	Runoff collected in roadside drains and culverts of the Great Western Highway adjacent to the Quarry Entrance.		
2	2.7[1]	Combined	Mining area – eastern slope.		
E	1.4[2]	Dirty	Mining area – central section below surface elevation (no runoff).	In-pit	N/R
3	0.5	Dirty	Site office, weighbridge area and selected haul roads.	Office Sediment Basin (SB5)	0.15[3]
4	6.0	Dirty	Processing and stockpiling areas, internal access roads.	Main Sediment Basin (SB1)	2.1
6b	0.9	Dirty	Lower tier of the Western Stockpile Area.		
6a	0.6	Dirty	Upper Tier of the Western Stockpile Area.	Western Sediment Basin (SB6)	0.3
7	0.5	Dirty	Eastern Stockpile Area.	Eastern Sediment Basins (SB7/b)	0.3 (each)

Note 1: Catchment to reduce in size as Catchment E increases in size

Note 2: Catchment to increase in size as the extraction area is developed below surface elevation

Note 3: Catchment to be removed as Catchment E extends to replace Catchment 2



Legend

- Quarry Site - ML1633
- Approved Extraction Area
- Catchment Boundary
- Approved Area of Disturbance
- Office, Weighbridge and Carpark
- Drying Cell
- Stockpile Area
- Stabilised Surface (groundcover)
- Sediment Basin
- Silt Cell
- Storage Dam
- Water Storage Sumps
- Clean Water Drain
- Dirty water drain
- Haul Road
- Water Pipeline
- Watercourses
- Electricity Transmission Lines

FIGURE 3.1

Existing Quarry Water Management System

Image Source: ESRI World Imagery (2019) Data source: Walker Quarries (2019); Umwelt (2019); NSW LPI DTDB (2019); CEH Survey (November 2016)

With reference to the type of runoff identified in **Table 3.1**:

- dirty water refers to runoff from disturbed areas of the Quarry Site
- clean water refers to runoff from upslope catchments unaffected by Quarry Site activities (regardless of water quality)
- where the water type is identified as 'combined' this refers to catchments receiving both clean and dirty water runoff.

As shown in **Table 3.1**, seven existing catchments are considered to contain dirty water runoff. With the exception of runoff from Catchment E (the below ground level area of the existing open cut), this runoff is to be diverted to one of six sediment basins (SB1, SB2, SB5, SB6, SB7a and SB7b). Additional capacity for water storage is provided by two storage dams (SD1 and SD2).

One existing catchment is identified as carrying clean water (Catchments GWH). By virtue of the construction of the Quarry Site intersection with the Great Western Highway, runoff from the small section of the highway drainage (Catchment GWH) is diverted via road side drains to a culvert below the Quarry Site Access Road which also accepts dirty water runoff from Catchment 1. This runoff is diverted to SB2. The remaining clean water runoff from the Great Western Highway is segregated from Quarry Site disturbance, captured within a clean water drain (CWD-5), which includes a section of below ground pipe transfer, and allowed to discharge to natural drainage to the south of the SD1.

As detailed in the Soil and Water Management Plan (SWMP) (Umwelt, 2019) surface water runoff generated within "dirty" catchments is captured and directed into sediment basins by site topography, a drain or a bund. Runoff is diverted by rock-lined drains into one of seven sediment basins which have been designed to provide water settlement and sediment storage capacity up to the design rainfall conditions (56.4 mm in five days (five day 95th percentile rainfall event for Lithgow). In accordance with the existing site Erosion and Sediment Control Plan (ESCP), these structures are maintained as 'dry' structures, i.e. emptied to reinstate the required storage capacity within five days of water accumulation.

A further two storage dams are maintained at the Quarry to which water accumulated in the sediment basins after rainfall is discharged (either by overflow from SB1 to SD1, or pumping to SD2). Water for dust suppression and processing operations is drawn from these dams.

Three silt cells are operated at the Quarry, these structures accept water from sand washing operations containing elevated silt and fines content. The silty water flows through these cells, allowing for the settlement and collection of silt, before discharge into SD2 (Top Working Dam) from which the water is redrawn for washing and operations.

Table 3.2 presents information on the existing permanent water storages on the Quarry Site.

Table 3.2 Quarry Existing Site Water Storage Information

Storage	Volume (ML)	Purpose	Water Use
Sediment Basins			
SB1: Main Sediment Basin	2.1	Collection and storage of runoff Catchment 4 and 6 (Main and Western Stockpile Areas).	Source of water for dust suppression and sand washing. Discharges via spillway to Main Storage Dam (SD1).
SB2: Bottom Working Dam	2.8	Collection and storage of runoff from Catchment 1 (Site Entrance and Roads) and Catchment 2 (Extraction area). Collection of overflow from the drying cell.	Transferred to Top Working Dam (SD2) to maintain design storage for sediment control or discharged to the receiving environment if of suitable quality.
SB5: Office Sediment Basin	0.15	Collection and storage of runoff from the Site office and selected haul roads.	Transferred to Top Working Dam (SD2) to maintain design storage for sediment control or discharged to CWD-5 (subject to compliance with the ESCP).
SB6: Western Sediment Basin	0.3	Collection and storage of runoff from the upper tier of the Western Stockpile Area.	Either transferred to Top Working Dam (SD2) to maintain design storage for sediment control or captured in collection sump of Catchment 6b for transfer to SB1.
SB7a and SB7b[1]	0.3	Collection and storage of runoff from ESEA.	Transferred to Top Working Dam (SD2) to maintain design storage for sediment control.
Storage Dams			
SD1: Main Storage Dam	8.1	Storage of runoff to ensure sediment basins can retain nominated capacity.	Supplementary supply for processing or dust suppression. Discharge to receiving environment under rainfall conditions exceeding design event or if of suitable quality.
SD2: Top Working Dam	4	Process water supply. Storage of water accumulated within sediment basins.	Primary supply for sand washing and dust suppression.
Silt Cells			
Cells 1 to 3	3 x 2.4 (7.2)	Progressive settlement of silt from water used in sand washing. Discharge to SD2 for re-use in sand washing.	
Note 1: Both sediment basins have been sized to account for all runoff from the ESEA			

EPL 13172 allows for the discharge of water from SB2 and SD1, either following rainfall exceeding the design rainfall event (five day 95th percentile rainfall, 56.4 mm) or on confirmation of compliance with the quality criteria of EPL 13172. As nominated in **Table 3.1** and **Table 3.2**, water accumulated in the sediment basins is transferred to the two storage dams from which the water is drawn for dust suppression and processing operations.

3.1.1 Erosion and Sediment Controls

In addition to the sediment basins discussed in **Section 3.1** other erosion and sediment control (ESC) measures are installed as required to reduce flow velocities and capture sediment from disturbed areas of the Quarry. Additional ESCs include the following as required:

- sediment fencing
- straw bale filters and check dams
- rock armouring and jute mesh to reduce erosion
- energy dissipaters and outlet protection.

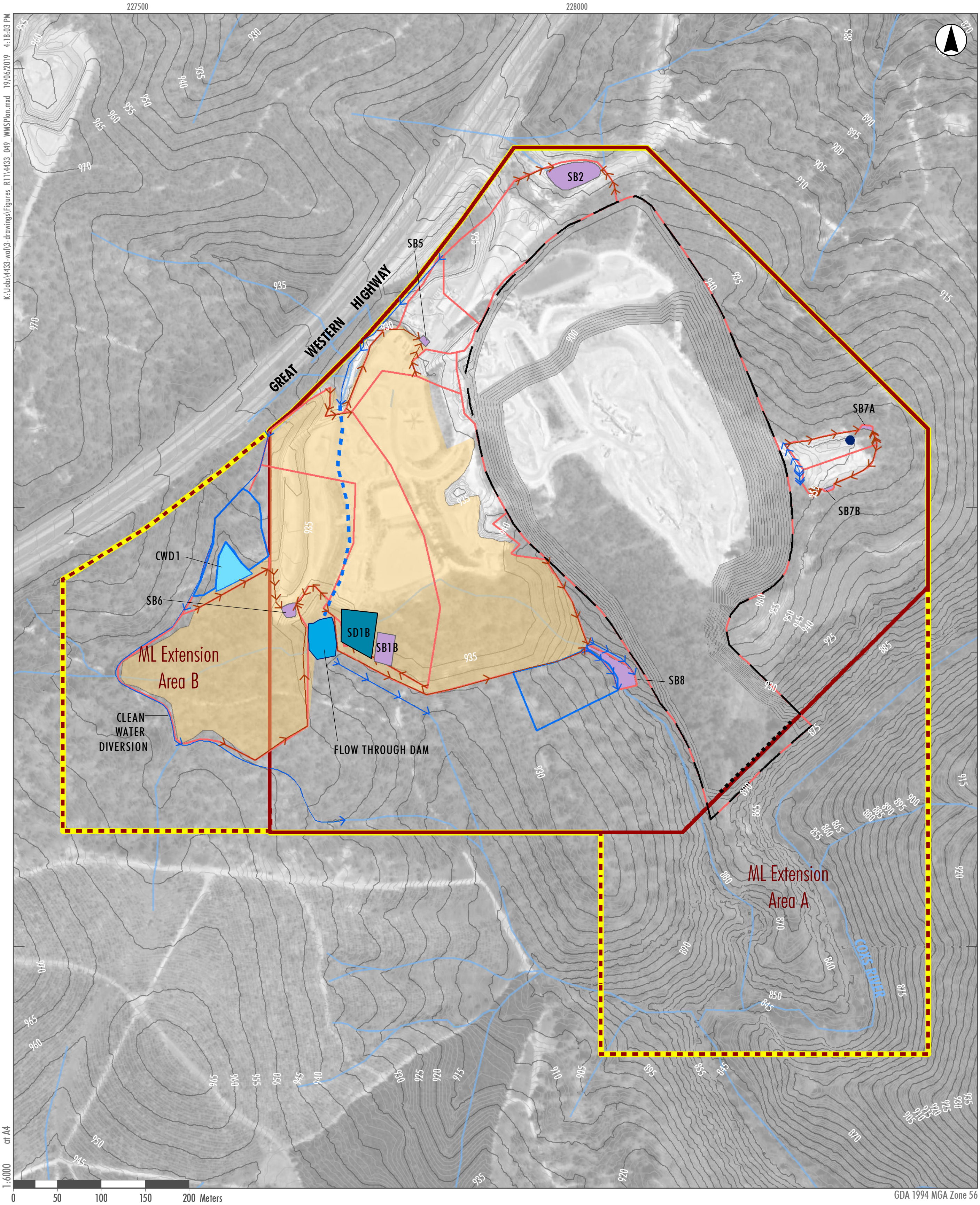
The location and details of ESCs are detailed within the Quarry ESCP (Appendix 3 of the Water Management Plan (Umwelt, 2019)).

3.2 Proposed Water Management

A plan and schematic of the proposed WMS (for 2045) are presented in **Figure 3.2** and **Figure 3.3** respectively. The proposed WMS will incorporate:

- additional undisturbed upslope catchment and clean water diversions
- extended quarry pit catchments
- additional sediment basins and storage dams to capture, manage and store runoff from the extended and new stockpiling areas
- dirty and clean water diversions to ensure appropriate separation and management of clean and dirty water across the site.

Progression of the proposed quarry plan will result in the decommissioning of the existing Storage Dams 1 and 2 (SD1 and SD2), as well as Sediment Basin 1 (SB1). The proposed WMS will incorporate the following sediment basins a listed in **Table 3.3**. Additional temporary sediment basins may be constructed as required as quarrying and spoils emplacement progresses. These sediment basins will be designed, constructed and managed in accordance with *Managing Urban Stormwater* (Landcom, 2004 and DECCW, 2008) and will be documented with the Quarry SWMP.



Legend

- Project Site
- Quarry Site - ML1633
- Quarry Site Extension
- Proposed Extraction Pit Shell (Pit to RL860)
- Clean Water Catchments
- Clean Water Dam
- Dirty Water Catchments
- Flow Through Dam
- Sediment Basins
- Settlement Ponds
- Storage Dam
- Water Tank
- Proposed_Stockpile_Area_MGA56.DGN Polygon
- Buried Pipe Culvert
- Clean Water Diversions
- Dirty Water Diversions
- In Pit Sed Basin Wall

FIGURE 3.2

Year 2045 Proposed Water Management System

Image Source: Google Earth (2016) Data source: Walker Quarries (2019); Umwelt (2019); NSW LPI DTDB (2019); CEH Survey (November 2016)

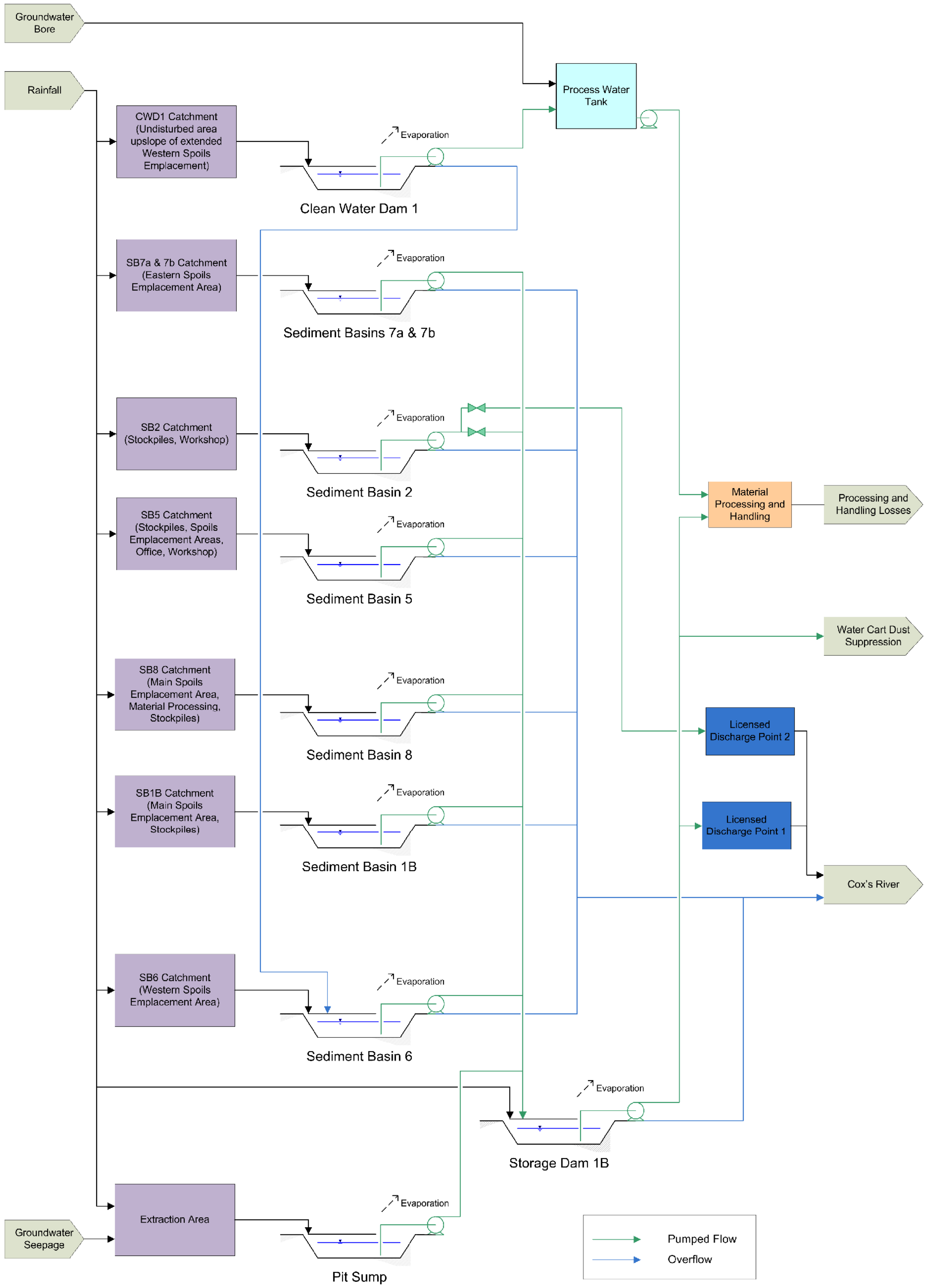


FIGURE 3.3

Year 2045 Proposed Water Management System Schematic

Table 3.3 Proposed WMS Catchment Areas and Design Sediment Basin Sizes (Year 2045)

Sediment Basin	Existing or Proposed	Catchment Area (ha)	Runoff Type	Description of Contributing Catchment	Required Basin Design Volume		
					Settlement Zone (m^3)	Sediment Storage Zone (m^3)	Total (m^3)
Bottom Working Dam (SB2)	Existing	1.57	Combined	Entrance road, west facing slope of the extraction area, haul road and miscellaneous disturbance.	656	328	984
Pit Sump	Proposed	15.30	Dirty	Existing and proposed quarrying area	6,386	3,193	9,579
Office Sediment Basin (SB5)	Existing	0.84	Dirty	Existing: Site office, weighbridge area and selected haul roads. Proposed: A portion of the main stockpile area	349	175	525
SB6	Existing	4.28	Dirty	Existing: a portion of the Western Stockpile Area. Proposed: Western Stockpile Extension Area	1,786	894	2,680
SB7a	Existing	0.26	Dirty	Eastern Stockpile Area	110	55	165
SB7b	Existing	0.22	Dirty	Eastern Stockpile Area	93	47	140
SB8	Proposed	4.33	Dirty	Portions of the Main stockpile area and southern stockpile extension	1,808	904	2,712
SB1B	Proposed	2.90	Dirty	Portions of the Main stockpile area and southern stockpile extension	1,211	608	1,818
SD1B	Proposed	N/A	Dirty	Turkey's Nest (no catchment) – storage of water from various basins across the site as required	-	-	8,000[1]
CWD1	Proposed	0.65	Clean	Captures upslope clean water which is unable to be diverted around the site due to site topography	NA	NA	3,200[2]

Notes:

1. **Proposed sizing to match existing Main Storage Dam (SD1) capacity.**
2. **CWD1 capacity is based on the volume of the depression in the landform up to spill level.**

All runoff generated on disturbed catchments of the Quarry will be directed to one of the sediment basins as listed in **Table 3.3** above. These sediment basins have been conceptually sized as Type D sediment basins (refer to Standard Drawing SD 6-4 of Landcom (2004)) for their respective catchments. The contributing catchments for each proposed or existing sediment basin are displayed on **Figure 3.2**. Where a disturbed area is created (such as for the new stockpiling areas) then the landform will be shaped to ensure water drains towards the correct sediment basin. The design criteria for sediment basins is presented in **Table 3.4**.

Table 3.4 Sediment Basin Design Criteria

Parameter	Value or Description
Total Sediment Basin Volume (m^3)	= Settling Zone (m^3) + Sediment Storage Zone (m^3)
Settling Zone, V (m^3)	$V = 10 \times C_v \times A \times R_{x\text{-day, y-\%ile}}$ Where: 10 = a unit conversion factor C_v = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the x-day period A = total catchment area for the basin (ha) $R_{x\text{-day, y-\%ile}}$ = the x-day total rainfall depth (mm) that is not exceeded in y percent of rainfall events.
Sediment Storage Zone (m^3)	On soil loss class 1 to 4 lands the sediment storage zone is calculated as 50 percent of the settling zone capacity or the two-month soil loss as calculated by the RUSLE (Revised Universal Soil Loss Equation) (whichever is larger) On soil loss class 5-7 lands the sediment storage zone is calculated as the 2-month soil loss as calculated by the RUSLE
Volumetric Runoff Coefficient, C_v	0.74 (refer to Table F2 of Landcom, 2004)
Design Rainfall Event, $R_{x\text{-day, y-\%ile}}$	5 day, 95th percentile event for Lithgow = 56.4 mm
RUSLE	A = R x K x LS x P x C Where: A = computed soil loss (tonnes/ha/year) R Factor = Rainfall erosivity factor = 1,471 for the Quarry Site K-Factor = soil erodibility factor = 0.053 for the Quarry Site LS = slope length/ gradient factor Slope Length = Default = 80 m, otherwise determined based on catchment topography Slope gradient = Determined based on catchment topography P = erosion control practice factor = 1.3 C = ground cover and management factor = 1

Details of the proposed WMS and required management strategies will be documented in the Quarry SWMP.

3.2.1.1 In-Pit water management

The majority of runoff generated within the proposed extraction area will be produced by rainfall due to the nature of the surrounding natural topography, proposed Quarry development sequence and WMS. It is therefore proposed that all water captured in-pit will be contained within a pit sump, to be constructed and relocated as required within the extraction area to service the active extraction area of the time. The required design volume of this pit sump in 2045 is provided in **Table 3.3**.

3.2.1.2 Clean water diversions

Modification to the approved WMS of the Quarry would result in the following changes to clean water diversions at the site:

- The extension and burial of the central pipeline (CWD-5) which collects runoff from the roadside drainage of the Great Western Highway and diverts this to the south of the Southern Stockpile Area and into a tributary of the Coxs River.
- The diversion of an ephemeral, second order drainage line around the extended stockpile area (to the west).

Clean water from the Great Western Highway to the northwest of the Quarry Site is currently diverted through the Quarry via CWD-5. CWD-5 is an existing open, rock lined drain which is collected and transferred below the existing stockpile areas via a 400 mm HDPE pipe, before discharging into an open, rock lined drain again. The clean water is then diverted to the south of the Quarry where it discharges into a second order tributary of the Coxs River. An energy dissipator and outlet protection is currently maintained at the discharge point from the pipeline and open drain sections of CWD-5. In order to ensure continued transfer of clean water through the Quarry the existing HDPE pipe will be extended below the Main Stockpile Area (which is to be increased in elevation and keyed into the lower tier of the Western Stockpile Area) and discharged to a new energy dissipation structure between the Southern Stockpile Area and Western Stockpile Area Extension. This energy dissipation structure will flow into an open rock lined drain before discharging to a tributary of the Coxs River. All clean water diversion structures (including pipes, drains and energy dissipation structures) will be designed appropriately (during detailed design phase) to ensure no impacts to downstream flows or water quality as a result of scouring and sedimentation occurs.

As shown on **Figure 3.2**, an existing second order ephemeral drainage line will be intercepted by the proposed Western Stockpile Extension Area. A clean water diversion drain is proposed to be constructed upstream to divert clean water from the second order drainage line originating within the Lidsdale State Forrest to the south into a tributary of Coxs River. Once the diversion is in place and adequately stabilised with appropriate ground cover the Western Stockpile Extension Area would be constructed. A conceptual size for this clean water diversion is presented in **Table 3.5**. Detailed design of the clean water diversion will be undertaken prior to construction and will consider appropriate sizing based on upstream and downstream receiving water, channel stability assessment and consideration of environmental flows. Clean water diversions will be appropriately stabilised before being permitted to carry clean water as will be documented within the site’s ESCP.

Table 3.5 Western Clean Water Diversion Conceptual Design Information

Diversion Drain Name	Catchment area (ha)	Design Storm				Channel Lining		Hydraulic Results				Long Section Design	Cross Section Design				
		Average Recurrence Interval (ARI) (years)	Time of Concentration (mins)	C10[2]	Frequency Factor	Mannings 'n	Channel Lining	Flow (m^3/s)	Velocity (m/s)	Maximum Permissible Velocity (m/s)	Depth of Flow	Slope (%)	Base Width (m)	Site Batters (v:h)	Freeboard	Minimum Channel Depth (m)	Channel Top Width (m)
Western Clean Water Diversion	56.8	20	37	0.25	1.21	0.022	Jute Mesh (close weave, bitumen sprayed) & seeded [3]	2.47	1.3	1.7	0.22	1%	8[3]	1:3[3]	0.15	0.37	9.1

1 Using Manning's Equation

2 Undisturbed upslope catchment, determined using Figure 5.1 Volume 2 – Australian Rainfall and Runoff (ARR) 1987

3 To be determined if appropriate during detailed design

3.2.1.3 Erosion and Sediment Controls

Prior to the commencement of any surface disturbing works, appropriate erosion and sediment controls will be installed to ensure appropriate diversion of clean water around areas of disturbance and capture and management of runoff from areas of disturbance. Priority will be given to minimising erosion from disturbed areas through appropriate use of ground cover followed by management of sediment laden waters through the installation of appropriate sediment controls. The installation or construction of any erosion and sediment control structures will be undertaken in accordance with *Managing Urban Stormwater Volumes 1 and 2* (Landcom, 2004 and DECCW, 2008) and the approved Quarry Soil and Water Management Plan.

The existing Quarry ESCP, which is an appendix to the Quarry SWMP, will be updated to reflect any changes to the quarry WMS and required ESCs as a result of the proposed modification.

4.0 Water Balance

4.1 Existing Water Balance

Table 4.1 presents the water balance sourced from the Quarry SWMP (Umwelt, 2019) for the existing operation for a range of annual exceedance probability (AEP) rainfall years. The water balance results presented in **Table 4.1** for the existing operation indicates a water surplus in all but the driest rainfall years. Although discharge volumes and frequencies for the existing operations water balance were not predicted, the predicted water surplus in most years suggests that controlled discharges would be required at times to manage site water inventories. Detailed water quantity monitoring data for the existing operation was not available to verify the existing operations water balance results.

Table 4.1 Existing Operation Water Balance

Rainfall AEP	Runoff (ML)	Site Water Demands/Losses (ML)	Water Balance (ML)
95%	36.3	38.5	-2.1
90%	40.3	38.5	1.9
80%	45.5	38.5	5.1
50%	46.6	38.5	18.2
10%	75.8	38.5	37.4
5%	81.6	38.5	43.2

4.2 Water Balance of the Proposed Modification

A predictive water balance model (the Model) has been developed using GoldSim software for the proposed conceptual Year 2045 Quarry WMS. The daily time step Model uses historical climate data to estimate direct rainfall inflows and evaporative losses. Runoff inflows are estimated based on the Australian Water Balance Model (AWBM).

Quarry operations at Year 2045 of the Proposed Modification have been modelled as this operational stage will have the greatest water demands.

4.2.1 Quarry Water Sources and Demands

4.2.1.1 Water Sources

The following water sources are utilised by the Quarry to supply operational demands:

- rainfall and runoff captured within the proposed Quarry WMS (refer to **Section 3.2**) including clean water harvesting
- an incidental groundwater inflow seepage to the Quarry Pit of 25.55 ML/year (Jacobs, 2019)

- up to 100 ML/year of groundwater entitlement in the Coxs River Fractured Rock Groundwater Source (WAL 42081) extracted from the site bore
- potable water trucked to site for amenities usage (note that amenities water use and disposal has not been incorporated in the Model).

4.2.1.2 Water Demands

Operational Quarry water demands are listed below:

- evaporative losses from water storage surfaces
- material processing and handling (i.e. product moisture losses, dust suppression)
- haul road and dust suppression.

4.2.2 Model Basis and Assumptions

4.2.2.1 Climate Data and Runoff Model

The historical rainfall data set used in the Model is based on the BoM Lidsdale station (Station 63132) with data gaps infilled from the BoM Lithgow station (Station 63226).

Catchment runoff has been estimated using the AWBM which is incorporated in the Model. The AWBM has been calibrated for undisturbed catchment runoff to the average regional runoff for the quarry site of 0.85 ML/ha/year (WaterNSW Maximum Harvestable Right Calculator, 2019). Runoff from disturbed catchments and pit catchments has also been estimated using the AWBM with input parameters based on those used in calibrated models prepared by Umwelt for other hard rock quarries. The AWBM parameters used in the Model are presented in **Table 4.2**. Runoff from hardstand areas (roofs and sealed roads) has been estimated using a runoff coefficient of 0.9 (Landcom, 2004).

Table 4.2 Australian Water Balance Model Parameters

Catchment	Surface Store Capacities (mm)			Surface Store Partial Areas			Ks (day^{-1})	BFI	Kb (day^{-1})
	C_1	C_2	C_3	A_1	A_2	A_3			
Undisturbed	6.12	62.49	124.99	0.134	0.433	0.433	0.5	0.22	0.991
Disturbed	10	23	55	0.185	0.43	0.385	0	0.05	0.985
Pit	5	25	-	0.2	0.8	-	0	0.05	0.985

4.2.2.2 Demands

Quarry water demands for the modelled Year 2045 scenario were as follows.

- Evaporative losses were based on average monthly evaporation at the BoM Bathurst Agricultural Station (Station 63005), a pan factor of 0.8 and water storage surface areas calculated using area-volume relationships at each Model time step.
- Dust suppression for crushing operations of 6 ML/year (provided by Walker Quarries).
- A sand and cobble washing demand of 34 ML/year (provided by Walker Quarries).

- A water cart dust suppression demand of 24 ML/year based on an historical usage rate of 16 ML/year (provided by Walker Quarries) with an increase in demand based on an estimate of the additional exposed areas (including haul roads) requiring dust suppression. Approximately 70% of the annual water cart demand occurs during the period October to March.

4.2.2.3 Operating Rules an Assumptions

The following operating rules were incorporated into the Model.

- Dirty water captured in the Quarry WMS is used in priority to captured clean water and groundwater imports.
- Clean water captured in CWD1 is used in priority to extracted groundwater.
- Clean water and groundwater are imported to the Process Water Tank (or tanks) which was assumed to have a capacity of 0.5 ML.
- The relocated Main Storage Dam (SD1B) was assumed to have a capacity equivalent to the existing SD1 of 8 ML.
- All sediment basins are dewatered to the Main Storage Dam (SD1B) at a rate to ensure the settling zone of each basin (i.e. the volume required to contain runoff from a five day 95th percentile rainfall event) is dewatered within five days following a rainfall event.
- Sediment basins (excluding Sediment Basin 2) were modelled to continue to dewater to the SD1B regardless of the available freeboard in SD1B. As such controlled discharges from SD1B were estimated based on the overflows from SD1B. Please note that in practise, all measures will be taken to ensure SD1B does not overflow by managing SD1B inventories with controlled discharges of suitable water quality.
- Controlled discharges from Sediment Basin 2 were modelled to occur when SD1B was at capacity and Sediment Basin 2 did not have sufficient freeboard to accommodate a five day 95th percentile rainfall event.
- The Pit Sump is only dewatered to SD1B when there is sufficient freeboard available. It was assumed excess water will be accommodated in the Quarry pit for short periods with extractive activities being able to continue at working faces away from areas impeded by stored water.
- Of the 25.55 ML/year of incidental groundwater inflow seepage to the Quarry pit, only 50% reports to the Pit Sump as pumpable water, with the remainder being lost to evaporation.

4.2.3 Water Balance Results

4.2.3.1 Gross Water Balance

Table 4.3 presents the statistical 10th, 50th and 90th percentile gross water balance results (excludes controlled discharges and potable water imports) for the Year 2045 Quarry stage plan. **Table 4.4** presents the rainfall runoff inflow statistics to the WMS for the Year 2045 Quarry stage plan.

Table 4.3 Year 2045 Gross Water Balance Results

Statistic	Result (ML/year)
10th percentile	-19.7
50th percentile	3.1
90th percentile	23.1

Table 4.4 Year 2045 Rainfall Runoff Inflows

Statistic	Result (ML/year)
10th percentile	31.4
50th percentile	65.5
90th percentile	127.9

The gross water balance results indicate that in a median year the Quarry will operate with a close neutral water balance. During dry years the results indicate that the Quarry will need to import water to meet operational demands while during wet years the Quarry will need to discharge surplus water. The median rainfall runoff inflow result of 65.5 ML is greater than the predicted 50% AEP rainfall runoff inflow of 56.6 ML in the existing operations water balance results (refer to **Table 4.1**), however, a greater discrepancy in these values was expected given the relative difference in catchment areas (the Year 2045 WMS catchment area is approximately 1.7 times larger than the existing WMS catchment area). This suggests that the existing operations water balance may over predict rainfall runoff inflows.

4.2.3.2 Median Year Net Water Balance

Table 4.5 presents the net water balance results for the modelled rainfall year closest to gross water balance 50th percentile prediction for the Year 2045 Quarry stage plan.

Table 4.5 Year 2045 Median Year Net Water Balance

Parameter	Result (ML)
Inflows	
Rainfall Runoff	93.8
Groundwater Seepage	12.7
Bore Import	6.8
Total Inflows	*113.3*
Outflows	
Evaporation	20.7
Haul Road Dust Suppression	24.0
Material Handling and Processing	40.0
Controlled Discharges	9.4
Sediment Basin Spills	9.5
Clean Water Dam Spills	0.0

Parameter	Result (ML)
Total Outflows	*103.5*
Change in Storage	9.8
Net Water Balance	**0.0**

While the gross water balance results (refer to **Section 4.2.3.1**) indicated an approximately neutral annual water balance for a median year, and therefore limited requirements for imports and discharges, the net water balance for the median year shows significant volumes of bore water import and controlled discharge. This is a consequence of short to medium term variations in climatic conditions and limited site storage capacity. That is, after prolonged dry periods site water inventories are diminished and imports are required and after high or prolonged rainfall events site storages are full and discharges are required to maintain adequate freeboard in sediment basins. **Chart 4.1** presents the median net water balance year rainfall, groundwater imports and controlled discharges.

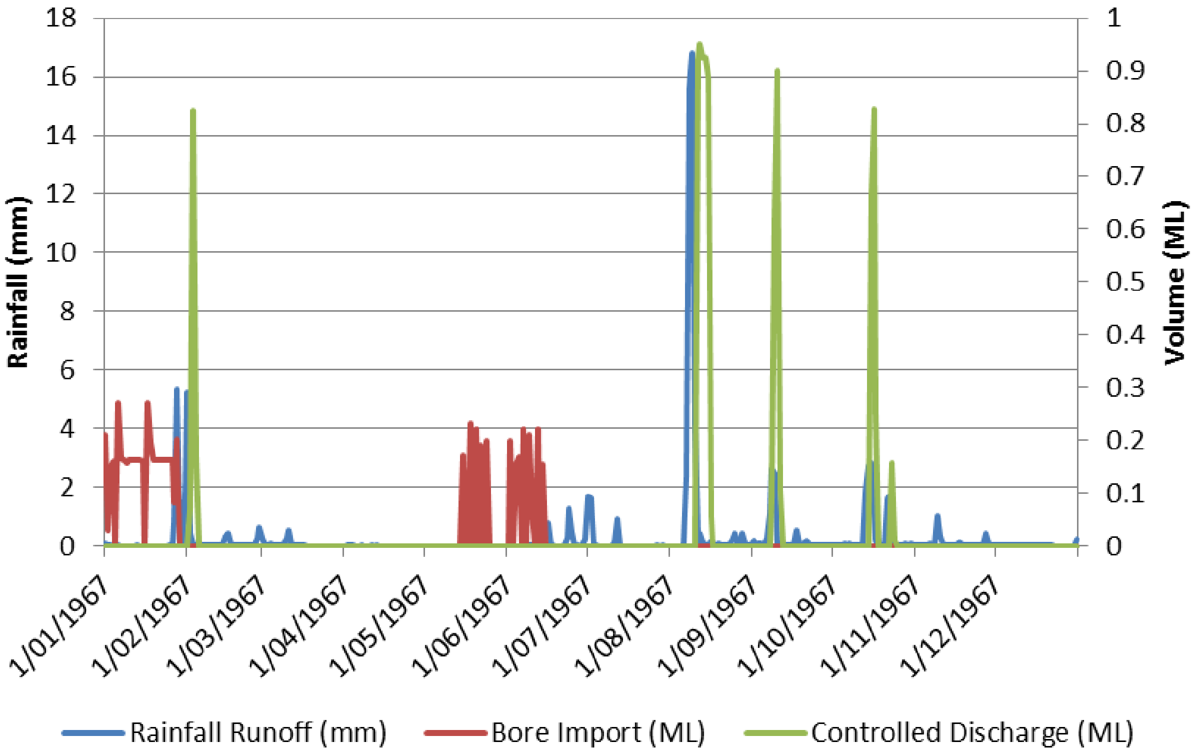


Chart 4.1 Median Net Water Balance Rainfall, Imports and Discharges

4.2.3.3 Imports and Discharges

Table 4.6 presents the predicted bore water import volume statistics for the Year 2045 Quarry stage plan. The results indicate that the even in the driest years the bore water import demand is significantly less than the groundwater entitlement of 100 ML/year associated with WAL 42081.

Table 4.6 Bore Water Imports

Statistic	Result (ML/year)
Minimum	0.0
10th percentile	0.0
50th percentile	5.9
90th percentile	19.6
Maximum	35.6

Table 4.7 and **Table 4.8** present the predicted controlled discharge volume and frequency statistics respectively for the Year 2045 Quarry stage plan.

Table 4.7 Controlled Discharge Volumes

Statistic	SD1B Discharge (ML/year)	SB2 Discharge (ML/year)
Minimum	0.0	0.0
10th percentile	0.0	0.0
50th percentile	7.0	0.0
90th percentile	21.2	0.0
Maximum	41.4	1.6

Table 4.8 Controlled Discharge Frequency

Statistic	SD1B Discharge (days/year)	SB2 Discharge (days/year)
Minimum	0.0	0.0
10th percentile	0.0	0.0
50th percentile	17.0	0.0
90th percentile	38.4	0.0
Maximum	67.0	17.0

The results indicate that discharges from the Quarry WMS to manage water inventories are required in median to wet years. As was demonstrated for the median year net water balance (refer to **Section 4.2.3.2**), due to the limited site storage capacity, controlled discharges may still be required in median rainfall years to manage high site water inventories as a result of high or prolonged rainfall events. As SB2 (an existing sediment basin) is oversized for the Year 2045 catchment that it services and has capacity in excess of the five day 95th percentile rainfall event, predicted discharges are less frequent than from SD1B. As such surplus water can be held in SB2 without the requirement to dewater.

Table 4.9 presents the frequency of spill events from sediment basins for the Year 2045 Quarry stage plan. A spill event may occur across more than one day.

Table 4.9 Sediment Basin Spill Frequency

Sediment Basin	Minimum (events/year)	Average (events/year)	Maximum (events/year)
SB2	0	<1	1
SB5	0	<1	6
SB6	0	<1	5
SB7a and SB7b	0	<1	3
SB8	0	<1	5
SB1B	0	<1	4

The frequency of spill events from sediment basins are predicted to be less than one spill per year which is less than the expected frequency of sediment spills (one to two spills/year) from sediment basins designed in accordance with the Blue Book to accommodate the five day 95th percentile rainfall event.

5.0 Surface Water Impacts and Mitigation Measures

5.1 Impacts

5.1.1 Water Quality

Water balance modelling predicts that both controlled discharges and sediment basin spills will occur for the modified Quarry operations (refer to **Section 4.2.3.3**). Controlled discharges will occur from SD1B and SB2 to manage surplus water inventories during median to high rainfall periods. Water in SD1B and SB2 should be tested prior to commencing a controlled discharge to whether stored water quality is within EPL concentration limits, and if it is not, the water should be treated to ensure EPL criteria is achieved prior to discharge.

Spills from sediment basins occur when rainfall exceeds the sediment basin design rainfall capacity and may have elevated concentrations of suspended solids. For sediment basins designed and managed to accommodate a five day 95^{th} percentile rainfall event, the Blue Book expects spills to occur at a frequency of one to two times per year. Water balance modelling (refer to **Section 4.2.3.3**) predicts that all sediment basins for the Year 2045 Quarry stage plan will spill at a frequency of less than one per year. Further, these spills will only occur during periods of high rainfall when runoff from the broader catchment will be high and is already likely to contain elevated concentrations of suspended solids.

As such, impacts on downstream water quality associated with controlled discharges and sediment basin spills are considered to be acceptable.

5.1.2 Water Quantity

The Proposed Modification will result in a significant increase in WMS catchment area and therefore an increase in the rainfall and runoff captured within the Quarry WMS. There will also be an increase in operational water demands which will consume most of the additional captured water during dry to median years. During median to wet years, excess water will be discharged from the WMS to the environment. The increase in Quarry WMS catchment associated with the Proposed Modification will be 12.60 ha. This is an increase of 70% relative to the existing approved operation and accounts for only 0.005% of the Coxs River catchment. Overall, the proposed Quarry WMS catchment area accounts for only 0.018% of the Coxs River catchment.

Following the Quarry extraction phase, the majority of the Quarry WMS catchment will be rehabilitated and drain freely to the downstream environment. The total capacity of any remaining water storages will be limited to the landholding MHRDC. As such, the impacts associated loss of surface water catchment during the operational phase and post operation are expected to be negligible with respect to the existing approved operation.

5.1.3 Stream Stability

As discussed in **Section 3.2.1.2** the proposed Western Stockpile Extension Area will intercept an existing second order ephemeral drainage line. A clean water diversion will be appropriately designed and constructed to capture the intercepted catchment and drainage line and divert the water back to a natural drainage line to the south of the Quarry. The existing clean water diversion pipe under the main stockpiling area will also be extended to divert clean water south of the proposed stockpile extension.

On construction, these diversions will result in an increase in upslope catchment area for the drainage channels to receive the diverted runoff resulting in an increase in the volume of runoff flowing to those natural drainage channels and in stream flows. Prior to construction of these diversions, modelling to review existing flow conditions within the drainage channels (including flow depths, velocities and tractive stresses) for a range of design storm events will be completed. Channel stability assessment outcomes will include appropriate mitigation measures (which may include channel armouring or even realignment of the proposed diversions) to be implemented to minimise detrimental impacts to downstream drainage channel reaches.

5.2 Cumulative Impacts

In a mining context, Franks, et al (2010) describes cumulative impacts as impacts that:

"…arise from compounding activities of a single operation or multiple mining and processing operations, as well as the aggregation and interaction of mining impacts with other past, current and future activities that may not be related to mining."

With respect to the surface water resources potentially impacted by the Proposed Modification there has been significant past development in the upstream, immediate and downstream catchment areas including agricultural development, urbanisation and also significant development of the surface water resources themselves including regulation and extraction of water for local, regional and metropolitan water supply. The effects of past development on water resources in the immediate vicinity of the Quarry (i.e. the upper Coxs River) are inherent in the baseline condition of the surface water resource which has been developed for the Proposed Modification based on contemporary monitoring.

The 2016 Audit of Sydney Drinking Water Catchment (Alluvium Consulting Australia, 2017) shows a significant industrial and coal mining presence within the upper Coxs River catchment including the Mt Piper Power Station, the Wallerawang Power Station (permanently closed in 2014), Angus Place Colliery (presently in care and maintenance), Pine Dale Coal Mine (presently in care and maintenance) and the Springvale Coal Mine. All three coal mines are licensed to discharge water to the receiving environment, however, based on publicly available records it would appear that the Pine Dale Coal Mine has not discharged for some time. Springvale Coal Mine and Angus Place Colliery discharge surplus water from their respective WMSs. The surplus water is largely a result of groundwater extracted to maintain underground workings in a dewatered state. The extracted groundwater has elevated concentrations of Total Dissolved Solids (TDS) and as such, both the Springvale Coal Mine and Angus Place Colliery have projects underway to treat surplus water prior to discharge, or in the case of the Springvale Coal Mine, transfer up to 42 ML/day to Mount Piper Power Station for reuse. The Springvale Coal Mine Water Treatment Project is presently under construction while the Angus Place Colliery Water Treatment Project was approved in September 2018.

Given the relatively small footprint of the Quarry compared to the nearby powers stations and coal mines, the cumulative impact associated with loss of catchment draining to the upper Coxs River is considered negligible. Further, the closure of the Wallerawang Power Station and the planned reuse of surplus mine water from the Springvale Coal Mine at the Mount Piper Power Station will reduce the surface water taken from the Coxs River for power generation.

The closure of the Wallerawang Power Station and the planned water treatment measures for the Springvale Coal Mine and Angus Place Colliery will have a positive impact on upper Coxs River water quality. Suspended solids is the primary pollutant of concern with regard to discharges from the Quarry WMS.

Water balance modelling (refer to **Section 4.2.3.3**) predicts that the majority of discharges from the Quarry WMS will be controlled and water quality will be managed such that these discharges meet EPL concentration limits (refer to **Section 6.1.1**), including those for suspended solids. Spills from sediment basins are predicted to be infrequent and will occur during high or prolonged rainfall events when suspended solids concentrations associated with runoff from the broader catchment will already be elevated. As such, the cumulative impacts on Coxs River water quality are predicted to be negligible.

5.3 Mitigation and Contingency

The following mitigation measures are proposed to minimise impacts on surface water resources.

- Capture of stormwater runoff within the quarry WMS and treatment of water (flocculation, coagulation and pH correction) with the existing water treatment systems to meet EPL discharge criteria prior to off-site discharge.

- Implementation of ESCs in accordance with Landcom's *Managing Urban Stormwater Volume 1* (Landcom, 2004) and *Volume 2E Mines and Quarries* (DECC, 2008) (the Blue Book) during stripping/development of new extraction areas or any other ground disturbing activities.

- Ongoing water quality monitoring upstream and downstream of the Quarry and the development of site specific water quality trigger values in accordance with ANZECC guidelines. The site specific trigger values will be used to initiate investigation in the event of any deviations in receiving water quality from the normal water quality range.

- The storage and handling of hydrocarbons and chemicals will be managed in accordance with relevant Australian Standards including *AS1940 - 2017 The storage and handling of flammable and combustible liquids* and other guidelines.

- In the event of water source restrictions, Walker Quarries will limit production to ensure environmental controls (i.e. dust suppression) are maintained as a priority with the available water supply.

6.0 Licensing, Monitoring and Reporting

6.1 Licensing

The Quarry operation is a scheduled activity under the Protection of the Environment Operations (POEO) Act, 1997 and operates under EPL 13172. Specific discharge criteria and monitoring requirements relating to water in the EPL are provided in **Section 6.2.1** and reporting requirements are provided in **Section 6.3.1**.

6.1.1 Environment Protection Licence

The Quarry operates under EPL 13172 which includes limit conditions for two LDPs for water (LDP 1 and LDP 2) (refer to **Figure 2.2**). **Table 6.1** presents the limit conditions for the SD1 and SD2.

L1 Pollution of waters

L1.1 Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the *Protection of the Environment Operations Act 1997*.

L2 Concentration limits

L2.1 For each monitoring/discharge point or utilisation area specified in the table\s below (by a point number), the concentration of a pollutant discharged at that point, or applied to that area, must not exceed the concentration limits specified for that pollutant in the table.

L2.2 Where a pH quality limit is specified in the table, the specified percentage of samples must be within the specified ranges.

L2.3 To avoid any doubt, this condition does not authorise the pollution of waters by any pollutant other than those specified in the table\s.

L2.4 Water and/or Land Concentration Limits

L2.5 The concentration limits stipulated by condition L2.4 for EPA identification points 1 and 2 are deemed not to apply when the discharge from the stormwater control structures (sediment dams) occurs solely as a result of rainfall measured at the premises which exceeds:

a) a total of 56 millimetres of rainfall over any consecutive 5 day period.

   Note: A 56 mm rainfall event is defined by the EPA endorsed publication "Managing urban stormwater: soils and construction" (Landcom 2004; 6-24) as the rainfall depth in millimetres for a 95th percentile 5 day rainfall event for "Lithgow" which is also consistent with the storage capacity (recommended minimum design criteria) for Type D sediment basins for mines and quarries (see "Managing urban stormwater: soils and construction, Volume 2E, mines and quarries" (DECC, 2008).

L2.6 The concentration limit for total suspended solids stipulated by condition L2.4 for EPA identification points 1 and 2 are deemed not to have been breached where:

a) the water discharged is covered by condition L2.5; OR

b) when not covered by condition L2.5, the water discharged (in accordance with conditions O4.1 and O4.2) is within pH range 6.5 - 8.5 and has a turbidity (as measured in nephelometric turbidity units (NTU) using a hand held turbidity meter) of 25 NTU or less at the time of the discharge; and

c) the EPA is advised within 3 working days of the completion of the sample testing and analysis as required by condition M2.2 of any results above the licence discharge limits specified under condition L2.4.

Note: *The purpose of condition L2.6 is to expediate the assessment and subsequent discharge of the clarified water from the stormwater control structures (sediment basins).*

Table 6.1 EPL Discharge Limit Conditions, LDP 1 and LDP 2

Pollutant	Units	100^{th} Percentile Concentration Limit
Oil & Grease	mg/L	10
pH	-	6.5 – 8.5
Sulfate (SO_4)	mg/L	250
Total Suspended Solids (TSS)	mg/L	30

6.1.2 Surface Water Extraction

As outlined in **Section 2.1.1.2**, all water extraction in NSW (apart from some exemptions for government authorities and basic landholder rights extractions) must be authorised by a water licence. Harvestable rights, which are a basic landholder right under the *Water Management Act 2000*, allow a landholder to capture and use up to 10% of the average regional runoff from a landholding. Basic landholder rights are exempt from volumetric licensing requirements, however, water extracted under basic landholder rights must be taken into consideration when assessing licensing requirements.

Water take under harvestable rights is typically managed by sizing site dams to the Maximum Harvestable Rights Dam Capacity (MHRDC) which equates to 10% of the average regional runoff for the landholding area. Based on a total landholding of 89 ha and an average regional runoff of 0.85 ML/ha/year, the landholding has a MHRDC of approximately 7.6 ML which is less than the proposed CWD1 capacity of approximately 3.2 ML.

Water captured within the disturbed areas of the Quarry WMS is also considered exempt from surface water licensing based on the following schedules in the Water Management (General) Regulation 2018:

Schedule 4

12 Excluded works

(1) Any landholder—in relation to the taking of water from or by means of an excluded work referred to in item 1, 2, 3, 4, 6, 7 or 9 in Schedule 1 that is situated on the land, for the purposes and in the circumstances specified in Schedule 1 in respect of the work.

Schedule 1

3 Dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by a public authority (other than Landcom or the Superannuation Administration Corporation or any of their subsidiaries) to prevent the contamination of a water source, that are located on a minor stream.

The Quarry presently holds one surface WAL (WAL 41884) within the Upper Nepean and Upstream Warragamba water source, however, WAL 41884 has a 0 ML/year share component. As such, the Quarry would be required to purchase entitlement from other WAL licence holders in the water source to allow for surface water take in excess the Quarry's harvestable right. However, the water balance of the Proposed Modification (refer to **Section 4.0**) indicates that the Quarry will have an adequate supply of water to meet operational water demands in all but the driest years from the following water sources:

- rainfall and runoff captured within the disturbed Quarry catchment
- rainfall and runoff captured in CWD1 under harvestable rights provisions
- incidental groundwater seepage inflows to the extraction area (extracted under WAL 42081)
- up to 100 ML/year of groundwater entitlement in the Coxs River Fractured Rock Groundwater Source (WAL 42081) from an approved bore (Approval No. 10CA123169).

As the final landform will be free draining (refer to **Section 5.1.2**) there will be no ongoing licensing requirement for surface water runoff.

Licensable water take associated with base flow losses to the Coxs River have been addressed in the *Wallerawang Quarry Extension – Groundwater Impact Assessment* (Jacobs, 2019).

6.2 Monitoring

Surface water monitoring at the Quarry includes discharge water quality monitoring in accordance with EPL 13172 (refer to **Section 6.2.1.1**), monitoring of water quality in receiving waters (refer to **Section 6.2.1.2**), monitoring of amenities water quality (refer to **Section 6.2.1.3**), monitoring water usage and imports (refer to **Section 6.2.2**) and regular monitoring of site erosion and sediment controls (ESCs) (summarised in **Section 6.2.3**) as detailed in the Quarry SWMP.

6.2.1 Water Quality

6.2.1.1 Controlled Discharges

Under EPL 13172, the Quarry is presently licensed to discharge to waters from LDP 1 and LDP 2 (refer to **Figure 2.2**). While the location of LDP 2 is expected to remain unchanged for the life of the Quarry, LDP 1 is presently located at the spillway from the Main Storage Dam (SD1). LDP 1 will move to be co-located at the new/relocated Main Storage Dam (SD1B). The monitoring requirements for both are proposed to remain unchanged from those contained within the present version of EPL 13172 (see **Table 6.2**).

Table 6.2 Discharge Water Quality Monitoring

Pollutant	Units	Frequency	Sampling Method
EC	µS/cm	Monthly during discharge	Grab sample
O&G	mg/L		
pH	-		
SO_4	mg/L		
TSS	mg/L		

Water in the Main Storage Dam (SD1/SD1B) and SB2 should be sampled and analysed prior to commencement of controlled discharges to ensure discharge water quality is within EPL 13172 concentration limits.

6.2.1.2 Receiving Waters

As described in **Section 2.3.2** water quality in the Coxs River upstream (RW1) and downstream of the Quarry (RW2) has been monitored previously by Walker Quarries. Water Quality monitoring in the Coxs River should continue to develop site specific trigger values in accordance with ANZECC 2000 based on the 80^{th} percentile (and/or 20^{th} percentile for lower limit trigger values) result from 24 months of contiguous monitoring results at the Coxs River Upstream monitoring location (RW1). Monitoring in the Coxs River downstream of the Quarry (at RW2) should continue and be compared with the site specific trigger values to inform of any potential Quarry impacts on receiving water quality.

Table 6.3 Coxs River Monitoring, RW1 and RW2

Pollutant	Units	Frequency
O&G	mg/L	Monthly
pH	-	
SO_4	mg/L	
TSS	mg/L	
EC	µS/cm	

6.2.1.3 Amenities Water

Potable water from the amenities water reticulation system should be sampled on a six monthly basis and analysed to ensure the water meets the requirements of the ADWG (National Health and Medical Research Council, 2011).

6.2.2 Water Quantity

Table 6.4 outlines the water inventories and flows that should be monitored. The water quantity monitoring data should be utilised to prepare an annual site water balance for the Annual Review required as a condition of DA 344-11-2001 (refer to **Section 6.3.2**).

Table 6.4 Water Quantity Monitoring

Parameter	Measurement Methodology	Units	Frequency of Monitoring
Main Storage Dam Inventory (SD1B)	Staff gauge located in SD1B to provide water level and inventory (volume) calculated based on storage level- volume relationship for SD1B.	ML	Monthly
Material processing demands	Flow meter or pump flow rate and run time.	ML	Daily or Monthly depending on measurement method
Water cart demands	Water cart volume and number of fills	ML	Daily
Groundwater Import	Flow meter or pump flow rate and run time.	ML	Daily during extraction

6.2.3 Erosion and Sediment Controls

Regular inspections of all water management (including erosion and sediment control structures) will continue to be completed as per the Quarry SWMP (Umwelt, 2019). Inspections will be completed on a monthly basis and following a rainfall event of greater than 25 mm in a 24 hour period. The inspections of water management structures will record the following.

- storage and sediment volumes held in each sediment basin and storage dam
- evidence of overflow and condition of the downstream catchment of any sediment basin or storage dam
- visual water quality of each sediment basin or storage dam (e.g. presence of oil or grease, water colour (turbidity) etc).
- the general condition of all water management structures, other erosion and sediment controls and any areas of rehabilitation.

All inspections will be documented and all actions identified will be closed out within a reasonable and practical time frame. The inspection records will include the following as a minimum:

- recording the condition of all erosion and sediment controls
- recording any maintenance required for each sediment control
- recording the requirement for any additional erosion or sediment controls.

All erosion and sediment controls will be maintained in proper working order at all times during their operational lives and maintained in a functioning condition until all construction activities are completed and full stabilisation of disturbed areas is achieved (i.e. greater than 70% ground cover across the whole of the disturbed area within the catchment).

The ESCP contained within the Quarry SMWP will be updated to reflect the proposed modification and will be continually updated as site conditions change or if the installed controls are not operating effectively. Additional erosion and/or sediment controls will be installed as might become necessary to ensure the desired protection is provided to downslope lands and waterways.

6.3 Reporting

6.3.1 Environment Protection Licence

Walker Quarries is required to complete and submit an Annual Return to the NSW Environment Protection Authority (EPA) that includes a summary of water monitoring, any complaints and a statement of compliance with EPL conditions.

In the event that an incident occurs that threatens or causes environmental harm such as discharge of water that does not meet EPL criteria, Walker Quarries must notify the EPA immediately after becoming aware of the incident. Walker Quarries must also provide a written report to the EPA within seven days of the date on which the incident occurred.

6.3.2 Annual Review and Incidents

Walker Quarries will submit an Annual Review (AR) to DPIE that will include a summary of the WMS performance. The AR will include the annual site water balance results, receiving water and discharge water quality monitoring results and details of any incidents or complaints. If an environmental incident involving surface water occurs the relevant authorities (including DPIE, the EPA, Natural Resources Assessment Regulator and DoI Crown Lands and Water Division) will be notified and reports provided as required. Details of incident response management and procedures will be provided in the Quarry SWMP.

7.0 Conclusions

The Proposed Modification will result in additional loss of catchment to the Coxs River and therefore the Upper Nepean and Upstream Warragamba water source. However, the Quarry only comprises 0.018% of the entire Coxs River catchment (refer to **Section 5.1.2**) and the final landform following the Quarry operational phase will be rehabilitated and free draining. As such, the loss of catchment yield to the Coxs River is considered to be negligible and only for the duration of the Quarry operational phase.

The volume and frequency of discharges (refer to **Section 4.2.3.3**) from the Quarry are considered to be minimal with respect broader catchment runoff volumes and discharges from upstream power generation and mining operations. Further, the majority of water discharged from the Quarry will be undertaken in a controlled manner from the two site LDPs with discharge water quality being managed to meet EPL concentration limits. As such, incremental Quarry impacts on receiving water quality and cumulative impacts associated with the Quarry contribution to receiving water quality are considered to be negligible.

With 100 ML of groundwater entitlement in the Coxs River Fractured Rock Groundwater Source (WAL 42081) to supplement runoff captured in the Quarry WMS, the Proposed Modification is considered to have secure source of water for even the driest years (refer to **Section 4.2.3.3**).

While no flood mapping for the Quarry Site is available, the Quarry is not considered to be located on flood prone land based on the elevation relative to the Coxs River (refer to **Section 1.1.2**) and therefore no impacts on flooding are expected.

The updated SWMP for the Quarry will include the proposed WMS, revised ESCs, amenities water management details, the proposed surface water monitoring program and trigger action response plans (TARPS) to ensure that Walker Quarries actively monitor the effectiveness of the WMS and update water management practices on a regular basis (as required).

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APPENDIX 10

Noise Impact Assessment

Noise and Vibration Impact Assessment

Wallerawang Quarry
Wallerawang, NSW.

Prepared for: Umwelt (Australia) Pty Limited
May 2019
MAC180681RP1V01

Muller Acoustic Consulting

Document Information

Noise and Vibration Impact Assessment

Wallerawang Quarry

Wallerawang, NSW.

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MAC180681RP1V01	Final	15 May 2019	Oliver Muller	[signature]	Rod Linnett	[signature]

CONTENTS

1 Introduction

Muller Acoustic Consulting Pty Ltd (MAC) has been commissioned by Umwelt (Australia) Pty Limited (Umwelt) on behalf of Walker Quarries Pty Ltd (Walker Quarries) to complete a Noise and Vibration Impact Assessment (NVIA) to quantify potential noise and vibration emissions associated with the proposed extension to the existing Wallerawang Quarry (the "Project"), located on the Great Western Highway, 8km to the northwest of Lithgow, NSW.

This NVIA has been prepared in consideration of the following relevant policies and standards:

- Environment Protection Authority (EPA) 2017, NSW Noise Policy for Industry (NPI); and
- NSW Government, Voluntary Land Acquisition and Mitigation Policy (VLAMP), 2018.

This NVIA has also considered and applied the following additional policy, guidelines and standards where relevant:

- Australian Standard AS 1055:2018 - Acoustics - Description and measurement of environmental noise - General Procedures;
- Australian Standard AS2187.2-2006 (AS2187.2) – Explosives—Storage and Use Part 2: Use of Explosives;
- Australian Standard AS 2436-2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites;
- NSW Government, Voluntary Land Acquisition and Mitigation Policy (VLAMP), 2018
- ISO 9613-1 Acoustics - Attenuation of sound during propagation outdoors. Part 1: Calculation of the absorption of sound by the atmosphere;
- ISO 9613-2 Acoustics - Attenuation of sound during propagation outdoors. Part 2: General method of calculation; and
- Australia and New Zealand Environment Council (ANZEC) Guideline – Technical Basis For Guidelines To Minimise Annoyance Due To Blasting Overpressure And Ground Vibration (ANZEC Guideline), 1990.

1.1 Objectives

This NVIA summarises the noise and vibration related findings of the Project and noise mitigation and management measures that may be implemented to effectively manage noise emissions at off-site receivers.

The objectives of the NVIA are as follows:

- identify the closest and/or potentially most affected receivers situated within the area of influence to the Project;
- review operating activities to identify noise generating plant, equipment, machinery or activities proposed to be undertaken that have the potential to exceed Project Noise Trigger Levels (PNTL) for all operating periods;
- utilise 3D noise modelling to predict noise levels that may occur as a result of the operation of the Project at the closest and/or potentially most affected receptors;
- assess the potential noise impacts associated with operation of the Project, and provide a comparison of predicted noise levels against the PNTLs;
- provide feasible and reasonable noise mitigation and management measures, and monitoring options, where PNTLs may be exceeded; and
- assess the potential for blasting impacts from the operation of the Project and provide a comparison with the relevant blasting emissions criteria.

A glossary of terms, definitions and abbreviations used in this report is provided in **Appendix A**.

1.2 Background

The Project will include the following activities:

- extraction of rock using drill and blast techniques from the proposed extraction area, with a current approved production of 500,000tpa;
- crushing and screening is undertaken in-pit to produce quartzite aggregates, road base and other hard rock products, washing and stockpiling of extracted material; and
- a screening and washing plant is also operated at the Project to produce a range of fine aggregates and sand products.

The modification for the Project includes

- extend the current period of consent beyond July 2019;
- extend the extraction area (both laterally and vertically); and
- increase the area available for stockpiling to the west of the Western Stockpile Area, see **Figure 1** (Umwelt 2019).

It is noted that there is no proposed increase in the Project's annual production rate nor any significant change to processing operations are proposed as part of the Project.

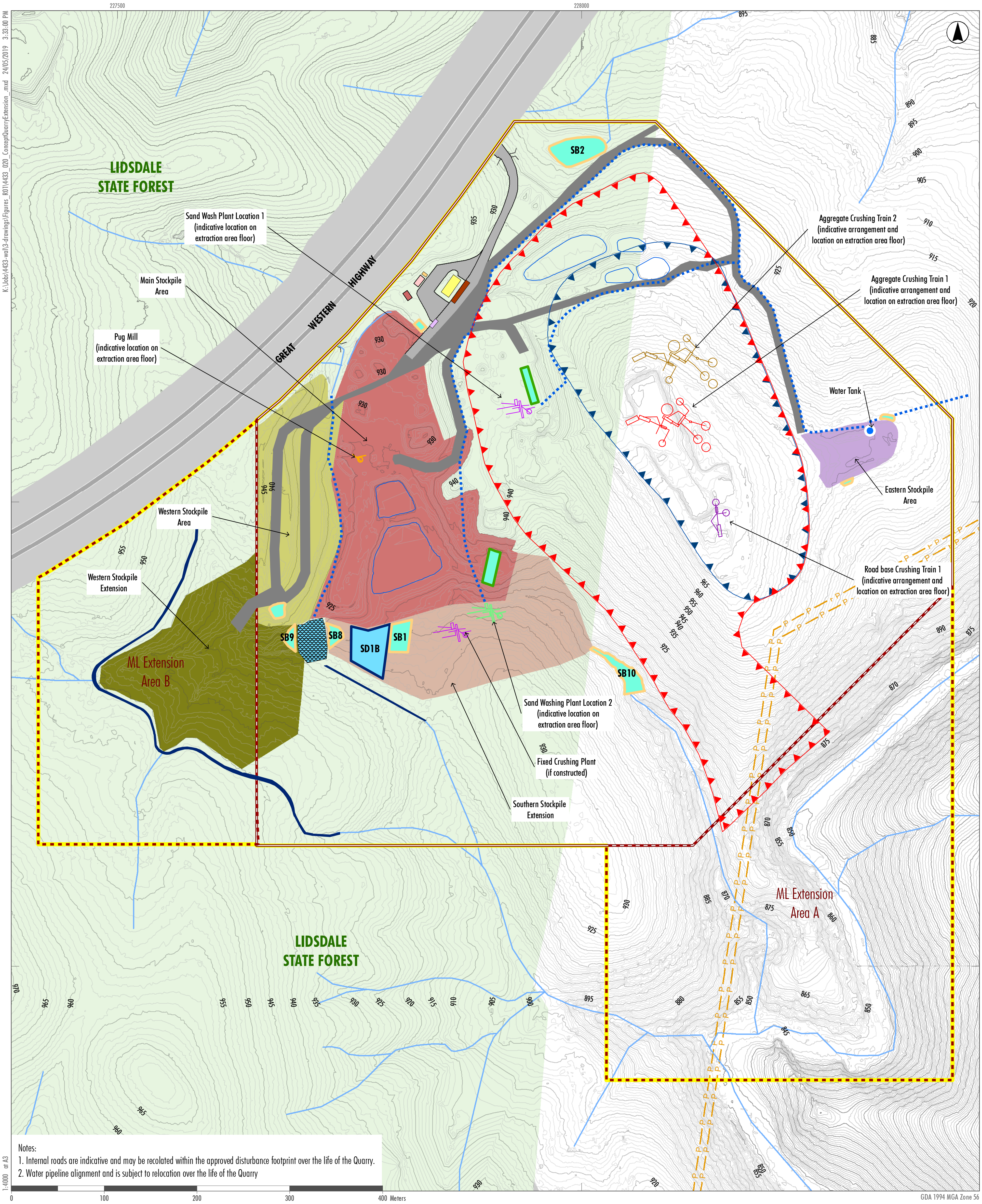
1.3 Hours of Operation

Table 1 presents the proposed operating hours for the Project. The proposed hours and combination of activities for the Project have formed the basis of the noise modelling scenarios for this assessment.

Table 1 Hours of Operation

Operation	Monday to Friday[1]	Saturday[1]	Sunday
Quarrying operations	7am to 6pm	8am to 1pm	N/A
Loading and dispatch of trucks	May be conducted at any time, provided these activities comply with the noise criteria.		
Blasting	9am to 5pm	9am to 1pm	N/A
Maintenance	May be conducted at any time, provided these activities are not audible at any privately-owned residence.		

Note 1: Excludes public holidays which would operate as per the proposed hours of operation for Sunday.



Legend

- Project Site
- Quarry Site (ML1633)
- Quarry Site Extension
- Electricity Transmission Lines
- Clean Water Drainage
- State Forest

Site Infrastructure

- Amenities
- Site Meeting Room
- Site Office
- Site Workshop
- Vehicle Washdown Area
- Weighbridge
- Sealed Internal Roads
- Indicative Internal Roads

Indicative Plant Infrastructure Locations

- Aggregate Crushing Train 1
- Aggregate Crushing Train 2
- Fixed Crushing Plant (if constructed)
- Pug Mill
- Road base Crushing Train 1
- Sand Wash Plant

Approved & Proposed Quarry Layout

- Approved Extraction Area
- Proposed Extraction Area
- Main Stockpile Area (935m AHD)
- Southern Stockpile Extension (935m AHD)
- Western Stockpile Area
- Western Stockpile Extension (940m AHD)
- Eastern Stockpile Area

Water Management Infrastructure (Proposed)

- Clean Water Diversion
- Sediment Basins
- Settlement Ponds
- Storage Dam
- Water Tank
- Rubbled Lined Clean
- Existing Dams & Sediment Basins
- Water Pipeline (Indicative)
- Clean Water Drainage

FIGURE 1

Modified Quarry Site Layout

Data source: Walker Quarries (2019); Umwelt (2019); NSW LPI DTDB (2019)

2 Receiver Review

The Project is situated at Wallerawang, NSW, and receivers in the locality surrounding the Project are primarily rural residential. The receiver addresses and coordinates MGA(56) for the nearest potentially affected receivers to the Project are summarised in **Table 2** and shown in **Figure 2.**

Table 2 Residential Receiver Locations

Receiver ID	Easting (m)	Northing (m)
N1	229123	6297277
N2	228434	6296924
N3	227851	6297338
N4	228051	6297289
N5	228082	6297423
N6	227903	6297526
N7	228296	6297531
N8	228441	6297533
N9	228450	6297642
N10	228897	6297804
N11	229021	6297355
N12	229267	6297232
N13	229211	6297098
N14	227748	6297404
N15	227742	6297556
N16	227631	6297408
N17	227683	6297680
N18	227442	6297521
N19	227357	6297524
N20	227380	6297703
N21	227519	6297872
N22	227238	6297511
N23	227130	6297830
N24	227006	6297529
FR1	228218	6297549
FR2	228312	6297466

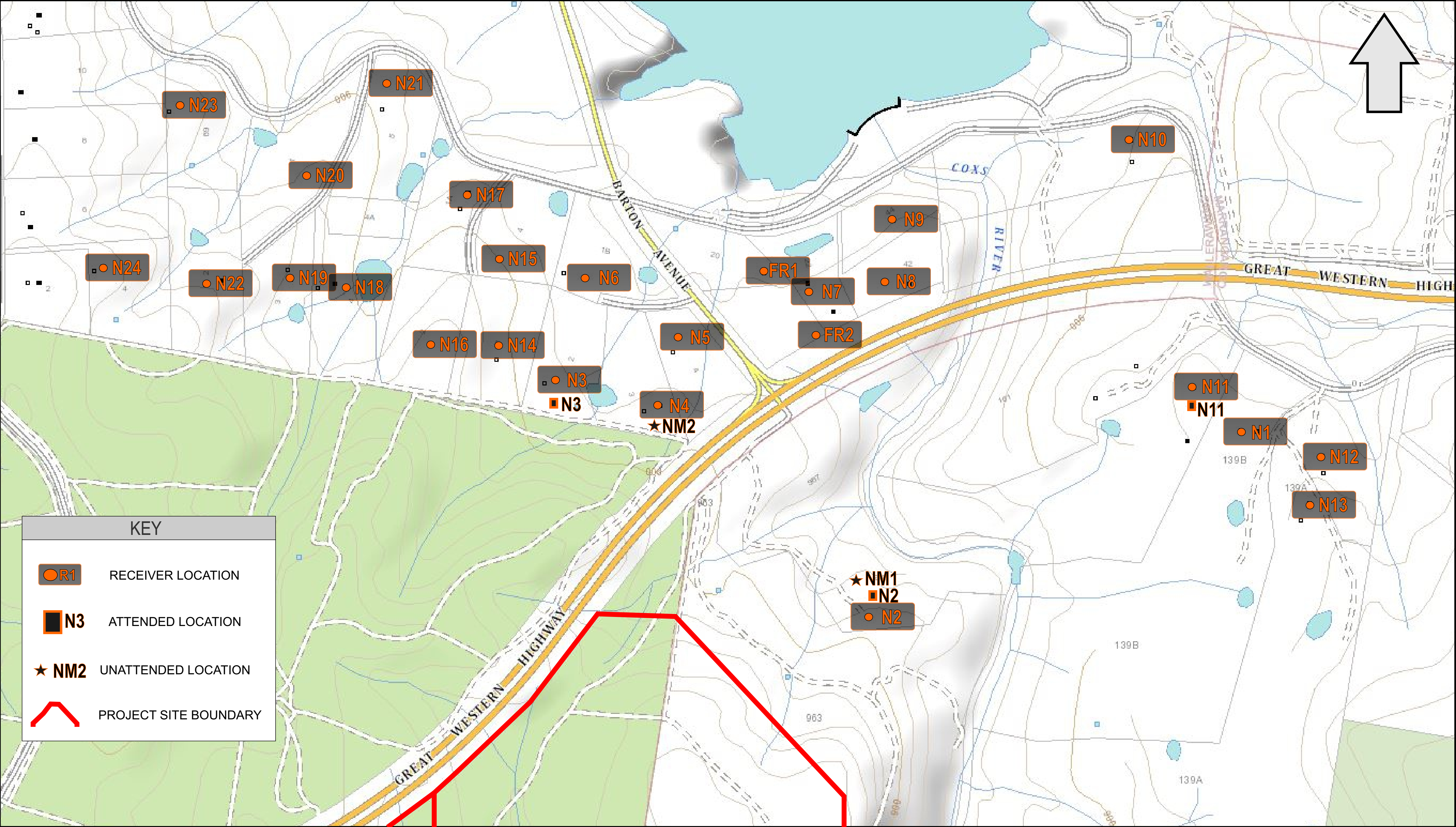


FIGURE 2

LOCALITY PLAN

REF: MAC180681

MAC Muller Acoustic Consulting

*Imagery Source : sixmaps

3 Noise Policy and Guidelines

3.1 Noise Policy for Industry

The EPA released the Noise Policy for Industry (NPI) in October 2017 which provides a process for establishing noise criteria for consents and licenses enabling the EPA to regulate noise emissions from scheduled premises under the Protection of the Environment Operations Act 1997. The objectives of the NPI are to:

- provide noise criteria that are used to assess the change in both short term and long term noise levels;
- provide a clear and consistent framework for assessing environmental noise impacts from industrial premises and industrial development proposals;
- promote the use of best-practice noise mitigation measures that are feasible and reasonable where potential impacts have been identified; and
- support a process to guide the determination of achievable noise limits for planning approvals and/or licences, taking into account the matters that must be considered under the relevant legislation (such as the economic and social benefits and impacts of industrial development).

The policy sets out a process for industrial noise management involving the following key steps:

1. Determine the Project Noise Trigger Levels (PNTLs) (ie criteria) for a development. These are the levels, above which noise management measures are required to be considered. They are derived by considering two factors: shorter-term intrusiveness due to changes in the noise environment; and maintaining the noise amenity of an area.
2. Predict or measure the noise levels produced by the development with regard to the presence of annoying noise characteristics and meteorological effects such as temperature inversions and wind.
3. Compare the predicted or measured noise level with the PNTLs, assessing impacts and the need for noise mitigation and management measures.

4. Consider residual noise impacts, that is, where noise levels exceed the PNTLs after the application of feasible and reasonable noise mitigation measures. This may involve balancing economic, social and environmental costs and benefits from the proposed development against the noise impacts, including consultation with the affected community where impacts are expected to be significant.

5. Set statutory compliance levels that reflect the best achievable and agreed noise limits for the development.

6. Monitor and report environmental noise levels from the development.

3.1.1 Project Noise Trigger Levels

The policy sets out the procedure to determine the PNTLs relevant to an industrial development. The PNTL is the lower (ie, the more stringent) value of the **Project Intrusiveness Noise Level** (PINL) and the **Project Amenity Noise Level** (PANL) determined in accordance with Section 2.3 and Section 2.4 of the NPI.

3.1.2 Rating Background Level

The Rating Background Level (RBL) is a determined parameter from noise monitoring and is used for assessment purposes. As per the NPI, the RBL is an overall single figure background level representing each assessment period (day, evening and night) over the noise monitoring period.

3.1.3 Project Intrusiveness Noise Level

The PINL ($LA_{eq(15min)}$) is the RBL + 5dB and seeks to limit the degree of change a new noise source introduces to an existing environment. Hence, when assessing intrusiveness, background noise levels need to be measured.

3.1.4 Project Amenity Noise Level

PANL is relevant to a specific land use or locality. To limit continuing increases in intrusiveness levels, the ambient noise level within an area from all combined industrial sources should remain below the recommended amenity noise levels specified in Table 2.2 (of the NPI) and are reproduced in **Table 3**. The NPI defines two categories of amenity noise levels:

- **Amenity Noise Levels (ANL)** – are determined considering all current and future industrial noise within a receiver area.

- **Project Amenity Noise Levels (PANL)** – is the recommended levels for a receiver area, specifically focusing the project being assessed.

Additionally, Section 2.4 of the NPI states: "*to ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise levels applies for each new source of industrial noise as follows*":

- areas with high traffic noise levels;
- proposed developments in major industrial clusters;
- existing industrial noise and cumulative industrial noise effects; and
- greenfield sites.

Additionally, Section 2.4 of the NPI states: "*to ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise levels applies for each new source of industrial noise as follows*":

- areas with high traffic noise levels;
- proposed developments in major industrial clusters;
- existing industrial noise and cumulative industrial noise effects; and
- greenfield sites.

The NPI states with respect to high traffic noise areas:

The level of transport noise, road traffic noise in particular, may be high enough to make noise from an industrial source effectively inaudible, even though the LAeq noise level from that industrial noise source may exceed the project amenity noise level. In such cases the project amenity noise level may be derived from the LAeq, period(traffic) minus 15 dB(A).

Where relevant this assessment has considered influences of traffic with respect to amenity noise levels (ie areas where existing traffic noise levels are 10dB greater than the recommended amenity noise level).

Furthermore, where the PANL is applicable and can be satisfied, the assessment of cumulative industrial noise is not required. The recommended amenity noise levels as per Table 2.2 of the NPI reproduced in **Table 3**.

Table 3 Amenity Criteria

Receiver Type	Noise Amenity Area	Time of day	Recommended amenity noise level dB $L_{Aeq(period)}$
Residence	Rural	Day	50
		Evening	45
		Night	40

Notes: The recommended amenity noise levels refer only to noise from industrial noise sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated.

Types of receivers are defined as rural residential; suburban residential; urban residential; industrial interface; commercial; industrial – see Table 2.3 and Section 2.7.

Time of day is defined as follows: (These periods may be varied where appropriate, for example, see A3 in Fact Sheet A.)

- day – the period from 7am to 6pm Monday to Saturday or 8am to 6pm on Sundays and public holidays.
- evening – the period from 6pm to 10pm.
- night – the remaining periods.

3.2 Maximum Noise Level Assessment

The potential for sleep disturbance from maximum noise level events from a project during the night-time period needs to be considered. The NPI considers sleep disturbance to be both awakenings and disturbance to sleep stages.

Where night-time noise levels from a development/premises at a residential location exceed the following criteria a detailed maximum noise level event assessment should be undertaken.

- $L_{Aeq,15min}$ 40dBA or the prevailing RBL plus 5dB, whichever is the greater, and/or
- L_{Amax} 52dBA or the prevailing RBL plus 15dB, whichever is the greater,

A detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night-time period.

Other factors that may be important in assessing the impacts on sleep disturbance include:

- how often the events would occur;
- the distribution of likely events across the night-time period and the existing ambient maximum events in the absence of the development;
- whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods); and

- current understanding of effects of maximum noise level events at night.

The maximum screening criteria is discussed further in **Section 5**.

3.3 Voluntary Land Acquisition and Mitigation Policy

The Voluntary Land Acquisition and Mitigation Policy (VLAMP November 2018) describes the NSW Government's policy for voluntary mitigation and land acquisition actions undertaken to address noise impacts from State significant mining, petroleum and extractive industry developments. It aims to provide a balance between the economic development and protecting the health, preserve amenity and control intrusive noise where potential impacts are identified.

The VLAMP provides guidance for consent authorities as to when voluntary mitigation or voluntary acquisition rights are to be applied to reduce operational noise impacts from a development on privately owned land. The policy does not apply to construction noise impacts, impacts from the public road or rail network or modifications to existing developments with legacy noise issues.

An assessment has been undertaken of potential impacts for receivers and vacant privately-owned land surrounding the Project. The relevant criteria are outlined in **Section 5.**

3.4 Road Noise Policy

The road traffic noise criteria are provided in the Department of Environment, Climate Change and Water NSW (DECCW), Road Noise Policy (RNP), 2011. The policy sets out noise criteria applicable to different road classifications for the purpose of quantifying traffic noise impacts. Notwithstanding, production volumes for the Project remain unchanged hence, off-site truck movements will be unchanged, therefore an assessment of road noise impacts has been excluded from the assessment.

3.5 Blasting Guideline

The limits adopted by EPA for blasting are provided in the Australian and New Zealand Environment Conservation Council (ANZECC) - Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration. Blasting criteria relevant to this assessment are presented in detail in **Section 5.**

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4 Existing Noise Criteria and Environment

4.1 Environmental Protection License Noise Limits

Table 4 reproduces the noise criteria for the quarry as per Condition L4.1 of the existing Environmental Protection Licence (EPL) 13172.

Table 4 Noise Limits, dBA

Location	Day	Evening	Night
	LAeq(15min)	LAeq(15min)	LAeq(15min)
All privately owned residences	43	43	39

Note: Day Period is 7am to 6pm, Evening Period is 6pm to 10pm, Night Period is 10pm to 7am.

It is noted that Condition L4.3 of EPL 13172 identifies conditions under which the noise criteria do not apply and include:

a) Wind speeds greater than 3m/s at 10m above ground level;

b) Temperature inversion conditions greater than 3 degrees Celsius / 100m; or

c) Under "non-significant weather conditions".

These criteria have been included in this assessment for reference and were established under the predeceasing Industrial Noise Policy and derived from data measured in 2001 (Atkins, 2001), hence are required to be reviewed under the current NPI.

4.2 Background Noise Environment

4.2.1 Unattended Noise Monitoring

To establish contemporary background levels in accordance with the NPI and to quantify the existing background noise environment of the area, unattended noise monitoring was conducted at two representative locations adjacent to the Project. The unattended noise survey was conducted in general accordance with the procedures described in Australian Standard AS 1055:2018, "Acoustics - Description and Measurement of Environmental Noise".

The measurements were carried out using two Svantek Type 1, 977 and 958 noise analysers from Friday 29 June 2018 to Wednesday 11 July 2018. Observations on site identified that the surrounding locality was typical of a rural environment, with wind, birds and traffic noise dominant. Calibration of all instrumentation was checked prior to and following measurements. Drift in calibration did not exceed ±0.5dB(A). All equipment carried appropriate and current NATA (or manufacturer) calibration certificates. Data affected by adverse meteorological conditions have been excluded from the results in accordance with methodologies provided in Fact Sheet B of the NPI. The results of long-term unattended noise monitoring are provided in **Table 5**. The noise monitoring charts for the background assessment are provided in **Appendix B**.

Table 5 Background Noise Monitoring Summary

Logging Location	Coordinates (MGA56) Easting	Coordinates (MGA56) Northing	Period[1]	Measured Background Noise Level RBL, dB LA_{90}	Measured Ambient Level dB $LA_{eq(period)}$
NM1 987 Great Western Highway	228428	6296930	Day	38	47
			Evening	34	46
			Night	30 (29)[2]	43
NM2 1B Cypress Place	227857	6297332	Day	40	56
			Evening	35	55
			Night	30 (27)[2]	40

Note: Excludes periods of wind or rain affected data, meteorological data obtained from the Bureau of Meteorology Marrangaroo AWS (33.4347°S 150.1349°E 936m AMSL).

Note 1: Day - the period from 7am to 6pm Monday to Saturday or 8am to 6pm on Sundays and public holidays; Evening - the period from 6pm to 10pm; Night - the remaining periods.

Note 2 : Minimum NPI RBL adopted for night, bracketed value denotes measured level.

4.2.2 Attended Noise Monitoring

To gain a better understanding of the existing noise environment and to quantify the existing Project's noise emissions against criteria, MAC conducted attended noise monitoring at three locations surrounding the Project during calm clear weather conditions. The purpose of the measurements was to ascertain dominant ambient noise sources and to quantify any existing industrial noise contributions.

Attended noise monitoring was conducted at the three locations listed in **Table 6.**

Table 6 Receiver Locations

Assessment ID	Address	Distance to Project Boundary
N11	139 Gemalong Close, Marrangaroo, NSW	1000m
N2	987 Great Western Highway, Marrangaroo, NSW	160m
N3	2 Cypress Close, Wallerawang, NSW	480m

The results of the attended noise survey and observations conducted on Tuesday 28 August 2018 and Wednesday 29 August 2018 are summarised in **Table 7**.

Table 7 Operator-Attended Noise Survey Results

Date	Time (hrs)	Descriptor (dBA re 20 µPa)			EPL Limit	Meteorology	Comments
		L_{Amax}	L_{Aeq}	L_{A90}			
N11							
28/08/2018	12:25	70	52	43	43	WS: 1.5m/s WD: NW Rain: Nil	Traffic 40 – 72 Livestock 55 – 58 Wind in Trees 30 – 41 Aircraft Noise 45 – 51
Quarry Site $L_{Aeq(15min)}$ Contribution							Quarry Inaudible
29/08/2018	08:15	77	52	45	43	WS: 0.1m/s WD: E Rain: Nil	Traffic 50 – 64 Birds 50 – 77
Quarry Site $L_{Aeq(15min)}$ Contribution							Quarry Inaudible
N2							
28/08/2018	13:01	56	45	38	43	WS: 1.2m/s WD: NW Rain: Nil	Traffic Noise 45 – 56 Birds 41 – 45 Wind in trees 40 – 45
Quarry Site $L_{Aeq(15min)}$ Contribution							Quarry Inaudible
29/08/2018	08:45	57	41	36	43	WS: 0.6m/s WD: E Rain: Nil	Traffic 34 – 42 Birds 43 – 57 Aircraft 37 – 45
Quarry Site $L_{Aeq(15min)}$ Contribution							Quarry Inaudible
N3							
28/08/2018	15:22	66	50	41	43	WS: 0.2m/s WD: NW Rain: Nil	Traffic 40 – 66 Aircraft 59 – 64 Birds 50 – 60
Quarry Site $L_{Aeq(15min)}$ Contribution							Quarry Inaudible
29/08/2018	09:31	65	45	38	43	WS: 1.4m/s WD: E Rain: Nil	Traffic 40 – 54 Birds 35 – 65
Quarry Site $L_{Aeq(15min)}$ Contribution							Quarry Inaudible

Generally, attended noise monitoring identifies that the noise catchment surrounding the Project site is dominated by non-project sources such as traffic, birds and other ambient rural sources. Attended monitoring demonstrates that Project emissions did not influence unattended monitoring data obtained for this assessment.

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5 Assessment Criteria

5.1 Operational Noise Criteria

5.1.1 Project Intrusiveness Noise Levels

The PINLs for the Project are presented in **Table 8** and have been determined based on the RBL +5dBA and have been derived from unattended monitoring data for NM1. Data sets from both unattended monitoring locations were generally consistent, notwithstanding, NM1 unattended data has been selected at is it the most conservative and is generally consistent with current EPL criteria.

Table 8 Intrusiveness Noise Levels

Receiver	Period[1]	Adopted RBL dB L_{A90}	PINL dB $L_{Aeq(15min)}$
Residential Receivers	Day	38	43
	Evening	34	39
	Night	30	35

Note 1: Day - the period from 7am to 6pm Monday to Saturday or 8am to 6pm on Sundays and public holidays; Evening - the period from 6pm to 10pm; Night - the remaining periods.

5.1.2 Project Amenity Noise Levels

The PANLs for residential receivers potentially affected by the Project are presented in **Table 9.** The amenity assessment methodology takes into consideration areas of high traffic noise when assessing ambient industrial noise.

Table 9 Project Amenity Noise Levels

Receiver Type	Noise Amenity Area	Assessment Period[1]	Recommended ANL dB $L_{Aeq(period)}$[2]	PANL dB $L_{Aeq(period)}$[3]	PANL dB $L_{Aeq(15min)}$[4]
Residential Receivers	Rural	Day	50	45	48
		Evening	45	40	43
		Night	40	35	38

Note 1: Day - the period from 7am to 6pm Monday to Saturday or 8am to 6pm on Sundays and public holidays; Evening - the period from 6pm to 10pm; Night - the remaining periods.

Note 2: Recommended amenity noise levels as per Table 2.2 of the NPI.

Note 3: Includes a -5dB adjustment to account for the presence of existing industrial noise.

Note 4: Includes a +3dB adjustment to the amenity period level to convert to a 15-minute assessment period as per Section 2.2 of the NPI.

5.1.3 Project Noise Trigger Levels

The PNTLs are the lower of either the PINL or the PANL. **Table 10** presents the derivation of the PNTL's in accordance with the methodologies outlined in the NPI.

Table 10 Project Noise Trigger Levels

Receiver Type	Assessment Period[1]	PINL dB $L_{Aeq(15min)}$	PANL dB $L_{Aeq(15min)}$	PNTL dB $L_{Aeq(15min)}$
Residential Receivers	Day	43	48	43
	Evening	39	43	39
	Night	35	38	35

Note 1: Day - the period from 7am to 6pm Monday to Saturday or 8am to 6pm on Sundays and public holidays; Evening - the period from 6pm to 10pm; Night - the remaining periods.

5.2 Maximum Noise Level Assessment Criteria

The maximum noise level screening criteria shown in **Table 11** is based on night time RBLs and trigger values as per Section 2.5 of the NPI.

Table 11 Maximum Noise Level Assessment Screening Criteria

Residential Receivers			
$L_{Aeq(15min)}$		L_{Amax}	
40dB $L_{Aeq(15min)}$ or RBL + 5dB		52dB L_{Amax} or RBL + 15dB	
Trigger	40	Trigger	52
RBL 30+5dB	35	RBL 30+15dB	45
Highest	**40**	**Highest**	**52**

Note 1: As per Section 2.5 of the NPI, the highest of each metric are adopted as the screening criteria.

5.2.1 Voluntary Land Acquisition and Mitigation Policy

The Voluntary Land Acquisition and Mitigation Policy (VLAMP, 2018) outlines methods to determine the significance of potential exceedances of relevant noise assessment criteria and identifies potential treatments for those exceedances (VLAMP Table 1) and is replicated below in **Table 12**.

Voluntary Mitigation Rights

A consent authority should only apply voluntary land acquisition rights where, even with the implementation of best practice management at the mine site:

- the noise generated by the development would meet the requirements of Table 1 (VLAMP) such that the impacts would be characterised marginal, moderate or significant at any residence or privately owned land; or
- the development would increase the total industrial noise level at any residence on privately owned land by more than 1dBA and noise levels at the residence are already above the recommended amenity noise levels in Table 2.2 of the NPI; or
- the development includes a private rail line and the use of that private rail line would cause exceedances of the recommended acceptable levels in Table 6 of Appendix 3 of the RING by greater than or equal to 3dBA at any residences on privately owned land.

Table 12 Characterisation of Noise Impacts and Potential Treatments (VLAMP Table 1)			
If the predicted noise level minus the project noise trigger level is:	And the total cumulative industrial noise level is:	Characterisation of impacts:	Potential treatment:
All time periods 0-2dBA	Not applicable	Impacts are considered to be **negligible**	The exceedances would not be discernible by the average listener and therefore would not warrant receiver based treatments or controls
All time periods 3-5dBA	←recommended amenity noise level in Table 2.2 of the NPI; or > recommended amenity noise level in Table 2.2 of the NPI, but the increase in total cumulative industrial noise level resulting from the development is >1dB	Impacts are considered to be **marginal**	Provide mechanical ventilation / comfort condition systems to enable windows to be closed without compromising internal air quality / amenity.
All time periods 3-5dBA	> recommended amenity noise level in Table 2.2 of the NPI, and the increase in total cumulative industrial noise level resulting from the development is >1dB	Impacts are considered to be **moderate**	As for marginal impacts but also upgraded facade elements like windows, doors or roof insulation, to further increase the ability of the building facade to reduce noise levels.
Day and evening >5dBA	←recommended amenity noise levels in Table 2.2 of the NPI	Impacts are considered to be **moderate**	As for marginal impacts but also upgraded facade elements like windows, doors or roof insulation, to further increase the ability of the building facade to reduce noise levels.
Day and evening>5dBA	> recommended amenity noise levels in Table 2.2 of the NPI	Impacts are considered to be **significant**	Provide mitigation as for moderate impacts and see voluntary land acquisition provisions above.
Night >5dBA	Not applicable	Impacts are considered to be **significant**	Provide mitigation as for moderate impacts and see voluntary land acquisition provisions above.

Voluntary Acquisition Rights

A consent authority should only apply voluntary land acquisition rights where, even with the implementation of best practice management at the mine site:

- the noise generated by the development would be characterised as significant, according to Table 1 (VLAMP), at any residence on privately owned land; or
- the noise generated by the development would contribute to exceedances of the acceptable noise levels plus 5dB in Table 2.2 of the NPI on more than 25% of any privately owned land where there is an existing dwelling or where a dwelling could be built under existing planning controls; or
- the development includes a private rail line and the use of that private rail line would cause exceedances of the recommended maximum criteria Table 6 of Appendix 3 of the RING by greater than or equal to 3dBA at any residences on privately owned land.

The VLAMP Significance criteria (for acquisition) applicable to the extractive industry developments are as follows:

For the daytime and evening periods: noise levels from the project are >5dBA above the PNTLs and the total cumulative industrial noise level is greater than the recommended amenity noise levels in Table 2.2 of the NPI; or

For the night time period: noise levels from the project are >5dBA above the PNTLs.

5.3 Blasting Criteria

The Project would be expected to operate within the overpressure and ground vibration limits stipulated in ANZECC guidelines which are reproduced in **Table 13.**

Table 13 Blasting Emissions Criteria

Receiver	Airblast Overpressure (dBZ Peak)	Ground Vibration (mm/s)	Allowable Exceedance
Any Residences on privately owned land	120	10	0%
	115	5	5% of the total number of blasts over a period of 12 months

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6 Noise Assessment Methodology

6.1 Operational Noise Modelling Methodology

A computer model was developed to determine the impact of Project noise emissions to neighbouring receivers for typical operational scenarios. iNoise (Version 2019) noise modelling software was used to assess potential noise impacts associated with the Project. A three-dimensional digital terrain map giving all relevant topographic information was used in the modelling process.

Additionally, the model uses relevant noise source data, ground type, shielding such as barriers and/or adjacent buildings and atmospheric information to predict noise levels at the nearest potentially affected receivers. Plant and equipment were modelled at various locations and heights, representative of realistic operating conditions for assessed scenarios.

The model calculation method used to predict noise levels was in accordance with ISO 9613-1 'Acoustics - Attenuation of sound during propagation outdoors. Part 1: Calculation of the absorption of sound by the atmosphere' and ISO 9613-2 'Acoustics - Attenuation of sound during propagation outdoors. Part 2: General method of calculation'.

6.2 Operational Noise Modelling Parameters

The model incorporated three-dimensional digitised ground contours for the fixed plant and surrounding area, as derived from proposed Project plans superimposed onto the surrounding land base topography. Where relevant, modifying factors in accordance with Fact Sheet C of the NPI have been applied to calculations.

6.2.1 Meteorological Parameters

Noise emissions from industry can be significantly affected by prevailing weather conditions. Wind has the potential to increase noise at a receiver when it is at low velocities and travels from the direction of the noise source. As the strength of the wind increases, the noise produced by the wind will mask the audibility of most industrial sources.

Meteorological conditions that enhance received noise levels include source to receiver winds and the presence of temperature inversions. This assessment has adopted Option 1 of Fact Sheet D of the NPI for noise enhancing meteorological conditions. Therefore, results of the assessment should be considered as a worst-case.

The noise-enhancing meteorological conditions adopted in this assessment are summarised in **Table 14**.

Table 14 Modelled Noise-enhancing Meteorological Conditions

Assessment Condition	Temperature	Wind Speed / Direction	Relative Humidity	Stability Class
Day	20°C	3m/s (all directions)	60%	D
Evening	10°C	3m/s (all directions)	60%	D
Night[1]	10°C	Nil	60%	F

Note 1: For the night assessment period, as there is intervening topography between the project site and surrounding receivers, 2m/s winds for drainage flows have been excluded from the assessment.

6.2.2 Operational Noise Modelling Scenarios

One modelling scenario was assessed to represent typical operational noise emissions from the Project and is representative of six operational scenarios. The scenarios are summarised below.

- Scenario 1A (Day) – All operations within the approved (930m AHD) and proposed extractive areas (930m AHD to 950m AHD);
- Scenario 1B (Evening/Night) – Loading and transport only (930m AHD);
- Scenario 2A – All operations within the approved (920m AHD) and proposed extractive areas (920m AHD to 930m AHD);
- Scenario 2B (Evening/Night) – Loading and transport only (920m AHD);
- Scenario 3A (Day) – All operations within the approved (920m AHD) and proposed extractive areas (920m AHD to 930m AHD) and fixed crushing within the southern stockpile extension area; and
- Scenario 3B (Evening/Night) – Loading and transport only (920m AHD).

6.3 Sound Power Levels

Mobile plant noise emission data used in modelling for this assessment are summarised in **Table 15**. **Appendix C** presents the plant locations within the Project for each assessed scenario.

Table 15 Single Octave Equipment Sound Power Levels, dB LAeq(15min) (re10^{-12}W)

Noise Source/Item	Octave Band Centre Frequency, Hz								Total, dBA
	63	125	250	500	1000	2000	4000	8000	
Sandvik Crusher	85	91	96	103	106	106	102	94	111
Pugmill	81	90	95	101	104	101	96	90	108
Service Vehicle[1]	70	76	79	73	70	68	64	50	82
Wirtgen Kleeman Secondary/Tertiary Crusher	92	92	96	101	104	106	104	97	111
Wirtgen MR130Z Track Mounted Impact Crusher	82	93	99	107	108	107	101	90	113
Wirtgen Kleeman Cone/Sand Plant	73	92	97	103	106	103	98	92	110
Wirtgen Kleeman Screen	84	95	101	106	107	102	97	89	111
Drill	82	104	105	107	110	109	101	93	115
Cat D8 Dozer	90	95	100	106	106	104	98	87	111
Komatsu PC450 Excavator	89	102	104	103	101	100	93	85	109
Komatsu Loader[1]	79	86	88	91	94	93	89	78	99
Komatsu WA500 Loader[1]	79	97	98	99	99	96	90	82	105
Komatsu WA480 Wheel Loader[1]	71	84	87	93	96	93	92	79	100
Komatsu HM400 Articulated Dump Truck (x3)	75	98	93	100	100	97	93	86	106
Volvo 6 Wheeled Water Cart[1]	81	82	89	91	95	97	89	81	101
Manitou[1]	72	82	87	89	90	90	83	74	96
Standard Road Truck (x3)[1]	89	95	90	89	93	97	92	85	102
Sleep Disturbance Assessment (LAmax)									
Loading Aggregate into Standard Road Truck	76	91	91	99	102	106	112	114	117

Note 1: Denotes plant that will be used during evening and night periods.

6.4 Blasting Assessment Methodology

An estimation of air-blast overpressure and ground-borne vibration levels has been conducted in accordance with methods in AS2187.2. The estimation adopted an MIC of 90kg (the average MIC from historic blasts at the Project site) with blasting locations assumed to be at the nearest drilling position within the proposed pit extension of the extraction area to receivers, which is a worst-case scenario.

6.4.1 Air-Blast Overpressure

Calculation of overpressure have been completed using the following AS2187.2 equation:

Where:

$$\mathrm{P} = K_a \left(\frac{R}{(Q^{1/3})}\right)^a$$

P = Pressure, in kilopascals;

Q = Effective explosives charge mass, in kilograms (MIC);

R = Distance from charge, in metres;

Ka = Site constant, a value of 20 is adopted; and

a = Site exponent, a value of -1.45 is adopted.

The conversion of 'P' to unweighted decibels (dBZ) is completed using the following formula:

$$\mathrm{SPL} = 10\, x \log\left(\frac{P}{P_0}\right)^2$$

6.4.2 Ground-Borne Vibration

Preliminary estimations for vibration have been completed using the following AS2187.2 equation:

$$\mathrm{V} = K_g \left(\frac{R}{(Q^{1/2})}\right)^{-B}$$

Where:

V = ground vibration as vector peak particle velocity, in mm/s;

R = distance between charge and point of measurement, in m;

Q = maximum instantaneous charge (effective charge mass per delay, MIC), in kg;

Kg = a constant related to site and rock properties, a value of 1140 is adopted; and

B = a constant related to site and rock properties for estimation purposes, a value of 1.6 is adopted.

7 Noise Modelling Results and Discussion

7.1 Operational Scenario – Scenario 1

Tabulated results of the noise modelling for Scenario 1 are shown in **Table 16** with noise contours for each scenario presented in **Appendix D**. The results of the model show that noise emissions from operations satisfy relevant criteria at all assessed receivers.

Table 16 Predicted Operational Noise Levels

Receiver ID	Scenario 1 Daytime dB LAeq(15min)	Scenario 1 Evening dB LAeq(15min)	Scenario 1 Night dB LAeq(15min)	PNTL dB LAeq(15min)		
				Day	Evening	Night
N1	38	30	30	43	39	35
N2	41	33	33	43	39	35
N3	36	<30	<30	43	39	35
N4	42	35	35	43	39	35
N5	42	34	34	43	39	35
N6	40	32	32	43	39	35
N7	38	30	30	43	39	35
N8	41	34	34	43	39	35
N9	35	<30	<30	43	39	35
N10	<30	<30	<30	43	39	35
N11	38	<30	<30	43	39	35
N12	38	30	30	43	39	35
N13	38	30	30	43	39	35
N14	39	31	31	43	39	35
N15	40	32	32	43	39	35
N16	42	33	33	43	39	35
N17	38	31	31	43	39	35
N18	36	<30	<30	43	39	35
N19	39	30	30	43	39	35
N20	38	30	30	43	39	35
N21	38	<30	<30	43	39	35
N22	39	31	31	43	39	35
N23	37	<30	<30	43	39	35
N24	37	<30	<30	43	39	35
FR1	36	<30	<30	43	39	35
FR2	42	33	33	43	39	35

• Day – the period from 7am to 6pm Monday to Saturday or 8am to 6pm on Sundays and public holidays;

• Evening – the period from 6pm to 10pm;

• Night – the remaining periods.

7.2 Operational Scenario – Scenario 2

Tabulated results of the noise modelling for Scenario 2 are shown in **Table 17** with noise contours for each scenario presented in **Appendix D**. The results of the model show that noise emissions from operations satisfy relevant criteria at all assessed receivers.

Table 17 Predicted Operational Noise Levels

Receiver ID	Scenario 2 Daytime dB LAeq(15min)	Scenario 2 Evening dB LAeq(15min)	Scenario 2 Night dB LAeq(15min)	PNTL dB LAeq(15min)		
				Day	Evening	Night
N1	36	<30	<30	43	39	35
N2	38	30	30	43	39	35
N3	34	<30	<30	43	39	35
N4	40	33	33	43	39	35
N5	40	33	33	43	39	35
N6	37	30	30	43	39	35
N7	37	<30	<30	43	39	35
N8	40	31	31	43	39	35
N9	34	<30	<30	43	39	35
N10	<30	<30	<30	43	39	35
N11	36	<30	<30	43	39	35
N12	35	<30	<30	43	39	35
N13	35	<30	<30	43	39	35
N14	36	<30	<30	43	39	35
N15	37	<30	<30	43	39	35
N16	40	31	31	43	39	35
N17	36	<30	<30	43	39	35
N18	34	<30	<30	43	39	35
N19	35	<30	<30	43	39	35
N20	37	<30	<30	43	39	35
N21	38	<30	<30	43	39	35
N22	38	30	30	43	39	35
N23	37	<30	<30	43	39	35
N24	38	<30	<30	43	39	35
FR1	35	<30	<30	43	39	35
FR2	41	32	32	43	39	35

- Day – the period from 7am to 6pm Monday to Saturday or 8am to 6pm on Sundays and public holidays;
- Evening – the period from 6pm to 10pm;
- Night – the remaining periods.

7.3 Operational Scenario – Scenario 3

Tabulated results of the noise modelling for Scenario 3 are shown in **Table 18** with noise contours for each scenario presented in **Appendix D**. The results of the model show that noise emissions from operations satisfy relevant criteria at all assessed receivers.

Table 18 Predicted Operational Noise Levels

Receiver ID	Scenario 3 Daytime dB LAeq(15min)	Scenario 3 Evening dB LAeq(15min)	Scenario 3 Night dB LAeq(15min)	PNTL dB LAeq(15min)		
				Day	Evening	Night
N1	36	<30	<30	43	39	35
N2	38	32	32	43	39	35
N3	34	<30	<30	43	39	35
N4	40	32	32	43	39	35
N5	39	31	31	43	39	35
N6	36	<30	<30	43	39	35
N7	37	30	30	43	39	35
N8	40	30	30	43	39	35
N9	34	<30	<30	43	39	35
N10	<30	<30	<30	43	39	35
N11	37	<30	<30	43	39	35
N12	36	<30	<30	43	39	35
N13	36	<30	<30	43	39	35
N14	36	<30	<30	43	39	35
N15	37	<30	<30	43	39	35
N16	40	31	31	43	39	35
N17	35	<30	<30	43	39	35
N18	33	<30	<30	43	39	35
N19	35	<30	<30	43	39	35
N20	37	<30	<30	43	39	35
N21	37	<30	<30	43	39	35
N22	37	<30	<30	43	39	35
N23	36	<30	<30	43	39	35
N24	38	<30	<30	43	39	35
FR1	35	<30	<30	43	39	35
FR2	40	31	31	43	39	35

• Day – the period from 7am to 6pm Monday to Saturday or 8am to 6pm on Sundays and public holidays;

• Evening – the period from 6pm to 10pm;

• Night – the remaining periods.

7.4 Maximum Noise Level Assessment

In assessing sleep disturbance, a typical LAmax noise source of 117dB was used to represent typical transient events such as loading trucks with aggregate, to the nearest residential receivers during F Class Stability meteorological conditions. Predicted noise levels from LAmax events for assessed receivers are presented in **Table 19.** Results identify that maximum level screening criteria will be satisfied for all residential receivers. It is noted that predictions are below the EPA screening criteria, hence no further assessment or detailed analysis is required.

Table 19 Maximum Noise Levels Assessment (Night)[1]

Receiver	Predicted Level		Screening Criteria		Compliant
	dB LAeq(15min)[2]	dB LAmax	dB LAeq(15min)	dB LAmax	
N1	30	<30	40	52	✓
N2	33	<30	40	52	✓
N3	<30	<30	40	52	✓
N4	35	<30	40	52	✓
N5	34	<30	40	52	✓
N6	32	<30	40	52	✓
N7	30	<30	40	52	✓
N8	34	<30	40	52	✓
N9	<30	<30	40	52	✓
N10	<30	<30	40	52	✓
N11	<30	<30	40	52	✓
N12	30	<30	40	52	✓
N13	30	<30	40	52	✓
N14	31	<30	40	52	✓
N15	32	<30	40	52	✓
N16	33	<30	40	52	✓
N17	31	<30	40	52	✓
N18	<30	<30	40	52	✓
N19	30	<30	40	52	✓
N20	30	<30	40	52	✓
N21	<30	<30	40	52	✓
N22	31	<30	40	52	✓
N23	<30	<30	40	52	✓
N24	<30	<30	40	52	✓
FR1	<30	<30	40	52	✓
FR2	33	<30	40	52	✓

Note 1: Monday to Saturday; Night 10pm to 7am. On Sundays and Public Holidays Night 10pm to 8am.

Note 2 : Highest predicted operational noise level from the night period for all modelled scenarios.

7.5 VLAMP Assessment Results

Results of the operational noise modelling remain below the amenity noise levels in Table 2.2 of the NPI and hence satisfy the requirements of the VLAMP assessment.

Furthermore, review of the noise contours presented in **Appendix D** demonstrates that Project noise emissions would not exceed the relevant amenity levels (+5dB) of 55dB $LA_{eq(day)}$, 50dB $LA_{eq(evening)}$ and 45dB $LA_{eq(night)}$ on more than 25% for any privately-owned land parcels. Hence, the characterisation of noise emissions from the Project are considered as negligible under the VLAMP.

7.6 Blast Assessment Results

Blast overpressure and vibration have been calculated to each assessed receiver for the Project adopting an MIC of 90kgs, which is the average MIC of historic blasts for the Project site. Calculated level for overpressure and vibration have been compared to the relevant ANZECC criteria and are presented in **Table 20**. Results identify blasting using historic average MICs would satisfy relevant ANZECC overpressure and vibration criteria.

Notwithstanding, the proposed MIC blast patterns should be designed specifically to meet the relevant ANZECC guidelines at receivers and be completed in conjunction with an appropriate blast monitoring program. These programs are already in place at the Project site and has shown a demonstrated track record of compliance with respect to ground vibration.

Table 20 Blast Overpressure and Vibration Results					
Receiver	Predicted Level		Criteria[1]		Compliant
	Airblast Overpressure - dBL	Ground Vibration - PPV, mm/s	Airblast Overpressure - dBL	Ground Vibration - PPV, mm/s	
FR1	110	0.5	115	5	✓
FR2	111	0.6	115	5	✓
N1	108	0.4	115	5	✓
N10	106	0.3	115	5	✓
N11	109	0.4	115	5	✓
N12	108	0.4	115	5	✓
N13	109	0.4	115	5	✓
N14	111	0.6	115	5	✓
N15	110	0.5	115	5	✓
N16	111	0.6	115	5	✓
N17	108	0.4	115	5	✓
N18	109	0.4	115	5	✓
N19	108	0.4	115	5	✓
N2	118	1.5	115	5	✓
N20	107	0.4	115	5	✓
N21	106	0.3	115	5	✓
N22	108	0.4	115	5	✓
N23	105	0.3	115	5	✓
N24	106	0.3	115	5	✓
N3	112	0.7	115	5	✓
N4	114	0.8	115	5	✓
N5	112	0.7	115	5	✓
N6	110	0.5	115	5	✓
N7	110	0.5	115	5	✓
N8	110	0.5	115	5	✓
N9	109	0.5	115	5	✓

Note 1: Criteria relevant to 5% of the total number of blasts over a period of 12 months.

8 Conclusion

Muller Acoustic Consulting Pty Ltd (MAC) has conducted a Noise and Vibration Impact Assessment (NVIA) of potential emissions from the proposed extension to the existing Wallerawang Quarry.

The results of the NIA demonstrate that operational noise levels comply with the relevant NPI criteria for the daytime, evening and night time assessment periods at all assessed receivers.

Results of the maximum level assessment are identified to remain below the relevant screening criteria at all residential receivers. Therefore, sleep disturbance due to noise sources within the Project are unlikely to cause awakening reactions to adjacent receivers.

Additionally, the NIA demonstrates that the voluntary land and acquisition policy that is applicable to state significant extraction projects would also be satisfied at all receivers with impacts being categorised as negligible under this policy.

Predictions of blast overpressure and vibration are demonstrated to satisfy the relevant ANZECC guidelines at all assessed receivers by adopting an MIC of 90kgs. Notwithstanding, the proposed MIC blast patterns should be designed specifically to meet the relevant ANZECC guidelines at receivers and be completed in conjunction with an appropriate blast monitoring program.

Based on the NVIA results, there are no noise related issues which would prevent the approval of the Project. The results of the assessment show compliance with the relevant operational, sleep disturbance, VLAMP and ANZECC criteria without ameliorative measures being required.

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Appendix A – Glossary of Terms

Table A1 provides a number of technical terms have been used in this report.

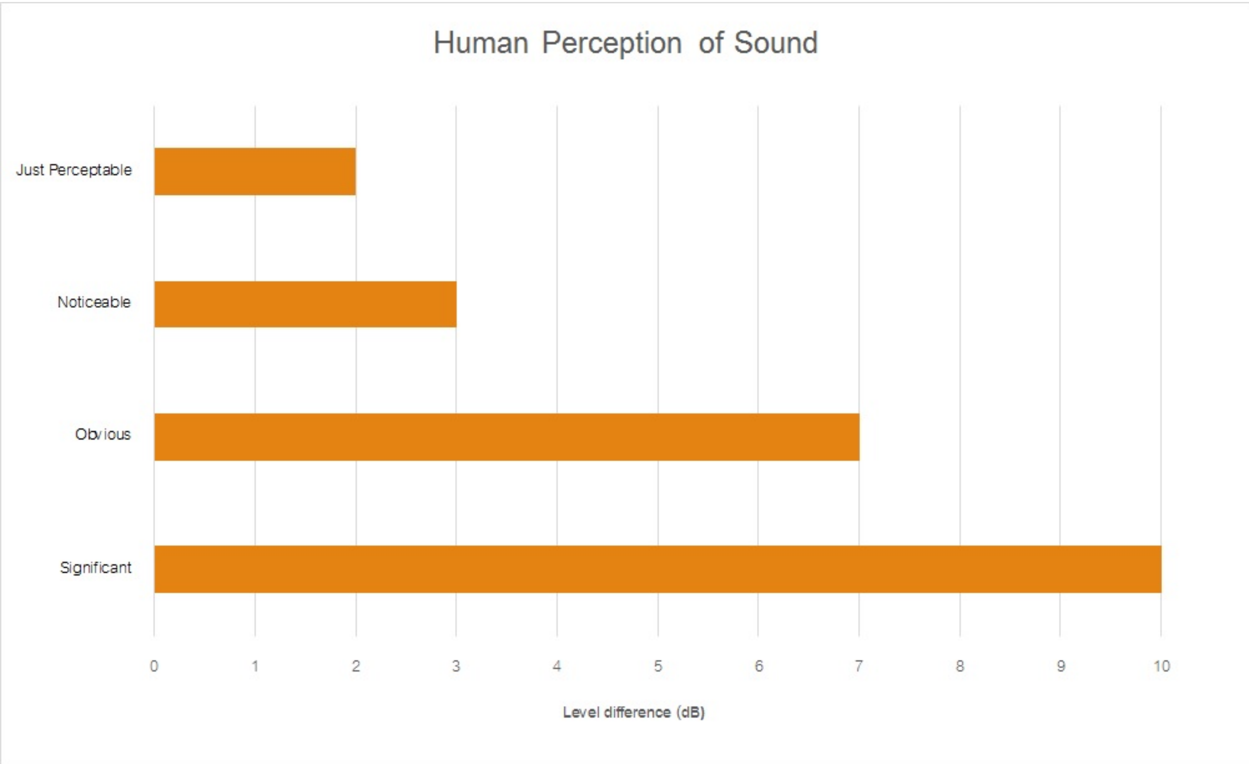
Table A1 Glossary of Terms	
Term	Description
1/3 Octave	Single octave bands divided into three parts
Octave	A division of the frequency range into bands, the upper frequency limit of each band being twice the lower frequency limit.
ABL	Assessment Background Level (ABL) is defined in the NPI as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured LA_{90} statistical noise levels.
Adverse Weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient Noise	The noise associated with a given environment. Typically a composite of sounds from many sources located both near and far where no particular sound is dominant.
A Weighting	A standard weighting of the audible frequencies designed to reflect the response of the human ear to noise.
dB(A)	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear. In some cases the overall change in noise level is described in dB rather than dB(A), or dB(Z) which relates to the weighted scale.
dB(Z)	Linear Z-weighted decibels.
Hertz (Hz)	The measure of frequency of sound wave oscillations per second - 1 oscillation per second equals 1 hertz.
LA_{10}	A noise level which is exceeded 10 % of the time. It is approximately equivalent to the average of maximum noise levels.
LA_{90}	Commonly referred to as the background noise, this is the level exceeded 90 % of the time.
LA_{eq}	The summation of noise over a selected period of time. It is the energy average noise from a source, and is the equivalent continuous sound pressure level over a given period.
LA_{max}	The maximum root mean squared (rms) sound pressure level received at the microphone during a measuring interval.
RBL	The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the ABL's.
Sound power level (LW)	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental location of the source and is independent of the surrounding environment. Or a measure of the energy emitted from a source as sound and is given by : = 10.log10 (W/Wo) Where : W is the sound power in watts and Wo is the sound reference power at 10-12 watts.

Table A2 provides a list of common noise sources and their typical sound level.

Table A2 Common Noise Sources and Their Typical Sound Pressure Levels (SPL), dB(A)

Source	Typical Sound Level
Threshold of pain	140
Jet engine	130
Hydraulic hammer	120
Chainsaw	110
Industrial workshop	100
Lawn-mower (operator position)	90
Heavy traffic (footpath)	80
Elevated speech	70
Typical conversation	60
Ambient suburban environment	40
Ambient rural environment	30
Bedroom (night with windows closed)	20
Threshold of hearing	0

Figure A1 – Human Perception of Sound



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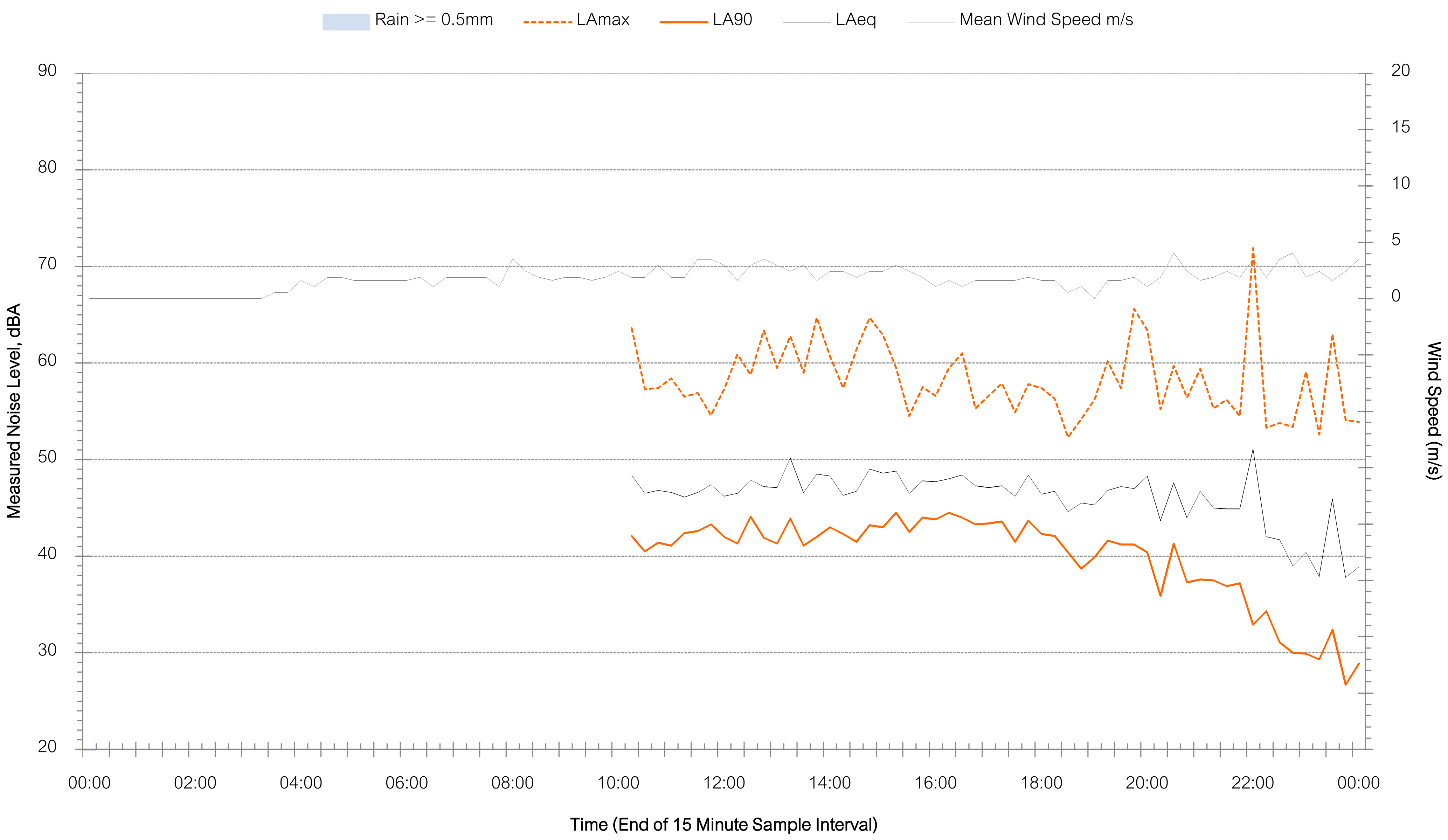
Appendix B – Noise Monitoring Charts

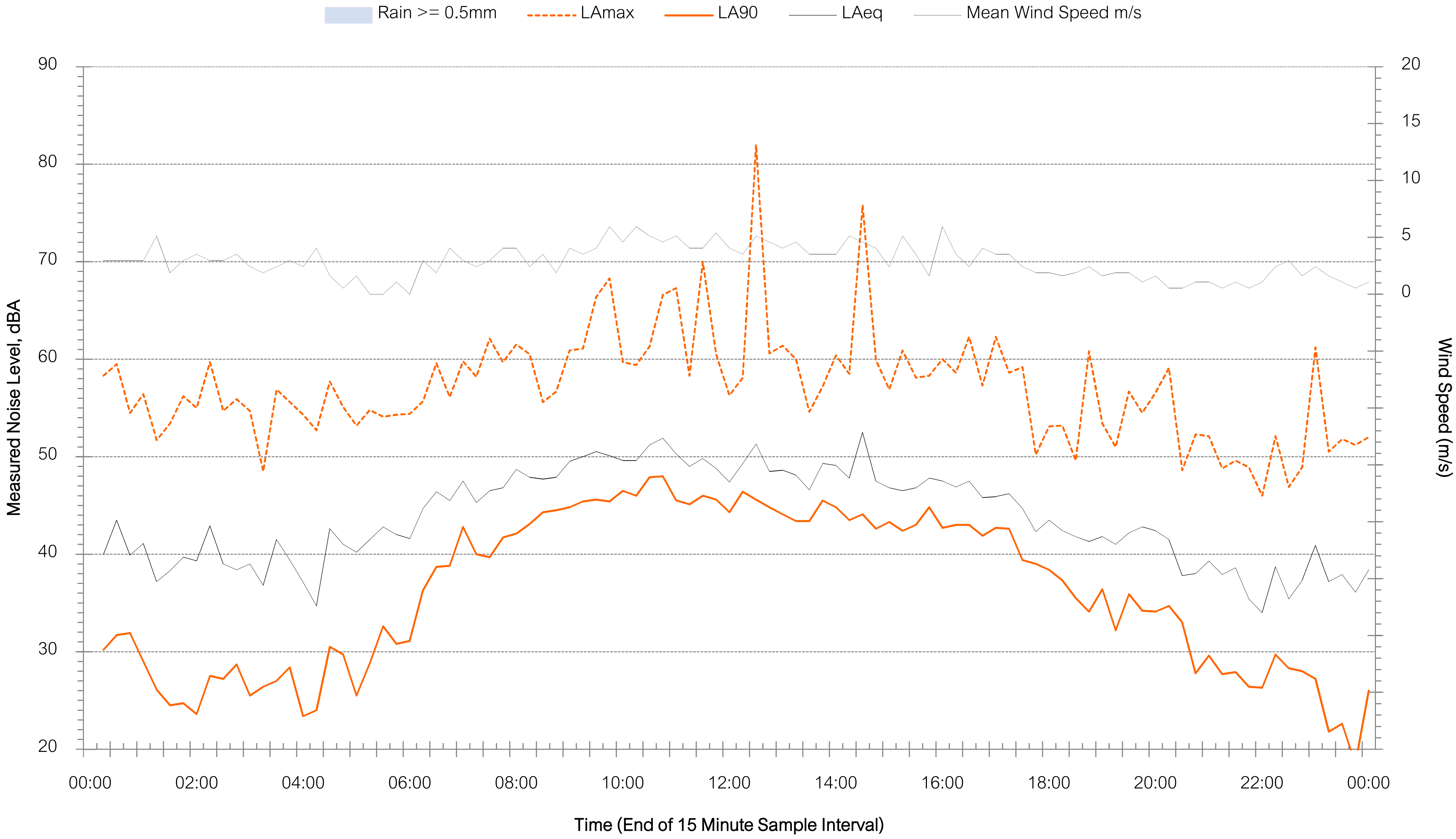
Background Noise Levels

Logger N1 - 987 Great Western Highway, Marrangaroo - Friday 29 June 2018



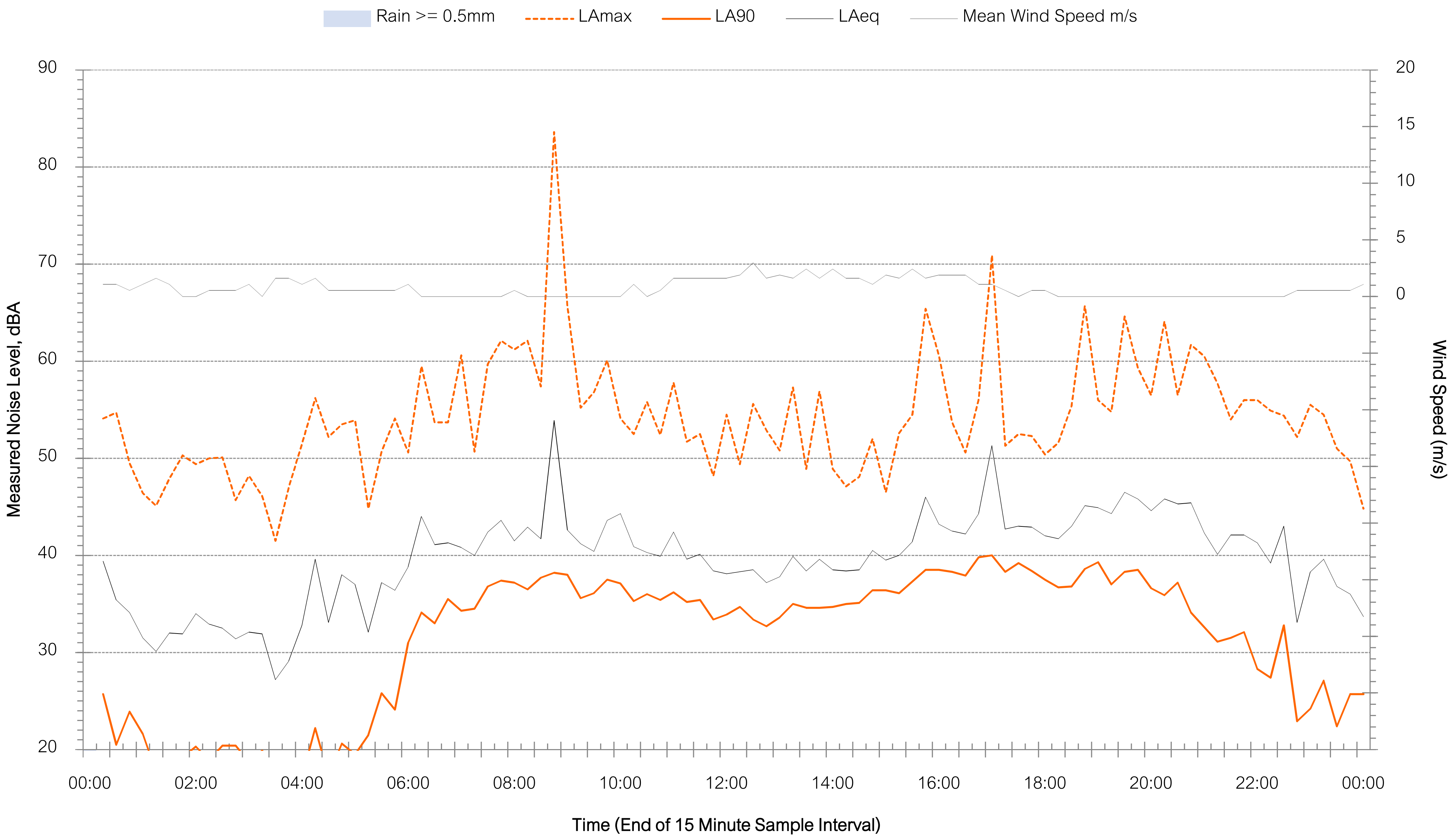
Background Noise Levels

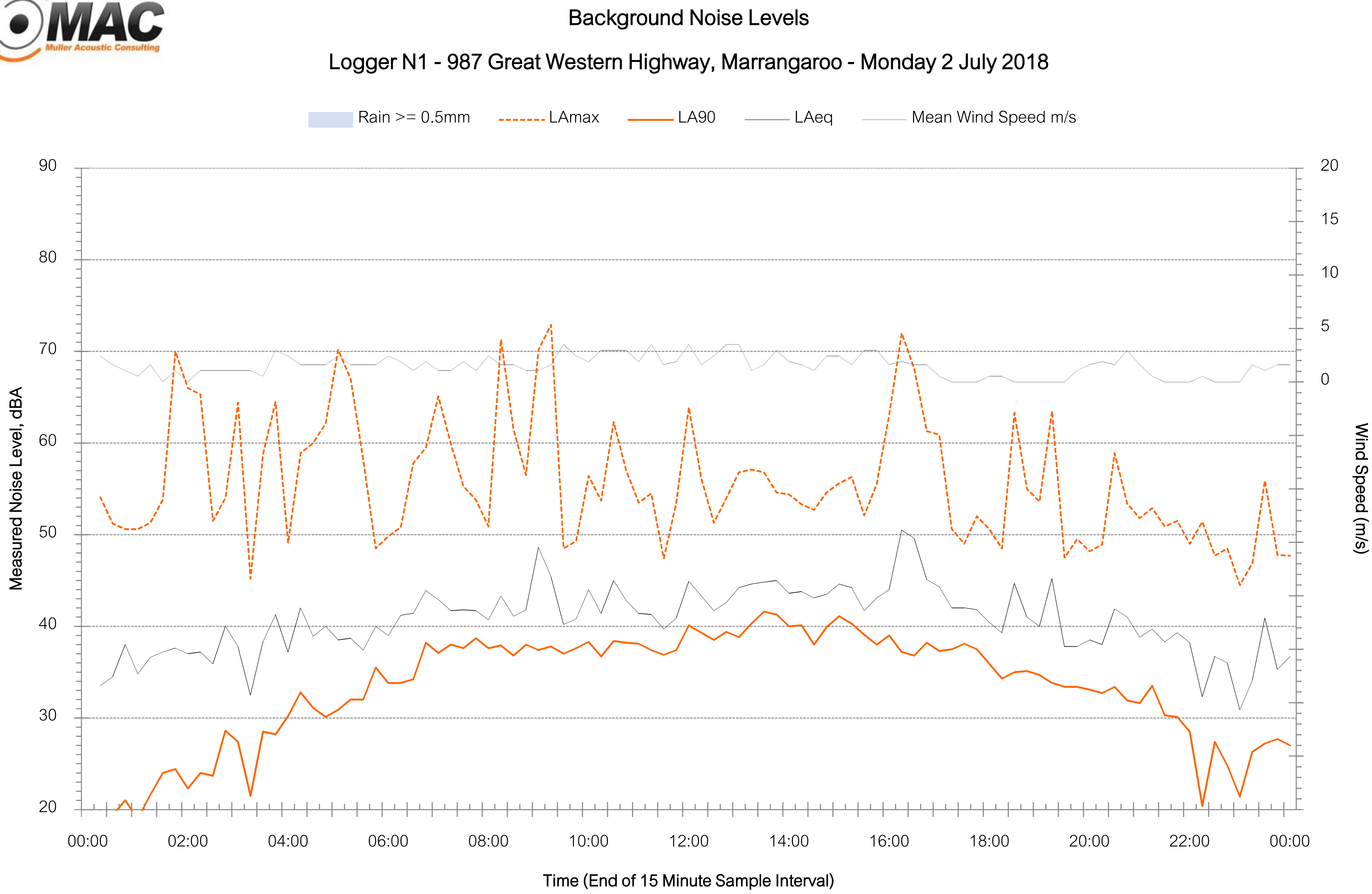
Logger N1 - 987 Great Western Highway, Marrangaroo - Saturday 30 June 2018

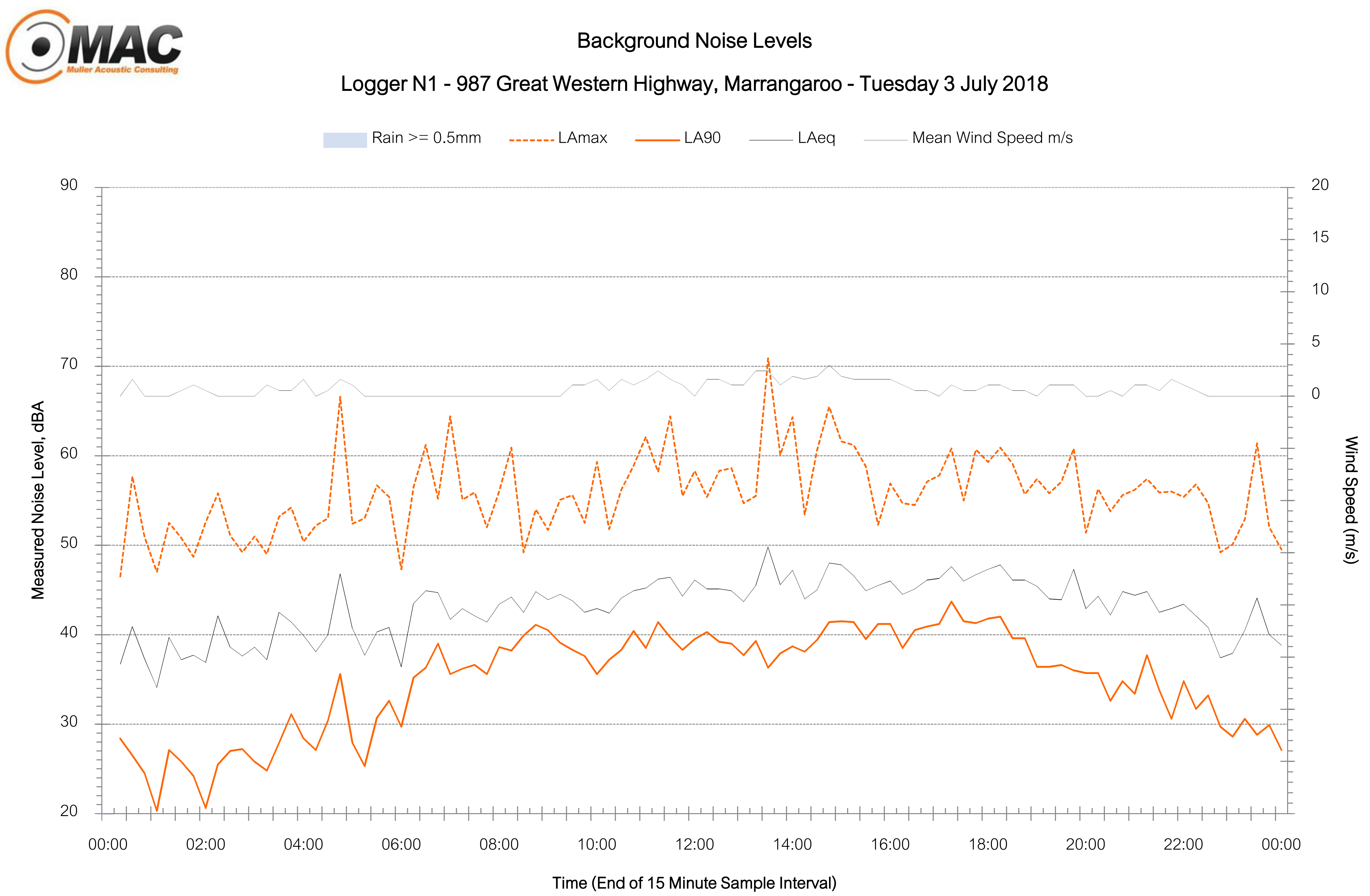


Background Noise Levels

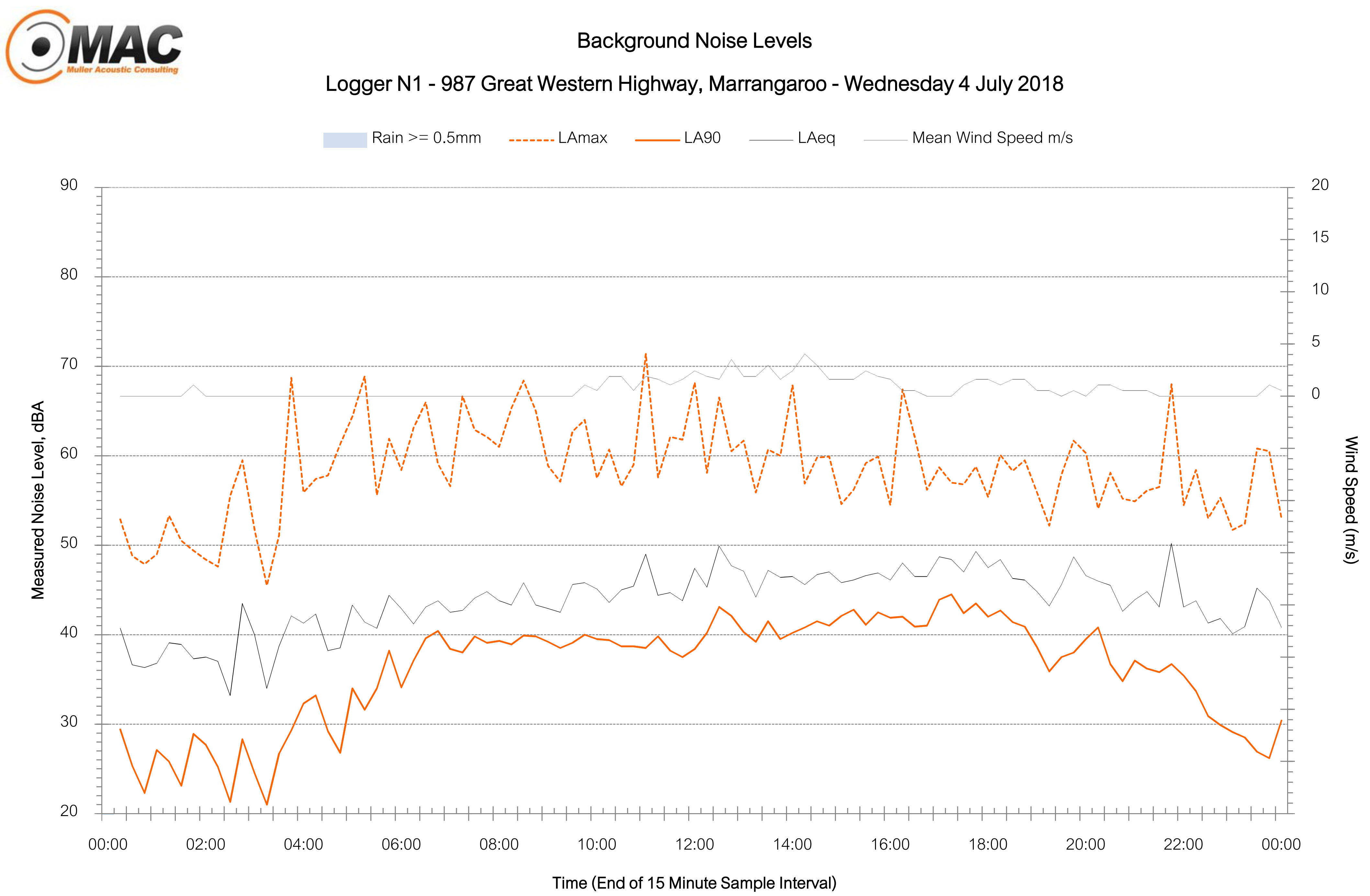
Logger N1 - 987 Great Western Highway, Marrangaroo - Sunday 1 July 2018



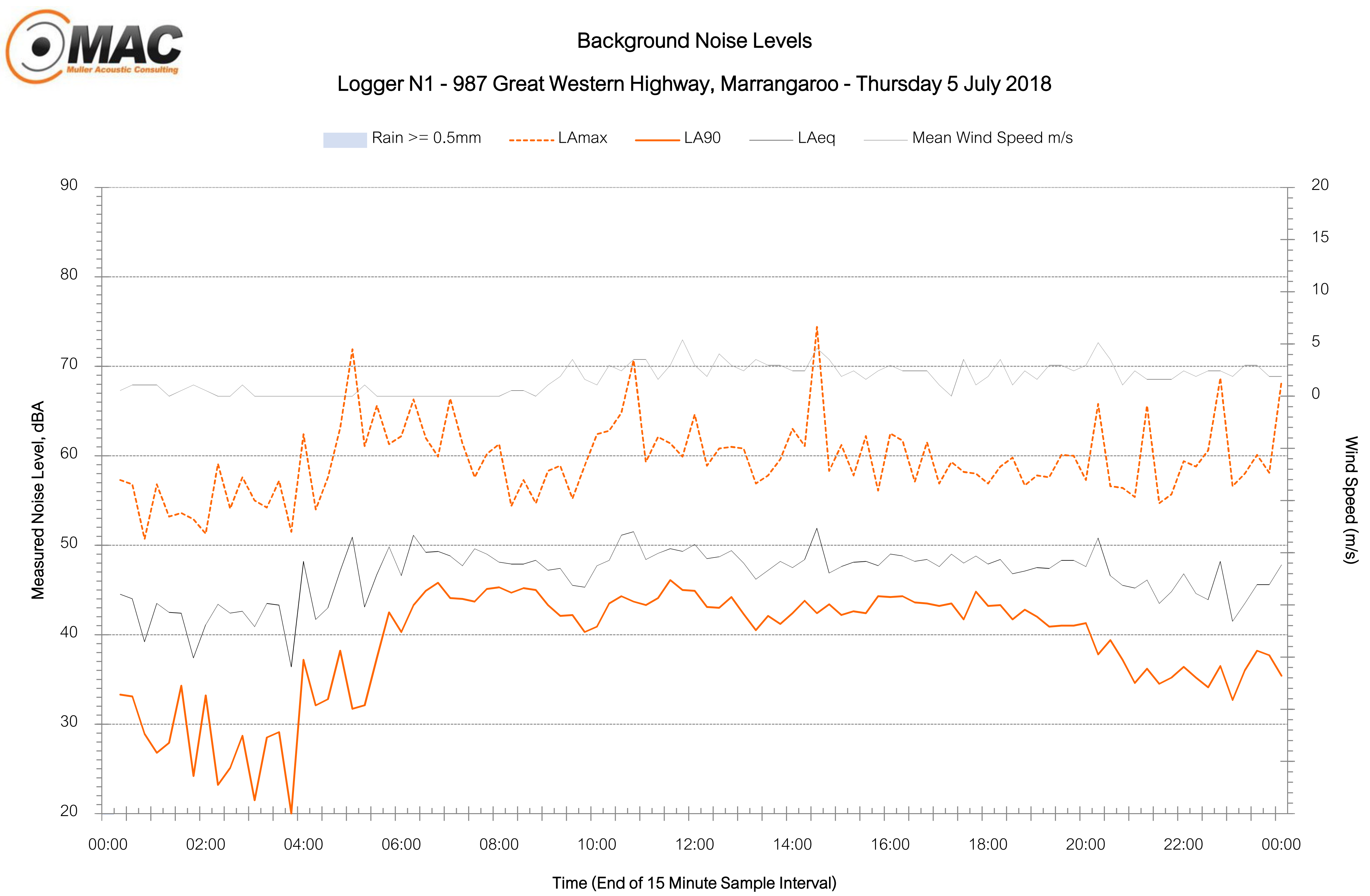

Background Noise Levels
Logger N1 - 987 Great Western Highway, Marrangaroo - Monday 2 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
90
80
70
60
50
40
30
20
Wind Speed (m/s)
20
15
10
5
0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Time (End of 15 Minute Sample Interval)



MAC
Muller Acoustic Consulting
Background Noise Levels
Logger N1 - 987 Great Western Highway, Marrangaroo - Tuesday 3 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
90
80
70
60
50
40
30
20
Wind Speed (m/s)
20
15
10
5
0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Time (End of 15 Minute Sample Interval)



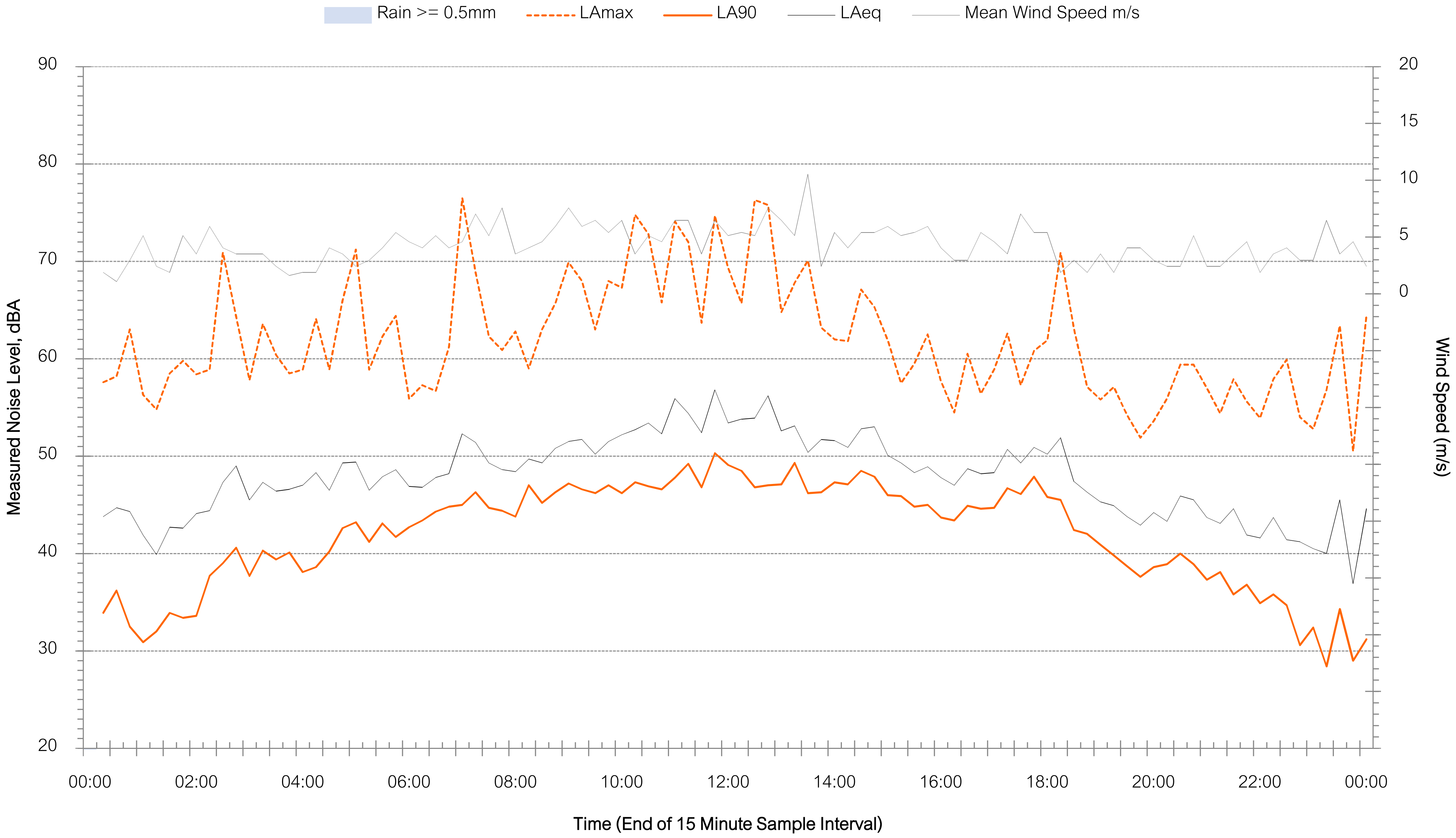
Muller Acoustic Consulting
Background Noise Levels
Logger N1 - 987 Great Western Highway, Marrangaroo - Wednesday 4 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
Wind Speed (m/s)
Time (End of 15 Minute Sample Interval)
90
80
70
60
50
40
30
20
20
15
10
5
0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

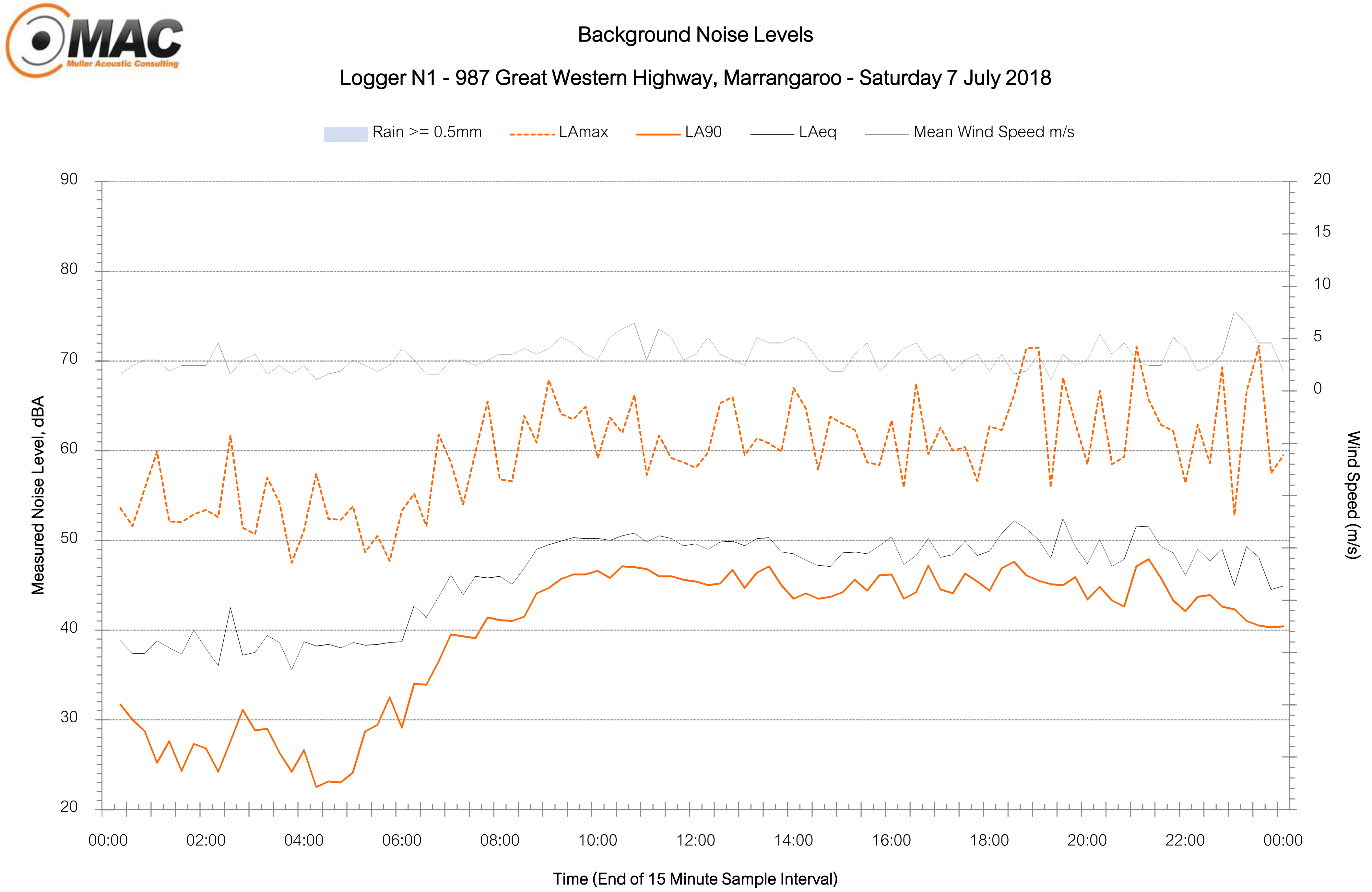


MAC
Muller Acoustic Consulting
Background Noise Levels
Logger N1 - 987 Great Western Highway, Marrangaroo - Thursday 5 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
90
80
70
60
50
40
30
20
Wind Speed (m/s)
20
15
10
5
0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Time (End of 15 Minute Sample Interval)

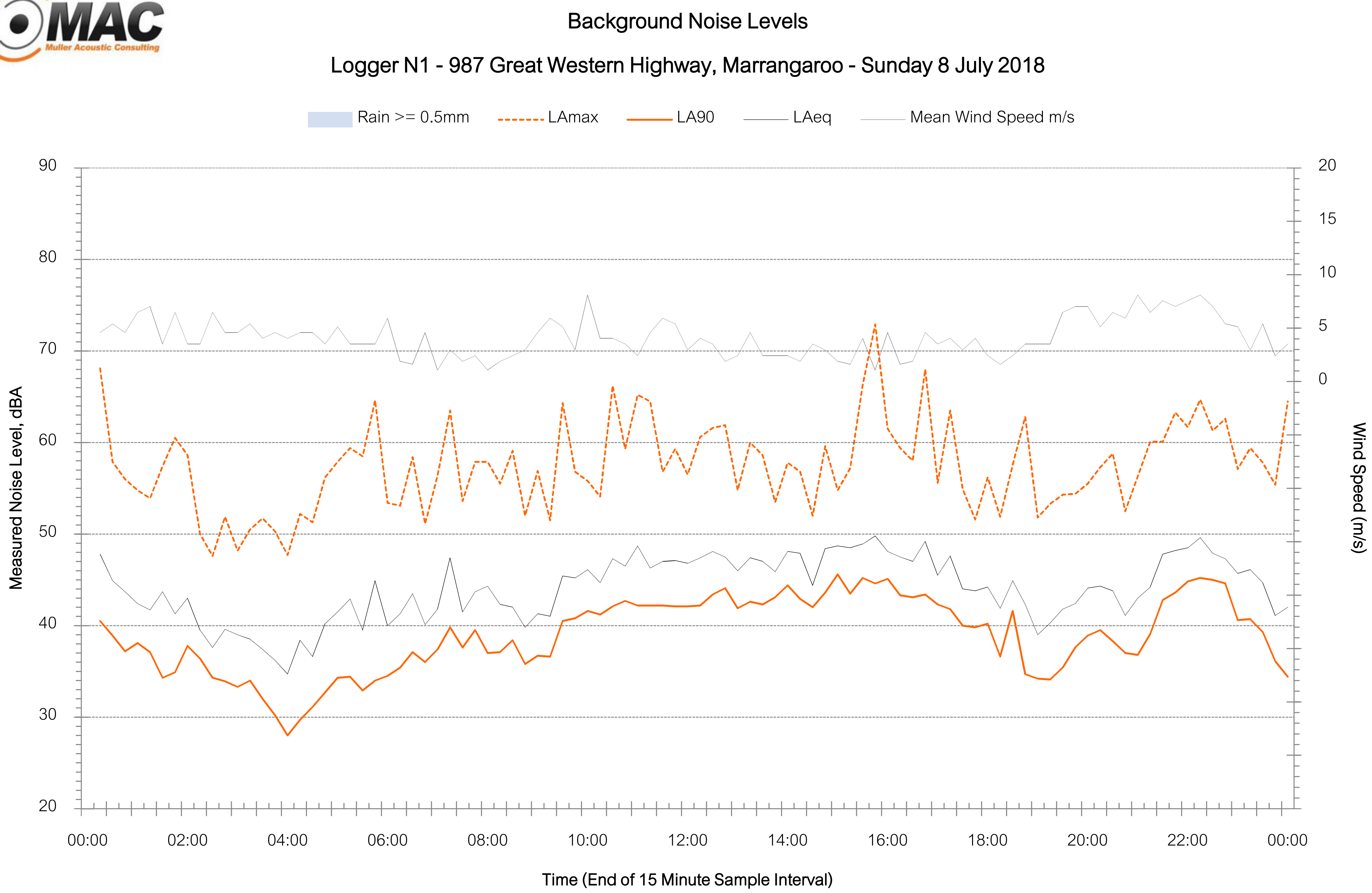
Background Noise Levels

Logger N1 - 987 Great Western Highway, Marrangaroo - Friday 6 July 2018





MAC
Muller Acoustic Consulting
Background Noise Levels
Logger N1 - 987 Great Western Highway, Marrangaroo - Saturday 7 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
Wind Speed (m/s)
90
80
70
60
50
40
30
20
20
15
10
5
0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Time (End of 15 Minute Sample Interval)


Background Noise Levels
Logger N1 - 987 Great Western Highway, Marrangaroo - Sunday 8 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
Wind Speed (m/s)
Time (End of 15 Minute Sample Interval)
90
80
70
60
50
40
30
20
15
10
5
0
00:00
02:00
04:00
06:00
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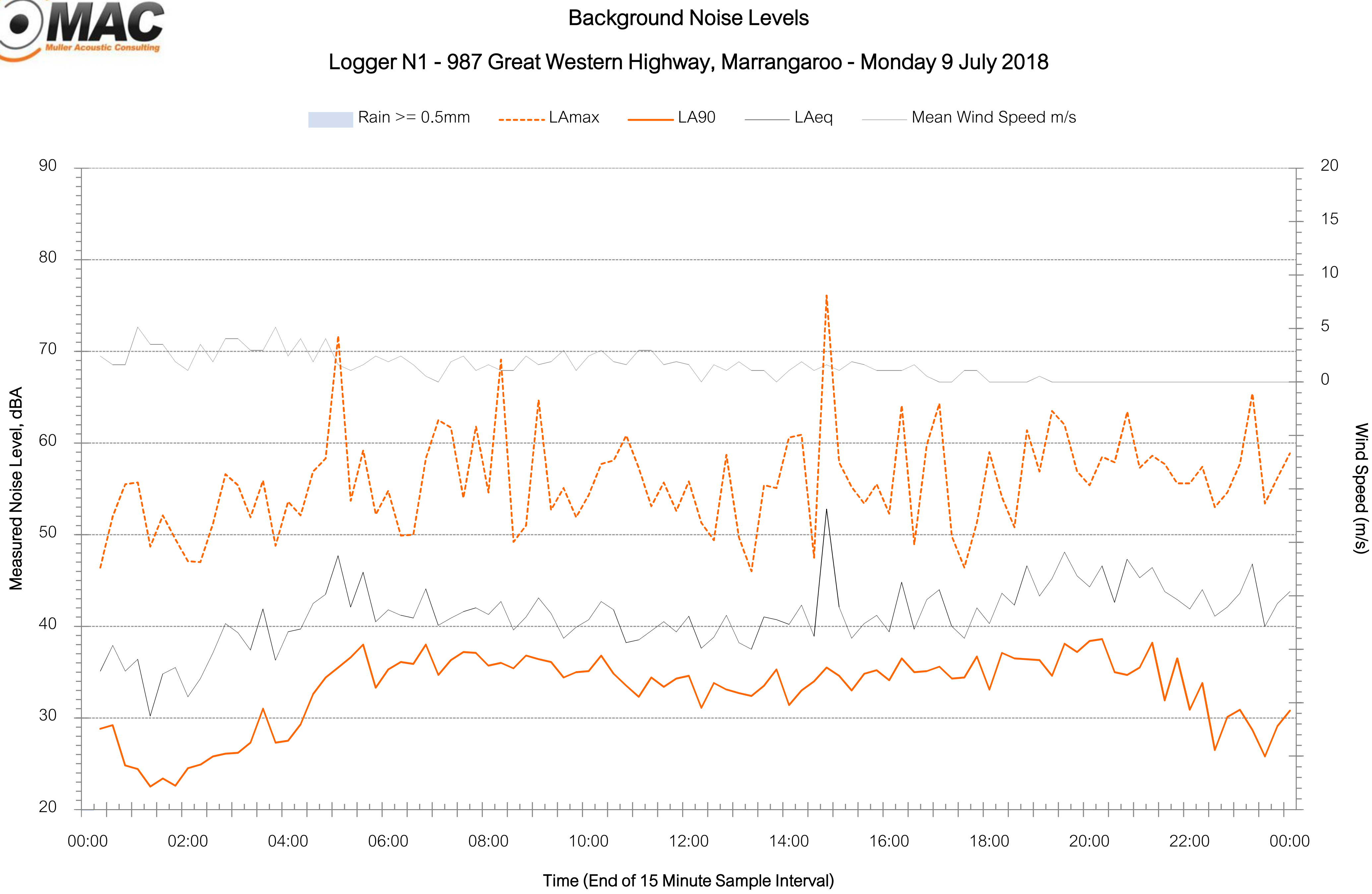
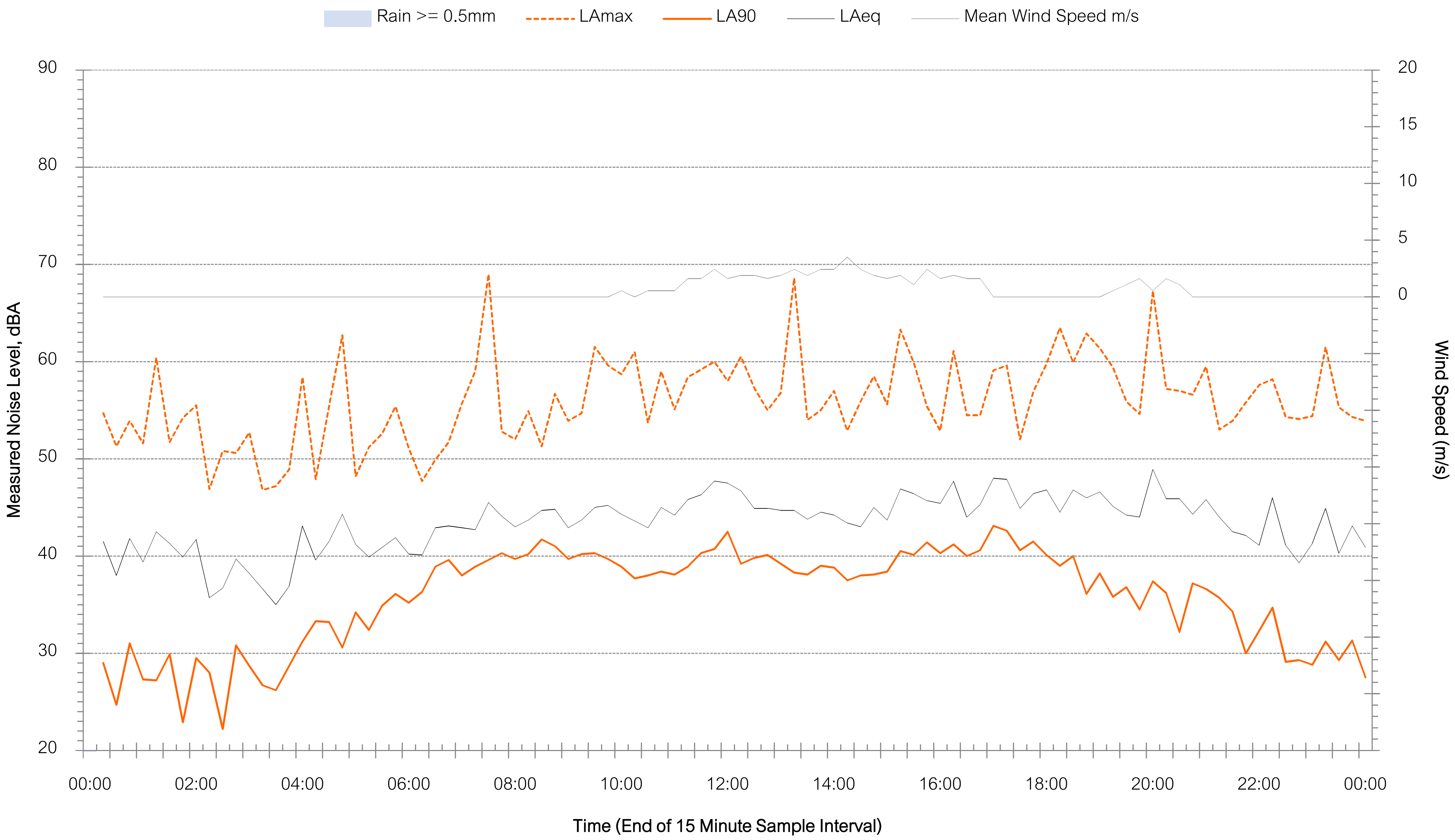
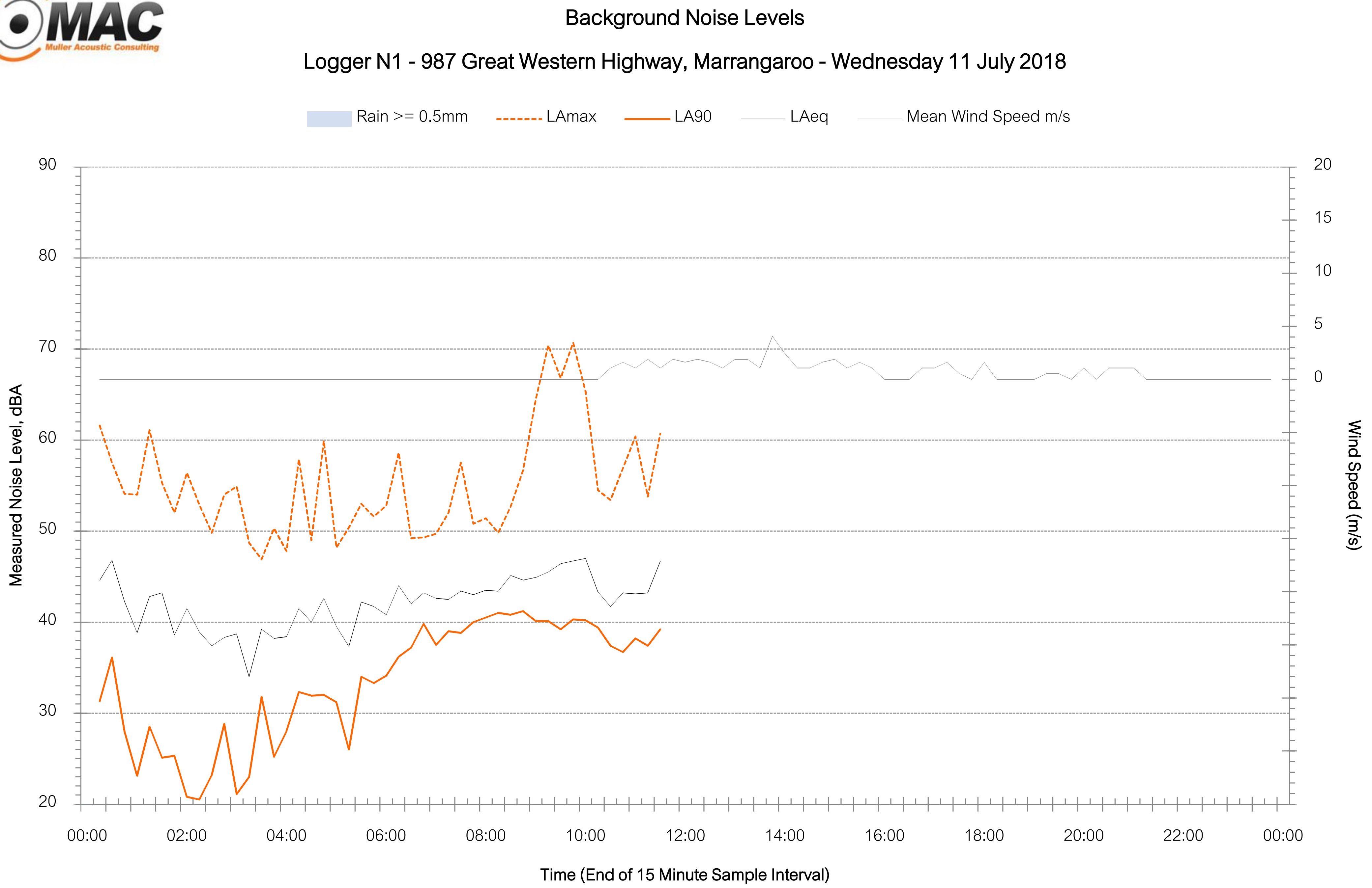


Background Noise Levels
Logger N1 - 987 Great Western Highway, Marrangaroo - Monday 9 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
90
80
70
60
50
40
30
20
Wind Speed (m/s)
20
15
10
5
0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Time (End of 15 Minute Sample Interval)

Background Noise Levels

Logger N1 - 987 Great Western Highway, Marrangaroo - Tuesday 10 July 2018

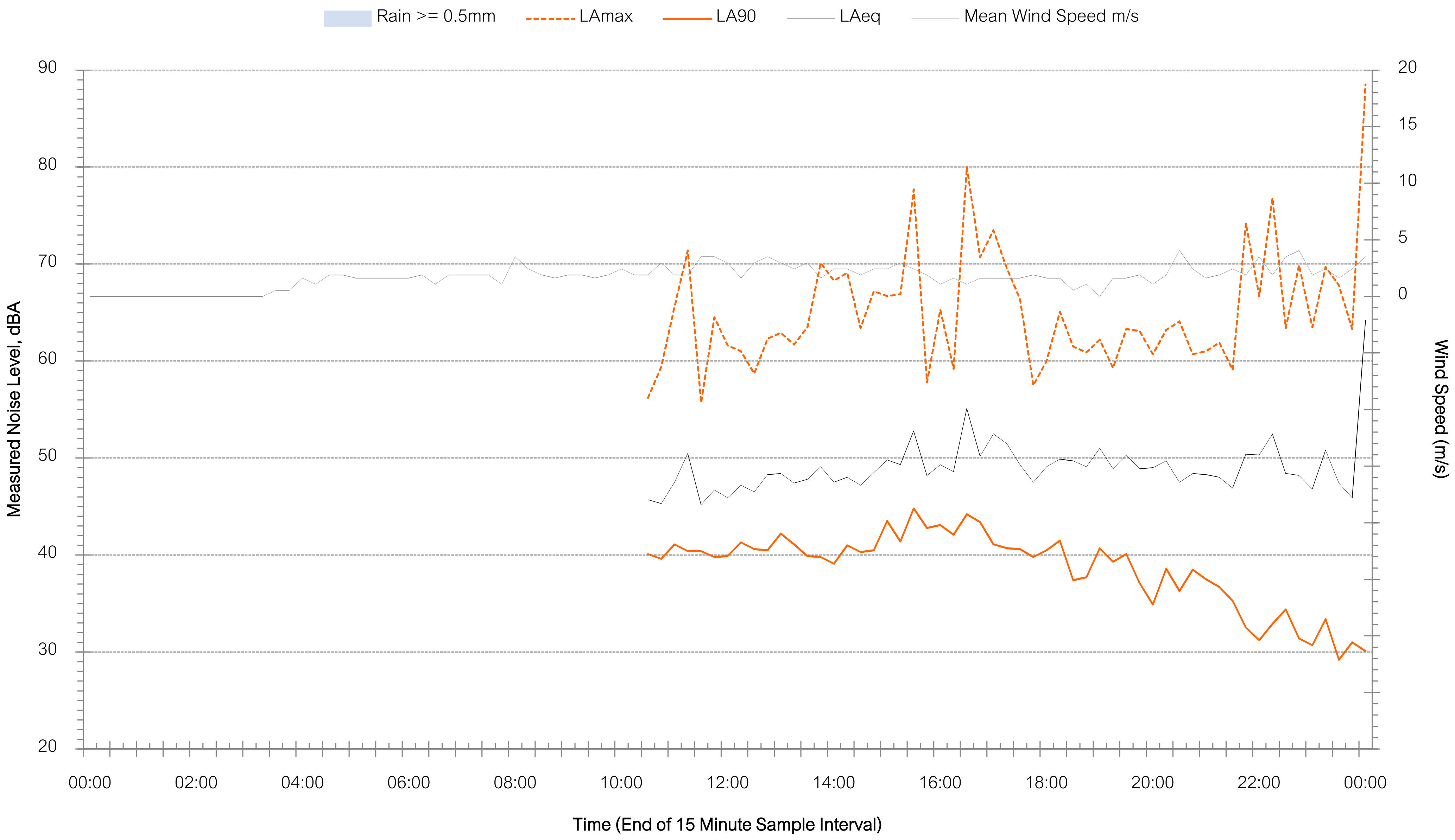


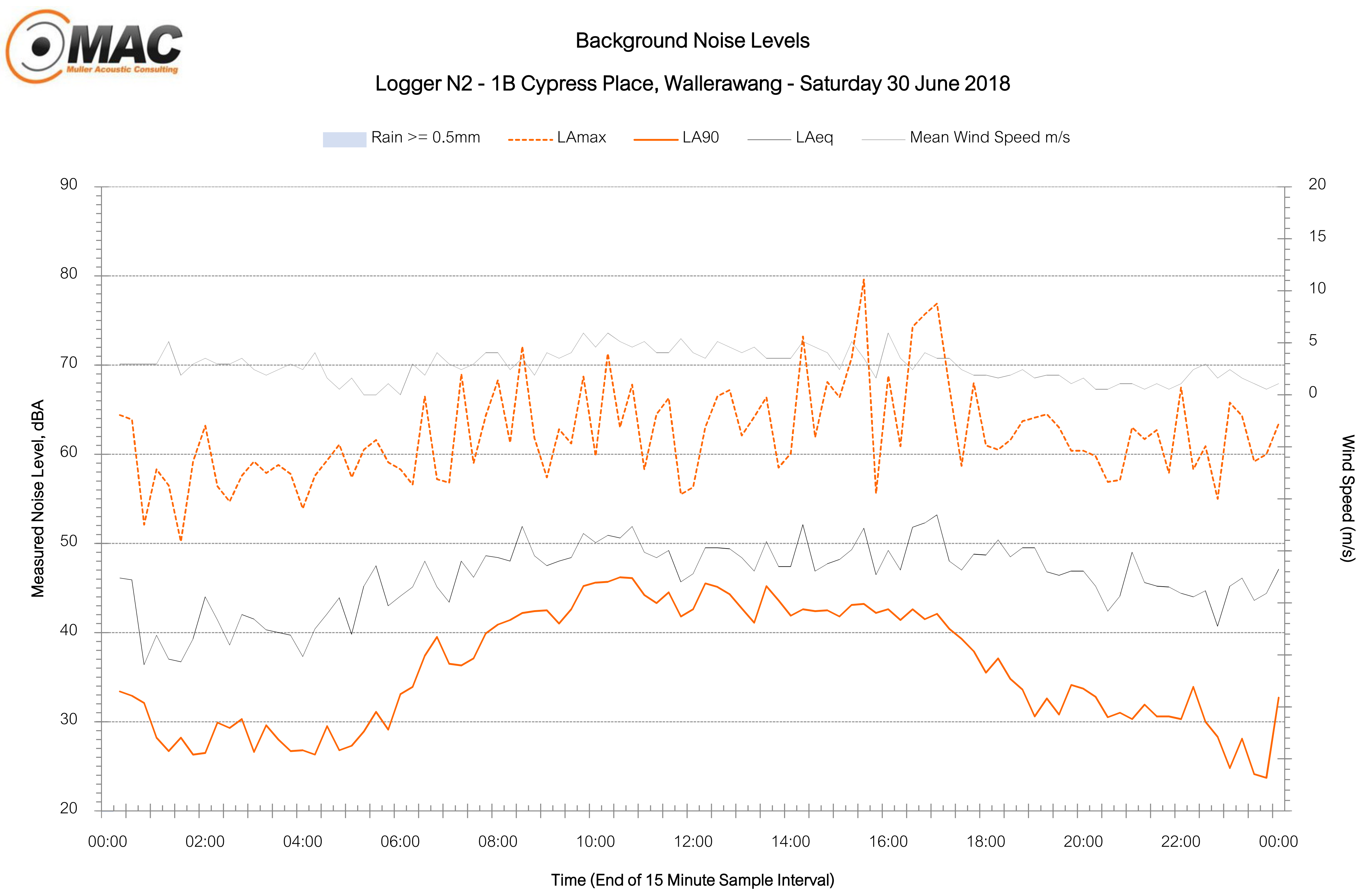


Background Noise Levels
Logger N1 - 987 Great Western Highway, Marrangaroo - Wednesday 11 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
90
80
70
60
50
40
30
20
20
15
10
5
0
Measured Noise Level, dBA
Wind Speed (m/s)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Time (End of 15 Minute Sample Interval)

Background Noise Levels

Logger N2 - 1B Cypress Place, Wallerawang - Friday 29 June 2018





MAC
Muller Acoustic Consulting
Background Noise Levels
Logger N2 - 1B Cypress Place, Wallerawang - Saturday 30 June 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
Wind Speed (m/s)
90
80
70
60
50
40
30
20
15
10
5
0
00:00
02:00
04:00
06:00
08:00
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16:00
18:00
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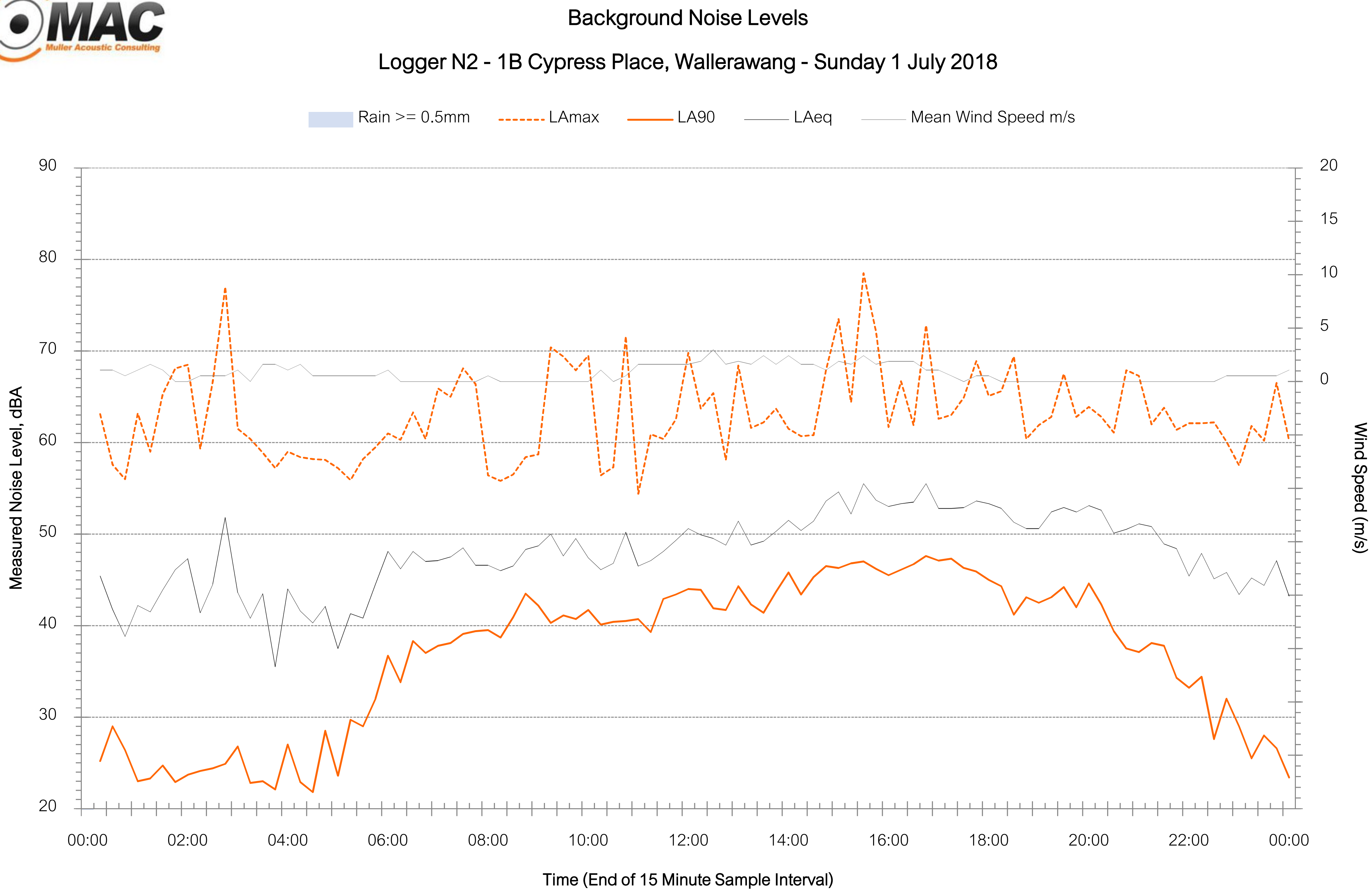
22:00
00:00
Time (End of 15 Minute Sample Interval)



Background Noise Levels
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Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
90
80
70
60
50
40
30
20
Wind Speed (m/s)
20
15
10
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0
00:00
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04:00
06:00
08:00
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12:00
14:00
16:00
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22:00
00:00
Time (End of 15 Minute Sample Interval)

Background Noise Levels

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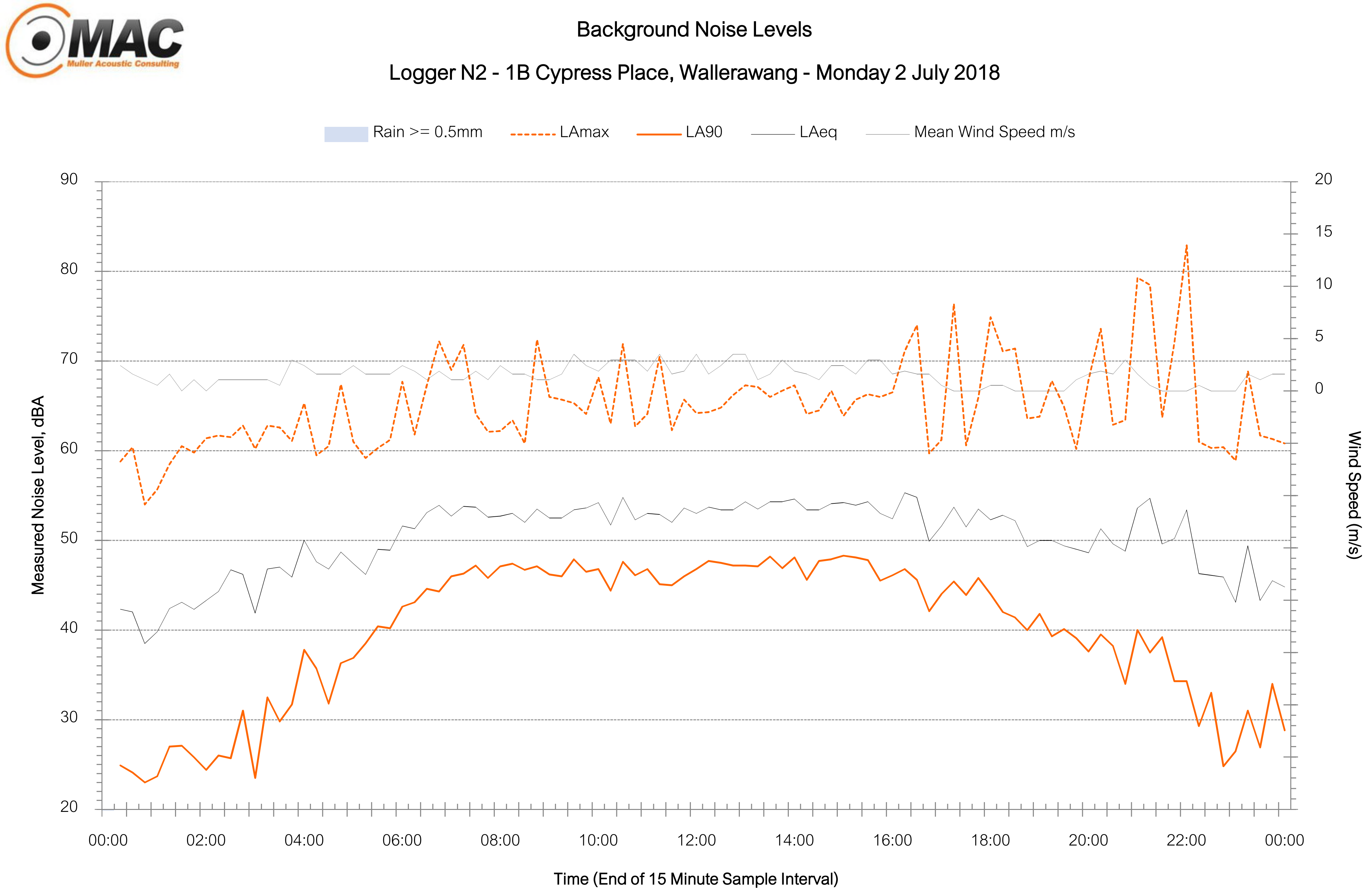

Background Noise Levels

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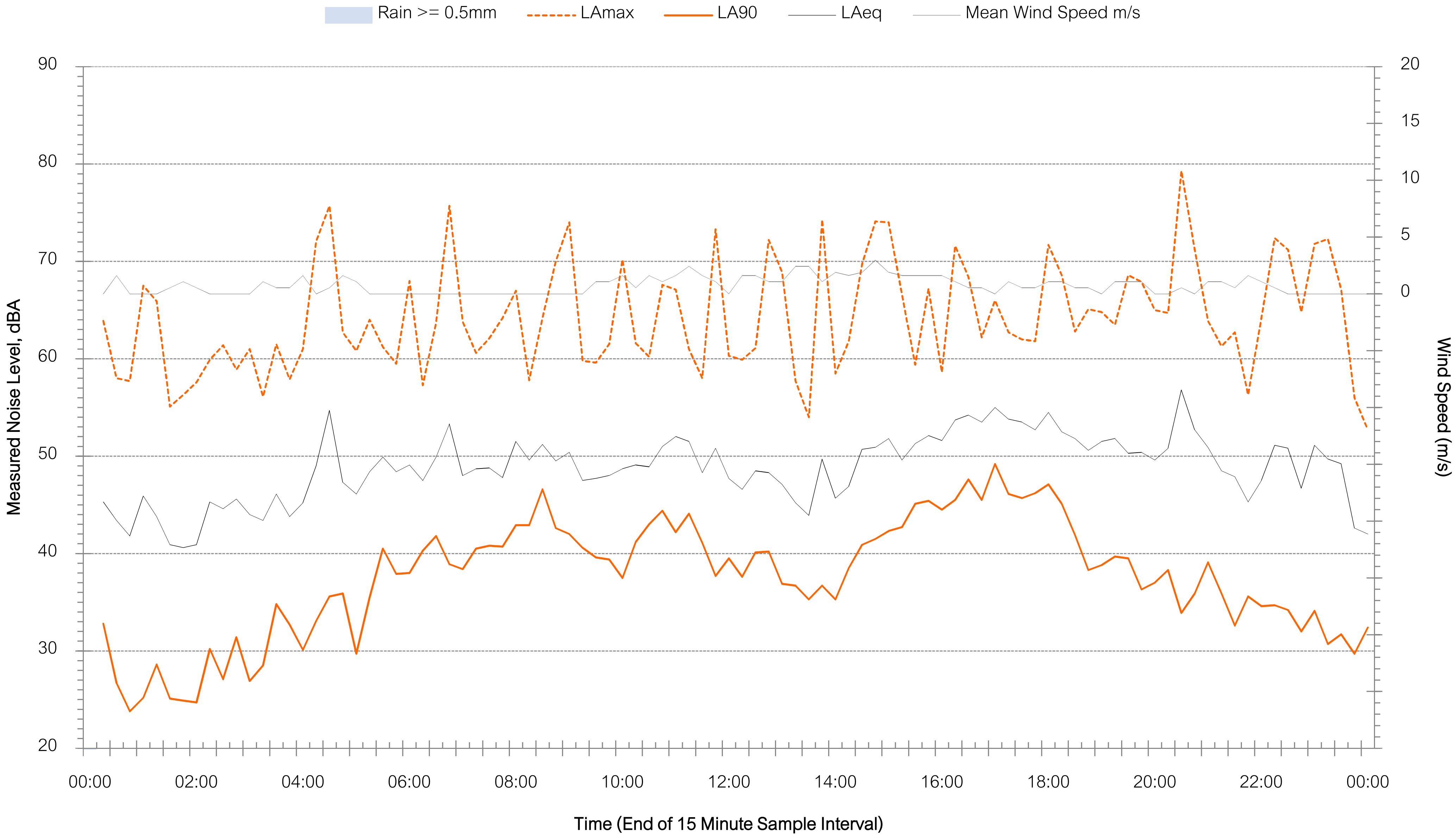

MAC
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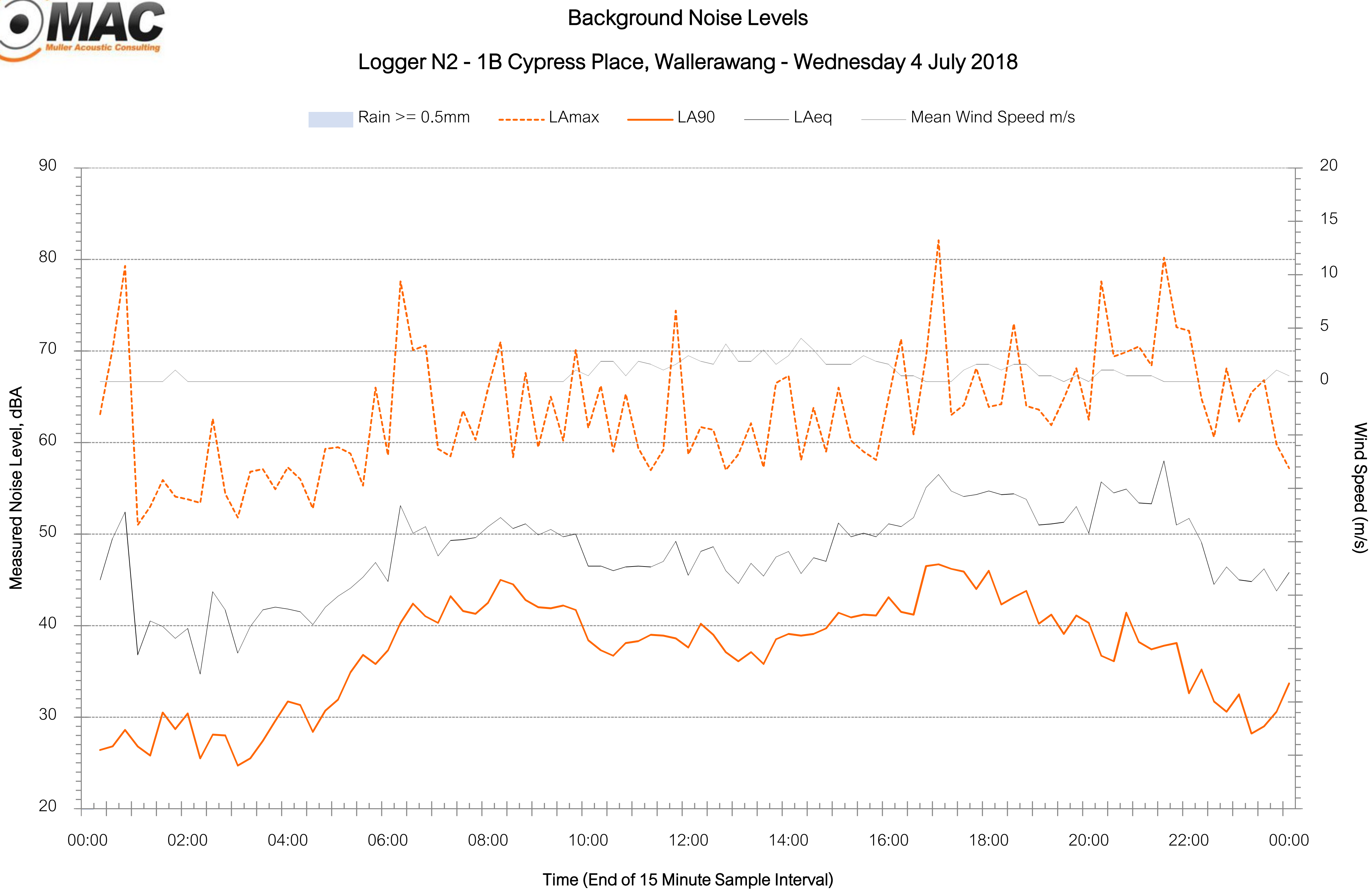

Background Noise Levels

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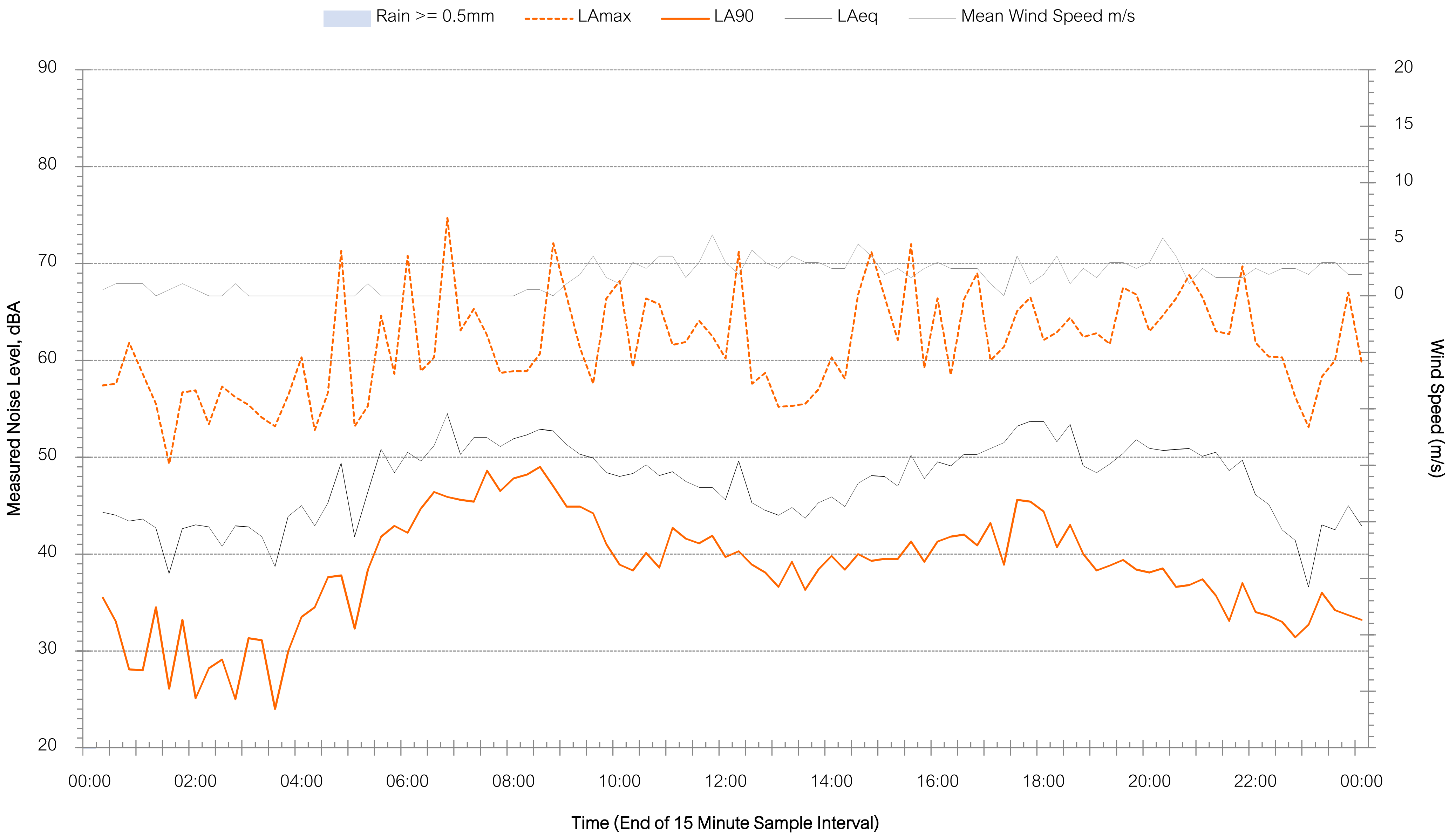

Background Noise Levels

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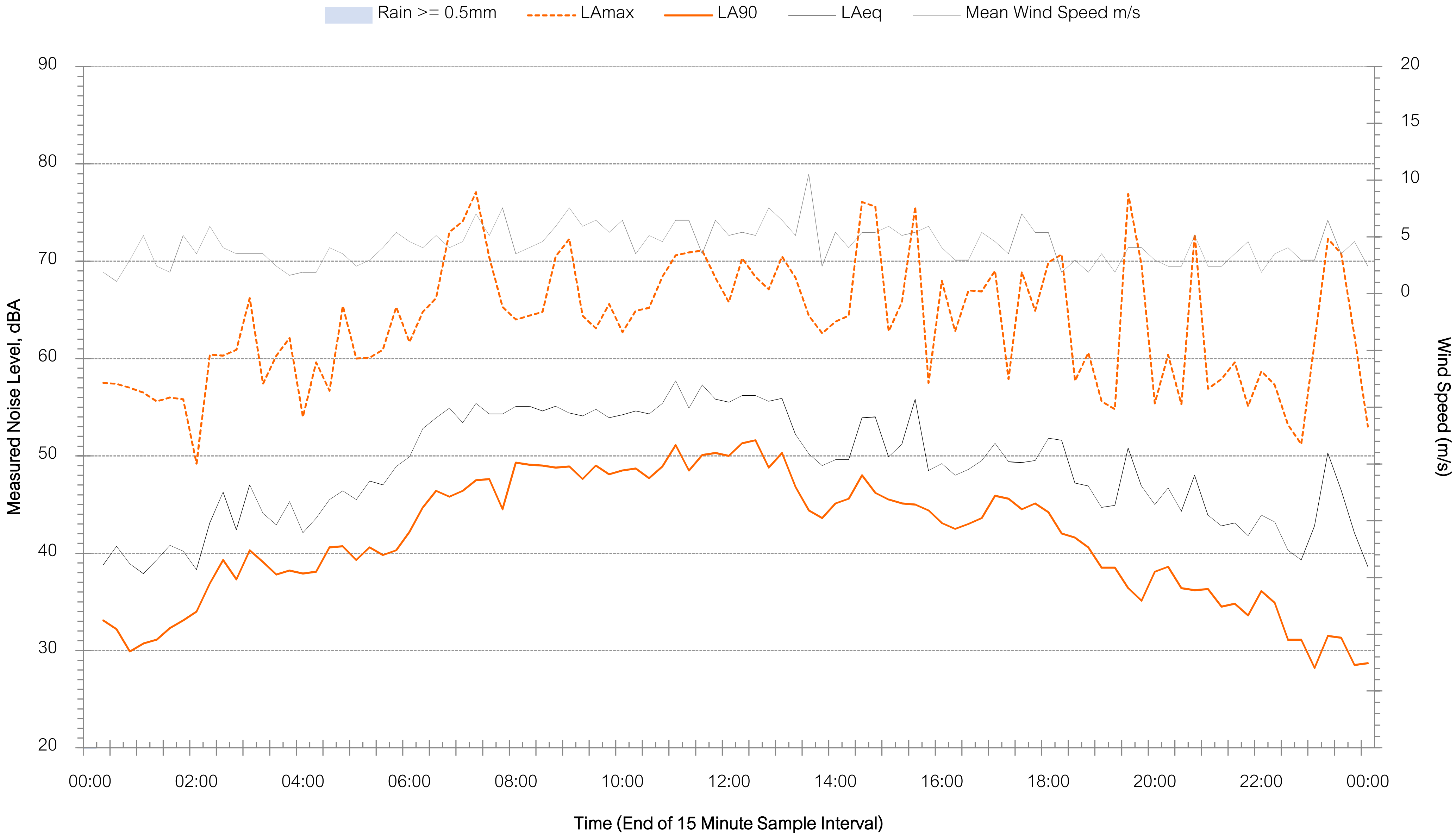

Background Noise Levels

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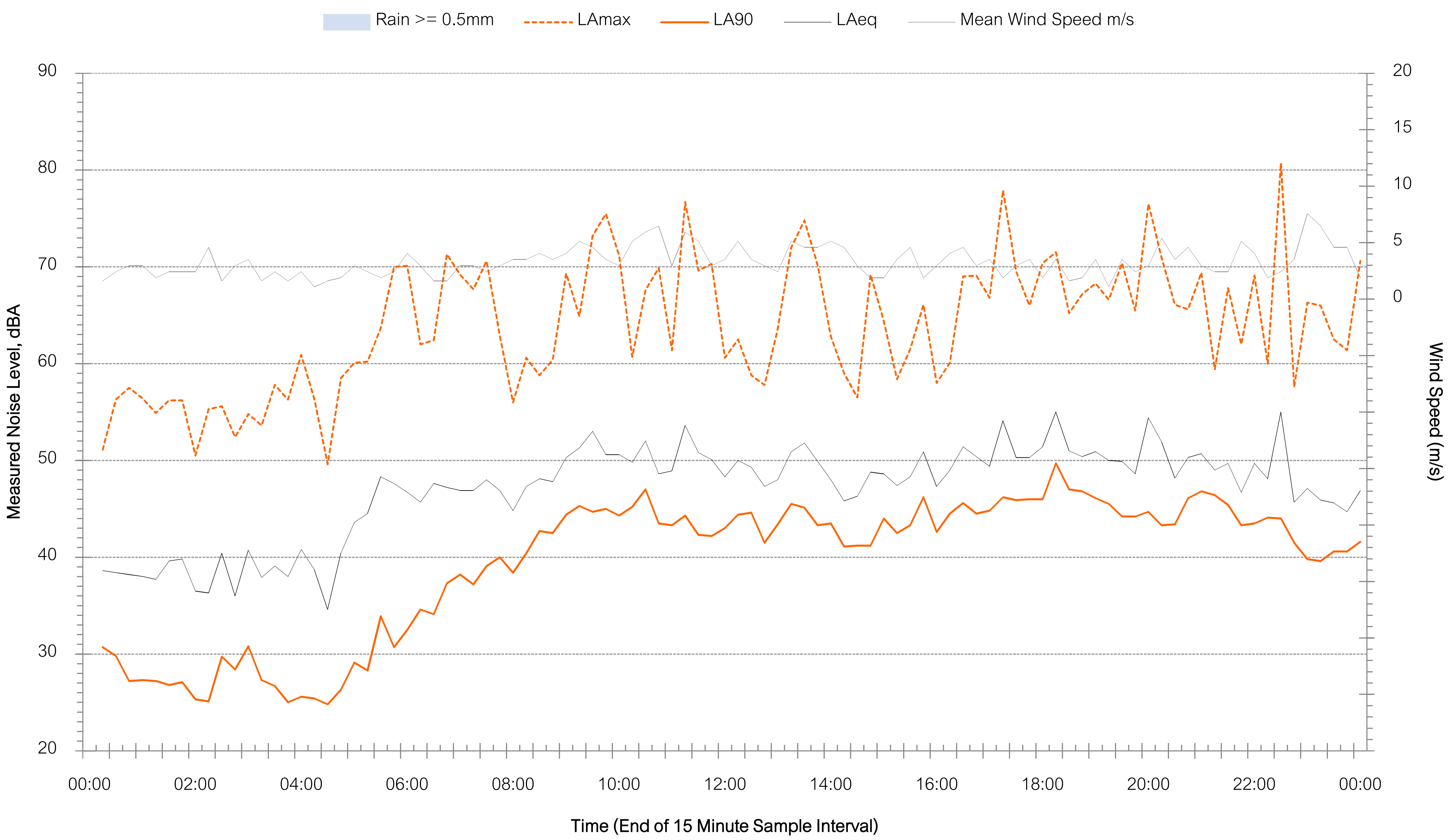

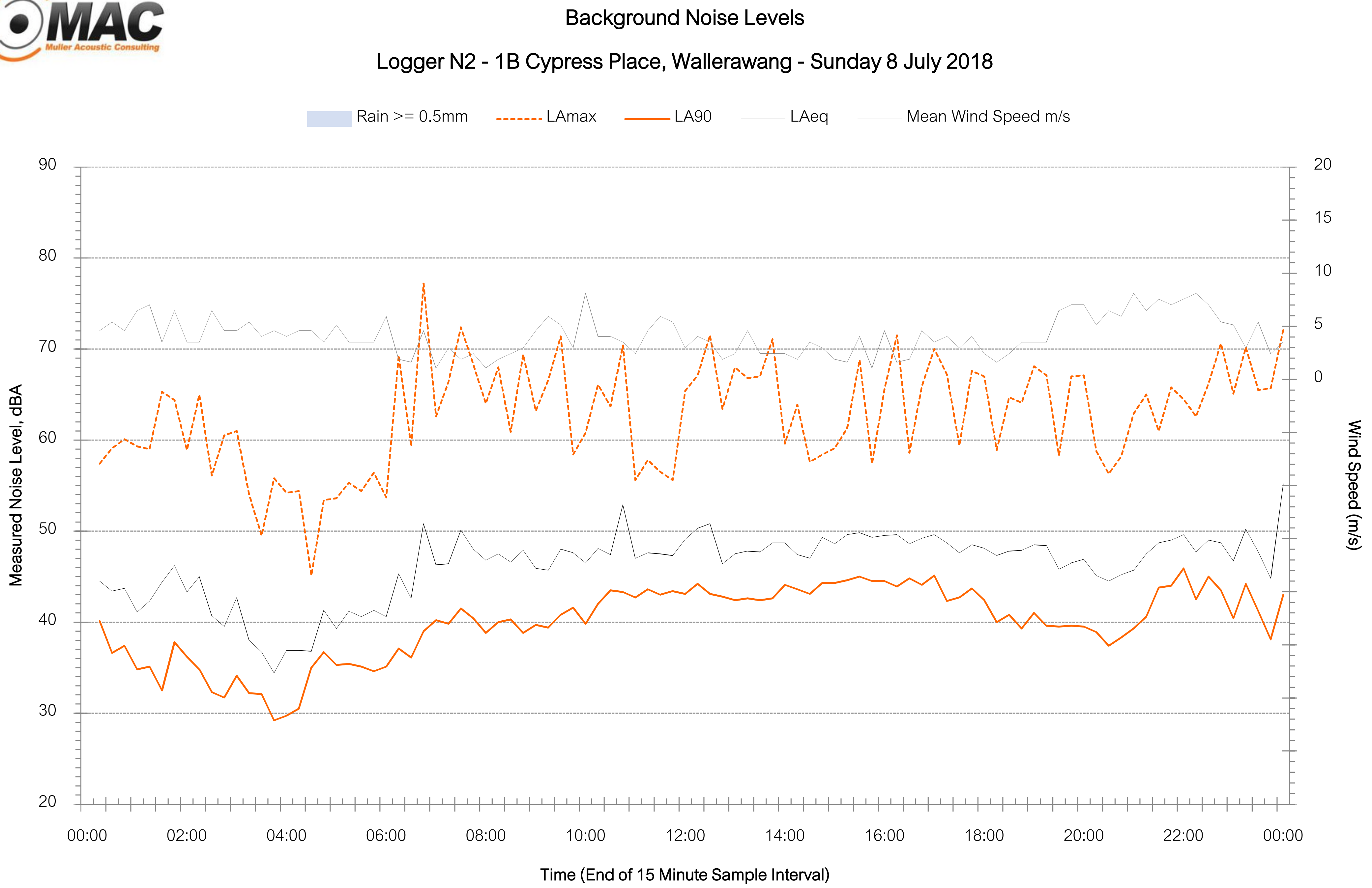

Background Noise Levels
Logger N2 - 1B Cypress Place, Wallerawang - Sunday 8 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
90
80
70
60
50
40
30
20
Wind Speed (m/s)
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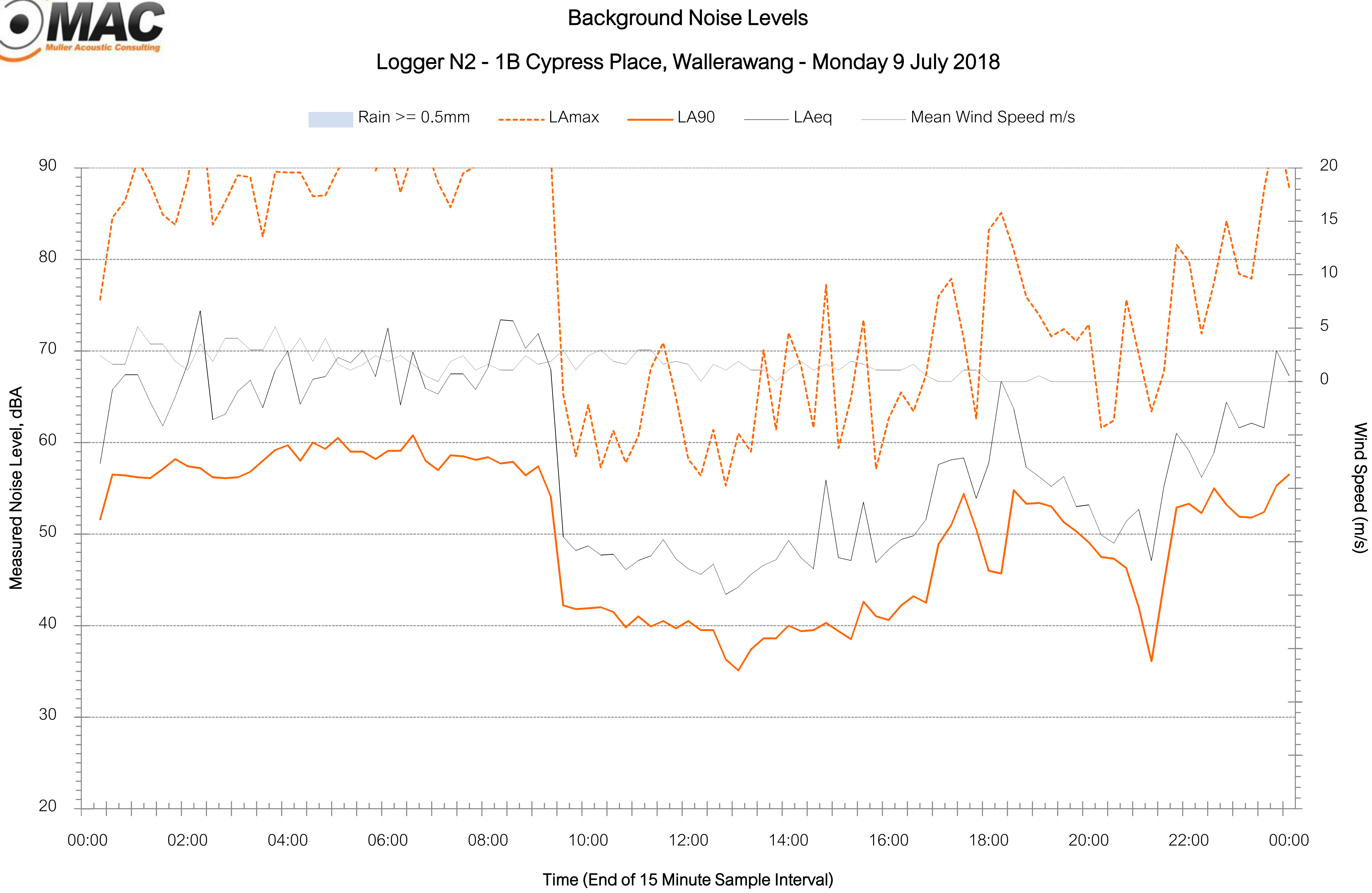
20:00
22:00
00:00
Time (End of 15 Minute Sample Interval)



Background Noise Levels
Logger N2 - 1B Cypress Place, Wallerawang - Monday 9 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
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80
70
60
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40
30
20
Wind Speed (m/s)
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04:00
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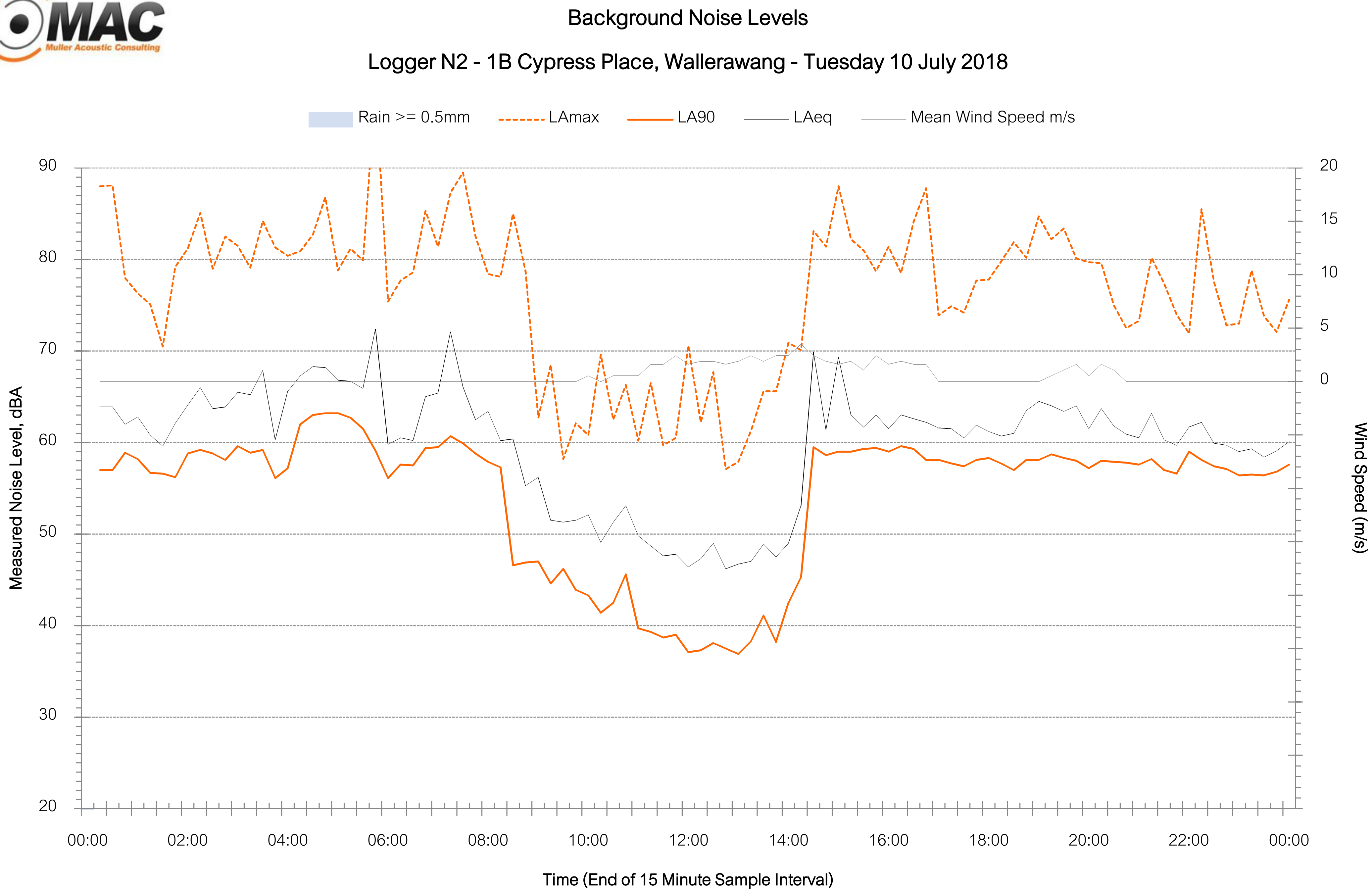
14:00
16:00
18:00
20:00
22:00
00:00
Time (End of 15 Minute Sample Interval)



Background Noise Levels
Logger N2 - 1B Cypress Place, Wallerawang - Tuesday 10 July 2018
Rain >= 0.5mm
LAmax
LA90
LAeq
Mean Wind Speed m/s
Measured Noise Level, dBA
Wind Speed (m/s)
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70
60
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40
30
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15
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00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
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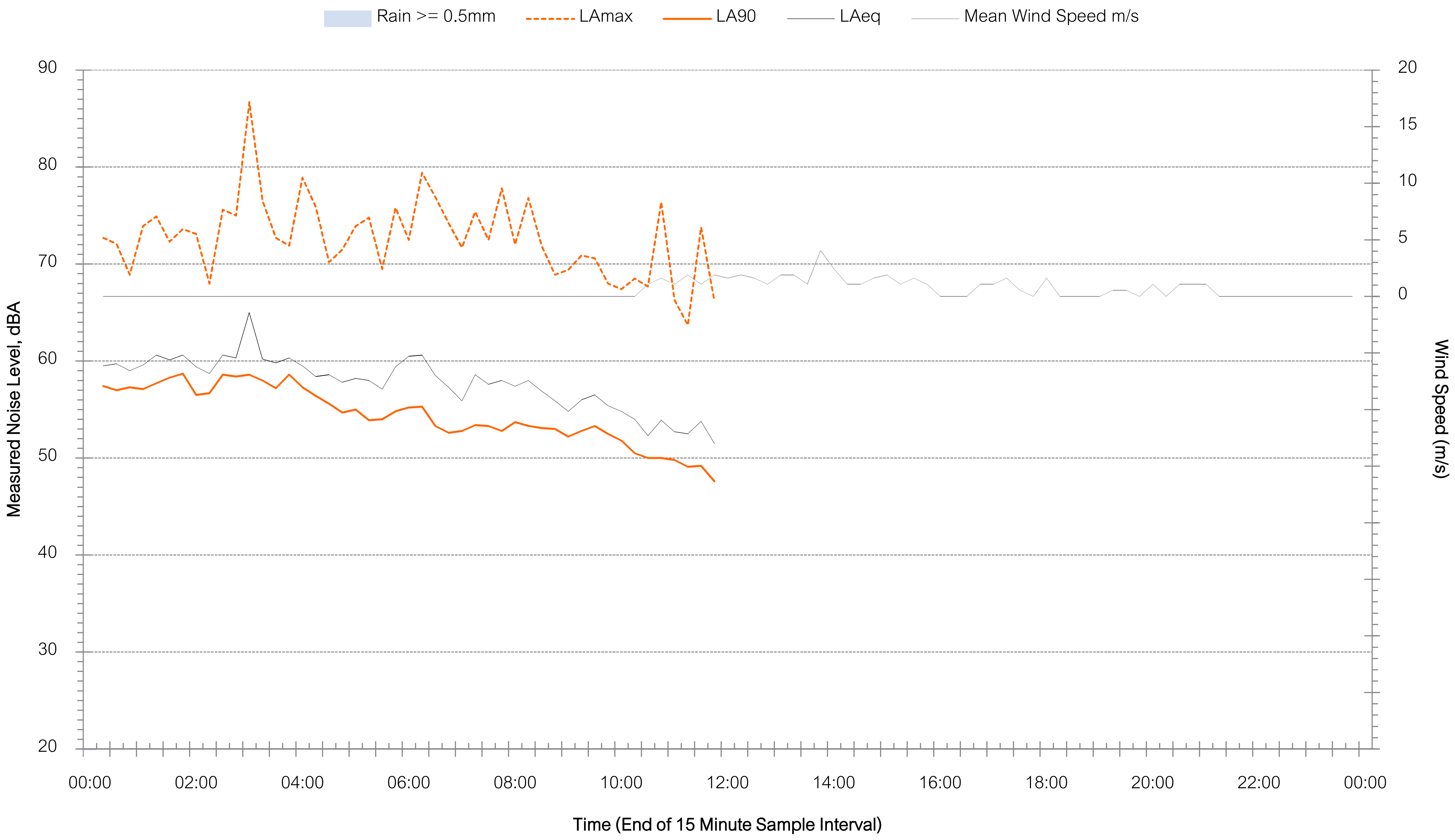
22:00
00:00
Time (End of 15 Minute Sample Interval)

Background Noise Levels

Logger N2 - 1B Cypress Place, Wallerawang - Wednesday 11 July 2018

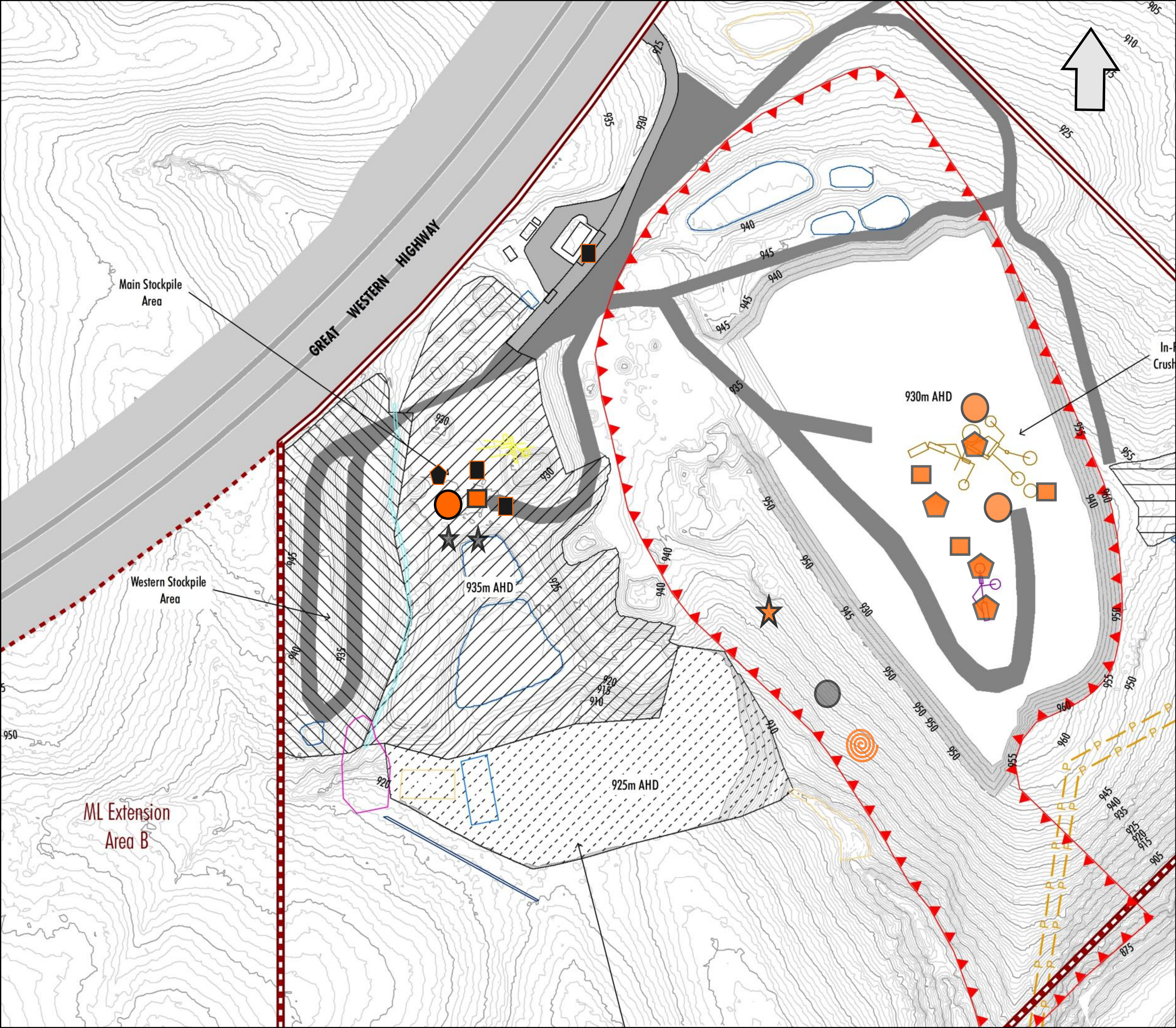


Appendix C – Plant Layout

FIGURE C1

SCENARIO 1 - MODELLED PLANT LOCATIONS

REF: MAC180681



Key

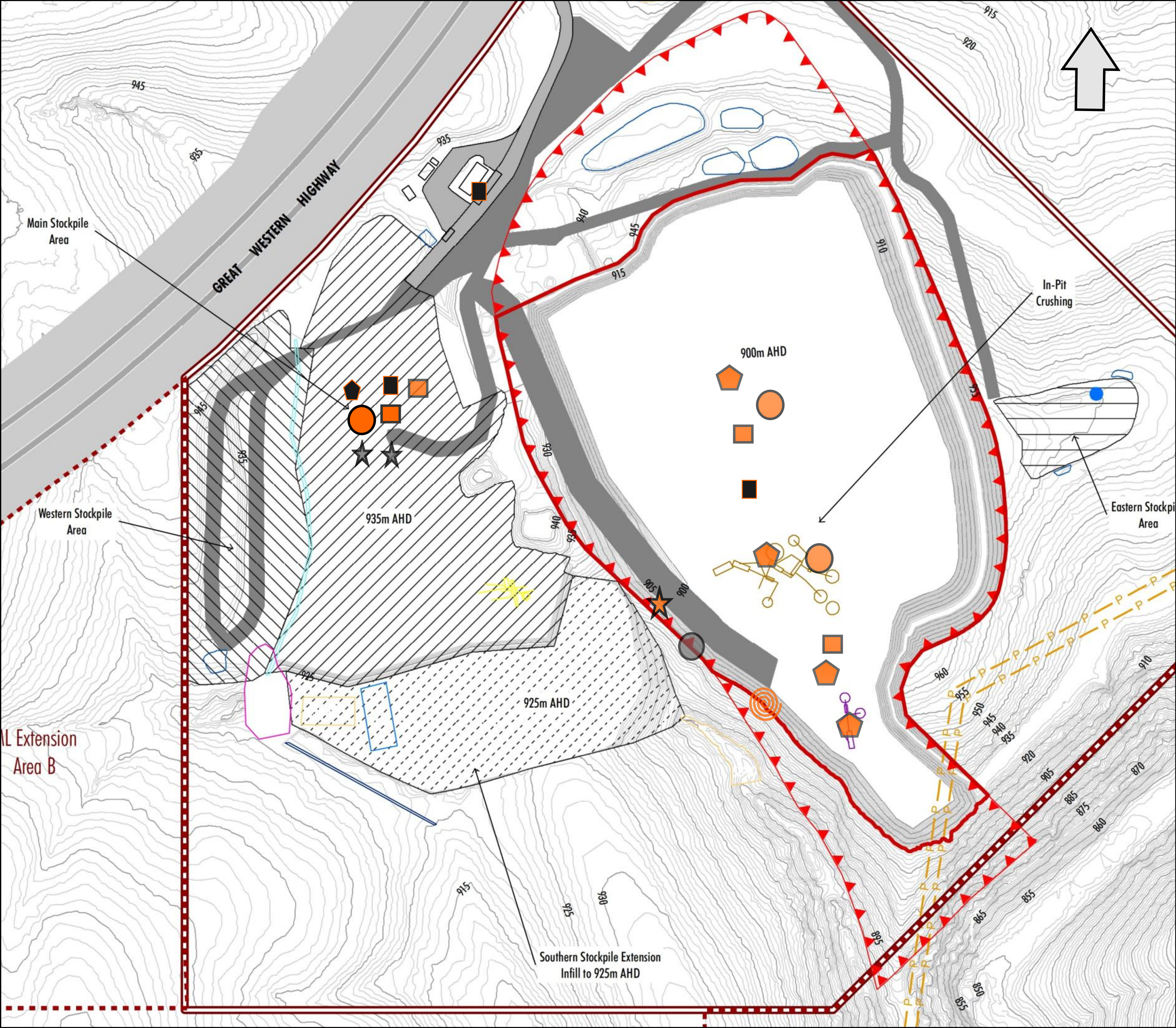
- Loader
- Excavator
- Water Cart/Haul Truck
- Dozer
- Crushing/Screening Plant
- Pugmill/Sandplant
- Drill
- Road Truck
- Manitou

MAC Muller Acoustic Consulting

FIGURE C2

SCENARIO 2 - MODELLED PLANT LOCATIONS

REF: MAC180681



Key

- Loader
- Excavator
- Water Cart/Haul Truck
- Dozer
- Crushing/Screening Plant
- Pugmill/Sandplant
- Drill
- Road Truck
- Manitou

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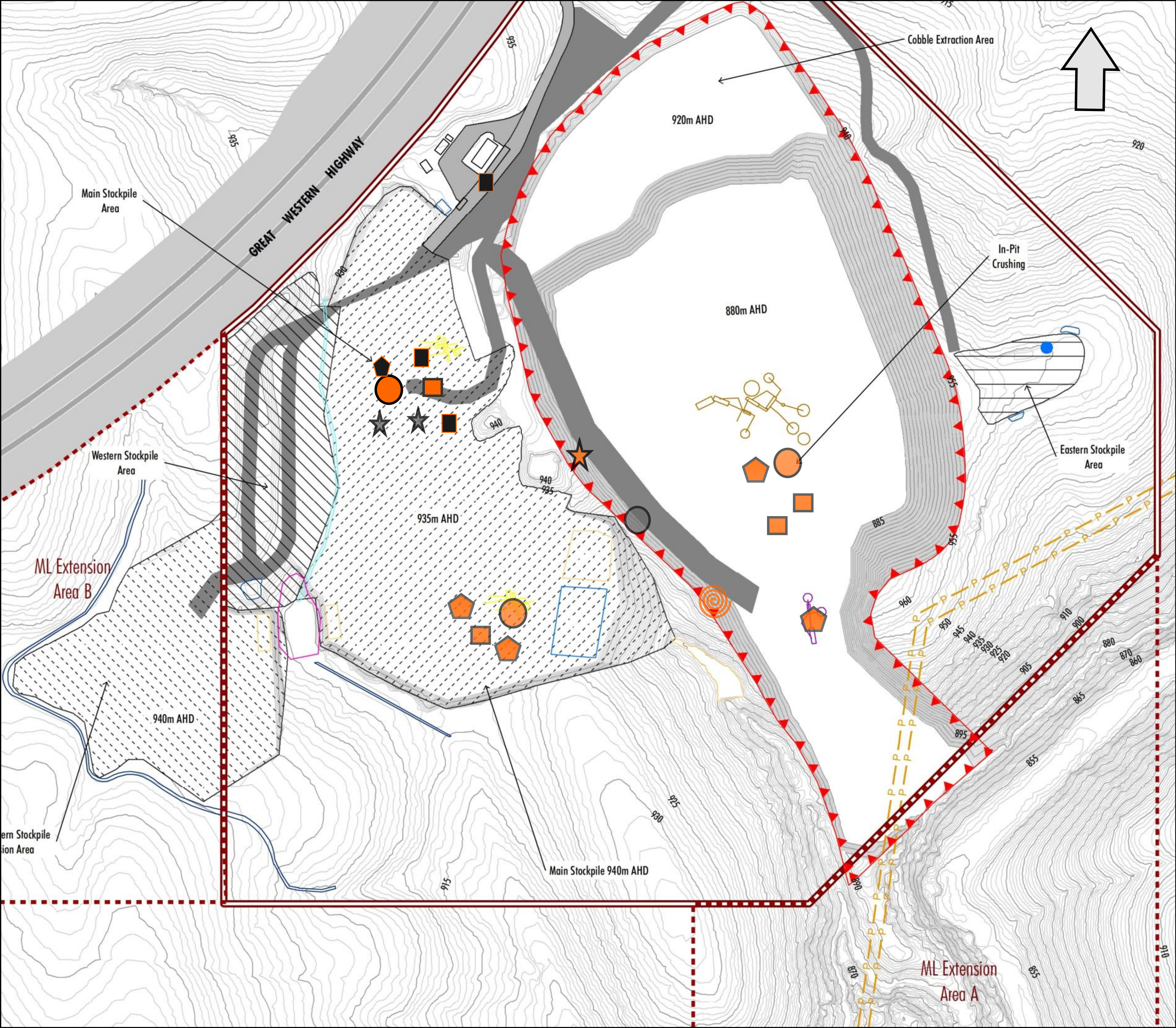

FIGURE C3

SCENARIO 3 - MODELLED PLANT LOCATIONS

REF: MAC180681

Key

- Loader
- Excavator
- Water Cart/Haul Truck
- Dozer
- Crushing/Screening Plant
- Pugmill/Sandplant
- Drill
- Road Truck
- Manitou

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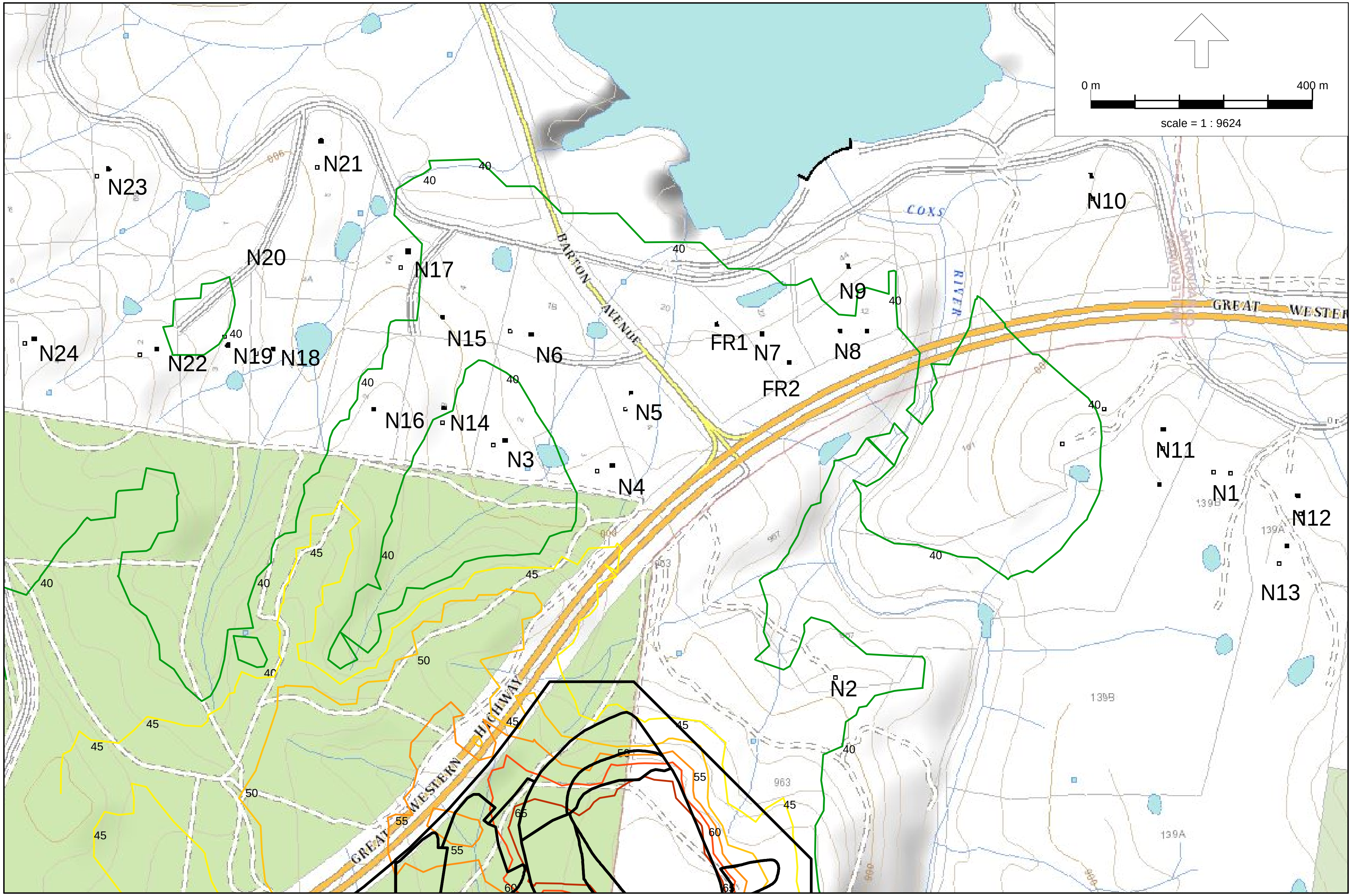
Appendix D – Noise Contours



Appendix C : Scenario 1 - Day, LAeq(15min)

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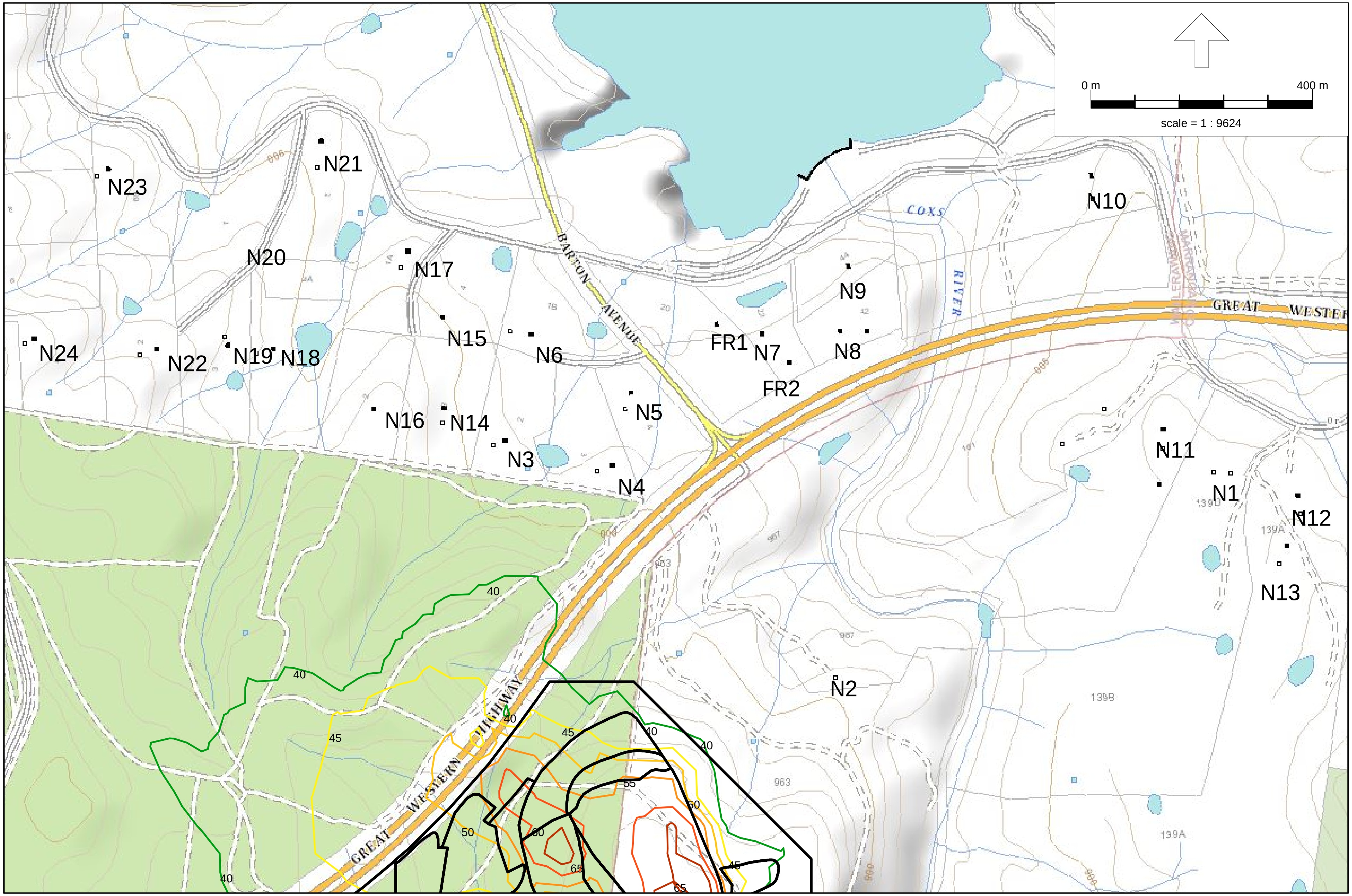
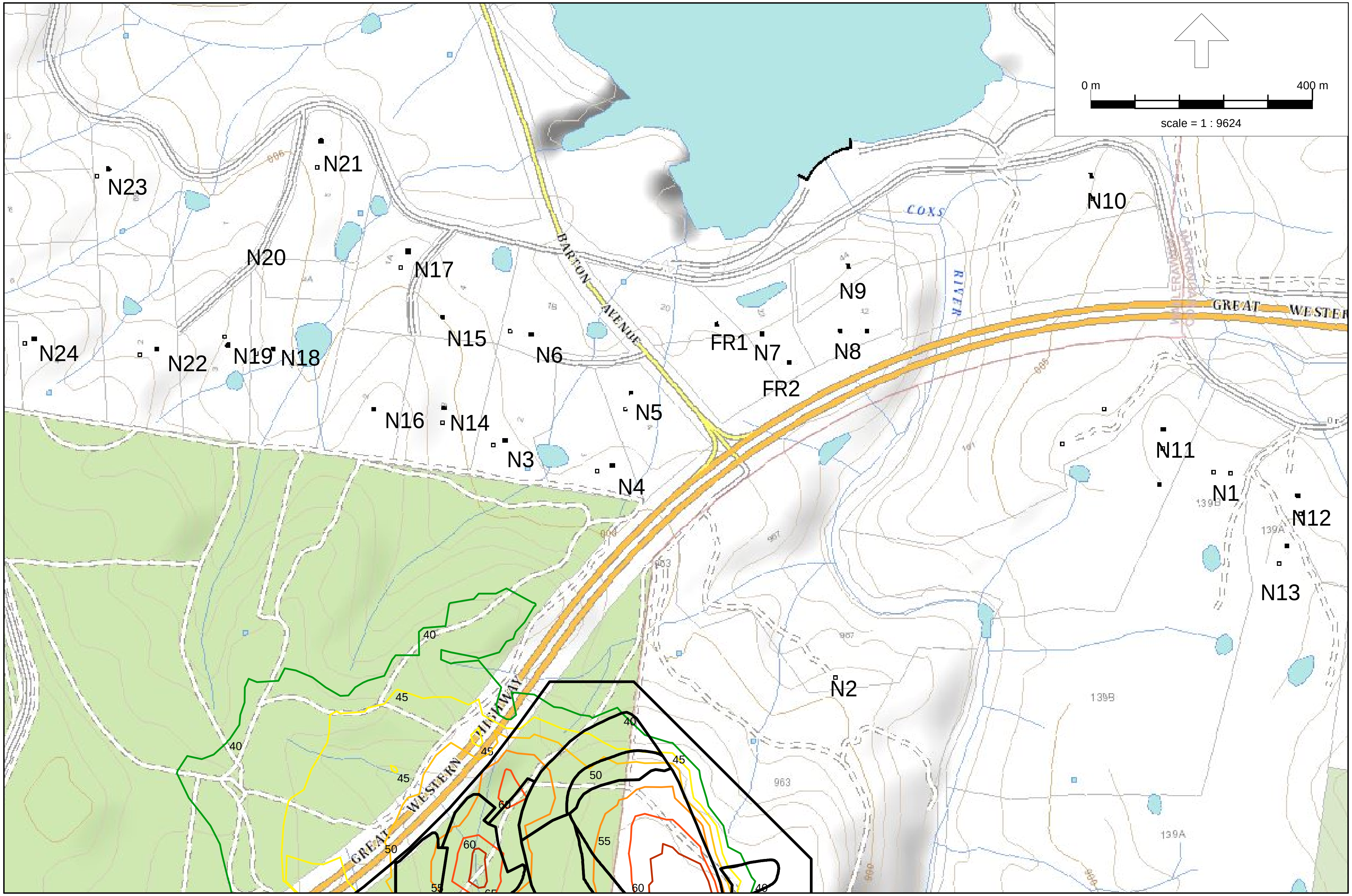
Appendix C : Scenario 1 -Night, LAeq(15min)



Muller Acoustic Consulting - Australia



Appendix C : Scenario 2 - Night, LAeq(15min)

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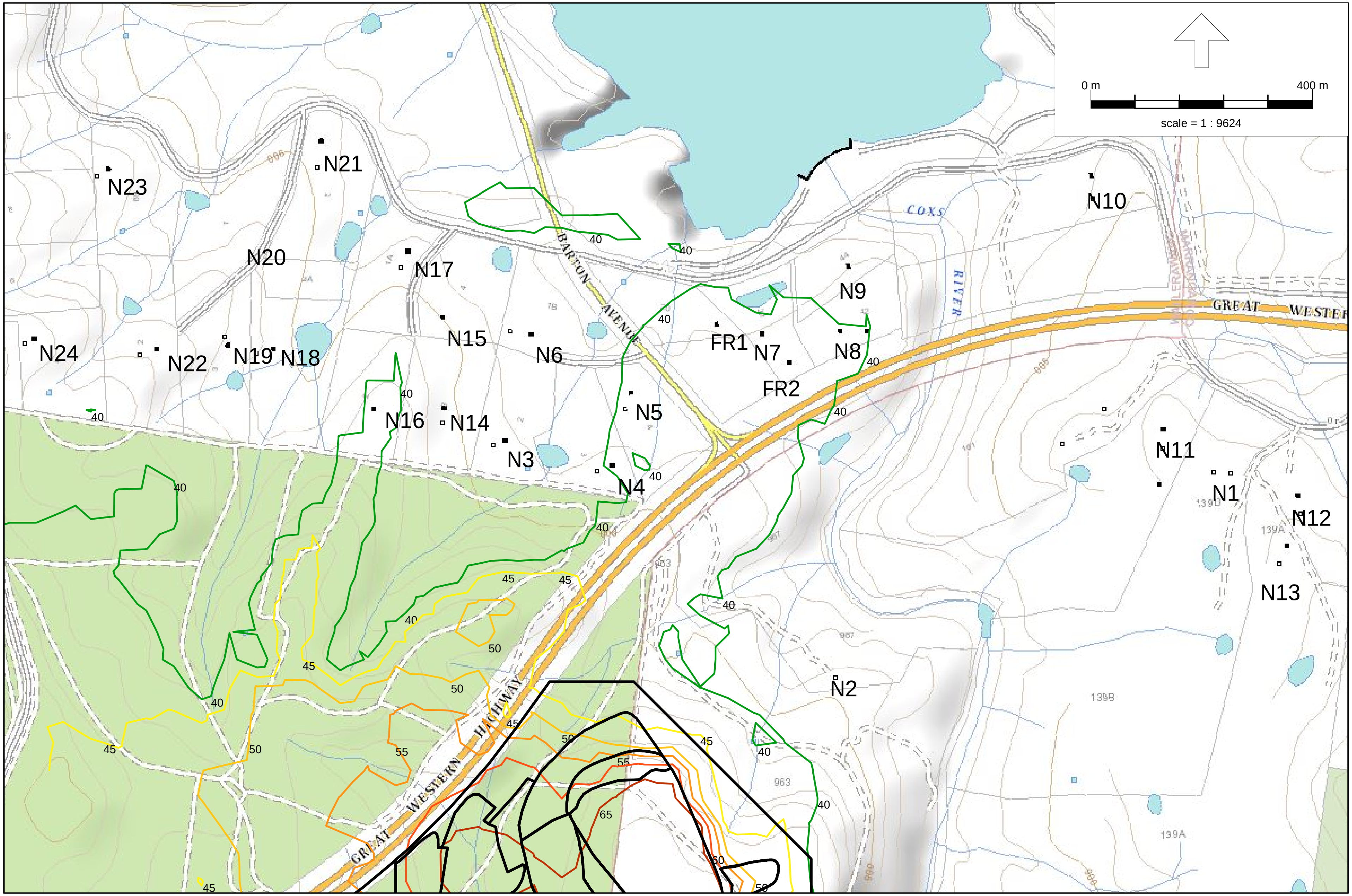
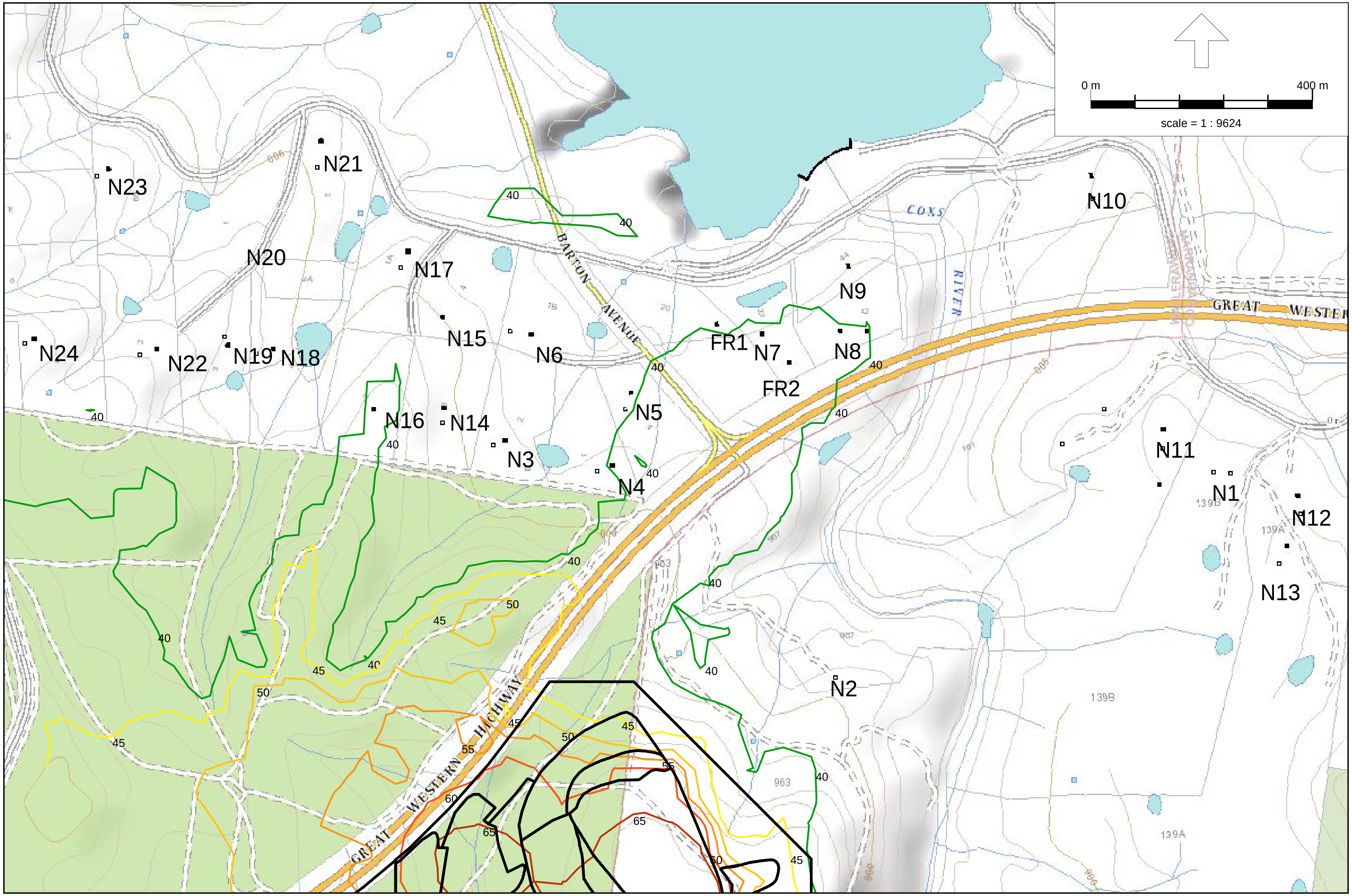
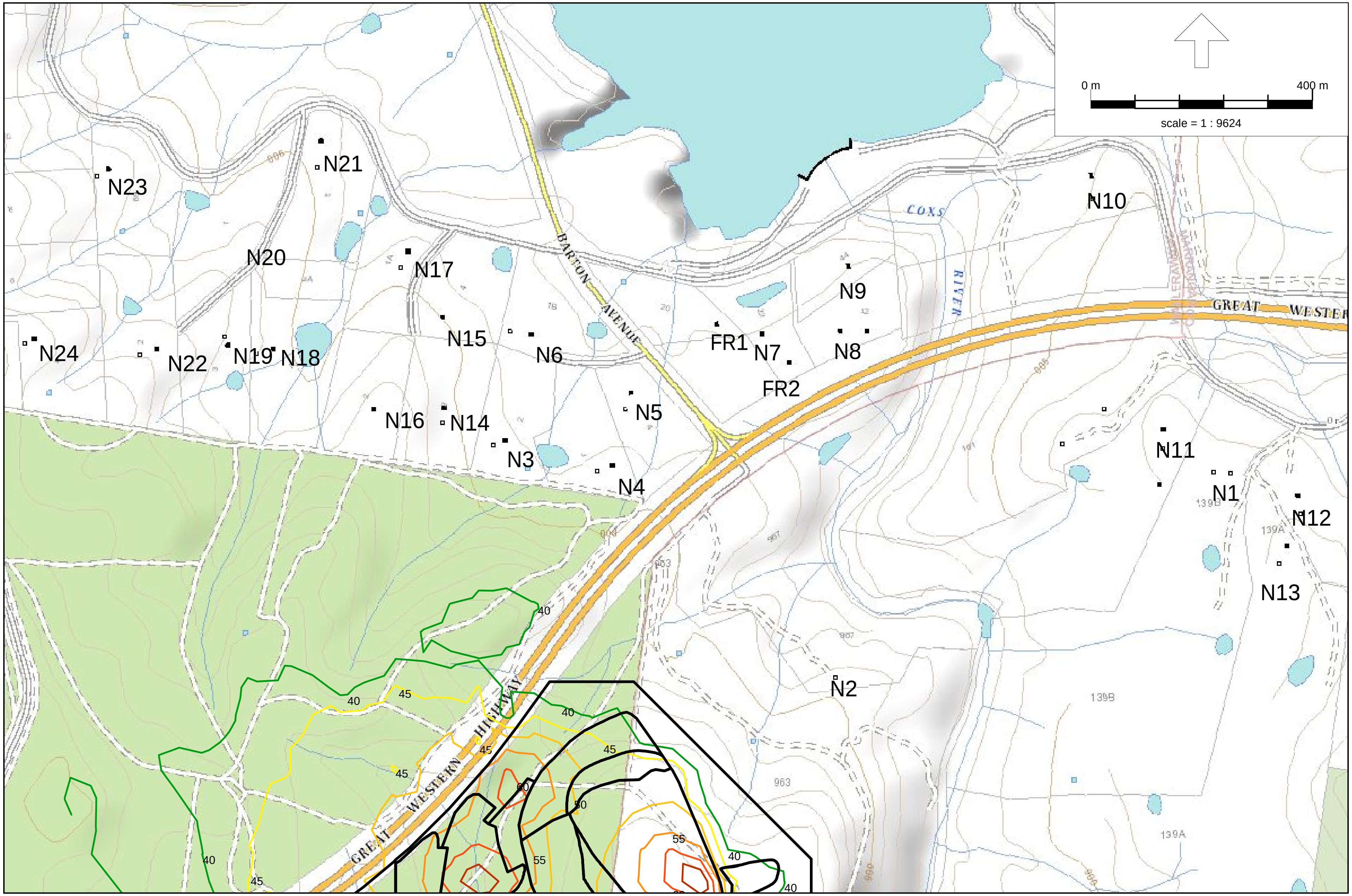
Appendix C : Scenario 2 - Day, LAeq(15min)



Muller Acoustic Consulting - Australia


0 m
400 m
scale = 1 : 9624
N1
N2
N3
N4
N5
N6
N7
N8
N9
N10
N11
N12
N13
N14
N15
N16
N17
N18
N19
N20
N21
N22
N23
N24
FR1
FR2
BARTON AVENUE
COXS RIVER
GREAT WESTERN HIGHWAY
40
45
50
55
60
65

Appendix C : Scenario 3 - Night, LAeq(15min)



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APPENDIX 11

Air Quality Impact Assessment

Intended for
Walker Quarries Pty Ltd

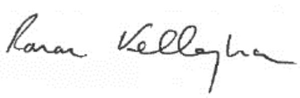
Document type
Report

Date
May 2019

Project No.
318000514

WALLERAWANG QUARRY MODIFICATION
AIR QUALITY ASSESSMENT

WALLERAWANG QUARRY MODIFICATION
AIR QUALITY ASSESSMENT

Revision	Date	Made by	Checked by	Approved by	Signed
Final V1	29/05/2019	R. Kellaghan	M. Parsons	V. Sedwick	

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www.ramboll.com

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1. INTRODUCTION

The Wallerawang Quarry ("the Quarry") is located at 963 Great Western Highway, to the south of Wallerawang and approximately 8km northwest of Lithgow in New South Wales (NSW) (**Figure 1-1**). The Quarry is owned and operated by Walker Quarries Pty Ltd (the Applicant), a subsidiary company of Sitegoal Pty Ltd, under development consent DA 344-11-2001.

An application to modify the consent is sought to secure Quarry operations for the next 30 years and involves the following key components.

- Extension of the approved extraction area to increase the quartzite which can be recovered and incorporate additional resources to quartzite, namely, hornfels, sandstone and cobble conglomerate from which a wider variety of products can be produced.
- Extension to the stockpiling areas on the Quarry Site to accommodate both an increase in overburden materials generated by the increased extraction area and additional Quarry products.
- Modifications to water diversion, capture and storage on the Quarry Site to accommodate the extended stockpile areas and improve the water security of the Quarry.
- Extension to the current limit on Quarry operations from July 2020 to July 2050.

This Air Quality Assessment (AQA) forms part of a Statement of Environment Effects (SEE), which has been prepared to support the Proposed Modification application.

1.1 Overview of modification

The modified Quarry Site Layout, identifying the key modifications, is shown in **Figure 1-2**. The Proposed Modification includes the following key modifications to approved Quarry operations:

- An extension to the period of consent beyond July 2020 to allow for the recovery of the remaining resource approved currently by DA 344-11-2001, as well as an extension of this resource proposed by an extension to the extraction area. Based on an additional 12 to 15 Mt of extractable resource (including quartzite, hornfels, sandstone and conglomerate pebbles), an extension of 30 years (to July 2050) is sought.

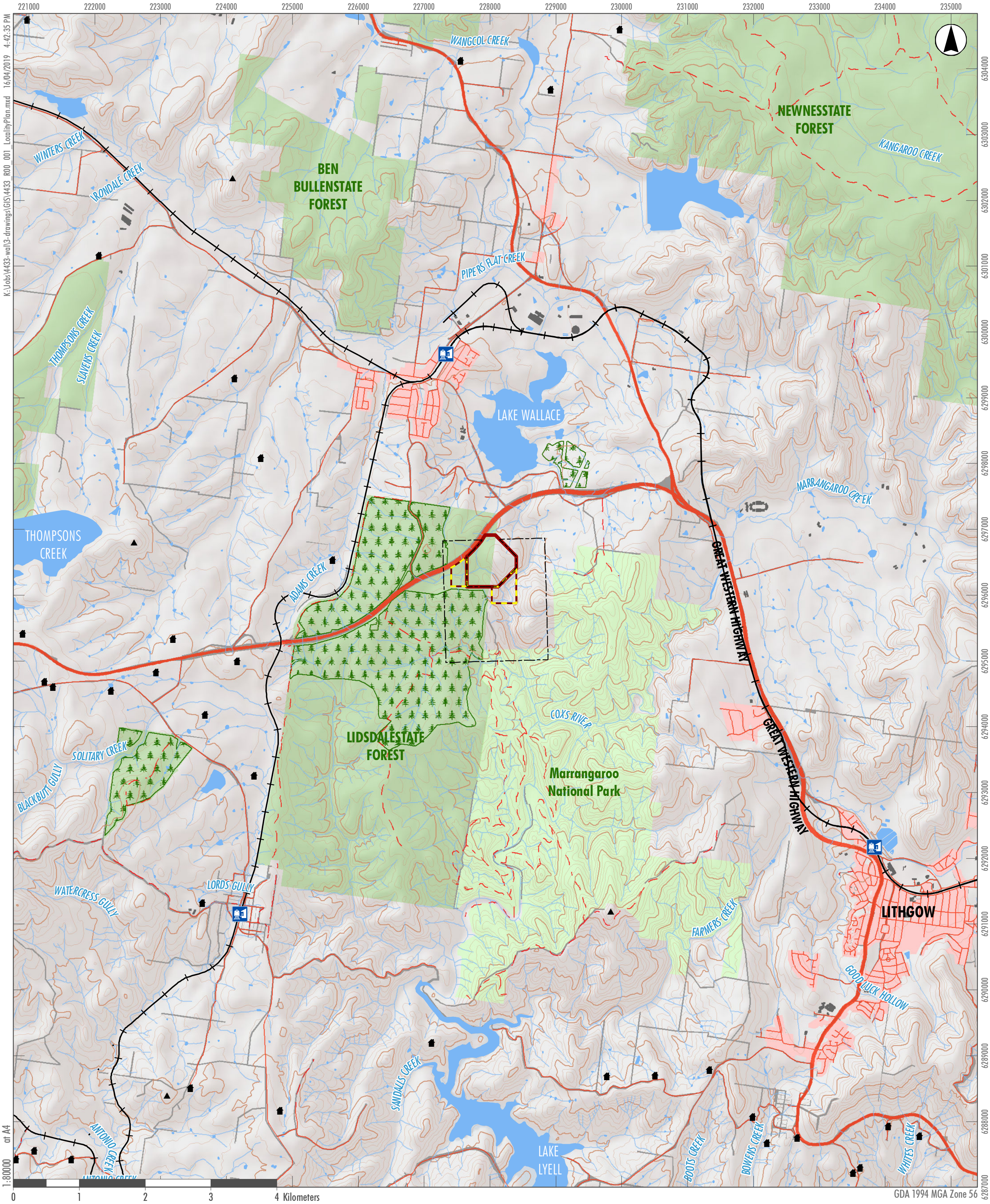
- An extension to the extraction area which would increase the surface area of extraction from 6.5 to 13.3 ha, depth of extraction from 930m AHD to 860m AHD, and allow for the extraction of non-quartzite materials including hornfels and sandstone (to the east of the approved extraction area) and cobble conglomerate (to the northern of the approved extraction area). Extraction would continue to be by standard drill and blast methods.

- An extension to the stockpile areas of the Quarry Site to allow for the maintenance of the increased type and volume of Quarry products, as well as the effective use of overburden which occurs either above or interbedded within the quartzite, hornfels and other resources of the extended extraction area.

- Modification to the approved water management system of the Quarry, required as a result of the modified stockpile area construction. The Proposed Modification involves the diversion of ephemeral, second order watercourses around the extended stockpile areas, as well as the construction of an additional water storage dam for the harvesting and storage of water (required for processing and dust suppression).

There is no proposed change to the annual production limit of 500,000 tonnes per annum (tpa). It is noted that the crushing components of the processing operations are currently being undertaken within the extraction area, however, these may also be undertaken on the stockpile areas of the Quarry Site.

umwelt



Legend

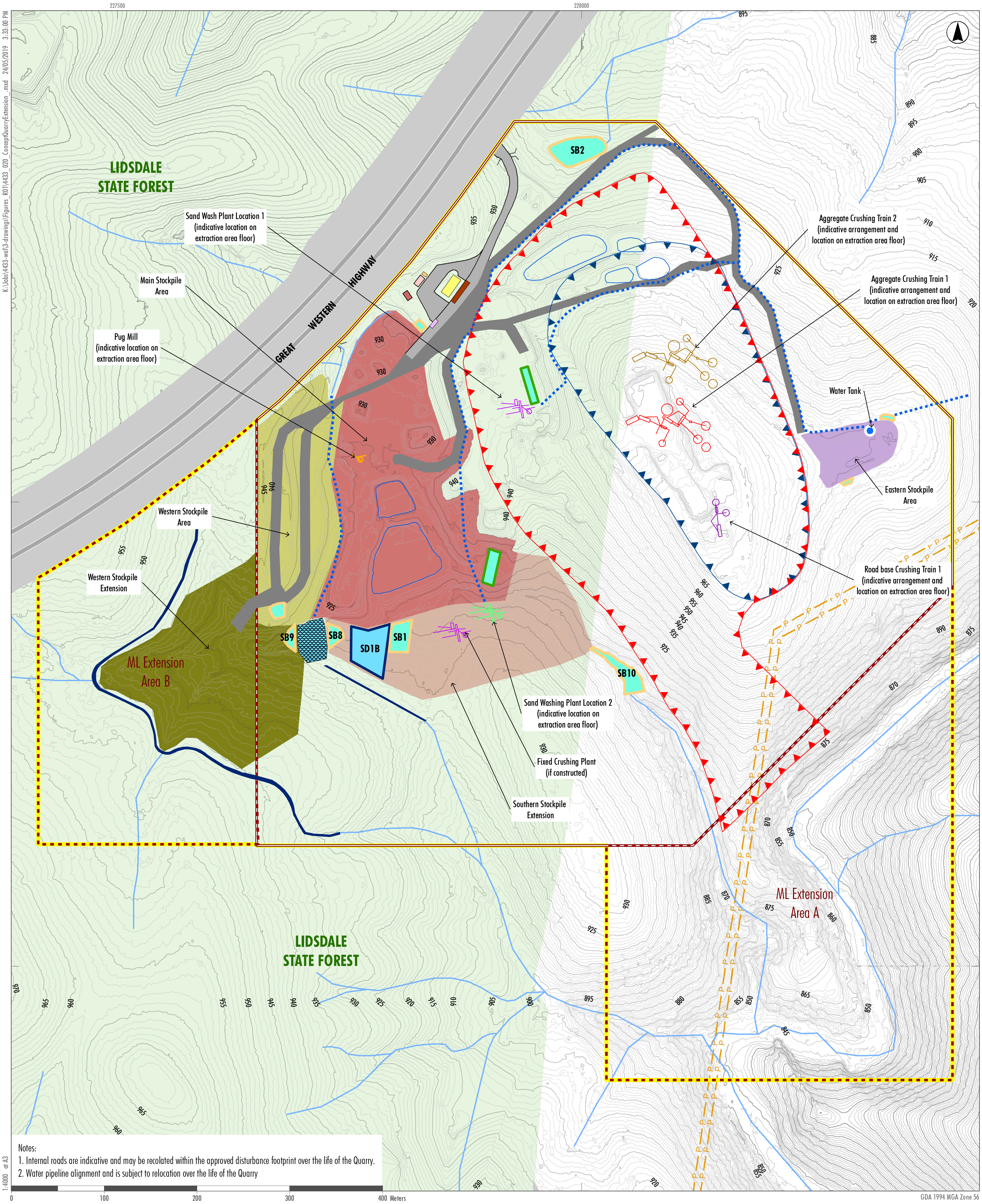
- Quarry Site - ML1633
- Proposed Quarry Site Extension
- EL 4473
- State Forest
- NPWS Estate

FIGURE 1.1

Locality Plan

Note:

Image Source: Copyright:© 2014 Esri Data source:



Legend

Project Site
Quarry Site (ML1633)
Quarry Site Extension
Electricity Transmission Lines
Clean Water Drainage
State Forest

Site Infrastructure
Amenities
Site Meeting Room
Site Office
Site Workshop
Vehicle Washdown Area
Weighbridge
Sealed Internal Roads
Indicative Internal Roads

Indicative Plant Infrastructure Locations
Aggregate Crushing Train 1
Aggregate Crushing Train 2
Fixed Crushing Plant (if constructed)
Pug Mill
Road base Crushing Train 1
Sand Wash Plant

Approved & Proposed Quarry Layout
Approved Extraction Area
Proposed Extraction Area
Main Stockpile Area (935m AHD)
Southern Stockpile Extension (935m AHD)
Western Stockpile Area
Western Stockpile Extension (940m AHD)
Eastern Stockpile Area

Water Management Infrastructure (Proposed)
Clean Water Diversion
Sediment Basins
Settlement Ponds
Storage Dam
Water Tank
Rubbled Lined Clean
Existing Dams & Sediment Basins
Water Pipeline (Indicative)
Clean Water Drainage

FIGURE 2.1

Modified Quarry Site Layout

Data source: Walker Quarries (2019); Umwelt (2019); NSW LPI DTDB (2019)

2. ASSESSMENT APPROACH

The AQA presents a quantitative assessment of potential air quality impacts, with an emphasis on emissions of particulate matter (PM), the key pollutant associated with quarrying operations. The AQA has been prepared in general accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales ("the Approved Methods") (NSW EPA, 2016) using a Level 2 assessment approach, as follows:

- Emissions are estimated for all relevant activities, using best practice emission estimation techniques.
- Dispersion modelling using a regulatory dispersion model is used to predict ground level concentrations for key pollutants at surrounding sensitive receptors.
- Cumulative impacts are assessed, taking into account the combined effect of existing baseline air quality, other local sources of emissions, reasonably foreseeable future emissions and any indirect or induced effects.

2.1 Assessment criteria

When first regulated, airborne PM was assessed based on concentrations of "total suspended particulate matter" (TSP). In practice, this typically referred to PM smaller than about 30-50 micrometres (µm) in diameter. As air sampling technology improved and the importance of particle size and chemical composition become more apparent, ambient air quality standards have been revised to focus on the smaller particle sizes, thought to be most dangerous to human health. Contemporary air quality assessment typically focuses on "fine" and "coarse" inhalable PM, based on health-based ambient air quality standards set for PM_{10} and $PM_{2.5}$[1].

Air quality criteria for PM in Australia are given for particle size metrics including TSP, PM_{10} and $PM_{2.5}$. The 2016 update to the 'Approved Methods', gazetted on 20 January 2017, includes particle assessment criteria that are consistent with revised National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) national reporting standards (National Environment Protection Council [NEPC], 1998; NEPC, 2015).

For the purpose of this report, predicted ground level concentrations (GLCs) are assessed against the NSW EPA's impact assessment criteria presented in **Table 2-1**.

The revised AAQ NEPM also establishes long-term goals for $PM_{2.5}$ to be achieved by 2025 (NEPC, 2015). It is noted that the purpose of the AAQ NEPM is to attain *'ambient air quality that allows for the adequate protection of human health and wellbeing'*, and compliance with the AAQ NEPM is assessed through air quality monitoring data collected and reported by each state and territory. The long-term goals for $PM_{2.5}$ are therefore not applicable to the assessment of impacts of emissions sources on individual sensitive receptors, and are shown in **Table 2-1** for information only.

Table 2-1: Impact assessment criteria for PM

PM metric	Averaging period	Concentration (µg/m^3)	Purpose of goal
TSP	Annual	90	Impact assessment criteria
PM_{10}	24 hour	50	
	Annual	25	
$PM_{2.5}$	24 hour	25	
	Annual	8	

Note: µg/m^3 = micrograms per cubic metre.

[1] Particulate matter with an aerodynamic diameter of less than 10 µm and 2.5 µm respectively.

The Approved Methods also prescribes nuisance-based goals for dust deposition, which relate to amenity type impacts such as soiling of exposed surfaces. The NSW EPA impact assessment criteria for dust deposition are summarised in **Table 2-2**, illustrating the maximum increase and total dust deposition rates which would be acceptable so that dust nuisance can be avoided.

Table 2-2: Dust deposition criteria

Pollutant	Averaging period	Maximum Increase in Dust Deposition	Maximum Total Dust Deposition Level
Deposited dust (assessed as insoluble solids)	Annual	2 g/m^2/month	4 g/m^2/month

Note: g/m^2 = grams per square metre.

The Approved Methods specifies that the impact assessment criteria for 'criteria pollutants[2]' are applied at the nearest existing or likely future off-site sensitive receptor and compared against the 100th percentile (i.e. the highest) dispersion modelling prediction. Both the incremental and cumulative impacts need to be considered (consideration of existing ambient background concentration is required).

2.2 Dispersion model selection

Local air quality impacts are modelled using AERMOD, the United States Environmental Protection Agency's (US EPA) recommended steady-state plume dispersion model for regulatory purposes. The model is designed to handle a variety of pollutant source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain. AERMOD is able to predict pollutant concentrations from point, area and volume sources in addition to 'open cut' sources.

AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006. Ausplume, a steady state Gaussian plume dispersion model developed by the Victorian EPA and recommended in the Approved Methods for simple near-field applications, is largely based on the ISC model. AERMOD has replaced Ausplume as the regulatory model for EPA Victoria (EPA Victoria, 2013) and is approved for use for extractive industries in NSW (NSW EPA (2015)[3]).

Compared to ISC and Ausplume, AERMOD represents an advanced new-generation model, which requires additional meteorological and land use inputs to provide more refined predictions. The most important feature of AERMOD, compared to ISC and Ausplume, is its modification of the basic dispersion model to account more effectively for a variety of meteorological factors and surface characteristics. In particular, it uses the Monin-Obukhov length scale rather than Pasquill-Gifford stability categories to account for the effects of atmospheric stratification. Whereas Ausplume and ISC parameterise dispersion based on semi-empirical fits to field observations and meteorological extrapolations, AERMOD uses surface-layer and boundary layer theory for improved characterisation of the planetary boundary layer turbulence structure.

Further detail on model set up, in particular the process for preparation of meteorological data in the AERMET pre-processor, is provided in **Appendix 1**.

2.3 Cumulative impacts

Cumulative impacts are assessed by combining the contribution from the Proposed Modification with the existing ambient air quality environment, described based on baseline monitoring data for the area (described in **Section 5**).

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[2] 'Criteria pollutants' is used to describe air pollutants that are commonly regulated and typically used as indicators for air quality. In the Approved Methods, the criteria pollutants are TSP, PM_{10}, nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), deposited dust, hydrogen fluoride and lead.

[3] https://majorprojects.affinitylive.com/public/c254b6926cbde2e6358bdbc1aaaca9b4/Agency%20Submission_%20EPA.pdf

2.4 Emissions from the combustion of diesel fuel

The combustion of diesel in mining equipment results in combustion-related emissions, including $PM_{2.5}$, oxides of nitrogen (NO_x), SO_2, CO, carbon dioxide (CO_2) and volatile organic compounds (VOCs). Gaseous combustion emissions from mining equipment would not result in significant off-site concentrations and are unlikely to compromise ambient air quality goals. Therefore, except for PM, combustion emissions have not been quantitatively assessed.

The US EPA AP-42 emission factors developed for fugitive sources do not separate PM emissions from mechanical processes (i.e. crustal material) and diesel exhaust (combustion), and are therefore assumed to include the diesel component of PM. However, the emissions controls (i.e. watering) are often only relevant to the crustal fraction of total PM, for example the watering of haul roads does not control the diesel component of the emissions (US EPA, 1998a). Adjustments to the emission inventories have been made to account for this and discussed further in **Appendix 2**.

3. LOCAL SETTING AND RECEPTOR LOCATIONS

The Quarry Site is located to the south of Wallerawang and approximately 8km northwest of Lithgow. The land use of the area is a mixture of cleared agricultural land, scattered forests and various industry. The Wallerawang Power Station (closed) and Mt Piper Power Station are located approximately 4km northeast and approximately 8km northwest, respectively. Existing coal operations include the Lidsdale coal siding, located approximately 4km to the north and the Springdale Colliery, located approximately 4.5km to the northeast. The Metromix Marrangaroo Quarry is located approximately 3.5km to the southeast.

The town of Wallerawang is located approximately 2km to the north while the smaller township of Marrangaroo is located approximately 3km to the east. Lake Wallace is located approximately 1.5km to the northeast.

The Quarry Site and surrounding region is defined by undulating topography, with an elevated ridgeline immediately to the southeast and the broader elevated terrain of the Great Dividing Range further to the east. A three-dimensional representation of the topography of the local area surrounding the Quarry Site is presented in **Figure 3-1**.

In addition to the towns of Wallerawang and Marrangaroo, the local area contains a number of rural residential properties situated at varying distances from the Quarry Site.

The locations of the closest privately owned and project-related residences assessed in this report are shown on **Figure 3-2**.

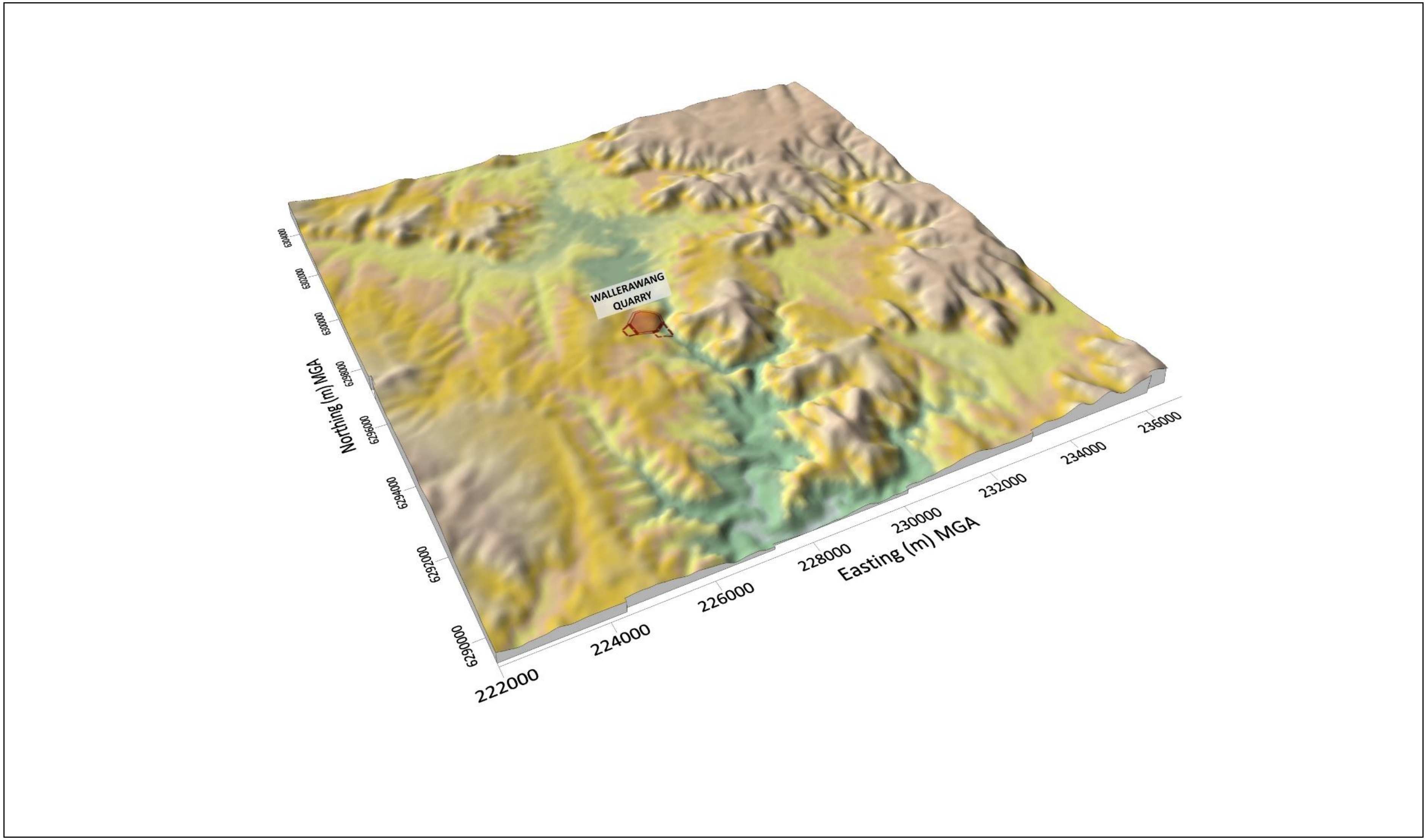


Figure 3-1: Local and regional topography

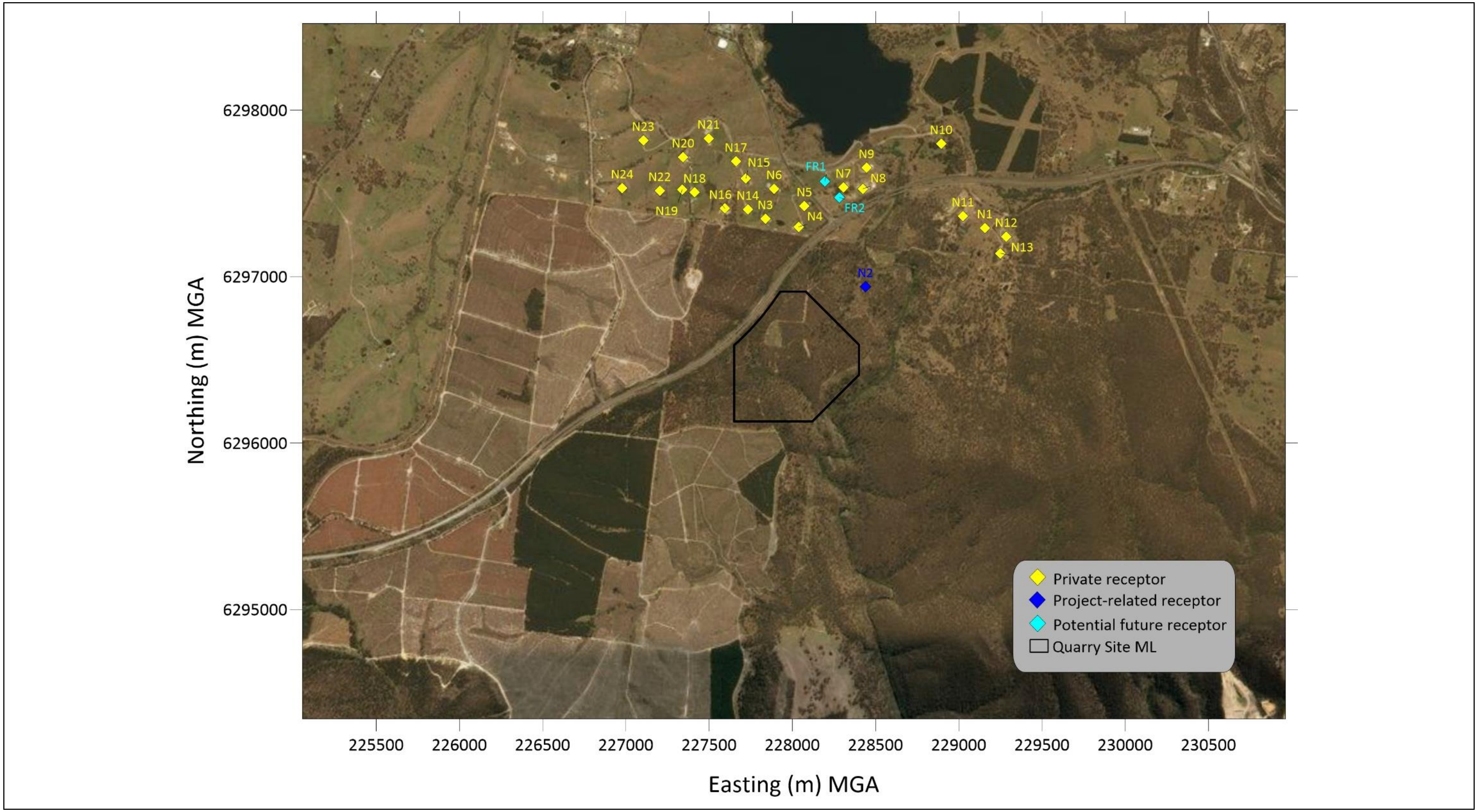


Figure 3-2: Closest receptor locations surrounding the site

4. OVERVIEW OF LOCAL AND REGIONAL METEOROLOGY

4.1 Introduction

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

Analysis of meteorology for the local area is presented based on an onsite automatic weather station (AWS), which records 15-minute averages of wind speed and direction, temperature (at 2 and 10 m), rainfall and relative humidity.

Reference is also made to the closest Bureau of Meteorology (BoM) AWS, primarily to obtain parameters not measured by the onsite station but required for modelling (i.e. cloud amount and atmospheric pressure), including:

- Marrangaroo (Defence) AWS (station number 063308) – located approximately 6km east of the Quarry Site;
- Lidsdale (Maddox Lane) AWS (station number 063132) – located approximately 5.5km northeast of the Quarry Site; and
- Mt Boyce AWS (station number 063292) – located approximately 26km southeast of the Quarry Site.

4.2 Prevailing winds

Annual wind roses for 2017 and 2018 for the onsite data are presented in **Figure 4-1** and compared with annual wind roses for the nearby Marrangaroo (Defence) AWS data for 2018[4]. Winds at the onsite station are recorded for all directions from northeast through to northwest (in a clockwise direction). There is an absence of winds from the northwest through to northeast. The Marrangaroo (Defence) AWS data is aligned more along an east-west axis.

There is a high degree of consistency in the onsite winds across the two years, with very similar wind patterns and average wind speeds (~1.9 m/s). The percentage occurrence of calm winds (<= 0.5 m/s) is higher in 2018 (11.5%) than 2017 (6.4%).

The calendar year 2018 was selected for modelling as there was available data from the nearby Marrangaroo (Defence) AWS for this year (to obtain parameters not measured by the onsite station but required for modelling).

Seasonal wind roses for daytime and night-time periods for 2018 at the onsite station are shown in **Figure 4-2**. The wind roses show lighter and more calm winds at night. There is also a seasonal variation evident in the wind direction, with less of the easterly component in winter and more of the easterly component in summer.

[4] The Marrangaroo (Defence) AWS only opened in December 2017

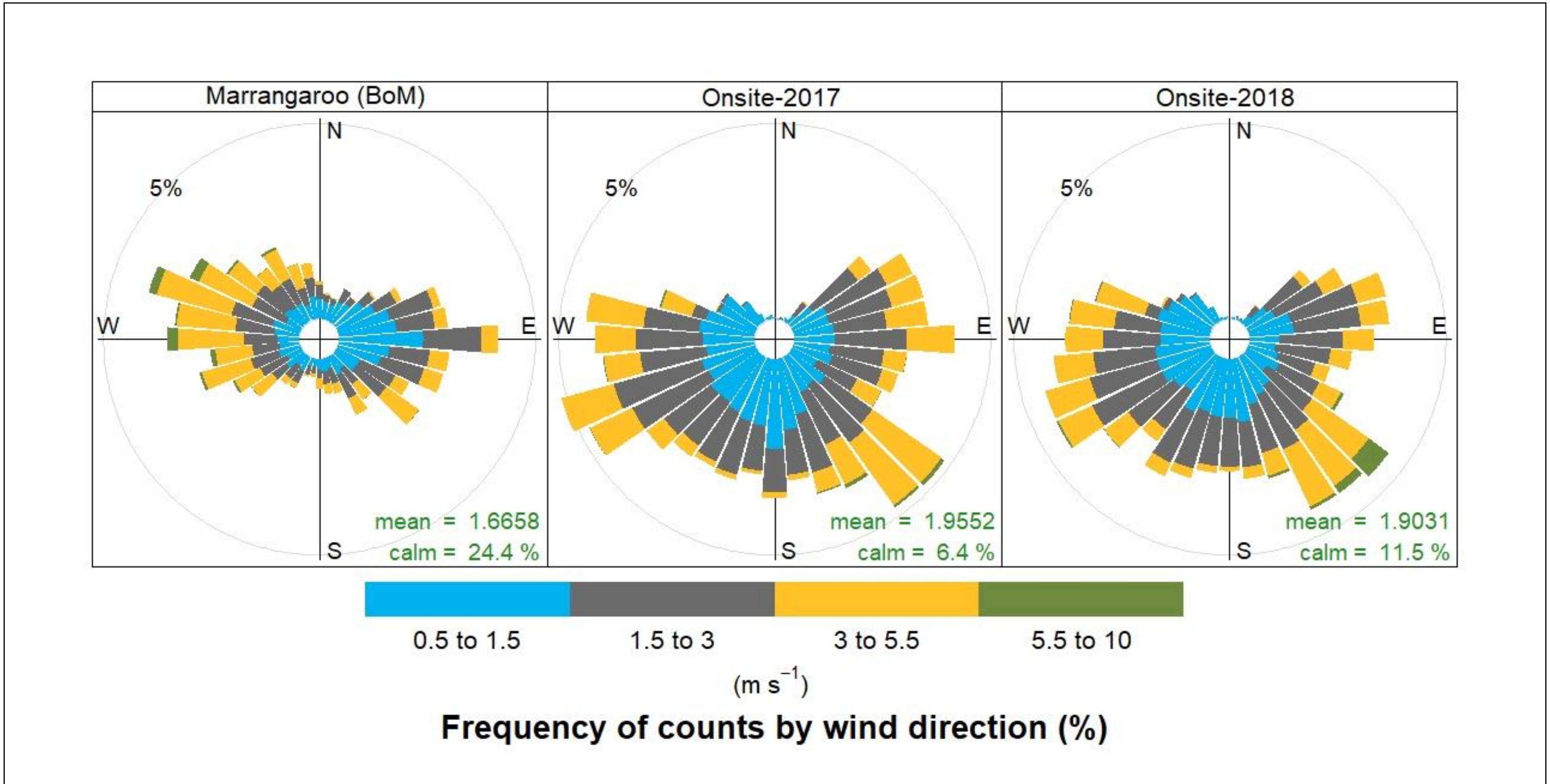


Figure 4-1: Annual wind roses for the Quarry Site and Marrangaroo (Defence) AWS

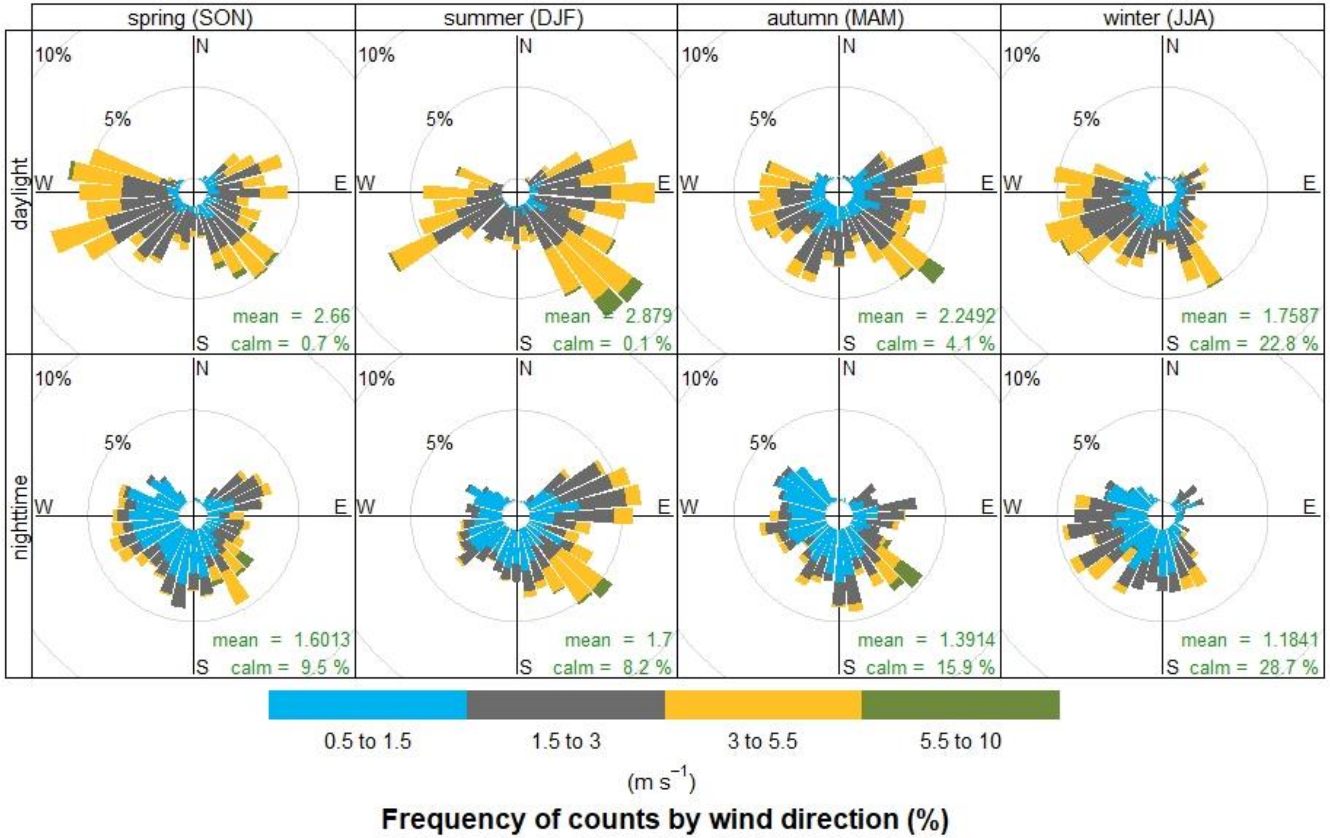
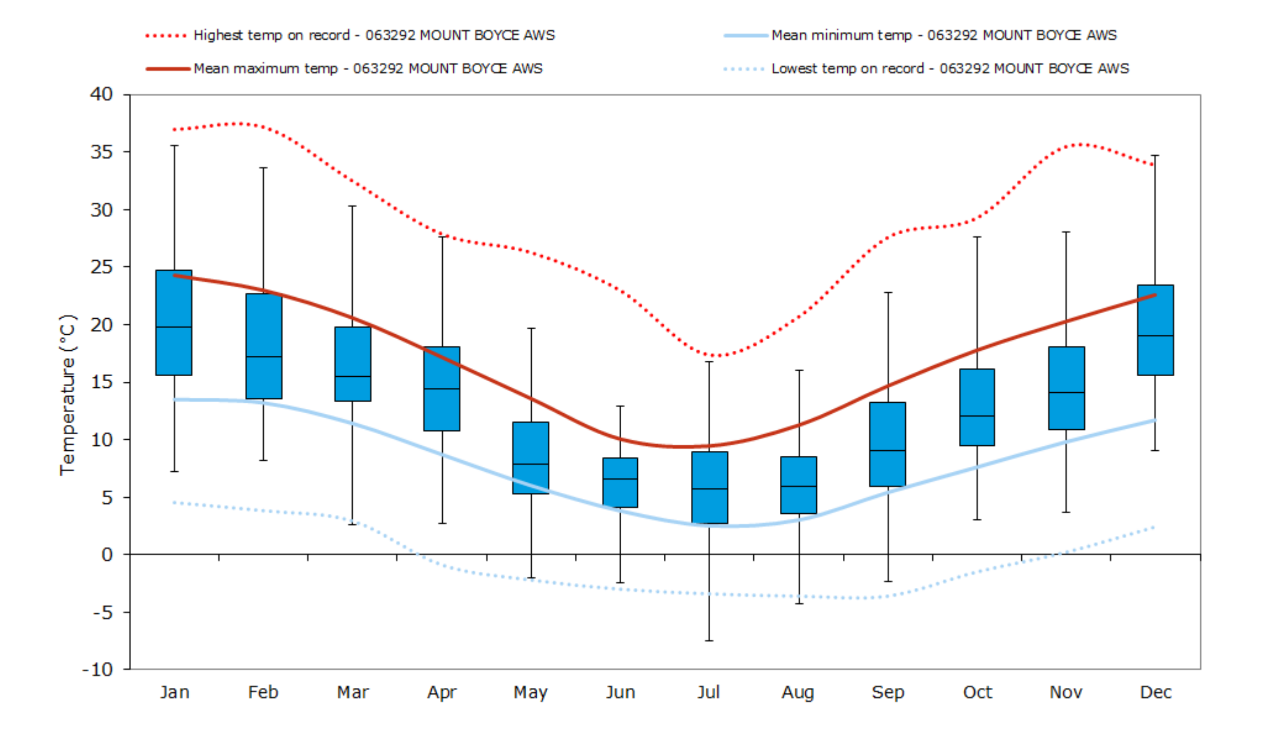


Figure 4-2: Seasonal wind roses for daytime and night time periods for the onsite station

4.3 Ambient temperature

The minimum, maximum, mean and upper and lower quartile temperatures derived from the on-site AWS for each month of the modelling period (i.e., 2018) are presented as a box and whisker plot shown in **Figure 4-3**. The 2018 data is compared with long-term records from the Mount Boyce AWS.

The plot shows that temperatures recorded during 2018 correlate well with the long-term historical trends. The upper and lower quartiles (shown by the boxes) generally fall within the long-term mean minimum and maximum temperature, while the highest and lowest temperatures for 2018 (shown by the whiskers) are also comparable with the long-term minimum and maximum for each month.



2018 onsite data are illustrated by the 'box and whisker' plot. Boxes indicate 25th, median and 75th percentile temperature values while upper and lower whiskers indicate maximum and minimum values.

Figure 4-3: Comparison of long-term temperature records with 2018 data from the on-site AWS

4.4 Rainfall

Precipitation is important to air pollution since it impacts on dust generation potential and represents a removal mechanism for atmospheric pollutants. Fugitive emissions may be harder to control during low rainfall years while drier periods may also result in more frequent dust storms and bushfire activity, resulting in higher regional background dust levels. Rainfall also acts as a removal mechanism for dust, lowering pollutant concentrations by removing them more efficiently than during dry periods.

Based on historical data recorded at Lidsdale, rainfall for the region is considered moderate. Average annual rainfall records indicate the area receives approximately 758mm. Rainfall is relatively consistent throughout the year, with slightly higher rainfall experienced during the summer months than the remainder of the year.

Analysis of the local data for 2018 shows that the measured rainfall for the modelling period is less than the long-term average (~700mm for 2018). To provide a conservative (upper bound) estimate of the PM concentrations, wet deposition (removal of particles from the air by rainfall) was excluded from the dispersion modelling simulations undertaken in this report.

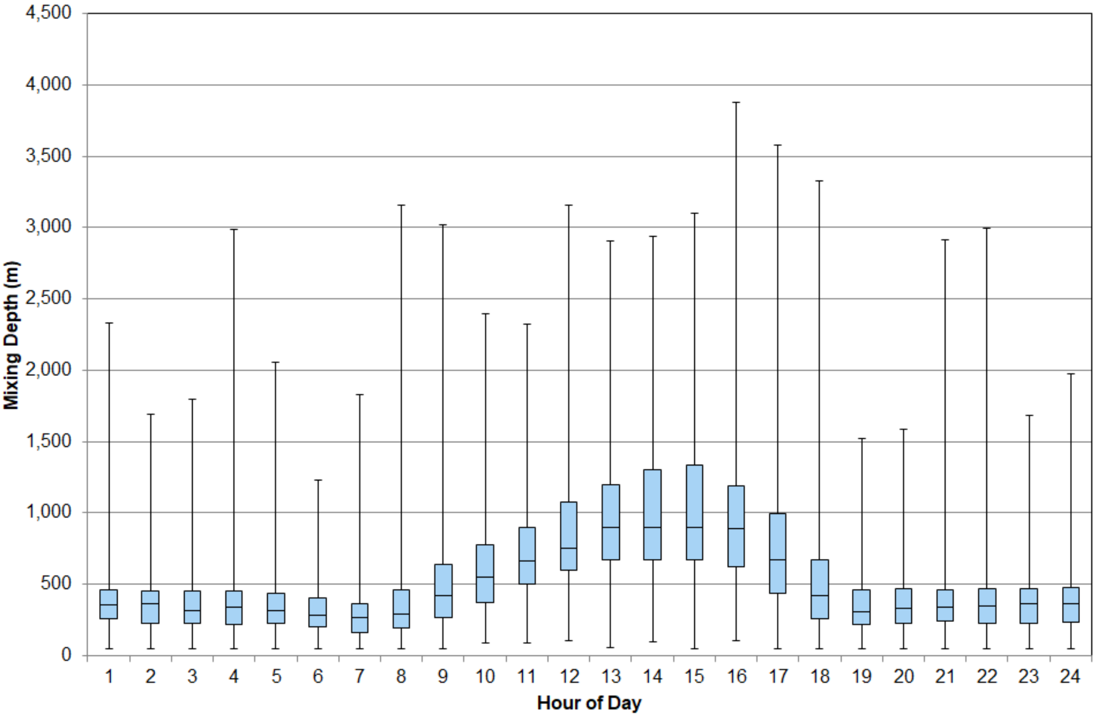
4.5 Boundary layer heights

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of air flow due to the frictional drag of the earth's surface (mechanical mechanisms), or as result of the heat and moisture exchanges that take place at the surface (convective mixing) (Stull, 1997; Oke, 2003).

During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated subsidence inversion. Elevated inversions may occur for a variety of reasons including anticyclonic subsidence and the passage of frontal systems. Due to radiative flux divergence, nights are typically characterised by weak to no vertical mixing and the predominance of stable conditions. These conditions are normally associated with low wind speeds and hence lower dilution potentials.

Hourly-varying atmospheric boundary layer heights were generated for modelling by AERMET, the meteorological processor for the AERMOD dispersion model, using a combination of surface observations from the on-site weather station and an adjusted TAPM-predicted upper air temperature profile (further discussion provided in **Appendix 1**).

The variation in average boundary layer heights by hour of the day is illustrated in **Figure 4-4**. It can be seen that greater boundary layer heights are experienced during the day time hours, peaking in the mid to late afternoon. Higher day-time wind velocities and the onset of incoming solar radiation increases the amount of mechanical and convective turbulence in the atmosphere. As turbulence increases, so too does the depth of the boundary layer, generally contributing to higher mixing depths and greater potential for atmospheric dispersion of pollutants.



Lower, middle and upper box markers indicate 25th percentile, median and 75th percentile of AERMET-generated mixing height data respectively, while upper and lower whiskers indicate maximum and minimum values.

Figure 4-4: AERMET-generated hourly variations in average boundary layer depth

4.6 Atmospheric stability

Atmospheric stability refers to the degree of turbulence or mixing that occurs on the atmosphere and is a controlling factor in the rate of atmospheric dispersion of pollutants. The Monin-Obukhov length (L) provides a measure of the stability of the surface layer (i.e. the layer above the ground in which vertical variation of heat and momentum flux is negligible - typically about 10% of the mixing height). Negative L values correspond to unstable atmospheric conditions, while positive L values correspond to stable atmospheric conditions. Very large positive or negative L values correspond to neutral atmospheric conditions.

Figure 4-5 illustrates the hourly variation of atmospheric stability derived from the Monin-Obukhov length calculated by AERMET for modelling. The profile presented illustrates that atmospheric instability increases during daylight hours as convective energy increases, whereas stable atmospheric conditions prevail during the night-time. This indicates that the potential for atmospheric dispersion of emissions would be greatest during day time hours and lowest during evening through to early morning hours.

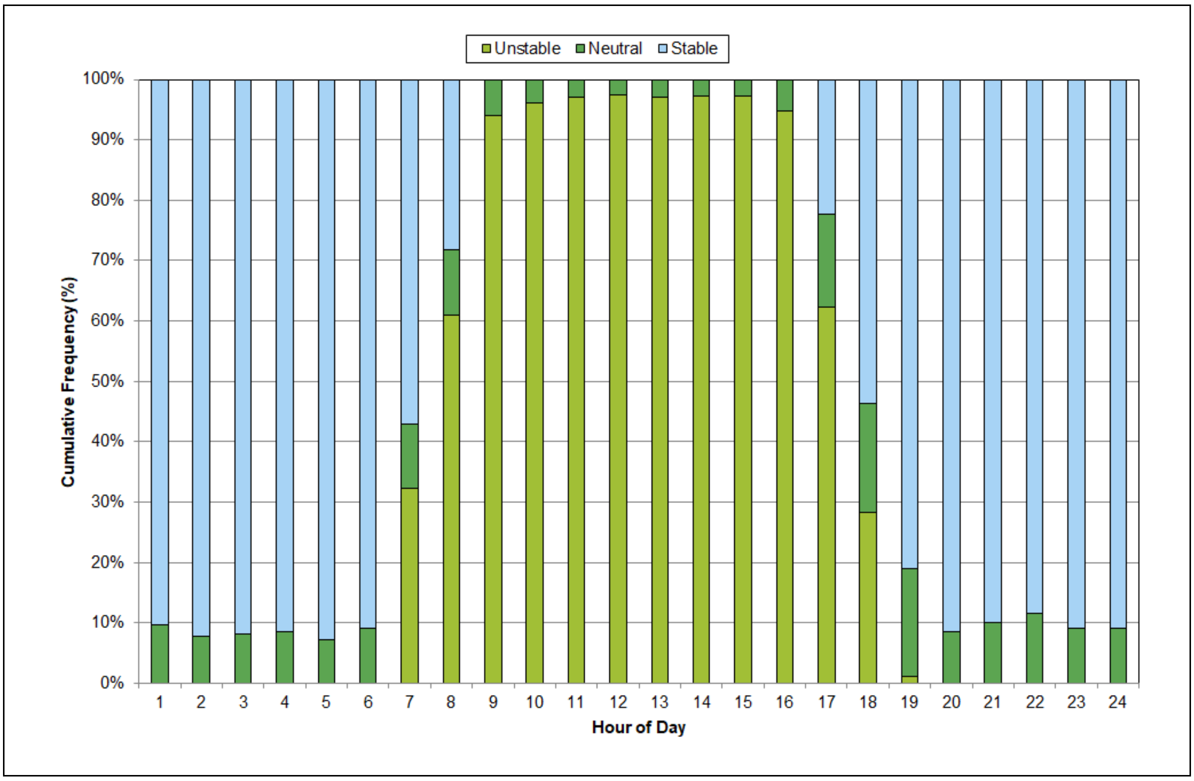


Figure 4-5: Hourly variations in AERMET-generated atmospheric stability

5. BASELINE AMBIENT AIR QUALITY

5.1 Introduction

The existing air quality environment in the vicinity of the Quarry Site is expected to be influenced by existing industry, including:

- The Mt Piper Power station located approximately 8km to the north.
- The Lidsdale coal siding located approximately 4km to the north.
- The Springdale Colliery located approximately 4.5km to the northeast.
- The Metromix Marrangaroo Quarry located approximately 3.5km to the southeast.

In addition to these specific sources, the local airshed will also be influenced by:

- Wind generated dust from exposed areas.
- Fugitive dust emissions from agricultural activities during dry conditions.
- Dust entrainment due to vehicle movements along unsealed and sealed roads.
- Seasonal emissions from household wood heaters.
- Vehicle emissions from populated areas such as Lithgow.
- Episodic emissions from vegetation fires.
- Long-range transport of fine particles into the region.

5.2 Onsite air quality monitoring data

Under DA 344-11-2001 (condition 3(14)), the Applicant is required to prepare an Air Quality Management Plan which includes an air quality monitoring program. The Air Quality Management Plan[5] developed for the Quarry Site includes the monitoring of dust deposition at four locations on and surrounding he Quarry Site.

The dust deposition monitoring results for 2018 are presented in **Table 5-1**, showing that the annual average dust deposition ranges from 1.0g/m^2/month to 2.4g/m^2/month, with an average across all sites of 1.5g/m^2/month.

Table 5-1: Wallerawang Quarry dust deposition monitoring for 2018

Month	DGS-1 (g/m^2/month)	DGS-2 (g/m^2/month)	DGS-3 (g/m^2/month)	DGS-4 (g/m^2/month)
January	2.2	0.4	0.8	0.6
February	2.6	1.1	0.6	1.0
March	0.7	1.0	1.2	0.7
April	0.6	0.6	0.8	1.0
May	0.3	0.3	2.4	0.9
June	0.1	0.3	0.1	0.2
July	0.4	0.8	1.6	1.0
August	0.7	0.9	3.9	0.9
September	0.9	1.6	0.8	0.8
October	0.2	0.4	1.6	0.4
November	3.6	1.0	12.0	3.0
December	2.7	3.3	3.5	5.1
Annual average	**1.3**	**1.0**	**2.4**	**1.3**

[5] http://walkerquarries.com.au/wp-content/uploads/2019/04/4433_R04_AQMP_April-2019_V1.pdf

5.3 Other local monitoring data

The Mt Piper Ash Placement Project Lamberts North Annual Environment Management Report (Mt Piper AEMR) reports air quality monitoring results for dust deposition, as well as PM_{10} (from the Blackmans Flat AQMS and Mt Piper Power Station TEOM) and $PM_{2.5}$ (from the Blackmans Flat AQMS). The Springvale Colliery measures dust deposition at two locations while the Lidsdale Coal Siding measures dust deposition at seven locations and PM_{10} at one location. Access to these data are not available, but summaries are provided in their Annual Reviews.

Annual average dust deposition reported in the Mt Piper AEMR across the five sites for 2018 was 1.2 g/m^2/month while annual average dust deposition reported for 2018 was, on average, 1.5 g/m^2/month at the Springvale Colliery and 1.9 g/m^2/month at the Lidsdale Coal Siding. These average dust deposition levels are similar to the levels recorded in the vicinity of the Quarry Site.

Annual average PM_{10} and $PM_{2.5}$ concentrations for the Mt Piper AEMR period at Blackmans Flat were 12.5µg/m^3 and 2.8µg/m^3 respectively, while the highest 24-hour average PM_{10} concentrations was 50µg/m^3[6]. The annual average PM_{10} concentration for 2018 at the Lidsdale Coal Siding was 14µg/m^3, while the highest 24-hour average PM_{10} concentrations was 74µg/m^3.

5.4 Overview of PM_{10} and $PM_{2.5}$ concentrations for Bathurst - 2018

The closest publicly available monitoring dataset for PM_{10} and $PM_{2.5}$ is the Bathurst air quality monitoring station, operated by the Office of Environment and Heritage (OEH) and located approximately 40km from the Quarry.

The annual average PM_{10} concentration reported in the Mt Piper AEMR is lower than Bathurst for the same period[7] (14.1µg/m^3), while the annual average $PM_{2.5}$ concentration reported in the Mt Piper AEMR is significantly lower than Bathurst for the same period (6.1µg/m^3).

Similarly, the annual average and maximum 24-hour average PM_{10} concentrations reported in the Lidsdale Coal Siding Annual Review are significantly lower than at Bathurst for 2018 (see **Table 5-2**). As the Lidsdale Coal Siding is located only 4km north of the Wallerawang Quarry, the Bathurst monitoring data is therefore considered a suitable, and conservatively high, background dataset for cumulative assessment, and would account for all existing emission sources in the area.

Summary statistics for the Bathurst monitoring site for 2018 (the modelled year) are presented in **Table 5-2**. When compared with the previous five years of monitoring data at Bathurst, the annual average and 24-hour average PM_{10} and $PM_{2.5}$ concentrations for 2018 are significantly higher[8]. It is noted that 2018 was dominated by very dry conditions, the driest since 2002, and reduced landcover, resulting in higher ambient dust concentrations across much of NSW[9]. This makes 2018 a conservative dataset for use as background.

Table 5-2: Summary statistics for PM_{10} and $PM_{2.5}$ concentrations (µg/m^3) at Bathurst (2018)

Metric	Annual mean	Criteria	Max 24-hour average	Criteria	Days above the criteria	Highest 24-hour average concentration not above the criteria
PM_{10}	18.8	25	274.1	50	8	49.7
$PM_{2.5}$	7.0	8	40.5	25	2	22.1

6 These measurements are from a High Volume Air Sampler (HVAS), which are typically run on a one-day-in-six run cycle. As the measurement is not continuous, it does not always represent a true annual average or accurate indication of the number of days above the criteria.

7 September 2017 – August 2018

8 https://www.environment.nsw.gov.au/AQMS/search.htm

9 http://www.bom.gov.au/climate/current/annual/nsw/summary.shtml

Timeseries plots of the 24-hour average PM_{10} and $PM_{2.5}$ concentrations measured at Bathurst in 2018 are presented in **Figure 5-1** and **Figure 5-2**. The periods when the 24-hour average PM_{10} and $PM_{2.5}$ concentrations are above the impact assessment criteria (red dash line) are clearly shown.

The daily varying 24-hour PM_{10} concentrations shown in **Figure 5-1** and **Figure 5-2** are paired with each daily modelling prediction for cumulative assessment. The only exception to this is when the background measurement is already above the impact assessment criteria. The highest 24-hour average concentrations not above the criteria are shown in in **Table 5-2** and these will therefore be utilised in the cumulative assessment to represent the highest background 24-hour average concentrations.

This approach is consistent with the guidance provided in Section 5.1.3 of the Approved Methods for dealing with elevated background concentrations.

5.5 TSP concentrations

Annual average TSP concentrations are not reported in the Mt Piper AEMR and have not been measured at Bathurst; however annual average TSP concentrations can be derived from the Bathurst data, based on typical ratios of PM_{10}/TSP, which would typically range from 0.4 to 0.5 for rural areas. A PM_{10}/TSP ratio of 0.4 has been applied to the annual average PM_{10} concentration (of 18.8 µg/m³) to derive a conservatively high TSP background concentration of 47.1 µg/m³.

5.6 Adopted background for cumulative assessment

As described above, the Bathurst 2018 dataset is considered a conservatively high background for cumulative assessment. Given the dust deposition levels recorded in the vicinity of the Quarry Site are similar in magnitude to other local monitoring, an average value of 1.5 g/m²/month has therefore been utilised for the cumulative assessment.

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

- 24-hour PM_{10} concentration – daily varying with a maximum of 49.7µg/m³.
- Annual average PM_{10} concentration – 18.8µg/m³.
- 24-hour $PM_{2.5}$ concentration – daily varying with a maximum of 22.1µg/m³.
- Annual average $PM_{2.5}$ concentration – 7.0µg/m³.
- Annual average TSP concentration – 47.1µg/m³.
- Annual average dust deposition – 1.5g/m²/month.

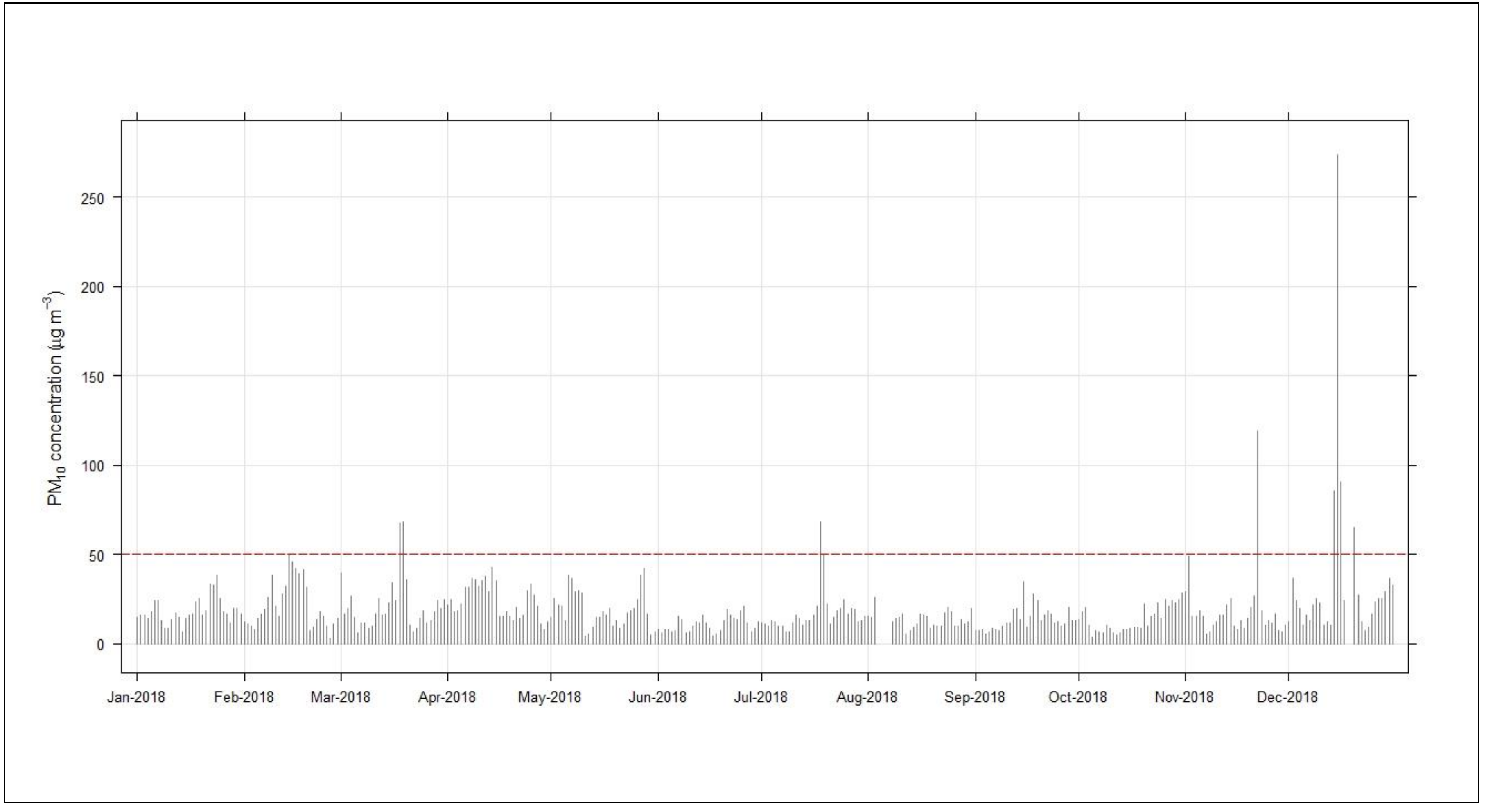


Figure 5-1: 24-hr average PM_{10} concentration – Bathurst 2018[10]

[10] Gaps in the dataset are filled using a simple linear regression analysis. All available PM_{10} and $PM_{2.5}$ data are plotted and the linear relationship between PM_{10} and $PM_{2.5}$ is derived. Where PM_{10} data are missing and $PM_{2.5}$ data are available, this linear relationship is used to 'fill' the missing PM_{10} data.

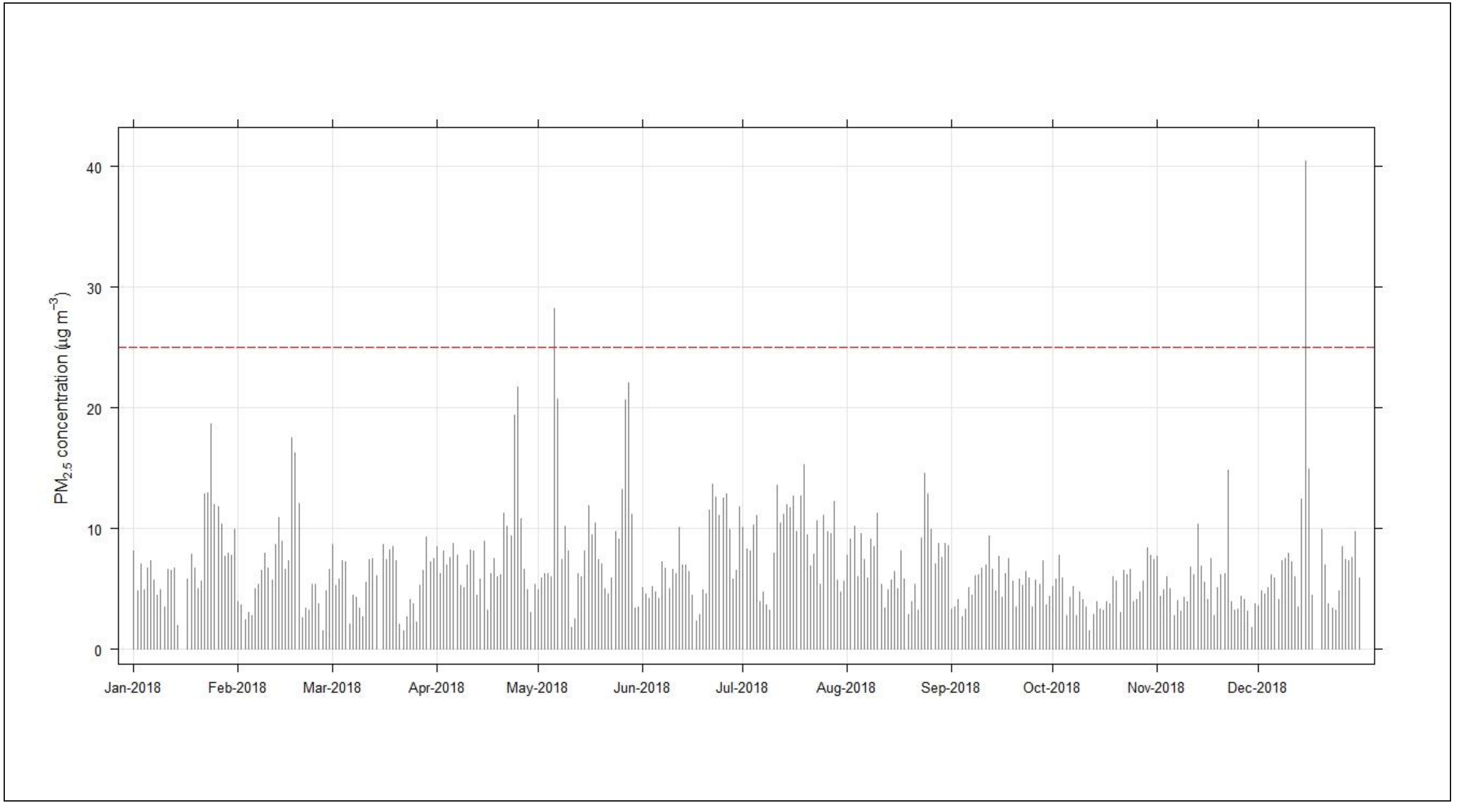


Figure 5-2: 24-hr average $PM_{2.5}$ concentration – Bathurst 2018[11]

[11] Gaps in the dataset are filled using a simple linear regression analysis. All available PM_{10} and $PM_{2.5}$ data are plotted and the linear relationship between PM_{10} and $PM_{2.5}$ is derived. Where $PM_{2.5}$ data are missing and PM_{10} data are available, this linear relationship is used to 'fill' the missing $PM_{2.5}$ data.

6. EMISSION INVENTORY

Emissions inventories have been developed for two representative scenarios for the Proposed Modification, selected to assess the air quality impacts of worst-case operations, for example where material movement is high and where extraction or wind erosion areas are largest, or where operations are located closest to receptors.

Both scenarios are based on a maximum approved production rate of 500,000 tpa, with similar extraction/processing volumes for topsoil, overburden, cobble and rock. Both scenarios also assume the following:

- Direct placement of overburden and soil where possible, reducing the double handling of material, potential for wind erosion and haulage distances.
- Minimising the double handling of material, wherever practicable (i.e. direct movement of rock to the processing plant).
- Avoiding disturbance, or temporary rehabilitation of long-term soil stockpiles and waste emplacements.

As described in **Section 1.1**, the crushing components of the processing operations are currently undertaken within the extraction area, however, these may also be undertaken on the stockpile areas of the Quarry Site. To assess the air quality impact associated with both processing locations, for Scenario 1 we assume the processing plant is located within the extraction area and for Scenario 2, we assume the processing plant is located at the stockpile areas. Scenario 2 also assumes larger extraction areas and longer hauling associated with the fixed crusher location. The locations of the modelled source locations are shown in **Appendix 1**.

6.1 Summary of estimated emissions

Emission factors developed by the US EPA[12], have been applied to estimate the amount of dust produced by each activity (topsoil stripping, overburden removal, rock extraction and processing, wind erosion, hauling). PM_{10} and $PM_{2.5}$ emissions inventories are summarised in **Table 6-1**. The emission totals are similar, with slightly higher emissions for Scenario 2.

Further details on the emission inventory development, including the assumptions, input data and emission factors used, are provided in **Appendix 2**. The full emission inventories for TSP are also shown in **Appendix 2**.

[12] US EPA AP-42 Compilation of Air Pollutant Emission Factors (US EPA, 1998b; US EPA, 2004; US EPA, 2006).

Table 6-1: Annual PM_{10} and $PM_{2.5}$ emissions (kg/annum)

	Scenario 1		Scenario 2	
Activity	**PM_{10}**	**$PM_{2.5}$**	**PM_{10}**	**$PM_{2.5}$**
Topsoil				
Dozer stripping topsoil (main extraction area)	19.7	9.6	19.7	9.6
Dozer stripping topsoil (cobble extraction area)	10.2	4.9	10.2	4.9
Excavator loading topsoil from main extraction area to trucks	0.6	0.1	0.6	0.1
Excavator loading topsoil from cobble extraction area to trucks	0.3	0.0	0.3	0.0
Hauling topsoil from main extraction area to stockpiles	22.3	9.2	37.5	10.7
Hauling topsoil from cobble extraction area to stockpiles	29.4	6.5	29.3	6.5
Unloading all trucks to stockpiles	0.9	0.1	0.9	0.1
Removal of overburden				
Excavator removing overburden in main extraction area	12.5	1.9	12.5	1.9
Excavator loading overburden to trucks	12.5	1.9	12.5	1.9
Hauling overburden to overburden tipping area	1,301.4	276.8	1,214.1	268.1
Unloading trucks to overburden tipping area	12.5	1.9	12.5	1.9
Bulldozers - overburden stockpiles	417.1	202.3	417.1	202.3
Cobble extraction				
Dozer ripping cobble	107.6	46.6	107.6	46.6
Loading cobble to dry screen	3.2	0.5	3.2	0.5
Screening	2.3	0.2	2.3	0.2
Unloading cobble to stockpile	3.2	0.5	3.2	0.5
Excavator loading cobble to haul trucks	3.2	0.5	3.2	0.5
Hauling cobble to southern end of extraction area for washing	38.1	11.7	38.1	11.7
Rock extraction				
Drilling rock	226.8	13.1	226.8	13.1
Blasting rock	86.3	5.0	86.3	5.0
Excavator loading rock to haul trucks	261.8	39.6	261.8	39.6
Hauling rock to primary crusher at southern end of extraction area	2,336.1	871.4	4,276.5	1,065.4
Processing				
Unloading rock to primary jaw crusher	183.3	27.7	183.3	27.7
Primary crushing	135.0	25.0	135.0	25.0
Screening	185.0	12.5	185.0	12.5
Secondary crushing	135.0	25.0	135.0	25.0
Conveying to second screen	183.3	27.7	183.3	27.7
Screening	185.0	12.5	185.0	12.5
Unloading screened rock to stockpile (>40mm)	36.7	5.5	36.7	5.5
Conveying <40mm rock to tertiary crusher	146.6	22.2	146.6	22.2
Tertiary crushing	108.0	20.0	108.0	20.0
Screening	148.0	10.0	148.0	10.0
Unloading screened rock to stockpile (<40mm)	146.6	22.2	146.6	22.2
Loading to trucks	261.8	39.6	261.8	39.6
Hauling to main stockpile area	2,262.6	226.3	1,947.5	194.8
Unloading to main stockpile area	91.6	13.9	91.6	13.9
Hauling to washer	1,131.3	113.1	1,639.6	164.0
Transfer product to pug mill	13.1	2.0	13.1	2.0
Screening at pug mill	18.5	1.3	18.5	1.3
Transfer from pug mill to stockpile	13.1	2.0	13.1	2.0
Loading material from pug mill stockpile to trucks	26.2	4.0	26.2	4.0

	Scenario 1		Scenario 2	
Activity	**PM_{10}**	**$PM_{2.5}$**	**PM_{10}**	**$PM_{2.5}$**
Haul pug mill product off-site	226.3	22.6	393.8	39.4
Excavator loading rock to trucks	265.0	40.1	265.0	40.1
Haul product off-site	4,061.1	1,051.7	4,061.1	1,051.7
Bulldozer - main stockpile area	8,722.7	3,781.2	8,722.7	3,781.2
Wind erosion				
Topsoil stockpiles	19.7	3.0	33.9	5.1
Extraction extension area	394.5	59.2	750.8	112.6
Cobble extraction area	203.4	30.5	245.2	36.8
Main stockpiles area	1,809.2	271.4	1,809.2	271.4
Western stockpile area	850.6	127.6	850.6	127.6
Western stockpile extension	1,204.0	180.6	1,204.0	180.6
Eastern stockpile area	200.6	30.1	200.6	30.1
Southern stockpile area	989.4	148.4	989.4	148.4
ROM stockpile	50.9	7.6	61.3	9.2
Pug mill stockpile	50.9	7.6	61.3	9.2
Miscellaneous				
Grader (road maintenance)	232.2	20.6	232.2	20.6
Total (kg/yr)	**29,599**	**7,899**	**32,261**	**8,187**

7. DISPERSION MODELLING RESULTS

The predicted Project-only and cumulative modelling results are presented below, in tabular form, at each receptor location. The modelling results are also presented as contour plots in **Appendix 3**, showing the extent of predicted impacts across private land.

7.1 Annual average PM_{10} and $PM_{2.5}$ concentration

The predicted Project-only and cumulative annual average PM_{10} and $PM_{2.5}$ concentrations are presented in **Table 7-1**. The highest predicted increment in annual average PM_{10} is 0.9µg/m³ (at receptor N2). The highest predicted increment in annual average $PM_{2.5}$ is 0.2µg/m³ (also at receptor N2). It is noted that receptor N2 is a project-related receptor.

There are no receptors where the cumulative annual average PM_{10} concentrations are greater than 25µg/m³ or where the cumulative annual average $PM_{2.5}$ concentrations are greater than 8µg/m³, even assuming a conservatively high background from Bathurst.

Table 7-1: Predicted Project-only and cumulative annual average PM_{10} and $PM_{2.5}$ concentration (µg/m³)

ID	Project-only				Cumulative			
	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)	
	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2
N1	0.2	0.2	0.1	0.1	19.0	19.1	7.1	7.1
N2	0.9	0.8	0.2	0.2	19.7	19.7	7.2	7.2
N3	0.3	0.3	0.1	0.1	19.1	19.2	7.1	7.1
N4	0.5	0.5	0.1	0.2	19.3	19.4	7.1	7.1
N5	0.4	0.4	0.1	0.1	19.2	19.2	7.1	7.1
N6	0.2	0.3	0.1	0.1	19.1	19.1	7.1	7.1
N7	0.3	0.4	0.1	0.1	19.2	19.2	7.1	7.1
N8	0.3	0.3	0.1	0.1	19.1	19.2	7.1	7.1
N9	0.3	0.3	0.1	0.1	19.1	19.1	7.1	7.1
N10	0.1	0.1	0.04	0.04	19.0	19.0	7.0	7.0
N11	0.2	0.2	0.1	0.1	19.0	19.0	7.0	7.0
N12	0.2	0.2	0.1	0.1	19.0	19.1	7.1	7.1
N13	0.3	0.3	0.1	0.1	19.1	19.1	7.1	7.1
N14	0.2	0.3	0.1	0.1	19.1	19.1	7.1	7.1
N15	0.2	0.2	0.05	0.1	19.0	19.0	7.0	7.0
N16	0.2	0.2	0.1	0.1	19.1	19.1	7.1	7.1
N17	0.1	0.2	0.04	0.04	19.0	19.0	7.0	7.0
N18	0.2	0.2	0.1	0.1	19.0	19.0	7.0	7.0
N19	0.2	0.2	0.05	0.1	19.0	19.0	7.0	7.0
N20	0.1	0.1	0.04	0.04	19.0	19.0	7.0	7.0
N21	0.1	0.1	0.03	0.03	18.9	18.9	7.0	7.0
N22	0.2	0.2	0.05	0.1	19.0	19.0	7.0	7.0
N23	0.1	0.1	0.03	0.03	18.9	18.9	7.0	7.0
N24	0.1	0.1	0.04	0.04	19.0	19.0	7.0	7.0
FR1	0.3	0.3	0.1	0.1	19.1	19.1	7.1	7.1
FR2	0.4	0.4	0.1	0.1	19.2	19.2	7.1	7.1

7.2 Maximum 24-hour average PM_{10} and $PM_{2.5}$ concentration

The predicted Project-only and cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentrations for receptors are presented in **Table 7-2**.

The highest predicted increment in 24-hour average PM_{10} is 10.3µg/m³ (at receptor N4). The highest predicted increment in 24-hour average $PM_{2.5}$ is 2.8µg/m³ (also at receptor N4).

There are no non-project related receptors where the cumulative 24-hour average PM_{10} concentrations are greater than 50µg/m³ or where the cumulative 24-hour average $PM_{2.5}$ concentrations are greater than 25µg/m³, even assuming a conservatively high background from Bathurst. The highest predicted cumulative 24-hour average PM_{10} concentrations at the project-related receptor (N2) is marginally above the impact assessment criteria (50.5µg/m³), however this is due to an elevated background concentration (49.2µg/m³), with the incremental contribution from the project on this day considered minor (1.3µg/m³).

Table 7-2: Predicted Project-only and cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentration (µg/m³)

ID	Project-only				Cumulative			
	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)	
	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2
N1	1.8	2.1	0.5	0.6	49.8	49.8	22.2	22.2
N2	5.5	5.7	1.6	1.5	50.3	50.5	22.7	22.7
N3	3.3	3.7	1.0	1.1	49.8	49.9	22.5	22.5
N4	7.4	10.3	2.2	2.8	49.9	49.9	22.4	22.4
N5	5.9	8.0	1.8	2.1	49.8	49.8	22.3	22.3
N6	2.8	3.4	0.9	1.0	49.8	49.8	22.4	22.4
N7	4.7	5.8	1.5	1.8	49.8	49.8	22.2	22.2
N8	5.1	7.5	1.6	2.0	49.8	49.8	22.2	22.2
N9	4.8	6.7	1.5	1.9	49.8	49.8	22.2	22.2
N10	1.6	1.9	0.5	0.5	49.7	49.7	22.2	22.2
N11	2.5	2.8	0.7	0.7	49.8	49.8	22.3	22.3
N12	2.4	2.6	0.7	0.8	49.7	49.7	22.2	22.2
N13	3.7	4.1	1.1	1.2	49.8	49.8	22.2	22.2
N14	2.5	2.8	0.7	0.8	49.8	49.8	22.4	22.4
N15	1.8	2.0	0.5	0.6	49.8	49.8	22.3	22.3
N16	2.4	2.7	0.7	0.7	49.8	49.8	22.2	22.2
N17	1.5	1.7	0.4	0.5	49.8	49.8	22.2	22.2
N18	1.7	2.0	0.5	0.5	49.8	49.8	22.2	22.2
N19	1.7	1.9	0.5	0.5	49.8	49.8	22.2	22.2
N20	1.3	1.5	0.4	0.4	49.8	49.8	22.2	22.2
N21	1.2	1.4	0.4	0.4	49.8	49.8	22.2	22.2
N22	1.5	1.7	0.4	0.5	49.8	49.8	22.2	22.2
N23	1.1	1.2	0.3	0.3	49.7	49.8	22.2	22.2
N24	1.8	2.0	0.5	0.6	49.7	49.7	22.1	22.1
FR1	4.1	5.7	1.3	1.6	49.8	49.8	22.2	22.2
FR2	5.2	6.4	1.7	2.0	49.8	49.8	22.2	22.2

It is noted that for PM_{10}, based on 2018 data, the maximum 24-hour average cumulative concentration will be the 9th highest concentration (as there are already 8 days over), while for $PM_{2.5}$, the maximum 24-hour average cumulative concentration will be the 3rd highest concentration (as there are already 2 days over).

7.3 TSP concentration and dust deposition

The predicted Project-only and cumulative annual average TSP concentrations for all receptors are presented in **Table 7-3**. There are no receptors where the Project-only or cumulative annual average TSP concentrations are greater than 90 µg/m³.

The predicted Project-only and cumulative annual average dust deposition for all private receptors is presented in **Table 7-3**. For all receptors, Project-only modelling predictions are less than 2g/m²/month and cumulative annual average dust deposition are less than 4g/m²/month.

Table 7-3: Predicted Project-only and cumulative annual average TSP (µg/m³) and dust deposition (g/m²/month)

ID	Project-only				Cumulative			
	TSP (µg/m³)		Deposition (g/m²/month)		TSP (µg/m³)		Deposition (g/m²/month)	
	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2
N1	0.7	0.8	0.1	0.1	47.8	47.8	1.6	1.6
N2	2.9	2.8	0.4	0.4	50.0	49.9	1.9	1.8
N3	1.1	1.2	0.2	0.2	48.2	48.2	1.7	1.7
N4	1.7	1.9	0.2	0.2	48.7	48.9	1.7	1.7
N5	1.3	1.4	0.1	0.1	48.3	48.5	1.6	1.6
N6	0.8	0.9	0.1	0.1	47.9	48.0	1.6	1.6
N7	1.1	1.2	0.1	0.1	48.2	48.3	1.6	1.6
N8	1.1	1.2	0.1	0.1	48.1	48.2	1.6	1.6
N9	0.9	1.0	0.1	0.1	48.0	48.1	1.6	1.6
N10	0.5	0.5	0.0	0.05	47.6	47.6	1.5	1.5
N11	0.7	0.7	0.1	0.1	47.8	47.8	1.6	1.6
N12	0.7	0.8	0.1	0.1	47.8	47.9	1.6	1.6
N13	0.9	0.9	0.1	0.1	47.9	48.0	1.6	1.6
N14	0.8	0.9	0.1	0.1	47.9	48.0	1.6	1.6
N15	0.6	0.6	0.1	0.1	47.7	47.7	1.6	1.6
N16	0.8	0.8	0.2	0.2	47.9	47.9	1.6	1.6
N17	0.5	0.5	0.1	0.1	47.6	47.6	1.6	1.6
N18	0.6	0.7	0.1	0.1	47.7	47.7	1.6	1.6
N19	0.6	0.6	0.1	0.1	47.7	47.7	1.6	1.6
N20	0.4	0.5	0.1	0.1	47.5	47.5	1.6	1.6
N21	0.4	0.4	0.1	0.1	47.5	47.5	1.6	1.6
N22	0.6	0.6	0.1	0.1	47.6	47.7	1.6	1.6
N23	0.4	0.4	0.1	0.1	47.4	47.5	1.6	1.6
N24	0.5	0.5	0.1	0.1	47.5	47.6	1.6	1.6
FR1	1.0	1.1	0.1	0.1	48.1	48.2	1.6	1.6
FR2	1.3	1.4	0.1	0.1	48.3	48.4	1.6	1.6

8. MANAGEMENT AND MONITORING

The Quarry Site operates under an existing Air Quality Management Plan (AQMP), developed for approved operations at the site. The AQMP will be updated to include the Modification. The dust management measures applied to the emission estimates for the Proposed Modification are consistent with the AQMP and are outlined in **Appendix 2**.

Other control measures, while not explicitly applied as reduction factors in the emission calculations, are accounted for in the modelled emissions on the basis of the quarry plan, including:

- Direct placement of overburden and soil where possible, reducing the double handling of material, potential for wind erosion and haulage distances.
- Minimising the double handling of material, wherever practicable (i.e. direct movement of rock to the processing plant).
- Avoiding disturbance, or temporary rehabilitation of long-term soil stockpiles and waste emplacements.

These measures are currently in place for the existing Quarry and will be implemented for the Project.

In addition to the preventative measures outlined above, the AQMP outlines reactive management measures and corrective actions, applied in response to complaints and exceedances of air quality criteria.

8.1 Monitoring

The Applicant currently operates an air quality monitoring network for the Wallerawang Quarry, consisting of a meteorological monitoring station and four dust deposition gauges. This existing monitoring network is considered suitable for ongoing operations associated with the Proposed Modification.

9. CONCLUSION

Air quality impacts from the Project are assessed using a Level 2 assessment approach in general accordance with the Approved Methods for Modelling and Assessment of Air Pollutants in NSW.

Emissions inventories have been developed for two scenarios, selected to assess the air quality impacts of worst-case operations. Dispersion modelling was used to predict ground level concentrations for key pollutants from the Proposed Modification, at surrounding receptors. Cumulative impacts were assessed, taking into account the combined effect of the Proposed Modification with existing baseline air quality.

The predicted Project-only and cumulative annual average PM_{10}, $PM_{2.5}$ and TSP concentrations and dust deposition levels indicate that no receptors would experience exceedances of the impact assessment criteria. Similarly, the predicted Project-only and cumulative 24-hour PM_{10} and $PM_{2.5}$ indicate that no non-project related receptors would experience any additional exceedances of the impact assessment criteria.

It is noted that the emission estimates do not account for natural mitigation due to rainfall and the modelling does not incorporate removal of particles due to wet deposition. The results therefore incorporate a level of conservatism and should be viewed with this in mind.

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APPENDIX 1
OVERVIEW OF DISPERSION MODELLING

Overview of modelling

Local air quality modelling is presented using the AERMOD system, which is composed of two pre-processors that generate the input files required by the AERMOD dispersion model: AERMET (for the preparation of meteorological data) and AERMAP (for the preparation of terrain data).

AERMET is run using the 'onsite' processing option using hourly measurements from the onsite meteorological station. For parameters not measured by the onsite station but required for modelling (i.e. cloud amount and atmospheric pressure), the Marrangaroo and Mt Boyce BoM AWS data were used. Gaps in the dataset were supplemented with prognostic meteorological data from TAPM. TAPM was also used to derive a vertical temperature profile for modelling. The TAPM vertical temperature profile was adjusted by first substituting the predicted 10 m above ground temperature with the hourly measured temperature at 10 m. The difference between the TAPM predicted temperature and the measured 10 m temperature was applied to the entire predicted vertical temperature profile.

Values for surface roughness length, albedo, and Bowen ratio were selected using the AERSURFACE Utility by assigning appropriate land use types in the vicinity of the Quarry Site.

Surface roughness length is the height at which the mean horizontal wind speed approaches zero and is related to the roughness characteristics of the surrounding area. For example, low flat landscapes are assigned a lower surface roughness length than urban or forest areas. Bowen ratio relates to the amount of moisture at the surface and plays an important role in deriving Monin-Obukhov length and therefore atmospheric stability. Albedo is defined as the fraction of incoming solar radiation reflected from the ground when the sun is overhead.

Terrain data for the wider modelling domain was sourced from NASA's Shuttle Radar Topography Mission data. This data set provided a high-resolution topography at approximately 30m grid spacing.

Activities (hauling, dozers, excavators, wind erosion etc.) are represented by a series of volume sources located according to the quarry plan for each scenario. The modelled volume source locations and modelled haul road locations are shown on Figures A1-1 and A1-2. For modelling volume sources, estimates of horizontal spread (initial sigma y [σy]) and vertical spread (initial sigma z [σz]) need to be assigned. For sources other than hauling, values of sigma y are assigned based on source separation (divided by 2.15) which is chosen to 'spread' emissions across the source footprint. A value of 2m is assigned for source height with sigma z assigned as source height divided by 2.15. For hauling, sigma y is assigned based on source separation (divided by 2.15) and sigma z based on recommendations made in the US EPA Haul Road Workgroup. Modelling was completed for three size fractions; TSP, PM_{10} and $PM_{2.5.}$

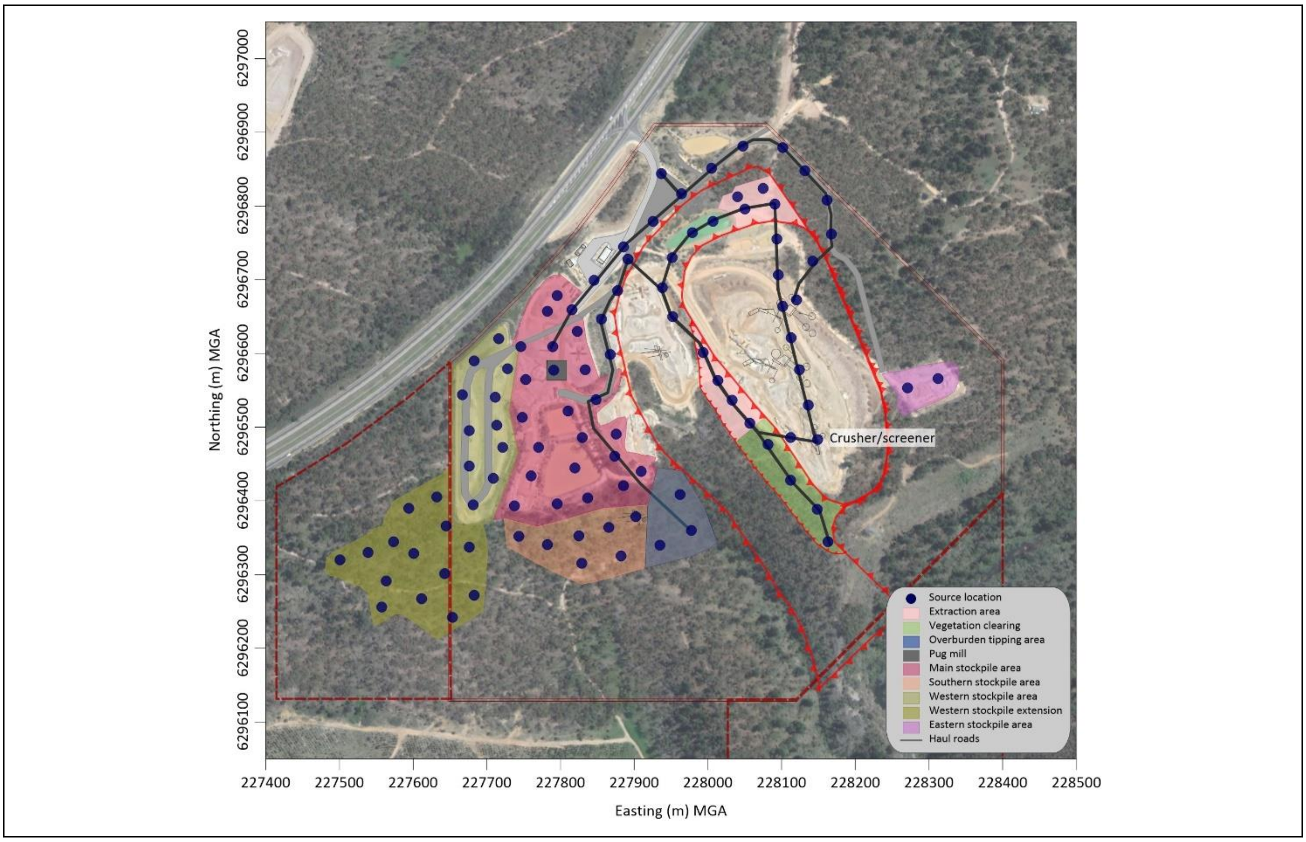

Figure A1-1: Modelled source locations – Scenario 1

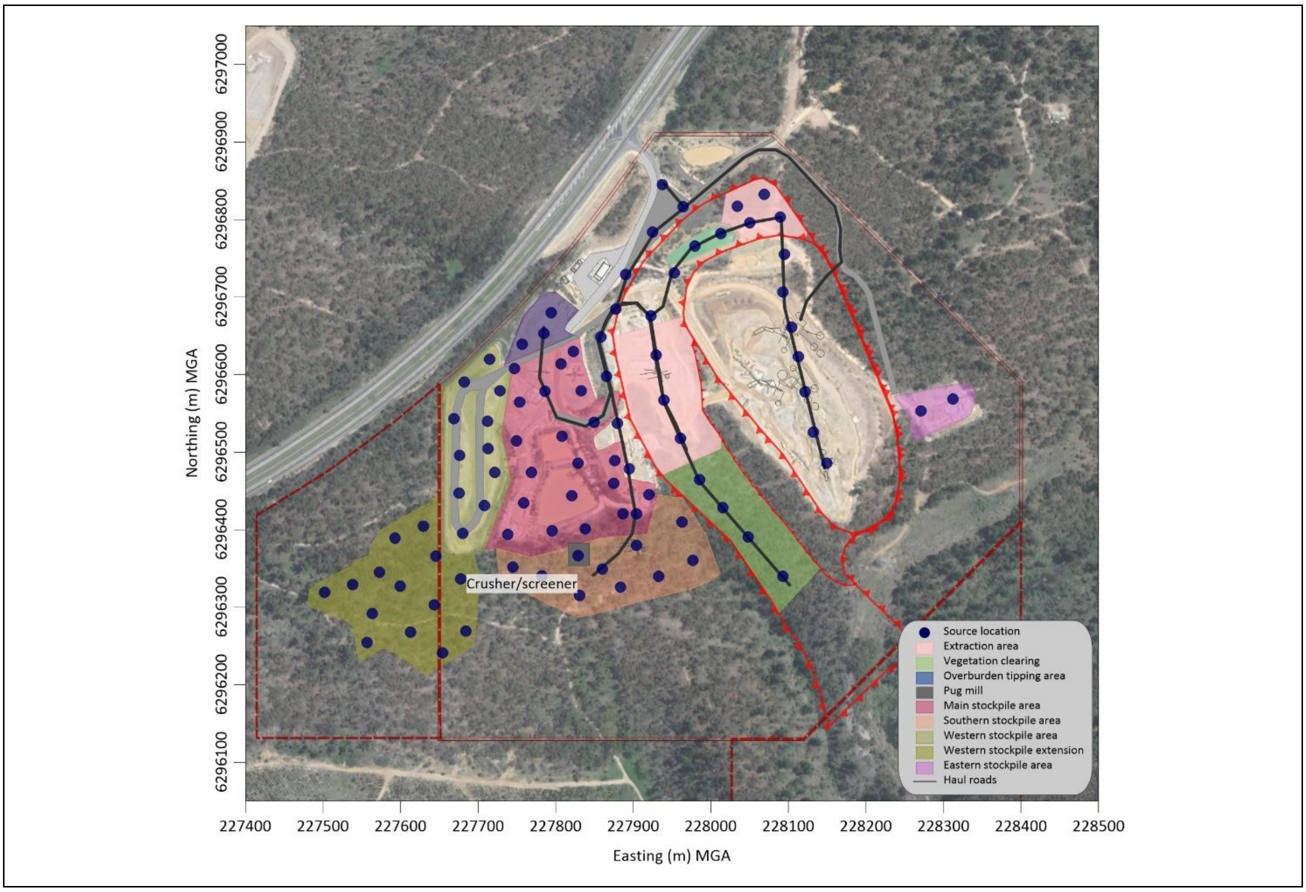

Figure A1-2: Modelled source locations – Scenario 2

APPENDIX 2
EMISSIONS INVENTORY DEVELOPMENT

Dust emissions were estimated using US EPA AP-42 emission factors and predictive equations taken from the following chapters:

- Chapter 11.9 Western Surface Coal Mining.
- Chapter 13.2.2 Unpaved Roads.
- Chapter 13.2.4 Aggregate Handling and Storage Piles.
- Chapter 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing.
- Chapter 13.2.5 Industrial Wind Erosion.

The material properties listed in **Table A2-1** are used as input to the various emission factor equations listed in **Table A2-2** to derive site specific uncontrolled emission factors for each source. In the absence of site-specific material properties, the silt and moisture contents (%) for each material handled are generally based on values used for similar quarry operations in NSW. Emissions were quantified for each particle size fraction, with the TSP size fraction also used to predict dust deposition rates. Fine particles (PM_{10} and $PM_{2.5}$) were estimated using the fraction specific equations or ratios for the different particle size fractions available within the literature (shown in **Table A2-2**).

Table A2-1: Material properties

Properties	Value	Source of Information
Silt content of unpaved roads	8.1%	Based on an average taken from values used for similar quarry operations
Silt content of soil/overburden/rock	10%	Value typically used modelling of extractive industries, selected as a conservative value.
Moisture content of soil/overburden	6%	Based on an average taken from values used for similar quarry operations
Moisture content of rock/product	2%	Based on an average taken from values used for similar quarry operations

Diesel emissions

Emissions of PM_{10} and $PM_{2.5}$ from diesel combustion are assumed to be included in the total emissions for each relevant source and are not explicitly modelled as a separate emission source. However, adjustments have been made to account for the fact that emission reductions applied to the inventory (i.e. watering) are not relevant to control of diesel exhaust emissions. The emissions inventory applies no controls for dozers/loaders and excavators, therefore the adjustments for diesel emissions are only needed for haul road controls. Diesel emissions are estimated based on US EPA emission factors (Tier 1), expressed as g/kWh. The activity data (kWh/annum) is estimated based on two Komatsu HM200 trucks with an engine power of 353kW, a load factor of 0.59 and 3,130 operating hours per annum. The total emissions are allocated to haul roads pro-rata, based on the tonnage hauled along each route. The estimated diesel emissions for hauling are subtracted from the uncontrolled haul road emissions to derive the wheel-generated component of emissions for each haul road. The control for watering is then applied to the wheel-generated component only, and the diesel emissions are then added back to derive the final emission estimate from haul trucks.

Hourly varying emissions

The activities included in the emissions inventory can be categorised into three emission source types; wind-insensitive sources, where the emission rate is independent of the wind speed, wind-sensitive sources, where there is a relationship between the emission rate and wind speed and wind erosion sources, where the emission is dependent on the wind speed. For wind dependent and wind independent sources, emissions are evenly apportioned for each hour of operation. For wind erosion, hourly emissions are adjusted according to the cube of the hourly average wind speed and normalised so that the total emission over all hours in the year adds up to the estimated annual total emission.

Table A2-2: Equations and emission factors

Inventory activity	Units	TSP emission factor/equation	PM_{10} emission factor/equation	$PM_{2.5}$ emission factor/equation	EF source
Material handling (loading trucks, unloading trucks, rehandle, conveyor transfer	kg/t	$0.74 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	$0.35 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	$0.053 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	AP42 13.2.4
Dozers	kg/hr	$2.6 \times \frac{s^{1.2}}{M^{1.3}}$	$0.3375 \times \frac{s^{1.5}}{M^{1.4}}$	0.105 x TSP	AP42 11.9
Wind erosion from exposed ground	kg/ha/yr	0.85×1000	0.5 * TSP	0.075 * TSP	AP42 11.9 & 13.2.5
Stockpile wind erosion and maintenance	kg/ha/hr	1.8 * u	0.5 * TSP	0.075 * TSP	AP42 11.9 & 13.2.5
Hauling on unsealed roads	kg/VKT	$\left(\frac{0.4536}{1.6093}\right) \times 4.9 * \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	$\left(\frac{0.4536}{1.6093}\right) \times 1.5 * \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	$\left(\frac{0.4536}{1.6093}\right) \times 0.15 * \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	AP42 13.2.2
Grading roads	kg/VKT	$0.0034 \times S^{2.5}$	$0.00336 \times S^{2.0}$	$0.0001054 \times S^{2.5}$	AP42 11.9
Crushing (controlled)	kg/t	0.0006	0.00027	0.00005	AP42 11.19.2
Screening (controlled)	kg/t	0.0011	0.00037	0.00003	AP42 11.19.2
Soil stripping	kg/t	0.029	TSP x 0.5	TSP x 0.105	AP42 11.9

Note: VKT = vehicle kilometre travelled; U/u = wind speed (m/s); M = moisture content (%); s = silt content (%); W = vehicle weight (t); S = speed (km/hr); ha = hectares.

Scenario 1 - TSP emission inventory																	
Activity	**Emission estimate (kg/year) - controlled**	**Intensity**	**Units**	**Emission Factor**	**Units**	**Variable 1**		**Variable 2**		**Variable 3**		**Variable 4**		**Variable 5**		**Control %**	**Control**
Topsoil																	
Dozer stripping topsoil (main extraction area)	91	23	h/y	4.0	kg/h	6	moisture content in %	10	silt content in %								
Dozer stripping topsoil (cobble extraction area)	47	12	h/y	4.0	kg/h	6	moisture content in %	10	silt content in %								
Excavator loading topsoil from main extraction area to trucks	1.2	5,431	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading topsoil from cobble extraction area to trucks	0.6	2,800	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling topsoil from main extraction area to stockpiles	59	5,431	t/y	0.037	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.4	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Hauling topsoil from cobble extraction area to stockpiles	94	2,800	t/y	0.128	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.3	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Unloading all trucks to stockpiles	1.9	8,230	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Removal of overburden																	
Excavator removing overburden in main extraction area	26	115,000	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading overburden to trucks	26	115,000	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling overburden to overburden tipping area	4,175	115,000	t/y	0.139	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.4	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Unloading trucks to overburden tipping area	26	115,000	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Bulldozers - overburden stockpiles	1,927	480	h/y	4.0	kg/h	6	moisture content in %	10	silt content in %								
Cobble extraction																	
Dozer ripping cobble	444	26	h/y	17.2	kg/h	2	moisture content in %	10	silt content in %								
Loading cobble to dry screen	7	6,167	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Screening	7	6,167	t/y	0.0011	kg/t												Control (watering) assumed in emission factor.
Unloading cobble to stockpile	7	6,167	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading cobble to haul trucks	7	6,167	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling cobble to southern end of extraction area for washing	112	6,167	t/y	0.0666	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.7	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Rock extraction																	
Drilling rock	436	2,465	holes/y	0.59	kg/hole											70	Wet suppression
Blasting rock	166	13	blast/y	12.8	kg/blast	1,500	Area of blast (m2)										
Excavator loading rock to haul trucks	554	500,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling rock to primary crusher at southern end of extraction area	6,403	500,000	t/y	0.0454	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.4	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Processing																	
Unloading rock to primary jaw crusher	387	500,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Primary crushing	300	500,000	t/y	0.0006	kg/t												Control (watering) assumed in emission factor.
Screening	550	500,000	t/y	0.0011	kg/t												Control (watering) assumed in emission factor.
Secondary crushing	300	500,000	t/y	0.0006	kg/t												Control (watering) assumed in emission factor.
Conveying to second screen	387	500,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Screening	550	500,000	t/y	0.0011	kg/t												Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (>40mm)	77	100,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Conveying <40mm rock to tertiary crusher	310	400,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Tertiary crushing	240	400,000	t/y	0.0006	kg/t												Control (watering) assumed in emission factor.
Screening	440	400,000	t/y	0.0011	kg/t												Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (<40mm)	310	400,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Loading to trucks	554	500,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling to main stockpile area	8,000	500,000	t/y	0.064	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.6	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Unloading to main stockpile area	194	250,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Hauling to washer	4,000	250,000	t/y	0.064	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.6	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Transfer product to pug mill	28	50,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Screening at pug mill	55	50,000	t/y	0.0011	kg/t												Control (watering) assumed in emission factor.
Transfer from pug mill to stockpile	28	50,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Loading material from pug mill stockpile to trucks	55	50,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul pug mill product off-site	800	50,000	t/y	0.064	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.6	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Excavator loading rock to trucks	560	506,167	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul product off-site	12,480	506,167	t/y	0.093	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.9	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Bulldozer - main stockpile area	36,012	2,088	h/y	17.2	kg/h	2	moisture content in %	10	silt content in %								
Wind erosion																	
Topsoil stockpiles	39	0.9	ha	850	kg/ha/yr											95	Seeding
Extraction extension area	789	0.9	ha	850	kg/ha/yr												
Cobble extraction area	407	0.5	ha	850	kg/ha/yr												
Main stockpiles area	3,618	4.3	ha	850	kg/ha/yr												
Western stockpile area	1,701	2.0	ha	850	kg/ha/yr												
Western stockpile extension	2,408	2.8	ha	850	kg/ha/yr												
Eastern stockpile area	401	0.5	ha	850	kg/ha/yr												
Southern stockpile area	1,979	2.3	ha	850	kg/ha/yr												
ROM stockpile	102	0.1	ha	850	kg/ha/yr												
Pug mill stockpile	102	0.1	ha	850	kg/ha/yr												
Miscellaneous																	
Grader (road maintenance)	665	2,160	km/y	0.615	kg/km	8	speed of graders in km/h	270	grader hours							50	Watering grader routes
Total (kg/yr)	**93,446**																

Scenario 1 - PM10 emission inventory																	
Activity	**Emission estimate (kg/year) - controlled**	**Intensity**	**Units**	**Emission Factor**	**Units**	**Variable 1**		**Variable 2**		**Variable 3**		**Variable 4**		**Variable 5**		**Control %**	**Control**
Topsoil																	
Dozer stripping topsoil (main extraction area)	20	23	h/y	0.9	kg/h	6	moisture content in %	10	silt content in %								
Dozer stripping topsoil (cobble extraction area)	10	12	h/y	0.9	kg/h	6	moisture content in %	10	silt content in %								
Excavator loading topsoil from main extraction area to trucks	0.6	5,431	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading topsoil from cobble extraction area to trucks	0.3	2,800	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling topsoil from main extraction area to stockpiles	22	5,431	t/y	0.011	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.4	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Hauling topsoil from cobble extraction area to stockpiles	29	2,800	t/y	0.036	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.3	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading all trucks to stockpiles	0.9	8,230	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Removal of overburden																	
Excavator removing overburden in main extraction area	13	115,000	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading overburden to trucks	13	115,000	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling overburden to overburden tipping area	1,301	115,000	t/y	0.039	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.4	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading trucks to overburden tipping area	13	115,000	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Bulldozers - overburden stockpiles	417	480	h/y	0.9	kg/h	6	moisture content in %	10	silt content in %								
Cobble extraction																	
Dozer ripping cobble	108	26	h/y	4.2	kg/h	2	moisture content in %	10	silt content in %								
Loading cobble to dry screen	3	6,167	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Screening	2	6,167	t/y	0.00037	kg/t												Control (watering) assumed in emission factor.
Unloading cobble to stockpile	3	6,167	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading cobble to haul trucks	3	6,167	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling cobble to southern end of extraction area for washing	38	6,167	t/y	0.0188	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.7	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Rock extraction																	
Drilling rock	227	2,465	holes/y	0.31	kg/hole											70	Wet suppression
Blasting rock	86	13	blast/y	6.65	kg/blast	1,500	Area of blast (m2)										
Excavator loading rock to haul trucks	262	500,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling rock to primary crusher at southern end of extraction area	2,336	500,000	t/y	0.0128	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.4	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Processing																	
Unloading rock to primary jaw crusher	183	500,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Primary crushing	135	500,000	t/y	0.00027	kg/t												Control (watering) assumed in emission factor.
Screening	185	500,000	t/y	0.00037	kg/t												Control (watering) assumed in emission factor.
Secondary crushing	135	500,000	t/y	0.00027	kg/t												Control (watering) assumed in emission factor.
Conveying to second screen	183	500,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Screening	185	500,000	t/y	0.00037	kg/t												Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (>40mm)	37	100,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Conveying <40mm rock to tertiary crusher	147	400,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Tertiary crushing	108	400,000	t/y	0.00027	kg/t												Control (watering) assumed in emission factor.
Screening	148	400,000	t/y	0.00037	kg/t												Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (<40mm)	147	400,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Loading to trucks	262	500,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling to main stockpile area	2,263	500,000	t/y	0.018	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.6	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading to main stockpile area	92	250,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Hauling to washer	1,131	250,000	t/y	0.018	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.6	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Transfer product to pug mill	13	50,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Screening at pug mill	19	50,000	t/y	0.00037	kg/t												Control (watering) assumed in emission factor.
Transfer from pug mill to stockpile	13	50,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Loading material from pug mill stockpile to trucks	26	50,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul pug mill product off-site	226	50,000	t/y	0.018	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.6	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Excavator loading rock to trucks	265	506,167	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul product off-site	4,061	506,167	t/y	0.026	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.9	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Bulldozer - main stockpile area	8,723	2,088	h/y	4.2	kg/h	2	moisture content in %	10	silt content in %								
Wind erosion																	
Topsoil stockpiles	20	0.9	ha	425	kg/ha/yr											95	Seeding
Extraction extension area	395	0.9	ha	425	kg/ha/yr												
Cobble extraction area	203	0.5	ha	425	kg/ha/yr												
Main stockpiles area	1,809	4.3	ha	425	kg/ha/yr												
Western stockpile area	851	2.0	ha	425	kg/ha/yr												
Western stockpile extension	1,204	2.8	ha	425	kg/ha/yr												
Eastern stockpile area	201	0.5	ha	425	kg/ha/yr												
Southern stockpile area	989	2.3	ha	425	kg/ha/yr												
ROM stockpile	51	0.1	ha	425	kg/ha/yr												
Pug mill stockpile	51	0.1	ha	425	kg/ha/yr												
Miscellaneous																	
Grader (road maintenance)	232	2,160	km/y	0.215	kg/km	8	speed of graders in km/h	270	grader hours							50	Watering grader routes
	29,599																

Scenario 1 - PM2.5 emission inventory																	
Activity	**Emission estimate (kg/year) - controlled**	**Intensity**	**Units**	**Emission Factor**	**Units**	**Variable 1**		**Variable 2**		**Variable 3**		**Variable 4**		**Variable 5**		**Control %**	**Control**
Topsoil																	
Dozer stripping topsoil (main extraction area)	10	23	h/y	0.4	kg/h	6	moisture content in %	10	silt content in %								
Dozer stripping topsoil (cobble extraction area)	5	12	h/y	0.4	kg/h	6	moisture content in %	10	silt content in %								
Excavator loading topsoil from main extraction area to trucks	0.1	5,431	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Excavator loading topsoil from cobble extraction area to trucks	0.0	2,800	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Hauling topsoil from main extraction area to stockpiles	9	5,431	t/y	0.001	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.4	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Hauling topsoil from cobble extraction area to stockpiles	7	2,800	t/y	0.004	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.3	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading all trucks to stockpiles	0.1	8,230	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Removal of overburden																	
Excavator removing overburden in main extraction area	2	115,000	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Excavator loading overburden to trucks	2	115,000	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Hauling overburden to overburden tipping area	277	115,000	t/y	0.004	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.4	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading trucks to overburden tipping area	2	115,000	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Bulldozers - overburden stockpiles	202	480	h/y	0.4	kg/h	6	moisture content in %	10	silt content in %								
Cobble extraction																	
Dozer ripping cobble	47	26	h/y	1.8	kg/h	2	moisture content in %	10	silt content in %								
Loading cobble to dry screen	0	6,167	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Screening	0	6,167	t/y	0.000025	kg/t												Control (watering) assumed in emission factor.
Unloading cobble to stockpile	0	6,167	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading cobble to haul trucks	0	6,167	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling cobble to southern end of extraction area for washing	12	6,167	t/y	0.0019	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Rock extraction																	
Drilling rock	13	2,465	holes/y	0.02	kg/hole											70	Wet suppression
Blasting rock	5	13	blast/y	0.38	kg/blast	1,500	Area of blast (m2)										
Excavator loading rock to haul trucks	40	500,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling rock to primary crusher at southern end of extraction area	871	500,000	t/y	0.0013	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.4	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Processing																	
Unloading rock to primary jaw crusher	28	500,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Primary crushing	25	500,000	t/y	0.00005	kg/t												Control (watering) assumed in emission factor.
Screening	13	500,000	t/y	0.000025	kg/t												Control (watering) assumed in emission factor.
Secondary crushing	25	500,000	t/y	0.00005	kg/t												Control (watering) assumed in emission factor.
Conveying to second screen	28	500,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Screening	13	500,000	t/y	0.000025	kg/t												Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (>40mm)	6	100,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Conveying <40mm rock to tertiary crusher	22	400,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Tertiary crushing	20	400,000	t/y	0.00005	kg/t												Control (watering) assumed in emission factor.
Screening	10	400,000	t/y	0.000025	kg/t												Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (<40mm)	22	400,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Loading to trucks	40	500,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling to main stockpile area	226	500,000	t/y	0.002	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.6	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading to main stockpile area	14	250,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Hauling to washer	113	250,000	t/y	0.002	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.6	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Transfer product to pug mill	2	50,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Screening at pug mill	1	50,000	t/y	0.000025	kg/t												Control (watering) assumed in emission factor.
Transfer from pug mill to stockpile	2	50,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Loading material from pug mill stockpile to trucks	4	50,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul pug mill product off-site	23	50,000	t/y	0.002	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.6	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Excavator loading rock to trucks	40	506,167	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul product off-site	1,052	506,167	t/y	0.003	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.9	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Bulldozer - main stockpile area	3,781	2,088	h/y	1.8	kg/h	2	moisture content in %	10	silt content in %								
Wind erosion																	
Topsoil stockpiles	3	0.9	ha	64	kg/ha/yr											95	Seeding
Extraction extension area	59	0.9	ha	64	kg/ha/yr												
Cobble extraction area	31	0.5	ha	64	kg/ha/yr												
Main stockpiles area	271	4.3	ha	64	kg/ha/yr												
Western stockpile area	128	2.0	ha	64	kg/ha/yr												
Western stockpile extension	181	2.8	ha	64	kg/ha/yr												
Eastern stockpile area	30	0.5	ha	64	kg/ha/yr												
Southern stockpile area	148	2.3	ha	64	kg/ha/yr												
ROM stockpile	8	0.1	ha	64	kg/ha/yr												
Pug mill stockpile	8	0.1	ha	64	kg/ha/yr												
Miscellaneous																	
Grader (road maintenance)	21	2,160	km/y	0.019	kg/km	8	speed of graders in km/h	270	grader hours							50	Watering grader routes
Grader (road maintenance)	**7,899**																

Scenario 2 - TSP emission inventory																	
Activity	**Emission estimate (kg/year) - controlled**	**Intensity**	**Units**	**Emission Factor**	**Units**	**Variable 1**		**Variable 2**		**Variable 3**		**Variable 4**		**Variable 5**		**Control %**	**Control**
Topsoil																	
Dozer stripping topsoil (main extraction area)	91	23	h/y	4.0	kg/h	6	moisture content in %	10	silt content in %								
Dozer stripping topsoil (cobble extraction area)	47	12	h/y	4.0	kg/h	6	moisture content in %	10	silt content in %								
Excavator loading topsoil from main extraction area to trucks	1.2	5,431	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading topsoil from cobble extraction area to trucks	0.6	2,800	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling topsoil from main extraction area to stockpiles	112	5,431	t/y	0.077	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.8	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Hauling topsoil from cobble extraction area to stockpiles	93	2,800	t/y	0.127	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.3	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Unloading all trucks to stockpiles	1.9	8,230	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Removal of overburden																	
Excavator removing overburden in main extraction area	26	115,000	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading overburden to trucks	26	115,000	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling overburden to overburden tipping area	3,866	115,000	t/y	0.129	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.3	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Unloading trucks to overburden tipping area	26	115,000	t/y	0.0002	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Bulldozers - overburden stockpiles	1,927	480	h/y	4.0	kg/h	6	moisture content in %	10	silt content in %								
Cobble extraction																	
Dozer ripping cobble	444	26	h/y	17.2	kg/h	2	moisture content in %	10	silt content in %								
Loading cobble to dry screen	7	6,167	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Screening	7	6,167	t/y	0.0011	kg/t												Control (watering) assumed in emission factor.
Unloading cobble to stockpile	7	6,167	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading cobble to haul trucks	7	6,167	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling cobble to main stockpile area for washing	112	6,167	t/y	0.0666	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.7	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Rock extraction																	
Drilling rock	436	2,465	holes/y	0.59	kg/hole											70	Wet suppression
Blasting rock	166	13	blast/y	12.8	kg/blast	1,500	Area of blast (m2)										
Excavator loading rock to haul trucks	554	500,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling rock to fixed crushing plant in main stockpile area	13,265	500,000	t/y	0.1003	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.0	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Processing																	
Unloading rock to primary jaw crusher	387	500,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Primary crushing	300	500,000	t/y	0.0006	kg/t												Control (watering) assumed in emission factor.
Screening	550	500,000	t/y	0.0011	kg/t												Control (watering) assumed in emission factor.
Secondary crushing	300	500,000	t/y	0.0006	kg/t												Control (watering) assumed in emission factor.
Conveying to second screen	387	500,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Screening	550	500,000	t/y	0.0011	kg/t												Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (>40mm)	77	100,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Conveying <40mm rock to tertiary crusher	310	400,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Tertiary crushing	240	400,000	t/y	0.0006	kg/t												Control (watering) assumed in emission factor.
Screening	440	400,000	t/y	0.0011	kg/t												Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (<40mm)	310	400,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Loading to trucks	554	500,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling to main stockpile area	6,886	500,000	t/y	0.055	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.5	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Unloading to main stockpile area	194	250,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Hauling to washer	5,798	250,000	t/y	0.093	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.9	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Transfer product to pug mill	28	50,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Screening at pug mill	55	50,000	t/y	0.0011	kg/t												Control (watering) assumed in emission factor.
Transfer from pug mill to stockpile	28	50,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Loading material from pug mill stockpile to trucks	55	50,000	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul pug mill product off-site	1,392	50,000	t/y	0.111	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.1	km/return trip	4.1	kg/VKT	8.1	% silt content	75	Watering and/or suppressants
Excavator loading rock to trucks	560	506,167	t/y	0.0011	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul product off-site	12,480	506,167	t/y	0.093	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.9	km/return trip	4.1	kg/VKT	8.1	% silt content	75	watering and/or suppressants
Bulldozer - main stockpile area	36,012	2,088	h/y	17.2	kg/h	2	moisture content in %	10	silt content in %								
Wind erosion																	
Topsoil stockpiles	68	1.6	ha	850	kg/ha/yr											95	Seeding
Extraction area	1,502	1.8	ha	850	kg/ha/yr												
Cobble extraction area	490	0.6	ha	850	kg/ha/yr												
Main stockpiles area	3,618	4.3	ha	850	kg/ha/yr												
Western stockpile area	1,701	2.0	ha	850	kg/ha/yr												
Western stockpile extension	2,408	2.8	ha	850	kg/ha/yr												
Eastern stockpile area	401	0.5	ha	850	kg/ha/yr												
Southern stockpile area	1,979	2.3	ha	850	kg/ha/yr												
ROM stockpile	123	0.1	ha	850	kg/ha/yr												
Pug mill stockpile	123	0.1	ha	850	kg/ha/yr												
Miscellaneous																	
Grader (road maintenance)	665	2,160	km/y	0.615	kg/km	8	speed of graders in km/h	270	grader hours							50	Watering grader routes
Total (kg/yr)	**102,194**																

Scenario 2 - PM_{10} emission inventory																	
Activity	**Emission estimate (kg/year) - controlled**	**Intensity**	**Units**	**Emission Factor**	**Units**	**Variable 1**		**Variable 2**		**Variable 3**		**Variable 4**		**Variable 5**		**Control %**	**Control**
Topsoil																	
Dozer stripping topsoil (main extraction area)	20	23	h/y	0.9	kg/h	6	moisture content in %	10	silt content in %								
Dozer stripping topsoil (cobble extraction area)	10	12	h/y	0.9	kg/h	6	moisture content in %	10	silt content in %								
Excavator loading topsoil from main extraction area to trucks	0.6	5,431	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading topsoil from cobble extraction area to trucks	0.3	2,800	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling topsoil from main extraction area to stockpiles	38	5,431	t/y	0.022	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.8	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Hauling topsoil from cobble extraction area to stockpiles	29	2,800	t/y	0.036	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.3	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading all trucks to stockpiles	0.9	8,230	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Removal of overburden																	
Excavator removing overburden in main extraction area	13	115,000	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading overburden to trucks	13	115,000	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling overburden to overburden tipping area	1,214	115,000	t/y	0.036	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.3	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading trucks to overburden tipping area	13	115,000	t/y	0.0001	kg/t	6	moisture content in %	0.9	(wind speed/2.2)^1.3								
Bulldozers - overburden stockpiles	417	480	h/y	0.9	kg/h	6	moisture content in %	10	silt content in %								
Cobble extraction																	
Dozer ripping cobble	108	26	h/y	4.2	kg/h	2	moisture content in %	10	silt content in %								
Loading cobble to dry screen	3	6,167	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Screening	2	6,167	t/y	0.00037	kg/t												Control (watering) assumed in emission factor.
Unloading cobble to stockpile	3	6,167	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Excavator loading cobble to haul trucks	3	6,167	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling cobble to main stockpile area for washing	38	6,167	t/y	0.0188	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.7	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Rock extraction																	
Drilling rock	227	2,465	holes/y	0.31	kg/hole											70	Wet suppression
Blasting rock	86	13	blast/y	6.65	kg/blast	1,500	Area of blast (m2)										
Excavator loading rock to haul trucks	262	500,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling rock to primary fixed crusher at southern stockpile extensic	4,277	500,000	t/y	0.0284	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.0	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Processing																	
Unloading rock to primary jaw crusher	183	500,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Primary crushing	135	500,000	t/y	0.00027	kg/t												Control (watering) assumed in emission factor.
Screening	185	500,000	t/y	0.00037	kg/t												Control (watering) assumed in emission factor.
Secondary crushing	135	500,000	t/y	0.00027	kg/t												Control (watering) assumed in emission factor.
Conveying to second screen	183	500,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Screening	185	500,000	t/y	0.00037	kg/t											0	Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (>40mm)	37	100,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Conveying <40mm rock to tertiary crusher	147	400,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Tertiary crushing	108	400,000	t/y	0.00027	kg/t											0	Control (watering) assumed in emission factor.
Screening	148	400,000	t/y	0.00037	kg/t											0	Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (<40mm)	147	400,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Loading to trucks	262	500,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							0	0
Hauling to main stockpile area	1,948	500,000	t/y	0.0156	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.5	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading to main stockpile area	92	250,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Hauling to washer	1,640	250,000	t/y	0.0262	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.9	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Transfer product to pug mill	13	50,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Screening at pug mill	19	50,000	t/y	0.00037	kg/t												Control (watering) assumed in emission factor.
Transfer from pug mill to stockpile	13	50,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Loading material from pug mill stockpile to trucks	26	50,000	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul pug mill product off-site	394	50,000	t/y	0.0315	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.1	km/return trip	1.1	kg/VKT	8	% silt content	75	Watering and/or suppressants
Excavator loading rock to trucks	265	506,167	t/y	0.0005	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul product off-site	4,061	506,167	t/y	0.0262	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.9	km/return trip	1.1	kg/VKT	8	% silt content	75	watering and/or suppressants
Bulldozer - main stockpile area	8,723	2,088	h/y	4.2	kg/h	2	moisture content in %	10	silt content in %								
Wind erosion																	
Topsoil stockpiles	34	1.6	ha	425	kg/ha/yr											95	Seeding
Extraction area	751	1.8	ha	425	kg/ha/yr												
Cobble extraction area	245	0.6	ha	425	kg/ha/yr												
Main stockpiles area	1,809	4.3	ha	425	kg/ha/yr												
Western stockpile area	851	2.0	ha	425	kg/ha/yr												
Western stockpile extension	1,204	2.8	ha	425	kg/ha/yr												
Eastern stockpile area	201	0.5	ha	425	kg/ha/yr												
Southern stockpile area	989	2.3	ha	425	kg/ha/yr												
ROM stockpile	61	0.1	ha	425	kg/ha/yr												
Pug mill stockpile	61	0.1	ha	425	kg/ha/yr												
Miscellaneous																	
Grader (road maintenance)	232	2,160	km/y	0.215	kg/km	8	speed of graders in km/h	270	grader hours							50	Watering grader routes
Total (kg/yr)	**32,261**																

Scenario 2 - $PM_{2.5}$ emission inventory

Activity	Emission estimate (kg/year) - controlled	Intensity	Units	Emission Factor	Units	Variable 1		Variable 2		Variable 3		Variable 4		Variable 5		Control %	Control
Topsoil																	
Dozer stripping topsoil (main extraction area)	10	23	h/y	0.4	kg/h	6	moisture content in %	10	silt content in %								
Dozer stripping topsoil (cobble extraction area)	5	12	h/y	0.4	kg/h	6	moisture content in %	10	silt content in %								
Excavator loading topsoil from main extraction area to trucks	0.1	5,431	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Excavator loading topsoil from cobble extraction area to trucks	0.0	2,800	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Hauling topsoil from main extraction area to stockpiles	11	5,431	t/y	0.002	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.8	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Hauling topsoil from cobble extraction area to stockpiles	7	2,800	t/y	0.004	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.3	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading all trucks to stockpiles	0.1	8,230	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Removal of overburden																	
Excavator removing overburden in main extraction area	2	115,000	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Excavator loading overburden to trucks	2	115,000	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Hauling overburden to overburden tipping area	268	115,000	t/y	0.004	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.3	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading trucks to overburden tipping area	2	115,000	t/y	0.00002	kg/t	6	moisture content in %	1	(wind speed/2.2)^1.3								
Bulldozers - overburden stockpiles	202	480	h/y	0.4	kg/h	6	moisture content in %	10	silt content in %								
Cobble extraction																	
Dozer ripping cobble	47	26	h/y	1.8	kg/h	2	moisture content in %	10	silt content in %								
Loading cobble to dry screen	0	6,167	t/y	0.00008	kg/t	2	moisture content in %	1	(wind speed/2.2)^1.3								
Screening	0	6,167	t/y	0.000025	kg/t												Control (watering) assumed in emission factor.
Unloading cobble to stockpile	0	6,167	t/y	0.00008	kg/t	2	moisture content in %	1	(wind speed/2.2)^1.3								
Excavator loading cobble to haul trucks	0	6,167	t/y	0.00008	kg/t	2	moisture content in %	1	(wind speed/2.2)^1.3								
Hauling cobble to main stockpile area for washing	12	6,167	t/y	0.0019	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.7	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Rock extraction																	
Drilling rock	13	2,465	holes/y	0.02	kg/hole											70	Wet suppression
Blasting rock	5	13	blast/y	0.38	kg/blast	1,500	Area of blast (m2)										
Excavator loading rock to haul trucks	40	500,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling rock to primary fixed crusher at southern stockpile extension	1,065	500,000	t/y	0.0028	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.0	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Processing																	
Unloading rock to primary jaw crusher	28	500,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Primary crushing	25	500,000	t/y	0.00005	kg/t												Control (watering) assumed in emission factor.
Screening	13	500,000	t/y	0.000025	kg/t												Control (watering) assumed in emission factor.
Secondary crushing	25	500,000	t/y	0.00005	kg/t												Control (watering) assumed in emission factor.
Conveying to second screen	28	500,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Screening	13	500,000	t/y	0.000025	kg/t												Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (>40mm)	6	100,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Conveying <40mm rock to tertiary crusher	22	400,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Tertiary crushing	20	400,000	t/y	0.00005	kg/t												Control (watering) assumed in emission factor.
Screening	10	400,000	t/y	0.000025	kg/t												Control (watering) assumed in emission factor.
Unloading screened rock to stockpile (<40mm)	22	400,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Loading to trucks	40	500,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Hauling to main stockpile area	195	500,000	t/y	0.002	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.5	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Unloading to main stockpile area	14	250,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							30	Minimise drop ht (10m to 5m)
Hauling to washer	164	250,000	t/y	0.003	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.9	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Transfer product to pug mill	2	50,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Screening at pug mill	1	50,000	t/y	0.000025	kg/t												Control (watering) assumed in emission factor.
Transfer from pug mill to stockpile	2	50,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3							50	Watering
Loading material from pug mill stockpile to trucks	4	50,000	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul pug mill product off-site	39	50,000	t/y	0.003	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	1.1	km/return trip	0.11	kg/VKT	8	% silt content	75	Watering and/or suppressants
Excavator loading rock to trucks	40	506,167	t/y	0.00008	kg/t	2	moisture content in %	0.9	(wind speed/2.2)^1.3								
Haul product off-site	1,052	506,167	t/y	0.003	kg/t	40	t/load	55	Ave trip vehicle gross mass (t)	0.9	km/return trip	0.11	kg/VKT	8	% silt content	75	watering and/or suppressants
Bulldozer - main stockpile area	3,781	2,088	h/y	1.8	kg/h	2	moisture content in %	10	silt content in %								
Wind erosion																	
Topsoil stockpiles	5	1.6	ha	64	kg/ha/yr											95	Seeding
Extraction area	113	1.8	ha	64	kg/ha/yr												
Cobble extraction area	37	0.6	ha	64	kg/ha/yr												
Main stockpiles area	271	4.3	ha	64	kg/ha/yr												
Western stockpile area	128	2.0	ha	64	kg/ha/yr												
Western stockpile extension	181	2.8	ha	64	kg/ha/yr												
Eastern stockpile area	30	0.5	ha	64	kg/ha/yr												
Southern stockpile area	148	2.3	ha	64	kg/ha/yr												
ROM stockpile	9	0.1	ha	64	kg/ha/yr												
Pug mill stockpile	9	0.1	ha	64	kg/ha/yr												
Miscellaneous																	
Grader (road maintenance)	21	2,160	km/y	0.019	kg/km	8	speed of graders in km/h	270	grader hours							50	Watering grader routes
Total (kg/yr)	**8,187**																

APPENDIX 3
CONTOUR PLOTS

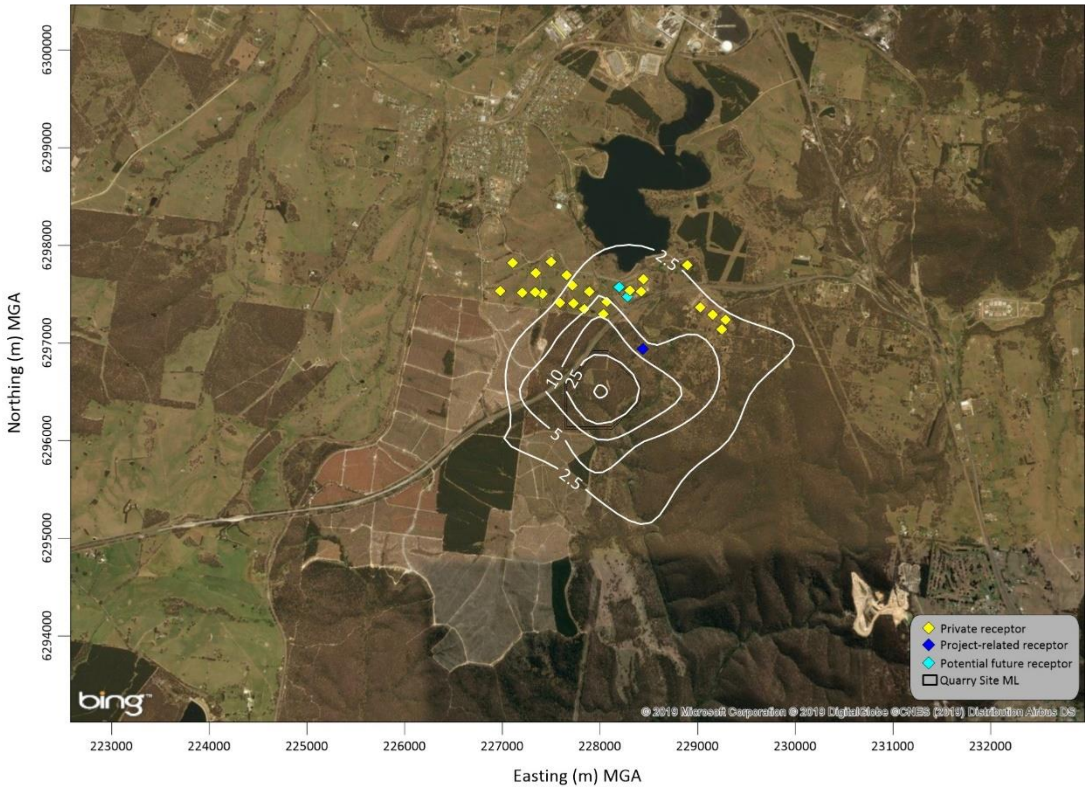

Figure A3-1: Project-only 24-hour average PM_{10} concentration ($\mu g/m^3$) contours – Scenario 1

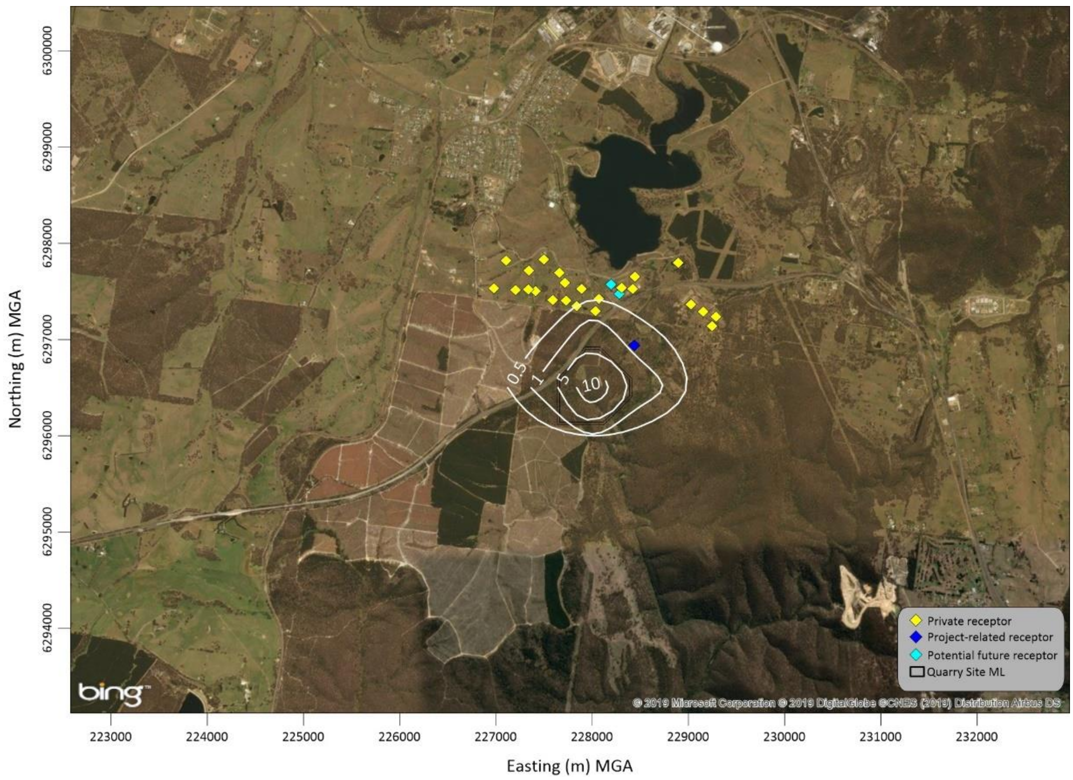

Figure A3-2: Project-only annual average PM_{10} concentration ($\mu g/m^3$) contours – Scenario 1

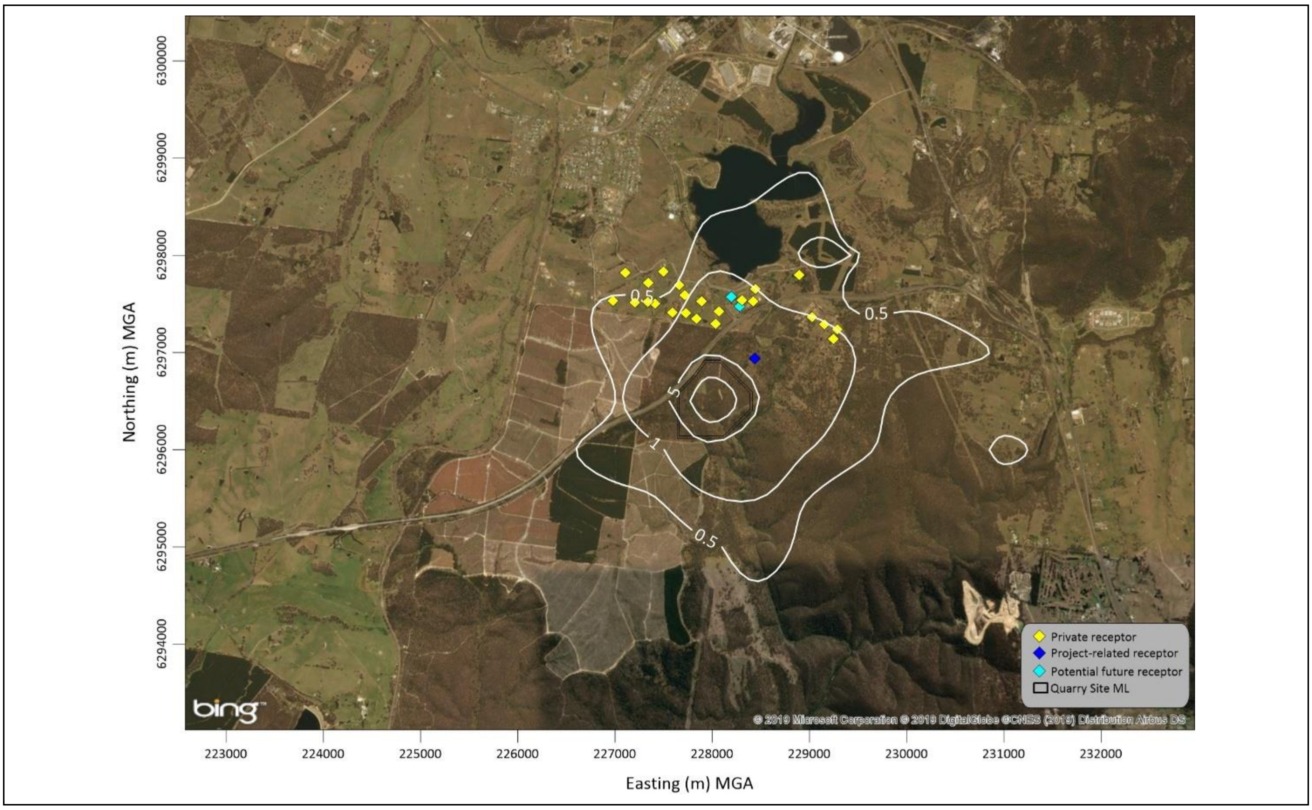

Figure A3-3: Project-only 24-hour average $PM_{2.5}$ concentration ($\mu g/m^3$) contours – Scenario 1

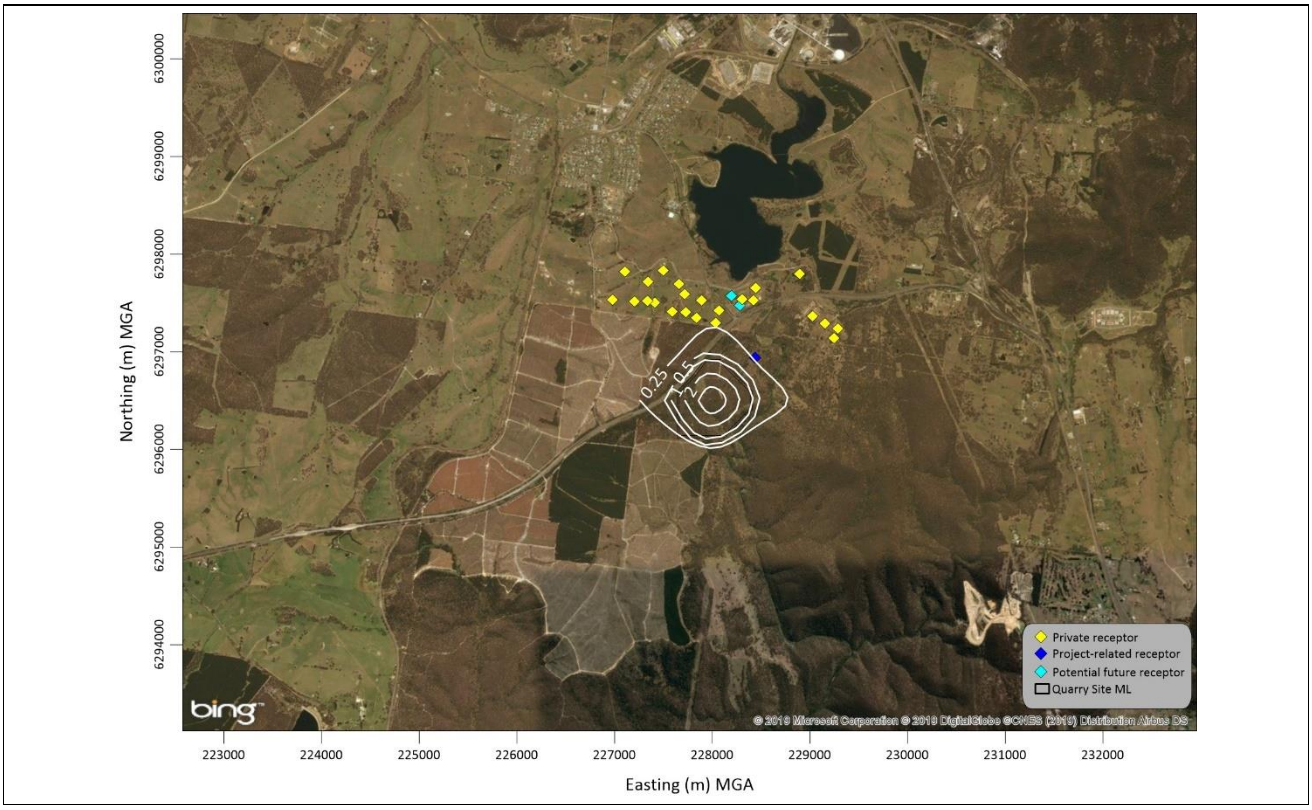

Figure A3-4: Project-only annual average $PM_{2.5}$ concentration ($\mu g/m^3$) contours – Scenario 1

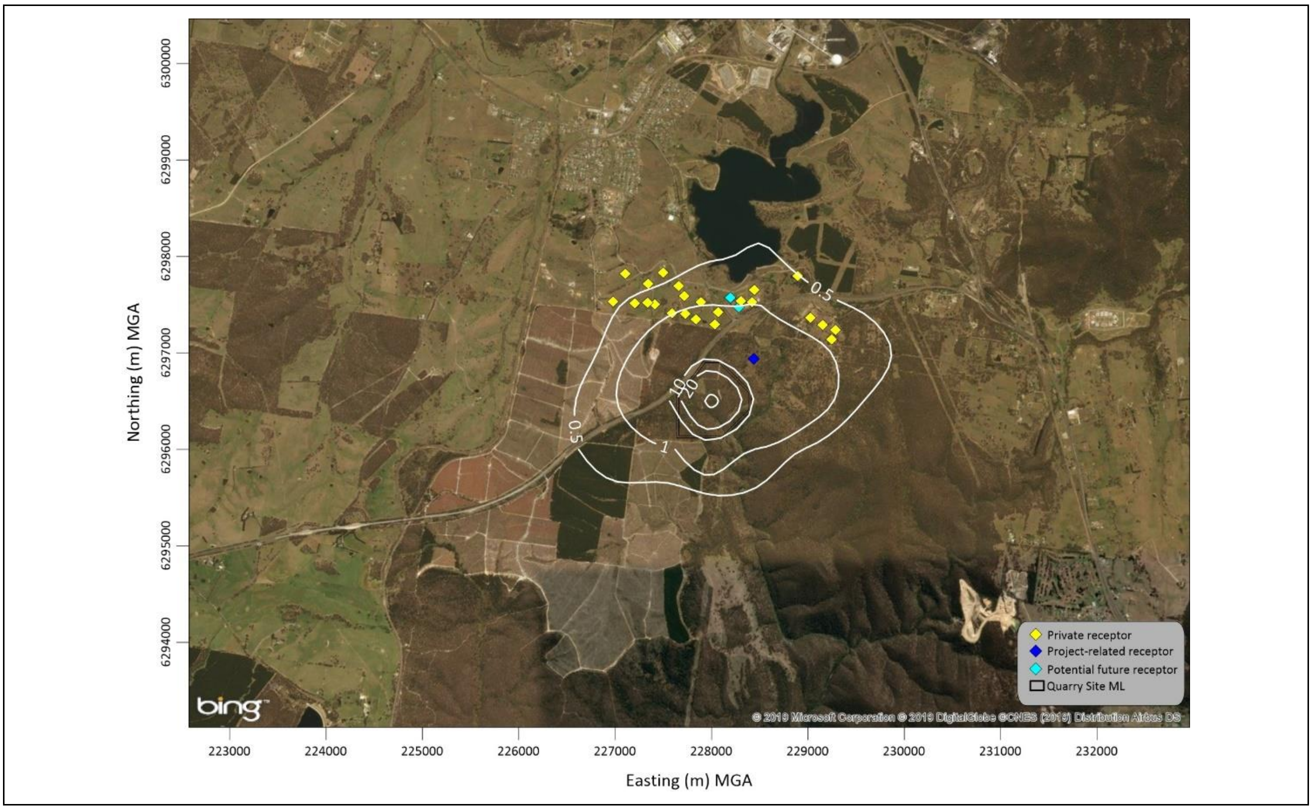

Figure A3-5: Project-only annual average TSP concentration (µg/m³) contours – Scenario 1

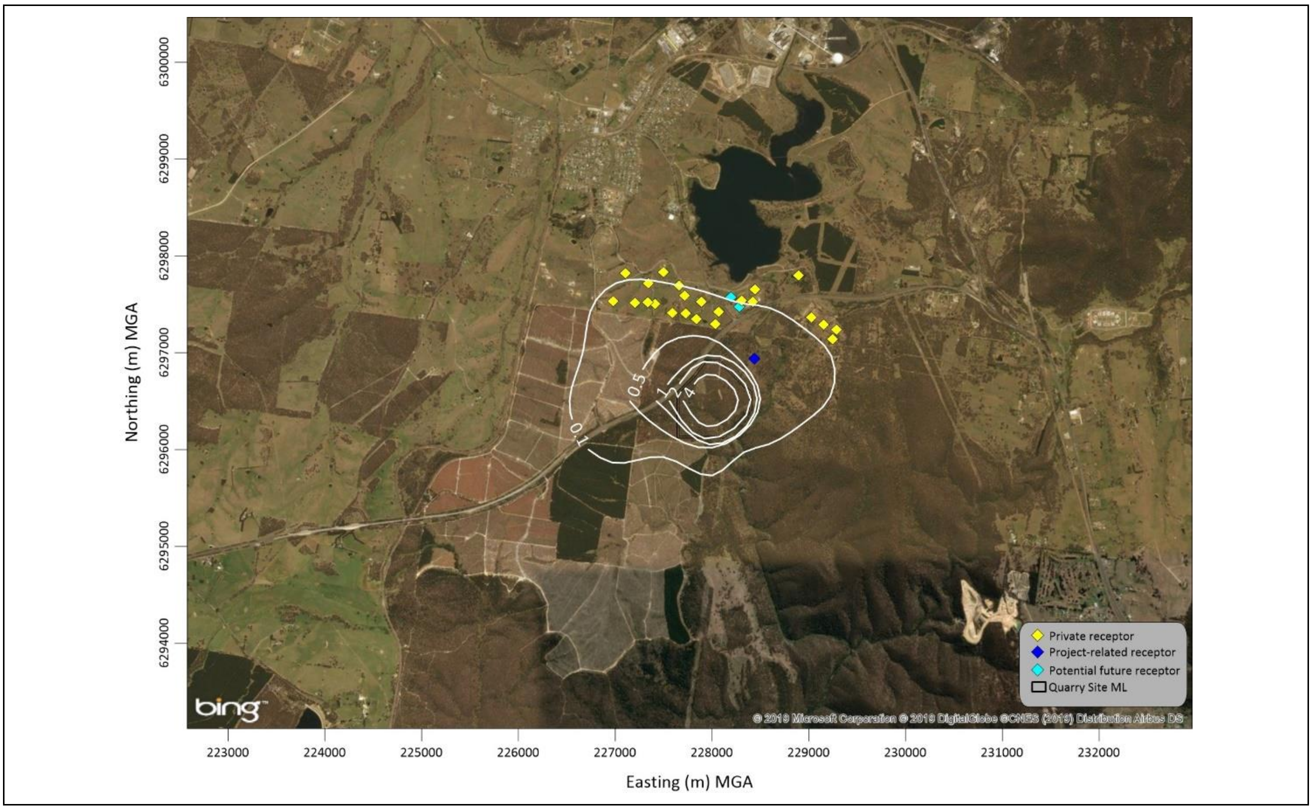

Figure A3-6: Project-only annual average dust deposition (g/m²/month) contours – Scenario 1

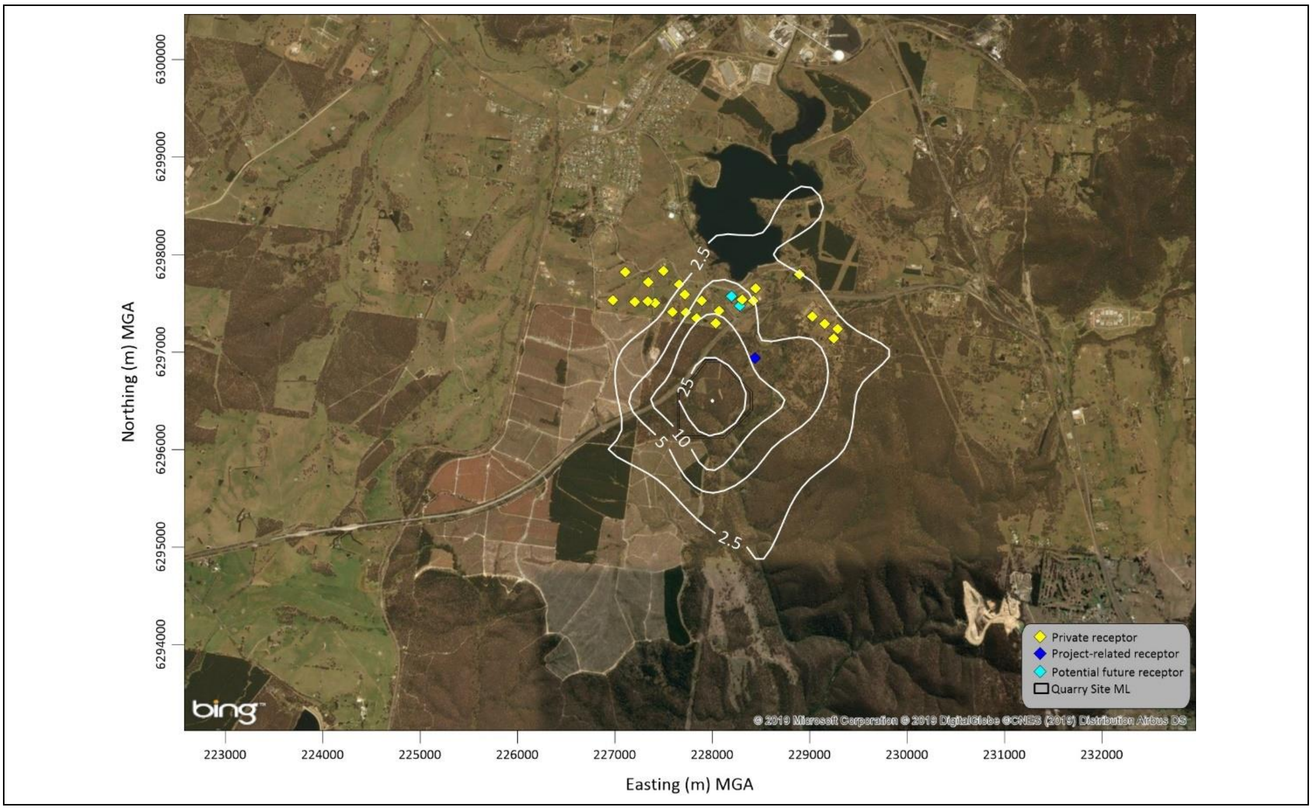

Figure A3-7: Project-only 24-hour average PM_{10} concentration ($\mu g/m^3$) contours – Scenario 2

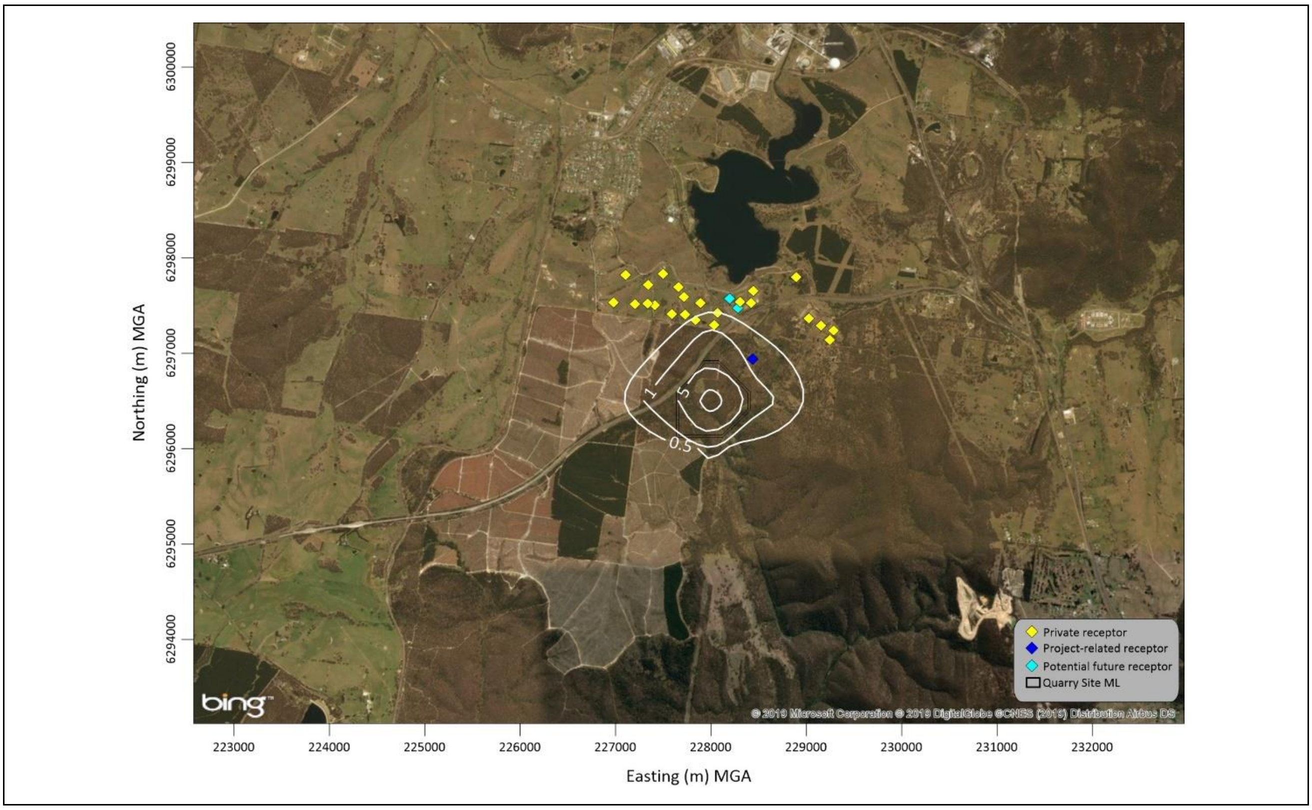

Figure A3-8: Project-only annual average PM_{10} concentration ($\mu g/m^3$) contours – Scenario 2

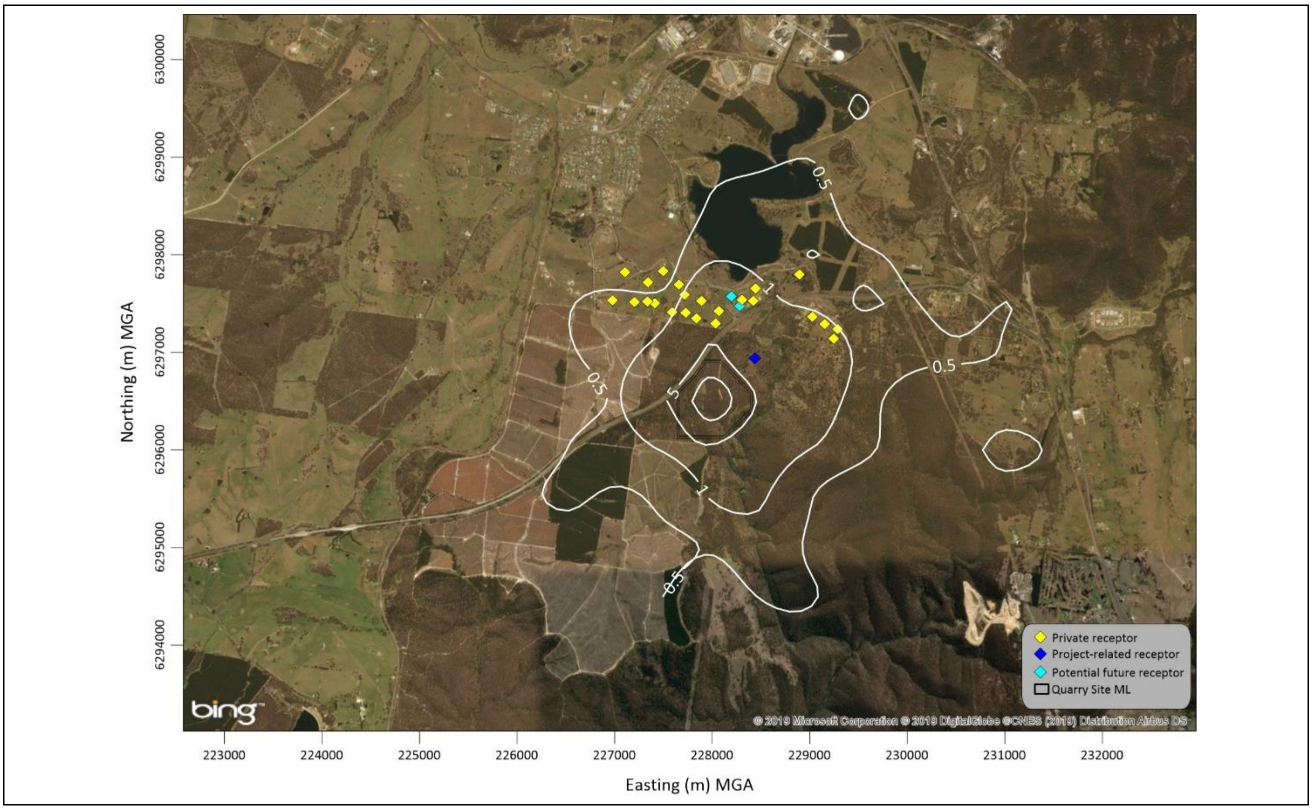

Figure A3-9: Project-only 24-hour average $PM_{2.5}$ concentration (μg/m^3) contours – Scenario 2

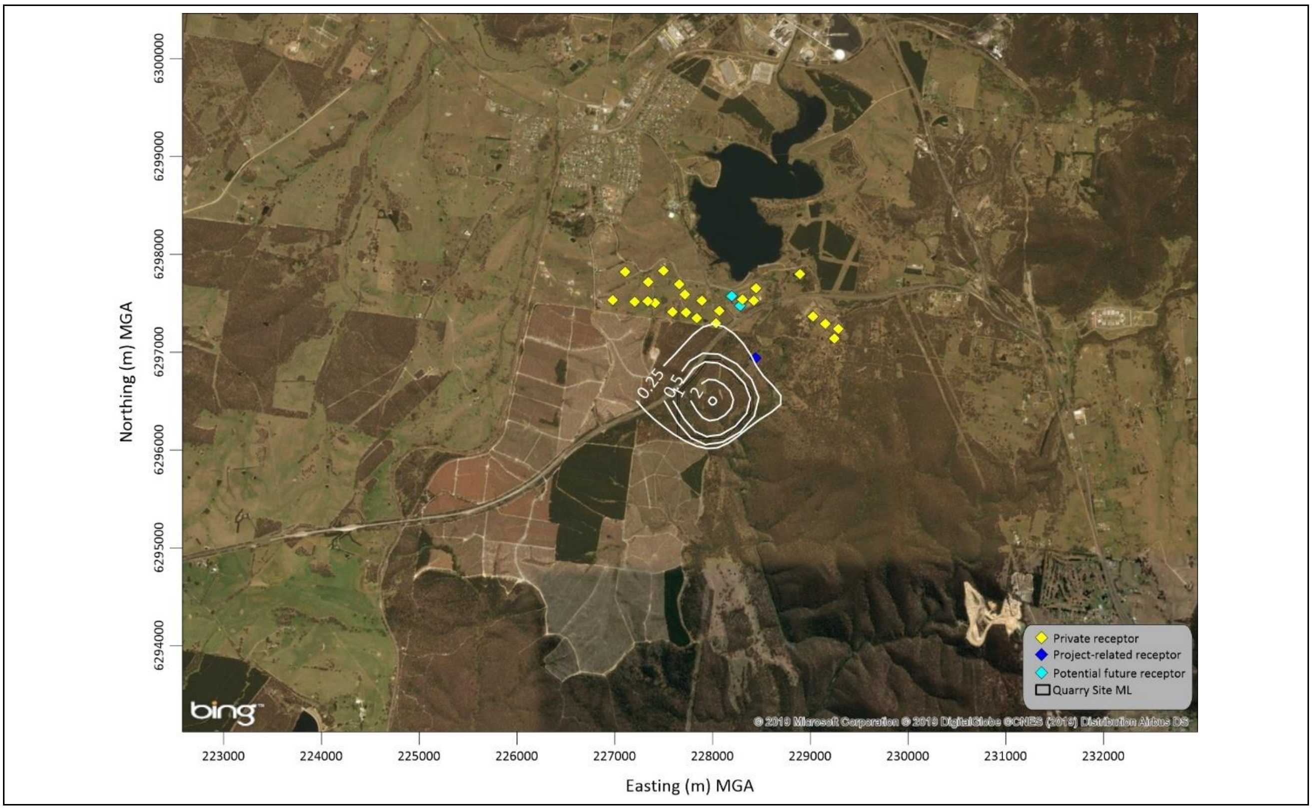

Figure A3-10: Project-only annual average $PM_{2.5}$ concentration (μg/m^3) contours – Scenario 2

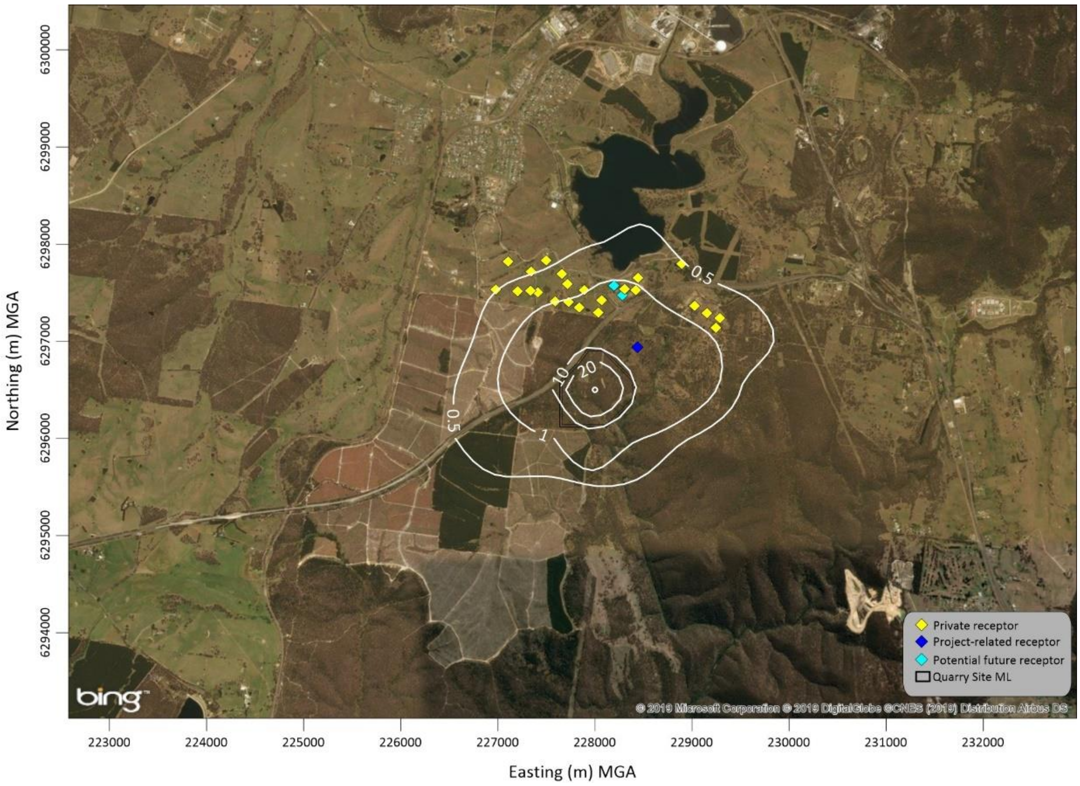

Figure A3-11: Project-only annual average TSP concentration (µg/m^3) contours – Scenario 2

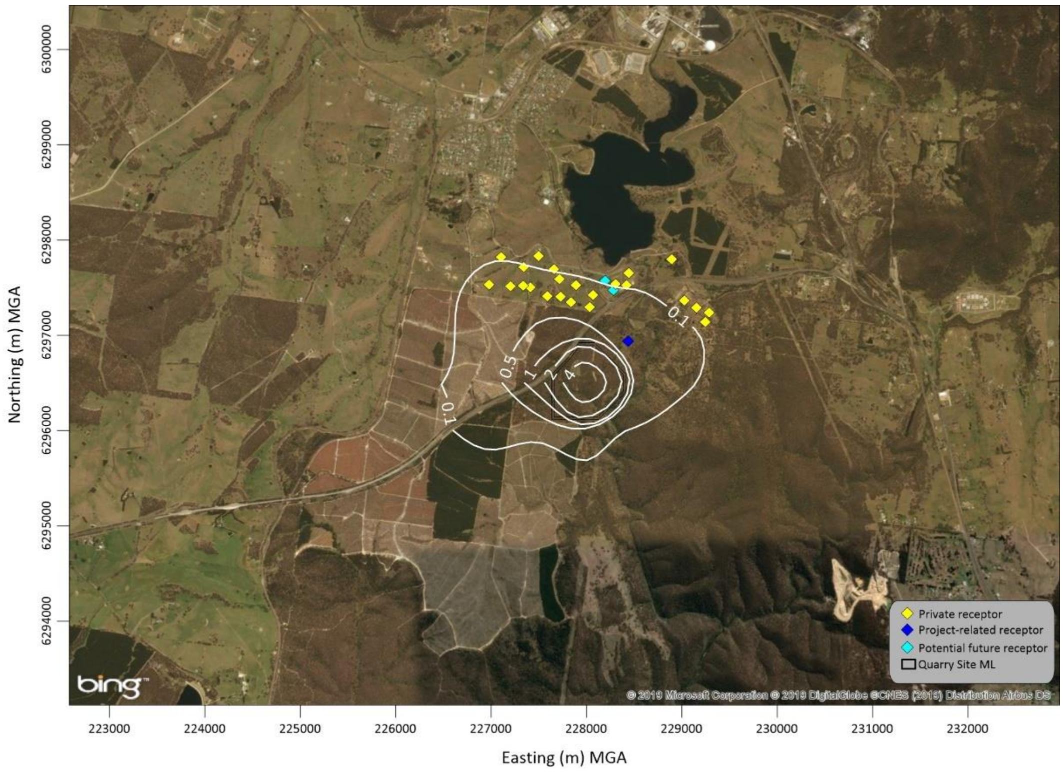

Figure A3-12: Project-only annual average dust deposition (g/m^2/month) contours – Scenario 2

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