Boral Limited
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Marulan South Limestone Mine Continued Operations
State Significant Development Application

V6

ENVIRONMENTAL IMPACT STATEMENT

Prepared for Boral Cement Limited | March 2019

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VOLUME 6

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Historic heritage assessment and statement of heritage impact

Boral Cement Limited | 9 August 2018

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Marulan South Limestone Mine Continued Operations Project

Final

Report J14107RP1 | Prepared for Boral Cement Limited | 9 August 2018

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Position	Senior Archaeologist/Archaeologist	Position	National Technical Leader – Heritage
Signature		Signature	
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Document Control

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Executive Summary

EMM Consulting Pty Limited (EMM) was commissioned by Boral Cement Limited (Boral) to prepare a historic heritage impact assessment to accompany the development application for the Marulan South Limestone Mine Continued Operations Project (the Project).

Boral proposes to continue mining limestone from the mine at a rate of up to 4 million tonnes per annum (mtpa) for a period of up to 30 years. A 30 year mine plan is proposed, which will access 120 million tonnes of limestone down to a depth of 335 m AHD. In addition to mining approximately 5 million tonnes of shale, the extraction of the limestone requires the removal of approximately 108 million tonnes of overburden over the 30 year period. This material will be emplaced within existing and proposed overburden emplacement areas.

Limestone will continue to be mined using drilling and blasting methods. Shale will continue to be mined by excavator/front end loader. Limestone, shale and overburden will be transported to the primary crusher, stockpile areas and overburden emplacements respectively, using the load and haul fleet of trucks.

Products produced at the mine will continue to be despatched by road and rail, with the majority despatched by rail.

The assessment identified eleven items, through field survey, of historic heritage significance in the Project site. The items are:

- MS01 Marulan South Village;
- MS03 Hut/camp;
- MS04 Aerial ropeway;
- MS05 Lime kiln group;
- MS07 Old alignment of Marulan South Road;
- MS08 the Feltham's house;
- MS09 the Armitt camp;
- MS11 ramp of earth and timber (possible camp site);
- MS12 Lime-kiln Road;
- MS13 Frome Hill Road;
- MS14 House site

Glenrock Homestead and Outbuildings (I314), which is a heritage item on the *Goulburn Mulwaree Local Environmental Plan 2009* is located approximately 240 m to the north of the Project site in the area where Marulan Creek Dam is proposed and 2.4 km north of the mine. A section of Bungonia National Park is also listed on the *Goulburn Mulwaree Local Environmental Plan 2009* but is recorded as the "Bungonia State Recreation Area" (I027). One unlisted site with heritage value was discovered during survey outside the Project site:

- MS10 Mt Frome mine and tramway

The historical development of the local area is a combination of mining and grazing. Limestone was sought at Marulan South as early as the 1860s and the location has provided an important contribution to the construction industry initially in the colony and now to the Southern Highlands/Tablelands, the Illawarra and Metropolitan Sydney markets. The Project site encompasses evidence of the early mining activities in the form of remnant lime kilns and early roads, camps and houses for mine workers and later technological developments in the form of the remnants of an aerial ropeway.

The geology of the region that has made the place so valuable occurs in a landscape of high relief, thus visibility from outside mine-owned (Boral) land is low except from the Bungonia Lookdown within the Bungonia National Park to the south of Bungonia gorge. Significant historical landscapes occur within the Project site but these are of a small scale and measures to record them have been developed. Wider significant historical landscapes do not exist within visual distance to the mine although the surrounding land is predominantly pastoral.

The impacts presented in this report were assessed and alternatives were discussed at length. The location, orientation and depth of the limestone dictates the location, depth and extent of the pit required to mine this resource and also the volume of overburden and the area required for the emplacement of overburden. The area required for the continuation of mining for the next 30 years precludes the retention of those heritage items identified for removal. The location that is proposed for the mine pit, infrastructure and overburden emplacements has been carefully considered to balance impacts on all relevant environmental values. The 30 year mine plan has been designed to most efficiently extract the limestone resource and minimise the amount of overburden material, while not mining the southern rim of the pit and limiting the height of the overburden emplacements to reduce long term visual impacts. The proposed 30 year mine plan is considered by the mine planners to be optimal.

Site and landscape-specific management measures are summarised in Table 1.1 below and in Table 7.1, Section 7 of this report. They have been developed to record information about the industrial/residential landscape inside the Project site associated with historic mining activities, before various historic heritage items are removed to accommodate the continued operations at the mine. It is anticipated that the data to be recorded will be useful for future research related to spatial and comparative analysis and will provide an understanding of the material culture created by nineteenth and early twentieth century miners. This is how the Project aims to create opportunities for research and learning on the themes identified in this report.

In the first instance, avoidance of impacts to areas of historic heritage significance is the preferred option. Where avoidance is not possible, the following measures apply:

i Undertake photographic archival recording of all sites to be removed

ii Archaeological recording of all identified items in the Project site which includes:

- all identified items, including those that will not be impacted, will be recorded with the use of topographic survey or their cadastral boundaries (refer to Table 1.1 below) so their relative location, elements and orientation can be mapped;
- archaeological excavation of representative structures of the lime kiln group (M05) prior to its removal; and
- archaeological excavation of a sample of camp site MS03.

iii Fence and signpost sites that will not be removed by the Project

iv Preparation of a historic heritage management plan addressing

- unexpected finds; and
- human skeletal material

Table E1 Site impact assessment and management summary

Site ID	Site description	Location	Significance	Impact level	Management
MS01	Marulan South village	North-east of the limestone processing and limestone production plant.	Local	No impact	Photographic archival recording Archaeological recording through topographic survey
MS02	Deleted				
MS03	Hut/camp site	Centre of proposed 30 year mine pit; directly west of existing mine	Local	Total impact	Photographic archival recording Archaeological recording through topographic survey Archaeological excavation (sample area)
MS04	Aerial ropeway	Southern area of 30 year mine pit to the north west of the Western Overburden Emplacement (and outside of Project site)	Local	Partial (majority) impact of elements	Photographic archival recording Archaeological recording through topographic survey Move metal buckets from former aerial ropeway for safekeeping. Buckets in locations that will not be impacted to remain in situ
MS05	Lime kiln group	Southern end of 30 year mine pit	Local	Total impact	Photographic archival recording of entire group Archaeological recording through topographic survey Archaeological excavation of at least one of each type (two types of kiln exist on the site)
MS06	Explosives hut	Southern end of 30 year mine pit	None	Total impact	Photographic archival recording (detail not required) Archaeological recording through topographic survey
MS07	Old alignment of Marulan South Rd (now closed)	Northern edge of the main Western Overburden Emplacement haul road, immediately south of the proposed Central Dam		Total impact	Include in final spatial mapping of sites; data to be extracted from cadastre Photographic archival record of a representative sample
MS08	The Feltham house	Western side of the mine and immediately west of the Western Overburden Emplacement	Local	No impact	Fence and signpost Photographic archival recording Archaeological recording through topographic survey Record any artefacts and structures that occur in the area of impact
MS09	Camp (Armitt family)	Western side of the existing mine pit and north of the lime kiln group	Local	Total impact	Photographic archival recording Archaeological recording through topographic survey
MS10	Mt Frome mine and rail	South of the mine (outside)	Local	No impact	None – these items are outside of the Project site

Table E1 Site impact assessment and management summary

Site ID	Site description	Location	Significance	Impact level	Management
MS11	Ramp of earth and timber	Immediately south of the Northern Overburden Emplacement, west of the 30 year mine pit and east of the Western Overburden Emplacement	Local	No impact	Fence and signpost Photographic archival recording Archaeological recording through topographic survey
MS12	Lime-kiln Road	Southern end of 30 year mine pit	Local	Total impact	Archival recording Archaeological recording through topographic survey
MS13	Mt Frome Road	Crosses into Project site on western side of the Western Overburden Emplacement	Local	Partial impact	Photographic archival recording of a representative sample of the section of road to be removed. Include in spatial mapping of sites; data can be extracted from cadastre.
MS14	House site – chimney remaining; planted trees, possibly quince; track.	Centre of proposed mine plan; directly west of 30 year mine pit	Local	No impact	Fence and signpost Photographic archival recording Archaeological recording through topographic survey Undertake archaeologically excavation if artefacts and structures occur in the area of impact

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1 Introduction

1.1 Overview

Boral Cement Limited (Boral) owns and operates the Marulan South Limestone Mine (the mine). It is a long standing open cut mine that has produced up to 3.38 million tonnes of limestone based products per year for the cement, steel, agricultural, construction and commercial markets.

The mine is a strategically important asset for Boral, as it supplies the main ingredient for the manufacture of cement at Boral's Berrima Cement Works. This is also a strategically important operation for Sydney based consumers of these products as this represents around 60% of the cement sold in NSW and feeds into more than 30% of concrete sold in Sydney.

The mine operates under Consolidated Mining Lease No. 16 (CML 16), Mining Lease No. 1716, Environment Protection Licence (EPL) 944 and a combination of development consents issued by Goulburn Mulwaree Council and continuing use rights.

Due to changes between the *Mining Act 1992* and the *Environmental Planning & Assessment Act 1979* (EP&A Act), when mining moves beyond the area covered by the current Mining Operations Plan, a development consent under the EP&A Act will need to be in place.

An Environmental Impact Statement has been prepared by Element Environment Pty Ltd on behalf of Boral for submission to the Department of Planning and Environment to satisfy the provisions of Part 4 of the EP&A Act. Boral is seeking approval for continued operations at the site through a development application for a State Significant Development including a 30 year mine plan, associated overburden emplacement areas and a mine water supply dam (hereafter referred to as 'the Project').

EMM Consulting Pty Limited Pty Limited (EMM) was commissioned by Boral Cement Limited (Boral) to prepare a historical heritage impact assessment to accompany the development application for the Marulan South Limestone Mine Continued Operations Project (the Project).

1.2 Site description

1.2.1 Site location

The mine is in Marulan South, 10 km southeast of Marulan village and 35 km east of Goulburn, within the Goulburn Mulwaree Local Government Area in the Southern Tablelands of NSW (Figure 1.1). Access is via Marulan South Road, which connects the mine and Boral's Peppertree Hard Rock Quarry (Peppertree Quarry) with the Hume Highway approximately 9 km to the northwest. Boral's private rail line connects the mine and Peppertree Quarry with the Main Southern Railway approximately 6 km to the north (Figure 1.2).

1.2.2 Land use and ownership

CML 16 (which encompasses ML 1716) covers an area of 616.5 hectares (ha), which includes land owned by Boral (approximately 475 ha), Crown Land (adjoining to the south and east) and five privately owned titles (refer to EIS Figure 1.3). There is also Boral owned land surrounding the mine that does not fall within CML 16.

Land use surrounding the mine is a mixture of extractive industry, grazing, rural residential, commercial/industrial and conservation.

The mine is separated from the Bungonia State Conservation Area and Bungonia National Park to the south by Bungonia Creek and is separated from the Shoalhaven River and Morton National Park to the east by Barbers Creek.

Peppertree Quarry, owned by Boral Resources (NSW) Pty Limited, borders the mine to the north. The site of the former village of Marulan South is between the mine and Peppertree Quarry on land owned by Boral. The village was established principally to service the mine but has been uninhabited since the late 1990's. The majority of the village's infrastructure has been removed and only a village hall and former bowling club remains. The bowling club has been converted into administration offices for the mine and the hall is used by the mine services team.

A small number of rural landholdings surround the Boral properties to the north and west, including an agricultural lime manufacturing facility, fireworks storage facility, turkey farm and rural residential (a number of these properties are actively grazed). The main access for these properties is via Marulan South Road. Rural residential properties are also located to the northeast of the mine along Long Point Road. These properties are separated from the mine by the deep Barbers Creek gorge. Sensitive receivers are shown in EIS Figure 1.3.

1.2.3 Zoning

The majority of the site is zoned RU1 - Primary Production zone under the Goulburn Mulwaree Local Environmental Plan (LEP) 2009. Mining and extractive industries are permissible in this zone with consent.

The remaining area is zoned E3 - Environmental Management. Under this zone mining and extractive industries are prohibited development, although historically mining has occurred within these areas under "existing use rights" as mining and processing operations commenced well before the commencement of the Mulwaree Planning Scheme Ordinance (PSO) on 15 May 1970. Notwithstanding that both mining and extractive industries are prohibited in the E3 zone these activities are permissible pursuant to *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*. In accordance with Clause 7(1)(b)(i) of this SEPP mining can be carried out with consent in any zone which has agriculture as a permissible land use (with or without consent). Agriculture is permitted with consent in the E3 - Environmental Management zone under the Goulburn Mulwaree LEP 2009. Similarly, Clause 7(3)(a) of this SEPP makes it clear that extractive industries can be carried out with consent in any zone which has agriculture as a permissible land use (with or without consent). Therefore, both mining and extractive industries are land uses which can be carried out provided development consent is granted.

Boral operates the mine pursuant to Section 109 of the EP&A Act and the continuance of an existing use and its expansion is possible provided the necessary approvals are in place. Therefore, there are no environmental planning issues that would prohibit approval of expanded operations at the mine.

Importantly, the Project aims to improve the stability of existing overburden emplacements and improve rehabilitation outcomes over the entire site.

1.2.4 Topography and hydrology

The Southern Highlands, similar to the Blue Mountains to the north-west, are predominantly comprised of a level plateau with the occasional high intrusive volcanic remnant mountains, such as Mount Jellore, Mount Gibraltar and Mount Gingenbullen. On the seaward side they decline into a steep escarpment that is heavily divided by the headwaters of the Shoalhaven River.

The Project site and surrounds is characterised by the rolling hills of pasture and grazing lands interspersed with woodland to the west, contrasting with the heavily wooded, deep gorges that begin abruptly to the east of the mine, forming part of the Great Escarpment and catchment of the Shoalhaven River. As such, local relief of Marulan South ranges from around 130 m Australian Height Datum (AHD) to over 630 m AHD.

The Project site is drained by a number of minor ephemeral drainage lines into Barbers Creek to the east and Bungonia Creek to the south. These creeks are tributaries of the Shoalhaven River, which is 1.5 km from the mine (at its closest point) and flows eastwards into Lake Yarrunga, approximately 20 km downstream and enters the Pacific Ocean approximately 15 km east of Nowra (approximately 100 km downstream).

1.2.5 Geology

The Marulan South limestone deposit lies within the Lachlan Geosynclinal Province. During the Palaeozoic Era (500 to 300 million years ago) thick sedimentary formations were laid down in the region. The formations included sediments, volcanic lavas and ash, and limestone reefs.

A reef complex formed the Bungonia Limestone Group, which was later folded and faulted by crustal collisions and then subsequently levelled by substantial erosion. About 65 million years ago the area was again uplifted giving way to a rejuvenated river system leading to the landscape of today.

The Bungonia Limestone formations at Marulan South consist of a number of generally parallel and north-south striking beds dipping to the west. The Bungonia Limestone includes:

- Eastern Limestone, which is the oldest, easternmost and thickest unit; and
- Mt Frome Limestone, which is the younger unit that lies to the west of the Eastern Limestone and is made up of three sub-parallel sub-units including the Upper Limestone (furthest west), Middle Limestone and Lower Limestone (furthest east).

Separating the limestone units are fine grained sediments including shales, mudstones, siltstones and minor fine sandstones.

The total horizontal width of the Bungonia Limestone is approximately 670 m east-west. The true depth of the Bungonia Limestone is not known as the termination of the limestone is not visible either in the mine or at the bottom of the Bungonia gorge to the south. To date even the deepest drill holes (approximately 300 m) in the mine have ended in limestone.

The Eastern Limestone has the highest grade and was therefore selected for the commencement of mining. The Eastern Limestone is still the focus of current mining operations, however mining of Mt Frome Middle Limestone commenced in approximately 2016.

The Bungonia Limestone Group is bound to the east by the older Tallong shale beds and in the west by the Tangarang Volcanics (younger shales, volcanic and associated sedimentary rocks). A north-south and various east-west dolerite dykes penetrate the limestone from beneath and the limestone bed is cut off in the north by the Glenrock Granodiorite intrusion, which is extracted by Peppertree Quarry.

1.2.6 Climate

The mine is in Australia's cool temperate climatic region, which is characterised by mild to warm summers and cold winters, with common frost and occasional snow fall.

Long term climatic data was obtained from the Bureau of Meteorology (BoM) automatic weather station at Goulburn Airport, approximately 25 km west-southwest of the mine.

The BoM weather station shows that January is the hottest month with a mean maximum temperature of 27.9 degrees Celsius (^{0}C) and July is the coldest month with a mean minimum temperature of 0.3ºC.

Average annual rainfall is 551.9 mm. Rainfall peaks during the summer and the month of June. June is the wettest month with an average rainfall of 60.9 mm over 7.0 days and April is the driest month with an average rainfall of 25.6 mm over 4.0 days.

Relative humidity levels exhibit variability and seasonal flux across the year. Mean 9am relative humidity levels range from 65% in October and December to 88% in June. Mean 3pm relative humidity levels vary from 39% in December to 63% in June. Wind direction is predominantly from the west in winter and from the east in summer.

Wind speeds have a generally similar spread between the 9am and 3pm conditions. The mean 9am wind speeds range from 12.2 km/h in March to 19.8km/h in September. The mean 3pm wind speeds vary from 19.8km/h in April to 26.5km/h in August.

1.3 Existing operations

The mine is sited on a high grade limestone resource. Subject to market demand the mine has typically produced 3 to 3.38 million tonnes of limestone and 120,000 to 200,000 tonnes of shale per annum.

The mine currently produces a range of limestone products for internal and external customers in the Southern Highlands/Tablelands, the Illawarra and Metropolitan Sydney markets for use primarily in cement and lime manufacture, steel making, agriculture and other commercial uses. Products produced at the mine are despatched by road and rail, with the majority despatched by rail.

Historically limestone mining was focused on the approximately 200-300 m wide Eastern Limestone and was split between a North Pit and a South Pit. A limestone wall (referred to by the mine as the 'centre ridge') rising almost to the original land surface, divided the two pits. The North and South Pits were recently joined in 2016/2017 by mining the centre ridge to form a single contiguous pit, approximately 2 km in length. However, the North Pit/South Pit nomenclature remains important as current mining operation locations continue to be reported with respect to one or other of the old pits.

Limestone and shale are extracted using open-cut hard rock drill and blast techniques. Material is loaded using front end loaders and hauled either to stockpiles or the processing plant using haul trucks. Oversized material is stockpiled and reduced in size using a hydraulic hammer attached to an excavator.

Limestone processing facilities including primary and secondary crushing, screening, conveying and stockpiling plant and equipment are in the northern end of the North Pit. Kiln stone grade limestone is also processed on site through the existing lime plant comprising kiln stone stockpiles, rotary lime kiln, hydration plant and associated auxiliary conveying, processing, storage, despatch plant and equipment. Overburden from stripping operations is emplaced in the Western Overburden Emplacement, west of the open cut pits.

The current operations are 24 hour, 7 days per week with personnel employed on a series of 8, 10 and 12 hour shifts to cover the different operational aspects of the mine. Blasting is restricted to daylight hours and on weekdays, excluding public holidays.

1.4 The proposed Project

1.4.1 Mining operations

Boral proposes to continue mining limestone from the mine at a rate of up to 4 million tonnes per annum (mtpa) for a period of up to 30 years. This represents an increase in extraction rate from historic levels (peak of 3.38 mtpa) due to forecast increased demand from the construction industry. Shale will continue to be extracted at a rate of up to 200,000 tonnes per annum (tpa).

The proposed 30 year mine plan accesses approximately 120 million tonnes of limestone down to a depth of 335 m AHD. The mine footprint focuses on an expansion of the North Pit westwards to mine the Middle Limestone and to mine deeper into the Eastern Limestone. As the Middle Limestone lies approximately 70 m to 15 m west of the Eastern Limestone, the 30 year mine plan avoids mining where practical the interburden between these two limestone units thereby creating a smaller second, north-south oriented West Pit with a ridge remaining between. The North Pit will also be expanded southwards, encompassing part of the South Pit, leaving the remainder of the South Pit for overburden emplacement and a visual barrier (Figure 1.3).

In addition to mining approximately 5 million tonnes of shale, the extraction of the limestone requires the removal of approximately 108 million tonnes of overburden over the 30 year period. This material will be emplaced within existing and proposed overburden emplacement areas (Figure 1.4).

Limestone will continue to be mined using drilling and blasting methods. Shale will continue to be mined by excavator/front end loader. Limestone, shale and overburden will be transported to the primary crusher, stockpile areas and overburden emplacements respectively, using the load and haul fleet of trucks.

Products produced at the mine will continue to be despatched by road and rail, with the majority despatched by rail.

The limestone sand plant produces a crushed and air classified limestone sand for use in concrete. The mine currently produces 500,000 tpa for Peppertree Quarry and propose to increase production of manufactured sand to approximately 1 million tpa.

Boral's adjoining Peppertree Quarry currently has approval to emplace some of its overburden in the South Pit mine void. As the South Pit is required for the emplacement of over 30 million tonnes of overburden from the mine after the removal of accessible limestone, Boral proposes to emplace up to 15 million tonnes of overburden from Peppertree Quarry within the Northern Overburden Emplacement (Figure 1.3).

1.4.2 Associated infrastructure

i Processing

The existing facilities for processing limestone will continue to be utilised to produce a series of graded and blended limestone products that are despatched from site for use primarily in cement manufacture, steel making, commercial and agricultural applications.

Limestone processing facilities (Figure 1.3) include primary and secondary crushing, screening, conveying and stockpiling plant and equipment located north-west of the North Pit and extending to the tertiary crushing, screening, bin storage and despatch (rail and road) systems that form part of the main processing facilities.

Kiln stone grade limestone will also continue to be processed on site through the existing lime plant comprising kiln stone stockpiles, rotary lime kiln, hydration plant and associated auxiliary conveying, processing, storage, despatch plant and equipment.

Processing infrastructure and the reclaim and stockpile area at the northern end of the North Pit will be relocated during the life of the 30 year pit to enable full development of the mine plan. The timing and location of this is presented in the EIS.

Shale and white clay will not be processed and will be stockpiled directly from the pit, ready for dispatch by road to the Berrima and Maldon cement operations.

ii Water supply

Water supply for the Project, including dust suppression, processing activities and some non-potable amenities will be from existing and new on-site dams and a proposed new water supply dam on Marulan Creek (Figure 1.4). This dam would be located on Boral owned land north of Peppertree Quarry and utilises Boral's adjoining Tallong water pipeline to transfer water to the mine. This dam would require the purchase of water entitlements.

Mine water demand will also be supplemented by Tallong Weir via the Tallong water pipeline.

iii Rail

No changes are proposed to the existing rail infrastructure. A 1.2 km long passing line was constructed at Medway Junction during construction of the Peppertree Quarry, which will also be used by the mine to enhance access to the Main Southern Railway.

iv Road

Road access from the mine to the Hume Highway is via Marulan South Road. The proposed Western Overburden Emplacement extends northwards over Marulan South Road. Boral propose to realign a section of Marulan South Road, to accommodate the northern portion of the proposed Western Overburden Emplacement (Figure 1.3).

All public roads within the former village of Marulan South as well as the section of Marulan South Road between Boral's operations and the entrance to the agricultural lime manufacturing facility will be de-proclaimed.

v Power

Power supply to the mine is via a high voltage power line that commences at a sub-station on the southern side of Marulan South Road, immediately west of the Project boundary. A section of this power line will be relocated to accommodate the proposed Northern Overburden Emplacement (Figure 1.3).

1.4.3 Transport

The majority of limestone products will continue to be transported to customers by rail for cement, steel, commercial and agricultural uses. Boral seeks no limitation on the volume of products transported by rail.

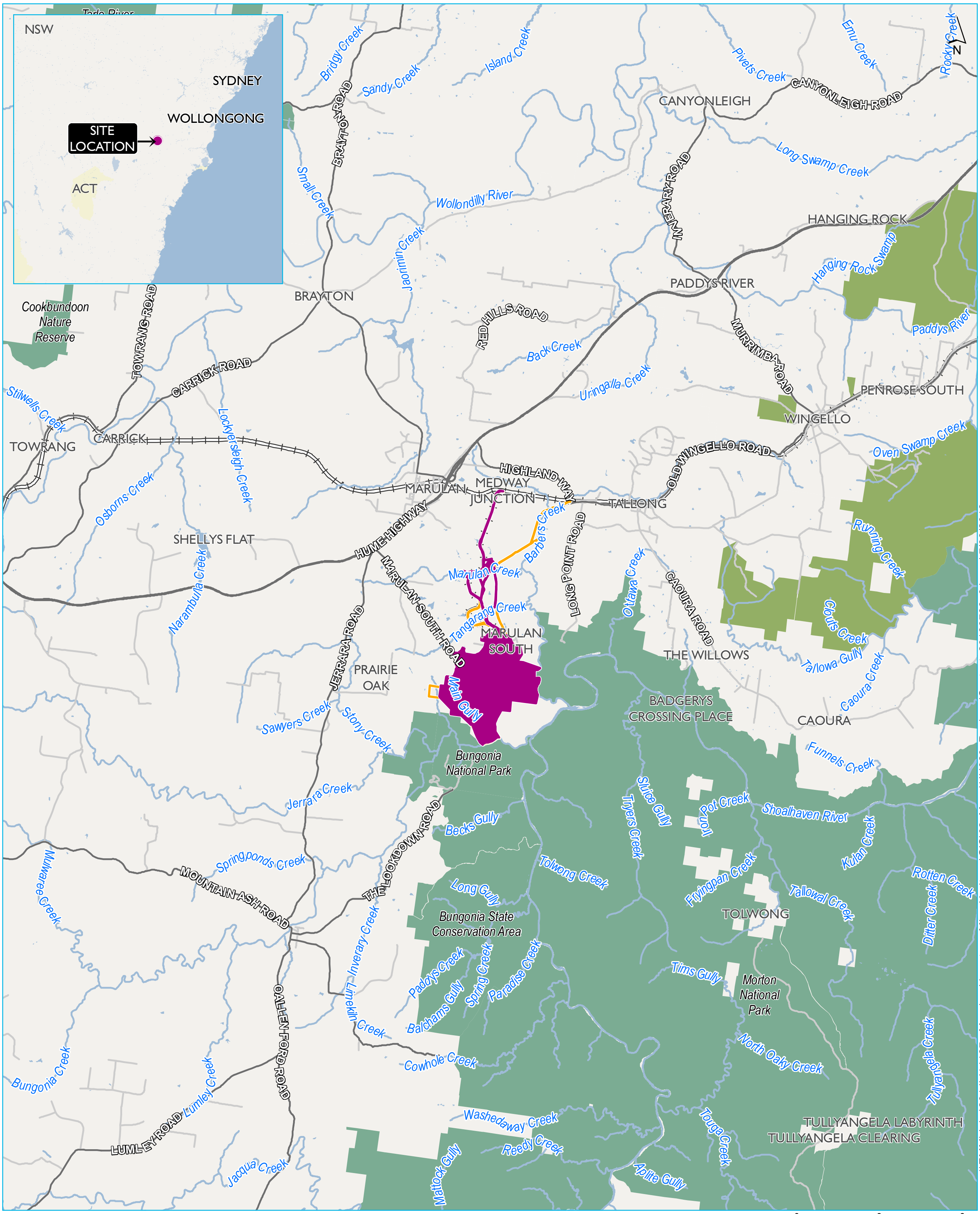
Manufactured sand will continue to be transported by truck along a dedicated internal road, across Marulan South Road and into Peppertree Quarry for blending and dispatch by rail.

Agricultural lime, quick lime and fine limestone products will continue to be transported by powder tanker, bulk bags on trucks or open tipper trucks along Marulan South Road.

Shale, limestone aggregates, sand and tertiary crushed products will be transported by predominantly truck and dog along Marulan South Road.

The adjoining Peppertree Quarry is currently approved to transport all products by rail. Boral will seek to transport approximately 150,000 tpa of Peppertree Quarry's products from the mine to customers via Marulan South Road. This could be achieved by back loading to a new shared road sales product stockpile area by the trucks carrying the limestone sand to Peppertree Quarry. A new shared road sales product stockpile area is proposed on the northern side of Marulan South Road, immediately west of the mine and Peppertree Quarry entrances (Figure 1.3). This shared finished product stockpile area, includes a weighbridge and wheel wash and will service both the mine and Peppertree Quarry.

In total, Boral is seeking to transport up to 600,000 tpa of limestone and hard rock products along Marulan South Road to the Hume Highway, as well as 120,000 tpa of limestone products to the agricultural lime manufacturing facility.



Source: EMM (2018); DFSI (2017); LPI (2015); GA (2015); LPMA (2011)

0 3 6 km
GDA 1994 MGA Zone 56

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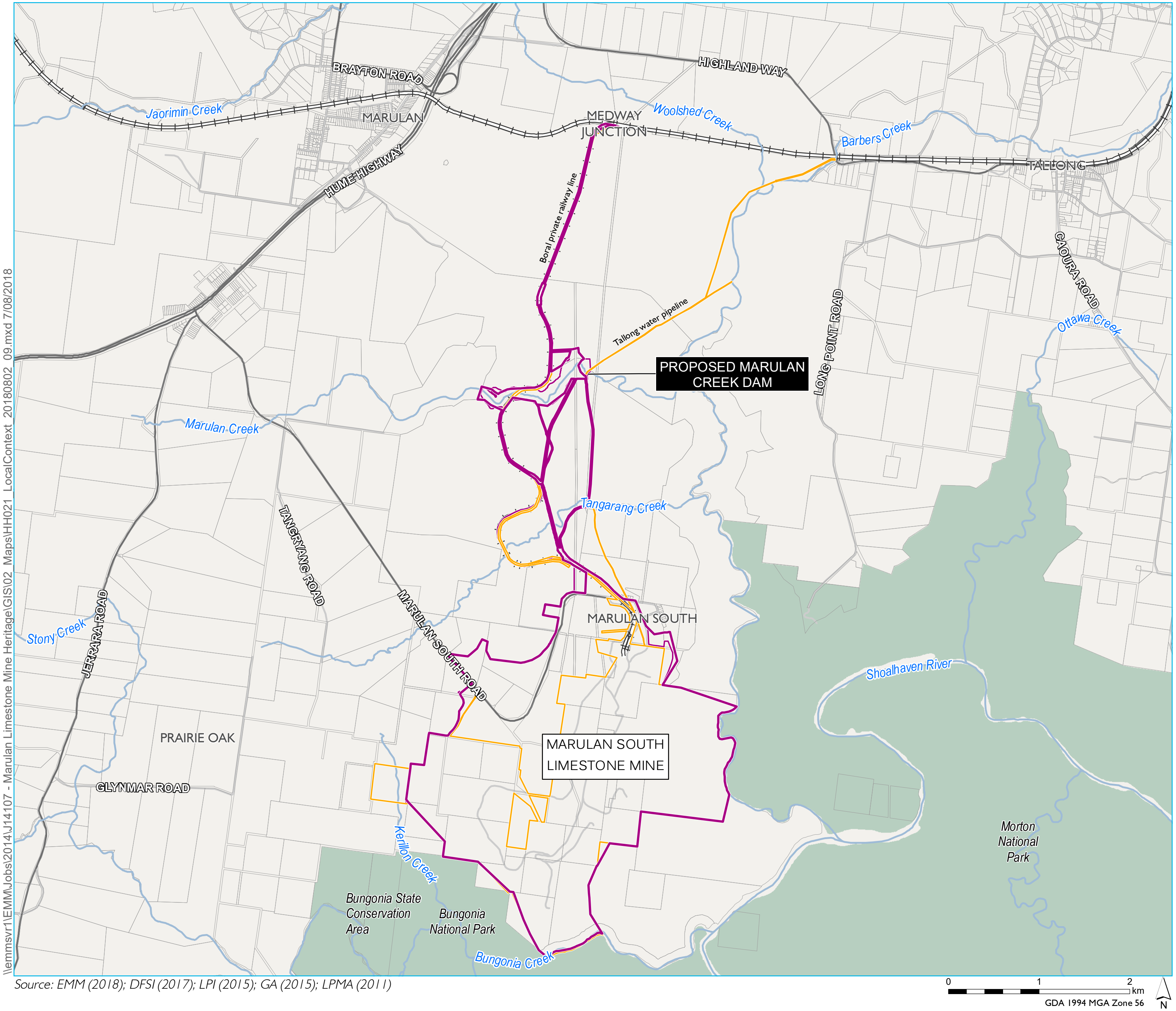
KEY

- Project area
- CML 16
- Main road
- Local road
- Rail line
- Watercourse
- Waterbody
- NPWS reserve
- State forest

Project site in the regional context

Marulan South Continued Operations Project
Historical heritage assessment and SoHI
Figure 1.1

EMM



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Source: EMM (2018); DFSI (2017); LPI (2015); GA (2015); LPMA (2011)

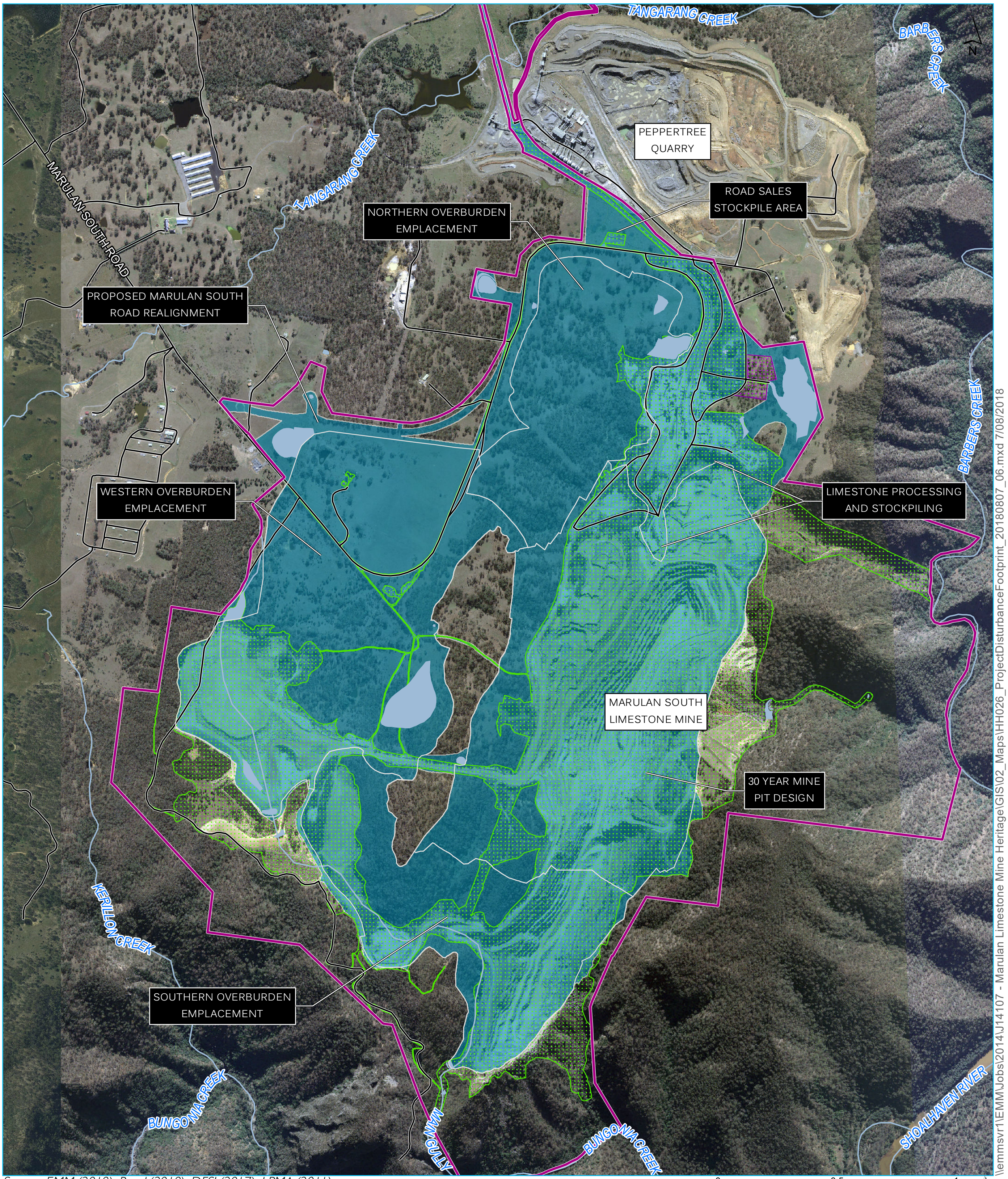
KEY
- Project boundary
- CML 16
- Main road
- Local road
- Watercourse
- Rail line
- Cadastral boundary
- NPWS reserve

Project site in the local context

Marulan South Continued Operations Project
Historical heritage assessment and SoHI

Figure 1.2

EMM



Source: EMM (2018); Boral (2018); DFSI (2017); LPMA (2011)

0 0.5 1 km

GDA 1994 MGA Zone 56 N

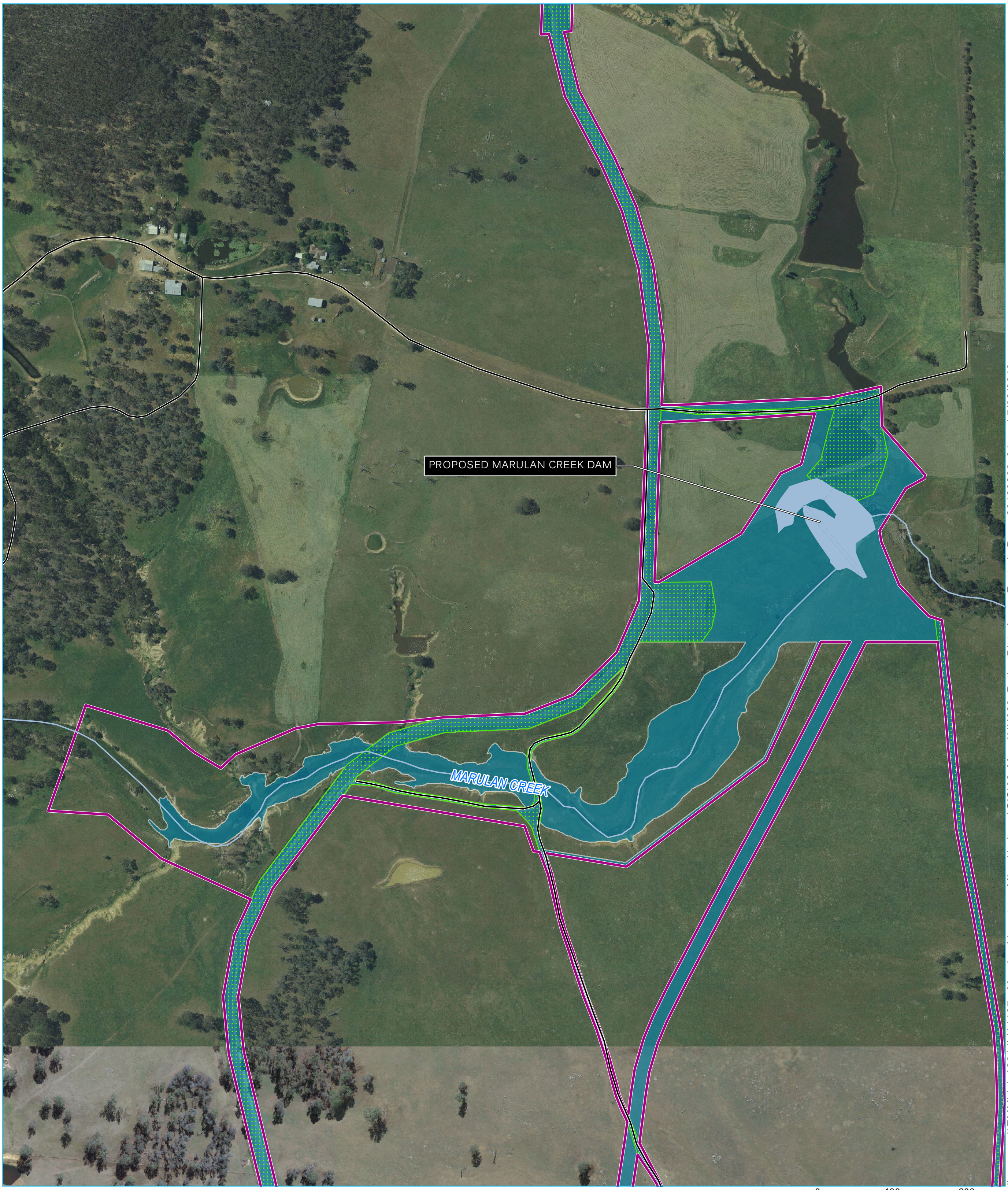
KEY

- Road/access track
- Watercourse
- Project boundary
- Overburden emplacement and 30 year mine pit design boundary
- Project (SSD) disturbance footprint
- Proposed dam location
- Historical disturbance footprint (pre - SSD)
- Additional historic area of disturbance (pre -SSD)

Project disturbance footprint mining operations

Marulan South Continued Operations Project
Historical heritage assessment and SoHI
Figure 1.3

EMM



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Source: EMM (2018); Boral (2018); DFSI (2017); LPMA (2011)

0 100 200 m
GDA 1994 MGA Zone 56
N

KEY

- Road/access track
- Watercourse
- Project boundary
- Proposed Marulan Creek Dam
- Historical disturbance footprint (pre -SSD)
- Project (SSD) disturbance footprint

Project disturbance footprint
proposed Marulan Creek Dam

Marulan South Continued Operations Project
Historical heritage assessment and SoHI
Figure 1.4

EMM

1.5 Legislative framework

Boral will be seeking approval as a State Significant Development (SSD) under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The proposal will be assessed for a project-based approval from the Department of Planning and Environment (DP&E). The individual issues that were identified in the early stages of the process will be investigated and the relevant departments will be consulted; however approval under the *Heritage Act 1977* (Heritage Act) is not required to permit impacts to heritage items.

In NSW, heritage is generally managed through statutory instruments that require approval for changes to be made. These instruments include schedules or registers of items that have been assessed and deemed to reach a threshold of significance values high enough to include them on the instrument itself.

Heritage items require a high level of consideration where a project is assessed as an SSD, so while individual approvals are not part of the overall process, a detailed level of assessment is required for the project's approval. Relevant heritage registers are provided in Section 1.6.2.

1.6 Objectives of this assessment

This report has been prepared to fulfil the Secretary's environmental assessment requirements (SEARs) for historic heritage under Part 4 Division 4 of the *Environmental Planning and Assessment Act, 1979* (EP&A Act). The SEARS and EMM's responsive approach are presented in Table 1.1.

Table 1.1 SEARS

Item	Requirement	Response
DP&E	**A Historic heritage assessment (including archaeology) which must:**	
	• Include a statement of heritage impact (including significance assessment) for any State significant or locally significant historic heritage items; and	Section 6 of this report presents the statement of heritage impact for all heritage items, including newly recorded sites, which will potentially be affected by the project.
	• Outline any proposed mitigation and management measures (including an evaluation of the effectiveness and reliability of the measures), having regard to the Heritage Branch of NSW's requirements.	Section 7 of this report details the mitigation measures for items of heritage significance identified in this report.
	In addition, the EIS must include:	
	• A list of any approvals that must be obtained before the development may commence;	This project is seeking approval as an SSD under Part 4, Division 4.1 of the EP&A Act. Approvals under the Heritage Act are not required; however, should archaeological excavation be required for this project or post-approval works, any works that may impact relics or potential relics must be accompanied by the appropriate documentary investigation and undertaken by a qualified consultant. Management of relics and potential relics will be guided by the proposed heritage management plan (recommendation 1 of this report).

Table 1.1 SEARS

Item	Requirement	Response
	• An assessment of the likely impacts of the development on the environment, focussing on the specific issues identified below, including:	Chapter 6 of this report is the assessment of impacts and includes the statement of heritage impact.
	a) a description of the existing environment likely to be affected by the development, using sufficient baseline data;	Chapter 1 describes the existing environment.
	b) an assessment of the potential impacts of all stages of the development, including any cumulative impacts, taking into consideration relevant laws, environmental planning instruments, guidelines, policies, plans and industry codes of practice;	Chapter 6
	c) a description of the measures that would be implemented to mitigate and/or offset the potential impacts of the development, and an assessment of: – whether these measures are consistent with industry best practice, and represent the full range of reasonable and feasible mitigation measures that could be implemented; – the likely effectiveness of these measures; and – whether contingency plans would be necessary to manage any residual risks;	Chapter 7details the management strategy, including the measures to mitigate the anticipated impacts of the project on identified heritage. The management strategy was formulated based on an assessment of the heritage significance of the area against project requirements.
	d) a description of the measures that would be implemented to monitor and report on the environmental performance of the development if it is approved.	Chapter 7

Table 1.1 SEARS

Item	Requirement	Response
Stakeholder consultation	During the preparation of the EIS, you must consult with relevant local, State and Commonwealth Government authorities, service providers, community groups and affected landowners. The EIS must describe the consultation process and the issues raised, and identify where the design of the development has been amended in response to these issues. Where amendments have not been made to address an issue, a short explanation should be provided.	Refer to the EIS for government consultation. Consultation was completed with local residents and former local residents to obtain information about the area as it was remembered by those individuals. The results are included in the report and informants acknowledged.
NSW Heritage Council		
Heritage	The Applicant must undertake a detailed archaeological assessment which includes a consideration of Aboriginal and non-Aboriginal heritage. The proposed mine pit expansion, overburden emplacement and haul road construction has a high potential to impact on Aboriginal sites. The detailed archaeological assessment should consider the proposed below ground impacts on any potential archaeology and in addition, consider what archaeological works have already been undertaken on this site which may provide information to aid in this assessment. The assessment should include overlay maps and assessments of significance for the potential archaeological resource utilising appropriate Heritage Council Guidelines such as 'Assessing the Significance of Archaeological Sites and Relics'. It is [*sic*] should also contain mitigation strategies to manage this potential archaeological resource which may include redesign to avoid significant archaeology or archaeological testing or salvage during project works.	This report documents the investigation of archaeological and built heritage significance. The significance of each site has been assessed and project impacts have been considered to arrive at site-specific management measures. This report addresses the heritage requirements identified by the NSW Heritage Council. Maps and overlays are included throughout the report to locate heritage items in and around the Project site. Relics associated with the lime burning enterprise will be removed by the project. Measures to record these sites prior to their removal are presented in Chapter 7 of this report.

Table 1.1 SEARS

Item	Requirement	Response
Visual	The Applicant should submit a Heritage Impact Assessment (HIA) as part of the EIS. The HIA should address the potential heritage impacts of the proposal to the Marulan Village and other state significant heritage items in the vicinity of the site, including views and settings to and from these heritage items. Identification of' potential impacts should include potential cumulative impacts from surrounding projects as the mine expansion proposal consists of a large scope of works in dislocated areas of Marulan. The HIA should include measures to manage, mitigate, monitor and offset potential adverse impacts. The applicant should also assess if the proposed works will have an impact on any archaeology protected under the Heritage Act 1977.	Significant views and vistas are addressed in Chapter 6.
Relics provision	The relics provisions in the Heritage Act 1977 require an excavation permit to be obtained from the Heritage Council of NSW, or an exception to be endorsed by the Heritage Council of NSW, prior to commencement of works if disturbance to a site with known or potential archaeological relics is proposed. Where possible, refer to archaeological zoning plans or archaeological management plans held by Local Councils. If any unexpected archaeological relics are discovered during the course of work, excavation should cease. An excavation permit, or an exception notification endorsement, should be obtained.	Archaeological sites containing relics were identified in the Project site. They have been assessed for significance (Section 5) and impacts (Section 6) and management measures have been developed (Section 7).
Make use of the following documents:		
	The *Burra Charter (The Australian ICOMOS charter for places of cultural significance)* (ICOMOS 2013).	Refer to section 1.7.1
	Heritage Manual (Heritage Office 1996 and updates)	Refer to section 1.7.1
	Statements of Heritage Impact Guidelines (Heritage Office 2006)	Refer to section 1.7.1
	Assessing Significance Historical Archaeological Sites and 'Relics'	Refer to section 1.7.1

1.7 Assessment method

1.7.1 Guidelines

This assessment is conducted using the principles of *The Charter for Places of Cultural Significance* (also known as the *Burra Charter,* Australian ICOMOS 2013) and the NSW *Heritage Manual* (Heritage Office 2006) to satisfy the SEARs for a historic heritage assessment.

The *Burra Charter* (Australian ICOMOS 2013) defines the concept of cultural significance as 'aesthetic, historic, scientific, social or spiritual value for past, present or future generations' (*Burra Charter* 2013 Article 1.2). It identifies that conservation of an item of cultural significance should be guided by the item's level of significance.

The Heritage Division of the Office of Environment and Heritage (OEH) provides guidelines for the assessment of heritage significance and the listing of heritage items in Council local environmental plans (LEPs) or on the State Heritage Register, known as the *Heritage Manual* (Heritage Office 1996 and updates). The components of the *Heritage Manual* are informed by the values and definitions in the *Burra Charter*. OEH provides other best practice guides which have informed this report including:

- *Statements of Heritage Impact Guidelines* (Heritage Office 2006);
- *Investigating Heritage Significance* (Heritage Office 2004); and
- *Assessing Significance for Historical Archaeological Sites and 'Relics'* (Heritage Branch Department of Planning 2009).

1.7.2 Heritage registers

Research has been undertaken through the review of statutory and non-statutory registers. All registers were searched online and included:

Statutory:

- The National Heritage Register (NHL) made under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- The Commonwealth Heritage Register (CHL) made under the EPBC Act.
- The State Heritage Register (SHR) made under Part 3A of the Heritage Act. Items on the SHR undergo a rigorous assessment process and must reach a high significance threshold to be included. Inclusion on the SHR is directed by the Minister of the agency that administers the Heritage Act.
- The Heritage and Conservation Register (s170 register) made under Section 170 of the Heritage Act and is also referred to as the section 170 (s170) register. It is a register of heritage items that are owned or managed by state government authorities. Items on the s170 register may also be listed on other registers.

- Schedule 5 of the *Goulburn Mulwaree Local Environmental Plan 2009* (LEP) Division 4 of the EP&A Act includes provision for the making of local environmental plans (LEPs) by the Minister. LEPs are prepared to a standard template, which includes environmental heritage in Schedule 5 (heritage schedule). Where an item is included in the heritage schedule, development applications must include an assessment of impacts to the item. Where a project is being assessed as a SSD, approval by the relevant council does not form part of the overall approval; however, the items require assessment and management if they are affected by the proposal.

- The State Heritage Inventory (SHI), which is a central collection of statutory heritage listings in NSW and, which was cross-checked with the Schedule 5 and s170 registers.

Non-statutory:

- National Trust of Australia, NSW (NT); and

- Register of the National Estate (RNE).

1.7.3 Relics provision Heritage Act 1979

Archaeological sites are protected by Section 139 of the Heritage Act if they are assessed to be relics, that is, of local or State significance. A formal listing is not required to ensure that protection and impacts can only be undertaken with approval, either under the Heritage Act or through a SSD approval.

1.7.4 Primary research

Primary research included investigating archives that may hold original material such as plans, written documents and photographs, including:

- newspaper articles, accessed through *Trove* online;

- photographs, accessed through *Trove* online and in secondary publications;

- Ancestry.com;

- online registry of Births Deaths and Marriages;

- interviews with people who lived in the local area – Barry Armitt, Pamela Cooper and Rosemary Turner;

- land titles information; and

- maps, plans, sketches.

1.7.5 Secondary research

Secondary sources including local histories and publications of research societies were also reviewed to understand the history of the local area and provide further detail on mining techniques possibly used in the historic mine workings.

1.7.6 Facilities

The following facilities were visited to obtain research material on the study area:

- Berrima District Historical & Family History Society Inc;
- Land and Property Information (LPI);
- National Library of Australia *Trove* Online;
- State Library (Mitchell Wing); and
- Wingecarribee Local Studies Library.

1.8 Report structure

The report is structured as follows:

- section 1 provides an introduction to the assessment and an outline of the legislative framework;
- section 2 includes a historical background;
- section 3 describes the historical survey methodology and results;
- section 4 is the comparative analysis for the industrial sites;
- section 5 is the assessment of significance;
- section 6 details the impact assessments for the items; and
- section 7 provides conclusions and recommendations for retaining significance followed by mitigation measures where change is unavoidable.

1.9 Authorship

This report was written by Rebecca Newell (EMM archaeologist) with additions in 2018 by Kerryn Armstrong and Pamela Kottaras. It was reviewed by Ryan Desic (EMM Senior Archaeologist. External review was provided by Neville Hattingh (Element Environment), Les Longhurst and Rod Wallace (Boral).

1.10 Acknowledgments

We would like to thank Barry Armitt, Pamela Cooper, Rosemary Turner, Maureen Eddy and Philip Leighton Daly for their time and invaluable information about the local area and Marulan South. An additional thank you to Grant Thompson of Boral, who escorted the team around the site and passed on his 20 years of knowledge about the mine.

1.11 Review of previous investigations

Historic heritage investigations have included two publications used in the historical background (Eddy 1985 and Leighton-Daly 2010) as well as many publications on aspects of mining and domestic life in the Southern Tablelands. Investigations specific to the study area, completed as part of a review of environmental factors for the mine operations were also reviewed.

RPS Harper Somers O'Sullivan (RPS HSO 2009) completed an investigation of Aboriginal and European heritage to support a Mine Operations Plan. They identified the remains of a historic structure and associated artefacts within one of their study units. It comprised a hut probably built in the nineteenth century and occupied until the early twentieth century. It was noted that kiln bricks were scattered around the historical structure. Research into the hut identified it as belonging to George Feltham, a mine worker, who built the structure on land he leased. While the construction date is unknown historical research has indicated that George and his wife lived in the house until 1908. The assessment did not consider the hut to be of heritage significance and no archaeological significance or research potential was identified (RPS HSO 2009, p.40). As the historical structure was located in an area of impact it was recommended that an application for an exception to the requirement for an excavation permit under Section 139(4) of the Heritage Act be completed prior to impacts to the structure. The structure was revisited during the historic heritage survey for this assessment.

ERM completed an environmental assessment as part of the proposal to establish and operate Peppertree Quarry, located adjacent to Marulan South Limestone Mine. A historic heritage assessment completed for the Peppertree Quarry Project did not identify any historic heritage sites or areas of potential historical archaeological deposit.

1.12 Register searches

All registers noted in Section 1.7.2 were reviewed for items located in the Project site. No registered historical heritage items have been previously recorded in the Project site.

In the wider study area the 'Bungonia State Recreation Area' has been identified immediately south of the Project site. It is an item of local heritage significance listed on the Goulburn Mulwaree LEP (Item No. I027). It is considered to be significant for its natural and cultural associations. The Bungonia State Recreation Area refers to what is now the Bungonia State Conservation Area and Bungonia National Park.

The site of Old Marulan Town (usually referred to as 'Old Marulan'), an item listed on the SHR (Item number 00127) is located approximately 9 km from the Project site. Old Marulan is a State significant archaeological site for its ability to illustrate, through its archaeological resource, details of an early colonial service town, predominantly from 1835–67.

The Glenrock Homestead and outbuildings is listed as an item of local heritage significance on the Goulburn Mulwaree LEP (Item No I314). It is considered to be significant for its aesthetic and historical values and for its association with George Barber and his wife Elizabeth Hume (sister to Hamilton Hume). The property boundary retains its historical extent but the identified heritage curtilage has been greatly reduced and is approximately 2.4 km from the closest area of impact at Marulan Creek (Figure 1.5).

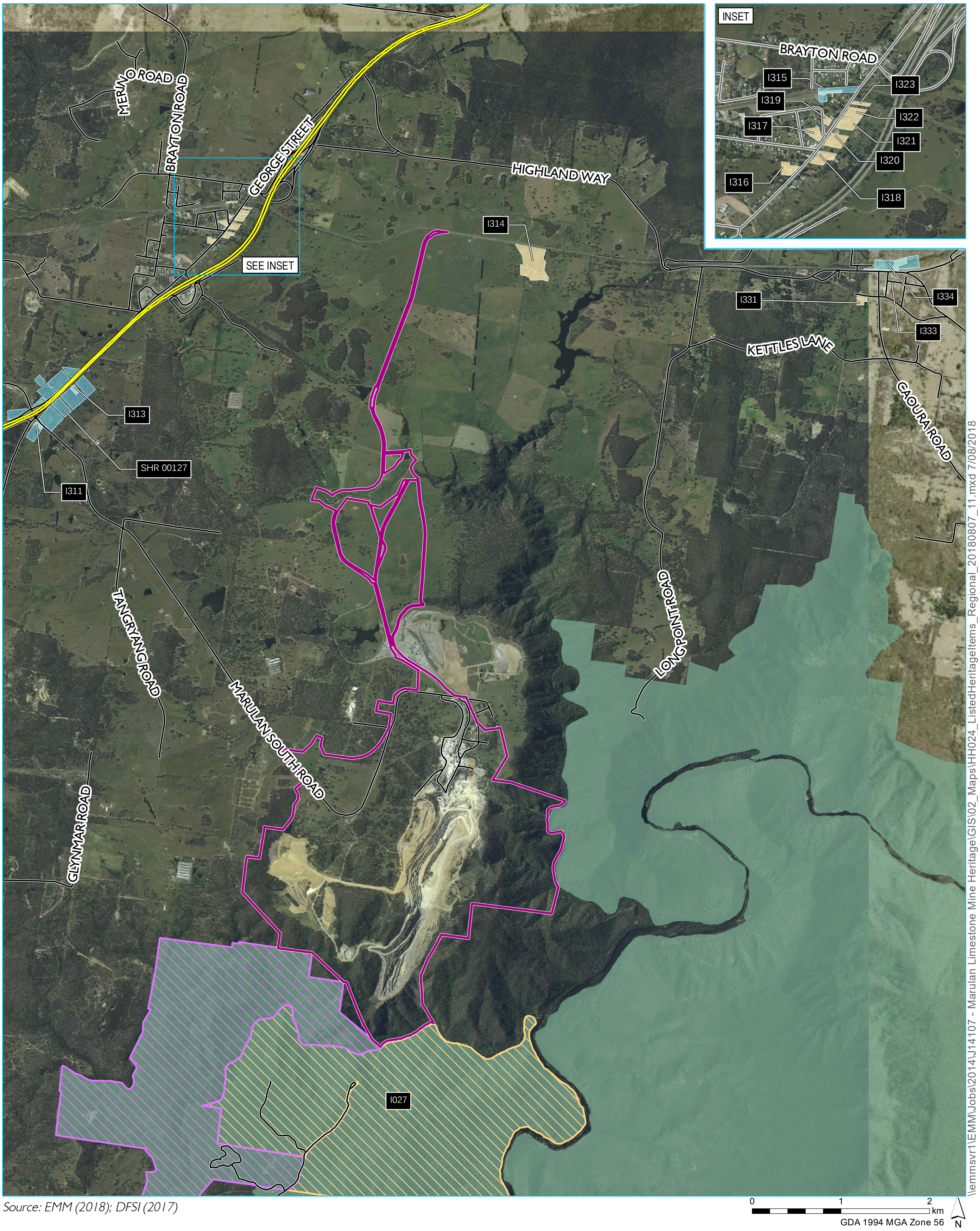
A summary table of heritage items listed on statutory registers is provided in Table 1.2. The locations of listed heritage items in vicinity of the Project site are shown on Figure 1.5. These items are within 6 to 6.5 km of the Project site.

Table 1.2 Listed heritage item in the vicinity of the Project site

Item	Listing	Listing ID	Significance
Bungonia National Park	LEP	I027	Local
Old Marulan Town	SHR	00127	State
Marulan Township Conservation Area	LEP	N/A but shown on Map	

Table 1.2 Listed heritage item in the vicinity of the Project site

Item	Listing	Listing ID	Significance
		HER 003D	
Old Marulan Anglican Cemetery	LEP	I311	Local
St Patrick's Catholic Cemetery	LEP	I313	Local
Marulan Railway Station and yard	SHR	01188	State
Marulan Railway Station and yard	LEP	I315	State
All Saints Church of England	LEP	I316	Local
Terminus Hotel	LEP	I317	Local
Badlock's Shed Store (c1870), Marulan Public School	LEP	I318	Local
Postmaster's residence, Post Office "Mooroowoolen"	LEP	I319	Local
Dwelling "Waverley"	LEP	I323	Local
Dwelling "Cora-Lyn", St Stephen's Uniting Church	LEP	I322	Local
Shop Group, "Wattle Glen", "Coronation Stores", Morgan's General Store, "the Boarding House"	LEP	I321	Local
"Royal Hotel", "Aunty Mary's" shop	LEP	I320	Local
Tallong Railway Station, Water Supply	SHR	01259	State
Tallong Railway Station, Water Supply	LEP	I334	State
Glenrock Homestead and Outbuildings	LEP	I314	Local
War Memorial Hall	LEP	I333	Local
Dwelling, Federation, Tallong Public School	LEP	I331	Local



Source: EMM (2018); DFSI (2017)

KEY

- Major road
- Road
- Project boundary
- Morton National Park
- Bungonia conservation area
- Bungonia National Park

Heritage sites

- State Heritage Register
- LEP item

Listed heritage items in the vicinity of the project area

Marulan South Continued Operations Project

Historical heritage assessment and SoHI

Figure 1.5

EMM

2 Historical background

2.1 Historic themes

The Australian and NSW heritage systems employ a series of historic themes to guide the understanding of history and historical investigation in Australia. Historic themes are used to identify context for understanding how a place has developed by identifying the factors that shaped its significance. The state and national themes are complementary to enable the historian to present a unified understanding of how an area fits into NSW and Australian history. The historic themes are also an important guide when assessing an item's heritage significance. They provide information on how an item may be historically significant at the local, state or national level. Finally, historic themes help develop interpretation and management strategies for items of heritage significance.

A full list of these themes can be found on the Heritage Division of OEH website (http://www.environment.nsw.gov.au/heritage/index.htm). Historic themes in the study area were identified based on the historical background (as described below) and the results of the historical survey (see Section 3). The Australian and NSW historic themes relevant to the study area that have been used in this report are listed in Table 2.1.

Table 2.1 Historic themes

NSW historic themes	Australian historic themes
2. Peopling Australia	Aboriginal cultures and interactions with other cultures
3. Developing local, regional and national economies	Agriculture Industry Mining Transport
4. Building settlements, towns and cities	Towns, suburbs and villages Land tenure Accommodation
5. Working	Labour
8. Developing Australia's cultural life	Domestic life

2.2 The pre-European past

Information about the socio-cultural structure of Aboriginal society prior to European contact largely comes from ethno-historic accounts made by Europeans. These accounts and observations were made after massive social disruption due to disease and displacement. As a result, this information is often contentious, particularly in relation to language area boundaries. The information presented in this report is based on previous studies and the traditional non-Aboriginal data but remains open to reinterpretation.

The study area is located on the boundary of the areas of four Aboriginal groups (based on Tindale 1974):

- the Ngunawal whose territory extended to the south-west from Queanbeyan to Yass and east to beyond Goulburn;
- the Gandangara whose territory extended to the north-west at Goulburn and Berrima, down the Hawkesbury River to Camden;

- the Wodiwodi whose territory extends to the north-east north of the Shoalhaven River to Wollongong; and

- the Wandandian whose territory extends to the south-east from Ulladulla to the Shoalhaven River and Nowra.

Further information can be found in the Aboriginal cultural heritage assessment, included in the EIS for the Project.

2.3 History of the study area

2.3.1 Exploration

European explorers first visited the Southern Tablelands as early as 1798 when Henry Hacking and John Wilson were sent to the area by Governor Hunter (Chisholm 2006, Jervis 1946). His reason for exploring the area was to dispel the myth that convicts would be able to walk to China (Higginbotham 2009, p.21). He ascended Mt Towrang and viewed the Goulburn Plains before returning home. The area was described as containing ‘fine open forest’ (Jervis 1946, p.108) and “pleasing to the eye, having a beautiful park-like appearance” (Atkinson 1979 p.6), suggesting land management practices by Aboriginal people before the British influx to the region.

The Southern Tablelands were also explored by James Meehan in 1818 (Firth 1983). In August 1820 Joseph Wild travelled south of the Cookbundoon Range and found what is now called Lake George. The County of Argyle was first surveyed in 1824 by Harper on the orders of the Surveyor General but the majority of the work was completed by Robert Hoddle (Jervis 1946, p.115).

2.3.2 Pastoralism and agriculture

Alongside explorers, astute settlers also expanded their interests into the County of Argyle (Plate 2.1).
Prior to the 1820s the Southern Tablelands were unavailable for settlement, although a number of prominent pastoralists occupied the land regardless. These included John Oxley and John Moore who both ran large herds of cattle beyond the regular limits of settlement in 1820 (Higginbotham 2009, p.26).

In 1820 the area was opened as permits to cross the ‘Cowpastures’ (now Camden) were issued. Settlers raced to establish themselves on the most prominent and profitable land with the result that land grants were issued. Despite this, many areas of illegal exploitation of Crown land to run sheep and cattle continued (Higginbotham 2009, p.27).

One of the earliest landholders in the County of Argyle was James Atkinson of Oldbury who settled in Sutton Forest, approximately 40 km toward Sydney. Atkinson received a permit in 1822 to occupy an area of land on the right bank of the Wollondilly River as a grazing farm and built a large, stately home he called Oldbury, which still stands. His brother John followed soon after and established his homestead, Mereworth, across the Great South Road (Hume Highway) from James.

William Bradbury was issued a ‘ticket of occupation’ at the river Jarara in the Bungonia area in the early 1820s (Rosen 2017, p.26; Jarvis 1946, p.113) and David Reid and Robert Futter were also early landowners in Bungonia (Rosen 2017, p.26).

One of the largest pastoral holdings in the area was the Glenrock Estate on Highland Way. George Barber (b.c1795, d.1844) took up a land grant in the Marulan district in 1826 and built the homestead some time in the mid-1830s or early 1840s (Osborne 2002, p.60-61; SHI DB 2934038). Barber was the stepson of Dr Charles Throsby (Osborne Sept/Oct 2002, p.60) and the husband of Isabella Hume (m.1815), sister to Hamilton. George Barber increased his holdings to approximately 1800 acres although Glenrock appears to have stayed the same size. Sources confirming the extent of Glenrock have not been found but an 1857 survey plan (Plate 2.2) suggests the boundary, which has since been reduced. The assumed original extent of Glenrock (but not Barber's total holdings) is shown in Plate 2.3)

Barber died by drowning in a flooded creek, probably after falling from his horse. On Tuesday 23 July 1844, the *Australian* ran a paragraph under "Country news" after Barber had been missing for three weeks after leaving 'Dunn's public house' for home. His body was found eleven weeks later in the Wollondilly River by Charles Lockyer (SMH 9 September 1844, p.2); the inquest determined that death was caused by accidental drowning as the post mortem found 'not the slightest mark of violence' on his person and the articles he had purchased the day he went missing, still in his pocket. Isabella died in 1855 at Glenrock (Ancestry.com). The property was sold to John Morris is 1862 (SMH 4 Nov 1862, p.8).

The lot boundary of the Glenrock Estate abuts the Peppertree Quarry landholdings but the identified heritage curtilage is a contracted area 2.4 km north of the mine and approximately 240 m from the Marulan Creek Dam site (Figure 1.5).

Opinions on the fertility of the country for agriculture varied; E.S Hall considered it to be barren in 1829 while Lieutenant Breton considered it admirable in 1830 (Jervis 1946, p.116). James Atkinson who settled in Sutton Forest, approximately 40 km towards Sydney on the Hume Highway, described the County of Argyle as being open forest of white and blue gum on a granite soil with large blocks of granite, of a coarse texture, and grey colour (Atkinson, 1979 p.5-6). Atkinson describes most of the land as poor for cultivation but well suited for grazing. In areas where whinstone[1] predominated, the land was considered suitable for grazing and cultivation (Atkinson 1979, p.5-6).

Stock and cattle stations were established in the 1820s throughout the Goulburn Plains and the wool industry dominated the area during the 1800s (Firth 1983). Pastoralists set up stations run by the convict labour force. The wealthiest pastoralists ran their stations from Sydney or the Cumberland Plain sending sons or overseers to run the day to day operations (Higginbotham 2009, p.27).

Expansion of the wool industry continued until the end of convict transportation and the resulting withdrawal of cheap convict labour. Along with the drought that started in 1839, affecting wool and wheat prices and its continued economic reliance on England, NSW experienced a depression that was to usher in hardship for the citizens of the new British colony. The 1841 Depression caused a collapse in the price of wool, with the expected domino effect on the rest of the economy. By 1845 the depression was officially over and life gradually went back to normal.

However, a recovery in the industry was nearly derailed by the discovery of gold in 1851. It once again reduced the labour pool as prospectors raced to the goldfields. The gold rush petered out by the 1860s allowing a return to pastoral occupations and a resulting economic growth period to the 1890s (Higginbotham 2009, p.27). The area directly around Marulan South has remained grazing land until the present day.

[1] Whinstone is defined as a "popular term for any dark, fine-grained igneous rock" in Kearey (2001, p. 293).

Plate 2.1 Map of the County of Argyle in 1843 with the approximate area of the Project site shown in red (National Library of Australia 2015)

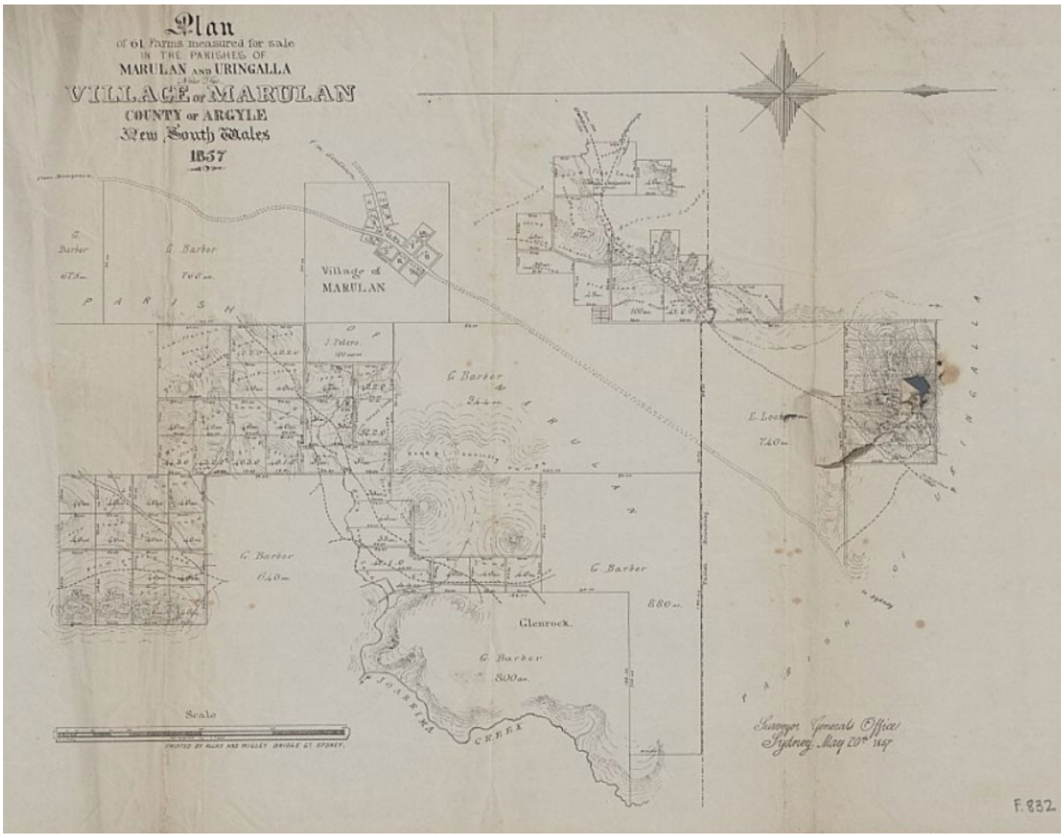


Plate 2.2 Plan of the village of Marulan 1857 (top left), which also shows the extent of Glenrock Estate and Barber's other holdings (National Library of Australia (2015b). North is pointing right

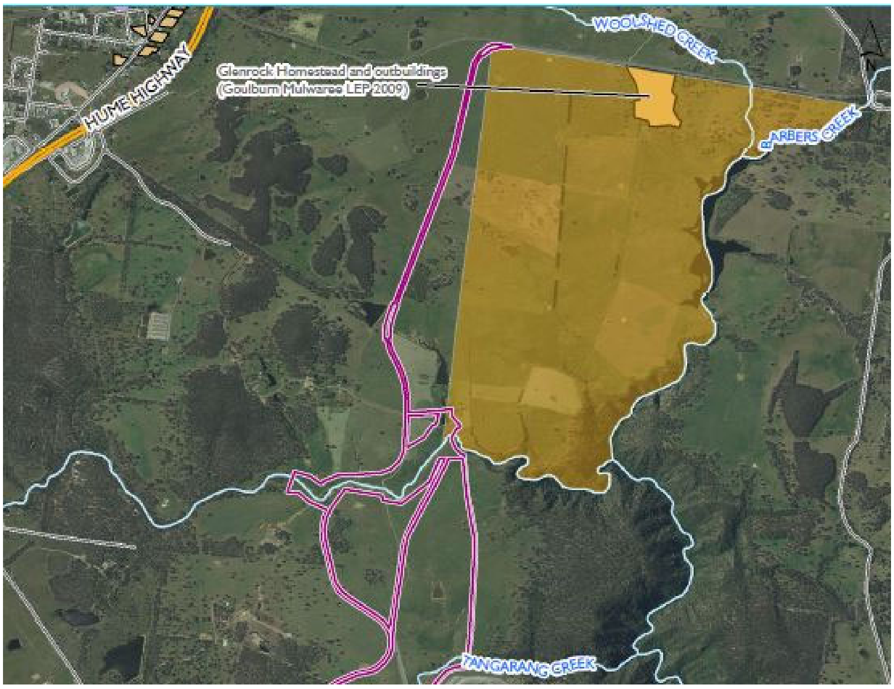


Plate 2.3 The estimated extent of historical Glenrock Station and the listed curtilage.

2.3.3 Towns

i Major towns in the region

Pastoral settlement necessitated that homesteads and the communities living there were self-sufficient because of the large distances between homesteads and centres of produce such as Goulburn and Sydney. This self-sufficiency also affected the establishment of towns, which was slower in areas where large pastoral stations were equipped with all they required. The settlement of towns is also based on the placement of infrastructure, with Goulburn and Old Marulan both established based on the location of the South or Argyle Road.

A town plan for Goulburn was approved in 1829 based on the lobbying of the local Bench of Magistrates who wanted a permanent meeting place and a commercial and government centre to be created (Higginbotham 2009, p.80). This town included a courthouse and lockup, barracks, veteran's huts and an inn. Sir Richard Bourke chose the area of the second town of Goulburn in 1832. He decided that the old location was flood prone. The growth of Goulburn mirrored that of the wider colony with periods of expansion before the Depression in the 1840s, followed by a sustained period of growth from the 1860s to the end of the nineteenth century. The railway to Goulburn was built in 1869.

Marulan was established first in 1834 but moved approximately 2 km away in 1868 when the Great South Railway Line was constructed. Initially the new Marulan was name 'Mooroowoolin' but reverted to Marulan with the old town taking on the moniker of Old Marulan. Other towns (or villages) established in the area included Tallong (1869), Wingello (1871) and Bungonia (1836). By 1882 Marulan sustained two hotels, three stores, a butcher, two blacksmiths, two wheelwrights, two bootmakers, a saddler, a bank, a public school, three places of worship and a population of approximately 200 (*Goulburn Evening Penny Post* 1882, p.4). It is clear that Marulan was one of the large towns between the Southern Highlands and Goulburn. Rumours also abounded that in 1903 a tiger roamed the surrounds (*Barrier Miner* 1903, p.3). The animal was, in fact, a leopard, brought to Australia by a young officer from South Africa. The beast escaped its owner and 'chased peaceable citizens' of Marulan (1903 'The Marulan Tiger', *Hawkesbury Herald*, 20 March, p. 12).

ii Marulan South

The most recent mining operations at Marulan South Limestone Mine led to the rise of the village of Marulan South. Before the village was established, families moved into the area and established camps and rudimentary houses so they could be close to the mines that they worked. A references to an earlier incarnation of 'Marulan South' dating to around the 1860s is made in Leighton-Daly (2010, p.33 and 145) but there is no evidence that a town or village as such existed. Plans, newspaper articles and photographs were reviewed to determine if in fact an early town existed and that the story of Old Marulan to Marulan was repeated to the south-east; nothing was found to suggest a town or a village although references to at least two schools have been found. It is far more likely that 'Marulan South' referred to the mining area and the scattering of dwellings in the area, many of which are likely to have been destroyed as the mine grew.

The earliest permanent resident of the now empty village at Marulan South was Les Cooper who arrived in 1929 to build his home. He obtained a pre-existing service store built for the railway workers at Marulan and began operating a local store and post office for the mine workers (P Cooper *pers. comm.*). The store was well known to contain almost anything that could be required for work and at home and Les Cooper was also the local banker and postman. Approximately 30 houses, a school and recreational facilities were built for workers who lived at Marulan South (Plate 2.4 to Plate 2.6). The houses were constructed for the companies running the mine and were lived in by many miners' families.

Before Les Cooper moved to Marulan South to open shop he worked near Freddy's Hill (location unidentified), which was at the junction of the skip line from Weenga and burnt lime at the Weenga Kilns. The location of the Weenga Quarry has not been established through research and references are rare except as text in newspapers and in the history prepared by Leighton-Daly. However, based on the drawings sketched according to Alma Armitt's memory, it is likely that it was in the current mine area (Leighton-Daly, p.161).

Marulan South became a community hub for the miners and their families and a well known place in the local district. In 1998 the decision was made to close the village rather than complete additional repairs and upgrades. Residents' houses were transported to Marulan as part of the closure and a large wake was held to farewell the town (P Cooper, R Turner and M Eddy pers comm).

EMM has been able to complete oral history interviews with former residents and workers of Marulan South and they have provided a picture of a close knit and self-sustaining community. The mine operators also contributed to the community atmosphere of the town, helping to provide recreational facilities and funding for functions.

Plate 2.4 A typical house in Marulan South circa 1960 (Boral Resources 2015).

Plate 2.5 Single men's quarters (Boral Cement 2015).

Plate 2.6 A section of an aerial photograph from 1972 showing the town of Marulan South and the mine (Boral Resources 2015).

2.3.4 Transport and communications

The most well known of the roads created from Sydney to the Southern Tablelands was Mitchell's Great South Road, which progressively opened from 1820 to 1843. In addition to this road there was the South or Argyle Road (1818 to 1833) and Macquarie's Government Road (1822 to 1839) (Higginbotham 2009, p.55). Smaller road systems also crisscrossed the area.

Formalised road construction was led by surveyors like General Thomas Mitchell and the majority of the work was completed by convict road gangs. The gangs would be sent out from their stockades to a distant portion of the road to work either retuning home in the evening or sleeping in mobile huts. Two stockades were known in the Southern Tablelands; Towrang and Wingello from which convicts would have constructed the Great South Road (Higginbotham 2009, p.56).

The Marulan South Road started off as the Lime-kiln Road which ended at Mr James A Hogg's (a son of the first James Hogg in the area) lime kilns. Some minor adjustments to this road have been made, the most substantial being the left turn (north) to Marulan South approximately 5.6 km from the Hume Highway. The earlier alignment of the road continued its trajectory south-east and took a slight left (south) where it travelled for another 500 m before veering east and then south again to the lime kilns (Figure 3.1).

In 1952 the road was in disrepair and was the subject of discussion. James Hogg complained to the Mulwaree Shire Council that the Lime-kiln Road (the original name for Marulan South Road) was being allowed to 'drift into ruin'. Hogg described the matter as 'one of "national importance" as it was a "great feeder road serving the steel and cement industry of this nation... the whole six miles needs urgent attention"' (Goulburn Evening Post 4 April 1952, p.1).

It is likely that the lime kilns mentioned above are those identified during field survey for this report. A haul road has been constructed over part of the Lime-kiln Road close to the lime kilns but the southernmost extent of this road is probably the small road leading north from those kilns. Other small roads can be seen in historical and current aerial photography and very likely relate to ad-hoc roads created by the smaller historic mining operations.

During 1888 James Hogg took out two advertisements in the *Goulburn Herald* (18 February 1888, p.5) searching for railway sleepers and a contractor for railway earth works. One year later the Hogg bros. were auctioning off their bullocks and horses as their tramway was complete (*Goulburn Evening Penny Post* 9 February 1889, p.5). The tramway followed the path of the current railway until approximately the first 2.5 km from the mines; it diverges north-west toward Marulan station. This was later replaced by the Medway junction line.

The rail line from Marulan South is privately owned by Boral to service Marulan South Limestone Mine and Peppertree Quarry. Tenders for construction were advertised in 1926 (*Robertson Mail* 2 November 1926, p.3) and the line was operational in 1928 (NSW Rail Net – Medway Junction [online]).

2.3.5 Education

A number of small schools dotted the Southern Tablelands, possibly due to the lack of reliable transportation for children to travel long distances to school (Eddy 1985, p.56). Two schools existed at Marulan. The first was opened in 1860 and remains open till this day. The second was opened in 1871 and closed shortly after in 1877 (NSW Department of Education 2015). The location of both schools is approximately 8 km west of the Project site.

The schools at Marulan moved based on the location of the township; the original school was moved twice to remain close to the town when it was relocated. Many of the schools in the area struggled with inadequate facilities, including lack of classrooms, desks and equipment for the varying numbers of students attending. The school at Marulan had an enrolment for 75 children but only desks for 45 (Eddy 1985, p.57).

A school was built at Marulan South in 1934 and existed in various guises until 1995. It began as a provisional school and was located in the Workers Mess Hut until a proper school building was constructed in 1937. From 1938–1940 Marulan South was a half time school with the remainder of classes held at a school at Brayton. Marulan South became a full time school in 1940 but also struggled with an inability to obtain the necessary equipment with the Parents and Citizens Association requesting desks and an assistant for the teacher (Eddy 1985, p.68). The high regard in which the teachers at Marulan South were held is evidenced in the inclusion of tributes to many in the Goulburn Post (*Goulburn Evening Post* 1936, p.1).

Another, earlier school listed as Argyle (Lime-kilns) public school was known to the area, situated approximately 4.5 km south-east from Old Marulan. The building of Argyle public school (not to be confused with East Argyle public school) began in 1884 (*Goulburn Evening Post* 1884, p.7). The exact position of this school is unknown but may be in one of two places:

- James Hogg owned land along South Marulan road (Lot 17) which is marked as “Argyle PS” site (Dep of Lands, 1953) (outlined in red in Plate 2.7); or

- Portion 193, on which the ruins of a building survive was owned by George Feltham, who sold it to FH Gall in 1910. This building has been variably called George and Elizabeth Feltham’s house (Leighton-Daly 2010, p.144) as well as the Argyle school (pers. comm. Philip Leighton-Daly 13/03/2018) (outlined in blue in Plate 2.7).

A report from the *Goulburn Evening Penny Post* (Thursday 12 September 1895, p.4) reporting on the loss of property due to bushfires states the *“...old school house on the Lime-kiln road has also succumbed to the fires. I understand that two workmen used it as a camping house, and that at the time of the fire it contained their bedding and also a saddle and bridle.”* This notice in the paper suggests that the old school house was not the place that the Feltham’s lived in for a time and it must have been somewhere on the main road to Marulan South.

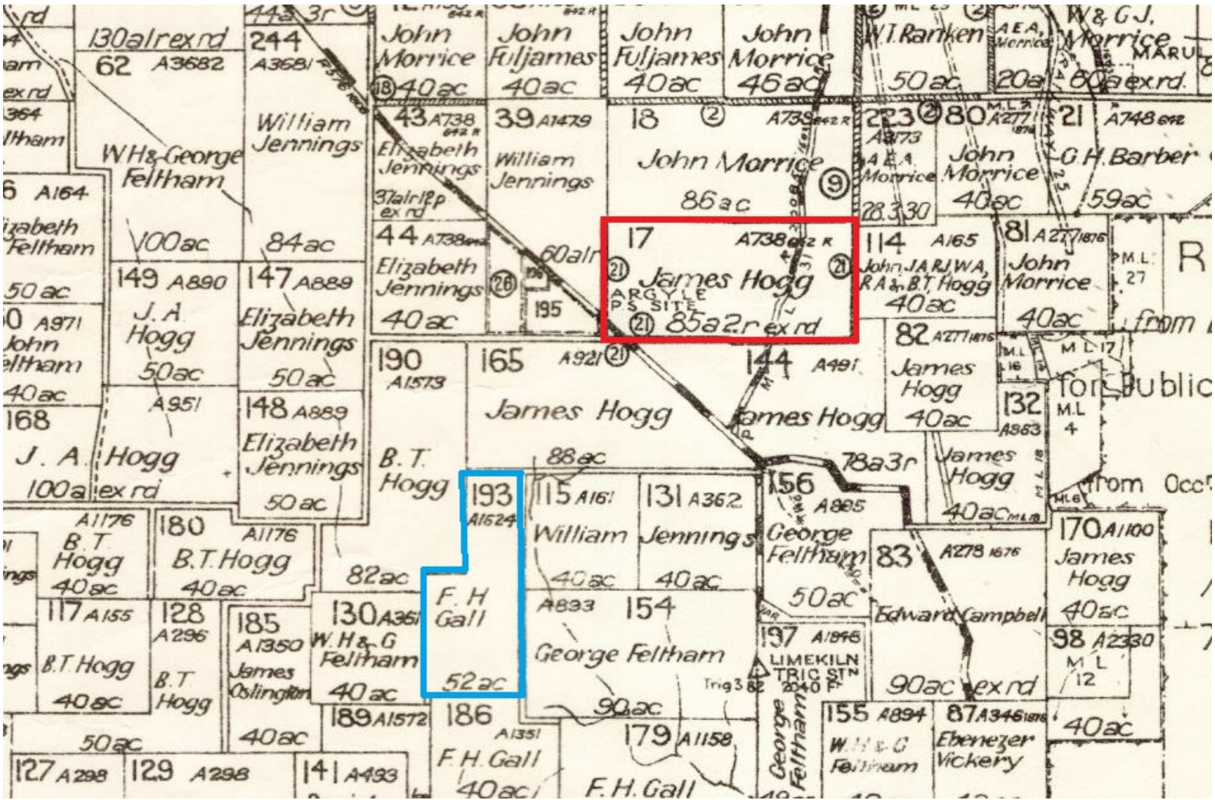


Plate 2.7 **1953 Department of lands map showing James Hogg Lot 17 with note "Argyle P.S Site" (red) and FH Gall's allotment (blue).**

2.3.6 Recreation

Marulan South was a centre of recreation for the community. It had one of the main bowling clubs in the district. It served the dual purpose of licensed facility and bowling green and was also a community hub regularly hosting functions for the town. This building survives as a Boral office facility today.

Tennis was also a popular pastime in the district. Many of the local tennis clubs looked forward to playing on the Marulan South courts which were believed to be some of the best in the district. Tennis was played at least twice a week, three times in the summer (P Cooper *pers comm*).

In the 1950s and 1960s Southern Portland Cement assisted in the creation of a local oval, community hall and tennis courts to further increase the facilities present for recreation. The community hall held a number of debutant balls and mock debutant balls, as well as touring entertainers.

2.3.7 Mining

i Region

The Southern Tablelands has a long and extensive history of extractive industries for a variety of products. Very fine limestone was noted at Barramaragoa and "Murroowallin"[2] by James Atkinson (Atkinson 1979, p.22). Exploration for minerals occurred in 1844 with Clarke and Throsby noting the deposits of quartz and limestone in the area (Jervis 1946, p.381). In 1833 there were two quarries recorded; a limestone quarry on Captain Rossi's land and a marble quarry near Stucky's Farm. Slate was quarried from Slateville Quarry in Chatsbury, 25 km in a straight line from Marulan, and provided roofing slate for public buildings in Sydney until the Second World War. Good quality sandstone was quarried at Marulan and used for colonial houses and gravestones in the area. The sandstone quarry was located on the western side of Mount Otway north of Marulan (Eddy 1985, p.86). Lockersleigh hosted a silver mine on a remote ridge (Higginbotham 2009, p.141). In 1849 the local Marulan South newspaper provided details of the discovery of good quality iron ore at a property belonging to Major Lockyer. However, no further information on the mining of this ore has been obtained and it is possible that the search for gold was more alluring than iron ore (Eddy 1985, p.87).

The gold in the local area was first ignored in favour of the diggings at Bathurst and Ballarat. Gold diggings in the area were located at Braidwood and along the Shoalhaven River and were worked after the 1860s. In 1881 it was reported that gold had been discovered in Wingello Creek. The discovery caused commotion and traffic jams with a number of miners coming into the area to pan for gold. Nuggets the size of peas were found (*Goulburn Evening Post* 1881, p.4).

ii Mining at Marulan South

Mining at Marulan South has been focused on the limestone deposits. By March 1826 it was clear that the deposits of limestone in the Marulan South area were recognised and it was recommended that these areas were not included in settlers grants (Leighton-Daly 2010, p.145).

The area of Marulan South was bought by Mr Fuljames who purchased the land for its limestone deposits in the early nineteenth century. James Hogg then purchased a number of lots in the 1860s. The limestone quarries were quick to gain attention and by 1869 a notice in *The Armidale Express* and *New England General Advertiser* (4 September 1869) talks of the three parties who are working in the limestone quarries near Marulan. The area continued to allow new leases and new mines including a nearby lease for arsenic on Hogg's property. The area was then held under adjoining leases by Weenga Lime Limited, Hoskins Iron and Steel Limited and Southern Portland Cement prior to 1928 when the area was consolidated and worked by Southern Portland Cement (Eddy 1985, p.87). A section of the mine area was worked for agricultural limestone and as a raw material for cement manufacturer at Maldon. The full amalgamation of the mine occurred when it was obtained by Blue Circle Southern Cement. Boral acquired Blue Circle Southern Cement in 1987 and in 2004 leases were consolidated under a mine lease (CML) for Boral-CML 16 (Plate 2.8; EIS Figure 1.3).

The Marulan South Limestone Mine operations were closely linked with the cement works at Berrima, both through its product and the connections of the company which ran both enterprises. For managers, a move to Berrima was seen as a step-up in the company and meant that it was unlikely that they would return to Marulan South. Also located close to Marulan South was a small granite quarry overlooking Barbers Creek (Leighton-Daly 2010, p.146).

[2] Also spelled "Mooroowoolen", previous name for "Marulan" (Geographical Names Board 2015).

The mining method employed at Marulan South has changed significantly over the many years mining has occurred in the area. When mining limestone at Marulan was first undertaken by James Hogg in the 1860s it was completed by hand with picks and shovels and hand–loaded into horse drawn wagons (Leighton-Daly 2010, p.188).

James Hogg was born in 1819 (Ancestry.com 2018); little is known about his parents but we do know that he shared his father's name. James married Mary Straker in 1843 and the couple had eight children. After Hogg died in 1886 the lime business was carried on by his sons (*Goulburn Evening Penny Post* 7 September 1886, p.4). By 1931 there was both Hogg Bros., lime merchants (*Sydney Morning Herald* 5 December 1931, p.17) and the Weenga Lime Company (*Goulburn Evening Penny Post* 11 May 1922, p.3). Weenga lime was still hiring in 1949 (*Goulburn Evening Post* 22 February 1949, p.4); however, by 1951 Weenga Lime Co was hiring in conjunction with Commonwealth Portland Cement Co Ltd. (*Goulburn Evening Post* 4 April 1951, p.4).

In 1898 the mining activity in the Marulan area was steadily increasing, particularly the Carrington Iron mines though issues with railway lines meant not all the product reached its destination (*Goulburn Evening Penny Post* 1898, p.2). By the early 1900s, the rock was carted from the pits by approximately 25 horses, while mining was completed with steam shovels (Leighton-Daly 2010, p.178) (refer to plates 2.9 to 2.13 for historical photographs).

A dispute, being heard at the Goulburn Mining Warden's court, was ongoing in September 1938 with the Metropolitan Products Ltd applying for access to build a dam, aerial ropeway and pipeline on Portion 135 and S3. The Commonwealth Portland Cement Company was the objecting party and in an effort to avoid creating deep divisions between the two companies, the mining warder WF Britz adjourned the application to October 10 (*Goulburn Evening Penny Post Thursday* 20 September 1938, p.1). Timber was cleared in preparation for the installation of an aerial ropeway sometime before October 1936 (*Goulburn Evening Penny Post Thursday* 25 February 1937, p.1).

Although disputes over access continue into 1939, the aerial ropeway was operating to the west of the mine. Problems with a bend in the alignment resulting in the rope breaking on a regular basis and holding the works up (*Goulburn Evening Penny Post* 29 November, 1939, p.1). Nonetheless, the technology to remove limestone was improving at a rapid rate.

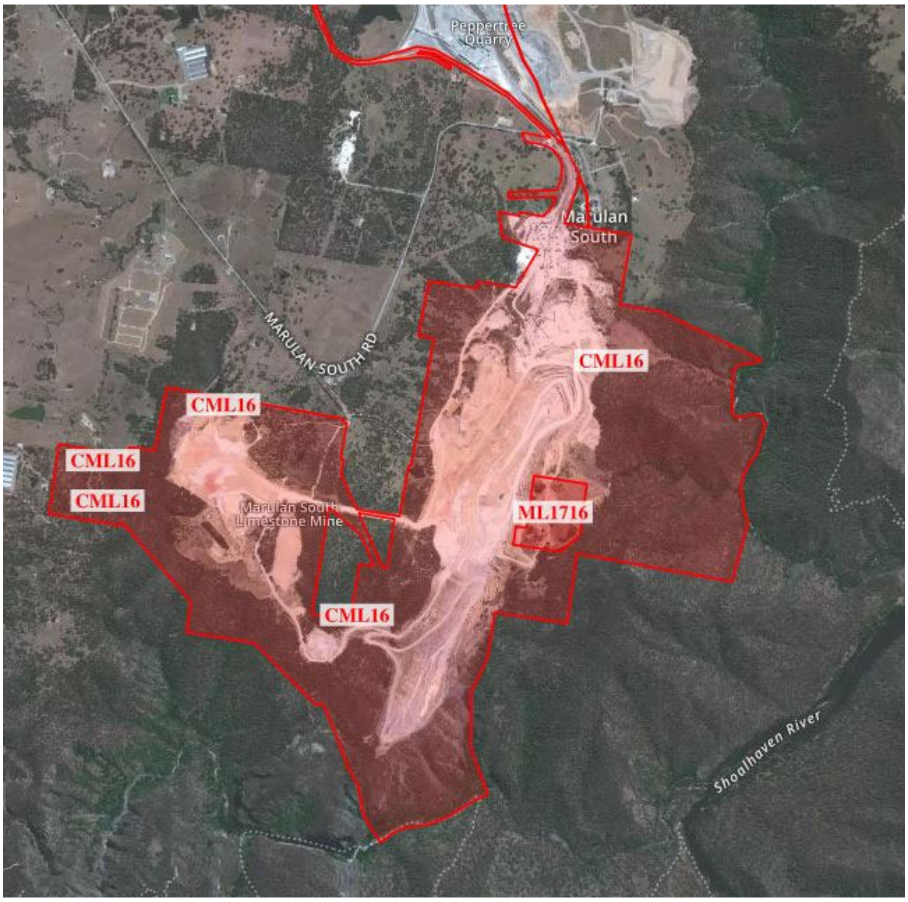


Plate 2.8 **CML16 held by Boral (Source: NSW Planning & Environment MinView: Current mineral leases 2018)**

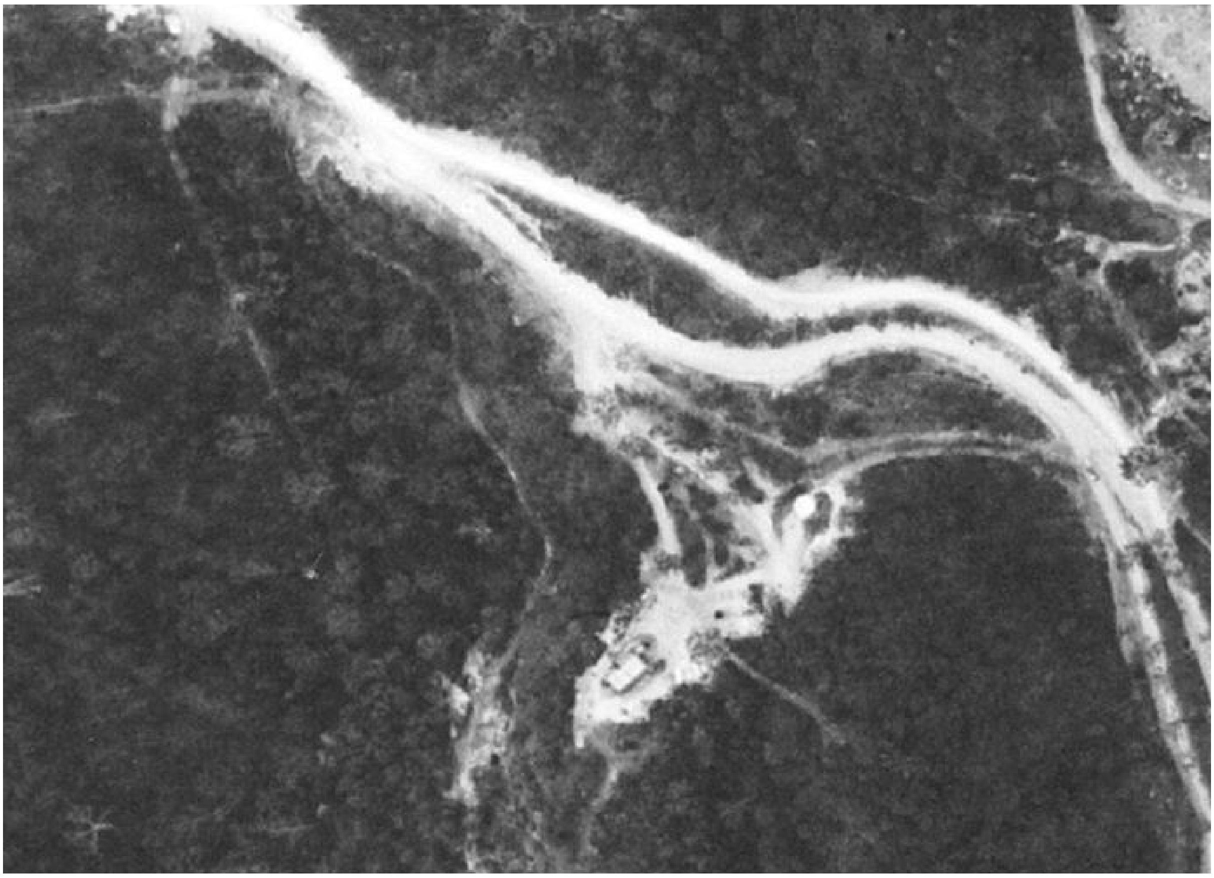


Plate 2.9 **1972 aerial photograph of the Lime-kiln group area (1) and Lime-kiln Road (2). Source: Dept of Lands 1972_11_31_Marulan31.**

Plate 2.10 **An early photograph of the Marulan South Limestone Mine including a conveyor (Boral Cement Limited 2015).**

Plate 2.11 **Marulan South Limestone Mine showing drays ready to transport limestone from the pit (courtesy of Boral Cement Limited)**

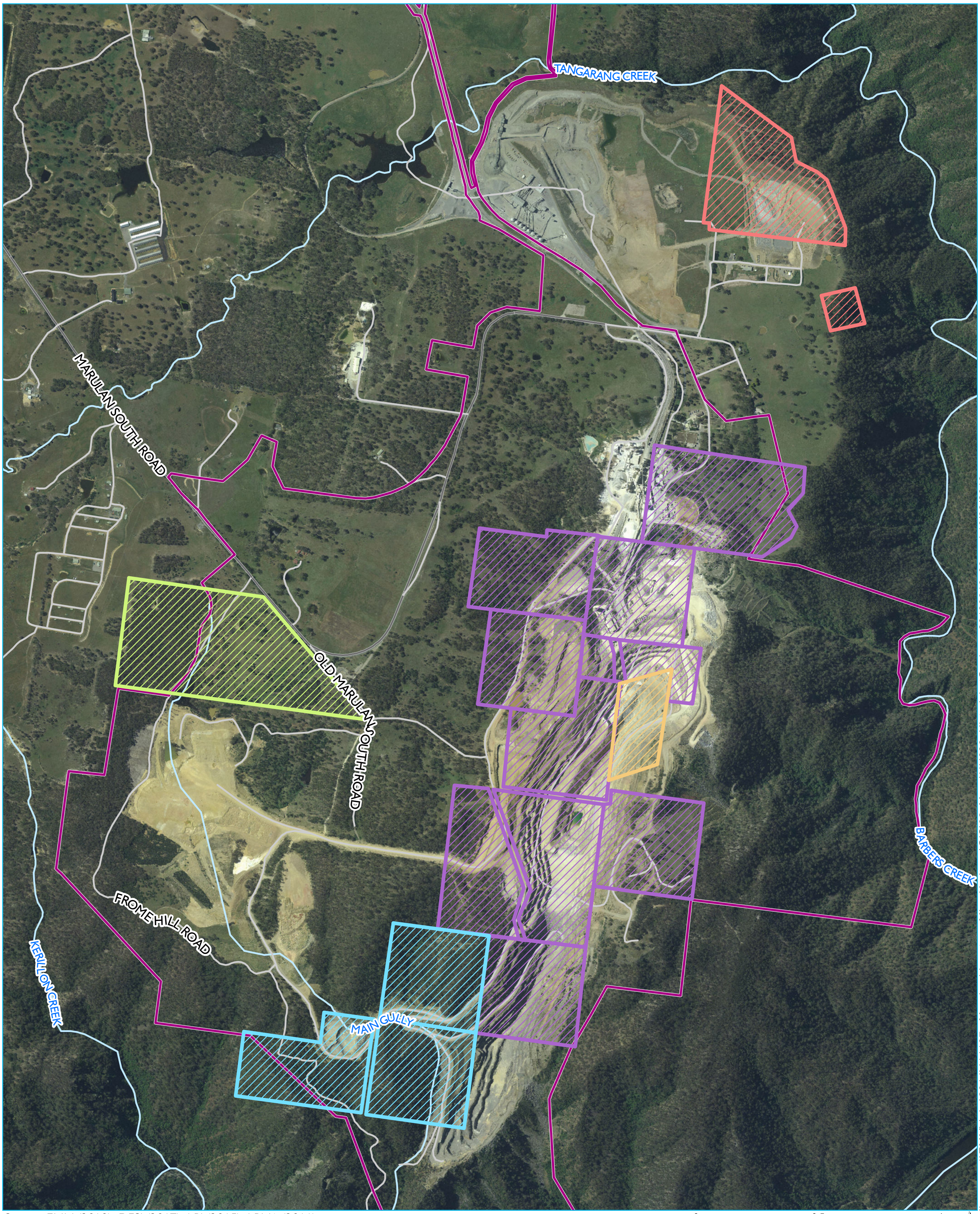
Plate 2.12 **Overview of the Marulan South Limestone Mine early twentieth century (Boral Cement Limited 2015).**

Plate 2.13 **Limestone outcrops at Marulan South Limestone Mine face in 1929. Note the tram bucket in front of the face (Boral Cement Limited 2015).**

Plate 2.14 **An example of the steam shovel and lorries used in the mine in the 1930s (Boral Cement Limited 2015).**

The decades of the mid-twentieth century saw varied demand for the limestone mined from Marulan South. Work was stopped at the mine for a month in 1927 as demand slowed (*Goulburn Evening Penny Post* 1934, p.1) and again in 1934 (*Goulburn Evening Penny Post* 1927, p.2), during the Great Depression.

The limestone mine at Marulan South is now owned by Boral Cement Pty Ltd and what started as a number of individual enterprises on a small scale was amalgamated into one large enterprise.



Source: EMM (2018); DFSI (2017); LPI (2015); LPMA (2011)

0 0.5 1 km
GDA 1994 MGA Zone 56
N

KEY

Mining lease type

- Marble
- Marble and limestone
- Limestone
- Granite
- Arsenic

- Project boundary
- Main road
- Local road
- Watercourse

Original mining leases prior to 1953

Marulan South Limestone Mine
Continued Operations Project
Historic heritage assessment and SoHI
Figure 2.1

EMM

3 Field survey

3.1 Method

The survey was planned using the information gathered in the background research for this report including the historical summary, the location of listed heritage items and local knowledge. Desktop assessment to prepare for the fieldwork included a review of historical aerial photographs of the area, a review of historical information related to the study area and a review of the LEPs. Information from the NSW Government Land and Property information Service and the State Library supplemented the desktop analysis. These investigations provided the basis for the on site historical investigations by identifying areas of historical potential requiring field survey.

Field survey targeted areas predicted to hold tangible evidence of the historical development of the Project site, therefore total coverage was not planned or achieved. The team was escorted to a number of areas where long-term Boral staff have identified 'ruins' and 'rubbish dumps'. Travel to the areas of interest was by car, but site inspection was completed on foot.

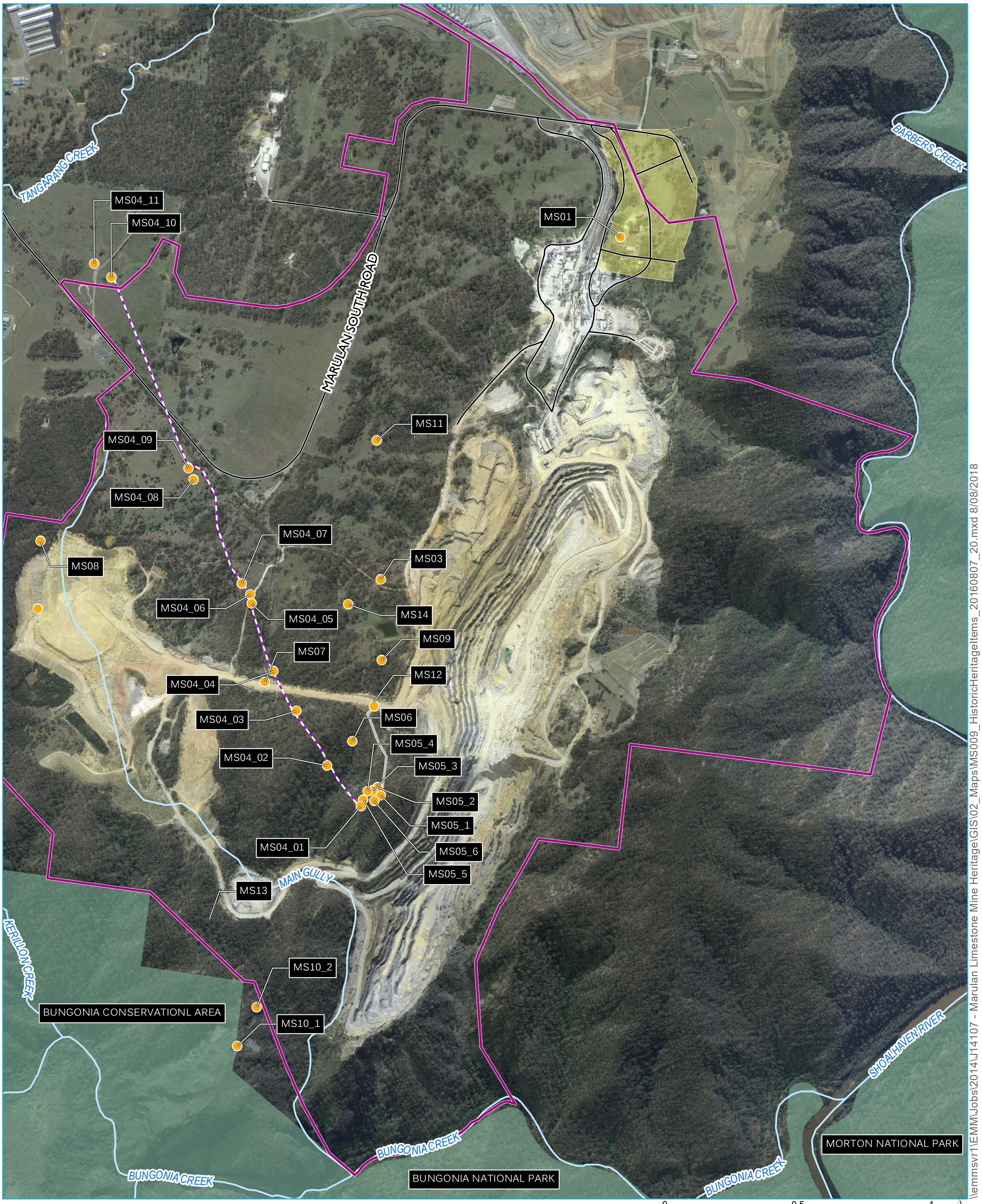
Items and places were recorded through digital photography, GPS coordinates and written descriptions.

The purpose of the field survey was to:

- identify potential relics or known relics in the Project site;
- ascertain the existence of structures over or in close proximity to the Project site; and
- identify significant cultural landscapes within the Project site.

Five categories have been described in this report, which were defined using a combination of field observations, oral history and local knowledge. Roads have been identified through aerial photography and field survey. The following terms have been used in this report to describe the results of the field survey:

- Village is the site of the former village of Marulan South. Presently a small number of buildings survive, as do roads and street plantings.
- Houses are former residential dwellings with evidence of substantial construction such as stone walls, mortar, chimney bases and/or considerable landscape modifications.
- Camps are areas that demonstrate habitation, possibly even short-term, with some evidence of landscape modifications.
- Industrial areas are those that are clearly the remnants of industrial processes, such as kilns and the aerial ropeway.
- Roads were identified through current and historical mapping, aerial photography and field survey. It is possible that not all roads have been identified.



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Source: EMM (2018); DFSI (2017); LPMA (2011)

0 0.5 1 km

GDA 1994 MGA Zone 56 N

KEY

- Historic heritage item within and immediately adjacent to the project site
- Approximate pathway of aerial ropeway
- Project boundary
- Watercourse
- Road
- Marulan South village
- National park

Survey results

Marulan South Continued Operations Project
Historical heritage assessment and SoHI
Figure 3.1

3.2 Results overview

A field survey was conducted on 1 April 2015 by Rebecca Newell, Ryan Desic (EMM) and Grant Thompson (Boral) to assess items identified during the desktop analysis. Archaeological potential was also considered during the survey. Additionally, historic heritage items were identified and recorded during the Aboriginal heritage survey conducted on 13–17 April 2015.

A second trip to view the kiln area (MS05) and two of the house sites (MS03 and MS08) was undertaken by Rebecca Newell, Pamela Chauvel (EMM), Pamela Kottaras (EMM) and Grant Thompson (Boral) on 26 June 2015.

The following sections provide details of the items of local heritage significance identified during the heritage survey. Refer to Figure 3.1 for all survey results.

3.3 Industrial areas

3.3.1 MS05 Lime kiln group

MS05 is inside the Project boundary and consists of a complex of structures, roads and associated landscape modification in the south of the Project site. It included two areas of lime kilns approximately 100 m apart on a hill slope.

Kiln Area A (Plate 3.1 to Plate 3.3) consisted of kiln towers of local stone, brick and mortar, and wooden and iron beams all with evidence of firing and burning. A road, areas of slag slipping down the road embankment, landscape modification for water management and areas of glass, ceramic and metal were identified around the kilns. The road is the terminus of Lime-kiln Road, which underwent a name-change to Marulan South Road and was redirected to the north approximately 1.3 km to its north. They were constructed of stone and built into the banks or side of steep hills. At the examples in Marulan South, only portions of the rear stone wall which was built against the hill and the side buttresses remain. It is this group of kilns that are those most likely built by Hogg.

The kilns in Area A are in poor condition but the ramps that connected the road to the kiln survive. The area is overgrown with thick woody weeds which will have to be removed for clear access.

Kiln Area B (Plates 3.4 to 3.6) consists of two kilns located on a hill slope approximately 100 m east from Kiln Area A, adjacent to a track. The remains of the kilns consisted of bricks, earthworks, wooden beams and stones with evidence of firing and burning. Glass, ceramic and metal has been dumped in the area around the kilns. Based on the historical research in Section 2 the kilns at Kiln Area B are D or round type kilns.

Analysis suggests that this area was mined by James Hogg, although it is in George Feltham's lot (refer Section 2).

Plate 3.1 Kiln Area A showing one remnant kiln and associated iron beams (DSCN2491).

Plate 3.2 Kiln Area A showing remnants of a kiln including bricks, iron and timber beams (DSCN2498).

Plate 3.3 **Kiln Area A showing slag slipping down slope and slope towards the creek (DSCN2492).**

Plate 3.4 **Kiln Area B showing landscape modification and metal elements (IMG_8996).**

Plate 3.5 **Kiln Area B showing an example of burnt bricks that form part of lime kilns (IMG_9004).**

Plate 3.6 **Kiln Area B. Shovel associated with lime kiln area (IMG_9000).**

3.3.2 MS04 Aerial ropeway

MS04 is inside the Project boundary and consists of a number of elements of the aerial ropeway system originally used to transport the lime from the base of the mine up the large hills to the processing and transport areas have been identified. The surviving elements consisted of the following items:

- the control room (MS04_11) a large brick and corrugated iron structure with sliding doors, opening at the top for the ropes and pulleys, and a water tank (Plates 3.11 to 3.13);
- concrete plinths (MS04_1, MS04_3, MS04_5, MS04_6, MS04_7, MS04_8, MS04_9 and MS04_10) in groups of two or four for the pulley towers;
- two pulley towers including plinths, constructed of steel and concrete approximately 20 m high and able to hold two cables to send carriers up and down; one tower is complete (MS04_2) (Plate 3.9) and the other has collapsed (MS04_4);
- metal carriers (buckets/bins for carrying the resource) (Plate 3.10); and
- steel rope (cable) (Plate 3.10).

These items are located in a line from the west of the Project site, and travel in a north-westerly direction upslope to the control room (M04_11) located on the north-western edge of the Project site. Two complete pulley towers remain (one of which has collapsed) with many more plinths located in a line from the easternmost plinth in the area of the lime kilns. Those that were accessible are shown in Plates 3.7 to 3.8. Figure 3.1 shows the location of identified components of the aerial ropeway and the original path the aerial ropeway would have used to transport product through the area. Discarded elements of the ropeway suggest that the Bale carriers were used with overhead grips (refer to 'Figs' 11 and 12 in Plate 4.4).

Plate 3.7 Example of groups of concrete plinths (IMG_8990).

Plate 3.8 Example of an upturned concrete plinth showing both above and below ground sections (IMG_8992).

Plate 3.9 **Tower 1 (MS04_2) is an example of a complete pulley tower. This tower is directly opposite the lime kiln group (refer to Figures 3.1 and 5.1 and is the only surviving complete and standing tower (IMG_9030).**

Plate 3.10 **Example of cables and the upper element of a Carrier (IMG_8988); (refer also to figure 2.11).**

Plate 3.11 **Front of the control room (MS04_11), facing west, showing the corrugated iron rolling doors which would have opened to let out heat (at the base) and for the rope to rotate (top) (20151006_144642).**

Plate 3.12 Rear of the control room showing corrugated iron engine housing, doors, bricked in openings and a water tank (20151006_145129).

Plate 3.13 Interior of control room showing wooden beams for piles and roof, concrete foundations and dirt floor (20151006_144957).

Plate 3.14 **MS04_1 in an aerial photograph from 1972; the easternmost plinth is marked with a red dot (Image reference: 1972_11_31_Marulan31)**

3.3.3 MS10 Mt Frome mining area

Note that the Mt Frome mining area is south of the Project site boundary but has been included here as one of the mine elements (tram rail) is adjacent to the Project site boundary.

An area of early mine workings was identified on Mt Frome including tracks from a short rail line (Plates 3.15 to 3.16 and Plate 2.13), which was used to haul offcuts for disposal downslope.

Plate 3.15 **Mt Frome showing the early mining area. The yellow colour in the rock is the result of blasting and excavation activities (IMG_9053).**

Plate 3.16 **Mt Frome mining area showing the rail track used to transport product down the mountain (IMG_9058).**

3.4 Residential

3.4.1 MS01 Marulan South

The former village of Marulan South was established as a result of limestone mining but was moved to make way for the expanding mine operations and because maintenance was not considered to be cost-effective. The village closed down in 1998 with a number of the buildings being moved to Marulan. What remains are components of the former village, which includes some buildings such as the former community hall, bowling club, bowling green, streets, and street plantings. A small building displaying what appears to be wattle and daub construction was recorded at the southern end of the former village. Plates 3.17 to 3.20 provide some examples of the remains of the village.

Plate 3.17 MS01 view south along Hume Street, South Marulan (IMG_8932).

Plate 3.18 MS01 remnant road, footpath and empty lots at Marulan South (IMG_8943).

Plate 3.19 **MS02 dilapidated building at the southern end of the former town (IMG_8949).**

Plate 3.20 **MS02 detail of the dilapidated building (above) showing possible wattle and daub construction (IMG_8951).**

3.4.2 MS03 camp/hut site

MS03 is inside the Project boundary on Portion 17, which was owned by James Hogg. The landform is a gentle slope which overlooks the mine and the site demonstrating evidence of land modification suggesting something more than a temporary camp site (Plates 3.21 to 3.23). This area was described by local knowledge holders as possibly containing a hut and a road. The presence of larger stone blocks may be evidence of a building or road border.

The road is visible in the landscape as it is defined by stones that act as a low retaining wall (Plate 3.23) and were created by excavation through the existing rocky terrain rather than being defined simply by lining with stones.

Fire pits, adjacent to the road, contain broken glass, ceramic, porcelain, bricks and tin. The interpretation of this area is undecided as it may have formerly contained a hut, which is evidence of something more substantial than an area to camp. It also contains strong evidence of being a camp site and therefore may be a workers' accommodation area. This location may also be where timber was cut to fire kilns.

MS03 is an archaeological site and has research potential.

Plate 3.21 MS03 example of landscape modification at MS03 overlooking the current mining area (IMG_8972). View east.

Plate 3.22 **MS03 example of metal fragments at MS03 (IMG_8976). View east.**

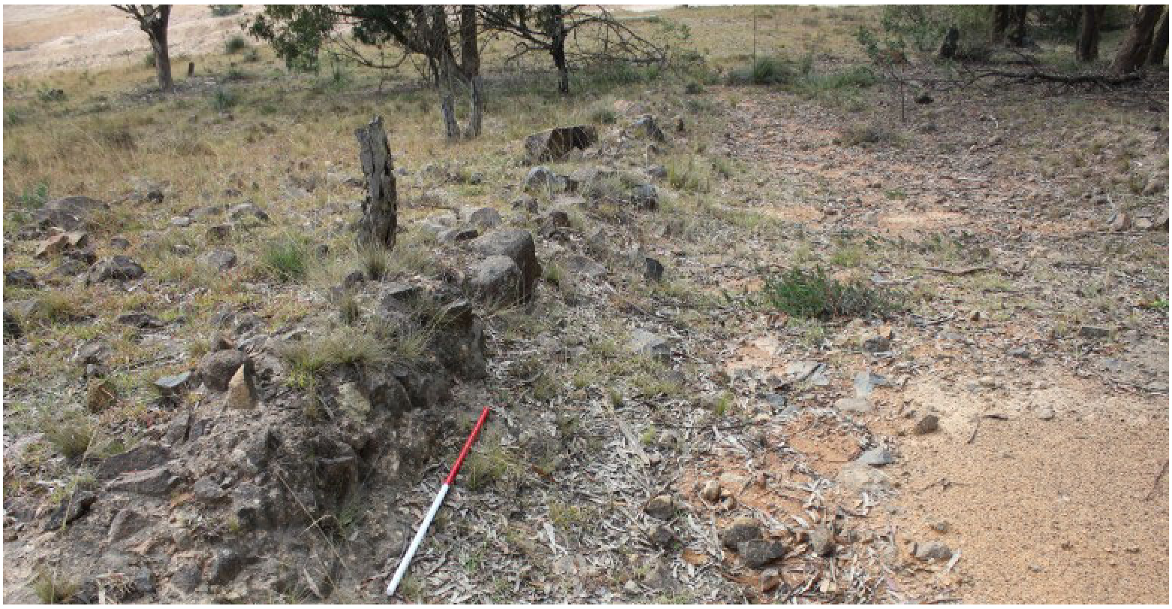


Plate 3.23 **MS03 detail of the road. Close inspection indicates that the road has been constructed by excavation/grading (IMG_8975). View east.**

3.4.3 MS08 house site

The elements of a structure identified by RPS HSO in 2009 were revisited during the survey. It was in similar condition to when it was recorded by RPS HSO, with some additional trees growing in and around it (Plate 3.24).

This item is on the western side of the Project site and immediately adjacent to the disturbance footprint. The historical research completed on this structure identified it as a house belonging to George Feltham who built the structure on his land. While the construction date is unknown historical research has indicated that George and his wife lived in the house until 1908, after which they relocated to the Marulan courthouse (Leighton-Daly 2010, p.144). The land was purchased by FH Gall in 1910. The courthouse was on the eastern side of the Marulan South Road, near the intersection with the Hume Highway and opposite a derelict cottage that once belonged to Harold Feltham, the son of George and Elizabeth and who was born at 'Limekiln'.

Plate 3.24 MS08 facing south-west (IMG_9034).

A variety of land holdings are recorded on parish maps with the name 'George Feltham' from 1917 to 1953 as Feltham was a well-known name in the region. The ruins have been identified as being the former home of George and Elizabeth Feltham and their children (Leighton-Daly 2010, p.143).

George (Laurence) Feltham was born on 17 July 1852 (d.1932), to parents Ann Read (d.1865) and William Feltham (d.1888). He married Elizabeth Neal (d.1948) on 10 September 1888. It appears that he also lived in Sydney for a brief period, as two of his children's births were recorded as being 'Sydney' or suburbs in Sydney, but the more likely explanation is that Elizabeth travelled to Sydney to give birth to some of her children. In total, Elizabeth gave birth to 10 children. George died in 1932 in Goulburn aged 79 years old (*Goulburn Evening Penny Post* 28 March 1932, p.2). Another son was born at 'Limekiln' near Marulan – Harold George Victor Feltham in 1891, who built the house near the Anglican cemetery on Marulan South Road close to the highway. The mention of 'Limekiln' as Harold's place of birth must be an indication of the name of the area that MS08 is in.

Another George Feltham was born in 1875 to John and Elizabeth Feltham, with John being the brother of the aforementioned George Feltham. He married Martha Theresa Halls in Goulburn 1899 and together they had 5 children; Doris May (b.1899), George Leo (b.1900), John Horace (1902), Neville (1904) and Marrietta Caroline (1905). George's listed occupation in 1903 is 'butcher' (Ancestry.com). He passed away in Marulan 1949 at age 74. An important fact to note is his son George Leo Feltham's place of birth is also listed a 'Limekiln' near Marulan. This George Feltham also appears to have different landholdings in the area, shared with his older and sole brother William H Feltham (WH Feltham b. 1973).

George and Elizabeth owned a number of allotments in the Marulan South area as did their relatives. The Felthams were a well-known family in Marulan South and George was a respected member of the community:

> The late Mr Feltham, for the greater part of his life, had lived in Marulan where he was well-known and esteemed. His kindly disposition gained for him many friends. He followed the occupation of grazier for many years, retiring some time ago.
>
> *Goulburn Evening Penny Post* 28 March 1932, p.2

The site of MS08 displays some disturbance through erosion and dereliction from time. While erosion has occurred in some locations, evidence of deposit was noted on site. The site was assessed in a previous study as lacking archaeological potential and suggested that a greater understanding of the occupation of the Marulan district would be gained through documentary sources relating to mining (RPS HSO 2009, p.33). Documentary sources were sought for this study that provide information about the area but it is argued here that the landscape features that survive at the site warrant further research despite the lack of substantial soil deposits across the site. An archaeological analysis of MS08 may provide an understanding into how the site was used and therefore a clearer picture of the Feltham family and what changes they made to make a home with a mine on one side and the Australian bush on the other.

MS08 is a potential archaeological site and has research potential.

Plate 3.25 **MS08 The land around George and Elizabeth Feltham's house at the mine (IMG_9042). View north.**

Plate 3.26 **MS08 view into the interior. The current mine is visible to the left (IMG_9036). View south.**

3.4.4 MS14 house site

Substantial evidence of a structure (Plates 3.27 to 3.31), probably a house with chimney was identified west of the 30 year mine pit. The site consisted of a flat area of ground overlooking a dam and an ephemeral creek line. The area contained evidence of extensive landscape modification in the form of rock structures, road or track edges, fences and exotic trees (possibly quince).

An accumulation of glass, ceramics and metal was also noted on the ground. Areas that had the appearance of a road or track with stone edging also exist at MS14.

Modifications to the landscape in this area are extensive and warrant further field and documentary investigation. An analysis of the spatial layout of MS14 and other archaeological investigation may shed light on the function of the ruins and perhaps the inhabitants. Detailed field and documentary research would also add to the knowledge about this and other sites like it in the Marulan and South Marulan district.

MS14 is an archaeological site and has research potential.

Plate 3.27 Area of MS14 showing landscape modification, possible wall, fence or water diversion (DSCN1243). View west.

Plate 3.28 **MS14 a view of the element considered to be part of a chimney with the dam and mine in the background (DSCN1250). View east.**

Plate 3.29 **MS14, with one of the two exotic trees, chimney remnant in the mid-ground and operational mine in the background (DSCN1254). View east.**

Plate 3.30 **MS14 showing close up of possible retaining wall and dump of glass and ceramic (DSM1261). View south.**

Plate 3.31 **MS14 close-up of what appears to be a chimney (DSCN1248). View south-west.**

3.4.5 MS09 camp site

MS09 is located to the west of the existing mine pit and north of the lime kiln group. It is inside the Project site but will not be impacted by the Project. It is understood that this is the abode lived in by the Armitt family (Barry Armitt *pers. comm.*), which was more akin to a tent than a solid structure. Barry Armitt and his sister, along with their parents who worked in the mine, lived in a basic hut near the mine during the early twentieth century. Remains of the hut included landscape modifications in the form of fences and tree cuttings, sandstone and brick fragments and small walls made of trees (Plates 3.32 to 3.33).

The camp site is in proximity to the other camp sites MS14 and MS03, approximately 260 m and 370 m respectively.

MS09 has research value focused on the development of the landscape and the spatial organisation of accommodation be it substantial structures or camps. An investigation of surface material, combined with oral history (if possible) would add to the body of information about the development of the site and may be able to answer questions related to life on the fringes of the mine before large-scale mechanisation.

Plate 3.32 MS09, facing east showing sandstone fragments and some tree modification in the left of frame (20151006_151424).

Plate 3.33 MS09 facing south-east showing the area cleared for the tent, also used for tethering horses and donkeys (20151006_152158).

3.4.6 MS11 Camp site

MS11 was identified as a camp because of the remnant features on the site including bricks, fence posts and a rubbish dump with tin cans, stoneware and other ceramic sherds (Plates 3.34 to 3.36). This area also contained what appears to be a ramp, the purpose of which can only be guessed at this stage of the assessment (Plates 3.37).

The ramp's presence supports that this area is a camp, or at least temporary/intermittent accommodation and possibly not even overnight. The fence posts suggest stock.

The Boral escort indicated that MS11 is known as a camp; the presence of a structure that may be a loading ramp suggest that this location may have been a temporary work camp.

Plate 3.34 MS11 with fence posts (DSCN1057). View south-east.

Plate 3.35 MS11 fence post indicating defined boundaries (DSCN1063). View north-west.

Plate 3.36 MS11 dumped rubbish (DSCN1053).

Plate 3.37 MS11 loading ramp (DSCN1067). View north-west.

3.5 Roads

3.5.1 MS07 Old Marulan South Road

Marulan South Road was originally known as the Lime-kiln Road, which extended from the Hume Highway at Old Marulan to Marulan South. From the Hume Highway, the road travelled in a south-easterly direction for 6 km at which point it turned south for approximately 500 m before turning east again for another 400 m (now a stretch of road that is a mine haul road). At this point the road turns south again and enters the area of the lime kilns (MS05). This last stretch of road is Lime-kiln Road (MS12).

The Old Marulan South Road is labelled as such on current mapping and is the stretch of road, now closed, that travels south for approximately 500 m before it reaches the haul road. Today Marulan South Road has been realigned to turn north on its way to the former village, which is now the Boral Marulan South offices.

This road was not surveyed, and it is blocked to traffic at both ends. It is a section of sealed road with bushland on either side.

Plate 3.38 The closed section of the former Marulan South Road, now called Old Marulan South Road (IMG_9031). View north.

3.5.2 MS12 Lime-kiln Road

Lime-kiln Road is the short stretch of road leading from what is now a recently created haul road (over the original Marulan South Road) to the lime kilns. It has been labelled Lime-kiln Road for the purposes of this report to differentiate it from other sections of Old Marulan Road in addition to the fact that it appears to retain its historical form.

The Lime-kiln Road is likely to date to the 1870s when the kilns were erected.

Plate 3.39 A stretch of Lime-kiln Road close to the kilns in Kiln Area A (DSCN2495). View north

3.5.3 MS13 Frome Hill road

Frome Hill Road was identified as a potential early road through the mining area that departed Marulan South Road approximately 400 m before it turns to the north and tracks south toward Mt Frome. Frome Hill Road passes in front of the ruin of the Felthams' house (MS08) and past the Armitt camp (MS09) where it continues to Mt Frome.

Frome Hill Road is likely to be one of many tracks through the area that provided access to individual mines.

3.6 Historic views and vistas

The Marulan South area is characterised by hills and ridges of varying heights and the majority of the area has been cleared and used for agriculture. The topography is such that it is shielded by rises in most places and is best seen up close, accessible mostly from Boral-owned land. Historic views and vistas that are significant to the area were not identified in the immediate external vicinity of the mine, and those impacts associated with the Project will generally not be visible from anywhere outside of the Boral-owned land. The most relevant and significant landscapes are present on a small scale within the Project site and impacts to these will be managed through recording various data.

In the wider area, the Bungonia Lookdown in the Bungonia National Park to the south of the Project site looks over a landscape considered to be a historic vista with natural values. It displays the unique geology of the area including the gorges bound by the Bungonia and Jerrara Creeks. The Bungonia Gorge is a slot canyon with vertical walls 275 m high in its base (NSW National Parks and Wildlife Service 1998). The current mine area is visible from Bungonia Lookdown (Plate 3.40) and to a lesser extent, from Morton National Park to the east of the mine. A detailed assessment of the visual impacts has been prepared by RLA 2018.

The mine is visible from a small number of public spaces with the largest visual impact being from Bungonia Lookdown where impacts are already visible. The rehabilitation plan will see large-scale tree planting to screen the mine in this area. A view from Bungonia Lookdown to the operating mine is shown in Plate 3.40. Rehabilitation as part of the 30 year mine plan is shown in Plate 3.41.

Plate 3.40 The view from Bungonia Lookdown to the existing limestone mine (Source: RLA 2018 and Cambium). View north.

Plate 3.41 Photomontage of the view to the mine pit from the Bungonia Lookdown 5 years after the end of the proposed 30 years of continued mining operations. (Source: RLA 2018 and Cambium).

3.7 Historic mining landscapes

The majority of the early mine landscape has been removed by the continuation of mine activities and very few elements of this landscape remain. Those that do survive are of value as they have changed insorfar as the encroachment of the bush rather through active impacts. The intact mining landscape identified through research and field survey is close to the southern end of the Project site and contains lime kilns that are associated with James Hogg's activities (c1870s) and the aerial ropeway, which has been dated to the late 1930s.

The kilns are at what was once the western fringe of the current mining area and to the north of the Mt Frome mine. The kilns are set into a low cliff and were accessed by Lime-kiln Road (MS12). The kilns are also set in a steep gully traversed by an unnamed creek flowing from north to south, and on the other side of this gully, the aerial ropeway extends to the north-west. The surviving elements of the aerial ropeway, being one complete iron lattice tower on concrete plinths, a fallen tower and a number of bare concrete plinths are testament to changing mining technology and the importance of the Marulan South Mine and all its previous incarnations. Smaller elements of the aerial ropeway are scattered across the gully. This landscape is only visible from within the Project site but its existence, along with the residential sites, is a legacy of the historic mine operations in the area.

Details of the elements that combine to create the historic mining landscape are presented in earlier sections as individual elements.

3.8 Local interviews

In addition to the field survey, interviews with local knowledge holders were conducted to understand the local area in more detail. The interviews provided information about Marulan South but did not provide additional information of items of possible heritage significance in the Project site. Talking to local residents also helped establish items of social significance in the area.

The interviews centred on the town of Marulan South from which some of the participants originated. Marulan South was of considerable social significance to the local community and was a hub for the families who worked in the Marulan South Limestone Mine. The local store which also operated as the bank and post office was well known in the local area as a place where almost anything could be purchased.

The majority of the buildings in Marulan South were removed as part of the closure of the town in the late 1990s. The buildings which remain include the former bowling club building and the community hall and have been reused by the mine. Evidence of the town is still visible with an oval and tennis court and a plaque where the school was located. The interviewees spoke of the connections made at the town and the generally positive interactions between the local people and the mining companies that operated the mine. For the generations who lived at Marulan South the town represented a time of great joy with the bonds made in the working and community life of the town continuing beyond the removal of the buildings and the closure of the town.

3.9 Summary

A number of heritage items and potential relics were recorded in the Project site during this investigation. All identified heritage items were recorded at the southern extent of the Project site, while the northern extent, comprising the Marulan Creek Dam was devoid of historical items. The heritage items and potential relics recorded during the investigation for this report include:

- MS01 - The Marulan South village area including the remains of the bowling club, a small structure and town hall as well as landscape modifications indicating the original town layout.

- MS04 - Elements of the aerial ropeway system operating in the Project site, including concrete plinths in groups of four or two used for holding up the pulley towers, two pulley towers (Tower 1 and Tower 2), metal buckets and steel cables.

- MS05 - A lime kiln group of five kilns in two areas was identified in the south of the Project site. Kiln Area A consisted of three D-type kilns and associated bricks, earthworks, wooden beams and stones with evidence of firing and burning. Kiln Area B consisted of two D-type or round type kilns and associated bricks, burning and stones. The lime kiln group also contained ephemeral road structures and areas where glass, ceramic and metal had been dumped. In addition to the kilns is a road that accessed them and a concrete slab that was used as the base for a shed at a later date.

- MS07 – Old Marulan South Road, which is an earlier but now disused alignment of Marulan South Road. The section continued to the lime kilns and has been called ‘Lime-kiln Road’ in this report.

- MS12 - Lime-Kiln Road, which is the terminus of the old road that started on the Hume Highway and ended at Hogg’s lime kilns.

- MS13 – Frome Hill Road, which is the road that departs the Marulan South Road and generally skirts the current mining area, terminating at the Mt Frome Mine.

- Two house sites:

    - MS08, a structure identified in previous assessments as a house probably built and occupied in the late nineteenth and early twentieth centuries by George and Elizabeth Feltham. The structure is rectangular and built of local stone and mortar. The roof is missing and walls are in varying states of repair; and

    - MS14, an accumulation of local stone with what appears to be a chimney in the centre. The area contained evidence of landscape modification in the form of rock structures, fences and exotic trees. A dump of glass, ceramics and metal was also evident. The remains of a chimney were also identified and the area has the potential to contain relics.

- Three 'camps', which may have been used as permanent dwellings for a time:

    - MS03, an area containing old huts but with little evidence of substantial structures that can be described as a dwelling. This site displays a high degree of landscape modification including roadways and dry-stone walls;

    - MS09, described as Barry Armitt's house where he and his family lived in the early twentieth century; and

    - MS11 consisting of in situ fence-posts, bricks, and artefact scatters including stoneware, whiteware and glass. This site is associated with a timber ramp made of logs, earth and old rubber matting. Corrugated iron is also tangled up in this feature.

Heritage items close to, but outside, the Project site includes:

- MS10 - Elements of the mining area at Mt Frome including a rail track and evidence of early blasting;

- a large portion of the alignment of Frome Hill Road (MS13);

- Bungonia National Park; and

- Glenrock Homestead and outbuildings (Item 314 on the Goulburn Mulwaree LEP 2009).

4 Comparative analysis

4.1 Introduction

The comparative analysis focuses on the industrial nature of the Project site and results of the field survey. It has been compiled to place the significance of the kilns and the aerial ropeway into its historical context.

4.2 Lime burning

There is evidence of limestone burning and working at Marulan South from the mid-nineteenth century. Low-density rural population and an undeveloped road network meant it was uneconomical to transport lime. Therefore lime production tended to be small scale and local (O'Keefe 1994, p.16).

Lime kilns can be categorised as either intermittent, where the kilns are loaded, fired and emptied each time, or continuous (Pearson 1990, p.28). While intermittent kilns are inexpensive to construct, continuous kilns are more efficient in terms of labour and fuel, as the kilns do not cool down after each load. Lime kilns in NSW in the late nineteenth to early twentieth century were predominantly the intermittent type, and the most common of these was the D-kiln (kiln 'B' as shown in Plate 4.1).

The D-kiln was "a cylindrical deep pit cut into a bank of earth and crowned, and sometimes lined with stone or brick" (Carne & Jones 1919, cited in Pearson 1990, p.30). A wall was built across the front to create a D shaped firing chamber. Ash boxes were built below the kiln floor and could be emptied by a door at the front. Above this was an arched fire door into which fire arches of limestone blocks were built. The kiln was then loaded from above with alternating layers of fuel and limestone. The firing process using an intermittent kiln took 48–90 hours. Completion was judged by the amount of shrinkage which could be gauged by inserting a metal rod into the kiln (Pearson 1990, p.30).

Pearson (1990, p.30) provides typical dimensions for D-kilns:

- 4.3–6.7 m long;
- 2.4–4.3 m broad; and
- 3–4.9 m deep.

Examples of kilns are found throughout Australia including the Pipers Creek Lime Kilns in Kumbatine National Park NSW. The Pipers Creek kilns may be similar in construction to those at Marulan South as they are D-type kilns built into a bank with a stone front wall; however it is possible that the Marulan South kilns are shaft kilns or a combination of the two techniques.

Locals describe the Piper's Creek Lime Kilns (Plate 4.2) process as a fire being set in the pit and wood and limestone blocks dropped in from above. Lime fell to the bottom and was scraped out through front openings. The men rotated from one kiln to the next for each task.

Another example of a lime kiln is the Moses Morley burning kiln at 501 Cooma Rd, Googong, NSW near Queanbeyan. It operated from 1876–77 to the early 1900s. It was a stone construction, built into the bank for top loading with a draw hole at the base and stone buttresses at the front of the kiln (McGowan 1996, p.164). It is shown in Plate 4.3.

Closer to Marulan South, the Kingsdale lime kilns and quarries were the second largest lime-producing centre in NSW. By 1925 around 90% of the state's lime production came from only two locations: Portland near Lithgow and Kingsdale. Kingsdale provided limestone of great purity, averaging 97% calcium carbonate. Quarrying of the material was costly however, due to the presence of 'overburden' with pockets and bands of clayey material.

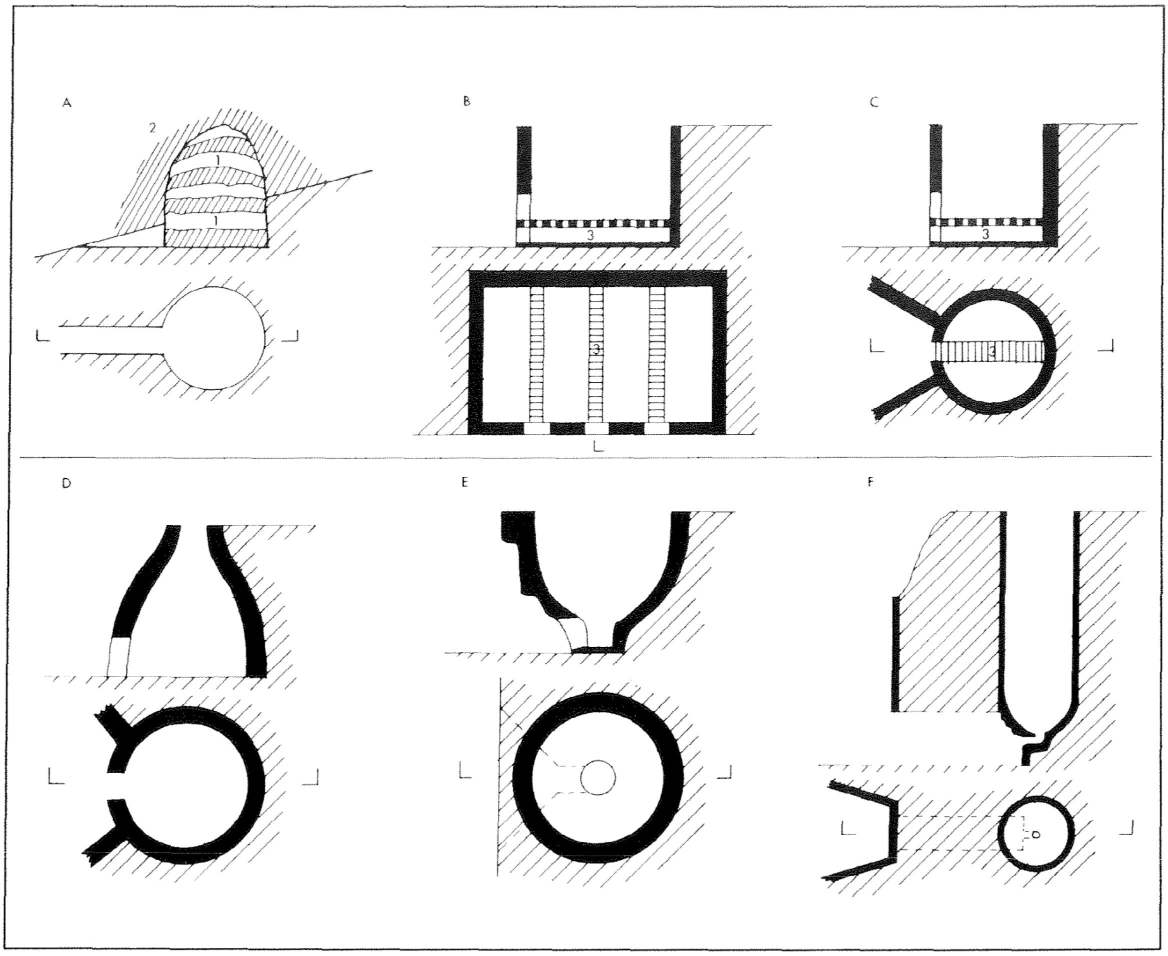


Fig. 1: Schematic outline of various kiln types, showing plan and cross-sectional elevation of each major type (not to scale). A. Pit-burn kiln; B. 'D' kiln; C. Small cylindrical shaft kiln; D. Inverted cone (bottle) kiln; E. Inverted bell kiln; F. Continous feed shaft kiln. 1. Limestone or shell; 2. fuel (wood or coal); 3. ash pit.

Plate 4.1 Types of lime kilns, including the D-kiln (from Pearson 1999, p.29).

Plate 4.2 Pipers Creek lime kilns showing front wall made of stone (OEH 2015).

Moses Morley's 1870s kiln on Stringybark Hill south of Queanbeyan. The massive tree trunk supporting the upper part of the kiln's front wall probably helped to stabilise it during the burning process. The front walls of kilns tended to bulge outward with the intense heat. (Photograph by author).

Plate 4.3 Moses Morley's lime kiln (OEH 2015).

There is conjecture on the establishment and operation of the lime kilns at Marulan South. An article in the *Illustrated Sydney News and New South Wales Agriculturalist and Grazier* (1860, p.11) describes the Marulan marble lime quarries as being situated six or seven miles from the railway station which has "retarded their success from a financial point of view" because of the terrible condition of the roads, especially in winter. However, the article goes on to mention that the new proprietors Dunlop Gall and Co are building kilns and other buildings as well as improving the roads from the

The date of 1860 for the establishment of the lime kilns is contradicted by an article in the *Goulburn Post,* (16 August 2013, p.10), which states that James Clewett and Mr Stuckey opened a marble quarry in the 1830s but that this enterprise was short-lived. James Hogg and a Mr Sieler began lime burning some time after the 1860s and this continued up until 1917. They sold the lime in Sydney through an agent. When Hogg took over the mining at Marulan in the 1860s, his kilns in Old Marulan supplied lime to Sydney. He had 16 teams of 60 men working to extract the product. At Marulan South, Hogg established three large kilns each with a 20 tonne capacity and four furnaces; the kilns identified in the field survey are most likely the kilns described in the article (*Goulburn Herald and Chronicle*, 2 November 1878). The article continues, *in addition to these there are two similar kilns near Mr Hogg's residence, and a circular kiln, the first of the kind introduced into the colony* (*Goulburn Herald and Chronicle*, 2 November 1878, p.3). These lime kilns were located within two miles of the railway station at Marulan and were in operation from at least 1876 to into the 1900s (Eddy 1985, p.87) so it is clear that the circular kiln and the two additional large kilns were situated at Old Marulan.

In 1885 Hogg trialled a traction engine (a self-propelled steam engine) to transport lime from the 'Shoalhaven gullies to the Marulan railway station' (*Goulburn Herald* 18 December 1884, p.4). The trial was successful enough that by August 1886 Hogg had two traction engines in circulation and was planning on removing horses from further haulage (*Goulburn Herald* 31 August 1886, p.2). However they must have held onto their stock a little while as a later advertisement in the *Goulburn Evening Penny Post* (9 February 1889, p.5) includes the Hogg bros. auctioning off all their bullocks and horses due to "*having no further use for them, they having constructed a tramway*'. Traction engines ran on wheels without tracks and the description of the trial is hair raising:

> Although there was no beaten track, and the engine had to climb a steep incline, the journey was accomplished on Monday without any further mishap than a tire coming off one of the waggon-wheels. In coming up the incline a stone eighteen inches high was encountered, and in passing over it the front of the engine became uplifted. This caused a scare among some of the bystanders, who ran away into the bush thinking the engine would fall over, but it passed on without interruption.
>
> *Goulburn Herald* 18 December 1884, p.4

The kilns at Marulan South operated during wet weather when the route to the kilns at Old Marulan was impassable (*Goulburn Post* 1988 p.2). Additional lime kilns in the mine pit remained in use at Marulan South until the 1960s when automatic kilns were introduced and they were removed (Leighton-Daly 2010, p.175).

It is no surprise that industrial accidents occurred as the kilns needed to burn continuously for 48–90 hours in order to produce lime. Continuous burning meant that someone would have needed to maintain the feed of fuel and limestone during the night. The Marulan lime kilns were the location of an unfortunate incident in 1927 when James Martin was found burned to death in the drying fire area of a kiln (*The Canberra Times* 1927, p.11).

4.3 Aerial ropeways and aerial tramways

Another component of the Marulan South mine system was an aerial ropeway to transport the mined material to a central facility for processing. The main advantage of this system is that it could be built to transport material along very rugged terrain and up steep inclines removing the need to haul heavy loads, by beast or automated vehicle, along winding tracks. This system meant that transportation in rugged country was faster and economically more sustainable than transportation along roads. The biggest obstacle was obtaining the funding to build them and the permission to erect them across other people's land.

Aerial ropeways, also called aerial tramways or cableways (Ritchie *et* al, 1997, p.11; Booth 1965, p.1), were generally consistent in design and form with major changes occurring around the 1850s when the stronger wire rope was developed. The first authenticated ropeway was constructed in 1644 for the city of Dantzig by Adam Wybe, from the Netherlands. The ropeway was comprised of hemp rope passed over pulleys on high posts and was used to transport soil from one point to another to strengthen the city's fortification (Booth 1965, p.7). The next substantial development in the ropeway system was in 1860 by Baron von Ducker in Germany in 1860. Von Ducker's first ropeway was a monocable system and by 1870, he had developed the bi-cable system (Booth 1965, p.8).

The monocable ropeway is a single, spliced wire rope, which supports and hauls the carriers. This system is limited as it cannot be detached from the ropeway and was, in the early period of its use, limited to 300 pounds (136 kg).

The bi-cable ropeway is characterised by a stationary wire rope that holds the carriers, while another wire traction rope is used to haul them along the stationary wire.

Another breakthrough was the standard coupling designed in the early 1870s by the Austrian Theobald Obach, which allowed the cars to be disengaged and reattached to the trackway. Until the end of the nineteenth century, aerial ropeways had been powered by humans (sometimes using a windlass or a treadwheel), by animals (horses or mules), by waterwheels and/or by gravity (DeDecker 2015).

Using gravity to move the aerial ropeway was only possible in mountainous areas where the descending carrier delivered the power to haul the ascending carrier. To make the system work, the descending carrier was filled with water or other materials to render it heavier than the ascending carrier and the angle of descent was made steep enough to facilitate the movement of the carriers (DeDecker 2015). The aerial ropeways at Marulan South were likely operated in this way. In 1911 aerial ropeways had a capacity of 15 to 200 tonnes and a possible length of 305 m to 4,600 m.

New power sources appeared at the turn of the century; first steam engines, then electric motors (DeDecker 2015). Engines were housed in brick and corrugated iron sheds with openings for the ropes and space to ventilate the building. Carrier designs are shown in Plate 4.4.

A similar example of an aerial ropeway is at Brogans Creek, formerly owned by Boral Cement. The ropeway was also used for a lime burning works, supplying lime to the Charbon Cement Works. Today the area is agricultural, used for cattle and sheep grazing. Tourism has increased as the improvements to the Hume highway connected the area to Sydney. The area was amalgamated into the Goulburn Mulwaree LGA in 2005 from the Goulburn and Mulwaree Shires previously.

Fig. 9. Carrier, with Webber Patent Compression Grip, showing Patent Automatic Attacher.

Fig. 10. Carrier, with Bleichert Patent Automatic Overhead Grip.

Fig. 11. Bale Carrier, with Overhead Grip.

Fig. 12. Carrier, with Bleichert Patent Automatic Underhung Grip.

Plate 4.4 **Various aerial ropeway carrier designs, Marulan South's aerial ropeway was likely similar to Figure 10 (DeDeker 2015).**

4.4 Archaeological resources

The heritage items discovered during field survey have been classed as archaeological resources and this report assesses them as such.

4.5 Relics in NSW

In New South Wales, relics are protected by the Heritage Act and their removal is permitted by approval from the Heritage Council or delegates. 'Relics' are defined in the Act as:

> any deposit, artefact, object or material evidence that:
>
> a) relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement, and
>
> b) is of State or local significance.

Where relics are known to exist, or where there is reasonable cause to suspect that they exist, it is illegal to disturb or excavate that land (s139 Heritage Act) except with an excavation permit.

The project is being assessed as an SSD (as a Major Project) and Division 4, Part 4.41 of the EP&A specifies a number of approvals under other Acts, including the Heritage Act are not required; however, any activities that relate to relics for the Project will be reviewed and assessed by the DPE in accordance to the same guidelines and standards that would be applied outside of the Major Projects framework.

4.6 Research value

All items discovered during the field survey component of this project have research value regardless of the presence of archaeological deposit. One of the most important aspects of the archaeological/mining landscape is the spatial organisation of the sites, internally and relative to each other and the adjacent topography.

5 Significance assessment

5.1 Defining heritage significance

The Heritage Division of OEH assesses heritage significance based on the *Burra Charter* (Australia ICOMOS 2013). It lists seven criteria to identify and assess heritage values that apply when considering if an item is of state or local heritage significance as follows:

a) An item is important in the course or pattern of NSW's (or the local area's) cultural or natural history (Historical Significance).

b) An item has strong or special association with the life or works of a person, or group of persons of importance in NSW's (or the local area's) cultural or natural history (Associative Significance).

c) An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area) (Aesthetic Significance).

d) An item has a strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons (Social Significance).

e) An item has the potential to yield information that will contribute to an understanding of NSW's (or the local area's) cultural or natural history (Research Significance).

f) An item possesses uncommon, rare or endangered aspects of NSW's (or the local area's) cultural or natural history (Rarity).

g) An item is important in demonstrating the principle characteristics of a class of NSW's (or the local area's), cultural or natural places or environments (Representativeness).

These criteria are then considered in combination to come to an overall level of significance for the site as either State or local significance.

5.2 Community heritage values

During the historic heritage survey, local residents were questioned in informal interviews about their memories of the area. These discussions helped to build an understanding of the places and items within the area which local residents valued. The area of highest community value, the town of Marulan South, has largely been removed and the former residents are now part of the wider Marulan and Goulburn town communities. The two remaining buildings related to the Marulan South town, the bowling club and the community hall are of value to the community and can be considered representative of the town and its importance to its former members.

5.3 Assessment of significance

The assessment of significance for each site recorded during survey is presented in Table 5.1. While Mt Frome is outside the Project site it is included in the assessment of significance because it is directly adjacent to the southern boundary.

The assessment has taken into account the fact that most of the sites recorded within the Project boundary are generally archaeological in nature. Camps, the ruins of a house, stone walls and lime kilns, while represented by above ground fabric, fall into the category of relics as defined by the Heritage Act. The old roads within the Project boundary are works that contribute to knowledge about site processes and development and have been assessed to be significant. The aerial ropeway is the only item that has been treated as a standing structure despite the fact that it is in poor condition.

The assessment of significance presented in Table 5.1 has considered heritage values from an archaeological perspective as it is in the archaeological information that most of the research values lie. The issues of acquiring information from archaeological excavation have been considered in the assessment of significance, particularly under criterion e) but also under the other criteria.

Table 5.1 Assessment of significance

a) ***An item is important in the course or pattern of NSW's (or the local area's) cultural or natural history (Historical Significance).***
MS01 Marulan South village and hut (MS02): The surviving elements of the village at Marulan South date to after 1926 when the first resident, Les Cooper moved there from his place of abode closer to Weenga Quarry. From that time, the village became an important aspect of the limestone mine, housing employees and their families and providing a strong sense of community. The village was established because of the limestone mine but as the mine expanded, it was no longer tenable to have a community situated there due to the cost of repairs and upgrades. Residents began moving in 1998 to Marulan, Goulburn and elsewhere and the village was reduced to two buildings, one hut, streets with kerbing and street trees. Marulan South village was an important aspect of the mine's growth and its logical extension. It demonstrates the success of the limestone mine and the company's care towards its employees. The Marulan South village demonstrates an early 20th century village in Southern tablelands of NSW which has come about due to a primary economical industry in the area. Its visual setting and contents both demonstrate the necessity of nearby facilities at the time of its establishment and the subsequent lack of need due to changing times. Marulan South village has *local* historical significance
MS02 – not used
MS03 House site The ruins of a probable house site, possibly comprised of a temporary structure but with substantial landscape modifications. The site comprises a road levelled out of the existing ground and tin and ceramic artefacts. Its position overlooking what would have historically been a mined area suggests that this was a miner's house site or camp. Local knowledge states that this site was the place of a hut and a road and the presence of large blocks may be evidence of such a building. MS03 demonstrates the settlement pattern associated with working at the limestone mines. MS03 is of *local* historical significance
MS04 Aerial ropeway system The aerial ropeway that survives on site is most likely to be a bi-cable because of the date of construction, which was in the late 1930s. Bi-cable became the preferred option as it allowed for greater flexibility to move the resource. The type however has not been confirmed and the ropeway may have been monocable. The ropeway has associated *in situ* elements including one standing iron lattice tower, one collapsed lattice tower and a number of concrete plinths arranged in an alignment out of the gully to Marulan South Road. Other elements that were noted during field survey were lengths of iron rope and metal fragments and ropeway carriers. The ropeway permitted a greater volume of resource to be transported out of the gully than traditional road vehicle method. It was however, short-lived as operations became more mechanised and roads improved. The aerial ropeway is of historical significance for its ability to provide information on the development of mining at Marulan South. It demonstrates the ways in which product was transported around the steep mining area using a common system. It has a connection to the remaining concrete pillars that together reveal the route of the ropeway across the landscape and its important role in connecting the mine to the railway. MS04 is of *local* historical significance.

Table 5.1 Assessment of significance

MS05 Lime kiln group

The lime kilns are a significant development of the lime quarrying industry at South Marulan signalling the importance of the mines by ensuring that processing could occur on site when climatic conditions were an obstacle to their transportation to the kilns at Old Marulan. The group is also significant as one of the earlier in the area, and may be the earliest as no other kilns have been discovered. They demonstrate the development of lime quarrying from small-scale operations to larger enterprises when James Hogg established his business here.

The lime kilns are significant as one of the elements of limestone mining infrastructure established across the colony by James Hogg and demonstrate the growing nature of industry.

MS05 and its component kilns are of *local* historical significance.

MS06 Explosives hut

The explosives hut relates to the later development of the mine. Its date of construction is not known but based on the fabric, it dates to the second half of the twentieth century, probably after 1970 when concrete Besser blocks became more readily available. While the explosives hut was part of the historical development of the limestone mine, it does not have a level of significance that meets the threshold.

MS06 does not fulfil criterion A.

MS07 Old Marulan South Road

Old Marulan South Road, originally known as 'Lime-kiln Road' is significant for its ability to track the development of the limestone quarries. It remains visible in the landscape and is still used but is closed off where it meets the haul road to the south. It is a remnant of the historic landscape amongst large-scale change.

MS07 is of *local* historical significance.

MS08 House site

The ruins of MS08 are the most intact of all the occupation/domestic sites in the Project site. The structure with all four walls, retains the ability to provide insight into the accommodation arrangements for workers at the mine(s). Evidence of group accommodation was not discovered but isolated habitation sites were, indicating the people fended for themselves by either building a stone house or humpy-like structure at the camps, or went back to Old Marulan and Marulan where they had more substantial homes.

MS08 has also been identified as the house of George and Elizabeth Feltham, a well-known family in the region who also owned much property as well.

MS08 is of *local* historical significance.

MS09 Camp site

This site is an old camp on a bend on the Mt Frome Road where Barry Armitt and his family lived while he worked at the Weenga Quarry (now the Marulan South Limestone Mine) and during the Great Depression. The camp demonstrates the ingenuity and tenacity that people displayed during hard economic times.

MS09 is of *local* historical significance.

MS10 Mt Frome Mine group

This item comprises mine workings and a segment of the tram used to haul offcuts down the embankment into the ravine below. It was one of the many limestone mines operating in the area in the early to mid-twentieth century and retains scars that can attest to its history. A tram track associated with the mine, was pulled by horse a short distance to dispose of offcuts. As a component of the history of limestone mining in the region, this item has historical value. It is however, outside of the Project site but directly adjacent to the boundary.

MS10 is of *local* historical significance.

MS11 Camp site

This camp is an example of working life at the mine at the turn of the century. It is likely that this was a place that one or more miners resided while employed at one of the mines. It may demonstrate ingenuity and resilience in difficult economic situations and forms a part of the larger industrial landscape. The existence of the makeshift ramp adds another layer to the story that is embedded in this place.

MS11 is of *local* historical significance.

Table 5.1 Assessment of significance

MS12 Lime-kiln Road

Lime-kiln Road is the earlier former alignment of Marulan South Road that provided access to James Hogg's kilns and was a vital component of resource transportation. It is now a dirt track with lime kiln by-product on the slopes into the gully and is generally in poor condition.

MS12 is of *local* historical significance.

MS13 Frome Hill Road

An alignment of the road from South Marulan Road to the quarry at Mt Frome. The general alignment of the road has significance as the access road to the Mt Frome workings. It demonstrates the development of the area for its industrial purposes.

MS13 is of *local* historical significance.

b) ***An item has strong or special association with the life or works of a person, or group of persons of importance in NSW's (or the local area's) cultural or natural history (Associative Significance).***

MS01 Marulan South village

The former village of Marulan South is associated with the employees of the limestone mine since the 1920s but it is not associated with any individual or group of persons that would reach the threshold for associative significance.

MS01 does not fulfil criterion B.

MS02 – not used

MS03 House site

MS03 House site is on the boundary of James Hogg and George Feltham's land (Portion 144 and 156 respectively). The site is situated on the north side of a long drive, which may be the delineation between Hogg's (north) and Feltham's (south) land. As the house site has been recorded on the north side, it has been taken here to be on Hogg's land. The residents of this site are not known and are likely to have been mine workers.

MS03 does not fulfil criterion B.

MS04 Aerial ropeway system

The Aerial ropeway system, was an important but short-lived technological solution, and is associated with the Hogg bros., who were the descendants of James Hogg and who continued the business he started.

MS04 is of *local* associative significance.

MS05 Lime kiln group

The group of lime kilns in the south-west of the Project site were established by James Hogg, one of the earliest limestone operators in the area. James Hogg not only established the most successful limestone mine of its time, he was an individual of note who owned and funded limestone extraction in the region. Hogg also owned limestone kilns in Parramatta in which he burned limestone from his mines in Mudgee, Rockhampton, Melbourne and Geelong. Hogg has been described as putting 'Marulan and its lime on the map'.

MS05 is of *local* associative significance.

MS06 Explosives hut

MS06 does not fulfil criterion B.

MS07 Old Marulan South Road

The Old Marulan South Road serviced Hogg's lime kilns at Marulan South and appears to be the southern terminus of the road from Marulan. This road is associated with the early workings of the limestone mines but is also directly associated with James Hogg, who was instrumental in the early development of the limestone industry at Marulan South.

MS07 is of *local* associative significance.

Table 5.1 Assessment of significance

MS08 House site

This site has been associated with George and Elizabeth Feltham who were late nineteenth century limestone workers. Local knowledge has identified this site as the home of the Felthams but also of the Argyle school although there is no evidence to back up this second assertion. Between them George and Elizabeth Feltham owned a number of allotments in the Marulan and Marulan South area and later their sons also amassed land there.

The Felthams were a well-known and esteemed family in the region, with George being the son of John and Elizabeth Feltham who were early residents in the area.

MS08 is of *local* associative significance.

MS09 Camp

Camp MS09 is the former residence of the Armitt family who lived and worked at the limestone mines in the middle of the twentieth century. The camp was short-lived and the Armitts moved to Marulan South after the village was established.

MS09 does not fulfil criterion B.

MS10 Mt Frome mine group

The research conducted to date has not indicated that the item fulfils criterion B.

MS11 Camp

The research conducted to date has not indicated that the item fulfils criterion B.

MS12 Lime-kiln Road

The research conducted to date has not indicated that the item fulfils criterion B.

MS13 Frome Hill Road

The research conducted to date has not indicated that the item fulfils criterion B.

C) An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area) (Aesthetic Significance).

MS01 Marulan South village

What survives of Marulan South Village is standard urban design from the 1920s to the 1990s. Elements of aesthetic characteristics and creative achievement are not demonstrated here.

MS01 does not fulfil criterion C.

MS02 – Not used

MS03 House site

The site of MS03 is characterised by the creation of a road and areas of dumped early to mid-nineteenth century rubbish. It has the appearance of being a residential site with landscape modifications but nothing was noted that would indicate it has evidence of creative or technical achievement embodied in the site.

MS03 does not fulfil criterion C.

MS04 Aerial ropeway system

The evidence shows that the aerial ropeway was the third method of innovation used to transport lime to the railway by the Hogg family. The preceding methods being livestock and traction engine. The type of technology represented by this item had been in used for approximately 70 years by this stage. The aerial ropeway was a creative use of technology for the local area and was a major achievement for the industry at Marulan South.

MS04 is of *local* aesthetic significance.

MS05 Lime kiln group

The lime kiln group is indicative of the early stages of mining in the Marulan area. James Hogg established the kilns in the 1870s which his sons continued on with at least until early 1900s. The lime kilns were repaired and maintained over time while still retaining their core technical characteristics. This group of items shows evidence of two types of kiln but they are in a poor state of repair. The lime kiln group may have the ability to demonstrate technical achievement in the local area.

MS05 is of *local* aesthetic significance.

MS06 Explosives hut

MS06 does not fulfil criterion C.

Table 5.1 Assessment of significance

MS07 Old Marulan South Road
Old Marulan South Road is of standard road construction and a continuation, albeit a now-defunct alignment of the road from Marulan to the mines.
MS07 does not fulfil criterion C.
MS08 House site
This former house of George and Elizabeth Feltham has some technical interest due to its mid-nineteenth century vernacular construction of local materials. The house does not appear to demonstrate technological innovation but it is a visual (aesthetic) indication of settlement pattern around the mines.
MS08 does not fulfil criterion C.
MS09 Camp
MS09 camp does not fulfil criterion C
MS10 Mt Frome mine group
Mt Frome mine includes visual remnants of early industry in Marulan. Where much of the surrounding area was more successfully quarried, Mt Frome has been passed over. Therefore the remnants of tracks for early trams to be pulled plus the quarry scars demonstrates an early industrial landscape. The Mt Frome quarry is outside the Project site but directly adjacent to the boundary.
MS10 is of local a*esthetic* significance.
MS11 Camp
MS11 does not fulfil criterion C.
MS12 Lime-kiln Road
MS12 is a now unused extension of the former Marulan South Road. The road does not demonstrate technological achievement on its own rather it is representative of the larger limestone mining activities in the local area.
MS12 Lime-kiln Road does not fulfil criterion C.
MS13 Mt Frome Road
MS13 is a track that took traffic from the Marulan South Road to the mining area of Mt Frome.
MS13 Mt Frome Road does not fulfil criterion C.
MS14 House site
MS14 is the site of a former dwelling or camp that is identifiable by two exotic trees and surface modification using locally sourced stone. The modifications are horizontally substantial but further research (archaeological) is required to gain a clearer understanding of what the elements at MS14 represent.
MS14 House site does not fulfil criterion C.
d) An item has a strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons (Social Significance).
MS01 South Marulan village and hut (MS02)
South Marulan village itself is a direct result from a need by the mining community for facilities and homes near work. The location of the village was chosen because of its proximity to the mine. The village was moved in the 1990s and residents were interviewed prior to the move. Interviews with local residents indicate strongly that the village was an important place to the people that lived there as it was a small and close-knit community.
MS01 is of *local* significance to the former residents of the village.
MS02 – Not used
MS03 House site
MS03 House site is not associated with a particular group of people or community.
MS03 House site does not fulfil criterion D.

Table 5.1 Assessment of significance

MS04 Aerial ropeway system The installation of the aerial ropeway was an important achievement for mining operations at Marulan South and would have improved the working lives of the workers for a short time. However, the item is not associated with a particular group or community. While not associated with a specific group or community today, the installation of the aerial ropeway would have made life easier and safer for the workers at the mine and thus has a low level of social significance but does not meet the threshold. MS04 Aerial ropeway system does not fulfil criterion D.
MS05 Lime kiln group The lime kilns are an important indicator of the significance of the place and the solutions needed to exploit the resource. However, the item is not associated with a particular group or community. MS05 Lime kiln group does not fulfil criterion D.
MS06 Explosives hut MS06 Explosives hut is not associated with a particular group or community. MS06 Explosives hut does not fulfil criterion D.
MS07 Old Marulan South Road MS07 Old Marulan South Road is not associated with a particular group or community. MS07 Old Marulan South Road does not fulfil criterion D.
MS08 House site MS08 house site was the home of George and Elizabeth Feltham for an unknown period of time. While the Felthams were a well-known family in the area, the house and property were/are not of any community importance. MS08 House site does not fulfil criterion D.
MS09 Camp site MS09 was the abode of the Armitt family during the Depression before they moved to Marulan South. It is not associated with a particular group or community. MS09 Camp site does not fulfil criterion D.
MS10 Mt Frome mine group The MS10 Mt Frome mine components site is not associated with a particular group or community. MS10 Mt Frome Mine group does not fulfil criterion D.
MS11 Camp site MS11 Camp site is not associated with any particular group or community. MS11 Camp site does not fulfil criterion D.
MS12 Lime-kiln Road MS12 Camp site is not associated with any particular group or community. MS12 Camp site does not fulfil criterion D.
MS13 Mt Frome Road MS13 Camp site is not associated with any particular group or community. MS13 Camp site does not fulfil criterion D.
e) An item has the potential to yield information that will contribute to an understanding of NSW's (or the local area's) cultural or natural history (Research Significance)
MS01 Marulan South village and hut (MS02) The village of Marulan South was established in the late 1920s to house workers at the various mines, and their families. Prior to the village being officially created, there is the possibility that earlier buildings existed in the general location. The hut (MS02) is one such building. Field research on Marulan South village has the ability to yield information about the place as a residential space prior to the village being built. MS01 Marulan South village is of *local* research significance.
MS02 – not used

Table 5.1 Assessment of significance

MS03 House site

MS03 House site has been identified as a camp, suggesting that it was an area used by various individuals at different times. The identification of MS03 is currently fluid and is subject to change based on the outcomes of archaeological excavation and research assisted by the material to shed light on the function of this site.

This site and the other 'house' and 'camp' sites identified in this report are significant as a group for their potential to demonstrate the use of the landscape in the early to mid-twentieth century days of mining at Marulan South. This period and class of habitation site is not represented comprehensively in existing research and literature and has the potential to shed light on individual miners who may have been working their own mines, or who found temporary employment and established themselves in the region for short-term stays.

The information that may be inherent in the archaeological resources may shed light on a certain group of the working class including itinerant workers and entrepreneurs trying to build a business in the growing colony.

MS03 House site is of *local* research significance.

MS04 Aerial ropeway system

The Aerial ropeway system, consisting of remaining concrete plinths, two towers (one collapsed) and scattered carriers and wire rope, was a significant development in the transport of the resource to Marulan for further processing. Ropeway operation is well understood in general but the equipment at Marulan South was not well documented. The Aerial ropeway system has the potential to yield information about the transportation of material from the limestone mine to its nearest destination, particularly on methods use to overcome the steep and difficult landscape. Closer inspection of the bins and other components that are scattered across the alignment will contribute to knowledge about the origins and operations of the aerial ropeway.

MS04 Aerial ropeway system is of *local* research significance.

MS05 Lime kiln group

MS05 Lime kiln group has the potential to answer a number of questions directly related to their purpose, ownership, construction and relationship of the kilns to the surrounding landscape. Two types of kiln were recorded during fieldwork but their condition is poor and a definitive assessment of their type has not been possible. Archaeological excavation of the kilns and their curtilage is likely to contribute to knowledge on the points raised above. Photographic archival recording and measured drawings will also provide additional information on the kilns and their setting, how they related to each other and the surrounding industrial landscape.

Additional physical research is likely to yield information about the grading of the elements belonging to the group and the surrounding industrial landscape.

The lime kiln group is of *local* research significance.

MS06 Explosives hut

The Explosives hut is of interest as part of the industrial landscape in the vicinity of the kilns and the aerial ropeway. It is part of the mine operations and its inclusion in the history and archival recording will contribute to the overall understanding of this specific area and its contribution to the mine, but it is does not meet the threshold for local significance.

MS06 Explosives hut does not fulfil criterion E.

MS07 Old Marulan South Road

The Old Marulan South Road is a vestige of the road to Marulan South from the Hume Highway and signals an earlier area of activity that is related to mining and potentially to habitation in the area. The road was re-directed to service the village of Marulan South and the alignment that continued south was abandoned.

The abandoned road alignment is of interest for its ability to provide information about the destination prior to its re-direction. As an item in isolation it does not meet the threshold for local significance but as part of a group, the abandoned road alignment provides insight into access to the historic mine area and its phases.

MS07 Old Marulan South Road is of *local* research significance when considered as a group with the surrounding historical industrial landscape.

Table 5.1 Assessment of significance

MS08 House site

MS08 house site has the ability to provide information about life in the local area that was directly related to living and working adjacent to a mine. While the site displays levels of erosion, deposit survives within the ruins of the building and to the west.

The house was lived in by George and Elizabeth Feltham and their children until 1908 but the duration of their lives there is not understood. Archaeological research into this house and its curtilage has the potential to shed light on the family's life there, landscape modifications that were made to accommodate their lives, how they lived and information about the construction of the house. Additional questions exist about the place possibly being a school house that have not been answered by documents or oral history and answers related to this will also contribute to the understanding of what life was like when closely connected to the mine.

MS08 House site is of *local* research significance for its ability to yield information about life in an industrial landscape.

MS09 Camp site

MS09 has been identified as the home camp of Barry Armitt and his family. The site was a place of permanent residence for a time so would have been used as a homestead by the family for a period of time until they moved to Marulan South. This site is of interest as it has the potential to yield information about how a family would treat the semi-wild landscape so that life was possible there. Questions that relate to landscape modifications, spatial patterns and material culture would contribute to knowledge about how people lived in this unusual context. While this is a 'camp site' it functioned as more and the material left behind has the potential also to provide information about life during the Depression, adaptation to hardship, isolation and the human relationship to the landscape.

MS09 Camp site is of *local* research significance for its ability to yield information about life on the fringes of town.

MS10 Mt Frome Mine group

MS10 Mt Frome Mine group is of significance to the local area as one of many limestone mines that was operating at the cusp of the nineteenth/twentieth century. It retains elements that have the potential to yield information about early limestone mining that has since been lost with the expansion of the current mine and it provides an insight into what the historical landscape could have looked like prior to the amalgamation of the earlier mines into the larger Marulan South Boral operation. It retains the potential for interpretation as it is a rare and representative example of attempts at blasting and the use of horse drawn rails to transport product down the mountain.

MS10 Mt From Mine group is of *local* research significance.

MS11 Camp site

The camp site MS11 is of interest because very little about this site is known. Locally, it is known as a 'camp' and its association with the ramp-like structure suggests it is a workers' camp. However, little is known about this site other than it has evidence of early twentieth century rubbish. As a camp site that appears to be related to the limestone mine, it has the potential to provide information about working life at the mine in the early twentieth century and may date to an earlier period of prospecting.

Moreover, comparisons between this and other camp or house sites on the edges of the mine(s) may provide a wider picture of life in general and landscape modifications in an unusual setting.

MS11 Camp site is of *local* research significance for its ability to yield information about working life and life on the fringes of town.

MS12 Lime-kiln Road

MS12 Lime-kiln Road is the southernmost extension of the Marulan South Road and terminates at the lime kilns that James Hogg had built. As with the Old Marulan South Road, this item is of significance for its ability to provide information about the destination prior to its re-direction.

Lime-kiln Road is significant as an integral part of the lime kiln operations, for its ability to yield information about the transportation of the limestone resource in the local area and may provide insight into the use of the natural landscape to achieve the desired economic ends. This abandoned road alignment is also a vestige of an earlier version of the current industry and has the ability to demonstrate the evolution of the place.

MS12 Lime-kiln Road is of *local* research significance when considered as a group with the surrounding historical industrial landscape.

Table 5.1 Assessment of significance

MS13 Frome Hill Road

MS13 Frome Hill Road is a significant alignment as it services the Mt Frome industrial area. The road was not fully made and retains its early twentieth century form. Research on the Mt From Road has the potential to yield information about the importance of this road through its construction techniques, where other residences may have been placed and landscape modifications to accommodate larger, industrial vehicles.

This road is part of the larger industrial landscape in the local area and can shed light on the various access routes to the various mines that existed here historically.

MS13 Frome Hill Road is of *local* research significance for its ability to yield information about the development of the area as a mining interest.

f) An item possesses uncommon, rare or endangered aspects of NSW's (or the local area's) cultural or natural history (Rarity).

MS01 Marulan South village and hut (MS02)

Marulan South village was established in the late 1920s to accommodate workers at the various mines that were operating at the time. The village does not meet the criterion for rarity but if earlier buildings such as huts existed on the site prior to the village, these items may be considered rare at a local level.

MS01 does not fulfil criterion F.

MS02 – not used

MS03 House site

MS03 House site is one of at least five similar sites (house or camp) in the immediate area, which suggest that there may be other such sites that were not discovered during field survey or interviews with Boral employees. Considering that little is known about MS03 or other similar sites, rarity is not a value that can be definitively established but knowledge about fringe camps, itinerant workers and individual mine owners living on the edge of mine pits is rare.

MS03 House site is of *local* significance for its rarity value.

MS04 Aerial ropeway system

The Aerial ropeway system consisting of concrete plinths, two iron lattice towers (one collapsed; one intact) and a scattering of associated items are common industrial items but rare in the local area. Aerial ropeways were a common method for transporting material from mining quarries across undulating landscapes in the nineteenth century but there are few remaining examples in NSW. The Bleichert Ropeway at Katoomba is the most notable example but its wooden construction is different to the concrete and iron towers at Marulan South.

MS04 Aerial ropeway system is of *local* significance for its rarity value.

MS05 Lime kiln group

The lime kiln group is a vestige of the historical period of limestone mining in the region. It is likely that there were more kilns associated with the mine in the immediate area but only those reported in this document were found during field survey. These kilns are most likely to be those that are reported in the various media as belonging to James Hogg and are therefore the earliest recorded in the Marulan South area. If there were more kilns closer to the earlier mines, they will have been removed, thus making Hogg's kilns rare in the local area.

MS05 Lime kiln group is of *local* significance for its rarity value.

MS06 Explosives hut

MS06 Explosives hut is of modern, utilitarian construction.

MS06 Explosives hut does not fulfil criterion F.

MS07 Old Marulan South Road

MS07 Old Marulan South Road is a vestige of the original road servicing the Marulan South area and in particular the mines. As a former road, this alignment is not rare.

MS07 Old Marulan South Road does not fulfil criterion F.

Table 5.1 Assessment of significance

MS08 House site

MS08 House site is one of at least five similar sites (house or camp) in the immediate area, which suggest that there may be other such sites that were not discovered during field survey or interviews with Boral employees. Considering that little is known about MS08 or other similar sites, rarity is not a value that can be definitively established but knowledge about fringe camps, itinerant workers and individual mine owners living on the edge of a mine pit is rare.

MS08 House site is of *local* significance for its rarity value.

MS09 Camp site

MS09 Camp site is one of at least five similar sites (house or camp) in the immediate area, which suggest that there may be other such sites that were not discovered during field survey or interviews with Boral employees. Considering that little is known about MS09 or other similar sites, rarity is not a value that can be definitively established but knowledge about fringe camps, itinerant workers and individual mine owners living on the edge of their lease is rare.

MS09 Camp site is of *local* significance for its rarity value.

MS10 Mt Frome Mine group

The Mt Frome Mine group is rare at the local level for its ability to demonstrate small-scale historical mining enterprises as these physical marks have been left in the rock face. Little to no impacts have occurred on this site, except for the removal of some of the infrastructure. Areas with evidence of mining, particularly early blasting and horse drawn rails are rare in the local area.

MS10 Mt From Mine group is of *local* significance for its rarity value.

MS11 Camp site

MS11 Camp site is one of at least five similar sites (house or camp) in the immediate area, which suggest that there may be other such sites that were not discovered during field survey or interviews with Boral employees. Considering that little is known about MS11 or other similar sites, rarity is not a value that can be definitively established but knowledge about fringe camps, itinerant workers and individual mine owners living on the edge of their lease is rare.

MS11 Camp site is of *local* significance for its rarity value.

MS12 Lime Kiln Road

MS12 Lime Kiln Road a vestige of the original road servicing the Marulan South and at its terminus to the lime kilns and the mines. As a former road, this alignment is not rare but it is a part of a larger industrial landscape that is disappearing through the continuation of the operations that created it. Lime Kiln Road is a rare vestige of the historic lime extraction industry in the local area.

MS12 is rare at a *local* level.

MS13 Frome Hill Road

MS13 Mount Frome Road is an early alignment of a road servicing the southern limestone mine of Mt Frome from Marulan South Road. As with all early roads identified in this report, it is not rare in that its type is represented by other unsealed country roads.

MS07 Frome Hill Road does not fulfil criterion F.

g) An item is important in demonstrating the principle characteristics of a class of NSW's (or the local area's), cultural or natural places or environments (Representativeness).

MS01 Marulan South village and hut (MS02)

MS01 Marulan South village does not fulfil criterion G

MS02 – not used

MS03 House site

Information to support significance under this criterion would be gathered through archaeological excavation.

MS04 Aerial ropeway system

The Marulan South aerial ropeway is representative of a concrete and iron aerial ropeway. It has examples of all the relevant components including the pulley tower, buckets, plinths and cables.

MS04 Aerial ropeway system is of *local* representative significance.

Table 5.1 Assessment of significance

MS05 Lime kiln group The lime kiln group is in poor condition and is missing many of its representative elements. More complete examples exist in other areas of NSW including at Piper's Creek in Kumbatine National Park, the Moses Morley burning kiln at 501 Cooma Rd, Googong, NSW and the Kingsdale Line Kilns in the Southern Tablelands. As individual items, the lime kilns do not meet the threshold for demonstrating a principal characteristic of lime kilns but as a group, set into the edge of a drop, the lime kiln group represent a historic lime processing area, specifically from an archaeological perspective. MS05 Lime kiln group is of *local* representative significance.
MS06 Explosives hut MS06 is a modern example of a concrete-block (Besser) storage hut. MS06 Explosives hut does not fulfil criterion G.
MS07 Old Marulan South Road MS07 Old Marulan South Road is a standard road alignment. It represents many such roads and is an improvement of the earlier road to the lime kilns. MS07 Old Marula South Road does not fulfil criterion G.
MS08 House site MS08 House site is the former residence of George and Elizabeth Feltham, who lived by the mine for a number of years and raised their family there for a time. The house, constructed of local stone and mortar is a vernacular structure; the surrounding landscape modifications represent attempts to create a home environment in the remote Australian landscape. MS08 House site is of *local* representative significance.
MS09 Camp site Little surface evidence survives from the occupation of this site. It may have representative value as an archaeological resource and as a site used to house a family and the modifications made to create a home environment in the remote Australian landscape. MS09 Camp site may be of *local* representative significance.
MS10 Mt Frome Mine group Mt Frome is representative of the ways in which mining was conducted in the Marulan area during the nineteenth century. MS10 Mt Frome Mine group is of *local* representative significance.
MS11 Camp site The surface evidence that survives at this site does not provide a clear indication of its origins. It may have representative value as an archaeological resource. MS09 Camp site may be of *local* representative significance.
MS12 Lime Kiln Road As a vestige of the earlier road network into the mining area, and particularly to the lime kilns, MS12 Lime Kiln Road has representative significance as an early industrial road. It may have elements in its construction, identifiable through archaeological excavation, that identify it clearly as an industrial road. MS12 Lime Kiln Road is of *local* representative significance.
MS13 Frome Hill Road As a vestige of the earlier road network into the mining area, and particularly to the lime kilns, MS13 Frome Hill Road has minor representative value as an early industrial road but does not meet the threshold for significance. MS13 Frome Hill Road does not fulfil criterion G.

5.4 Statements of significance

5.4.1 Overview

The following section presents the statements of significance for each historic item identified during the research and survey phase of the Project.

Evidence that any of the sites recorded within the Project boundary are of State significance was not found. However, the level of *local* significance must be considered in view of the entire landscape and the cumulative significance of the component parts. The archaeological resource is significant as it has the potential to demonstrate changes and adaptations of the pre-colonial ground to a landscape that was industrial and residential in nature. The spatial relationships of the sites, industrial and residential, to each other and the internal arrangements of each has the potential to shed light on the phasing and use of the landscape by the people that worked and lived there. As a result, the level of local significance of each item should be viewed as a cumulative high level of significance for the local area.

5.4.2 MS01 Marulan South (village)

The former village of Marulan South is of local significance for the esteem in which it is held by the former residents. The town of Marulan South represents a time of great joy and strong community bonds continuing beyond the removal of the buildings and the closure of the town. The former village also possesses research potential as it may retain evidence of earlier occupation there that is not visible in the ground or through documentary sources.

5.4.3 MS02

Refer to MS01

5.4.4 MS03 House site

MS03 House site is of local significance for its historical significance that also embodies rare surviving elements of domestic structures in close proximity to an industrial area. This site also possesses research value for its potential to answer questions that no other source can about life on the fringes of an industrial site and its relationship to the surrounding cultural landscape.

5.4.5 MS04 Aerial ropeway

The aerial ropeway at Marulan South is of local heritage significance for its ability to contribute to the historical understanding of mining processes at Marulan South in the nineteenth and twentieth centuries. It provides insight into the workings of the mine as a whole, and how the elements of the mine, lime kiln group, ropeway, roads and railway fitted together. There is research potential in locating the techniques and infrastructure within a global context, specifically the technologies that were adopted from Europe such as the pulley system. It is of social significance as a landmark in the local area, particularly for the employees of the mine. Aerial ropeways were a common method for transporting material from mining operations across undulating landscapes in the nineteenth century but there are few remaining examples in NSW, as such the Marulan South aerial ropeway is a rare, representative example of this type of mining technique.

5.4.6 MS05 Lime kiln group

The lime kiln group at Marulan South consists of five kilns and associated landscape modifications. The group is of local historical and research significance for its ability to contribute information about the development of a local industry and the mine of Marulan South. Despite its poor condition the lime kiln group is rare in the local area and has the potential to provide information on the construction and operation of lime kilns in the Southern Tablelands.

5.4.7 MS06 Explosives hut

This item does not possess heritage significance.

5.4.8 MS07 Old Marulan South Road

The blocked-off alignment of Old Marulan South Road is of local historical significance as a surviving element of the access network into the earlier mines. It has landscape value for its ability to allow interpretation of the earlier road networks associated with the local industry.

5.4.9 MS08 House site

MS08 House site if of local significance for its historical, representative and rarity values. It also has research potential as an archaeological site and as a modified landscape that is a residential component of a larger industrial landscape that surrounds it. Built using vernacular construction techniques and local materials, the site is of local historical significance for its ability to contribute to our understanding of the building techniques and materials used to construct houses in the local area. It is rare in the local area and is a representative example of vernacular buildings with the potential to provide research opportunities on construction methods.

5.4.10 MS09 Camp site

MS09 Camp site is of local significance for its historical values and research potential. It has the ability to provide insights into the arrangement of structures in the immediate area and on a broader scale when compared to other such sites. It also has the potential to reveal aspects of life in a semi-permanent camp. It is also of significance to the Armitt family, who lived at the camp as children, with their parents.

5.4.11 MS10 Mt Frome Mine group

The Mt From mine group is of local heritage significance for its ability to provide information on the early mining operations in the Marulan area. It provides a rare and representative example of attempts at blasting and the use of horse-drawn rails to transport product down the mountain.

5.4.12 MS11 Camp

The ephemeral camps are of local historical significance for their ability to contribute to our understanding of the relationship between workers and the mine and changes made to the natural landscape to make life a possibility in a remote location and at the edge of a mine pit. Their locations may provide information on the ways the landscape was used by workers.

5.4.13 MS12 Lime-Kiln Road

Lime-Kiln Road is of local significance for its historical values and rarity in the local area. Originally part of the original Lime-Kiln Road (now Marulan South Road), it gave access to the lime kilns and an early section of the mine. It is a surviving remnant of one of the earliest roads into Marulan South.

5.4.14 MS13 Frome Hill Road

Frome Hill Road is of local historical significance for its ability to contribute to knowledge about the development of the area and associated mining operations. This road provides access from Marulan South Road and is where one of the camps, MS08, was located and is therefore an early road to the mines. It is rare in the local context and also representative of early attempts to access the limestone resource.

5.4.15 MS14 House site

MS14 house site is a built and archaeological site with local historical significance and research potential as an example of the landscape modifications and building techniques used to create a home environment in the Australian landscape. It is a rare and representative example of vernacular buildings in the area and has the potential to provide research information on construction methods.

5.4.16 Bungonia National Park

The Bungonia National Park is adjacent to the Project site.

The Bungonia National Park is an item of local heritage significance for its ability to represent the geology of the local area and as a large natural landscape. The Lookdown lookout within the National Park highlights these qualities. As a recreational area it also has social significance to the local and wider community.

5.4.17 Glenrock Homestead and Outbuildings

Glenrock Homestead and Outbuildings is in the vicinity of the Project site.

George Barber began purchasing land in the Marulan district from around 1835 including an allotment of 800 acres that he named “Glenrock”. While the size of the original property has shrunk, today the listed component of the property includes the homestead and surrounding outbuildings.

Glenrock Homestead and Outbuildings is a good example of a Georgian style country home, particular the facade which is of aesthetic significance as a good example of Georgian stonework. Glenrock Estate and its early owners are of historical and associative significance for their contribution to the understanding of the history of the area and the connection to George Barber and Isabella Hume. The item is listed on the *Goulburn Mulwaree LEP*.

6 Impact assessment

6.1 Sources of development impact

The following ground disturbance activities have the potential to impact known and unknown historic heritage items in the Project site:

- the construction of Project infrastructure including haul roads, expansion of the pit, and realignment of Marulan South Road;
- the construction of the Marulan Creek Dam wall and associated inundation of Marulan Creek; and
- the covering of areas by overburden emplacements.

Heritage items of historical value were identified in the southern section of the Project site, that is, the location of the limestone mine. No historical heritage items or potential heritage items were identified, either through survey or documentary research, at the proposed Marulan Creek Dam site or within the area connecting the mine and the dam.

All identified historical heritage items and how they are affected are listed below. A summary of heritage items and management measures is presented in Table 7.1.

Items that are within the disturbance footprint are:

- the majority of MS04 Aerial ropeway system;
- MS05 lime kiln group;
- MS07 Old Marulan South Road (now blocked);
- MS03 camp;
- MS09 camp;
- MS13 Frome Hill Road (small section of the alignment);
- MS12 Lime Kiln Road (vestigial terminus of the original road from Marulan).

Sites identified in this report located within the Project boundary but outside the impact footprint are:

- MS01 (Marulan South village);
- two plinths belonging to the aerial ropeway (MS04_10 and MS04_3);
- the modern control room belonging to the aerial ropeway (MS04_11);
- MS08 (former house site);
- MS11 (camp with ramp);
- a large section of the alignment of MS13 (Frome Hill Road); and

- MS14 (former house site).

Items of heritage value, either listed or recently identified that are in the vicinity of the Project boundary will not be physically impacted. These items are:

- Glenrock Homestead (314 on the Goulburn Mulwaree LEP).
- MS10 Mt Frome Mine (unlisted); and
- Bungonia National Park (I027 on the Goulburn Mulwaree LEP as the Bungonia State Recreation Area).

6.1.1 MS01 Marulan South village

i Impact type

The former village will be avoided by new impacts.

ii Have all options for retention and adaptive re-use been explored?

Options for retention or adaptive re-use have not been considered as the location of the resource precludes moving to another location. The area of the former village will remain as the administrative centre of the mine operations. A small dam will be built to the east of the former village footprint. Impacts to this component of the historical landscape can be managed through archival recording using photography and existing documentary information such as interviews with former residents.

iii Can all of the significant elements of the heritage item be kept and any new development be located elsewhere on the site?

Impacts to the former village will be avoided and the area will continue to operate as the mine administrative centre.

iv Is demolition essential at this time or can it be postponed in case future circumstances make its retention and conservation more feasible?

Not applicable.

v Has the advice of a heritage consultant been sought? Have the consultant's recommendations been implemented? If not, why not?

Qualified heritage consultants have prepared this statement of heritage impact. As noted above, the Project is constrained by the limestone resource in the area and Project elements have aimed to reduce impacts on all environmental values wherever possible. Archival recording will ensure that information is gathered and retained for posterity and will be a legacy of the Project and the lives of the former community. The recommendations will be implemented to record the former village as it is now.

6.1.2 MS05 Lime kiln group

i Impact type

The lime kiln group is located within the proposed 30 year mine pit disturbance footprint. The development will result in the removal of all the identified lime kilns and their curtilage, which includes Lime-Kiln Road, the rock-face into which they are built and the associated ramps.

ii Have all options for retention and adaptive re-use been explored?

The lime kiln group is not in a state for adaptive reuse to be possible unless restoration is an option. The group has had many of its component parts destroyed or removed with the passing of time and not enough remains for reuse. The kilns themselves are outdated technology, which while providing historical information cannot be reintegrated into the current mining system. They are also on private property and not accessible by the public; interpretation is also not a feasible option.

Retention was considered but the location of the group in relation to the limestone resource does not allow for this.

iii Can all of the significant elements of the heritage item be kept and any new development be located elsewhere on the site?

The Project is constrained by the location of the limestone resource in the area. Therefore the location of the mine pit, overburden emplacements, haul roads and other mining infrastructure is guided by the location of the limestone resource. The proposed location and design of the mine pit, infrastructure and overburden emplacements have been carefully considered to reach a balance between impacts on all relevant environmental values while allowing for the economically viable extraction and processing of the limestone resource now and into the future. The proposed 30 year mine pit, which impacts on the lime kiln group, has been designed to provide 30 years of limestone resource, while limiting the disturbance footprint of the pit and avoiding mining the southern rim of the existing pit, to reduce long term visual impacts from the Bungonia Lookdown. The proposed 30 year pit design is considered by Boral to be the optimal design and therefore altering the disturbance footprint associated with this 30 year pit to avoid the lime kiln group is not feasible.

iv Is demolition essential at this time or can it be postponed in case future circumstances make its retention and conservation more feasible?

Timing of the removal of the lime kiln group will be based on the mining schedule. While demolition is only likely to take place within Stage 2 of the 30 year continued operations (after the first five years – refer to the EIS prepared by Element Environment 2018), it cannot be prevented and when operations reach their location the group will be removed.

v Is the development sited on any known, or potentially significant archaeological deposits? If so, have alternative sites been considered? Why were they rejected?

It is likely that the area of the lime kiln group has archaeological sensitivity, which has been considered in the assessment of impacts and the management measures. The preferred measure from a heritage perspective is to retain the topography on which the kilns and the surviving alignment of Lime Kiln Road are situated. The option of retention has been investigated but it is not possible because of the location and depths of the resource. As retention is not possible, archival recording in the form of archaeological excavation, photographic recording and topographical recording will be undertaken.

vi Has the advice of a heritage consultant been sought? Have the consultant's recommendations been implemented? If not, why not?

Qualified heritage consultants have prepared this statement of heritage impact. As noted above, the Project is constrained by the limestone resource in the area and Project elements have aimed to reduce impacts on all environmental values wherever possible. Due to the impact of the lime kiln group, recommendations for archival recording including all components and archaeological excavation of a representative kiln, prior to the development impacts, are made in Section 7. Archival recording will ensure that information from the lime kiln group is gathered to contribute to the understanding of early mining operations throughout the area. The recommendations will be implemented progressively as impacts are proposed to the area and will form part of the mitigation measures for the Project.

6.1.3 MS04 Aerial ropeway system

i Impact type

The majority of the aerial ropeway system will be impacted by the mine pit and Western Overburden Emplacement. The elements that will not be impacted are not significant in isolation.

ii Have all options for retention and adaptive re-use been explored?

Portions of the aerial ropeway will be retained, including the modern engine room, and a complete concrete plinth. Buckets located outside the mine disturbance area will also be avoided. These elements will remain *in situ* as a reminder of this historical technology in its original setting.

The elements that will be removed include some concrete plinths, some wire rope and the standing and collapsed pulley towers. Options for retention of these items were explored, however due to the location of the current mine and the limestone resource the Project impacts cannot be avoided in these locations. Options for adaptive reuse or removal were explored, however the aerial ropeway elements are large and difficult to move in the steep terrain of the Project site and moving the structure out of its industrial and landscape context would diminish its interpretive value considerably. Additionally, the aerial ropeway cannot be adaptively reused as it is outdated technology and is in poor condition. However, the archival recording of the aerial ropeway will ensure a complete record of the technology will be made to contribute to our understanding of this type of transport system and its place in history.

iii Can all of the significant elements of the heritage item be kept and any new development be located elsewhere on the site?

The Project is constrained by the limestone resource in the area. As noted above, the location of the pit, overburden emplacements, haul roads and other mining infrastructure is guided by the location of the limestone resource. The proposed location and design of the mine pit, infrastructure and overburden emplacements has been carefully considered to reach a balance between impacts on all relevant environmental values, while allowing for the economically viable extraction and processing of the limestone resource now, and into the future. The 30 year mine has been designed to most efficiently extract the limestone resource and minimise the amount of overburden material, while not mining the southern rim of the pit and limiting the height of the overburden emplacements to reduce long term visual impacts. The current design is considered to be optimal and it is preferential not to alter the disturbance footprints associated with the Project to avoid a portion of the aerial ropeway.

iv Is demolition essential at this time or can it be postponed in case future circumstances make its retention and conservation more feasible?

Only those portions of the aerial ropeway impacted by the Project will be removed and the removal of those elements of the aerial ropeway will be based on the mining schedule.

The elements of the system that will be retained include the engine room, one concrete plinth and some carriers. Other bins in the field may be able to be retrieved depending on the ruggedness of the surrounding topography.

v Has the advice of a heritage consultant been sought? Have the consultant's recommendations been implemented? If not, why not?

Qualified heritage consultants have prepared this statement of heritage impact. As noted above, the Project is constrained by the limestone resource in the area and the 30 year mine plan has aimed to reduce impacts on all environmental values wherever possible. Due to the impacts on portions of the aerial ropeway, a recommendation for archival recording of the aerial ropeway is made in Section 7, with photographs and measured drawing of selected elements and a plan of the ropeway. Archival recording will ensure that information from the aerial ropeway is gathered and retained even though portions of the aerial ropeway will be removed. This will also ensure that as close to a complete record of the current aerial ropeway is obtained before components are removed and will contribute to the understanding of early mining operations throughout the area. The recommendations will be implemented progressively as impacts are proposed to the area and will form part of the mitigation measures for the Project.

6.1.4 MS03 and MS09 Former house and camp sites

i Impact type

Impacts differ across the site with two sites (MS03 and MS09) being fully within the impact footprint. These sites are within the 30 year mine pit. All other former house and camp sites will be partially impacted or avoided completely as described:

- Total impact: MS03, MS09.
- Partial impacts: zero;
- No impacts: MS08, MS11 and MS14 (house and camp sites).

ii How is the impact of the new development on the heritage significance of the item or area to be minimised?

Recommendations have been provided in Section 7 with the aim of minimising impacts to the former house and camp sites by recording the elements of each site and their position in the landscape.

iii How does the new development affect views to, and from, the heritage item? What has been done to minimise negative effects?

The former house and camp sites that will be retained will be within view of the mine pit and the overburden emplacements. Views to the mining operations are acceptable in the historical context as these sites were lived at and used by those working in the industry. These sites exist here because the mine exists here.

iv Is the development sited on any known, or potentially significant archaeological deposits? If so, have alternative sites been considered? Why were they rejected?

All the house and camp sites have archaeological potential although deposits may not be deep. One of the most important areas of research from an archaeological perspective is that of the spatial arrangement of the habitation sites on an individual and collective scale. The sites that will be destroyed cannot be avoided because of the location of the limestone resource.

v Will the additions visually dominate the heritage item? How has this been minimised?

Additions in this context have been defined as overburden emplacements and views to the mine pit. These changes to the landscape directly around the former house and camp sites are acceptable as the landscape context has always been an industrial, mine-focused one. These sites exist because the mine exists.

vi Will the public and users of the item, still be able to view and appreciate its significance?

The public is currently unable to view any of these sites as they are on Boral land and close to the active mining operations. This situation is unlikely to change.

6.1.5 MS07, MS12 and MS13 Roads

The Old Marulan South Road (MS07), the Lime-Kiln Road (MS12) and the Frome Hill Road (MS13) are all remnants of the historic mining activities that developed into the enterprise it is today. While as a group, with each other as well as with the other historic elements in the landscape, the roads have the ability to demonstrate transport processes and different phases of the mining activities, their research potential and historical significance can be captured through archival recording in photographic format and by mapping their locations.

6.1.6 MS10 Mt Frome

The mining area at Mt Frome will not be impacted by the Project. It is located against the Project boundary which is approximately 200 m from the closest disturbance footprint associated with the Project.

6.1.7 Bungonia National Park

i Impact type

While Bungonia National Park was not re-assessed for significance in this report, it is included here because of its proximity to the Project.

The mine is currently and will remain, visible from the Bungonia Lookdown. Physical impacts to the recreation area and the national park are not anticipated. The mine, including the southern extent of the Project site (the South Pit) has been part of the landscape for over a century. The Project will therefore not result in any new or more significant impacts, closer to this heritage item, than have already occurred during historic mining operations.

ii How is the impact of the new development on the heritage significance of the item or area to be minimised?

As the Project progresses, the existing South Pit will start to be backfilled with overburden. Once the overburden emplacement extends above the current rim of the South Pit, the emplacement with start to screen the remainder of the mine void located to the north. The embankments of the Southern Overburden Emplacement will be progressively revegetated, blending the emplacement into the surrounding bushland and reducing the visual impact of the mine over time. This will minimise the impact of the Project on the Bungonia Recreational Area and Bungonia National Park (refer to RLA 2018 and Plate 3.41)

iii Why is the new development required to be adjacent to a heritage item?

iv How does the curtilage allowed around the heritage item contribute to the retention of its heritage significance?

The Bungonia National Park will remain a large protected park with good natural examples of the geology of the area. The mine is currently most visible from one area; the Bungonia Lookdown. The national park will retain its context and the visibility of the mine from the Lookdown lookout will not increase significantly, but is likely to improve over time with the backfilling of the South Pit with overburden and the revegetation of newly formed embankments with locally occurring native vegetation. Visitors will be able to enjoy all currently accessible areas of the Bungonia National Park.

v How does the new development affect views to, and from, the heritage item? What has been done to minimise negative effects?

The site is visible from the Bungonia National Park, particularly the Lookdown, one of the many lookouts available for visitors. As outlined above, the visibility of the mine from the Lookdown lookout will not increase significantly, but is likely to improve over time with the backfilling of the South Pit with overburden and the revegetation of newly formed embankments with locally occurring native vegetation.

vi Is the new development sympathetic to the heritage item? In what way (e.g. form, siting, proportions, design)?

The new development does not represent a dramatic change to the current view from the Lookdown the conservation area or the national park. Views from the Bungonia Lookdown can be considered intrusive to the dramatic bushland setting but they are also a part of historical mining operations. The Project will not represent a significant change to the views. The emplacements have been designed to have a minimal impact on the surrounding environment and will be revegetated, which will gradually reduce visibility to the mine.

vii Will the public, and users of the item, still be able to view and appreciate its significance?

The public will retain full access to the Bungonia National Park and be able to view and appreciate the natural environment throughout. It is understood that interpretive boards are placed at the lookdown that explain the mining operations.

6.1.8 Glenrock Homestead

Glenrock Homestead was not re-assessed for significance as it is a sufficient distance from the Project to be avoided by any new impacts. It is located more than 2 km from substantial Project impacts at the northern extent of the Project site.

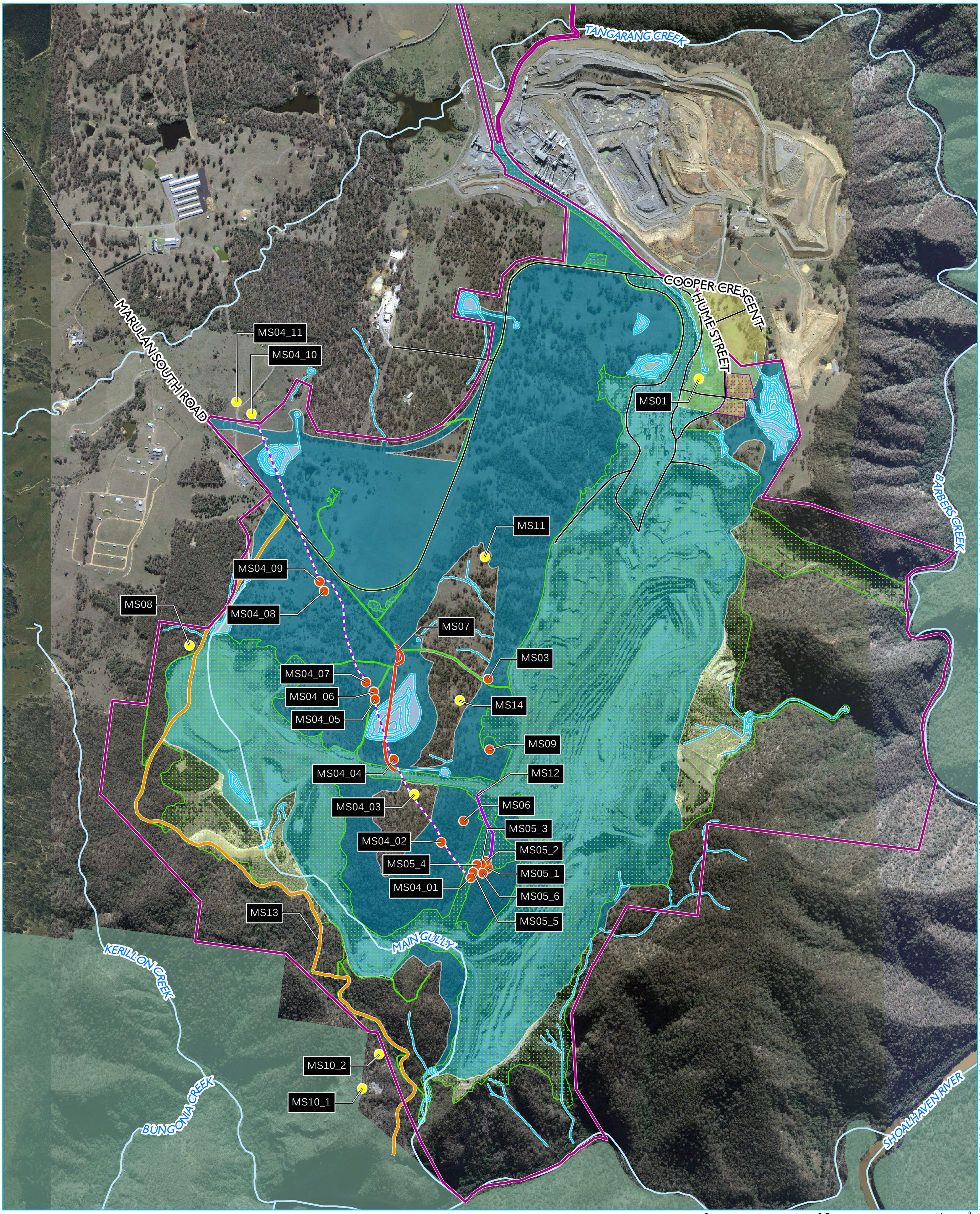
6.1.9 Visual impacts

A visual analysis was undertaken by Richard Lamb and Associates (RLA 2018). RLA assessed the impact to Bungonia National Park at the Lookdown, Morton National Park and the Bungonia State Conservation Area and determined that while there will be some residual impacts these will be mitigated through the management measures outlined in the visual impact assessment report.

6.1.10 Cumulative impacts

The cumulative impacts to the historic industrial landscape are high as almost all items discovered during field survey will be removed by the Project. The current landscape is of a mixed industrial and residential nature and is rare in the local context. It is also situated in such a way as not to be visible to those working away from the immediate vicinity. The loss of this type of landscape is probably common due to its conceptual invisibility when compared to landscapes created by activities such as gold mining and wealthy pastoral pursuits. The humble remnants of working life, labouring on the edge of a mine and where striking it rich was never an option, is not generally visible and therefore not as valued as the 'big' remnants of the past. The significance of this historic landscape and the continuation of the activities that created it, approximately one hundred and fifty years ago, lends an irony to the concept of minimising harm and retaining where possible.

One of the most valuable aspects of the collective sites however, is research potential, the Project will provide an opportunity to record all aspects and therefore a springboard for more research to answer questions posed throughout this report.



\\emmsvr1\EMM\Jobs\2014\J14107 - Marulan Limestone Mine Heritage\GIS\02_Maps\MS008_HistoricHeritageItemsInProjectArea_20180810_24.mxd 10/08/2018

Source: EMM (2018); DFSI (2017); LPMA (2011)

0 0.5 1 km

GDA 1994 MGA Zone 56

N

KEY

- Approximate pathway of aerial ropeway
- Proposed dam location
- Project boundary

Site impact

- No impact
- Total impact
- Frome Hill Road
- Lime-kiln Road
- Old Marulan South Road
- Road
- Watercourse
- Marulan South village
- Historical disturbance footprint (pre -SSD)
- Project (SSD) disturbance footprint
- Additional historic area of disturbance (pre -SSD)
- Proposed dam location

Project impacts

Marulan South Continued Operations Project

Historical heritage assessment and SoHI

Figure 6.1

EMM

7 Conclusion and recommendations

7.1 Conclusion

Management measures including site and landscape-specific actions are summarised in the Table 7.1. They have been developed to extract information about the industrial/residential landscape inside the Project site before it is both removed (where it will be removed), and during the window of opportunity presented by the Project application and approval process. It is anticipated that the data to be extracted will be useful for future research related to spatial analysis, comparative analysis and will provide an understanding of the material culture created by nineteenth and early twentieth century miners. This is how the Project aims to create opportunities for research and learning on the themes identified in this report.

This section describes the measures to manage the historical heritage values in the Project site that have the potential to be affected by the Project. The management measures have been developed to respond to the specific requirements of the Project. They are:

- the significance of the sites and their spatial relationship to each other;
- the proposed impacts to the sites;
- the need to mitigate against the loss of information by recording sites before they are destroyed; and
- the need to protect sites that will not be impacted by the Project but remain under the care of Boral.

The historic heritage assessment identified eleven items of historic heritage significance in or within 20 m of the Project site (MS06 is not a heritage item). Those items are:

- MS01: Marulan South village.
  - This item will not be impacted by the Project. A small dam will be built directly to the east.
- MS02: deleted.
- MS03: Hut/camp site. This item is characterised by collapsed structures of locally sourced stone, some of which has been bonded by mortar.
  - This item will be impacted by the Project.
- MS04: Elements of the aerial ropeway system that historically operated on the Project site include concrete plinths in groups of four, used for holding up the pulley towers, two pulley towers, metal buckets and steel cables.
  - The majority of this item will be impacted by the Project; the only element of this aerial ropeway in the Project site that will not be impacted is MS04_3.
- MS05: A lime kiln group of five kilns in two areas was identified in the southern part of the 30 year mine pit. The site consisted of D-type kilns and associated bricks, earthworks, wooden beams and stones with evidence of firing and burning. The lime burning complex includes the Lime-kiln Road (MS12) that was an extension of the Marulan South Road to the kilns and areas where glass, ceramic and metal have been dumped.

- This item will be impacted by the Project.

- MS07: Old Marulan South Road, which is an earlier alignment of the Marulan South Road (formerly the Lime-Kiln Road) connecting Marulan and the Hume Highway to Marulan South.
  - This item will be impacted by the Project.

- MS08: House site. This structure was identified in previous assessments as a house probably built and occupied in the late nineteenth and early twentieth centuries by George and Elizabeth Feltham. The structure is rectangular and built of local stone and mortar. The roof is missing and walls are in varying states of disrepair.
  - This item will not be impacted by the Project.

- MS09: Camp site.
  - This item will be impacted by the Project.

- MS11: Camp site, consisting of landscape modifications with ramp, suggesting either a residential camp or a temporary workers' camp.
  - This item will not be impacted by the Project.

- MS12: Lime-kiln Road, so called in this report because it is a vestige of the original road from Marulan to South Marulan and has been unused for a number of years. This road serviced the kilns (MS05) but went out of use when the kilns were no longer required.
  - This item will be impacted by the Project.

- MS13: Frome Hill Road.
  - This item will be partially impacted to the west where it diverges from the Marulan South Road but a considerable length will be avoided.

- MS14: House site, consisting of the elements of a structure, possibly a house consisting of a flat area of ground overlooking a dam and ephemeral creek line. The area contained evidence of landscape modification in the form of rock structures, fences and exotic trees (possibly quince trees). A dump of glass, ceramics and metal was also evident. The remains of a chimney were also identified and the area has the potential to contain relics.
  - This site will not be impacted by the Project.

One feature that is not a heritage item was identified for archival recording and topographic survey due to its relationship to the mining process and proximity to the Lime-kiln group and Aerial ropeway:

- MS06: Modern explosives hut – no heritage significance.
  - This item will be impacted by the Project.

Management recommendations for historic heritage items located within or in proximity to the Project are contained in Section 7.2 below. MS06 the modern explosives hut is included for mitigation because as it is a part of the current industrial landscape. Table 7.1 presents a summary of impacts and management measures.

7.2 Measures to minimise harm and alternatives

The Project is constrained by the nature of the limestone resource in this area and the angle of the resource in the ground. The removal of large amounts of overburden and interburden is necessary to access the resource, which does not allow a large amount of movement in the location of the mine across the landscape. The impacts identified in this report are therefore necessary for the Project to proceed.

Project elements have been designed to accommodate environmental considerations including historic heritage, Aboriginal heritage, ecology, noise and visual amenity. Each design element has been investigated to ensure it provides an optimal design which balances as many environmental considerations as possible. This has resulted in avoidance of some historic heritage items as well as minimising of impacts to other areas of historic heritage.

The management measures proposed in this report aim to retain as much of the modified landscape as possible so that its research potential and interpretability are not removed. There is no opportunity to alter the mine footprint but the recommendations for retention (Section 7.3.1) have been made in the event that an opportunity presents itself during future detailed mine planning.

The following statements of heritage impact have been prepared using the Heritage Office guidelines *Statements of Heritage Impact: A model* (Heritage Office and Department of Urban Affairs & Planning 1996, revised 2002). It has been prepared using the current disturbance footprint.

7.3 Management of impacts

7.3.1 Avoidance of impacts to areas of significance

The location of the limestone resource precludes the retention of the industrial landscape values associated with historical mining activities as described below. While retention through project modification is the preferred option, this approach is not possible on the Project. This measure to avoid impacts should be applied if the Project impacts change.

A group of items has been identified at the southern end of the site that are worthy of retention for their industrial landscape values (Figure 7.1). This area contains the following items:

- MS04 Aerial ropeway system;
- MS05 Lime kiln group; and
- MS12 Lime Kiln Road (surviving remnant).

Where avoidance and retention is not possible, the following management measures set out in Section 7.3.2 apply.

7.3.2 Apply appropriate management measures

The management measures below have been developed to acquire as much knowledge as possible before the archaeological resources and the historic landscape is impacted by the Project. The outcomes of the management measures will be to provide baseline data for further research, particularly for comparative analyses in future studies.

i Photographic archival recording

Archival recording compiles information about the technical, environmental, historical and aesthetic information from heritage items for future generations.

The standards of the Heritage Council's *How to Prepare Archival Records of Heritage Items* (1998) and *Photographic Recording of Heritage Items Using Film or Digital Capture* (2006) should be used as the guiding documents. Additional research on the ownership and operation of the aerial ropeway is considered a part of this archival recording.

A photographic archival recording will be created of:

- representative features of the aerial ropeway including the engine room prior to any impacts on the pulley system. That is, at least one pulley tower, an example of the cable, one set of tower plinths and one of each type of carrier. The report must also include the survey plan of the entire aerial ropeway;
- the pre-emplacement landscape of the Feltham's house MS08 (including the house ruins);
- any archaeological excavation prior to and during the excavation process; and
- the camp landscapes that will be impacted by the Project.

ii Archaeological recording of all identified items in the Project site

Archaeological recording of the landscape will be undertaken post-approval including:

- recording of all identified items with the use of topographic survey so their relative location, elements and orientation can be mapped;
- archaeological excavation of representative structures of the lime kiln group (M05) prior to its removal; and
- archaeological excavation of a sample of camp site MS03.

Any archaeological investigation involving excavation will be guided by a research design with relevant questions and other supporting information.

iii Fence and signpost

Heritage items within 20 m of the Project disturbance footprint will be avoided through measures to make them visible. This will require the installation of treated timber poles, or similar, painted with high visibility paint around the visible extent of the sites with an approximate 5 m buffer from the edge of visible site fabric. A suitably qualified archaeologist will demarcate site locations and where the poles should be erected.

A suitably durable sign will be attached to the posts including words to the effect of:

"Environmentally sensitive area; do not disturb; contact the Mine Manager for more information". The location of historic heritage items that are not to be impacted by the Project will be identified in the historic heritage management plan (discussed below) and will be included in induction and training procedures.

iv Moveable heritage

Items of moveable heritage should be retrieved before impact and stored in a suitable location on the Marulan South Limestone Mine site. Only one class of heritage item has been identified for removal being the metal buckets used in the aerial ropeway system.

Other items of moveable heritage were not identified during the historical heritage investigation.

v Historic heritage management plan

A historic heritage management plan will be prepared to provide information on the historic heritage items in the Project site and surrounds and details of their management. The following provisions for an unexpected finds protocol and a protocol for managing the discovery of human remains will be included in the historic heritage management plan:

- Unexpected finds

An unexpected finds protocol will be prepared as part of the historic heritage management plan. This protocol will outline the steps that should be taken in the event that intact and substantial relics or other forms of heritage that were not identified in this phase of investigation are discovered.

Aboriginal heritage material that is unexpectedly discovered during the Project operations will be managed in accordance with the Aboriginal heritage management plan.

- Human skeletal material

In the event that known or suspected human skeletal remains are encountered during mining, the procedure below will be followed. This management measure is to be included in the historic heritage management plan

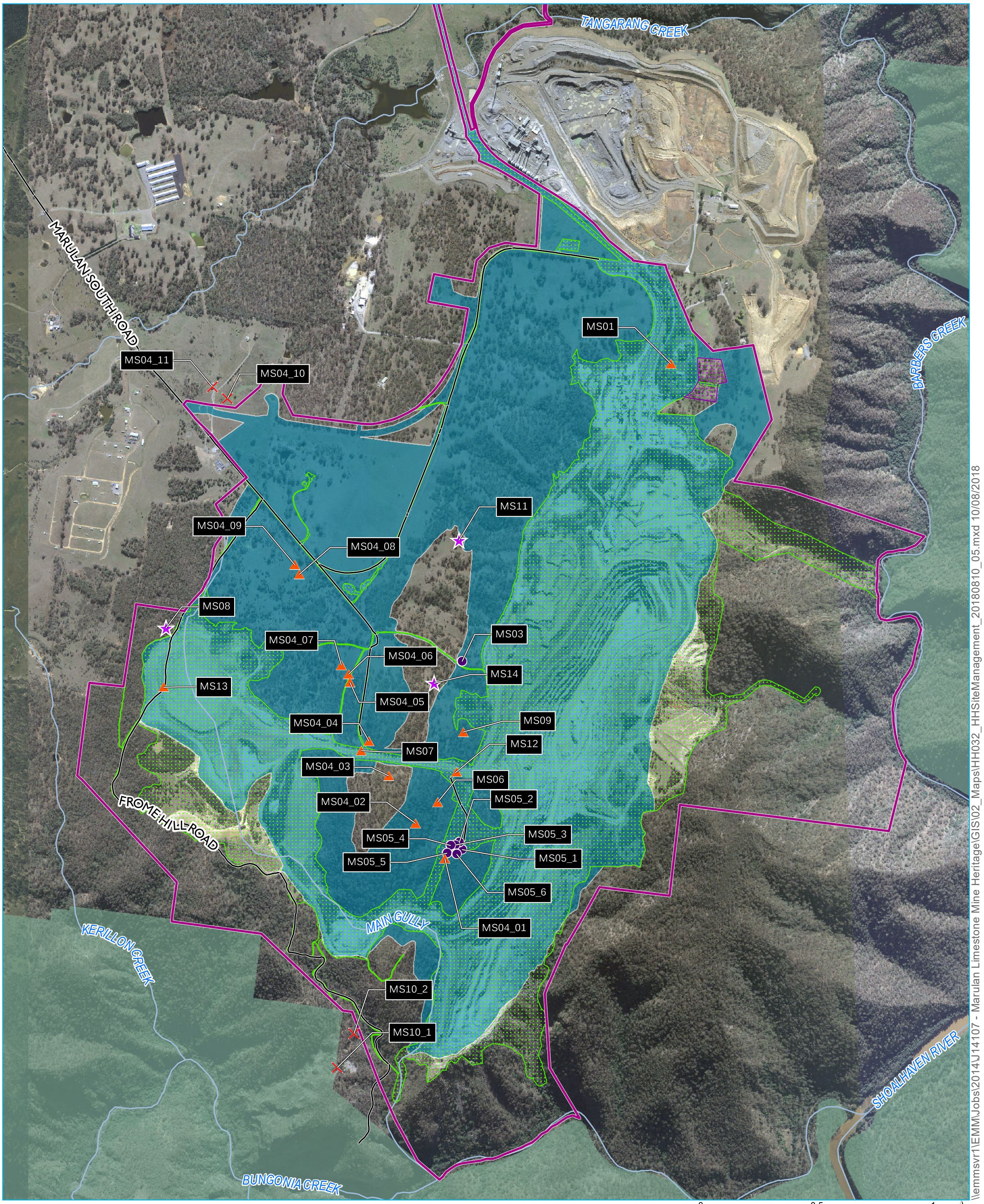
- all work in the immediate vicinity will cease;
- the find will be immediately reported to the work supervisor who will immediately advise the Mine Manager and Environmental Advisor or other nominated senior staff member;
- the Mine Manager, Environmental Advisor or other nominated senior staff member will promptly notify the police and the state coroner (as required for all human remains discoveries);
- the Mine Manager, Environmental Advisor or other nominated senior staff member will contact the OEH for advice on identification of the skeletal material as Aboriginal and management of the material; and
- if the skeletal material is of Aboriginal ancestral remains, the Local Aboriginal Land Council will be contacted and consultative arrangements will be made to discuss ongoing care of the remains.

Table 7.1 Site impact assessment and management summary

Site ID	Site description	Location	Significance	Impact level	Management
MS01	Marulan South village	North-east of the limestone processing and limestone production plant.	Local	No impact	Photographic archival recording Archaeological recording through topographic survey
MS02	Not used				
MS03	Hut/camp site	Centre of proposed 30 year mine pit; directly west of existing mine	Local	Total impact	Photographic archival recording Archaeological recording through topographic survey Archaeological excavation (sample area)
MS04	Aerial ropeway	Southern area of 30 year mine pit to the north west of the Western Overburden Emplacement (and outside of Project site)	Local	Partial (majority) impact of elements	Photographic archival recording Archaeological recording through topographic survey Move metal buckets from former aerial ropeway for safekeeping. Buckets in locations that will not be impacted to remain in situ
MS05	Lime kiln group	Southern end of 30 year mine pit	Local	Total impact	Photographic archival recording of entire group Archaeological recording through topographic survey Archaeological excavation of one of each type (two types of kiln exist on the site)
MS06	Explosives hut	Southern end of 30 year mine pit	None	Total impact	Photographic archival recording (detail not required) Archaeological recording through topographic survey
MS07	Old alignment of Marulan South Rd (now closed)	Northern edge of the main Western Overburden Emplacement haul road, immediately south of the proposed Central Dam		Total impact	Include in final spatial mapping of sites; data to be extracted from cadastre Photographic archival record of a representative sample
MS08	The Feltham house	Western side of the mine and immediately west of the Western Overburden Emplacement	Local	No impact	Fence and signpost Photographic archival recording Archaeological recording through topographic survey Record any artefacts and structures that occur in the area of impact

Table 7.1 Site impact assessment and management summary

Site ID	Site description	Location	Significance	Impact level	Management
MS09	Camp (Armitt family)	Western side of the existing mine pit and north of the lime kiln group	Local	Total impact	Photographic archival recording Archaeological recording through topographic survey
MS10	Mt Frome mine and rail	South of the mine (outside)	Local	No impact	None – these items are outside of the Project site
MS11	Ramp of earth and timber	Immediately south of the Northern Overburden Emplacement, west of the 30 year mine pit and east of the Western Overburden Emplacement	Local	No impact	Fence and signpost Photographic archival recording Archaeological recording through topographic survey
MS12	Lime-kiln Road	Southern end of 30 year mine pit	Local	Total impact	Archival recording Archaeological recording through topographic survey
MS13	Mt Frome Road	Crosses into Project site on western side of the Western Overburden Emplacement	Local	Partial impact	Photographic archival recording of a representative sample of the section of road to be removed. Include in spatial mapping of sites; data can be extracted from cadastre.
MS14	House site – chimney remaining; planted trees, possibly quince; track.	Centre of proposed mine plan; directly west of 30 year mine pit	Local	No impact	Fence and signpost Photographic archival recording Archaeological recording through topographic survey Undertake archaeologically excavation if artefacts and structures occur in the area of impact



Source: EMM (2018); Boral (2018); DFSI (2017), LPMA (2011)

KEY

- RoadClipped_01pl_LPMA_20150709
- Watercourse
- Bungonia National Park

Site management measures

- ▲ Photographic archival recording; topographic survey
- ★ Photographic archival recording; topographic survey & fence and sign post
- ● Photographic archival recording; topographic survey; archaeological excavation sample
- ✕ Not in project site (no management required)

- Project boundary
- Project (SSD) disturbance footprint
- Historical disturbance footprint (pre -SSD)
- Additional historic area of disturbance (pre -SSD)

Historic heritage management measures

Marulan South Continued Operations Project
Historical heritage assessment and SoHI
Figure 7.1

EMM

Abbreviations

Abbreviation	Term
£	Pounds
$	dollars
AHD	Australian Height Datum
AHIMS	Aboriginal heritage information management system
BOM	Bureau of Meteorology
BH	borehole
c	circa
cm	centimetres
DP	Deposited Plan
DP&E	Department of Planning and Environment
EMM	EMM Consulting Pty Limited Pty Limited
EP&A Act	*Environmental Planning and Assessment Act 1979*
km	kilometres
LEP	Local Environmental Plan
LGA	Local Government Area
m	metres
m^2	metres squared
mm	Millimetres
NT	National Trust
NSW	New South Wales
OEH	Office of Environment and Heritage
PAD	Potential archaeological deposit
RMS	Roads and Maritime Services
SHR	State Heritage Register
t	Tonne

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Appendix P

Air quality assessment

VOLUME 6

AIR QUALITY IMPACT ASSESSMENT

MARULAN SOUTH LIMESTONE MINE CONTINUED OPERATIONS

Boral Cement Limited

14 February 2019

Job Number 14060337A

Prepared by

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Air Quality Impact Assessment
Marulan South Limestone Mine
Continued Operations

DOCUMENT CONTROL

Report Version	Date	Prepared by	Reviewed by
DRAFT - 001	10/08/2015	P. Henschke	A. Todoroski & N Hattingh
DRAFT - 002	19/04/2016	P. Henschke & A Todoroski	A. Todoroski
DRAFT - 003	12/03/2018	P. Henschke & A Todoroski	
DRAFT - 004	04/07/2018	P. Henschke & A Todoroski	
FINAL - 001	07/08/2018	P. Henschke	
FINAL - 002	15/08/2018	P. Henschke	
FINAL - 003	14/02/2019	P. Henschke	

EXECUTIVE SUMMARY

This assessment investigates the potential air quality effects that may arise as a result of the proposed continued operations of the Marulan South Limestone Mine. The Marulan South Limestone Mine is located in the Goulburn Mulwaree Local Government Area in the Southern Tablelands region of New South Wales in an area comprised mostly of grazing, conservation, extractive industry, intensive agriculture and commercial/industrial land uses.

The proposed continued operations of the Marulan South Limestone Mine seek to continue mining the limestone resource at a rate of up to 4 million tonnes per annum for a period of 30 years with clay shale continuing to be extracted at a rate of up to 200,000 tonnes per annum. The continued extraction of the limestone resource would require the removal of approximately 107 million tonnes of overburden over the 30-year period with this material emplaced within dedicated overburden emplacement areas to the west, northwest and south of the active pit.

This air quality impact assessment is prepared in general accordance with the applicable regulatory requirements and guidelines and forms part of the environmental impact statement prepared for the development application.

The existing environmental conditions in the area surrounding the Marulan South Limestone Mine are governed by the local terrain features with the overall prevailing wind flows being directed along valleys and ridges that are characteristic of the area. The ambient air quality levels that are monitored at various locations surrounding the operation indicate that air quality in the area is generally good and typically below the relevant New South Wales Environment Protection Authority goals.

To assess the potential for air quality impacts associated with the proposed continued operations of the Marulan South Limestone Mine, indicative mine plan scenarios were selected to represent the periods of maximum potential impacts that may arise over the life of the proposed mining operation. The scenarios are selected with consideration of the position and scale of activities occurring at the operations which would most likely contribute to the highest dust levels at sensitive receptor locations. Air dispersion modelling with the CALPUFF modelling suite is utilised in conjunction with estimated emission rates for the air pollutants generated by the various mining activities. Best practice mitigation and management measures are applied to minimise the contribution of dust to local air quality and to ameliorate any potential adverse air quality impacts due to mining activity.

The assessment predicts that there would be a low potential for any dust impacts to occur at the privately-owned sensitive receptor locations surrounding the mine with dispersion modelling predicting no exceedances of the various dust criteria. Some elevated short term dust levels are predicted to occur at the nearby commercial and Boral-owned receiver locations close to the operations.

Overall the assessment indicates that adverse air quality impacts are unlikely to arise due to the continued operations of the Marulan South Limestone Mine if air emissions from the operations continue to be managed and mitigated effectively.

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1 INTRODUCTION

Todoroski Air Sciences has prepared this report for Element Environment on behalf of Boral Cement Limited (hereafter referred to as Boral). It presents an assessment of the potential air quality impacts associated with the proposed continued operation of the Marulan South Limestone Mine (hereafter referred to as the Project).

The Project seeks to continue mining limestone from the mine at a rate of up to 4 million tonnes per annum (Mtpa) for a period of up to 30 years.

To assess the potential air quality impacts associated with the proposed Project, this report incorporates the following aspects:

- An outline of the Marulan South Limestone Mine and a description of the Project;
- A review of the existing meteorological and air quality environment surrounding the site;
- A description of the dispersion modelling approach used to assess potential air quality impacts; and,
- Presentation of the predicted results and discussion of the potential air quality impacts.

The assessment incorporates the proposed cumulative effects of the approved operations and proposed modifications to the adjacent Peppertree Quarry.

2 PROJECT SETTING

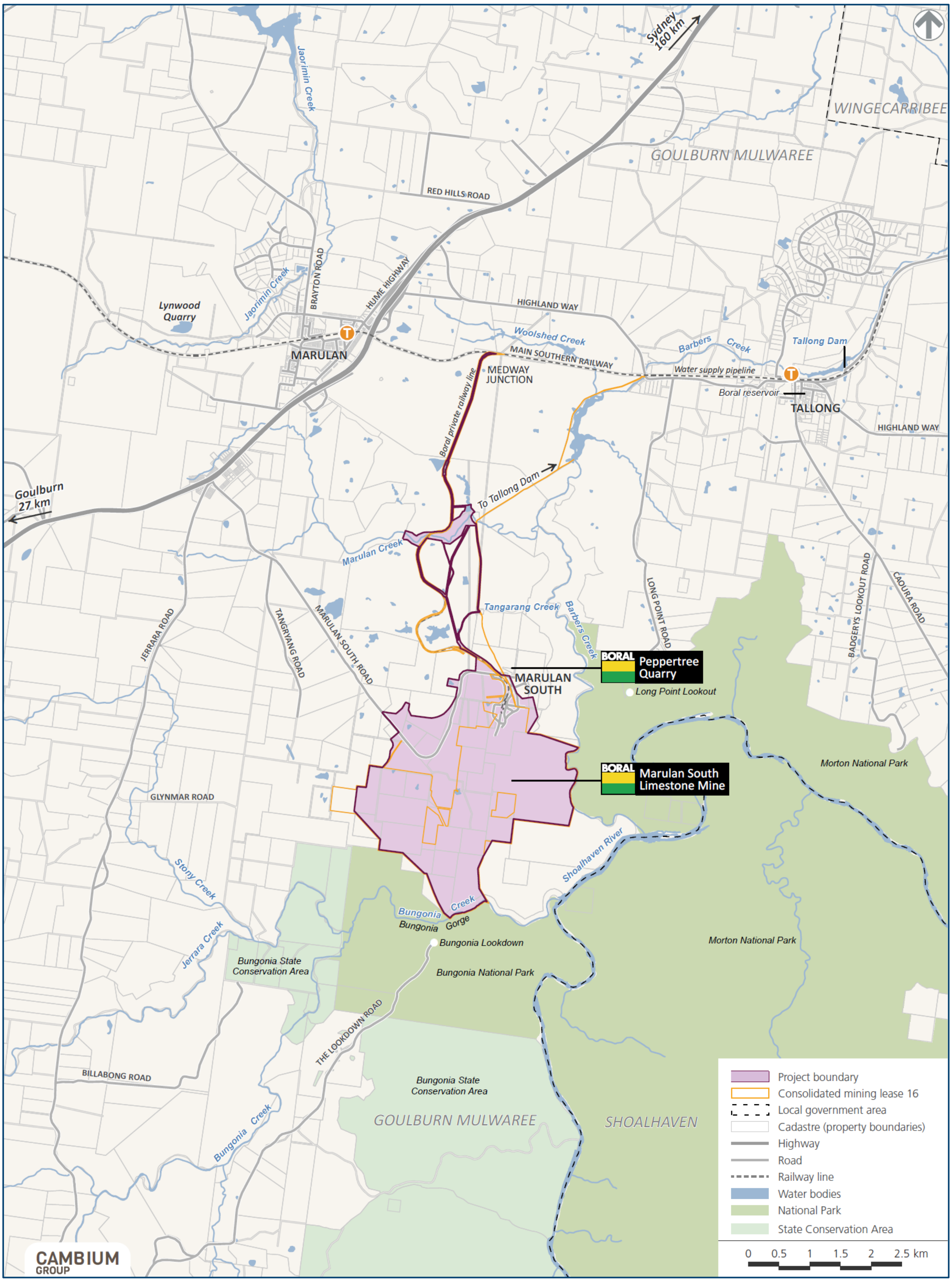
The Marulan South Limestone Mine (the mine) is located within the Goulburn Mulwaree Local Government Area in the Southern Tablelands region of New South Wales (NSW), approximately 5 kilometres (km) south of Marulan and 25km east of Goulburn (see **Figure 2-1**).

Land use surrounding the mine is a mixture of extractive industry, grazing, rural residential, commercial/industrial and conservation. The mine is separated from the Bungonia National Park and State Conservation Area to the south by Bungonia Creek and is separated from the Shoalhaven River and Morton National Park to the east by Barbers Creek. Peppertree Quarry, owned by Boral Resources (NSW) Pty Limited, borders the mine to the north.

A small number of rural landholdings surround the Boral properties to the north and west, including an agricultural lime manufacturing facility, fireworks storage facility, turkey farm and rural residential (a number of these properties are actively grazed). Rural residential properties are also located to the northeast of the mine along Long Point Road. These properties are separated from the mine by the deep Barbers Creek gorge.

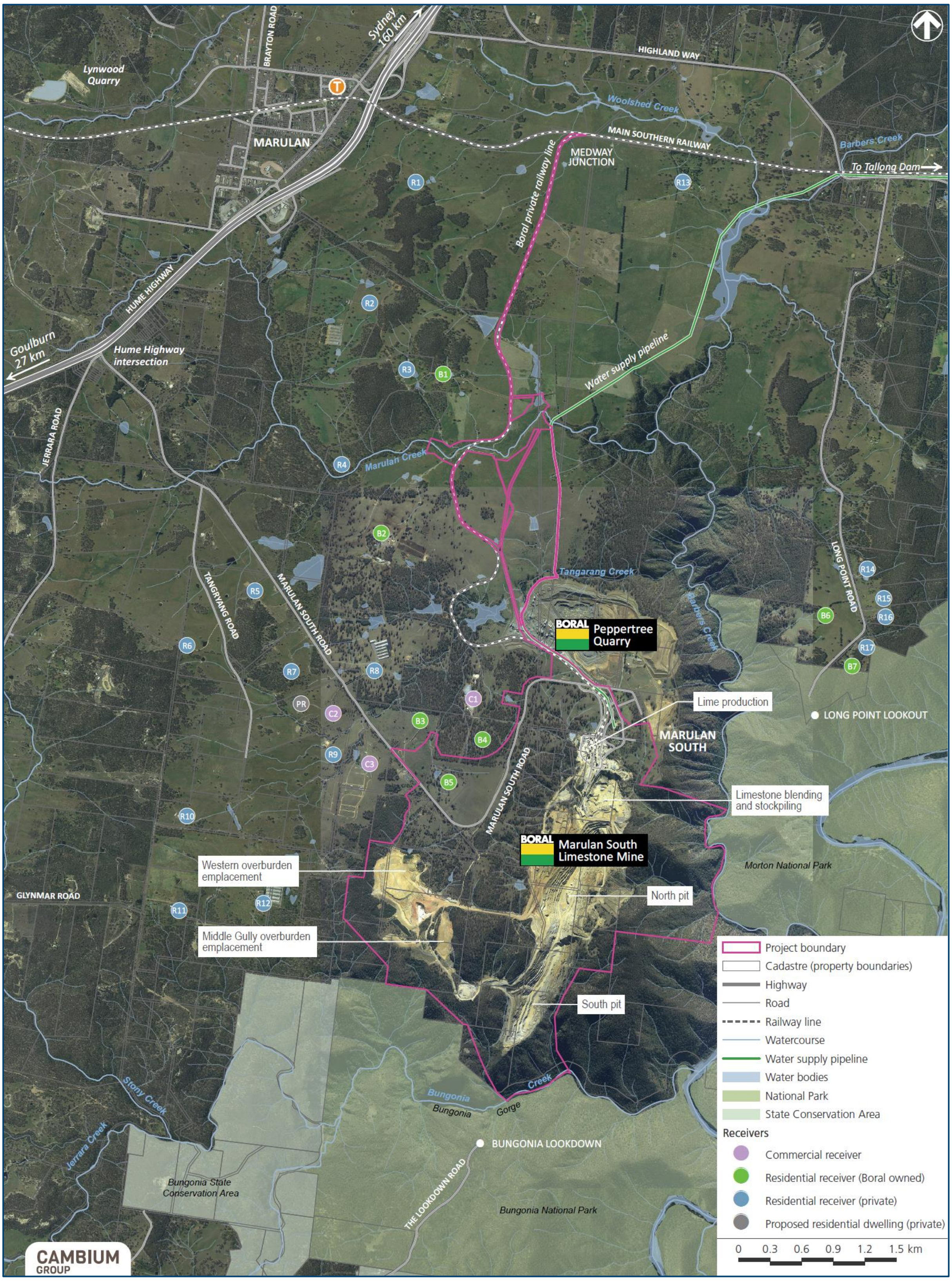
Figure 2-2 presents the location of the Project in relation to sensitive receivers of relevance to this assessment. **Appendix A** provides a detailed list of all the sensitive receivers assessed in this report.

Figure 2-3 presents a pseudo three-dimensional visualisation of the topography in the general vicinity of the Project site. The area can be characterised as complex to the southeast with the deep gorges and valleys associated with the Bungonia and Morton National Parks. To the west and northwest the terrain is generally more open and gently undulating. The complex local terrain in this area would have a significant effect on the wind patterns and dispersion of dust.



Source: **Element Environment, 2018**

Figure 2-1: Project location



Source: **Element Environment, 2018**

Figure 2-2: Sensitive receiver locations

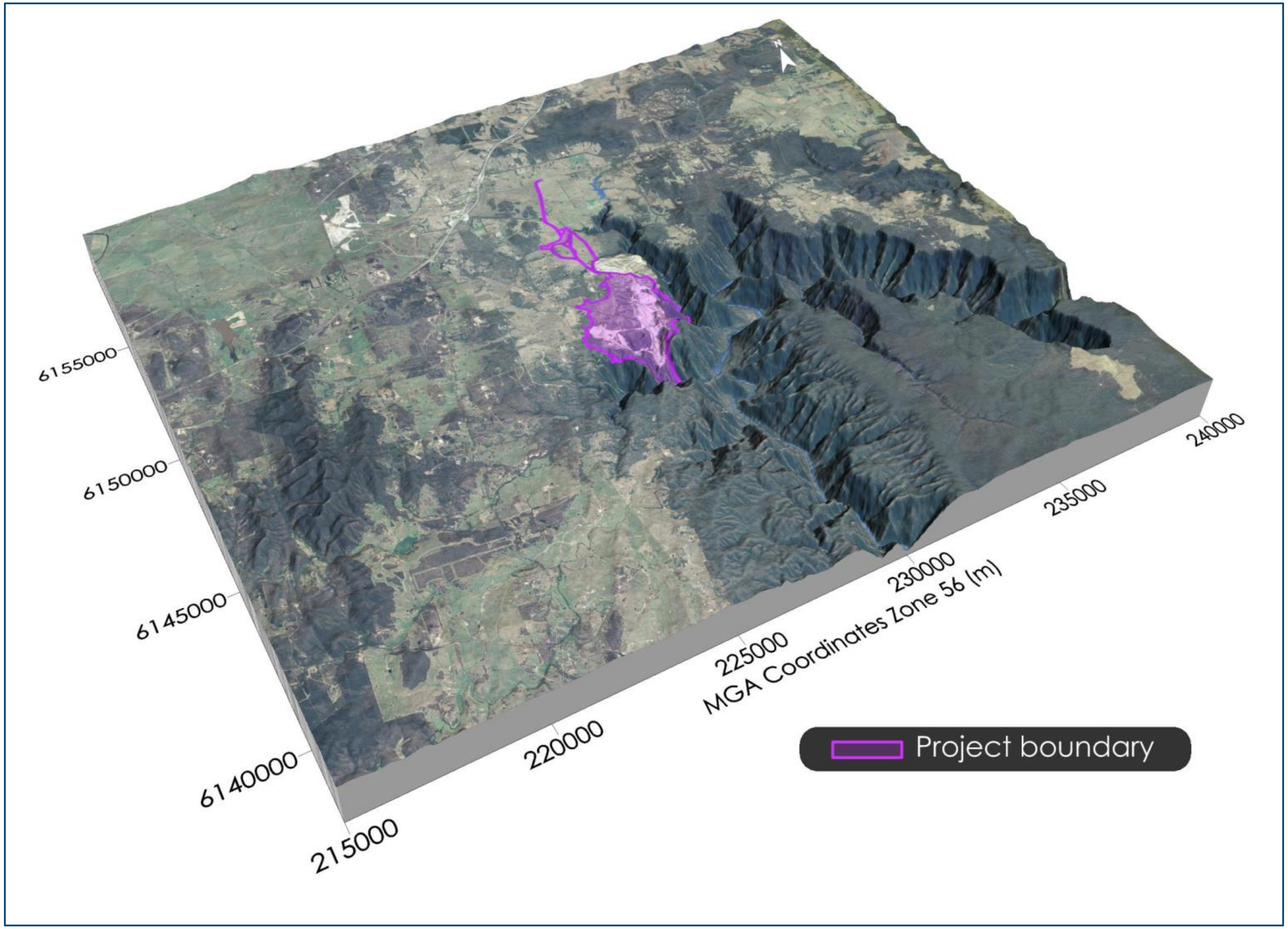


Figure 2-3: Representative view of the topography in the vicinity of the Project

3 EXISTING OPERATIONS AND PROPOSED PROJECT DESCRIPTION

3.1 Existing operations

The mine is sited on a high grade limestone resource. Subject to market demand the mine has typically produced 3 to 3.38 million tonnes of limestone and 120,000 to 200,000 tonnes of shale per annum.

The mine currently produces a range of limestone products for internal and external customers in the Southern Highlands/Tablelands, the Illawarra and Metropolitan Sydney markets for use primarily in cement and lime manufacture, steel making, agriculture and other commercial uses. Products produced at the mine are despatched by road and rail, with the majority despatched by rail.

Historically limestone mining was focused on the approximately 200-300 m wide Eastern Limestone and was split between a North Pit and a South Pit. A limestone wall (referred to by the mine as the 'centre ridge') rising almost to the original land surface, divided the two pits. The North and South Pits were recently joined in 2016/2017 by mining the centre ridge to form a single contiguous pit, approximately 2 km in length. However, the North Pit/South Pit nomenclature remains important as current mining operation locations continue to be reported with respect to one or other of the old pits.

Limestone and shale are extracted using open-cut hard rock drill and blast techniques. Material is loaded using front end loaders and hauled either to stockpiles or the processing plant using haul trucks. Oversized material is stockpiled and reduced in size using a hydraulic hammer attached to an excavator.

Limestone processing facilities including primary and secondary crushing, screening, conveying and stockpiling plant and equipment are in the northern end of the North Pit. Kiln stone grade limestone is also processed on-site through the existing lime plant comprising kiln stone stockpiles, rotary lime kiln, hydration plant and associated auxiliary conveying, processing, storage, despatch plant and equipment. Overburden from stripping operations is emplaced in the Western Overburden Emplacement, west of the open cut pits.

The current operations are 24-hour, 7 days per week with personnel employed on a series of 8, 10 and 12-hour shifts to cover the different operational aspects of the mine. Blasting is restricted to daylight hours and on weekdays, excluding public holidays.

3.2 Proposed Project

3.2.1 Mining operations

Boral proposes to continue mining limestone from the mine at a rate of up to 4 million tonnes per annum (mtpa) for a period of up to 30 years. This represents an increase in extraction rate from historic levels (peak of 3.38 mtpa) due to forecast increased demand from the construction industry. Shale will continue to be extracted at a rate of up to 200,000 tonnes per annum (tpa).

The proposed 30-year mine plan accesses approximately 120 million tonnes of limestone down to a depth of 335 m AHD. The mine footprint focuses on an expansion of the North Pit westwards to mine the Middle Limestone and to mine deeper into the Eastern Limestone. As the Middle Limestone lies approximately 70 m to 150 m west of the Eastern Limestone, the 30-year mine plan avoids mining where practical, the interburden between these two limestone units thereby creating a smaller second, north-south oriented West Pit with a ridge remaining between. The North Pit will also be expanded southwards, encompassing part of the South Pit, leaving the remainder of the South Pit for overburden emplacement and a visual barrier (**Figure 3-1**).

In addition to mining approximately 5 million tonnes of shale, the extraction of the limestone requires the removal of approximately 108 million tonnes of overburden over the 30 year period. This material will be emplaced within existing and proposed overburden emplacement areas (**Figure 3-1**).

Limestone will continue to be mined using drilling and blasting methods. Shale will continue to be mined by excavator/front end loader. Limestone, shale and overburden will be transported to the primary crusher, stockpile areas and overburden emplacements respectively, using the load and haul fleet of trucks.

Products produced at the mine will continue to be despatched by road and rail, with the majority despatched by rail.

The limestone sand plant, produces a crushed and air classified limestone sand for use in concrete. The mine currently produces 500,000 tpa for Peppertree Quarry and propose to increase production of manufactured sand to approximately 1 million tpa.

Boral's adjoining Peppertree Quarry currently has approval to emplace some of its overburden in the South Pit mine void. As the South Pit is required for the emplacement of over 30 million tonnes of overburden from the mine after the removal of accessible limestone, Boral proposes to emplace up to 15 million tonnes of overburden from Peppertree Quarry within the Northern Overburden Emplacement (**Figure 3-1**).

3.2.2 Associated infrastructure

3.2.2.1 Processing

The existing facilities for processing limestone will continue to be utilised to produce a series of graded and blended limestone products that are despatched from site for use primarily in cement manufacture, steel making, commercial and agricultural applications.

Limestone processing facilities (**Figure 3-1**) include primary and secondary crushing, screening, conveying and stockpiling plant and equipment located north-west of the North Pit and extending to the tertiary crushing, screening, bin storage and despatch (rail and road) systems that form part of the main processing facilities.

Kiln stone grade limestone will also continue to be processed on site through the existing lime plant comprising kiln stone stockpiles, rotary lime kiln, hydration plant and associated auxiliary conveying, processing, storage, despatch plant and equipment.

Processing infrastructure and the reclaim and stockpile area at the northern end of the North Pit will be relocated during the life of the 30-year pit to enable full development of the mine plan. The timing and location of this is presented in the EIS.

Shale and white clay will not be processed and will be stockpiled directly from the pit, ready for dispatch by road to the Berrima and Maldon cement operations.

3.2.2.2 Water supply

Water supply for the Project, including dust suppression, processing activities and some non-potable amenities will be from existing and new on-site dams and a proposed new water supply dam on Marulan Creek. This dam would be located on Boral owned land north of Peppertree Quarry and utilises Boral's adjoining Tallong water pipeline to transfer water to the mine. This dam would require the purchase of water entitlements.

Mine water demand will also be supplemented by Tallong Weir via the Tallong water pipeline.

3.2.2.3 Rail

No changes are proposed to the existing rail infrastructure. A 1.2 km long passing line was constructed at Medway Junction during construction of the Peppertree Quarry, which will also be used by the mine to enhance access to the Main Southern Railway.

3.2.2.4 Road

Road access from the mine to the Hume Highway is via Marulan South Road. The proposed Western Overburden Emplacement extends northwards over Marulan South Road. Boral propose to realign a section of Marulan South Road, to accommodate the northern portion of the proposed Western Overburden Emplacement (**Figure 3-1**).

All public roads within the former village of Marulan South as well as the section of Marulan South Road between Boral's operations and the entrance to the agricultural lime manufacturing facility will be de-proclaimed.

3.2.2.5 Power

Power supply to the mine is via a high voltage power line that commences at a sub-station on the southern side of Marulan South Road, immediately west of the Project boundary. A section of this power line will be relocated to accommodate the proposed Northern Overburden Emplacement (**Figure 3-1**).

3.2.3 Transport

The majority of limestone products will continue to be transported to customers by rail for cement, steel, commercial and agricultural uses. Boral seeks no limitation on the volume of products transported by rail.

Manufactured sand will continue to be transported by truck along a dedicated internal road, across Marulan South Road and into Peppertree Quarry for blending and dispatch by rail.

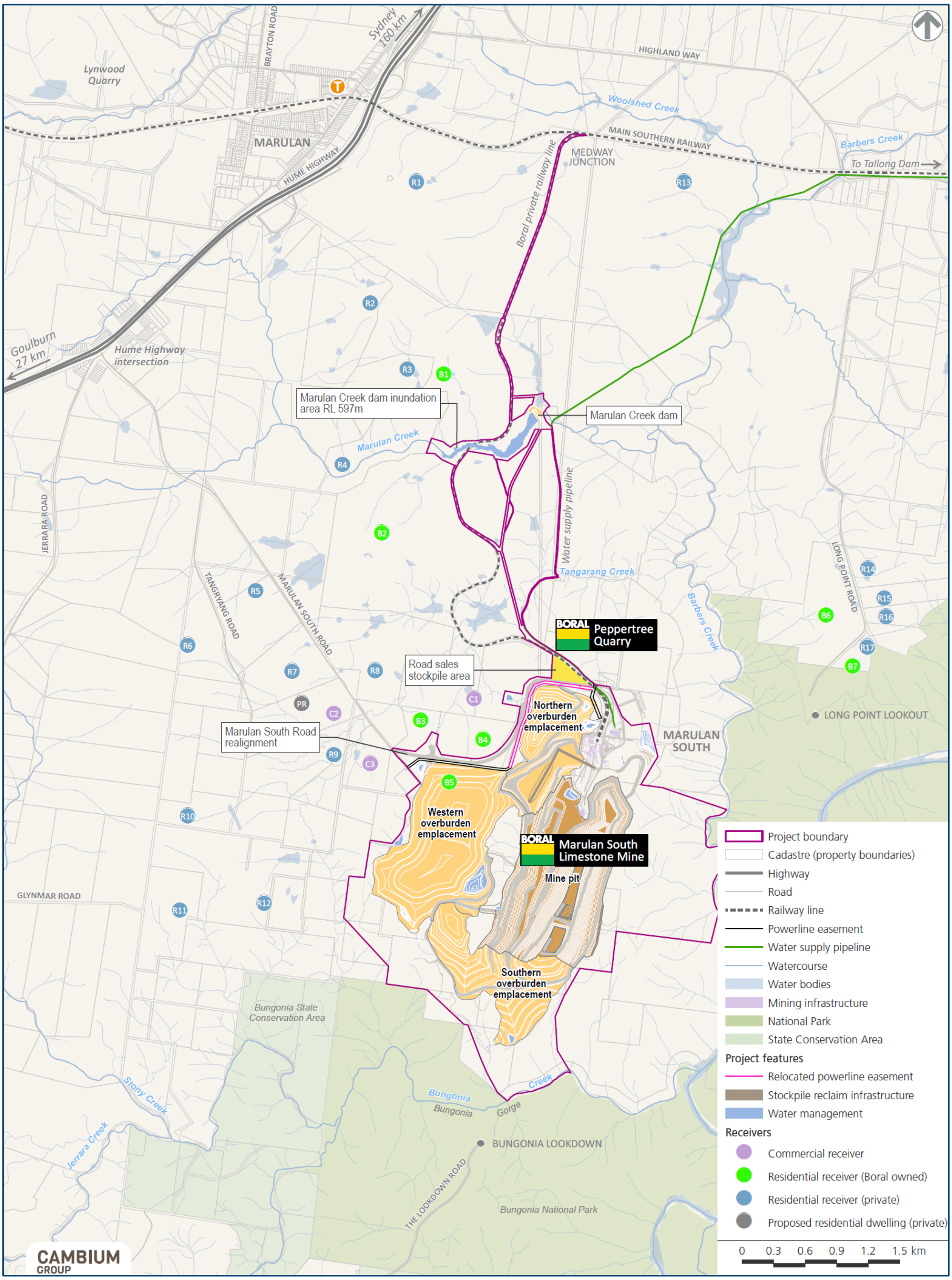
Agricultural lime, quick lime and fine limestone products will continue to be transported by powder tanker, bulk bags on trucks or open tipper trucks along Marulan South Road.

Shale, limestone aggregates, sand and tertiary crushed products will be transported predominantly by truck and dog along Marulan South Road.

The adjoining Peppertree Quarry is currently approved to transport all products by rail. Boral will seek to transport approximately 150,000 tpa of Peppertree Quarry's products from the mine to customers via Marulan South Road. This could be achieved by back loading to a new shared road sales product stockpile area by the trucks carrying the limestone sand to Peppertree Quarry. A new shared road sales product stockpile area is proposed on the northern side of Marulan South Road, immediately west of the mine and Peppertree Quarry entrances (**Figure 3-1**).

This shared finished product stockpile area, includes a weighbridge and wheel wash and will service both the mine and Peppertree Quarry.

In total, Boral is seeking to transport up to 600,000 tpa of limestone and hard rock products along Marulan South Road to the Hume Highway, as well as 120,000 tpa of limestone products to the agricultural lime manufacturing facility.



Source: **Element Environment, 2018**

Figure 3-1: Project features

4 STUDY REQUIREMENTS

The purpose of this report is to provide an assessment of the maximum likely effects on air quality that may arise due to the Project over its proposed life. The assessment presented in this report addresses planning and regulatory agency requirements, as set out below.

4.1 Secretary's Environmental Assessment Requirements

In preparing this Air Quality Impact Assessment, the Secretary's Environmental Assessment Requirements (SEARs) issued for the Marulan South Limestone Mine Extension Project (SSD-7009) on 10 June 2015 have been addressed and the key matters raised for consideration in the Air Quality Impact Assessment are outlined in **Table 4-1** along with a reference as to where the requirements are addressed in the report.

Table 4-1: Secretary's Environmental Assessment Requirements (SSD-7009)

Specific Issue	General Requirements	Section
Air quality – including:	An assessment of the likely air quality impacts of the development, in accordance with the *Approved Methods and Guidance for Modelling and Assessment of Air Pollutants in NSW* and the EPA's additional requirements, and having regard to the NSW Government's *Voluntary Land and Acquisition and Mitigation Policy: For State Significant Mining, Petroleum and Extractive Industry Developments*.	This report

On 8 September 2017, confirmation was received from the Department of Planning and Environment (DP&E) that the SEARs issued on 10 June 2015 can be relied upon until 30 June 2018. However, DP&E requested that "the Air Quality Assessment must be prepared in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (2016)".

4.2 NSW Environment Protection Authority

This Air Quality Impact Assessment has been prepared in general accordance with the NSW Environment Protection Authority (EPA) document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**) and the specific NSW EPA requirements which are set out in **Table 4-2**, along with a reference to the report section where each requirement is addressed.

Table 4-2: NSW EPA Recommended Requirements for Air Quality (SSD 7009)

Air	Section
• Identify all sources of air emissions from the development. *Note: emissions can be classed as either:* ○ *point (e.g. emissions from a stack or vent) or* ○ *fugitive (from wind erosion, leakages or spillages, associated with loading or unloading, conveyors, storage facilities, plant and yard operation, vehicle movements (dust from road, exhausts, loss from load), land clearing and construction works).*	8.3
• Provide details of the project that are essential for predicting and assessing air impacts including: a) the quantities and physio-chemical parameters (e.g. concentration, moisture content, bulk density, particle sizes etc) of materials to be used, transported, produced or stored b) and outline of procedures for handling, transport, production and storage c) the management of solid, liquid and gaseous waste streams with potential for significant air impacts.	5 & 8.3
• Describe the topography and surrounding land uses. Provide details of exact locations of dwellings, schools and hospitals. Where appropriate provide a perspective view of the study area such as the terrain file used in dispersion models.	2
• Describe surrounding buildings that may effect plume dispersion.	8.3

Air	Section
• Provide and analyse site representative data on following meteorological parameters: a) temperature and humidity b) rainfall, evaporation and cloud cover c) wind speed and direction d) atmospheric stability class e) mixing height (the height that emission will be ultimately mixed in the atmosphere)	6.1, 6.2 & 8.1
• Provide a description of existing air quality and meteorology, using existing information and site representative ambient monitoring data. This description should include the following parameters: a) PM_{10} (24-hour and annual average) b) Total suspended particulates c) deposited dust impacts.	6
• Identify all pollutants of concern and estimate emissions by quantity (and size for particles), source and discharge point.	7, 8.3 and App. C
• Estimate the resulting ground level concentrations of all pollutants. Where necessary (e.g. potentially significant impacts and complex terrain effects), use an appropriate dispersion model to estimate ambient pollutant concentrations. Discuss choice of model and parameters with the EPA.	9
• Describe the effects and significance of pollutant concentration on the environment, human health, amenity and regional ambient air quality standards or goals.	9 & 11
• Describe the contribution that the development will make to regional and global pollution, particularly in sensitive locations. Note: With dust and odour, it may be possible to use data from existing similar activities to generate emission rates.	8.3
• Reference should be made to relevant guidelines e.g. *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2001); Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (DEC, 2007); Load Calculation Protocol for use by holders of NSW Environment Protection Licences when calculating Assessable Pollutant Loads (DECC, 2009).*	8
• Outline specifications of pollution control equipment (including manufacturer's performance guarantees where available) and management protocols for both point and fugitive emissions. Where possible, this should include cleaner production processes.	10 & App. C

5 AIR QUALITY ASSESSMENT CRITERIA

Air quality criteria are benchmarks set to protect the general health and amenity of the community in relation to air quality. The sections below identify the potential air emissions generated by the Project and the applicable air quality criteria.

5.1 NSW EPA impact assessment criteria

5.1.1 Particulate emissions

Particulate matter consists of dust particles of varying size and composition. Air quality goals refer to measures of the total mass of all particles suspended in air defined as the Total Suspended Particulate matter (TSP). The upper size range for TSP is nominally taken to be 30 micrometres (µm) as in practice particles larger than 30 to 50µm will settle out of the atmosphere too quickly to be regarded as air pollutants.

Two sub-classes of TSP are also included in the air quality goals, namely PM_{10}, particulate matter with equivalent aerodynamic diameters of 10µm or less, and $PM_{2.5}$, particulate matter with equivalent aerodynamic diameters of 2.5µm or less.

Particulate matter, typically in the upper size range, that settles from the atmosphere and deposits on surfaces is characterised as deposited dust. The deposition of dust on surfaces may be considered a nuisance and can adversely affect the amenity of an area by soiling property in the vicinity.

Table 5-1 summarises the air quality goals that are relevant to this assessment as outlined in the NSW Environment Protection Authority (EPA) document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**).

The air quality goals for total impact relate to the total dust burden in the air and not just the dust from the Project. Consideration of background dust levels needs to be made when using these goals to assess potential impacts.

Table 5-1: NSW EPA air quality impact assessment criteria

Pollutant	Averaging Period	Impact	Criterion
Total suspended particulate (TSP) matter	Annual	Total	90µg/m³
Particulate matter ≤ 10µm (PM_{10})	Annual	Total	25µg/m³
	24 hour	Total	50µg/m³
Particulate matter ≤ 2.5µm ($PM_{2.5}$)	Annual	Total	8µg/m³
	24 hour	Total	25µg/m³
Deposited dust	Annual	Incremental	2g/m²/month
		Total	4g/m²/month

Source: NSW EPA (2017)

µm = micrometre µg/m³ = micrograms per cubic metre g/m²/month = grams per square metre per month

5.1.2 Other pollutants

Emissions of other air pollutants will also potentially arise from the processing facilities, the Hydration plant and kiln. Emissions from these sources generally include particulate matter, nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

NO_2 is reddish-brown in colour (at high concentrations) with a characteristic odour and can irritate the lungs and lower resistance to respiratory infections such as influenza. NO_2 belongs to a family of reactive gases called nitrogen oxides (NO_X). These gases form when fuel is burned at high temperatures, mainly from motor vehicles, power generators and industrial boilers (**USEPA 2011**). NO_X may also be generated by blasting activities. It is important to note that when formed, NO_2 is generally a small fraction of the total NO_X generated.

Sulphur dioxide (SO_2) is a colourless, toxic gas with a pungent and irritating smell. It commonly arises in industrial emissions due to the sulphur content of the fuel. SO_2 can have impacts upon human health and the habitability of the environment for flora and fauna. SO_2 emissions are a precursor to acid rain, which can be an issue in the northern hemisphere; however it is not known to have any widespread effect in NSW. Due to the potential impact on human health, sulphur is actively removed from fuel to prevent the release and formation of SO_2. The sulphur content of Australian diesel is controlled to a low level by national fuel standards.

Table 5-2 summarises the air quality goals for NO_2 and SO_2 considered in this report.

Table 5-2: NSW EPA air quality impact assessment criteria of air toxics

Pollutant	Averaging period	Criterion
Nitrogen dioxide (NO_2)	1 hour	246µg/m³
	Annual	62µg/m³
Sulphur dioxide (SO_2)	10 minutes	712µg/m³
	1 hour	570µg/m³
	24 hours	228µg/m³
	Annual	60µg/m³

Source: NSW EPA (2017)
mg/m³ = milligrams per cubic metre

5.2 NSW Voluntary Land Acquisition and Mitigation Policy

Part of the NSW VLAMP dated September 2018 describes the NSW Government's policy for voluntary mitigation and land acquisition to address particulate matter impacts from state significant mining, petroleum and extractive industry developments.

Voluntary mitigation rights may apply where, even with best practice management, the development contributes to exceedances of the criteria in **Table 5-3** at any residence on privately-owned land or workplace[1].

Table 5-3: VLAMP Particulate matter mitigation criteria

Pollutant	Averaging period	Mitigation Criterion		Impact Type
$PM_{2.5}$	Annual	8µg/m³*		Human health
	24 hour	25µg/m³**		Human health
PM_{10}	Annual	25µg/m³*		Human health
	24 hour	50µg/m³**		Human health
TSP	Annual	90µg/m³*		Amenity
Deposited dust	Annual	2g/m²/month**	4g/m²/month*	Amenity

Source: **NSW Government (2018)**
*Cumulative impact (i.e. increase in concentrations due to the development plus background concentrations due to all other sources).

[1] Where any exceedance would be unreasonably detrimental to workers health or carrying out of the business.

**Incremental impact (i.e. increase in concentrations due to the development alone), with zero allowable exceedances of the criteria over the life of the development.

Voluntary acquisition rights may apply per the VLAMP where, even with best practice management, the development contributes to exceedances of the criteria in **Table 5-4** at any residence on privately-owned land, workplace[2] or 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 (vacant land).

Table 5-4: VLAMP Particulate matter acquisition criteria

Pollutant	Averaging period	Acquisition Criterion		Impact Type
$PM_{2.5}$	Annual	8µg/m³*		Human health
	24 hour	25µg/m³**		Human health
PM_{10}	Annual	25µg/m³*		Human health
	24 hour	50µg/m³**		Human health
TSP	Annual	90µg/m³*		Amenity
Deposited dust	Annual	2g/m²/month**	4g/m²/month*	Amenity

Source: **NSW Government (2018)**

*Cumulative impact (i.e. increase in concentration due to the development plus background concentrations due to all other sources).

**Incremental impact (i.e. increase in concentrations due to the development alone), with up to 5 allowable exceedances of the criteria over the life of the development.

[2] Where any exceedance would be unreasonably detrimental to workers health or carrying out of the business.

6 EXISTING ENVIRONMENT

This section describes the existing environment including the climate and ambient air quality in the area surrounding the Project.

6.1 Local climate

Long term climatic data collected at the Bureau of Meteorology (BoM) weather station at Goulburn Airport Automatic Weather Station (AWS) were analysed to characterise the local climate in the proximity of the Project. The Goulburn Airport AWS is located approximately 25km west-southwest of the Project site and is the nearest BoM weather station with available long-term climate statistics.

Table 5-1 and **Figure 5-1** show climatic parameters that have been collected from the Goulburn Airport AWS over an 18 to 26-year period for the various meteorological parameters.

The data indicate that January is the hottest month with a mean maximum temperature of 27.9 degrees Celsius (°C) and July is the coldest month with a mean minimum temperature of 0.3°C.

Rainfall peaks during the summer and the month of June. The data show June is the wettest month with an average rainfall of 60.9 millimetres (mm) over 7.0 days and April is the driest month with an average rainfall of 25.6mm over 4.0 days.

Relative humidity levels exhibit variability and seasonal flux across the year. Mean 9am relative humidity levels range from 65% in October and December to 88% in June. Mean 3pm relative humidity levels vary from 39% in December to 63% in June.

Wind speeds have a generally similar spread between the 9am and 3pm conditions. The mean 9am wind speeds range from 12.2 kilometres per hour (km/h) in March to 19.8km/h in September. The mean 3pm wind speeds vary from 19.8km/h in April to 26.5km/h in August.

Table 6-1: Monthly climate statistics summary – Goulburn Airport AWS

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temp. (°C)	27.9	26.4	23.8	19.9	15.9	12.4	11.7	13.4	16.5	19.8	23.0	25.8	19.7
Mean min. temp. (°C)	12.7	12.7	10.1	5.7	2.5	1.3	0.3	0.5	3.1	5.2	8.3	10.7	6.1
Rainfall													
Rainfall (mm)	48.9	52.7	40.0	25.6	32.8	60.9	33.5	39.9	45.8	50.2	54.9	57.2	551.9
No. of rain days	4.7	5.1	5.3	4.0	4.3	7.0	6.2	6.1	6.9	6.1	6.0	5.8	67.5
9am conditions													
Mean temp. (°C)	19.0	17.8	15.1	12.7	8.8	5.9	5.0	6.7	10.8	13.9	15.3	17.7	12.4
Mean R.H. (%)	69	78	81	78	85	88	87	81	72	65	69	65	76
Mean W.S. (km/h)	15.5	13.8	12.2	12.6	12.5	13.3	13.5	17.1	19.8	19.4	17.5	16.8	15.3
3pm conditions													
Mean temp. (°C)	26.1	24.9	22.5	18.9	14.8	11.3	10.5	12.2	15.1	18.2	21.1	24.2	18.3
Mean R.H. (%)	41	45	46	46	54	63	61	52	50	46	45	39	49
Mean W.S. (km/h)	22.2	21.4	20.5	19.8	20.7	22.2	23.2	26.5	26.4	25.3	23.7	23.0	22.9

Source: **Bureau of Meteorology (2017), accessed December 2017**

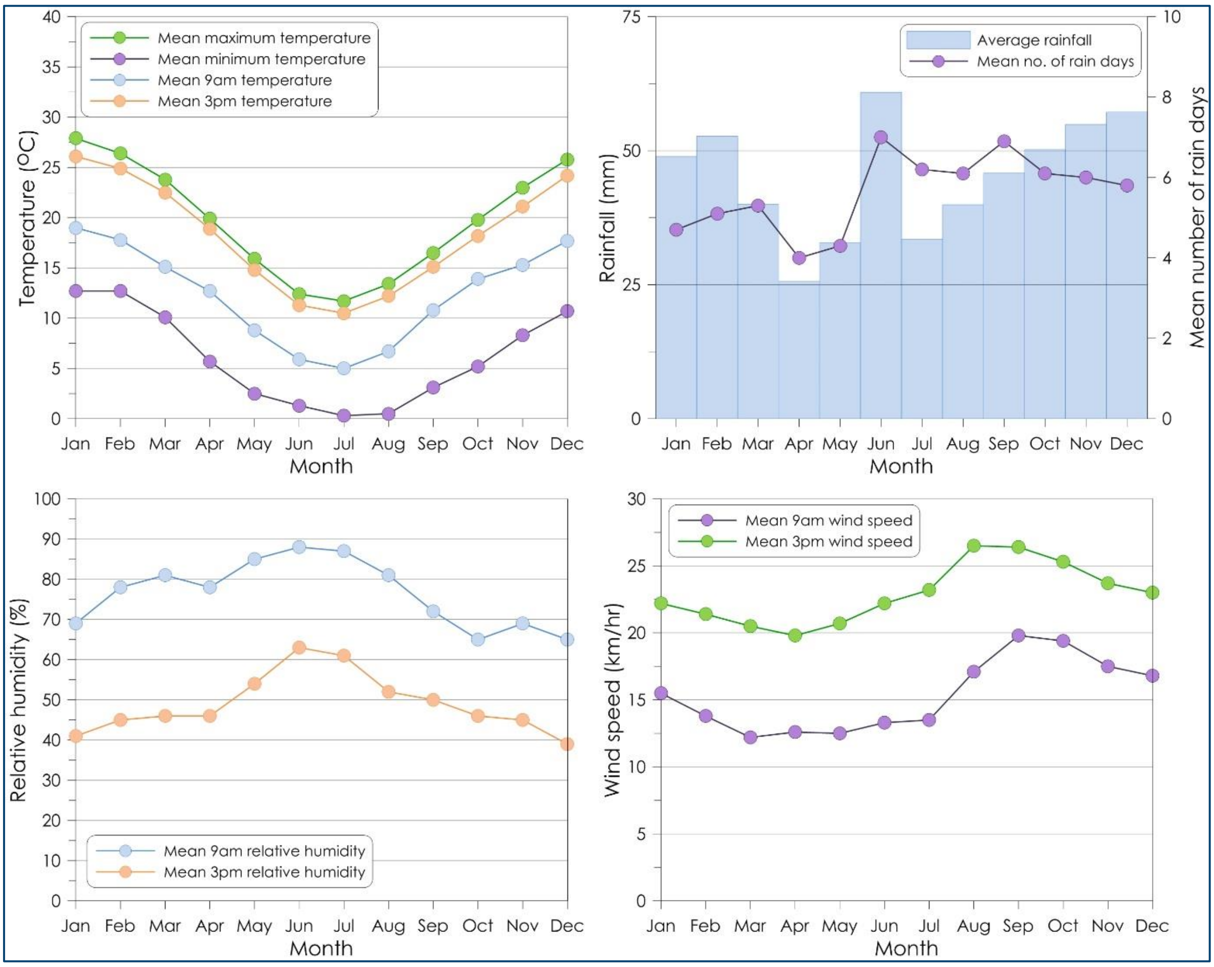


Figure 6-1: Monthly climate statistics summary – Goulburn Airport AWS

6.2 Local meteorological conditions

The mine and the neighbouring Peppertree Quarry both operate 10-metre (m) tall automatic weather stations to assist with the environmental management of site operations. The location of these stations is shown in **Figure 6-2**.

Annual and seasonal windroses prepared from data collected during the 2014 calendar period are presented in **Figure 6-3** and **Figure 6-4** for the Limestone mine weather station and Peppertree Quarry weather station respectively.

The 2014 meteorological year is applied in this assessment for consistency with the recent modelling for the Peppertree Quarry (**Todoroski Air Sciences, 2016 & 2018**), and thus allows a direct comparison to be made. The year is also most representative of typical conditions, as outlined in more detail in **Appendix B**.

The annual windroses from both stations indicate that the typical wind flow of the area is on a west to east axis with the strongest winds originating from the west. The Limestone mine weather station shows a greater spread of winds ranging from the west-southwest to the north-northwest relative to the Peppertree Quarry weather station which only has limited winds from the northeast. This may be due to the different positioning of the stations, with the Limestone mine weather station situated near a dense line of vegetation to the west of the station, whereas the Peppertree Quarry weather station is less obstructed with cleared land to the west.

In summer the winds predominately occur from the east and east-southeast at both stations. The autumn and spring wind distributions share similarities with the annual distributions with winds typically ranging from the west to the northwest and east. During winter, the Limestone mine weather station records varied winds from the west and south and south-southeast. In comparison the Peppertree Quarry weather station shows the dominant winds from the west with fewer winds from the other directions.

Overall, the wind distribution patterns of the stations are generally as expected of the local area considering the siting of the stations in relation to the local features such as terrain and vegetation.

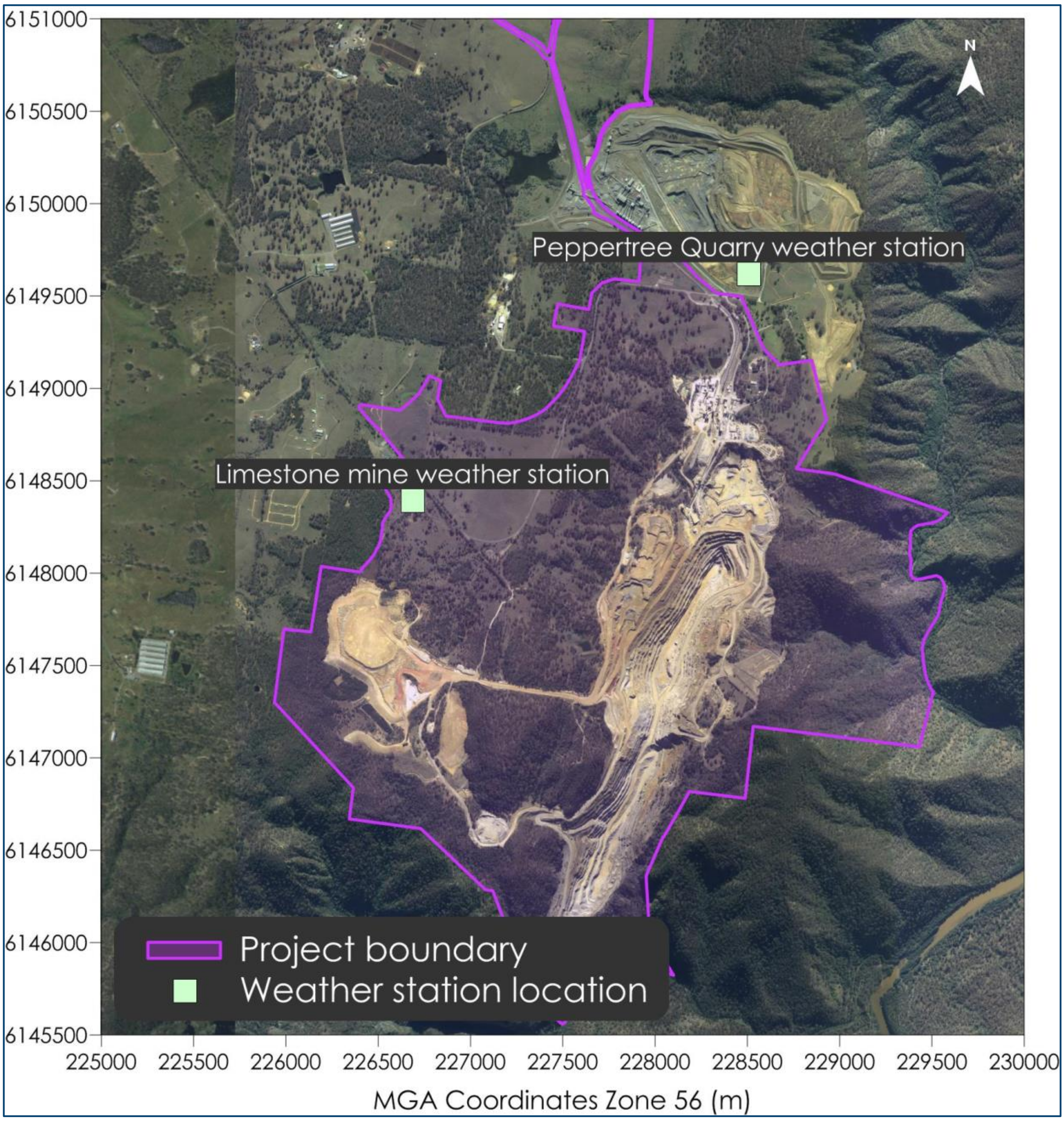


Figure 6-2: Weather station locations

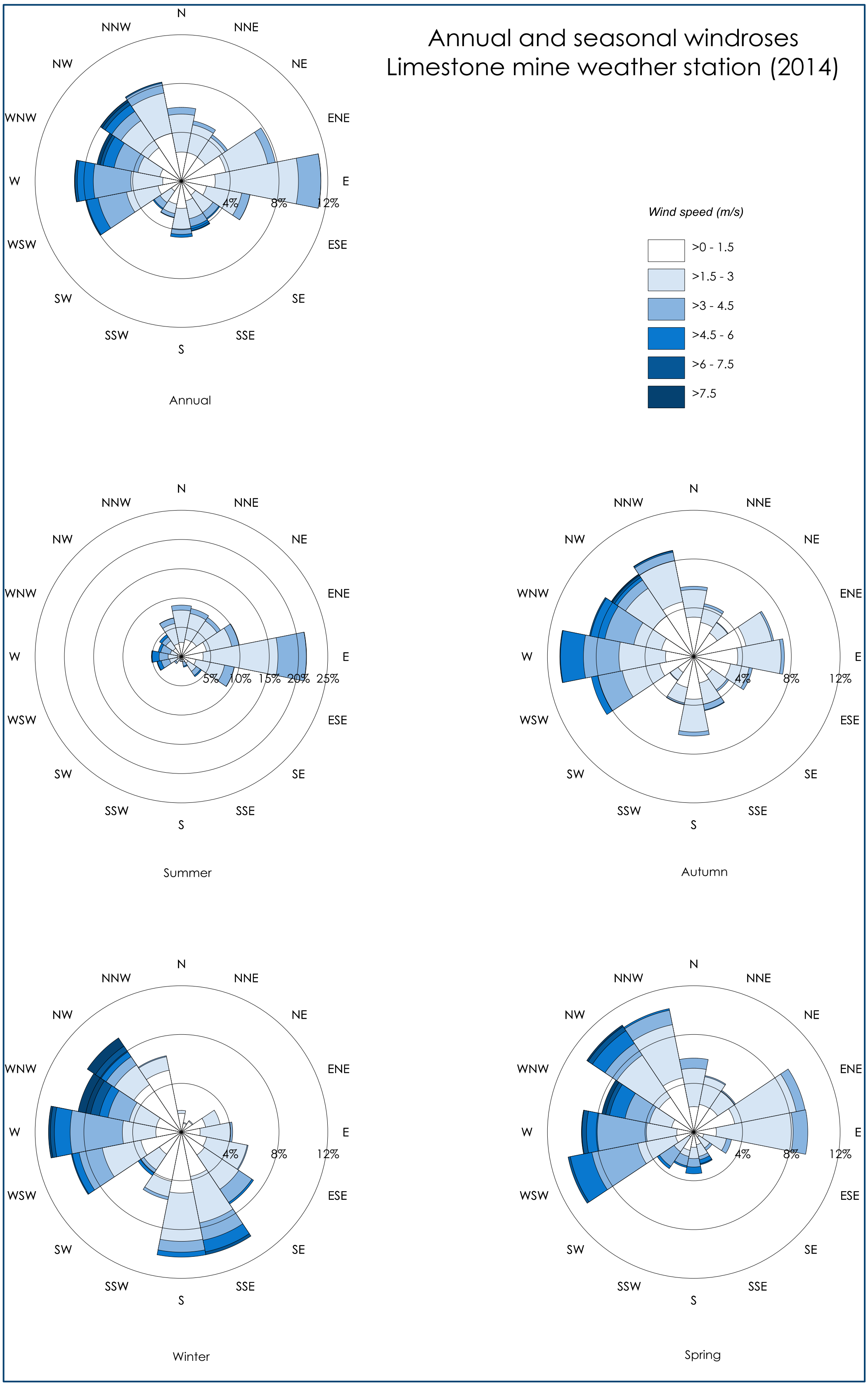


Figure 6-3: Annual and seasonal windroses for the Limestone mine weather station (2014)

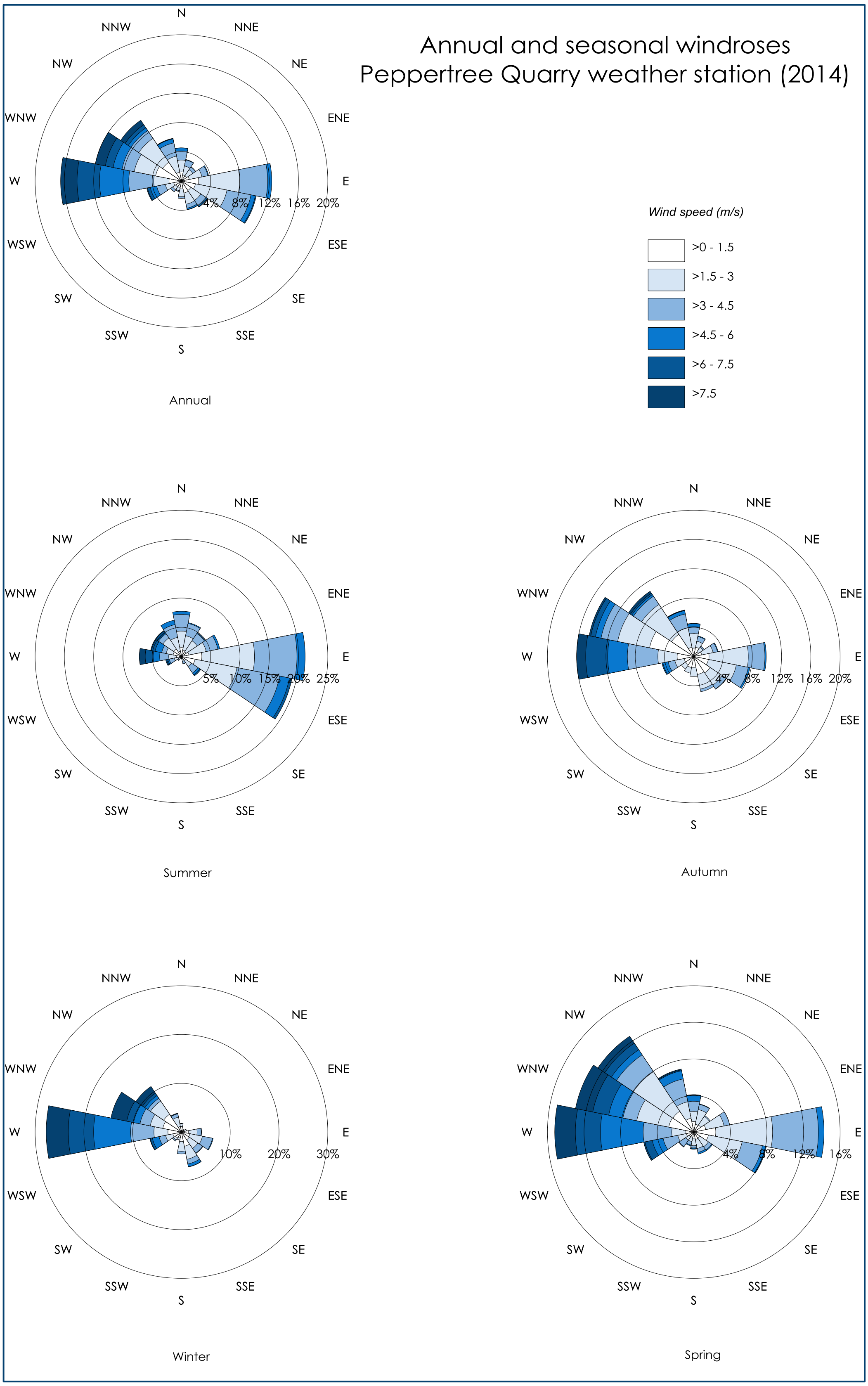


Figure 6-4: Annual and seasonal windroses for the Peppertree Quarry weather station (2014)

6.3 Local air quality monitoring

The main sources of air emissions in the wider area of the Project include extractive industries, commercial and industrial operations, agricultural activities, emissions from local anthropogenic activities (such as motor vehicle exhaust, dust from dirt roads, and domestic wood heaters) and various other rural activities.

This section reviews the available ambient monitoring data collected as part of the Marulan South Limestone Mine and Peppertree Quarry ambient air quality monitoring program between 2011 and 2017 to characterise the existing background levels of the surrounding area.

In addition to these data, the results from air quality monitors operated by the Lynwood Quarry located approximately 10km north-west of the Project and the NSW Office of Environment and Heritage (OEH) monitors at Wollongong and Bargo located approximately 73km north-east and 87km east-northeast of the Project respectively, have also been reviewed.

6.3.1 Air quality monitoring network description

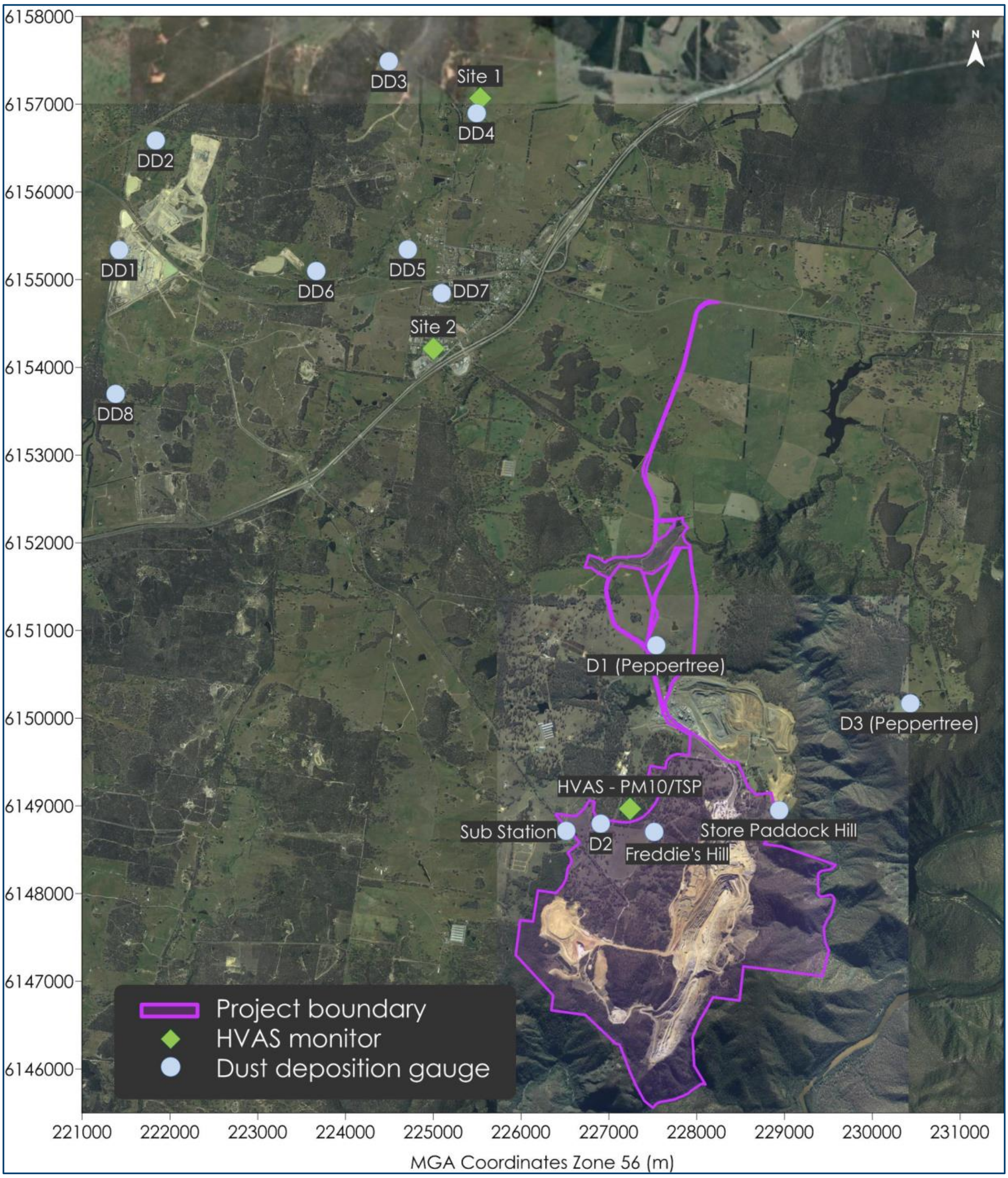
The air quality monitors operated as part of the Marulan South Limestone Mine and Peppertree Quarry air quality monitoring network include two High Volume Air Samplers (HVAS) measuring either TSP or PM_{10} and six dust deposition gauges.

The Lynwood Quarry operates two HVAS stations measuring PM_{10} and eight dust deposition gauges. The NSW OEH monitors ambient levels of PM_{10}, $PM_{2.5}$, NO_2, and SO_2 at Wollongong and Bargo.

Table 6-2 lists the monitoring stations reviewed in this section and **Figure 6-5** presents the approximate locations of these monitors.

Table 6-2: Summary of ambient monitoring stations

Monitoring site ID	Type
HVAS – PM_{10} (Marulan/Peppertree)	HVAS - PM_{10}
HVAS - TSP (Marulan/Peppertree)	HVAS - TSP
Sub Station (Marulan)	Dust Gauge
D2 (Marulan/Peppertree)	Dust Gauge
Freddie's Hill (Marulan)	Dust Gauge
Store Paddock (Marulan)	Dust Gauge
D1 (Peppertree)	Dust Gauge
D3 (Peppertree)	Dust Gauge
Site 1 (Lynwood)	HVAS - PM_{10}
Site 2 (Lynwood)	HVAS - PM_{10}
DD1 (Lynwood)	Dust Gauge
DD2 (Lynwood)	Dust Gauge
DD3 (Lynwood)	Dust Gauge
DD4 (Lynwood)	Dust Gauge
DD5 (Lynwood)	Dust Gauge
DD6 (Lynwood)	Dust Gauge
DD7 (Lynwood)	Dust Gauge
DD8 (Lynwood)	Dust Gauge
Wollongong (NSW OEH)	PM_{10}, $PM_{2.5}$, NO_2 & SO_2
Bargo (NSW OEH)	PM_{10}, $PM_{2.5}$, NO_2 & SO_2



Note: Wollongong and Bargo (NSW OEH) monitors not shown

Figure 6-5: Monitoring locations

6.3.2 PM_{10} monitoring

A summary of the results from the HVAS monitoring stations during 2011 to 2017 is presented in **Table 6-3** and **Figure 6-6**. The monitoring results in **Table 6-3** indicate that annual average PM_{10} levels at these monitors are below the criteria of 25µg/m^3 at all sites, the maximum 24-hour average PM_{10} concentrations were on occasion above the criteria of 50µg/m^3 during the monitoring period at the Marulan HVAS monitor.

The monitoring data indicate that levels are typically higher at the Marulan HVAS monitor compared to the Lynwood monitors. This may be due to the location of the Marulan HVAS monitor which is positioned close to the mining activities and near to a neighbouring lime processing facility that would influence the results. Due to its location, the monitor presents a conservative estimate of the actual conditions at the surrounding receiver locations.

It is also noted that the Site 2 – Lynwood monitor was subject to some technical difficulties and as a result recorded low levels (i.e. annual average levels less than 10µg/m^3) (**Holcim, 2017**).

It can be seen from **Figure 6-6** that PM_{10} concentrations recorded at the monitoring stations follow a seasonal trend and are nominally highest in the spring and summer months with the warmer weather raising the potential for drier ground elevating the occurrence of windblown dust, bushfires and pollen levels.

Table 6-3: PM_{10} levels from HVAS monitoring (µg/m^3)

Year	HVAS - Marulan(2)	Site 1 - Lynwood	Site 2 - Lynwood	Criterion
	Annual average			
2011(1)	-	-	-	25
2012	15.9	8.0	3.9	25
2013	13.8	10.0	-	25
2014	17.9	7.9	-	25
2015	23.7	12.1	-	25
2016	16.8	9.4	9.2	25
2017	24.8	9.1	12.6	25
	Maximum 24-hour average			
2011(1)	37.5	20.5	8.7	50
2012	**70.4**	38.1	11.8	50
2013	42.2	36.7	11.3	50
2014	**50.5**	20.6	18.2	50
2015	**158.3**	31.9	43.4	50
2016	**58.2**	23.2	21.9	50
2017	**64.7**	39.5	36.7	50
	Number of days >50µg/m^3			
2011(1)	0	0	0	-
2012	3	0	0	-
2013	0	0	0	-
2014	1	0	0	-
2015	5	0	0	-
2016	2	0	0	-
2017	4	0	0	-

(1)Data available from July 2011
(2)Data available till June 2017

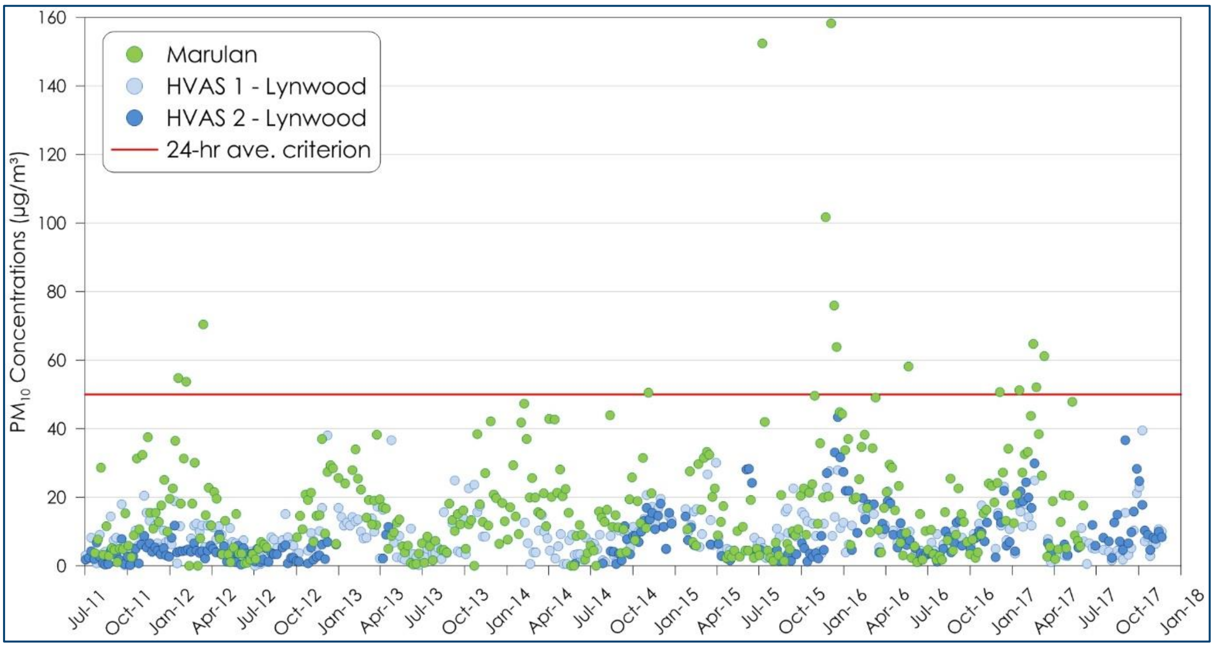


Figure 6-6: HVAS 24-hour average PM_{10} concentrations

A summary of the available PM_{10} data from January 2011 to December 2017 at the NSW OEH Wollongong and Bargo monitoring stations is presented in **Table 6-4**. Measured 24-hour average concentrations are presented graphically in **Figure 6-8**.

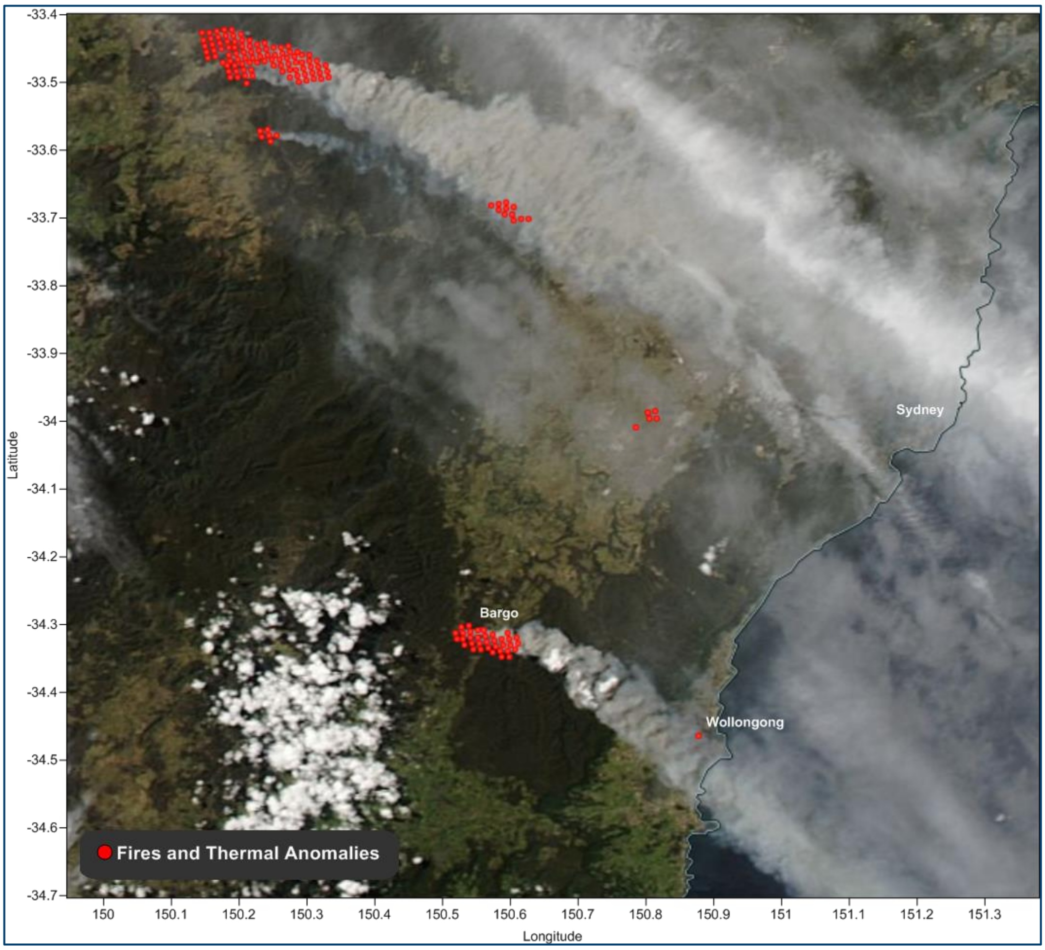
Table 6-4: Summary of PM_{10} levels from NSW OEH Wollongong and Bargo monitors (µg/m³)

Year	Wollongong	Bargo	Criterion
		Annual average	
2011	17.0	12.9	25
2012	18.0	14.3	25
2013	17.6	15.3	25
2014	17.7	14.5	25
2015	16.9	13.4	25
2016	17.3	14.4	25
2017	18.1	14.1	25
		Maximum 24-hour average	
2011	48.5	**89.7**	50
2012	47.5	45.2	50
2013	**93.8**	**208.9**	50
2014	45.3	**50.8**	50
2015	45.8	**52.2**	50
2016	**52.9**	**58.4**	50
2017	**55.2**	**53.5**	50
		Number of days >50µg/m³	
2011	0	1	-
2012	0	0	-
2013	6	2	-
2014	0	1	-
2015	0	2	-
2016	2	3	-
2017	1	1	-

A review of the data in **Table 6-4** indicates that the annual average PM_{10} concentrations recorded at the Wollongong and Bargo monitoring stations were below the relevant criterion of 25µg/m³ for all years reviewed.

The recorded maximum 24-hour average PM_{10} concentrations were found to exceed the relevant criterion of 50µg/m³ at times during the review period. Most notable is the recorded maximum 24-hour average at the Bargo monitoring on 17 October 2013 with a level of 208.9µg/m³. A large-scale bushfire event occurring nearby is identified as the likely main contributor to this reading.

Figure 6-7 presents satellite imagery which indicates the fire event and large smoke plumes affecting the area. The Wollongong monitor was also affected by this bushfire event which lasted for several days.



Source: **NASA, 2015**

Figure 6-7: Satellite imagery of 17 October 2013

Figure 6-8 shows a similar seasonal variation to the HVAS monitors, with higher levels during the warmer months recorded at the Wollongong and Bargo monitors.

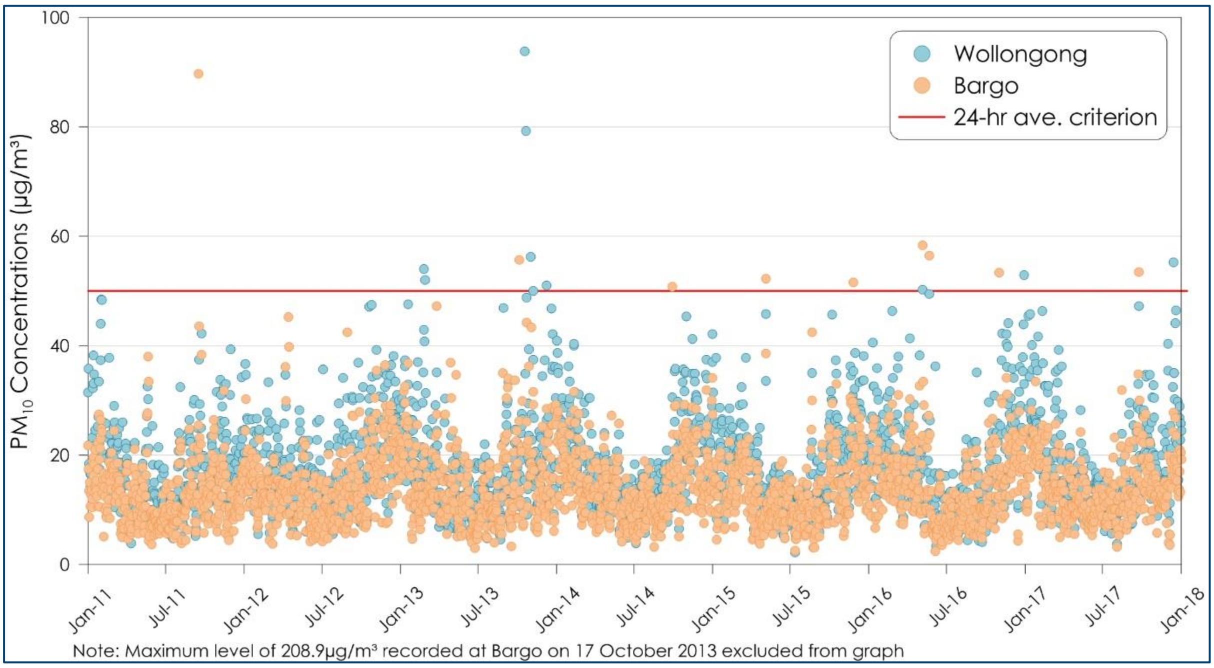


Figure 6-8: 24-hour average PM_{10} levels at Wollongong and Bargo

6.3.3 $PM_{2.5}$ monitoring

A summary of the available data from January 2011 to December 2017 at the NSW OEH Wollongong and Bargo monitoring stations is presented in **Table 6-5**. Measured 24-hour average concentrations are presented graphically in **Figure 6-9**.

A review of the data in **Table 6-5** indicates that the annual average $PM_{2.5}$ concentrations recorded at the Wollongong and Bargo monitoring stations were below the relevant criterion of 8µg/m³ for all years reviewed.

The recorded maximum 24-hour average $PM_{2.5}$ concentrations were found to exceed the relevant criterion of 25µg/m³ at times during the review period. Most notable is the recorded maximum 24-hour average at the Wollongong monitoring on 19 October 2013 with a level of 88.4µg/m³, which is likely associated with a large-scale bushfire event.

Table 6-5: Summary of $PM_{2.5}$ levels from NSW OEH Wollongong and Bargo monitors (µg/m³)

Year	Wollongong	Bargo	Criterion
		Annual average	
2011	4.6	-	8
2012	4.6	-	8
2013	7.7	-	8
2014	7.0	-	8
2015	7.6	-	8
2016	7.4	-	8
2017	7.1	6.3	8
		Maximum 24-hour average	
2011	17.7	-	25
2012	15.6	-	25
2013	**88.4**	-	25
2014	17.3	-	25
2015	**31.6**	-	25
2016	**33.7**	11.5	25
2017	24.7	20.9	25
		Number of days >25µg/m³	
2011	0	-	-
2012	0	-	-
2013	2	-	-
2014	0	-	-
2015	0	-	-
2016	0	0	-
2017	0	0	-

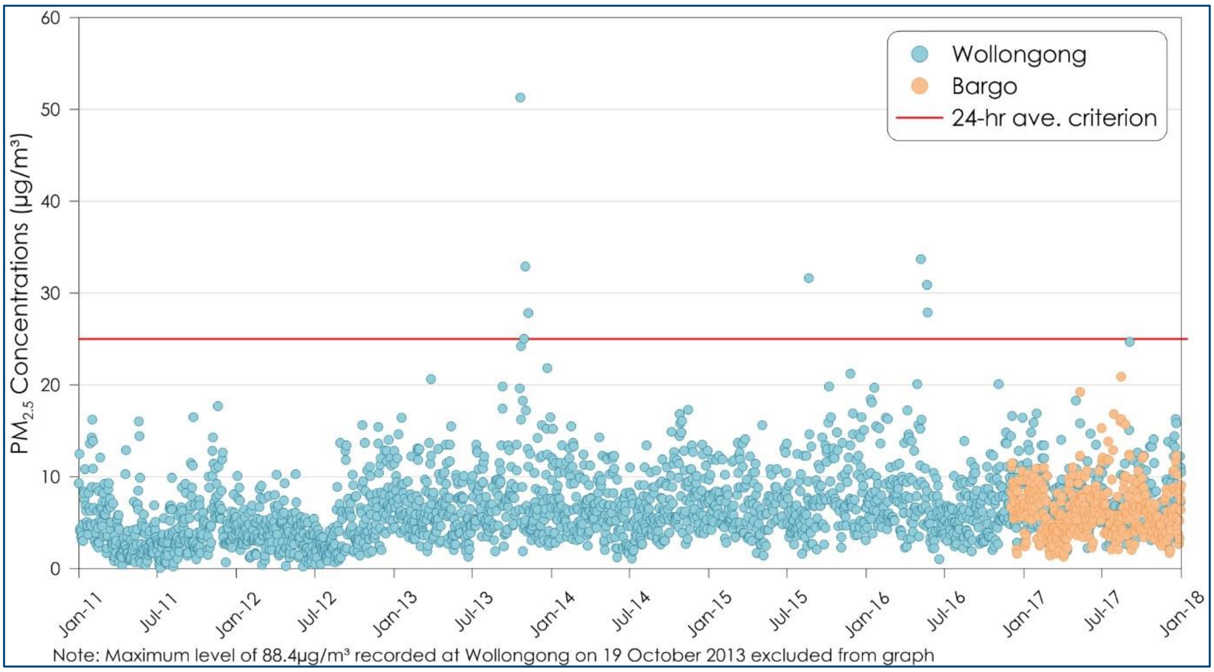


Figure 6-9: 24-hour average $PM_{2.5}$ levels at Wollongong and Bargo

6.3.4 TSP monitoring

The available TSP monitoring data collected between 2011 and 2017 are summarised in **Table 6-6** and presented in **Figure 6-10.**

The monitoring data summarised in **Table 6-6** indicate that the annual average TSP concentrations at the Marulan monitor were below the criterion of 90µg/m³.

Figure 6-10 shows that the 24-hour average TSP concentrations follow a similar seasonal trend to the PM_{10} monitoring data, with generally higher levels occurring during the spring and summer months. It should be noted that unlike PM_{10}, there is no applicable air quality criteria for 24-hour average TSP concentrations. The TSP dust metric is only assessed on an annual basis.

Table 6-6: TSP levels from HVAS monitoring (µg/m³)

Year	HVAS - Marulan	Criterion
	Annual average	
2011(1)	32.1	**90**
2012	31.4	**90**
2013	28.3	**90**
2014	39.5	**90**
2015	46.4	**90**
2016	38.8	**90**
2017(2)	52.1	**90**

(1)Data available from July 2011
(2)Data available till June 2017

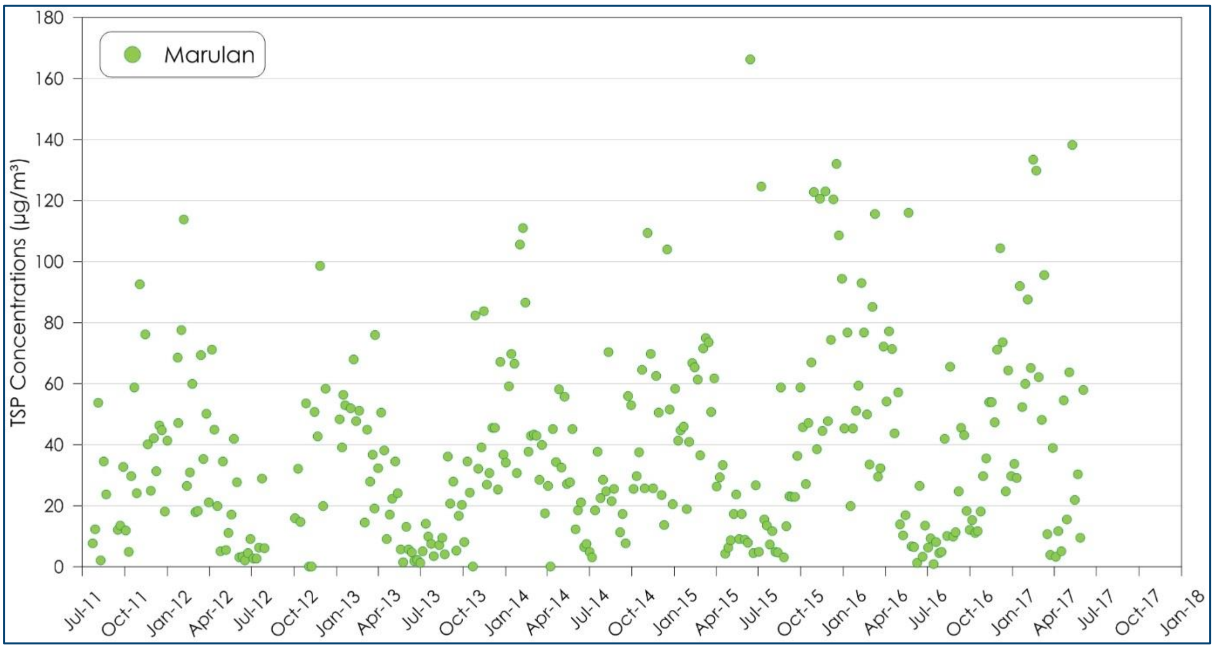


Figure 6-10: HVAS 24-hour average TSP concentrations

6.3.5 Dust deposition monitoring

The available annual average dust deposition levels recorded at Marulan/ Peppertree and Lynwood between 2012 and 2016 are summarised in **Table 6-7** and **Table 6-8**, respectively.

Many of the gauges are generally located in close proximity to the mining and quarrying activities (refer to **Figure 6-5**). These locations are likely to show the highest levels of deposited dust in the area due to their close proximity to dust sources, other sources such as traffic on unsealed roads and driveways and animal grazing would also contribute to the measured deposited dust levels. In this case, the measured dust deposition levels at these locations would not be representative of the sensitive receiver locations.

The dust gauges at Feddie's Hill, Store Paddock and D1 are all located approximately 500m from either the Project or neighbouring quarrying operations. The other dust gauges are located more than 1km from the Project or neighbouring quarrying operations and more than 500m from surrounding sensitive receivers.

The results in **Table 6-7** indicate the majority of dust gauges recorded annual average insoluble deposition levels below the criterion of 4g/m^2/month. As noted, the dust gauges that recorded generally higher levels are likely to be influenced by their location relative to the mining and quarrying activities (e.g. Freddie's Hill, Store Paddock and D1). Samples are also often contaminated with bird droppings and/or insects which can increase the insoluble solid content.

Table 6-7: Annual average dust deposition (insoluble solids) – Marulan / Peppertree (g/m^2/month)

Year	Annual average						
	Sub Station	Freddie's Hill	Store Paddock	D1	D2	D3	Criterion
2012	3.7	3.4	**7.0**	**6.8**	1.9	2.3	**4**
2013	2.5	3.3	3.6	**4.2**	2.2	2.8	**4**
2014	2.5	3.4	3.5	**4.5**	1.8	2.8	**4**
2015	3.2	3.1	4.0	-	2.6	-	**4**
2016	2.6	3.3	**7.5**	-	2.5	-	**4**

Table 6-8: Annual average dust deposition - Lynwood (g/m^2/month)

Year	Annual average								
	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	Criterion
2012	1.5	3.6	3.4	1.9	1.2	3.0	1.6	1.5	**4**
2013	0.6	1.0	**4.5**	0.6	0.6	2.1	0.7	0.6	**4**
2014	2.1	2.3	1.3	1.4	2.9	1.6	1.0	1.3	**4**
2015	1.5	**7.5**	2.9	2.0	2.9	2.5	0.9	1.1	**4**
2016	**5.9**	1.7	2.0	3.1	1.2	1.7	2.8	3.1	**4**

Source: **Holcim, 2017**

6.3.6 NO_2 monitoring

Figure 6-11 presents the maximum daily 1-hour average NO_2 concentrations from the NSW OEH Wollongong and Bargo monitoring stations from January 2011 to December 2017.

Ambient air quality monitoring data collected at these locations would include emissions from sources such as local power stations, industrial emissions, exhaust emissions from motor vehicles as well as various other combustion sources.

The monitoring data recorded at the monitors during this period are well below the 1-hour average goal of 246µg/m³. The data in **Figure 6-11** indicate that levels of NO_2 are relatively low compared to the criterion level and show some seasonal fluctuation.

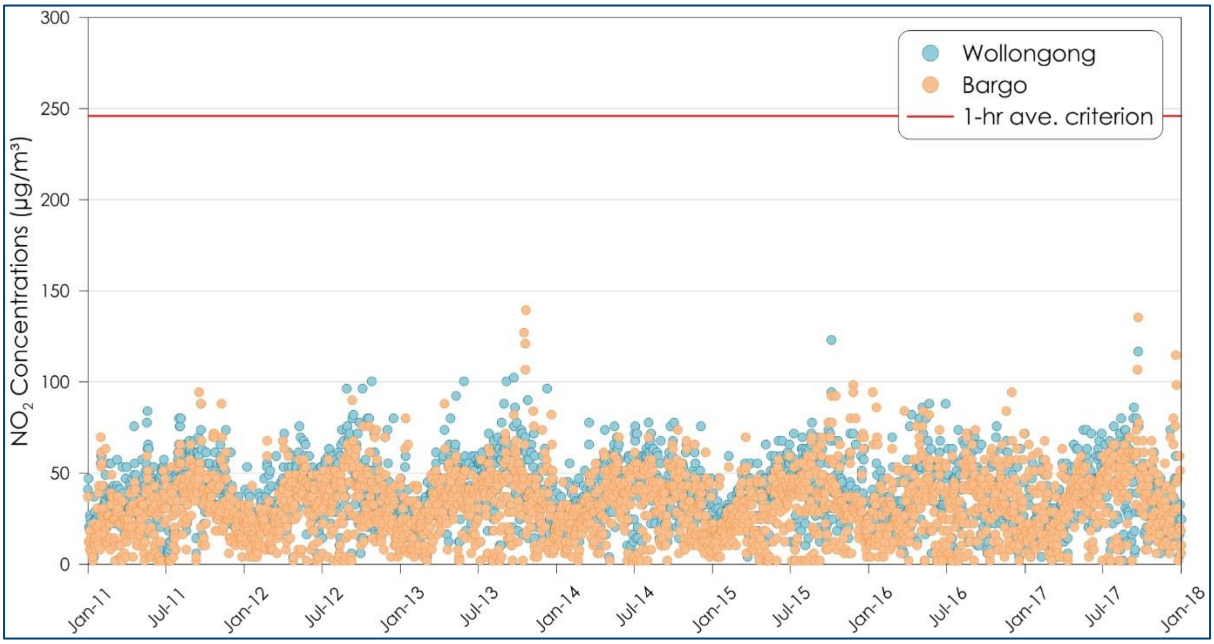


Figure 6-11: Daily 1-hour maximum NO_2 concentrations at Wollongong and Bargo

6.3.7 SO_2 monitoring

Figure 6-12 presents the maximum daily 1-hour average SO_2 concentrations from the NSW OEH Wollongong and Bargo monitoring stations from January 2011 to December 2017.

The monitoring data recorded at the monitors during this period are well below the 1-hour average goal of 570µg/m³. The data in **Figure 6-12** indicate that levels of SO_2 are very low compared to the criterion level with the Wollongong monitor recording slightly higher levels compared to Bargo which can generally be attributed to increased industrial emissions associated with the area.

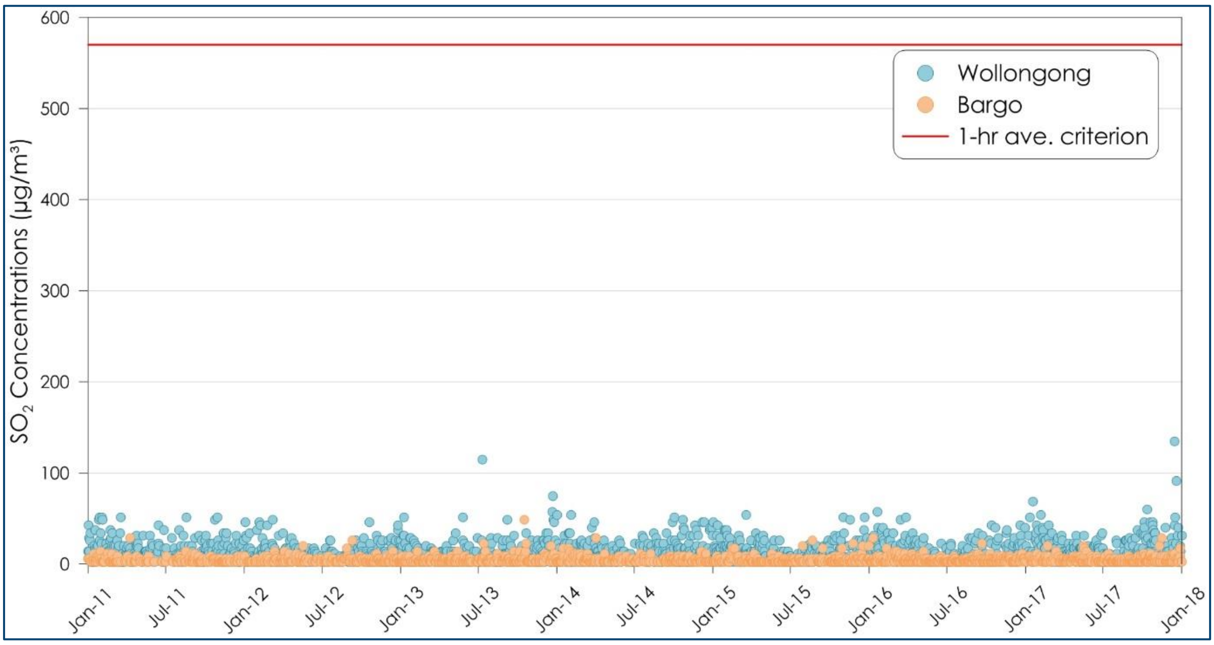


Figure 6-12: Daily 1-hour maximum SO_2 concentrations at Wollongong and Bargo

7 POTENTIAL CONSTRUCTION DUST EMISSIONS

The Project requires the construction of various infrastructure and associated facilities including the construction of the Marulan Creek Dam Wall, the realignment of the Marulan South Road, the relocation of the stockpile reclaim area, the construction of the road sales stockpile area and HV Powerline relocation. These construction activities associated with the Project have the potential to generate dust emissions.

Potential construction dust emissions will be primarily generated from material handling, vehicle movements and windblown dust from exposed areas. The operation of construction vehicles and plant will also generate exhaust emissions.

The potential particulate impacts due to these activities is difficult to accurately quantify on any given day due to the short sporadic periods of dust generating activity which may occur over the construction time frame. The sources of construction dust are temporary in nature and will only occur during the construction period which is estimated to take approximately two to four months for each of the infrastructure components.

The total amount of dust generated from the construction process is unlikely to be significant given the nature of the activities. As these activities would be generally located away from the sensitive receivers, any potential dust impacts would be unlikely to be discernible beyond the existing levels of dust in the area surrounding the Project. Given that the activities would occur for a limited period, no significant or prolonged effect at any off-site receiver is predicted to arise.

To ensure dust generation is controlled during the construction activities and the potential for off-site impacts is reduced, appropriate (operational and physical) mitigation measures in **Table 7-1** will be implemented as necessary.

Table 7-1: Construction dust mitigation measures

Source	Mitigation measure
General	Activities to be assessed during adverse weather conditions and modified as required (e.g. cease activity where reasonable levels of visible dust cannot be maintained)
	Engines of on-site vehicles and plant to be switched off when not in use
	Vehicles and plant are to be fitted with pollution reduction devices where practicable
	Vehicles are to be maintained and serviced according to manufacturer's specifications
	Visual monitoring of construction activities is to be undertaken to identify dust generation
Hauling material	Active haul roads are to be kept moist
	Public and private sealed haul roads are to be cleaned regularly
	Construction vehicle traffic is to be restricted to designated routes
	Construction speed limits are to be enforced
	Vehicle loads are to be covered when travelling off-site
	A wheel wash or rumble grids are to be established near exit points from construction sites onto Marulan South Road, to minimise mud/ dirt track out
Material handling	Drop heights from loading and handling equipment are to be reduced as much as practical
Exposed areas / stockpiles	The extent of exposed surfaces and stockpiles is to be kept to a minimum
	Exposed areas and stockpiles are to be dampened with water as far as is practicable if dust emissions are visible
	Disturbed areas are to be rehabilitated as soon as practicable after completion of works and in a staged manner

8 DISPERSION MODELLING APPROACH

8.1 Introduction

The following sections are included to provide the reader with an understanding of the dispersion model and modelling approach.

For this assessment the CALPUFF modelling suite is applied to dispersion modelling. The CALPUFF model is an advanced "puff" model which can deal with the effects of complex local terrain on the dispersion meteorology over the entire modelling domain in a three dimensional, hourly varying time step. CALPUFF is an air dispersion model approved by NSW EPA for use in air quality impact assessments. The model setup used is in general accordance with methods provided in the NSW EPA document *Generic Guidance and Optimum Model Setting for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia'* (**TRC**, **2011**).

As this location includes some significant terrain (a deep river valley near to the mine), the chosen modelling methodology was discussed with NSW EPA on 15 November 2015, as advised by the Approved methods. The EPA advised that the normal procedure for such modelling should be followed, which is as described in this section.

8.2 Modelling methodology

The dispersion modelling methodology applied in this assessment is the same as that applied in the Peppertree Quarry Modification 4 and 5 (**Todoroski Air Sciences, 2016 and 2018**) assessments using the CALPUFF modelling suite.

The CALMET meteorological modelling has been revised to incorporate the changes to the local terrain for the proposed modelling scenario which affect the local wind flows of the area. This assessment used the same meteorological conditions assessed in the Modification 4 and 5 assessments which were based on data for January 2014 to December 2014 from four surrounding monitoring sites.

The 2014 calendar year was selected as the meteorological year for the dispersion modelling to allow direct comparison with recent neighbouring assessments, but also because it is the most representative of typical conditions, based on the analysis of long-term data trends in meteorological data recorded for the area as outlined in **Appendix B**.

Dust emissions from each activity were represented by a series of volume sources and included in the CALPUFF model via an hourly varying emission file. Meteorological conditions associated with dust generation (such as wind speed) and levels of dust generating activity were considered in calculating the hourly varying emission rate for each source.

It should be noted that as a conservative measure, the effect of the precipitation rate (rainfall) in reducing dust emissions has not been considered in this assessment.

8.3 Modelling scenarios

This assessment considers three operational scenarios to represent the Project. The scenarios selected were chosen to represent potential worst-case impacts in regard to the quantity of material extracted in each year, the location of the operations occurring on-site and the potential to generate dust at the surrounding sensitive receivers.

The mining operations involve the stripping of overburden and the extraction of limestone and shale using open-cut hard rock conventional drill and blast techniques.

Overburden from stripping operations is emplaced in the various dedicated overburden emplacement areas located to the west, south and north of the mine pit with the rehabilitation of these overburden emplacements undertaken in stages as the emplacements progress. The overburden emplacement areas are known as the Western overburden emplacement (WOBE), Southern overburden emplacement (SOBE) and Northern overburden emplacement (NOBE). The active mining area and exposed areas are kept to a minimum for the efficiency of the operation and this also has a positive effect in minimising the potential dust levels generated from the operations.

Extracted limestone material is transported to stockpiles or the processing plant using haul trucks. The limestone material is crushed in various stages and conveyed to the main processing plant for further processing to make a range of products including aggregates, manufactured sand, quicklime and hydrated lime.

Products produced at the mine will continue to be despatched by road and rail, with the majority despatched by rail. The Project currently produces 500,000 tpa for Peppertree Quarry and proposes to increase production of manufactured sand to approximately 1,000,000 tpa. Limestone aggregate is also delivered to the road sales stockpile area where it is stockpiled before being loaded for delivery to customers. Clay shale is extracted at a rate of between 140,000 to 200,000 tpa for the various stages.

Peppertree Quarry currently has approval to emplace some of its overburden in the South Pit mine void. As the South Pit is required for the emplacement of over 30 million tonnes of overburden from the mine after the removal of accessible limestone, Boral proposes to emplace up to 15 million tonnes of overburden from Peppertree Quarry within the Northern Overburden Emplacement

The three worst-case operational scenarios that were developed for modelling assessment purposes occur during Stage 1, Stage 2 and Stage 3 of the 30-year continued mining operations. Indicative mine plan scenarios for each modelled stage are presented in **Figure 8-1** to **Figure 8-3**.

Stage 1:

- Limestone material is extracted from the pit and transported to the primary crusher;
- The entire limestone processing plant is operational;
- Overburden material is transported to either the lower benches of the southern half of the WOBE, south-eastern (in pit) portion of the SOBE or the southern portion of the NOBE;
- The distribution of overburden during this stage is as follows: approximately 31% emplaced in the WOBE, 53% in the SOBE and 16% in NOBE; and,
- Overburden from the Peppertree Quarry is also emplaced in the northern portion of the NOBE during this stage at a rate of approximately 3.1Mtpa.

This scenario is representative of overburden being emplaced in all of the WOBE, SOBE and NOBE locations.

Stage 2:

- Limestone material is extracted from the pit and transported to the primary crusher;
- The entire limestone processing plant is operational;
- Overburden material is transported to either the upper benches of the southern half of the WOBE or south-eastern (out of pit) portion of the SOBE;
- The distribution of overburden during this stage is as follows: approximately 87% emplaced in the WOBE and 13% in the SOBE; and,
- The NOBE is complete in this stage and overburden emplacement from the Peppertree Quarry has ceased.

This scenario is representative of maximum overburden emplacement occurring in the WOBE.

Stage 3:

- Limestone material is extracted from the pit and transported to the primary crusher;
- The entire limestone processing plant is operational;
- Overburden material is transported to either the northern half of the WOBE or the central portion of the SOBE; and,
- The distribution of overburden during this stage is as follows: approximately 74% emplaced in the WOBE and 26% in the SOBE.

This scenario is representative of maximum overburden being emplaced in the WOBE in the area to the north of Marulan South Road.

Stage 4 has not been modelled in this assessment as the overburden emplacement only occurs in the SOBE and limestone extraction reduces slightly from 4Mtpa down to 3.8Mtpa. Potential air quality impacts at surrounding sensitive receiver locations would therefore be lower compared to the other modelled stages.

The modelled operations represent a potential worst-case scenario with regard to dust generation and incorporate the proposed maximum amount of material handled per annum during each of these stages and at the closest location to sensitive receivers. For all scenarios, the limestone extraction and overburden activity is set to occur on a rotating cycle of three and half days per week for each activity to account for the proposed campaign nature of the operations with either limestone extraction or overburden activity being the major focus depending on market demands. All other operations at the Project including limestone processing occur 24-hours per day, seven days per week.

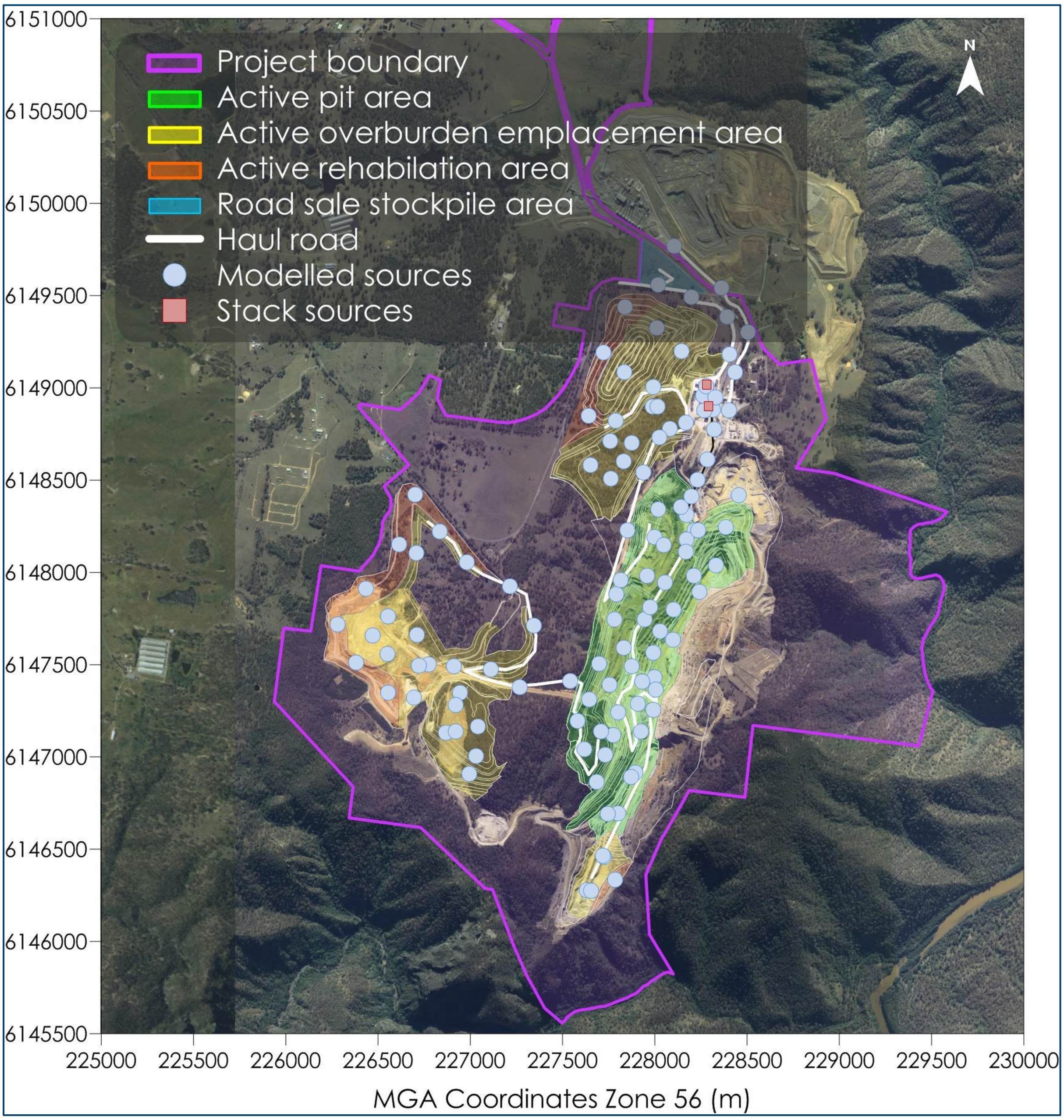


Figure 8-1: Worst-case operational scenario – Stage 1

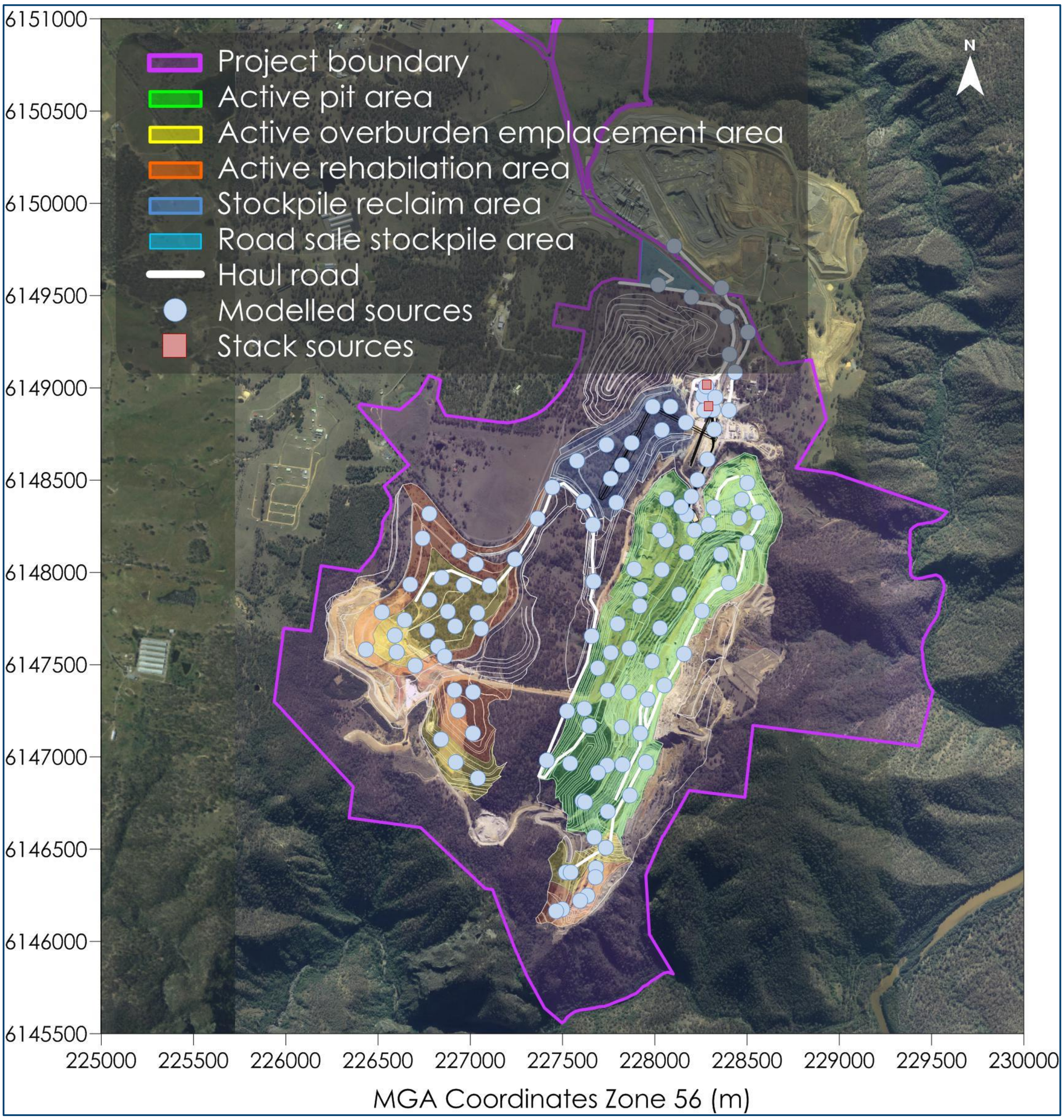


Figure 8-2: Worst-case operational scenario – Stage 2

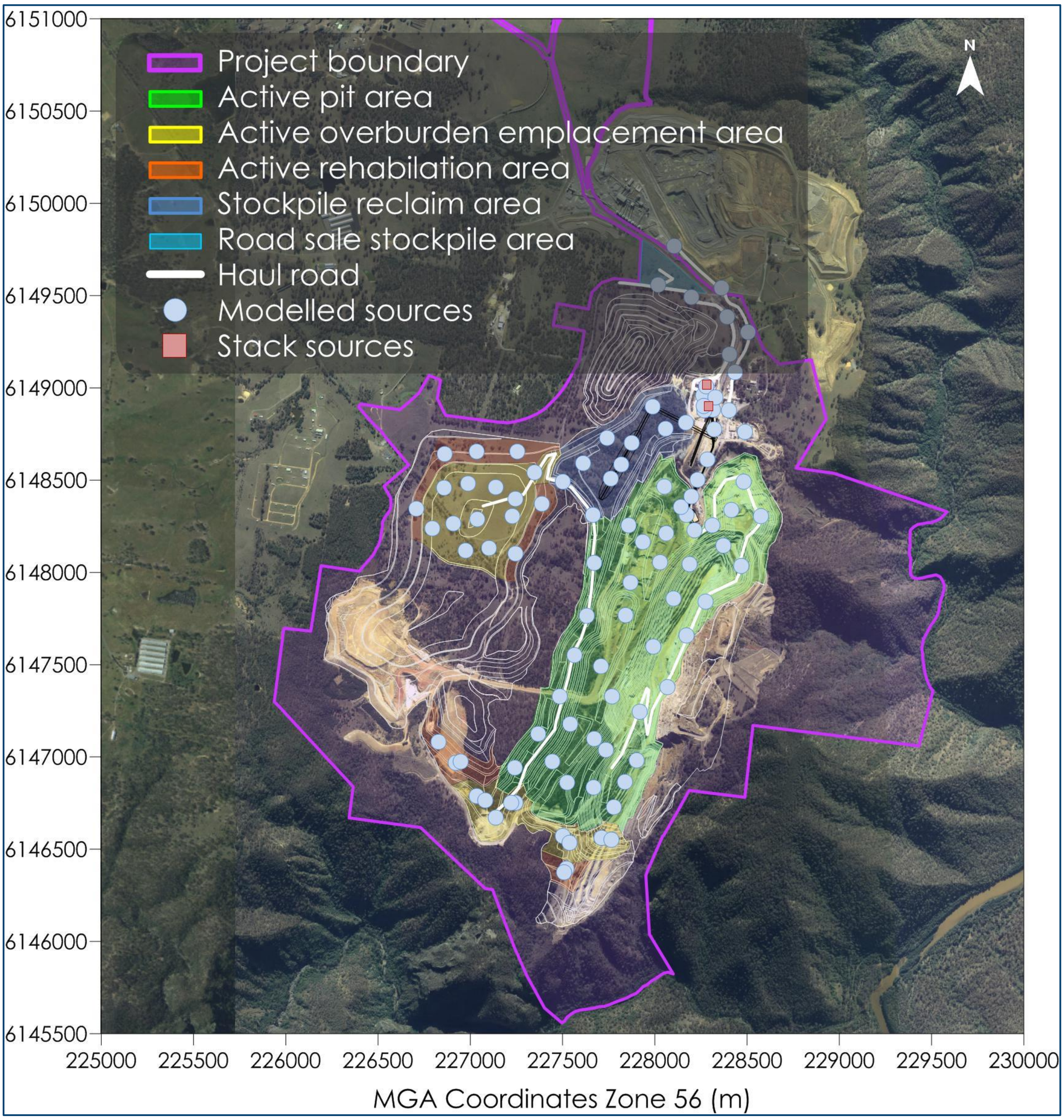


Figure 8-3: Worst-case operational scenario – Stage 3

8.4 Emissions estimation

For the modelled scenario, dust emission estimates have been calculated by analysing the various types of dust generating activities taking place and utilising suitable emission factors.

8.4.1 Mining and processing activity emissions

The emission factors were sourced from both locally developed and United States Environmental Protection Agency (US EPA) developed documentation. Total dust emissions from all significant dust generating activities for the Project are presented in **Table 8-1**. Detailed emission inventories and emission estimation calculations are presented in **Appendix C**.

The estimated emissions presented in **Table 8-1** are commensurate with an operation utilising reasonable and feasible best practice dust mitigation applied where applicable.

Table 8-1: Estimated TSP emissions for the Project - mining activities (kg/year)

Activity	Stage 1	Stage 2	Stage 3
Stripping topsoil with dozer	10,144	10,144	10,144
Loading topsoil to haul truck	5	5	5
Hauling topsoil to emplacement area	171	253	185
Emplacing topsoil at area	5	5	5
Loading OB to haul truck	6,214	6,214	7,824
Hauling to emplacement area - WOBE	40,580	141,564	111,066
Hauling to emplacement area - SOBE	38,816	9,421	18,993
Hauling to emplacement area - NOBE	17,087	-	-
Emplacing overburden - WOBE	1,932	5,409	5,796
Emplacing overburden - SOBE	3,316	805	2,029
Emplacing overburden - NOBE	966	-	-
Dozers on emplacement and rehab	47,149	45,958	57,864
Loading shale to haul truck	225	225	225
Hauling shale to stockpile area	2,239	2,239	2,239
Emplacing at shale stockpile area	225	225	225
Drilling	4,354	4,354	4,354
Blasting	1,743	1,743	1,743
Loading LS to haul truck	9,660	9,660	9,660
Hauling LS to primary crusher	104,675	156,289	151,626
Unloading LS to stockpile	9,660	9,660	9,660
Loading LS from stockpile to primary crusher	9,660	9,660	9,660
Primary crushing	16,600	16,600	16,600
Conveying from primary to secondary crusher	84	84	84
Secondary crushing	16,600	16,600	16,600
Conveying from secondary crusher to transfer	179	179	179
Conveying from transfer to stockpile	841	841	841
Transfer	2,898	2,898	2,898
Unloading at stockpile	6,400	6,400	6,400
Loading from stockpile	3,864	3,864	3,864
Conveying from stockpile to transfer	841	841	841
Transfer to plant	2,898	2,898	2,898
Conveying from transfer to plant	399	399	399
Transfer to surge bin	2,898	2,898	2,898
Screening	12,000	12,000	12,000
Transfer to bin 7/8 (Berrima)	1,884	1,884	1,884
Trommel Screening	4,200	4,200	4,200
Unloading from Trommel screen to kiln stockpile	1,120	1,120	1,120
Loading from kiln stockpile to kiln	8,400	8,400	8,400
Transfer to bins 1/4	203	203	203
Tertiary crushing	9,296	9,296	9,296

Activity	Stage 1	Stage 2	Stage 3
Tertiary screening	73	73	73
Transfer to bins 5/6	811	811	811
Loading to Trains for dispatch off-site	1,220	1,220	1,220
Loading to Truck for dispatch off-site	2,294	2,294	2,294
Hauling product from Marulan to off-site	4,998	4,998	4,998
Hauling product from Marulan to Peppertree	8,195	8,195	8,195
Hauling product from Marulan to shared road sale stockpile area	450	450	450
Unloading material at shared road sale stockpile area	121	121	121
WE - Overburden emplacement areas - WOBE	26,280	73,584	78,840
WE - Overburden emplacement areas - SOBE	45,114	10,950	27,594
WE - Overburden emplacement areas - NOBE	13,140	-	-
WE - Active Revegetation	40,986	58,352	32,650
WE - Open pit	252,288	287,328	318,864
WE - Stockpiles - Infrastructure Area and Stockpile	21,585	21,585	21,585
WE - Reclaim stockpiles	9,115	9,115	9,115
Grading roads	23,723	23,723	23,723
Total emissions	**850,820**	**1,008,235**	**1,025,438**

LS = limestone, WE = wind erosion

8.4.2 Processing activity stack emissions

The air emissions associated with the mine's processing facilities were calculated based on the measured data from stack emission testing reports and the emission point parameters provided by Boral. The average plus the standard deviation of the measured levels from the testing conducted during 2013 to 2016 for the Lime hydration plant stack and Kiln stack have been applied in the modelling for all hours of the year to represent a likely worst-case operating scenario, **Table 8-2** summarises the modelling inputs for the stack emission sources.

Table 8-2: Stack parameters for Lime hydration plant and Kiln

Parameter	Unit	Lime hydration plant	Kiln
Stack height	m	21.0	31.5
Stack diameter	m	0.9	1.3
Exit velocity	m/s	6.3	13
Temperature	K	351	473
TSP	g/s	0.03	1.2
PM_{10}	g/s	0.01	0.3
$PM_{2.5}$	g/s	0.01	0.1
NO_X	g/s	-	11.2
SO_X	g/s	-	0.1

Typically, due to the relatively low pressure in the combustion process, the NO_X emissions emitted from a kiln consist for the larger part (~95 per cent) of nitrogen monoxide (NO) and for a small part (~5 per cent) of NO_2. After emission from the stack, NO is converted to NO_2 through oxidation with atmospheric ozone (O_3) (**Janssen et al., 1988**). The rate of this reaction is governed by the level of ozone in the air, air dispersion and other meteorological factors such as temperature. The reactions are complicated and most pronounced in urban areas with high ozone and other levels of pollution which do not generally arise at the Project.

This assessment has conservatively assumed that all NO_X emissions from the operations would be emitted as NO_2. The predicted results are therefore likely to overestimate the actual impacts significantly (potentially up to 10 or 20 times higher than may actually occur) and provide an indication of a worst case impact. Similarly, SO_X emissions from the operations are assumed to be emitted as SO_2.

8.4.3 Emissions from other nearby operations

In addition to the estimated dust emissions from the Project, the adjacent Peppertree Quarry has been included in the modelling to assess potential for cumulative dust effects. The emissions estimates include the modified Quarry operations included in the recent Peppertree Quarry's Modification 5.

Other activities in the local area include an agricultural lime production facility. This is a relatively small operation, and the background data (HVAS) monitor is located within approximately 300m of the activity. This background data would capture any significant environmental emissions associated with this facility, hence it has not been explicitly modelled.

Table 8-3 summarises the emissions adopted in this assessment for the modelled scenario.

Table 8-3: Estimated emissions from nearby quarry operations (kg/year)

Quarry operation	Stage 1	Stage 2	Stage 3
Peppertree Quarry	402,700	264,096	264,096

Additionally, there would be numerous smaller or very distant sources that contribute to the total background dust level. Modelling these non-mining sources explicitly is impractical, however the residual level of dust attributable to all other such non-modelled sources has been included in the cumulative results.

8.5 Cumulative assessment – accounting for other non-modelled sources

To account for sources not explicitly included in the model, and to fully account for all cumulative dust levels, the unaccounted fractions of background dust levels (which arise from the other non-modelled sources), were added to the annual average model predictions.

The contribution of background dust levels was estimated by modelling the past (known) mining and quarrying activities during 2014 and comparing model predictions with the actual measured data from the corresponding monitoring stations. The average difference between the measured and predicted PM_{10}, TSP and deposited dust levels from each of the monitoring points was considered to be the contribution from other non-modelled dust sources.

In this case, the estimated background levels for TSP, PM_{10} and deposited dust are identical to the levels applied in the Peppertree Quarry Modification 4 and 5 assessment (**Todoroski Air Sciences, 2016 & 2018**).

In the absence of available $PM_{2.5}$ monitoring data for the area, an estimate of background levels was calculated based on the assumption that an annual average $PM_{2.5}$ concentration of 8µg/m^3 is equivalent to an annual average PM_{10} concentration of 25µg/m^3. Thus considering that the existing PM_{10} level is 11µg/m^3, the calculated $PM_{2.5}$ level to account for non-modelled sources, as applied in this assessment is 3.5µg/m^3.

Table 8-4 outlines the estimated annual average contribution from other non-modelled dust sources for the area surrounding the Project.

Table 8-4: Estimated annual average contribution from other non-modelled dust sources

Pollutant	Background level	Unit
TSP	27.0	µg/m³
PM_{10}	11.0	µg/m³
$PM_{2.5}$	3.5	µg/m³
Dust deposition	2.8	g/m²/month

For the process stack emissions, background pollutant levels have been conservatively estimated from the available monitoring data recorded at the Wollongong and Bargo monitors during 2014. The average level from these monitors has been assumed as the background level for the area surrounding the Project.

The monitoring data from the Wollongong and Bargo monitoring stations are representative of a more densely populated area with greater influences of anthropogenic sources compared to the area surrounding the Project. The monitoring data therefore would provide a conservative assessment of potential cumulative impacts for the area surrounding the Project.

Table 8-5 outlines the estimated background NO_2 and SO_2 levels for the area surrounding the Project.

Table 8-5: Estimated background levels – NO_2 and SO_2

Averaging period	NO_2	SO_2	Unit
1-hour	75.9	41.5	µg/m³
Annual	35.0	8.6	µg/m³

8.6 Best practice operational dust mitigation measures

The mine has considered the possible range of air quality mitigation measures that are feasible and can be applied to achieve a standard of mine operation consistent with current best practice for the control of dust emissions from coal mines in NSW, as outlined in the NSW EPA document, *NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining*, prepared by Katestone Environmental (**Katestone Environmental, 2010**).

A summary of the key current dust controls, which would continue to be applied for the Project, is shown in **Table 8-6**. Where applicable, these controls have been applied in the dust emission estimates shown in **Table 8-3**. Further detail on the level of control applied is set out in **Appendix C**.

Table 8-6: Best practice dust mitigation measures

Activity	Dust Control
Hauling on unsealed roads	✦ Watering roads ✦ Use the largest practical truck size ✦ Road edges to be clearly defined by the use of bunding for safety and to limit haul road width ✦ Obsolete roads will be ripped and re-vegetated as soon as practical ✦ Site speed restriction is 40kmh

Activity	Dust Control
Hauling on sealed roads	✦ Keep roads maintained ✦ Regular cleaning with road sweeper ✦ Covering of all loads leaving the mine ✦ Site speed restriction is 40kmh ✦ Wheel wash / full truck wash system with auto shut off
Drilling	✦ Well maintained dust filtration systems ✦ Cease operations if systems are not operating properly resulting in excessive visible dust ✦ Take care not to disturb drill cuttings
Blasting	✦ Meteorological conditions assessed prior to blasting ✦ Adequate stemming
Bulldozer activity	✦ Dozers travel on watered routes between work areas ✦ Modify activities during periods of high visible dust ✦ Modify activities during high winds
Loading/unloading material	✦ Minimise drop heights ✦ Modify activities during periods of high visible dust ✦ Modify activities during high winds
Crusher	✦ Regular cleaning/ housekeeping in and around buildings ✦ Regular servicing and inspection of dust cyclone ✦ Water sprays at tipping hopper
Conveyor and transfers	✦ Water sprays at certain transfer points ✦ Belt cleaning and spillage minimisation ✦ Belt Enclosures ✦ Regular cleaning
Wind erosion on overburden emplacements, stockpiles and exposed surfaces	✦ Profiling of surfaces to reduce wind speed over surface ✦ Contouring of stockpiles and overburden emplacements where practical to avoid strong wind flows and smooth gradients to reduce turbulence at surface ✦ Rehabilitation as soon as practical ✦ Review weather conditions and modify activities to minimise overburden emplacement and stockpile disturbance during adverse conditions ✦ Watering of overburden emplacements entry and tipping points with water cart
Road grading	✦ Watering grader routes
Train loading	✦ Enclosed ✦ Use of water sprays whilst loading train wagons ✦ Regular cleaning of spillage in loading areas
General	✦ Daily/weekly use of forecast weather conditions to evaluate any impacts these may have on dust control or generation

9 DISPERSION MODELLING RESULTS

The dispersion model predictions for each of the assessed scenarios is presented in this section. The results presented include those for the operation in isolation (incremental impact) and cumulative impacts with the operation of other sources and background levels.

9.1 Mining and process dust modelling results

The results show the estimated:

- Maximum 24 hour average $PM_{2.5}$ and PM_{10} concentrations;
- Annual average $PM_{2.5}$ and PM_{10} concentrations;
- Annual average TSP concentrations; and,
- Annual average dust (insoluble solids) deposition rates.

It is important to note that when assessing impacts per the maximum 24-hour average $PM_{2.5}$ and PM_{10} criteria, the predictions show the highest predicted 24-hour average concentrations that were modelled at each point within the modelling domain for the worst day (a 24-hour period) in the one year long modelling period. When assessing the total (cumulative) 24-hour average impacts based on model predictions, challenges arise with identification and quantification of emissions from non-modelled sources over the 24-hour period. Due to these factors, the 24-hour average impacts need to be calculated differently to annual averages and as such, the predicted total (cumulative) impacts for maximum 24-hour average $PM_{2.5}$ and PM_{10} concentrations have been addressed specifically in **Section 9.3**.

Each of the sensitive receivers shown in **Figure 2-1** and detailed in **Appendix A** were assessed individually as discrete receptors with the predicted results presented in tabular form for the assessed scenario.

In the tables of results, receptors are labelled according to the type of receptor, as follows:

- R - Residential receiver (privately-owned);
- C - Commercial receiver;
- B - Residential receiver (Boral owned); and,
- PR - Proposed residential dwelling (privately-owned).

Residential receivers are privately-owned locations and considered the most sensitive to potential environmental air quality impacts compared to the other receptor locations. Commercial receivers are identified as places of work with people unlikely to reside for extended periods. Boral-owned residential receivers are likely to be already subject to environmental impacts due to the existing operations. The proposed residential dwelling is similar to a residential receiver, however is not yet constructed.

Associated isopleth diagrams of the dispersion modelling results are presented in **Appendix D**.

9.2 Modelling predictions – incremental impact

9.2.1 Stage 1

Table 9-1 presents the predicted particulate dispersion modelling results for the incremental impact at each of the assessed sensitive receiver locations during Stage 1.

No exceedances of the criteria for dust deposition are predicted at any receiver due to emissions from the Project alone. The results do not indicate significant dust due to the Project alone at the privately-owned sensitive receiver locations (Receiver 1 to 17) during Stage 1.

Note the proposed residential dwelling (see **Table 9-1**) does not actually exist at this time. As a conservative measure potential impacts at this potential future dwelling have been considered on the basis of the modelled levels at the existing receivers located substantially closer to the Project where impacts would be higher.

Table 9-1: Incremental modelling predictions for the Project– Stage 1

Receiver ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average
	Air quality impact criteria					
	-	-	-	-	-	2
R1	1.1	0.0	6.2	0.2	0.4	0.01
R2	1.7	0.1	8.3	0.4	0.6	0.01
R3	2.1	0.1	11.2	0.6	0.8	0.01
R4	2.1	0.1	10.1	0.7	1.1	0.02
R5	2.4	0.2	10.3	1.1	1.7	0.03
R6	1.9	0.2	9.4	1.1	1.7	0.03
R7	3.5	0.4	14.2	1.9	3.0	0.05
R8	4.2	0.5	19.7	2.7	4.4	0.07
R9	4.7	0.7	18.8	3.7	6.2	0.10
R10	4.0	0.4	16.7	2.2	3.7	0.06
R11	3.8	0.5	16.8	2.7	4.5	0.06
R12	5.9	0.9	25.6	4.5	8.1	0.12
R13	0.6	0.0	3.9	0.1	0.2	0.00
R14	0.9	0.1	6.1	0.4	0.7	0.01
R15	0.7	0.1	3.6	0.5	0.8	0.02
R16	0.7	0.1	3.7	0.5	0.9	0.02
R17	0.9	0.1	5.3	0.8	1.3	0.03
B1	2.4	0.1	12.6	0.6	0.9	0.01
B2	2.7	0.2	14.7	1.1	1.7	0.03
B3	5.4	1.0	29.1	5.0	8.6	0.14
B4	8.5	1.9	56.0	10.2	18.5	0.31
B5	9.5	2.0	38.6	10.2	18.8	0.30
B6	1.0	0.1	7.1	0.6	1.1	0.02
B7	1.1	0.2	6.4	0.9	1.6	0.04
C1	6.9	1.1	45.3	5.8	9.9	0.17
C2	4.5	0.6	18.4	2.9	4.8	0.08
C3	6.3	1.0	25.2	5.0	8.7	0.14
PR*	4.5	0.6	18.4	2.9	4.8	0.08

*Impact is conservatively assumed to be the same as that at Receiver C2.

9.2.2 Stage 2

Table 9-2 presents the predicted particulate dispersion modelling results for the incremental impact at each of the assessed sensitive receiver locations during Stage 2.

No exceedances of the criteria for dust deposition are predicted at any assessed receiver due to emissions from the Project alone. The results do not indicate significant dust due to the Project alone at the privately-owned sensitive receiver locations (Receiver 1 to 17) during Stage 2.

Table 9-2: Incremental modelling predictions for the Project– Stage 2

Receiver ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average
	Air quality impact criteria					
	-	-	-	-	-	2
R1	1.1	0.0	6.3	0.3	0.4	0.01
R2	1.8	0.1	9.7	0.5	0.8	0.01
R3	2.1	0.1	12.0	0.6	1.0	0.02
R4	2.1	0.1	11.0	0.8	1.3	0.02
R5	2.3	0.2	11.7	1.2	2.0	0.03
R6	1.9	0.2	10.9	1.3	2.2	0.04
R7	3.1	0.4	15.5	2.0	3.5	0.06
R8	3.7	0.5	20.9	2.7	4.8	0.09
R9	3.3	0.6	20.9	3.7	6.5	0.11
R10	4.7	0.5	22.7	2.8	5.1	0.08
R11	4.2	0.5	22.5	3.1	5.7	0.09
R12	6.0	0.9	32.4	5.0	9.5	0.16
R13	0.6	0.0	3.8	0.1	0.2	0.00
R14	1.0	0.1	6.9	0.4	0.7	0.01
R15	0.7	0.1	4.1	0.5	0.9	0.02
R16	0.7	0.1	4.2	0.6	1.0	0.02
R17	0.9	0.1	5.4	0.8	1.4	0.03
B1	2.2	0.1	12.5	0.7	1.0	0.02
B2	2.8	0.2	15.9	1.2	2.0	0.04
B3	4.9	0.8	30.7	4.9	8.7	0.16
B4	8.0	1.6	55.4	9.7	18.1	0.31
B5	8.1	1.7	49.4	10.9	21.5	0.40
B6	1.1	0.1	8.2	0.7	1.1	0.02
B7	1.0	0.2	6.2	0.9	1.7	0.04
C1	6.8	0.9	45.8	5.4	9.6	0.17
C2	3.4	0.5	17.8	2.9	5.2	0.09
C3	4.4	0.8	25.2	5.0	9.0	0.16
PR*	3.4	0.5	17.8	2.9	5.2	0.09

*Impact is conservatively assumed to be the same as that at Receiver C2.

9.2.3 Stage 3

Table 9-3 presents the predicted particulate dispersion modelling results for the incremental impact at each of the assessed sensitive receiver locations during Stage 3.

No exceedances of the criteria for dust deposition are predicted at any assessed receiver due to emissions from the Project alone. The results do not indicate significant dust due to the Project alone at the privately-owned sensitive receiver locations (Receiver 1 to 17) during Stage 3.

Table 9-3: Incremental modelling predictions for the Project– Stage 3

Receiver ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average
	Air quality impact criteria					
	-	-	-	-	-	2
R1	1.2	0.1	6.8	0.3	0.4	0.01
R2	2.1	0.1	11.2	0.5	0.8	0.01
R3	2.5	0.1	13.6	0.6	1.1	0.02
R4	2.4	0.1	11.7	0.8	1.3	0.02
R5	2.5	0.2	11.6	1.2	2.0	0.03
R6	2.5	0.2	13.6	1.3	2.3	0.04
R7	3.6	0.4	16.2	2.1	3.7	0.06
R8	4.3	0.5	21.7	2.8	4.9	0.09
R9	4.4	0.7	21.0	3.9	6.9	0.13
R10	4.1	0.5	18.7	2.8	5.1	0.08
R11	3.6	0.5	16.5	2.9	5.1	0.07
R12	5.3	0.8	23.3	4.5	8.2	0.13
R13	0.6	0.0	4.1	0.1	0.2	0.00
R14	0.9	0.1	6.6	0.4	0.8	0.01
R15	0.7	0.1	4.1	0.5	0.9	0.02
R16	0.7	0.1	4.3	0.6	1.1	0.02
R17	1.1	0.1	6.6	0.8	1.5	0.04
B1	2.4	0.1	13.3	0.7	1.1	0.02
B2	3.4	0.2	16.6	1.2	2.1	0.04
B3	5.9	0.9	32.2	5.3	9.4	0.19
B4	8.5	1.8	55.9	10.5	19.6	0.35
B5	Receptor no longer exists - within overburden emplacement area					
B6	1.1	0.1	7.8	0.7	1.2	0.02
B7	1.3	0.2	7.7	1.0	1.8	0.04
C1	6.8	1.0	45.2	5.6	9.8	0.18
C2	4.4	0.5	20.1	3.1	5.4	0.10
C3	5.8	1.0	25.9	5.5	9.9	0.19
PR*	4.4	0.5	20.1	3.1	5.4	0.10

*Impact is conservatively assumed to be the same as that at Receiver C2.

9.3 Modelling predictions - cumulative impacts

9.3.1 Stage 1

The predicted cumulative annual average $PM_{2.5}$, PM_{10}, TSP and dust deposition levels due to the Project and other sources during Stage 1, including the estimated background levels (refer to **Section 8.5**), are presented in **Table 9-4**.

The results indicate the predicted levels would be below the relevant criteria at the privately-owned sensitive receiver locations (Receiver 1 to 17) for each of the assessed dust metrics.

Boral owned receiver B4, is predicted to exceed the annual average PM_{10} criteria of 25µg/m³. All other Boral owned and commercial receivers are predicted to experience dust levels below the relevant criteria for each of the assessed dust metrics.

Table 9-4: Cumulative modelling predictions for the Project – Stage 1

Receiver ID	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Annual average			
	Air quality impact criteria			
	8	25	90	4
R1	3.6	11.4	27.7	2.8
R2	3.6	11.8	28.3	2.8
R3	3.7	12.2	29.0	2.8
R4	3.8	12.8	29.9	2.8
R5	3.9	13.7	31.6	2.9
R6	3.9	13.6	31.5	2.9
R7	4.2	15.4	34.8	2.9
R8	4.6	17.7	39.4	3.0
R9	4.5	16.6	37.1	3.0
R10	4.1	14.1	32.2	2.9
R11	4.1	14.2	32.4	2.9
R12	4.5	16.2	36.2	2.9
R13	3.5	11.2	27.4	2.8
R14	3.8	12.9	30.4	2.9
R15	3.8	13.2	31.0	3.0
R16	3.9	13.4	31.4	3.0
R17	4.0	14.0	32.6	3.1
B1	3.7	12.3	29.2	2.8
B2	4.0	14.5	33.1	2.9
B3	5.1	19.9	43.9	3.1
B4	6.5	**27.5**	60.4	3.4
B5	6.0	24.0	51.5	3.2
B6	4.0	14.2	33.1	3.1
B7	4.1	14.5	33.7	3.1
C1	5.6	23.7	52.2	3.3
C2	4.5	16.5	36.9	3.0
C3	4.8	18.2	40.1	3.0
PR*	3.6	11.4	27.7	2.8

*Impact is conservatively assumed to be the same as that at Receiver C2.

9.3.2 Stage 2

The predicted cumulative annual average $PM_{2.5}$, PM_{10}, TSP and dust deposition levels due to the Project and other sources during Stage 2, including the estimated background levels (refer to **Section 8.5**), are presented in **Table 9-5**.

The results indicate the predicted levels would be below the relevant criteria at the privately-owned sensitive receiver locations (Receiver 1 to 17) for each of the assessed dust metrics.

All Boral owned and commercial receivers are also predicted to experience dust levels below the relevant criteria for each of the assessed dust metrics.

Table 9-5: Cumulative modelling predictions for the Project – Stage 2

Receiver ID	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Annual average			
	Air quality impact criteria			
	8	25	90	4
R1	3.6	11.4	27.6	2.8
R2	3.6	11.7	28.1	2.8
R3	3.7	11.9	28.5	2.8
R4	3.7	12.3	29.2	2.8
R5	3.8	13.0	30.3	2.9
R6	3.8	13.0	30.5	2.9
R7	4.0	14.2	32.7	2.9
R8	4.2	15.6	35.2	2.9
R9	4.2	15.3	34.6	2.9
R10	4.0	14.1	32.6	2.9
R11	4.1	14.3	33.0	2.9
R12	4.4	16.2	36.9	3.0
R13	3.5	11.2	27.3	2.8
R14	3.7	12.4	29.5	2.9
R15	3.8	12.6	29.9	3.0
R16	3.8	12.8	30.2	3.0
R17	3.8	13.2	31.0	3.0
B1	3.7	12.0	28.6	2.8
B2	3.9	13.4	31.2	2.9
B3	4.5	17.2	37.9	3.0
B4	5.2	22.0	47.2	3.1
B5	5.3	22.7	49.7	3.2
B6	3.9	13.4	31.4	3.0
B7	3.9	13.5	31.7	3.0
C1	4.7	18.6	40.4	3.0
C2	4.1	15.0	33.9	2.9
C3	4.4	16.7	37.1	3.0
PR*	3.6	11.4	27.6	2.8

*Impact is conservatively assumed to be the same as that at Receiver C2.

9.3.3 Stage 3

The predicted cumulative annual average $PM_{2.5}$, PM_{10}, TSP and dust deposition levels due to the Project and other sources during Stage 3, including the estimated background levels (refer to **Section 8.5**), are presented in **Table 9-6**.

The results indicate the predicted levels would be below the relevant criteria at the privately-owned sensitive receiver locations (Receiver 1 to 17) for each of the assessed dust metrics.

In Stage 3, Boral owned receiver B5, would be located within the overburden emplacement area for the Project (and would thus no longer exist). All other Boral owned and commercial receivers are predicted to experience dust levels below the relevant criteria for each of the assessed dust metrics.

Table 9-6: Cumulative modelling predictions for the Project – Stage 3

Receiver ID	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Annual average			
	Air quality impact criteria			
	8	25	90	4
R1	3.6	11.4	27.6	2.8
R2	3.6	11.7	28.1	2.8
R3	3.7	12.0	28.6	2.8
R4	3.7	12.3	29.2	2.8
R5	3.8	13.0	30.4	2.9
R6	3.8	13.1	30.6	2.9
R7	4.0	14.3	32.8	2.9
R8	4.3	15.7	35.3	3.0
R9	4.3	15.6	35.0	2.9
R10	4.1	14.1	32.6	2.9
R11	4.1	14.1	32.4	2.9
R12	4.4	15.7	35.5	2.9
R13	3.5	11.2	27.3	2.8
R14	3.7	12.4	29.5	2.9
R15	3.8	12.6	30.0	3.0
R16	3.8	12.8	30.3	3.0
R17	3.9	13.2	31.1	3.0
B1	3.7	12.0	28.6	2.8
B2	3.9	13.5	31.3	2.9
B3	4.6	17.5	38.5	3.0
B4	5.5	22.8	48.8	3.2
B5	**Receptor no longer exists - within overburden emplacement area**			
B6	3.9	13.4	31.5	3.0
B7	3.9	13.6	31.8	3.0
C1	4.8	18.8	40.7	3.0
C2	4.2	15.1	34.1	2.9
C3	4.5	17.1	38.0	3.0
PR*	3.6	11.4	27.6	2.8

*Impact is conservatively assumed to be the same as that at Receiver C2.

9.4 Assessment of total (cumulative) 24-hour average $PM_{2.5}$ and PM_{10} concentrations

Cumulative 24-hour average $PM_{2.5}$ and PM_{10} impacts at the closest and most potentially impacted privately-owned receiver locations are of most interest in this assessment.

This analysis has focused on the nearest privately-owned sensitive receiver locations surrounding the mine that would be most likely to experience maximum cumulative impacts due to the Project. All other receivers would be expected to experience levels lower than those assessed.

Figure 9-1 shows the locations at which the contemporaneous impact assessment was made.

As there are no readily available ambient $PM_{2.5}$ monitoring data collected near to the Project, monitoring data from the HVAS monitoring station and the NSW OEH monitoring station at Wollongong have been applied in the assessment.

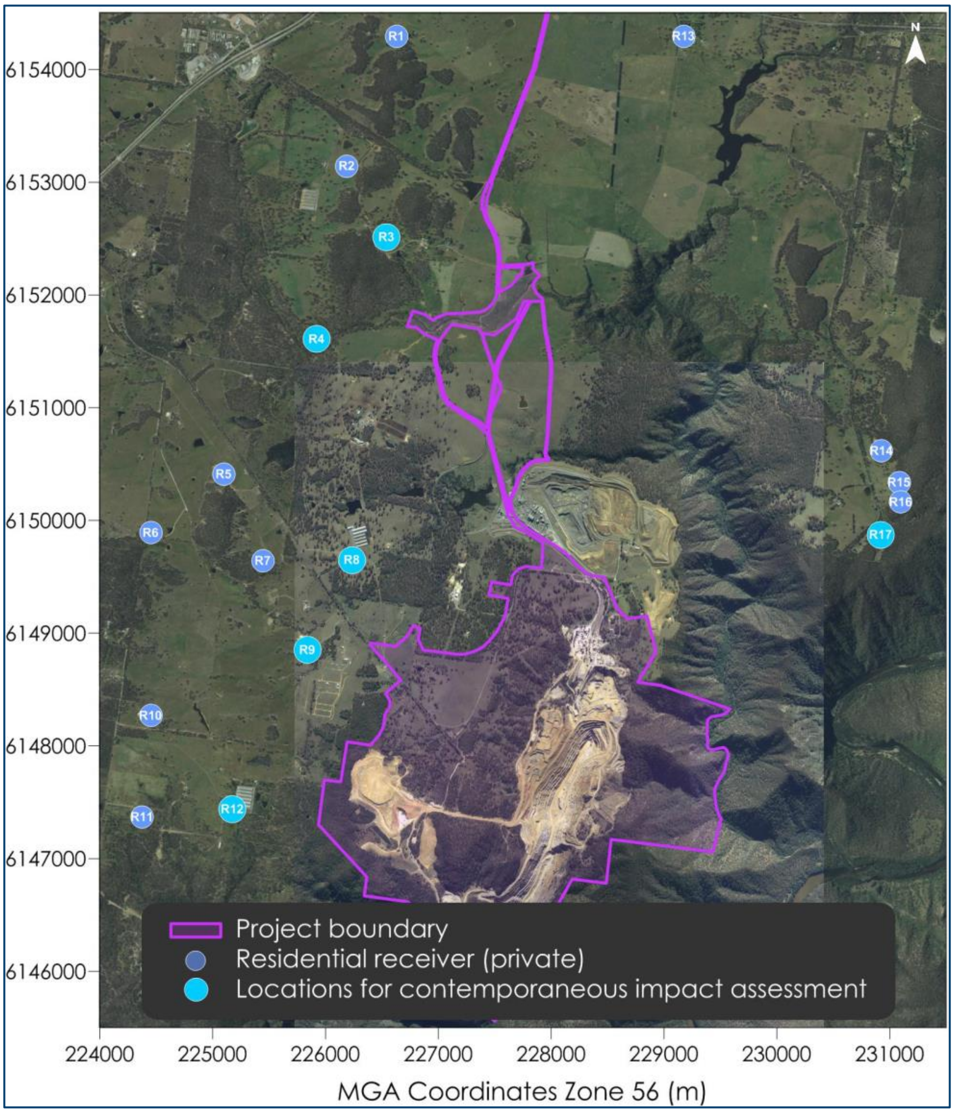


Figure 9-1: Locations for contemporaneous cumulative impact assessment

9.4.1 Assessment of cumulative $PM_{2.5}$ impacts

To assess the potential cumulative 24-hour average $PM_{2.5}$ impacts due to the Project, a Level 1 approach (i.e. adding the maximum background and maximum incremental level together) is applied per two different approaches to establish the background level, as follows:

- Assuming maximum ambient $PM_{2.5}$ level is 32% (i.e. 8/25 per the criteria ratio) of the maximum ambient PM_{10} levels – the criteria ratio approach; and
- Applying the Victorian EPA approach[3] with the available ambient $PM_{2.5}$ monitoring data from the NSW OEH monitoring station at Wollongong during 2014.

This has been done as there are no available ambient $PM_{2.5}$ monitoring data, which means the NSW EPA contemporaneous approach cannot be applied and thus the approaches applied are considered to be the next most suitable alternatives to use.

9.4.1.1 Criteria ratio approach

The PM_{10} HVAS monitoring data from the Marulan monitor were applied per the criteria ratio approach. The HVAS monitoring data already include a dust contribution from the existing mine and Peppertree Quarry during this period. The double counting in this case has not been accounted for and therefore the approach is likely to provide a relatively conservative assessment of potential cumulative impacts.

Per this approach, the maximum measured PM_{10} concentration during the 2014 assessment year is 50.5µg/m^3 (refer to **Table 6-3**) and 32% of this level, representing the maximum $PM_{2.5}$ level, is 16.1µg/m^3. This value was added with the maximum predicted $PM_{2.5}$ level and the results of the cumulative assessment are presented in **Table 9-7** for each of the assessed receivers. The results indicate that the predicted maximum cumulative impact would not exceed the relevant criterion of 25µg/m^3 for the receiver locations.

Table 9-7: Cumulative 24-hour average $PM_{2.5}$ assessment – criteria ratio approach – maximum number of additional days above 24-hour average $PM_{2.5}$ criterion

Receiver ID	Number of additional days above 24-hour average $PM_{2.5}$ criterion
R3	0
R4	0
R8	0
R9	0
R12	0
R17	0

9.4.1.2 Victorian EPA approach

The monitoring data from the Wollongong monitoring station are representative of a more densely populated area with greater influences of anthropogenic sources compared to the area surrounding the Project. The monitoring data therefore would provide a conservative assessment of potential cumulative impacts for the area surrounding the Project.

[3] The Victorian Government's State Environment Protection Policy (Air Quality Management), **SEPP (2001)** states at Part B, 3(b) "Proponents required to include background data where no appropriate hourly background data exists must add the 70th percentile of one year's observed hourly concentrations as a constant value to the predicted maximum concentration from the model simulation. In cases where a 24-hour averaging time is used in the model, the background data must be based on 24-hour averages."

The 70th percentile of the measured Wollongong $PM_{2.5}$ monitoring data during 2014 is 8.2µg/m^3 and is considered for the cumulative assessment.

The results of the cumulative assessment are presented in **Table 9-8** for each of the assessed receivers. The results indicate that the predicted maximum cumulative impact would not exceed the relevant criterion of 25µg/m^3 for the receiver locations.

Table 9-8: Cumulative 24-hour average $PM_{2.5}$ assessment – Victorian EPA approach – maximum number of additional days above 24-hour average $PM_{2.5}$ criterion

Receiver ID	Number of additional days above 24-hour average $PM_{2.5}$ criterion
R3	0
R4	0
R8	0
R9	0
R12	0
R17	0

9.4.2 Assessment of cumulative PM_{10} impacts

An assessment of cumulative 24-hour average PM_{10} impacts was undertaken in accordance with the methods outlined in Section 11.2 of the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**). The "Level 2 assessment - Contemporaneous impact and background approach" was applied to assess potential impacts.

As shown in **Section 6.3**, maximum background levels have in the past reached levels near to the 24-hour average PM_{10} criterion level (depending on the monitoring location and time). As a result, the screening Level 1 NSW EPA approach of adding maximum background levels to maximum predicted Project only levels would show levels above the criterion.

In such situations, (where a Level 1 assessment indicates that an impact may be possible due to elevated background levels) the NSW EPA approach requires a more thorough Level 2 assessment whereby the measured background level on a given day is added contemporaneously with the corresponding Project only level predicted using the same day's weather data. This method factors into the assessment the spatial and temporal variation in background levels affected by the weather and existing sources of dust in the area on a given day. However, even with a detailed Level 2 approach, any air dispersion modelling has limitations in predicting short term impacts which may arise many years into the future, and these limitations need to be understood when interpreting the results.

Ambient (background) dust concentration data for January 2014 to December 2014 from the HVAS monitoring station have been applied in the Level 2 contemporaneous 24-hour average PM_{10} assessment and represent the prevailing measured background levels at the monitoring location which is near to the Project.

As the Project and other nearby operations (the Peppertree Quarry) were operational during 2014, they would have contributed to the measured levels of dust at the monitor, making the levels higher than the likely background levels further away at residential receivers. Due to this it is important to account for these existing activities in the cumulative assessment.

To consider the Project's influence on prevailing dust levels, modelling of the actual operating scenario for the 2014 period (in which the weather and background dust data were collected) was conducted to estimate the existing contribution to the measured levels of dust. The results were applied in the cumulative assessment to minimise potential double counting of existing emissions (otherwise the contribution would occur in the measured data and in the modelled levels) and thus to make a more reliable prediction of the likely cumulative total dust level.

Specifically, to calculate the background levels at receivers, the predicted air quality concentrations from the mine and Peppertree Quarry during 2014 at the HVAS monitoring station location were subtracted from the measured levels at the HVAS. However, for conservatism, and as models tend to over predict source contributions, no level lower than the 25th percentile of the measured HVAS results for the 2014 period was applied to represent the underlying background level on any day.

As the HVAS monitoring data are only available on every sixth day in 2014 (per the EPA run cycle) and on a few occasions no result was recorded, the 70th percentile of the HVAS data for the period from July 2011 to June 2017 (20.7µg/m^3) was applied to substitute for these gaps.

This approach was tested by applying the complete set of 24-hour average PM_{10} monitoring data from Bargo in a contemporaneous 24-hour average PM_{10} assessment. The application of the Bargo data resulted in lower levels than calculated with the above approach, providing a reasonable indication that the assessment is likely to be conservative and thus to overestimate the actual background level and cumulative 24-hour average PM_{10} impacts.

Table 9-9 provides a summary of the findings of the contemporaneous assessment at each assessed sensitive receiver location. The results in **Table 9-9** indicate that it is unlikely that systemic (i.e. greater than five days) cumulative impacts would arise at assessed receiver locations during the assessed years.

Detailed tables of the full assessment results are provided in **Appendix E**.

Table 9-9: NSW EPA contemporaneous assessment - maximum number of additional days above 24-hour average PM_{10} criterion

Receiver ID	Number of additional days above 24-hour average PM_{10} criterion
R3	0
R4	0
R8	0
R9	0
R12	0
R17	0

The contemporaneous assessment indicates no potential for any cumulative 24-hour average PM_{10} impacts to occur at the assessed sensitive receiver locations. The sensitive receiver locations are considered to represent areas where the highest cumulative impacts are most likely to occur. Given that these locations have no potential for any significant impact to occur, it can be inferred that there would also be no prospect of any significant impact to occur at all other sensitive receiver locations.

Time series plots of the predicted cumulative 24-hour average PM_{10} concentrations for R8, R9, R12 and R17 during Stage 1, Stage 2 and Stage 3 are presented in **Figure 9-2** to **Figure 9-7**, respectively. R8 and R9 are located closest to the WOBE and most likely to be affected by the Project based on the prevailing weather conditions.

The orange bars in the figure represent the contribution from the Project and the Peppertree Quarry and the blue bars represent the background levels at the HVAS monitor. Note that on the days on which there is no HVAS data, the 70^{th} percentile level of the HVAS data is used to elevate the total cumulative level. It is clear from the figures that the Project (and Peppertree Quarry combined) would have a relatively small influence at these receiver locations and the cumulative levels would remain within criteria.

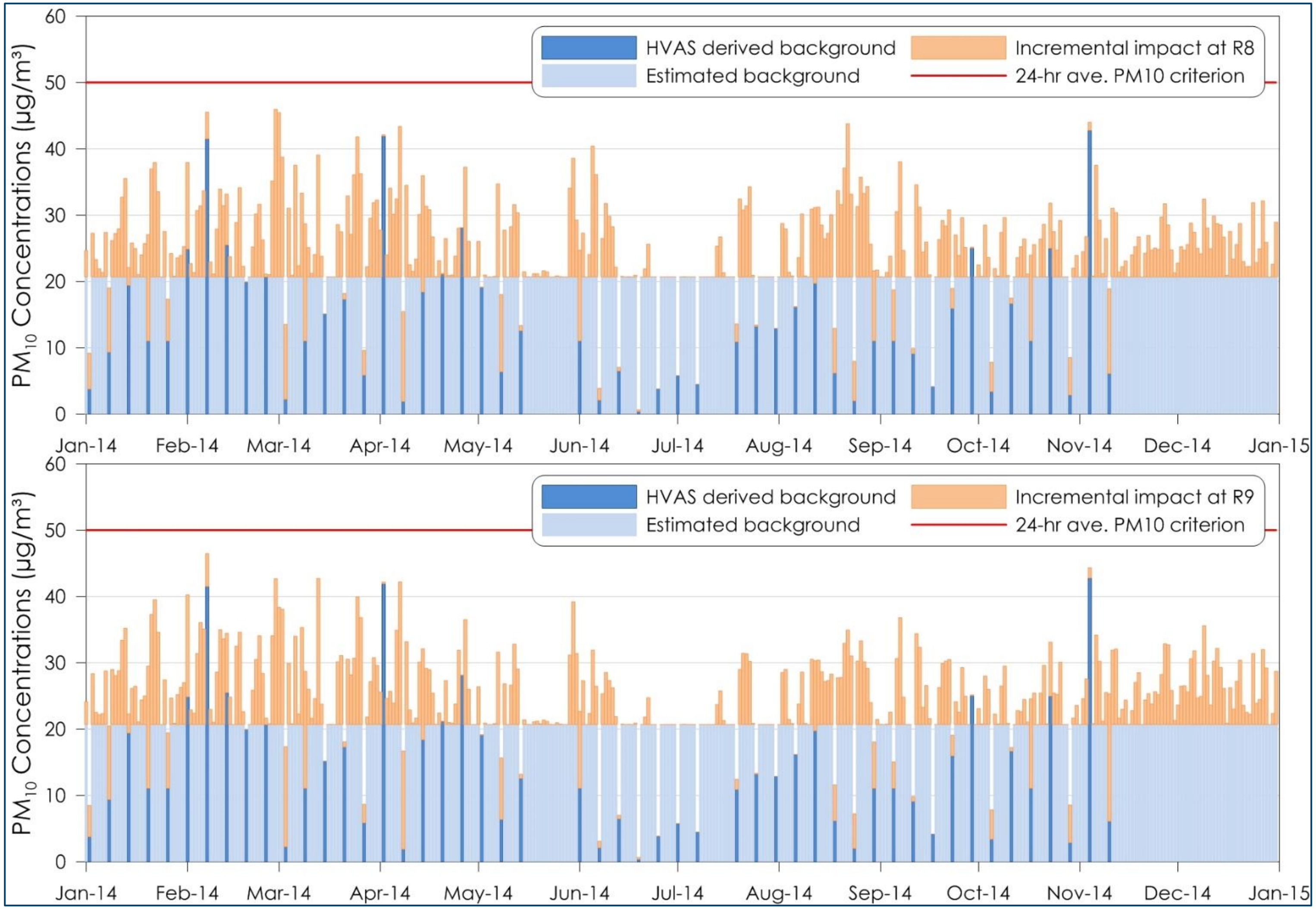


Figure 9-2: Time series plots of predicted cumulative 24-hour average PM_{10} concentrations for R8 and R9 – Stage 1

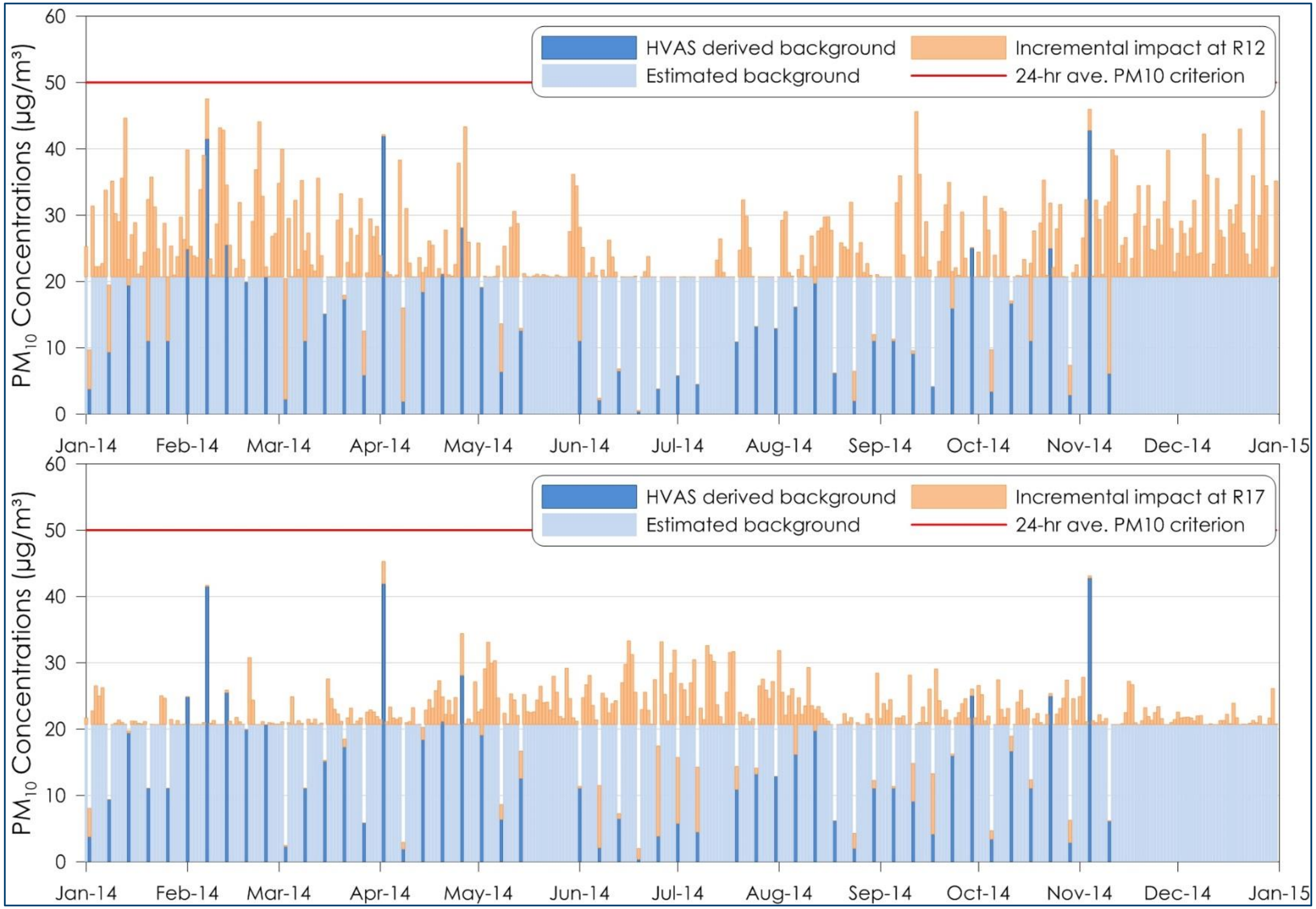


Figure 9-3: Time series plots of predicted cumulative 24-hour average PM_{10} concentrations for R12 and R17 – Stage 1

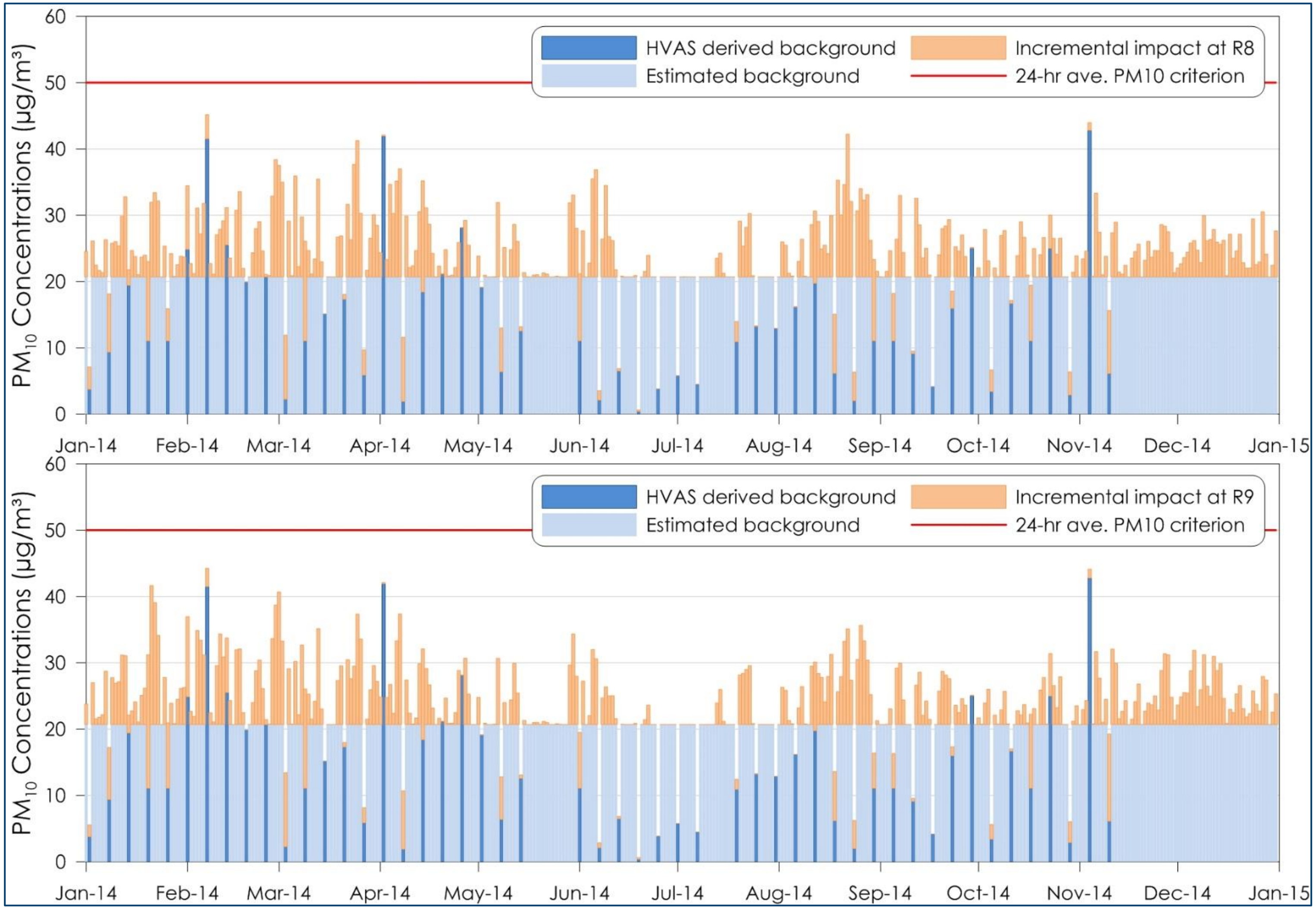


Figure 9-4: Time series plots of predicted cumulative 24-hour average PM_{10} concentrations for R8 and R9 – Stage 2

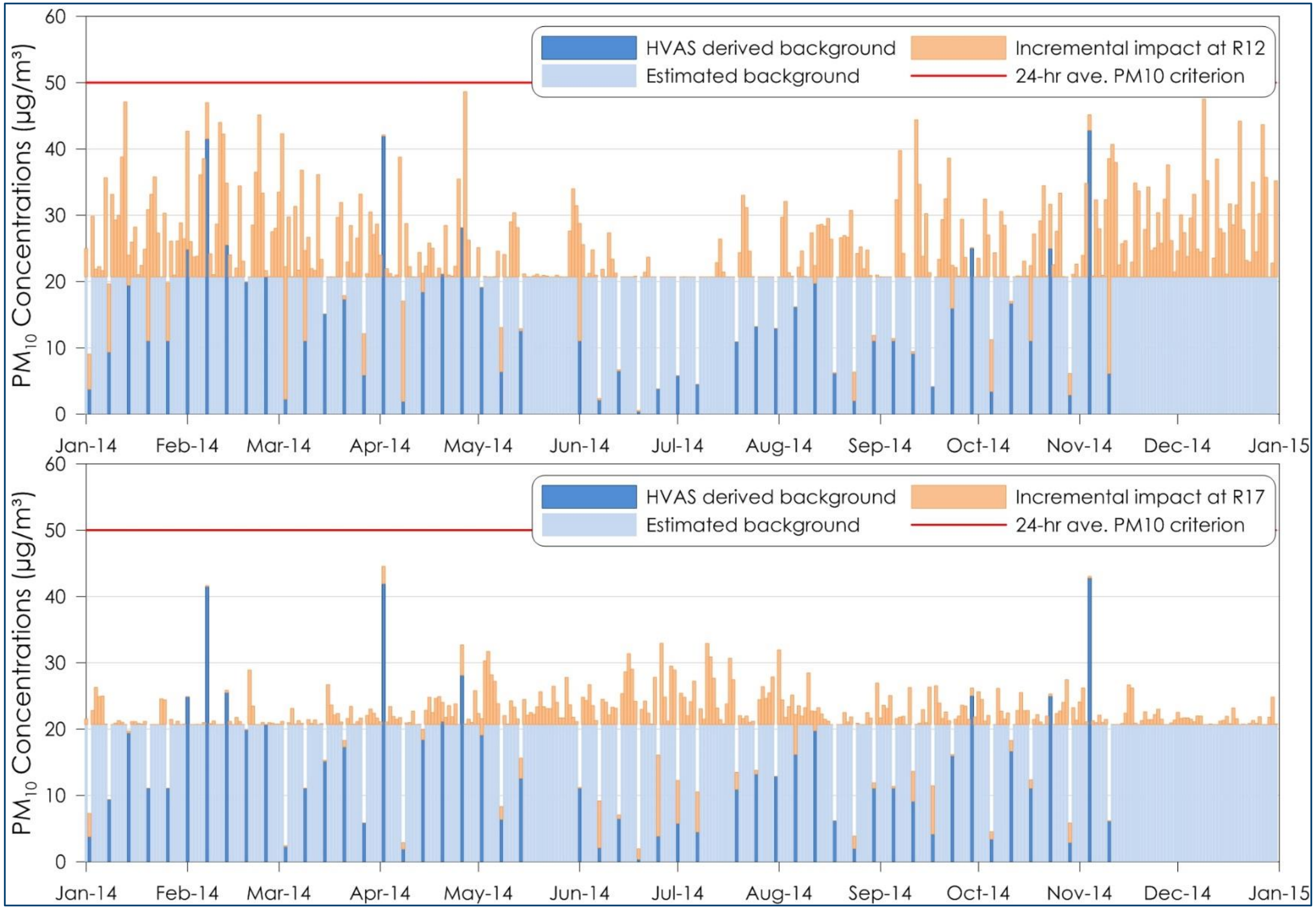


Figure 9-5: Time series plots of predicted cumulative 24-hour average PM_{10} concentrations for R12 and R17 – Stage 2

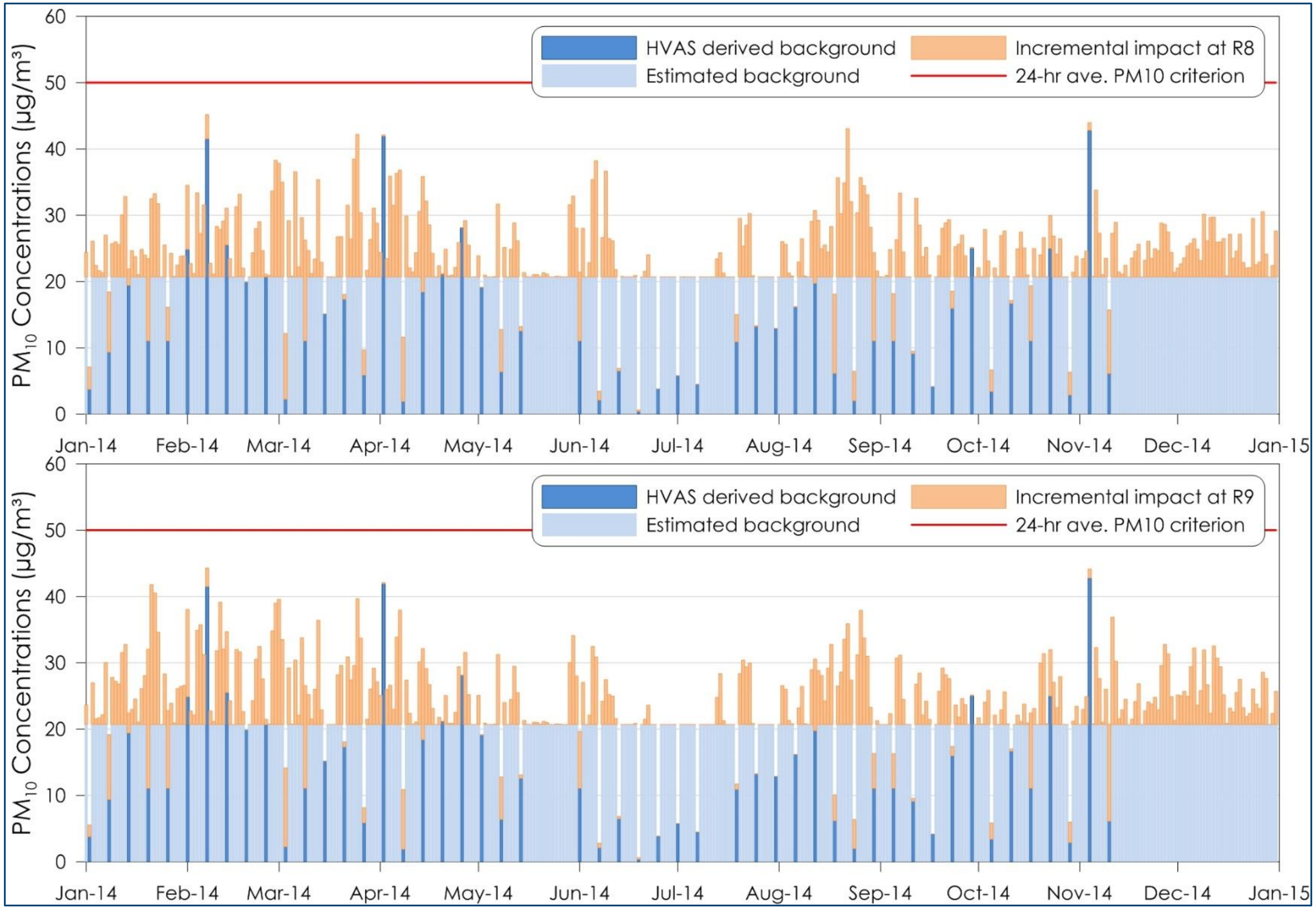


Figure 9-6: Time series plots of predicted cumulative 24-hour average PM_{10} concentrations for R8 and R9 – Stage 3

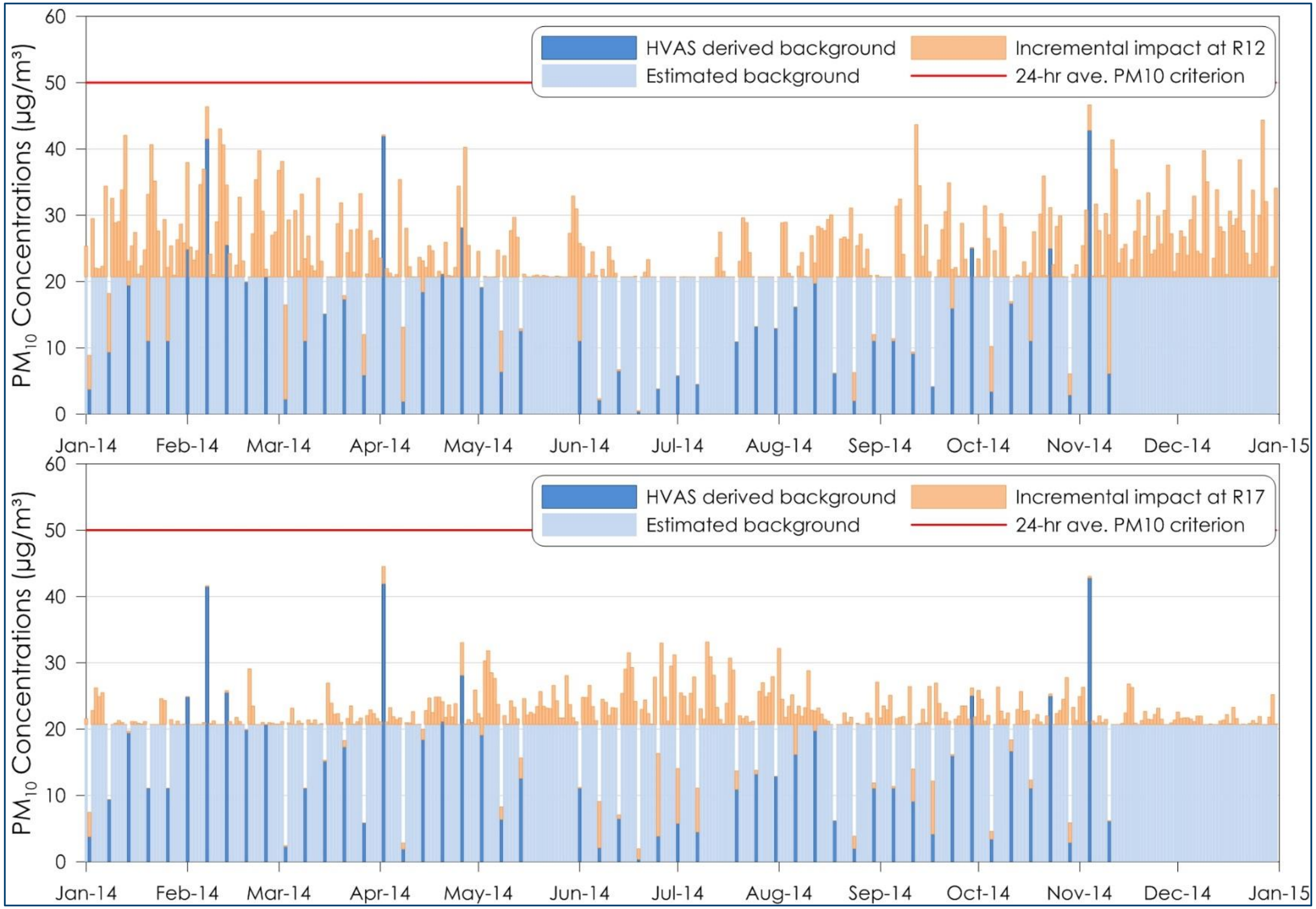


Figure 9-7: Time series plots of predicted cumulative 24-hour average PM_{10} concentrations for R12 and R17 – Stage 3

9.5 Dust impacts on more than 25 per cent of privately-owned land

An assessment was made to ascertain where the potential impacts due to the Project may extend over more than 25 per cent of any privately-owned land. Such an assessment can only be conducted approximately, based on the predicted pollutant dispersion contours.

For the Project, the maximum extent of the 24-hour average PM_{10} impact was greater than the extent of any of the other assessed dust metrics and hence represents the most impacting parameter across all modelled scenarios.

The contour presented in **Figure 9-8** defines the likely maximum 24-hour average PM_{10} level assessed over the life of the Project. The contour indicates that the Project would not impact greater than 25 per cent of any privately-owned land.

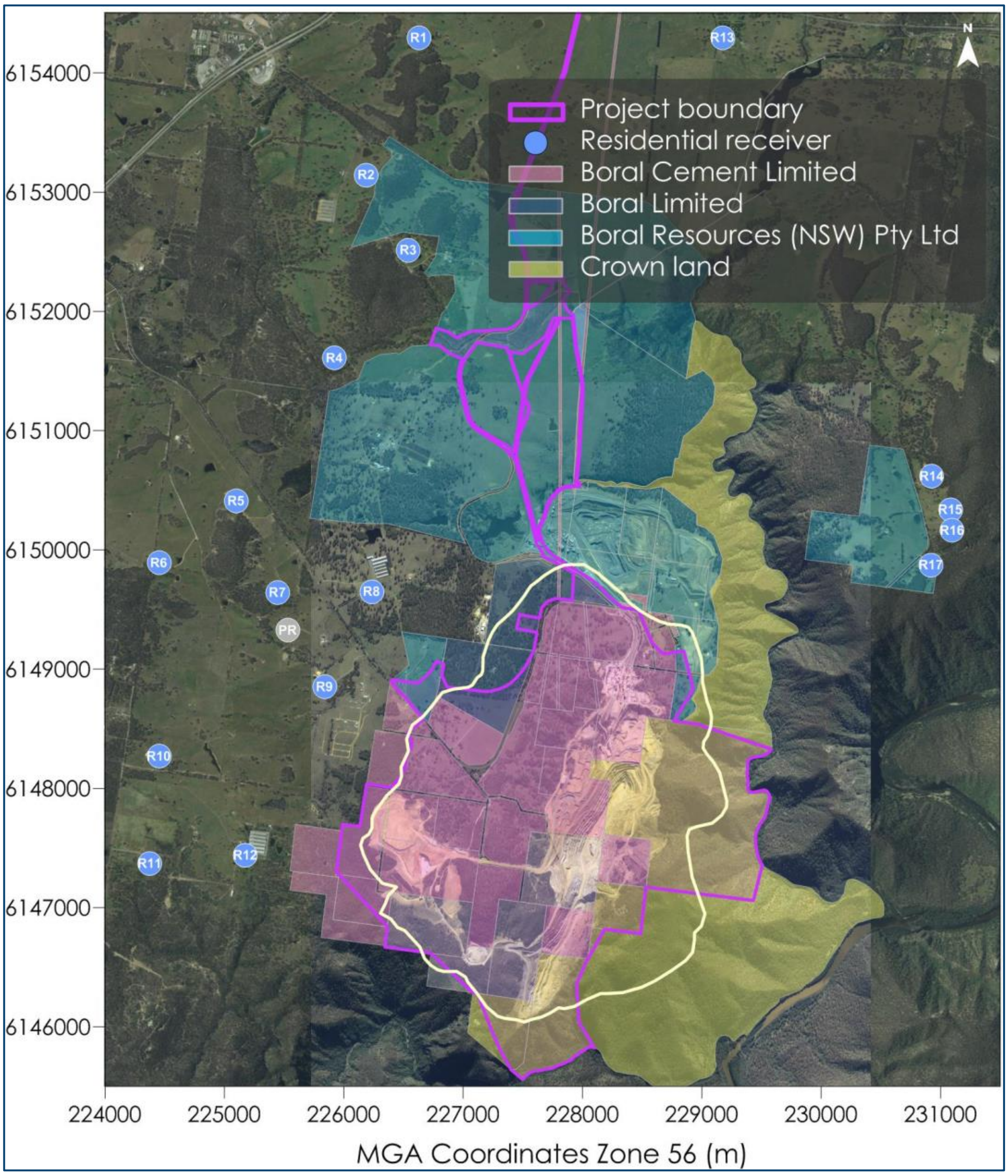


Figure 9-8: Predicted maximum 24-hour average PM_{10} level

9.6 Process stack modelling results

The predicted incremental NO_2 and SO_2 levels due to the Project are presented in **Table 9-10**. The results indicate the predicted incremental levels are minimal and well below the respective air quality impact criteria.

With consideration of the estimated background levels for the assessed pollutants (see **Section 8.5**), cumulative impacts are expected to also be below the relevant criteria for the assessed pollutants at the assessed sensitive receiver locations.

Table 9-10: Predicted stack emission modelling predictions for the Project

Receiver ID	NO_2 (µg/m³)		SO_2 (µg/m³)			
	Incremental impact					
	24-hour average	Annual average	10-minute average	1-hour average	24-hour average	Annual average
	Air quality impact criteria					
	246	60	712	570	228	60
R1	21.3	0.04	0.33	0.19	0.01	0.0003
R2	13.2	0.07	0.20	0.12	0.01	0.0006
R3	14.6	0.09	0.22	0.13	0.01	0.0008
R4	14.6	0.09	0.22	0.13	0.01	0.0008
R5	27.0	0.13	0.41	0.24	0.02	0.0012
R6	26.2	0.14	0.40	0.23	0.02	0.0013
R7	36.4	0.21	0.56	0.32	0.02	0.0019
R8	54.0	0.35	0.83	0.48	0.04	0.0031
R9	39.2	0.37	0.60	0.35	0.02	0.0033
R10	27.8	0.19	0.43	0.25	0.02	0.0017
R11	26.0	0.11	0.40	0.23	0.01	0.0010
R12	14.4	0.13	0.22	0.13	0.01	0.0011
R13	5.0	0.03	0.08	0.04	0.00	0.0002
R14	22.0	0.16	0.34	0.20	0.02	0.0014
R15	28.2	0.27	0.43	0.25	0.03	0.0024
R16	33.3	0.32	0.51	0.30	0.04	0.0029
R17	31.9	0.46	0.49	0.28	0.06	0.0041
B1	16.0	0.09	0.24	0.14	0.01	0.0008
B2	17.0	0.13	0.26	0.15	0.01	0.0012
B3	70.1	0.73	1.07	0.63	0.05	0.0065
B4	77.6	1.79	1.19	0.69	0.11	0.0160
B5	80.5	0.82	1.23	0.72	0.06	0.0074
B6	30.6	0.27	0.47	0.27	0.03	0.0024
B7	40.2	0.58	0.61	0.36	0.08	0.0051
C1	101.8	1.04	1.56	0.91	0.08	0.0093
C2	34.8	0.33	0.53	0.31	0.02	0.0029
C3	45.9	0.50	0.70	0.41	0.03	0.0045
PR*	34.8	0.33	0.53	0.31	0.02	0.0029

*Impact is conservatively assumed to be the same as that at Receiver C2.

10 BLAST FUME EMISSIONS

The existing and proposed operations of the Project require the use of blasting activities to assist with the extraction of the resource. Blasting activities have the potential to generate noxious gases such as NO_2.

The potential for blast fume impacts are rare, but possible when there are unforeseeable complications with a blast that causes high levels of NO_2 and when this occurs during unfavourable air dispersion conditions.

10.1 Assessment of blast impacts

The likelihood of blast impacts at the Project are assessed based on a review of detailed dispersion modelling of blast fume emissions from large-scale coal mine operations in the Hunter Valley, NSW (**Todoroski Air Sciences, 2014 & 2015**).

The blast fume assessments applied air dispersion modelling to predict the extent of impacts for each hour of the year, where blasting is permitted, coupled with estimated worst-case blast fume emissions obtained from measurements of blast fumes by the CSIRO in the Hunter Valley. The model source parameters were based on a typical blast size for an open cut coal mine, in the range of approximately 10,000 to 12,000m^2.

The assessments found that the potential for blast fume impacts are unlikely to arise when blasting occurs in the mid-daytime hours with the likely extent of worst-case impacts in the range of approximately 1.5 to 2km for this scale of blast.

In comparison, the expected blast size for this Project is much smaller at approximately one tenth of the scale of the coal mines with typical blasting hours at the Project between 10:00am to 4:00pm. Based on this, the likelihood of a blast impact occurring at the Project would be low and unlikely to reach the nearest privately-owned receivers.

10.2 Management of potential air quality impacts from blasting

There are no specific or unusual circumstances that would arise due to the Project that would alter the current, potential risk of impacts from blasting.

As blasting is currently permitted, and there has been no significant incident in this regard at the site, it is expected that this would remain the case in the future.

However, it is also reasonable to ensure that best practice blast management measures are being applied to ensure that blasting activities continue to be managed in a manner which would minimise the risk of impacts arising in the future.

To ensure potential air quality impacts associated with the blasting activity of the Project are minimised, it is recommended that good blast practices and appropriate blast management measures are applied during each event. Good blast practices would include understanding the size of each blast, the residence time of each blast (how long the explosive has been in the ground before detonation), the nature of the stemming material, the proximity to roads and nearby sensitive receptors, and the weather and dispersion conditions during each blast. The decision to blast in each instance is based on operator judgement of the actual prevailing weather conditions, forecast weather conditions and the expected nature of potential plume travel towards the nearest assessment locations.

With the implementation of good blast practices and blast management measures, potential impacts from blast fume emissions from the Project can be readily managed and adverse impacts in the surrounding environment can be minimised.

11 DUST MITIGATION AND MANAGEMENT

11.1 Introduction

The existing operations at the mine implement various dust mitigation and management measures, in accordance with the existing Dust Management Plan to minimise the potential for air quality impacts in the surrounding environment.

The monitoring data presented in **Section 6.3** indicate that the mine has generally been in compliance with NSW EPA air quality criteria. It is recommended that an appropriate desktop investigation is performed into the potential cause of any measured exceedance at the monitors in the network, it is anticipated that under normal operating conditions such an event may occasionally arise due to bushfires and other such external factors and it is relevant to investigate the likely cause.

Relative to the existing operations, the proposed continued operations of the mine are unlikely to lead to any significant or large change in dust levels at private receivers.

This is supported by the air quality assessment for the Project which predicts that there would be no exceedances of NSW EPA air quality criteria at any privately-owned receiver due to the mine incorporating the Project and other background dust sources (including the Peppertree Quarry).

Given this situation and the demonstrated performance of existing operations, it is considered that the continued implementation of the Dust Management Plan management measures would be suitable to manage potential air quality impacts from the Project.

The mining activities at the Project will however generate some level of dust, and to ensure these activities have a minimal effect on the surrounding environment and sensitive receivers, all reasonable and practicable dust mitigation measures would be applied as set out in the Dust Management Plan.

11.2 Mitigation and management measures

The existing operations at the mine implement various dust mitigation and management measures, in accordance with the existing Dust Management Plan. The existing Dust Management Plan will be reproduced to a full Air Quality Management Plan after approval of the Project and will incorporate air quality control measures outlined in **Table 11-1** and ongoing air quality monitoring outlined in **Section 11.3**.

The air quality control measures summarised in **Table 11-1** complement the measures outlined in **Section 8.6** to further assist with the management of air emissions from the Project.

Table 11-1: Air quality control measures summary

Operation	Control measures
General operation	✦ Temporarily cease operations during periods of high visible dust until conditions improve. ✦ Develop proactive management measures such as incorporating meteorological forecasting into daily planning to minimise potential dust impacts due to adverse weather conditions. Daily planning for predicted adverse conditions may include additional frequency of water cart on specific areas and postponing certain activities (e.g. blasting).
Crushing	✦ Regular maintenance of water sprayers in the system.

Operation	Control measures
	✦
Conveying and transfer points	✦ Regular cleaning and collection of spilt material at transfer points. ✦ Adjust belt speed to optimum level to minimise material loss. ✦
Stockpile management	✦ Continuous water spray at stockpile stacking points. ✦
Hauling on unsealed roads	✦ Regular use of truck wash station, especially before leaving the site. ✦ Training for haul truck operators to identify elevated dust levels from hauling activity and call for additional water suppression.
Drilling and blasting	✦ All drill rigs equipped with dust suppression/filtration systems. ✦ Inspection of drill dust suppression systems to ensure they are fully operational before use. ✦
Hauling on sealed roads	✦ Truck speed when carrying a covered load on sealed roads inside the plant to be limited to 40km/hr. ✦ Truck speed when carrying an uncovered load inside the plant, if unavoidable shall be limited to 20km/hr. ✦ Trucks carrying uncovered loads on internal roads, if cannot be avoided, to be loaded below 300mm of the freeboard. ✦

11.3 Monitoring network

The existing monitoring network for the mine is illustrated in **Figure 6-5**. The monitoring data presented in **Section 6.3** indicate that the mine has been generally in compliance with NSW EPA air quality criteria.

The proposed continued operations of the mine are unlikely to lead to any significant or large change in dust levels at private receiver locations. This is supported by the air quality assessment for the Project which predicts that there would be no exceedances of NSW EPA air quality criteria at any privately-owned receiver due to the continued operation of the mine incorporating background sources (including the presently proposed modifications to the Peppertree Quarry).

Given this situation and the demonstrated performance of existing operations, it is considered that the continued operation of the existing monitoring network would be generally suitable for monitoring the potential effects of the Project.

Due to the overburden emplacement areas to the west of the mine, a number of existing monitoring locations are likely to be compromised in the future.

It is therefore recommended that the air quality monitoring network, consisting of dust gauges and the HVAS monitor, is revised for the Project to consider locations away from mining and other nearby activities that are more representative of the nearby privately-owned sensitive receiver locations.

12 SUMMARY AND CONCLUSIONS

This study has examined potential air quality impacts which may arise from the proposed continued operation of the Marulan South Limestone Mine.

The assessment utilises air dispersion modelling and focuses on the potential dust impacts that may arise. The assessment considers additional potential dust impacts from the Project in isolation (incrementally) and cumulative with other nearby operations (the Peppertree Quarry) and background levels of dust. The assessment also investigates the potential air quality impacts associated with other (non-dust) air emissions from the processing activities.

The dispersion modelling predictions show that the Project with the application of suitable dust mitigation and management strategies would not lead to any air quality levels above the relevant criteria at any privately-owned sensitive receivers.

The assessment of cumulative 24-hour average PM_{10} concentrations found that the Project, in conjunction with operations at the Peppertree Quarry, would not result in any additional days above the 24-hour average PM_{10} criterion at the privately-owned sensitive receiver locations.

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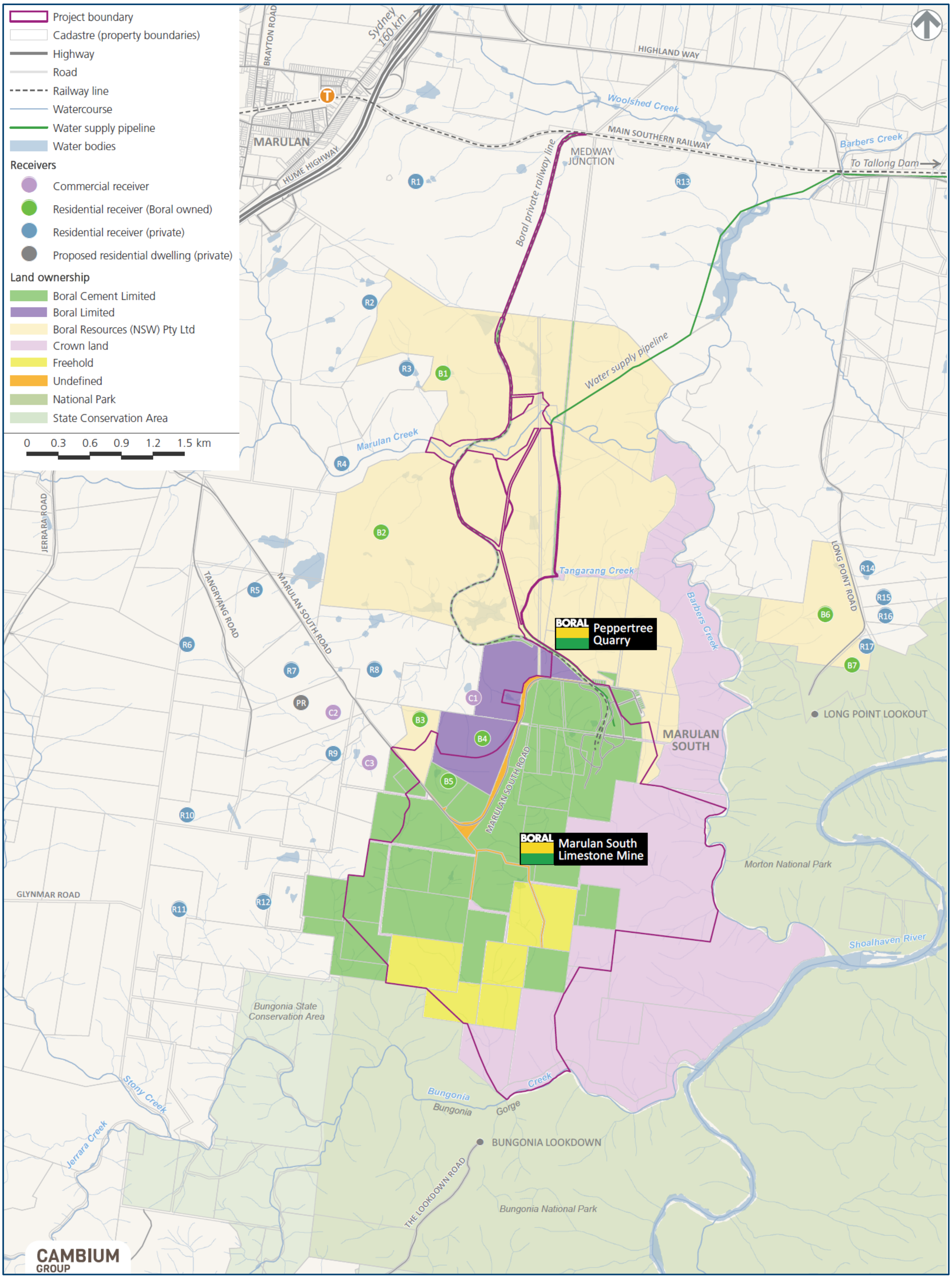
Appendix A

Sensitive Receivers



Source: **Element Environment, 2018**

Figure A-1: Sensitive receiver locations and land ownership

Table A-1: List of sensitive receivers considered in the study

Receiver ID	Easting (m)	Northing (m)
R1	226630	6154295
R2	226189	6153145
R3	226542	6152514
R4	225923	6151609
R5	225098	6150410
R6	224452	6149891
R7	225446	6149643
R8	226234	6149650
R9	225840	6148852
R10	224452	6148269
R11	224375	6147370
R12	225176	6147439
R13	229173	6154296
R14	230928	6150618
R15	231084	6150338
R16	231098	6150163
R17	230921	6149873
C1	227175	6149382
C2	225844	6149241
C3	226190	6148764
B1	226889	6152469
B2	226302	6150958
B3	226671	6149175
B4	227261	6148995
B5	226941	6148589
B6	230527	6150174
B7	230715	6149749
PR	225532	6149325

R – residential receiver (private)

C – commercial receiver

B – residential receiver (Boral owned)

PR – proposed residential dwelling (private)

Appendix B

Selection of Meteorological Year

Selection of meteorological year

The 2014 calendar year has been selected as the meteorological year for the dispersion modelling based on an analysis of the latest five years of meteorological data and wind patterns which reflect those patterns experienced in latest five years.

A statistical analysis of the latest five years of meteorological data from the nearest BoM weather station with suitable available data, Goulburn Airport AWS, is presented in **Table B-1**. The standard deviation of five years of meteorological data spanning 2012 to 2016 was analysed against the mean measured wind speed, temperature and relative humidity.

The analysis indicates that 2014 is closest to the average for wind speed and temperature, which is most relevant for modelling, and 2012 and 2015 are equally closest to the average for relative humidity.

Figure B-1 shows the frequency distributions for wind speed, temperature and relative humidity of the 2014 year compared with the mean of the 2012 to 2016 data set. The 2014 year data appears to be well aligned with the mean data.

Therefore, based on this analysis it was determined that 2014 is generally representative of the long-term trends compared to other years and is thus suitable for the purpose of modelling.

Table B-1: Statistical analysis results of standard deviation from mean five year meteorological data at Sydney Olympic Park AWS

Year	Wind speed	Temperature	Relative humidity
2012	0.41	0.70	4.21
2013	0.41	1.02	4.47
2014	0.40	0.9	4.69
2015	0.51	1.13	4.21
2016	0.56	1.17	5.01

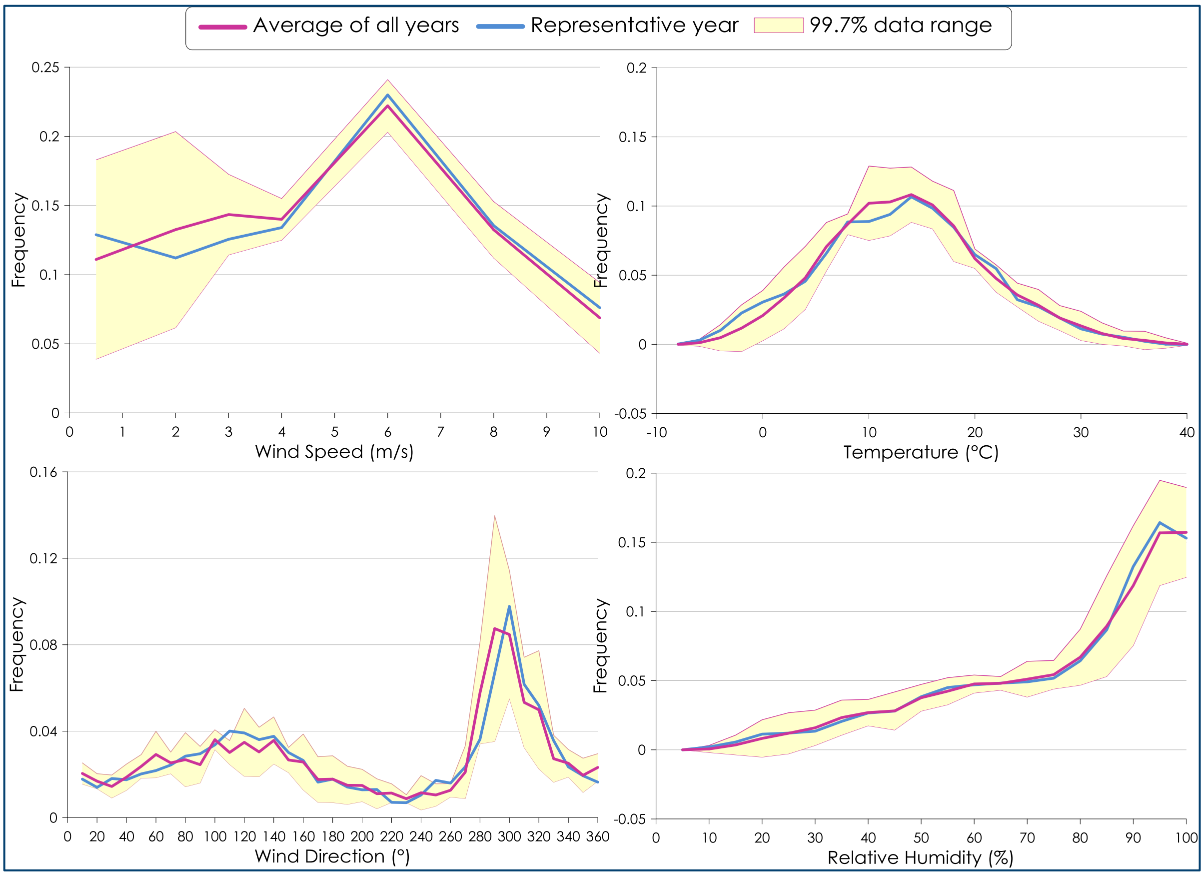


Figure B-1: Frequency distribution of meteorological parameters

Appendix C
Emission Calculation

Emission Calculation

The mine production schedule and mine plan designs provided by Boral have been combined with emissions factor equations that relate to the quantity of dust emitted from particular activities based on intensity, the prevailing meteorological conditions and composition of the material being handled.

Emission factors and associated controls have been sourced from:

- United States (US) EPA AP42 Emission Factors (**US EPA, 1985 and Updates**);
- National Pollutant Inventory (NPI) documents Emission Estimation Technique Manual for Mining, Version 3.1 (**NPI, 2012**) & Emission Estimation Technique Manual for Lime and Dolomite Manufacturing Version 1.1 (NPI, 2003);
- State Pollution Control Commission document "Air Pollution from Coal Mining and Related Developments" (**SPCC, 1983**); and,
- Office of Environment and Heritage document, "NSW Coal Mining Benchmarking Study: International Best Practise Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining", prepared by Katestone Environmental (**Katestone Environmental, 2010**).

The emission factor equations used for each dust generating activity are outlined in **Table C-1** below. Detailed emission inventory for the modelled scenarios is presented in **Table C-2** to **Table C-4**.

Control factors include the following:

- Hauling on unpaved surfaces – 80% control for watering of trafficked areas. Note the control factor is only applied to the mechanically generated emissions and not the contributions from the diesel exhaust emissions;
- Primary and Secondary crushing – 50% control for enclosure and dust cyclone;
- Conveyor transfer points – 70% control for enclosures;
- Stockpiles – 50% control for water sprays; and,
- Revegetation – 70% control for partial rehabilitation of exposed areas.

Table C-1: Emission factor equations

Activity	Emission factor equation		
	TSP	PM_{10}	$PM_{2.5}$
Drilling (overburden)	$EF = 0.59\ kg/hole$	$0.52 \times TSP$	$0.03 \times TSP$
Blasting (overburden)	$EF = 0.00022 \times A^{1.5}\ kg/blast$	$0.52 \times TSP$	$0.03 \times TSP$
Loading / emplacing material & conveyor transfer	$EF = 0.74 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right)\ kg/tonne$	$EF = 0.35 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right)\ kg/tonne$	$EF = 0.053 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right)\ kg/tonne$
Loading/ emplacing limestone material	$0.52 \times PM10$	$EF = 0.75 \times 0.001184 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right)\ kg/tonne$	$0.075 \times TSP$
Hauling on unsealed surfaces	$EF = \left(\frac{0.4536}{1.6093}\right) \times 4.9 \times (s/12)^{0.7} \times (1.1023 \times M/3)^{0.45}\ kg/VKT$	$EF = \left(\frac{0.4536}{1.6093}\right) \times 1.5 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45}\ kg/VKT$	$EF = \left(\frac{0.4536}{1.6093}\right) \times 0.15 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45}\ kg/VKT$
Dozers on overburden	$EF = 2.6 \times \frac{s^{1.2}}{M^{1.3}}\ kg/hour$	$EF = 0.45 \times \frac{s^{1.5}}{M^{1.4}} \times 0.75\ kg/hour$	$EF = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \times 0.105\ kg/hour$
Limestone crusher	$EF = 0.0083\ kg/tonne$	$0.5 \times TSP$	$0.075 \times TSP$
Primary screen	$EF = 0.003\ kg/tonne$	$0.5 \times TSP$	$0.075 \times TSP$
Tertiary screen	$EF = 6.5 \times 10^{-5}\ kg/tonne$	$0.5 \times TSP$	$0.075 \times TSP$
Loading stockpiles	$EF = 0.004\ kg/tonne$	$EF = 0.0017\ kg/tonne$	$0.075 \times TSP$
Unloading from stockpiles	$EF = 0.03\ kg/tonne$	$EF = 0.013\ kg/tonne$	$0.075 \times TSP$
Loading to trains	$EF = 0.0004\ kg/tonne$	$EF = 0.00017\ kg/tonne$	$0.075 \times TSP$
Wind erosion on exposed areas, stockpiles & conveyors	$EF = 3{,}504\ kg/ha/year$	$0.5 \times TSP$	$0.075 \times TSP$
Grading roads	$EF = 0.0034 \times sp^{2.5}\ kg/VKT$	$EF = 0.0056 \times sp^{2.0} \times 0.6\ kg/VKT$	$EF = 0.0034 \times sp^{2.0} \times 0.031\ kg/VKT$

EF = emission factor, A = area of blast (m^2), U = wind speed (m/s), M = moisture content (%), s = silt content (%), VKT = vehicle kilometres travelled (km), sp = speed of grader (km/h).

Table C-2: Emission inventory – Stage 1

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	TSP Emission Factor	PM10 Emission Factor	PM2.5 Emission Factor	Units	Var.1	Units	Var.2	Units	Var.3 - TSP / PM10 / PM2.5	Units	Var. 4	Units	Var. 5	Units	Var. 6	Units
Stripping topsoil with dozer	10,144	2,904	1,065	496	hr/yr	20.5	5.9	2.1	kg/h	21	S.C. (%)	3.4	M.C. (%)								
Loading topsoil to haul truck	5	2	0	6,000	t/yr	0.00077	0.00036	0.00005	kg/t	1.360	(W.S./2.2)1.3 (m/s)	3.4	M.C. (%)								
Hauling topsoil to emplacement area	171	38	4	6,000	t/yr	0.142	0.032	0.003	kg/t	80	tonnes/load	4.5	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Emplacing topsoil at area	5	2	0	6,000	t/yr	0.00077	0.00036	0.00005	kg/t	1.360	(W.S./2.2)1.3 (m/s)	3.4	M.C. (%)								
Loading OB to haul truck	6,214	2,939	445	3,860,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling to emplacement area - WOBE	40,580	9,077	908	1,200,000	t/yr	0.169	0.038	0.004	kg/t	80	tonnes/load	5.4	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Hauling to emplacement area - SOBE	38,816	8,683	868	2,060,000	t/yr	0.094	0.021	0.002	kg/t	80	tonnes/load	3.0	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Hauling to emplacement area - NOBE	17,087	3,822	382	600,000	t/yr	0.142	0.032	0.003	kg/t	80	tonnes/load	4.5	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Emplacing at area - WOBE	1,932	914	138	1,200,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Emplacing at area - SOBE	3,316	1,569	238	2,060,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Emplacing at area - NOBE	966	457	69	600,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Dozers on dump and rehab	47,149	11,394	4,951	2,817	hr/yr	16.7	4.0	1.8	kg/h	10	S.C. (%)	2	M.C. (%)								
Loading Shale to haul truck	225	107	16	140,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling to emplacement area	2,239	501	50	140,000	t/yr	0.080	0.018	0.002	kg/t	80	tonnes/load	2.5	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Emplacing at area	225	107	16	140,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Drilling	4,354	2,264	131	7,380	holes/yr	0.59	0.307	0.018	kg/hole												
Blasting	1,743	906	52	202	blasts/yr	8.63	4.49	0.26	kg/blast	1,154	Area of blast (m2)										
Loading LS to haul truck	9,660	4,830	724	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling LS to hopper	104,675	23,415	2,341	4,000,000	t/yr	0.131	0.029	0.003	kg/t	75	tonnes/load	3.9	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Unloading LS to stockpile	9,660	4,830	724	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Loading LS from stockpile to hopper	9,660	4,830	724	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Primary crushing	16,600	8,300	1,245	4,000,000	t/yr	0.0083	0.004	0.001	kg/t											50	%
Conveying from primary to secondary crusher	84	42	6	0.024	ha	3,504	1,752	263	kg/ha/yr												
Secondary crushing	16,600	8,300	1,245	4,000,000	t/yr	0.0083	0.004	0.001	kg/t											50	%
Conveying from secondary crusher to transfer	179	89	13	0.051	ha	3,504	1,752	263	kg/ha/yr												
Conveying from transfer to stockpile	841	420	63	0.240	ha	3,504	1,752	263	kg/ha/yr												
Transfer	2,898	1,449	217	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Unloading at stockpile	6,400	2,720	480	1,600,000	t/yr	0.004	0.0017	0.0003	kg/t												
Loading from stockpile	3,864	1,932	290	1,600,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								

Table C-2: Emission inventory – Stage 1 (cont.)

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	TSP Emission Factor	PM10 Emission Factor	PM2.5 Emission Factor	Units	Var.1	Units	Var.2	Units	Var.3 - TSP / PM10 / PM2.5	Units	Var. 4	Units	Var. 5	Units	Var. 6	Units
Conveying from stockpile to transfer	841	420	63	0.240	ha	3,504	1,752	263	kg/ha/yr												
Transfer to plant	2,898	1,449	217	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Conveying from transfer to plant	399	200	30	0.114	ha	3,504	1,752	263	kg/ha/yr												
Transfer to surge bin	2,898	1,449	217	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Screening	12,000	6,000	900	4,000,000	t/yr	0.003	0.0015	0.0002	kg/t												
Transfer to bin 7/8 (Berrima)	1,884	942	141	2,600,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Trommel Screening	4,200	2,100	315	1,400,000	t/yr	0.003	0.0015	0.0002	kg/t												
Unloading from Trommel screen to kiln stockpile	1,120	476	84	280,000	t/yr	0.004	0.0017	0.0003	kg/t												
Loading from kiln stockpile to kiln	8,400	3,640	630	280,000	t/yr	0.030	0.0130	0.0023	kg/t												
Transfer to bins 1/4	203	101	15	280,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Tertiary crushing	9,296	4,648	697	1,120,000	t/yr	0.0083	0.0042	0.00062	kg/t												
Tertiary screening	73	36	5	1,120,000	t/yr	0.00007	0.00003	0.00000	kg/t												
Transfer to bins 5/6	811	406	61	1,120,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Loading to Trains for dispatch off-site	1,220	519	92	3,050,000	t/yr	0.00040	0.0002	0.00003	kg/t												
Loading to Truck for dispatch off-site	2,294	1,147	172	950,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling product from Marulan to off-site	4,998	959	232	550,000	t/yr	0.009	0.002	0.000	kg/t	30	tonnes/load	2.4	km/trip	).1 / 0.02 / 0.0	kg/VKT	1.0	S.L. (g/m	30	GVM (t)		
Hauling product from Marulan to Peppertree	8,195	1,573	381	1,000,000	t/yr	0.008	0.002	0.000	kg/t	30	tonnes/load	2.1	km/trip	).1 / 0.02 / 0.0	kg/VKT	1.0	S.L. (g/m	30	GVM (t)		
Hauling product from Marulan to Road Sale Stoc	450	86	21	50,000	t/yr	0.009	0.002	0.000	kg/t	30	tonnes/load	2.4	km/trip	).1 / 0.02 / 0.0	kg/VKT	1.0	S.L. (g/m	30	GVM (t)		
Unloading material at shared Road sale stockpil	121	60	9	50,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Overburden emplacement areas - WOBE	26,280	13,140	1,971	7.5	ha	3,504	1,752	263	kg/ha/yr												
Overburden emplacement areas - SOBE	45,114	22,557	3,384	12.9	ha	3,504	1,752	263	kg/ha/yr												
Overburden emplacement areas - NOBE	13,140	6,570	986	3.8	ha	3,504	1,752	263	kg/ha/yr												
Active Revegetation	40,986	20,493	3,074	39.0	ha	3,504	1,752	263	kg/ha/yr											70	%
Open pit	252,288	126,144	18,922	72.0	ha	3,504	1,752	263	kg/ha/yr												
Stockpiles - Infrastructure Area and Stockpile	21,585	10,792	1,619	12.3	ha	3,504	1,752	263	kg/ha/yr											50	%
Reclaim stockpiles	9,115	4,557	684	2.6	ha	3,504	1,752	263	kg/ha/yr												
Grading roads	23,723	8,289	735	38,544	km	0.62	0.22	0.02	kg/VKT	8	speed (km/h)										
Total emissions (kg/yr)	**850,820**	**345,597**	**53,065**																		

Table C-3: Emission inventory – Stage 2

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	TSP Emission Factor	PM10 Emission Factor	PM2.5 Emission Factor	Units	Var.1	Units	Var.2	Units	Var.3 - TSP / PM10 / PM2.5	Units	Var. 4	Units	Var. 5	Units	Var. 6	Units
Stripping topsoil with dozer	10,144	2,904	1,065	496	hr/yr	20.5	5.9	2.1	kg/h	21	S.C. (%)	3.4	M.C. (%)								
Loading topsoil to haul truck	5	2	0	6,000	t/yr	0.00077	0.00036	0.00005	kg/t	1.360	(W.S./2.2)1.3 (m/s)	3.4	M.C. (%)								
Hauling topsoil to emplacement area	253	57	6	6,000	t/yr	0.211	0.047	0.005	kg/t	80	tonnes/load	6.7	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Emplacing topsoil at area	5	2	0	6,000	t/yr	0.00077	0.00036	0.00005	kg/t	1.360	(W.S./2.2)1.3 (m/s)	3.4	M.C. (%)								
Loading OB to haul truck	6,214	2,939	445	3,860,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling to emplacement area - WOBE	141,564	31,667	3,167	3,360,000	t/yr	0.211	0.047	0.005	kg/t	80	tonnes/load	6.7	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Hauling to emplacement area - SOBE	9,421	2,107	211	500,000	t/yr	0.094	0.021	0.002	kg/t	80	tonnes/load	3.0	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Hauling to emplacement area - NOBE	-	-	-	-	t/yr	0.000	0.000	0.000	kg/t	80	tonnes/load	0.0	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Emplacing at area - WOBE	5,409	2,559	387	3,360,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Emplacing at area - SOBE	805	381	58	500,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Emplacing at area - NOBE	-	-	-	-	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Dozers on dump and rehab	45,958	11,106	4,826	2,746	hr/yr	16.7	4.0	1.8	kg/h	10	S.C. (%)	2	M.C. (%)								
Loading Shale to haul truck	225	107	16	140,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling to emplacement area	2,239	501	50	140,000	t/yr	0.080	0.018	0.002	kg/t	80	tonnes/load	2.5	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Emplacing at area	225	107	16	140,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Drilling	4,354	2,264	131	7,380	holes/yr	0.59	0.307	0.018	kg/hole												
Blasting	1,743	906	52	202	blasts/yr	8.63	4.49	0.26	kg/blast	1,154	Area of blast (m2)										
Loading LS to haul truck	9,660	4,830	724	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling LS to hopper	156,289	34,960	3,496	4,000,000	t/yr	0.195	0.044	0.004	kg/t	75	tonnes/load	5.8	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Unloading LS to stockpile	9,660	4,830	724	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Loading LS from stockpile to hopper	9,660	4,830	724	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Primary crushing	16,600	8,300	1,245	4,000,000	t/yr	0.0083	0.004	0.001	kg/t											50	%
Conveying from primary to secondary crusher	84	42	6	0.024	ha	3,504	1,752	263	kg/ha/yr												
Secondary crushing	16,600	8,300	1,245	4,000,000	t/yr	0.0083	0.004	0.001	kg/t											50	%
Conveying from secondary crusher to transfer	179	89	13	0.051	ha	3,504	1,752	263	kg/ha/yr												
Conveying from transfer to stockpile	841	420	63	0.240	ha	3,504	1,752	263	kg/ha/yr												
Transfer	2,898	1,449	217	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Unloading at stockpile	6,400	2,720	480	1,600,000	t/yr	0.004	0.0017	0.0003	kg/t												
Loading from stockpile	3,864	1,932	290	1,600,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								

Table C-3: Emission inventory – Stage 2 (cont.)

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	TSP Emission Factor	PM10 Emission Factor	PM2.5 Emission Factor	Units	Var.1	Units	Var.2	Units	Var.3 - TSP / PM10 / PM2.5	Units	Var. 4	Units	Var. 5	Units	Var. 6	Units
Conveying from stockpile to transfer	841	420	63	0.240	ha	3,504	1,752	263	kg/ha/yr												
Transfer to plant	2,898	1,449	217	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Conveying from transfer to plant	399	200	30	0.114	ha	3,504	1,752	263	kg/ha/yr												
Transfer to surge bin	2,898	1,449	217	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Screening	12,000	6,000	900	4,000,000	t/yr	0.003	0.0015	0.0002	kg/t												
Transfer to bin 7/8 (Berrima)	1,884	942	141	2,600,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Trommel Screening	4,200	2,100	315	1,400,000	t/yr	0.003	0.0015	0.0002	kg/t												
Unloading from Trommel screen to kiln stockpile	1,120	476	84	280,000	t/yr	0.004	0.0017	0.0003	kg/t												
Loading from kiln stockpile to kiln	8,400	3,640	630	280,000	t/yr	0.030	0.0130	0.0023	kg/t												
Transfer to bins 1/4	203	101	15	280,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Tertiary crushing	9,296	4,648	697	1,120,000	t/yr	0.0083	0.0042	0.00062	kg/t												
Tertiary screening	73	36	5	1,120,000	t/yr	0.00007	0.00003	0.00000	kg/t												
Transfer to bins 5/6	811	406	61	1,120,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Loading to Trains for dispatch off-site	1,220	519	92	3,050,000	t/yr	0.00040	0.0002	0.00003	kg/t												
Loading to Truck for dispatch off-site	2,294	1,147	172	950,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling product from Marulan to off-site	4,998	959	232	550,000	t/yr	0.009	0.002	0.000	kg/t	30	tonnes/load	2.4	km/trip	).1 / 0.02 / 0.0:	kg/VKT	1.0	S.L. (g/m	30	GVM (t)		
Hauling product from Marulan to Peppertree	8,195	1,573	381	1,000,000	t/yr	0.008	0.002	0.000	kg/t	30	tonnes/load	2.1	km/trip	).1 / 0.02 / 0.0:	kg/VKT	1.0	S.L. (g/m	30	GVM (t)		
Hauling product from Marulan to Road Sale Stoc	450	86	21	50,000	t/yr	0.009	0.002	0.000	kg/t	30	tonnes/load	2.4	km/trip	).1 / 0.02 / 0.0:	kg/VKT	1.0	S.L. (g/m	30	GVM (t)		
Unloading material at shared Road sale stockpil	121	60	9	50,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Overburden emplacement areas - WOBE	73,584	36,792	5,519	21.0	ha	3,504	1,752	263	kg/ha/yr												
Overburden emplacement areas - SOBE	10,950	5,475	821	3.1	ha	3,504	1,752	263	kg/ha/yr												
Overburden emplacement areas - NOBE	-	-	-	-	ha	3,504	1,752	263	kg/ha/yr												
Active Revegetation	58,352	29,176	4,376	55.5	ha	3,504	1,752	263	kg/ha/yr											70	%
Open pit	287,328	143,664	21,550	82.0	ha	3,504	1,752	263	kg/ha/yr												
Stockpiles - Infrastructure Area and Stockpile	21,585	10,792	1,619	12.3	ha	3,504	1,752	263	kg/ha/yr											50	%
Reclaim stockpiles	9,115	4,557	684	2.6	ha	3,504	1,752	263	kg/ha/yr												
Grading roads	23,723	8,289	735	38,544	km	0.62	0.22	0.02	kg/VKT	8	speed (km/h)										
Total emissions (kg/yr)	**1,008,235**	**395,268**	**59,246**																		

Table C-4: Emission inventory – Stage 3

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	TSP Emission Factor	PM10 Emission Factor	PM2.5 Emission Factor	Units	Var.1	Units	Var.2	Units	Var.3 - TSP / PM10 / PM2.5	Units	Var. 4	Units	Var. 5	Units	Var. 6	Units
Stripping topsoil with dozer	10,144	2,904	1,065	496	hr/yr	20.5	5.9	2.1	kg/h	21	S.C. (%)	3.4	M.C. (%)								
Loading topsoil to haul truck	5	2	0	6,000	t/yr	0.00077	0.00036	0.00005	kg/t	1.360	(W.S./2.2)1.3 (m/s)	3.4	M.C. (%)								
Hauling topsoil to emplacement area	185	41	4	6,000	t/yr	0.154	0.035	0.003	kg/t	80	tonnes/load	4.9	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Emplacing topsoil at area	5	2	0	6,000	t/yr	0.00077	0.00036	0.00005	kg/t	1.360	(W.S./2.2)1.3 (m/s)	3.4	M.C. (%)								
Loading OB to haul truck	7,824	3,701	560	4,860,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling to emplacement area - WOBE	111,066	24,844	2,484	3,600,000	t/yr	0.154	0.035	0.003	kg/t	80	tonnes/load	4.9	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Hauling to emplacement area - SOBE	18,993	4,249	425	1,260,000	t/yr	0.075	0.017	0.002	kg/t	80	tonnes/load	2.4	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Hauling to emplacement area - NOBE	-	-	-	-	t/yr	0.000	0.000	0.000	kg/t	80	tonnes/load	0.0	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Emplacing at area - WOBE	5,796	2,741	415	3,600,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Emplacing at area - SOBE	2,029	959	145	1,260,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Emplacing at area - NOBE	-	-	-	-	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Dozers on dump and rehab	57,864	13,983	6,076	3,458	hr/yr	16.7	4.0	1.8	kg/h	10	S.C. (%)	2	M.C. (%)								
Loading Shale to haul truck	225	107	16	140,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling to emplacement area	2,239	501	50	140,000	t/yr	0.080	0.018	0.002	kg/t	80	tonnes/load	2.5	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Emplacing at area	225	107	16	140,000	t/yr	0.00161	0.00076	0.00012	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Drilling	4,354	2,264	131	7,380	holes/yr	0.59	0.307	0.018	kg/hole												
Blasting	1,743	906	52	202	blasts/yr	8.63	4.49	0.26	kg/blast	1,154	Area of blast (m2)										
Loading LS to haul truck	9,660	4,830	724	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling LS to hopper	151,626	33,917	3,392	4,000,000	t/yr	0.190	0.042	0.004	kg/t	75	tonnes/load	5.7	km/trip	2.5 / 0.6 / 0.1	kg/VKT	2.5	S.C. (%)	118	GVM (t)	80	%
Unloading LS to stockpile	9,660	4,830	724	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Loading LS from stockpile to hopper	9,660	4,830	724	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Primary crushing	16,600	8,300	1,245	4,000,000	t/yr	0.0083	0.004	0.001	kg/t											50	%
Conveying from primary to secondary crusher	84	42	6	0.024	ha	3,504	1,752	263	kg/ha/yr												
Secondary crushing	16,600	8,300	1,245	4,000,000	t/yr	0.0083	0.004	0.001	kg/t											50	%
Conveying from secondary crusher to transfer	179	89	13	0.051	ha	3,504	1,752	263	kg/ha/yr												
Conveying from transfer to stockpile	841	420	63	0.240	ha	3,504	1,752	263	kg/ha/yr												
Transfer	2,898	1,449	217	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Unloading at stockpile	6,400	2,720	480	1,600,000	t/yr	0.004	0.0017	0.0003	kg/t												
Loading from stockpile	3,864	1,932	290	1,600,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								

Table C-4: Emission inventory – Stage 3 (cont.)

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	TSP Emission Factor	PM10 Emission Factor	PM2.5 Emission Factor	Units	Var.1	Units	Var.2	Units	Var.3 - TSP / PM10 / PM2.5	Units	Var. 4	Units	Var. 5	Units	Var. 6	Units
Conveying from stockpile to transfer	841	420	63	0.240	ha	3,504	1,752	263	kg/ha/yr												
Transfer to plant	2,898	1,449	217	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Conveying from transfer to plant	399	200	30	0.114	ha	3,504	1,752	263	kg/ha/yr												
Transfer to surge bin	2,898	1,449	217	4,000,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Screening	12,000	6,000	900	4,000,000	t/yr	0.003	0.0015	0.0002	kg/t												
Transfer to bin 7/8 (Berrima)	1,884	942	141	2,600,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Trommel Screening	4,200	2,100	315	1,400,000	t/yr	0.003	0.0015	0.0002	kg/t												
Unloading from Trommel screen to kiln stockpile	1,120	476	84	280,000	t/yr	0.004	0.0017	0.0003	kg/t												
Loading from kiln stockpile to kiln	8,400	3,640	630	280,000	t/yr	0.030	0.0130	0.0023	kg/t												
Transfer to bins 1/4	203	101	15	280,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Tertiary crushing	9,296	4,648	697	1,120,000	t/yr	0.0083	0.0042	0.00062	kg/t												
Tertiary screening	73	36	5	1,120,000	t/yr	0.00007	0.00003	0.00000	kg/t												
Transfer to bins 5/6	811	406	61	1,120,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)							70	%
Loading to Trains for dispatch off-site	1,220	519	92	3,050,000	t/yr	0.00040	0.0002	0.00003	kg/t												
Loading to Truck for dispatch off-site	2,294	1,147	172	950,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Hauling product from Marulan to off-site	4,998	959	232	550,000	t/yr	0.009	0.002	0.000	kg/t	30	tonnes/load	2.4	km/trip	.1 / 0.02 / 0.0	kg/VKT	1.0	S.L. (g/m	30	GVM (t)		
Hauling product from Marulan to Peppertree	8,195	1,573	381	1,000,000	t/yr	0.008	0.002	0.000	kg/t	30	tonnes/load	2.1	km/trip	.1 / 0.02 / 0.0	kg/VKT	1.0	S.L. (g/m	30	GVM (t)		
Hauling product from Marulan to Road Sale Stockp	450	86	21	50,000	t/yr	0.009	0.002	0.000	kg/t	30	tonnes/load	2.4	km/trip	.1 / 0.02 / 0.0	kg/VKT	1.0	S.L. (g/m	30	GVM (t)		
Unloading material at shared Road sale stockpile	121	60	9	50,000	t/yr	0.00241	0.0012	0.0002	kg/t	1.360	(W.S./2.2)1.3 (m/s)	2	M.C. (%)								
Overburden emplacement areas - WOBE	78,840	39,420	5,913	22.5	ha	3,504	1,752	263	kg/ha/yr												
Overburden emplacement areas - SOBE	27,594	13,797	2,070	7.9	ha	3,504	1,752	263	kg/ha/yr												
Overburden emplacement areas - NOBE	-	-	-	-	ha	3,504	1,752	263	kg/ha/yr												
Active Revegetation	32,650	16,325	2,449	31.1	ha	3,504	1,752	263	kg/ha/yr											70	%
Open pit	318,864	159,432	23,915	91.0	ha	3,504	1,752	263	kg/ha/yr												
Stockpiles - Infrastructure Area and Stockpile	21,585	10,792	1,619	12.3	ha	3,504	1,752	263	kg/ha/yr											50	%
Reclaim stockpiles	9,115	4,557	684	2.6	ha	3,504	1,752	263	kg/ha/yr												
Grading roads	23,723	8,289	735	38,544	km	0.62	0.22	0.02	kg/VKT	8	speed (km/h)										
Total emissions (kg/yr)	**1,025,438**	**407,796**	**62,233**																		

Appendix D

Isopleth Diagrams

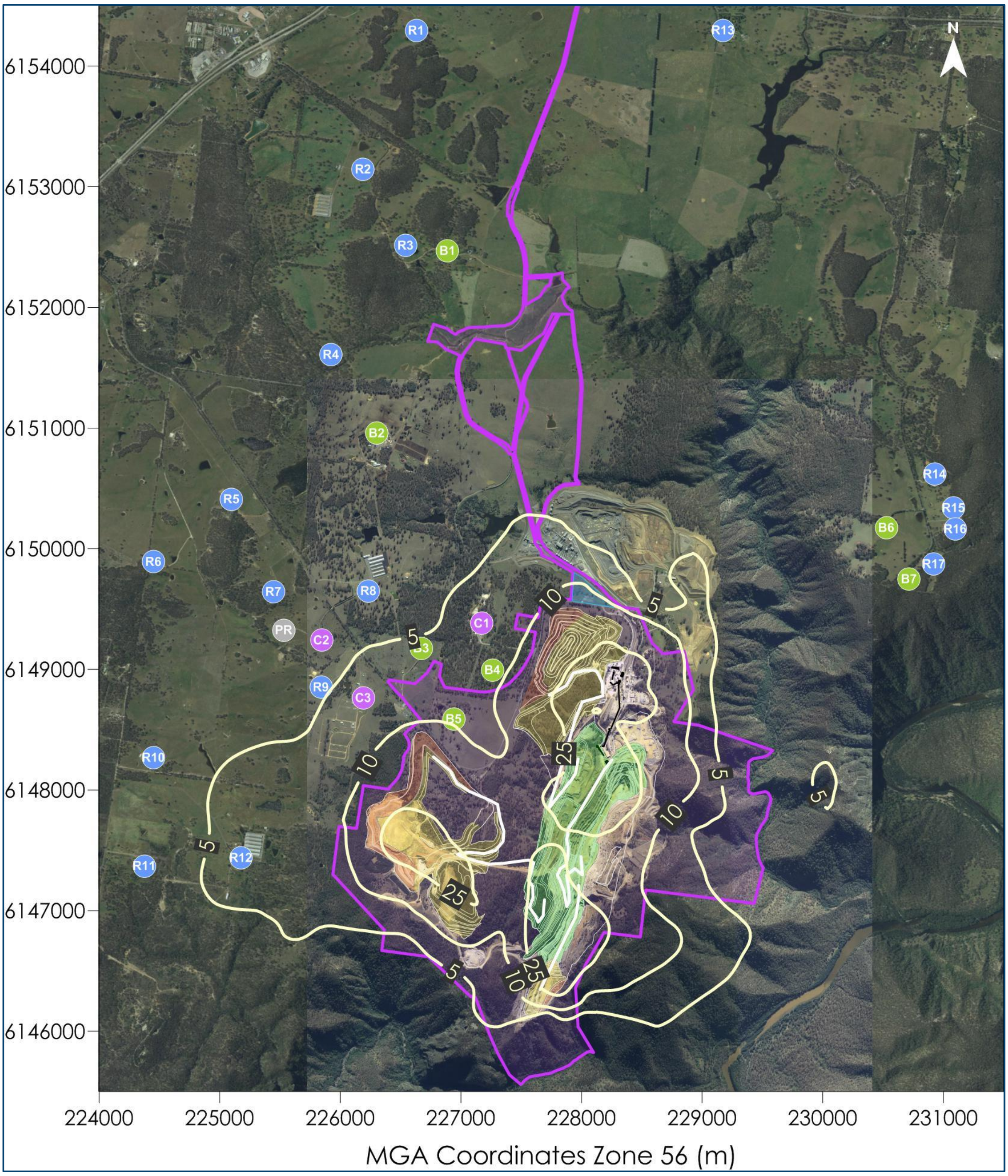


Figure D-1: Predicted maximum incremental 24-hour average $PM_{2.5}$ concentrations (µg/m³) – Stage 1

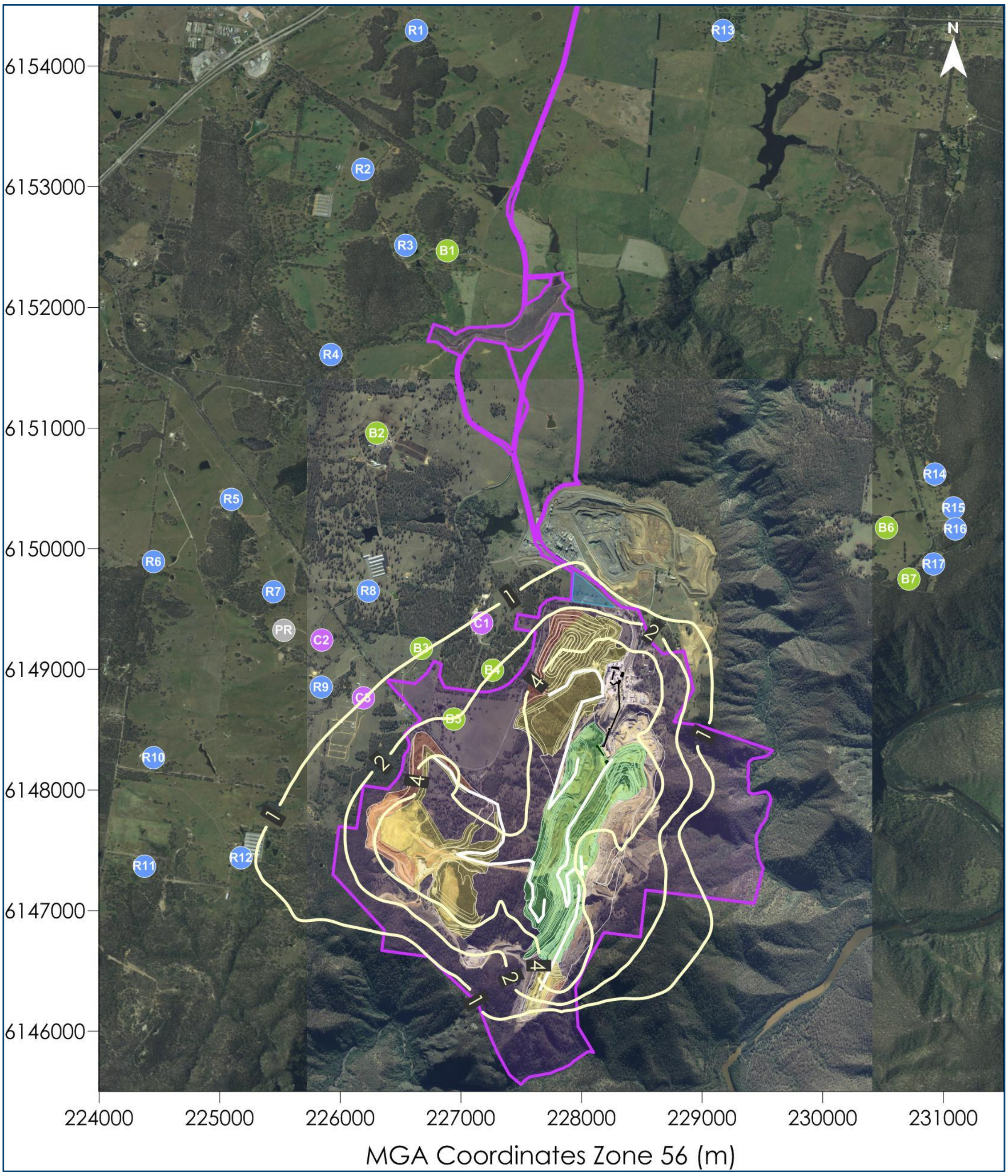


Figure D-2: Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³) – Stage 1

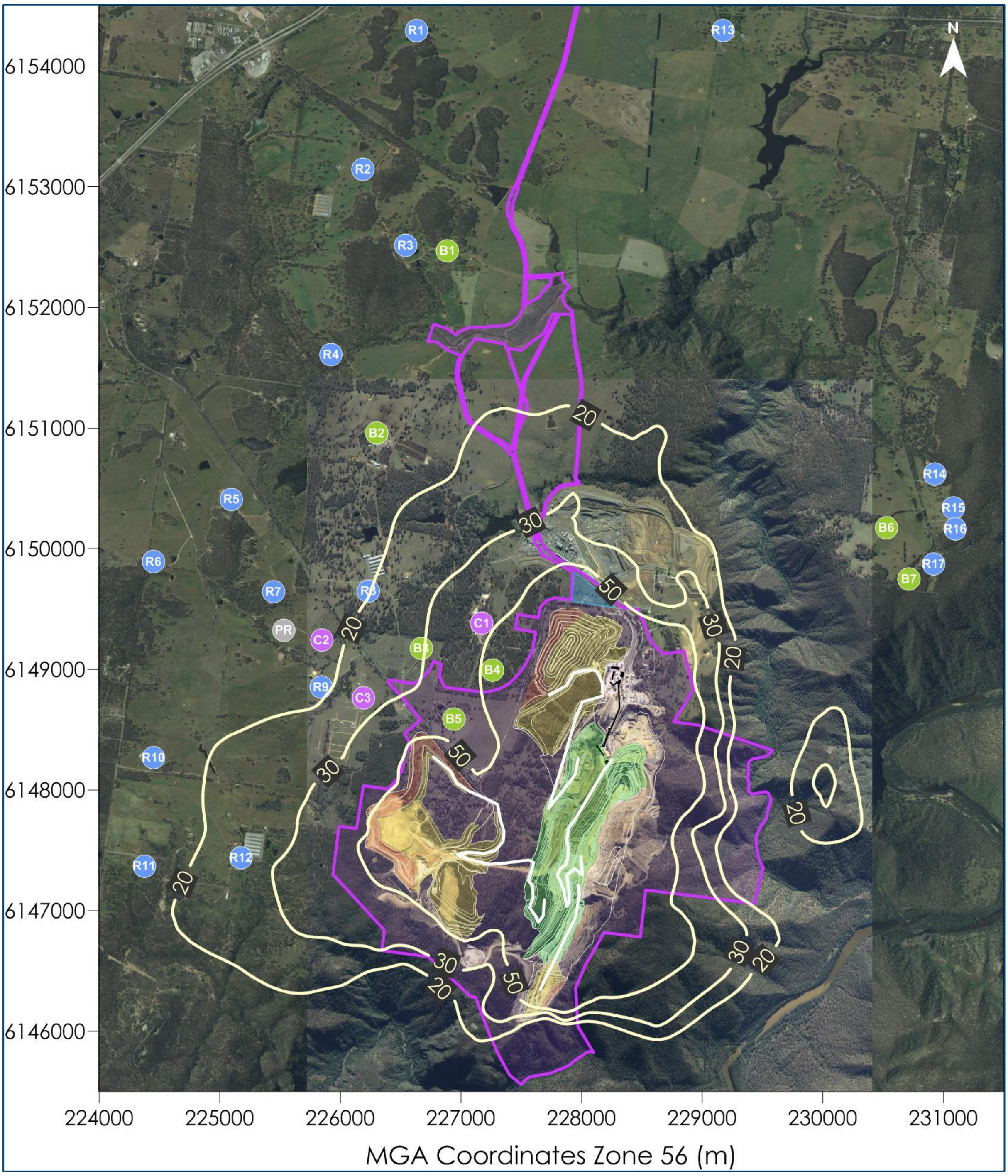


Figure D-3: Predicted maximum incremental 24-hour average PM_{10} concentrations (μg/m³) – Stage 1

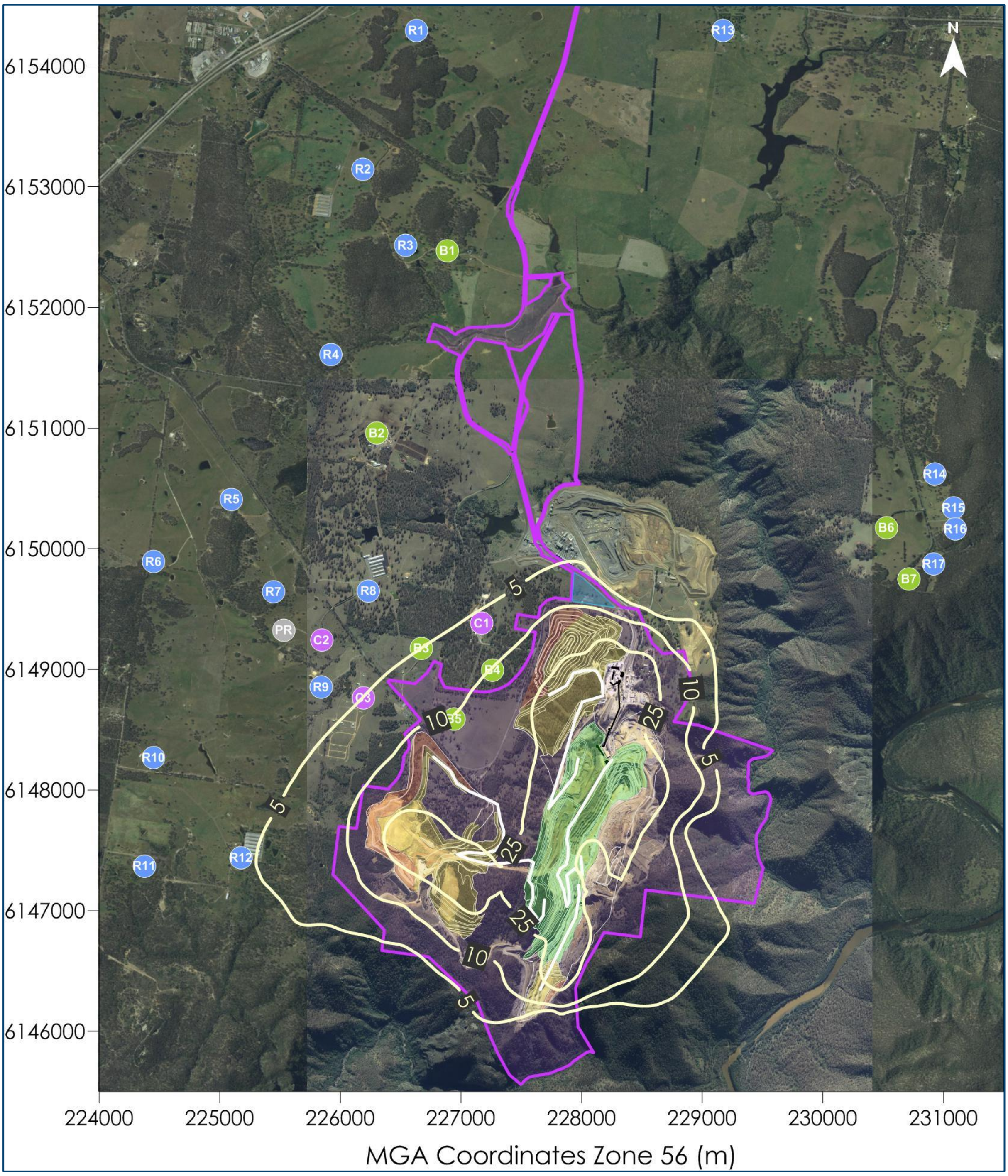


Figure D-4: Predicted incremental annual average PM_{10} concentrations (µg/m³) – Stage 1

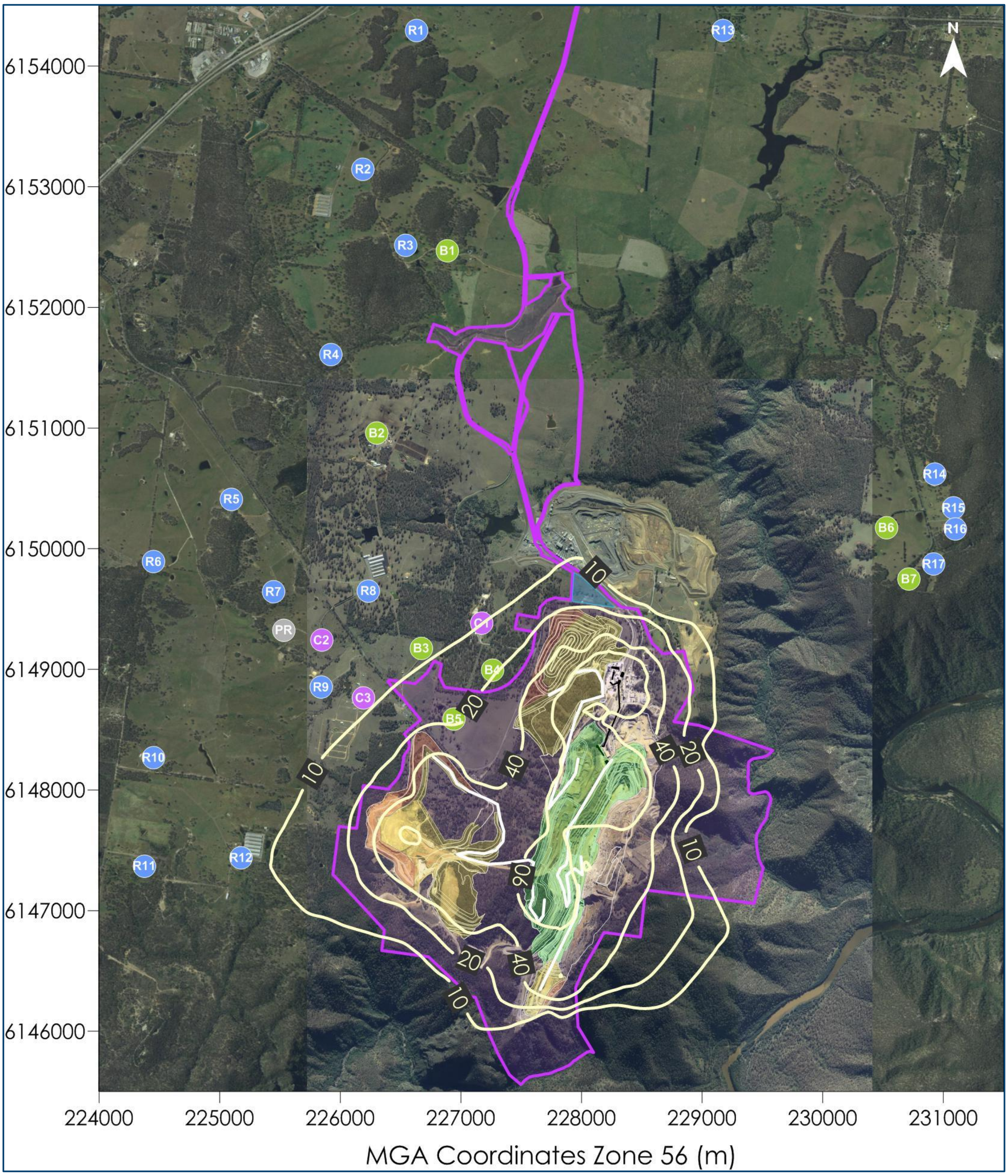


Figure D-5: Predicted incremental annual average TSP concentrations (μg/m³) – Stage 1

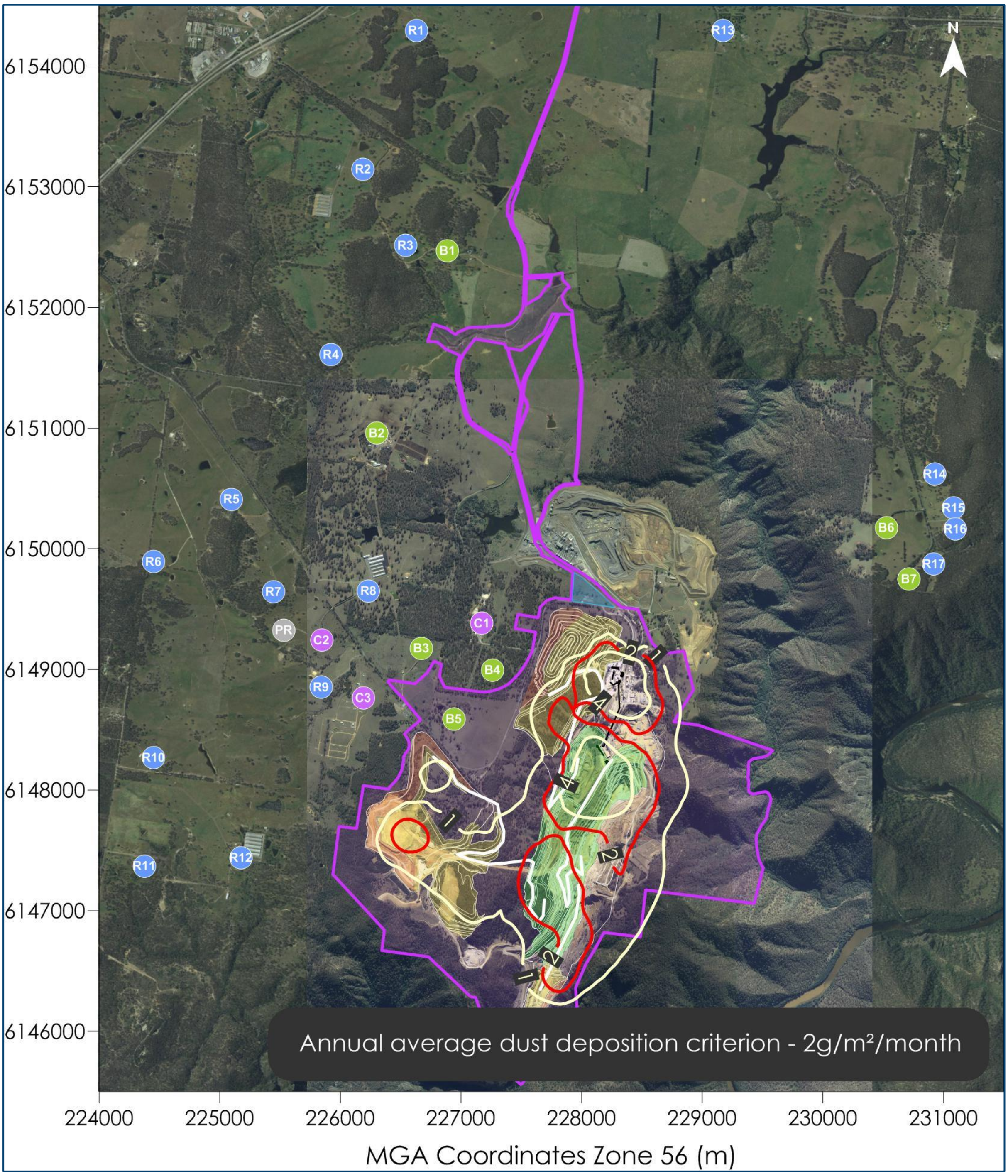


Figure D-6: Predicted annual average dust deposition levels (g/m²/month) – Stage 1

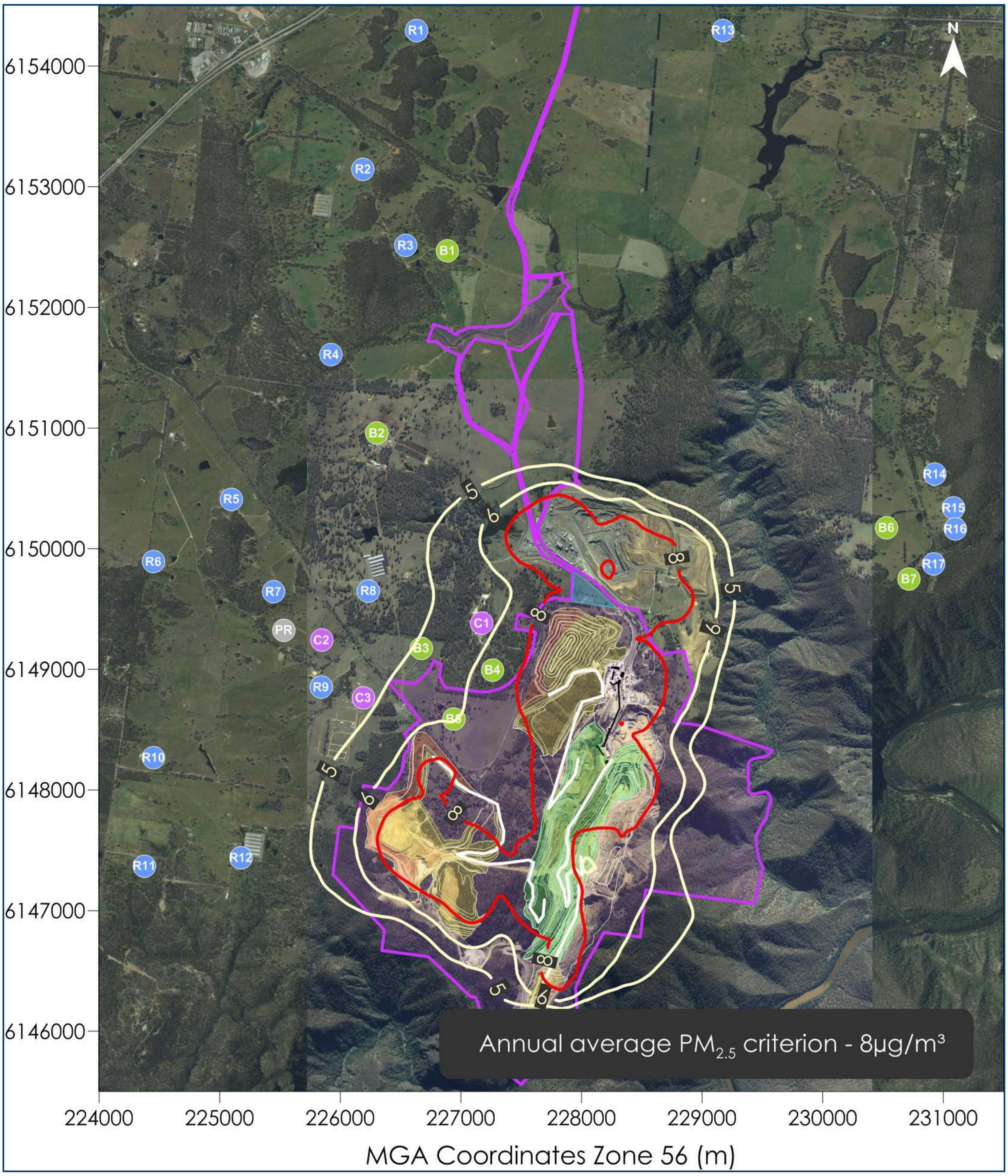


Figure D-7: Predicted cumulative annual average $PM_{2.5}$ concentrations (µg/m³) – Stage 1

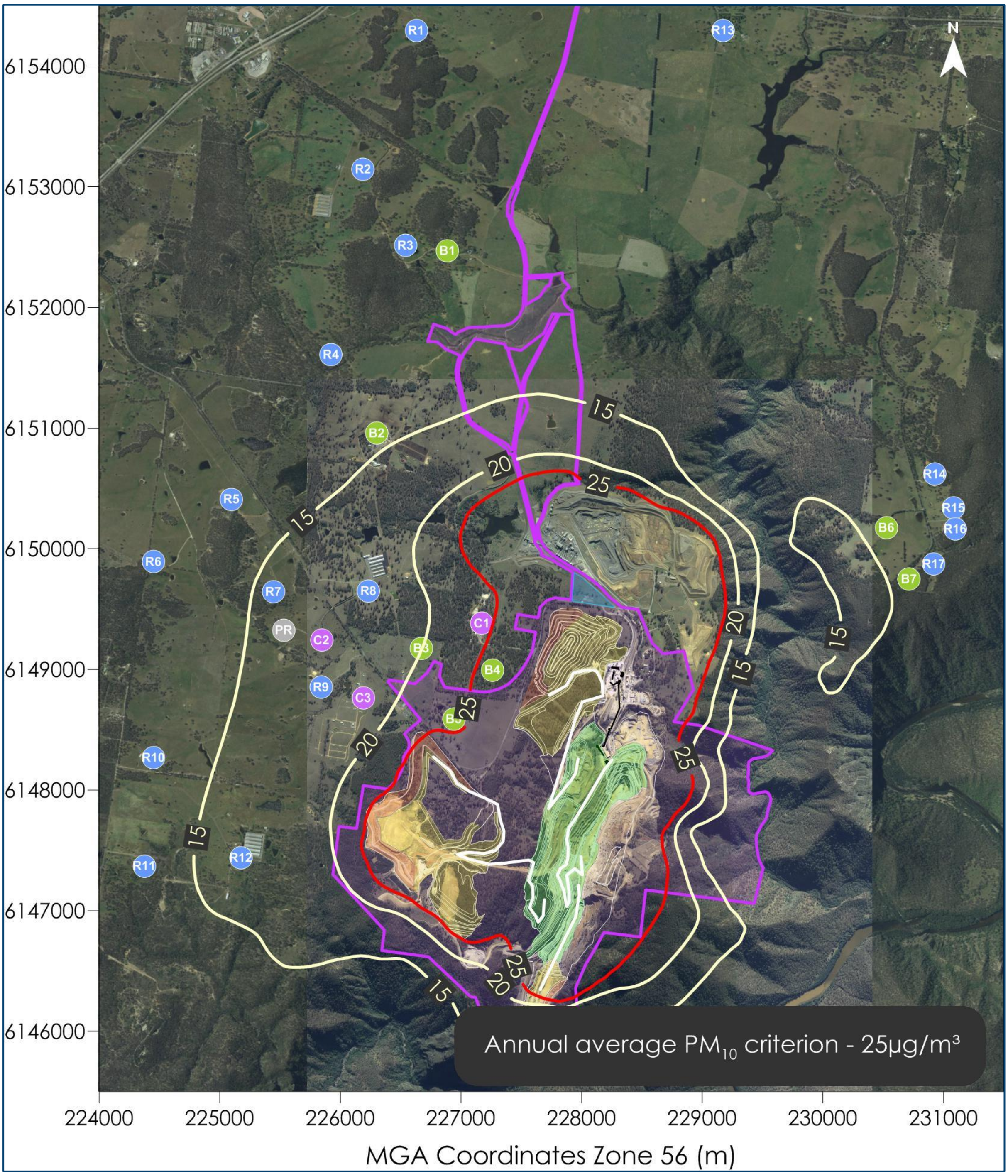


Figure D-8: Predicted cumulative annual average PM_{10} concentrations (µg/m³) – Stage 1

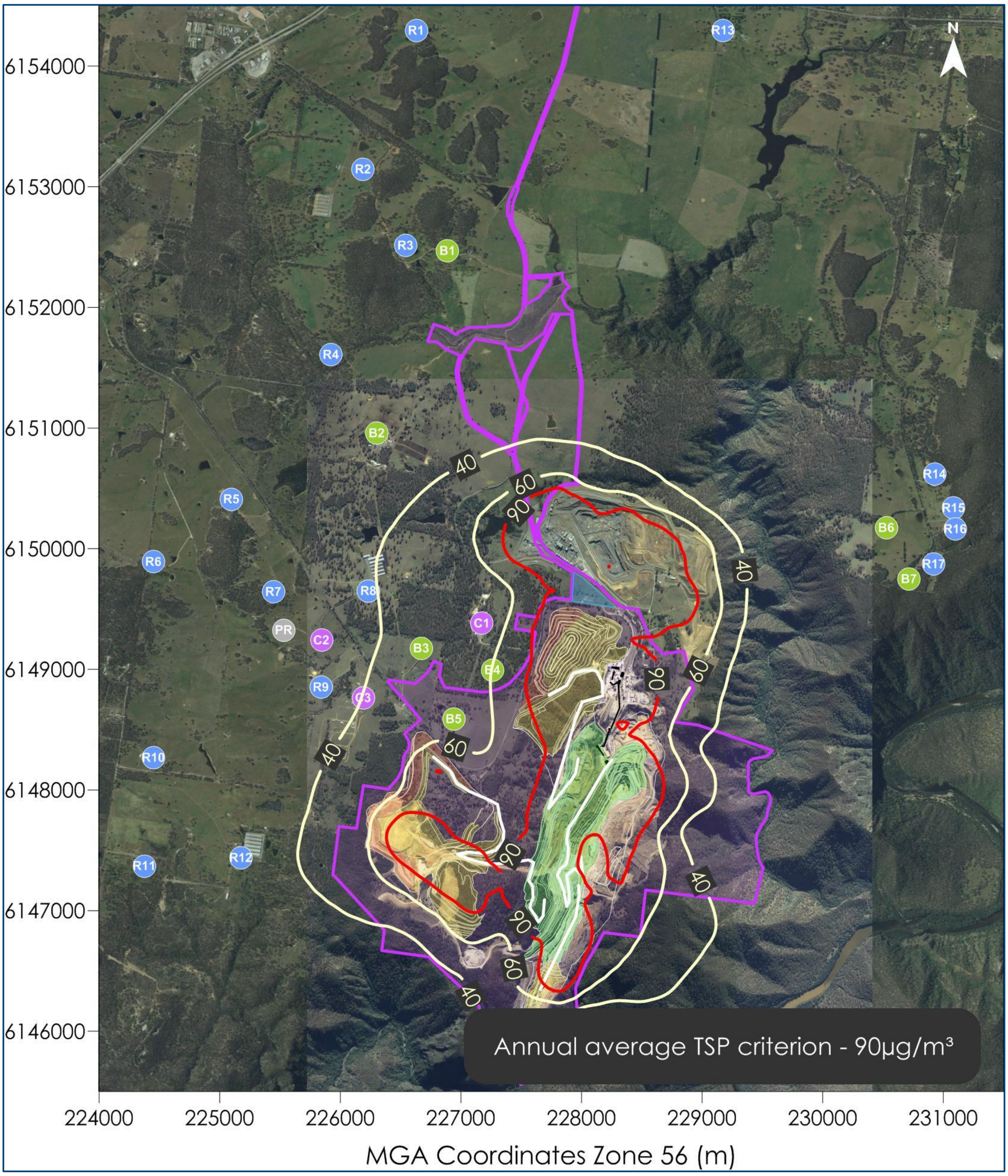


Figure D-9: Predicted cumulative annual average TSP concentrations (µg/m³) – Stage 1

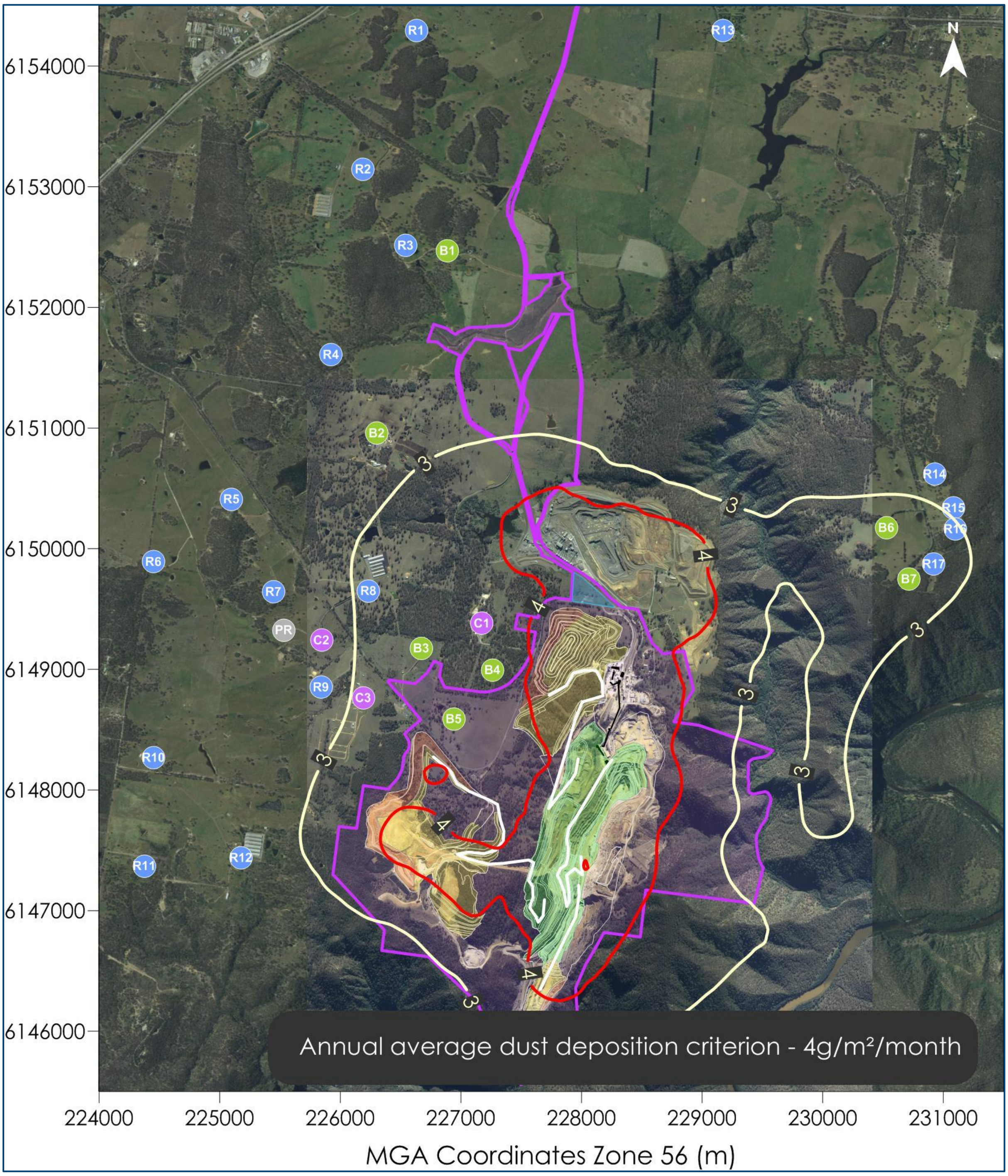


Figure D-10: Predicted cumulative annual average dust deposition levels (g/m²/month) – Stage 1

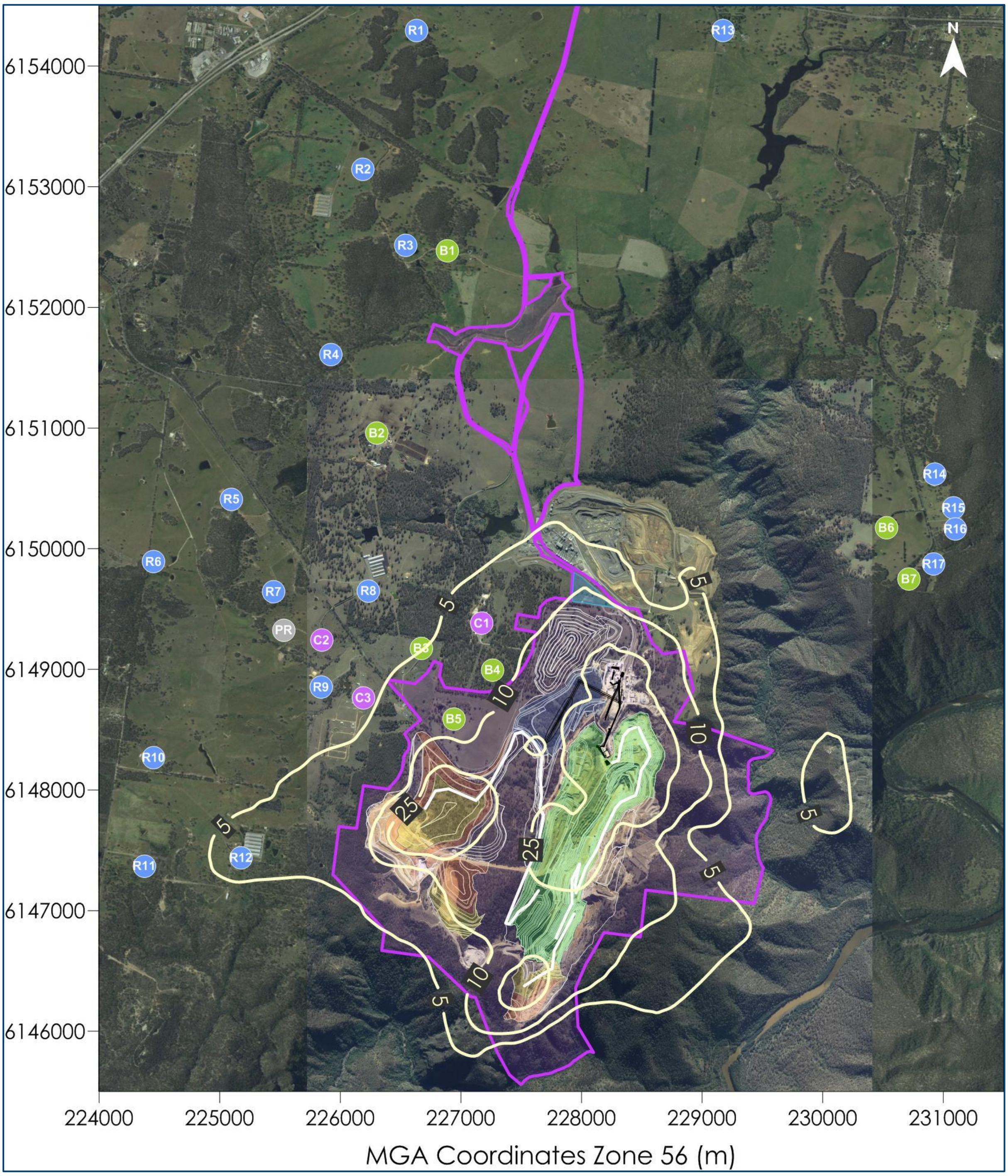


Figure D-11: Predicted maximum incremental 24-hour average $PM_{2.5}$ concentrations (µg/m³) – Stage 2

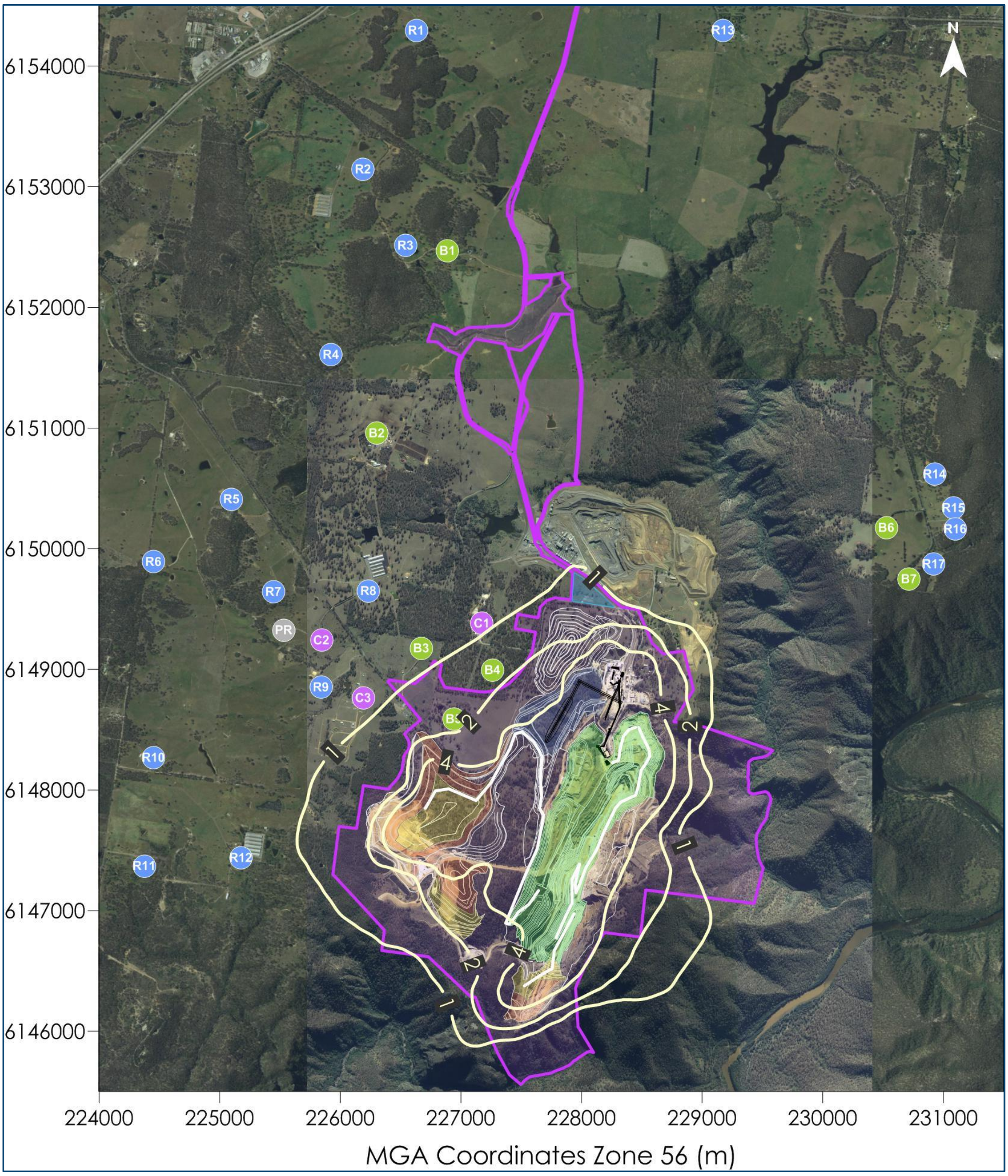


Figure D-12: Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³) – Stage 2

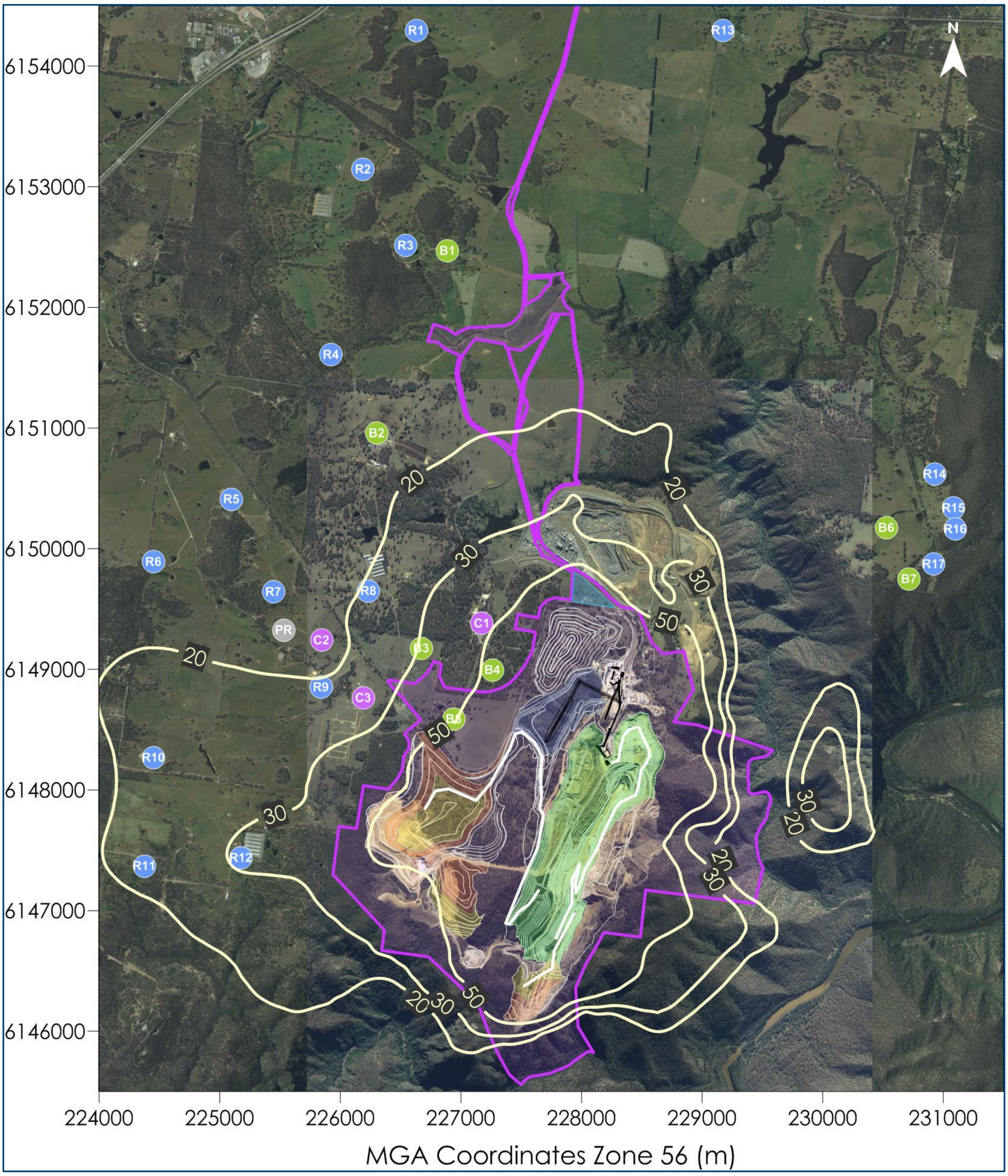


Figure D-13: Predicted maximum incremental 24-hour average PM_{10} concentrations (µg/m³) – Stage 2

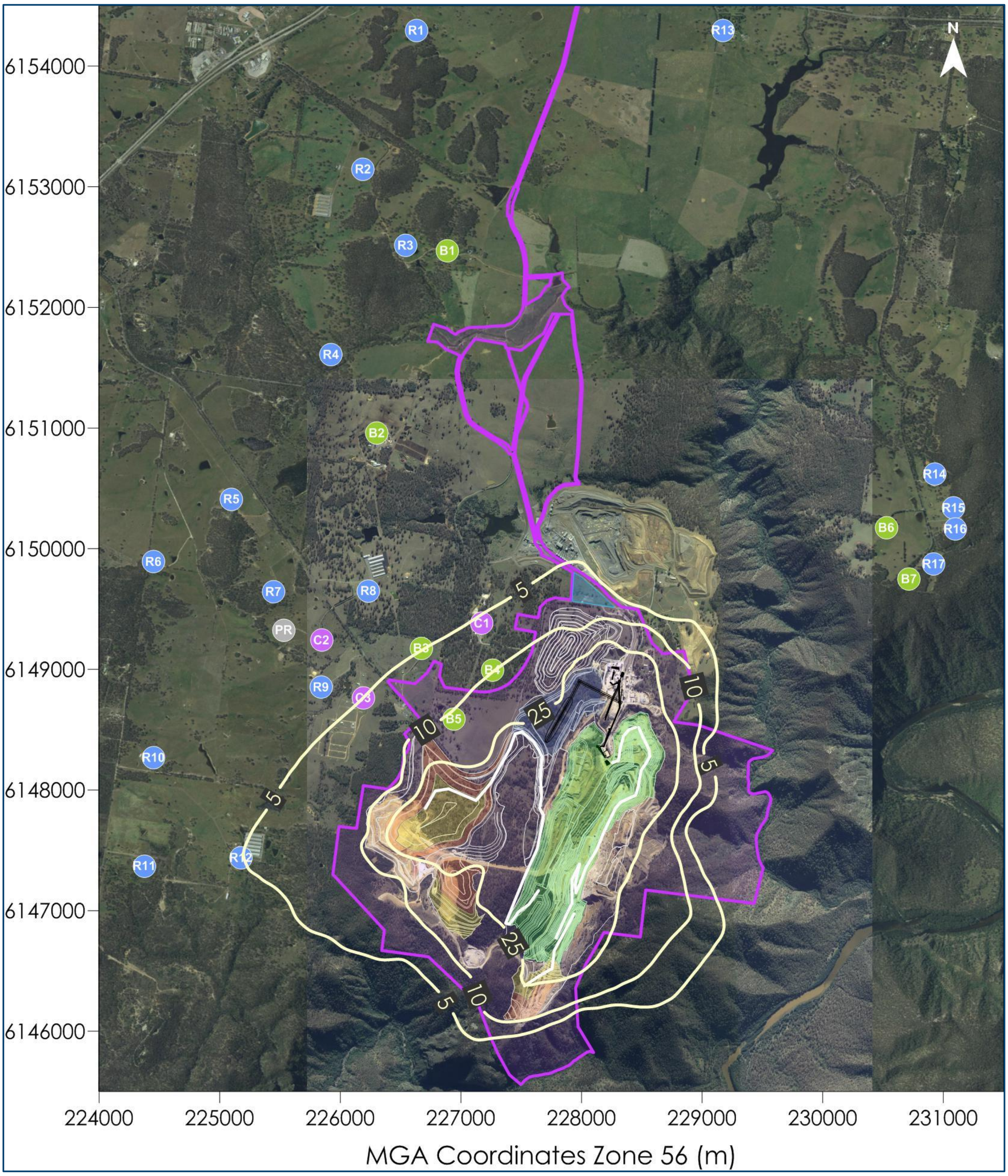


Figure D-14: Predicted incremental annual average PM_{10} concentrations (µg/m³) – Stage 2

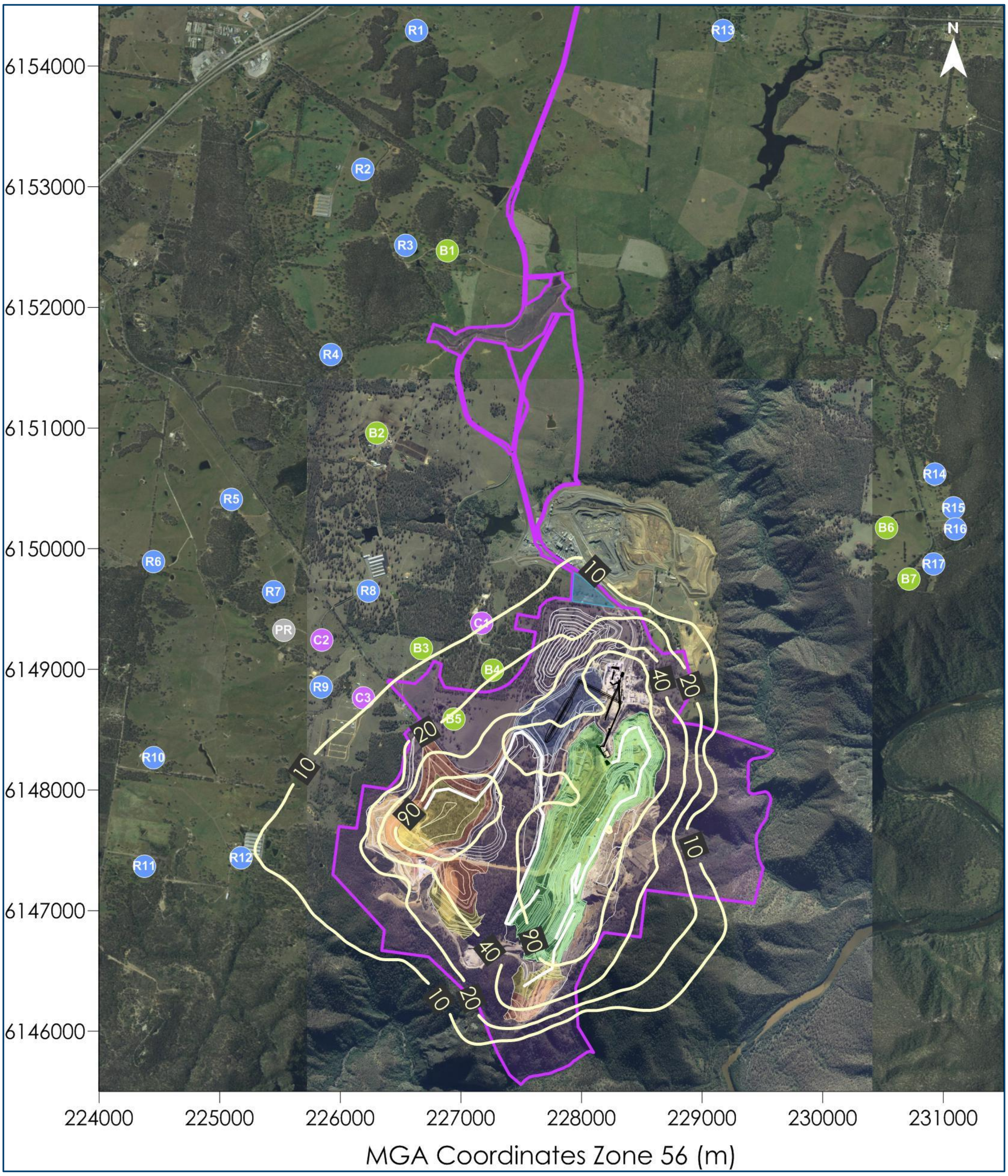


Figure D-15: Predicted incremental annual average TSP concentrations (µg/m³) – Stage 2

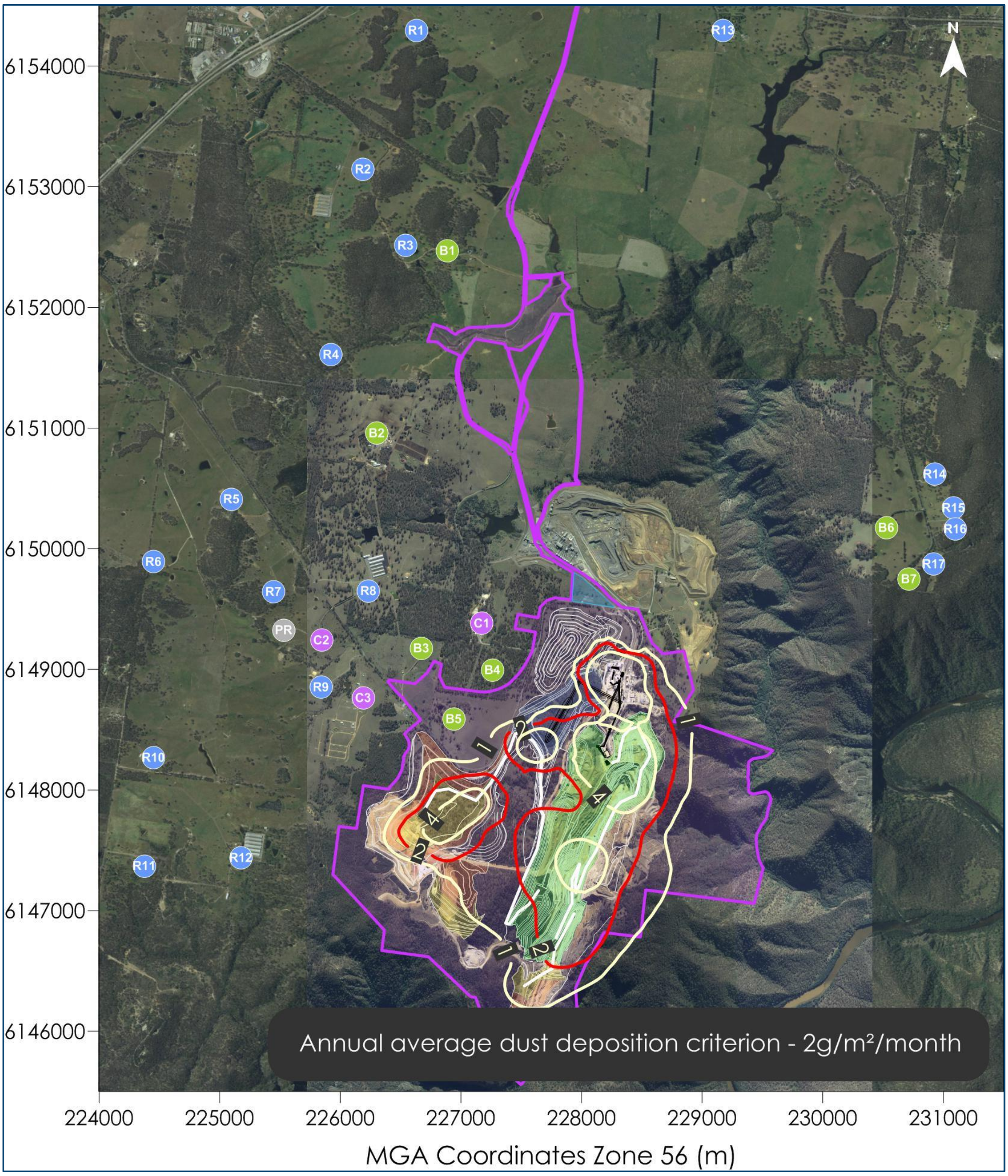


Figure D-16: Predicted annual average dust deposition levels (g/m²/month) – Stage 2

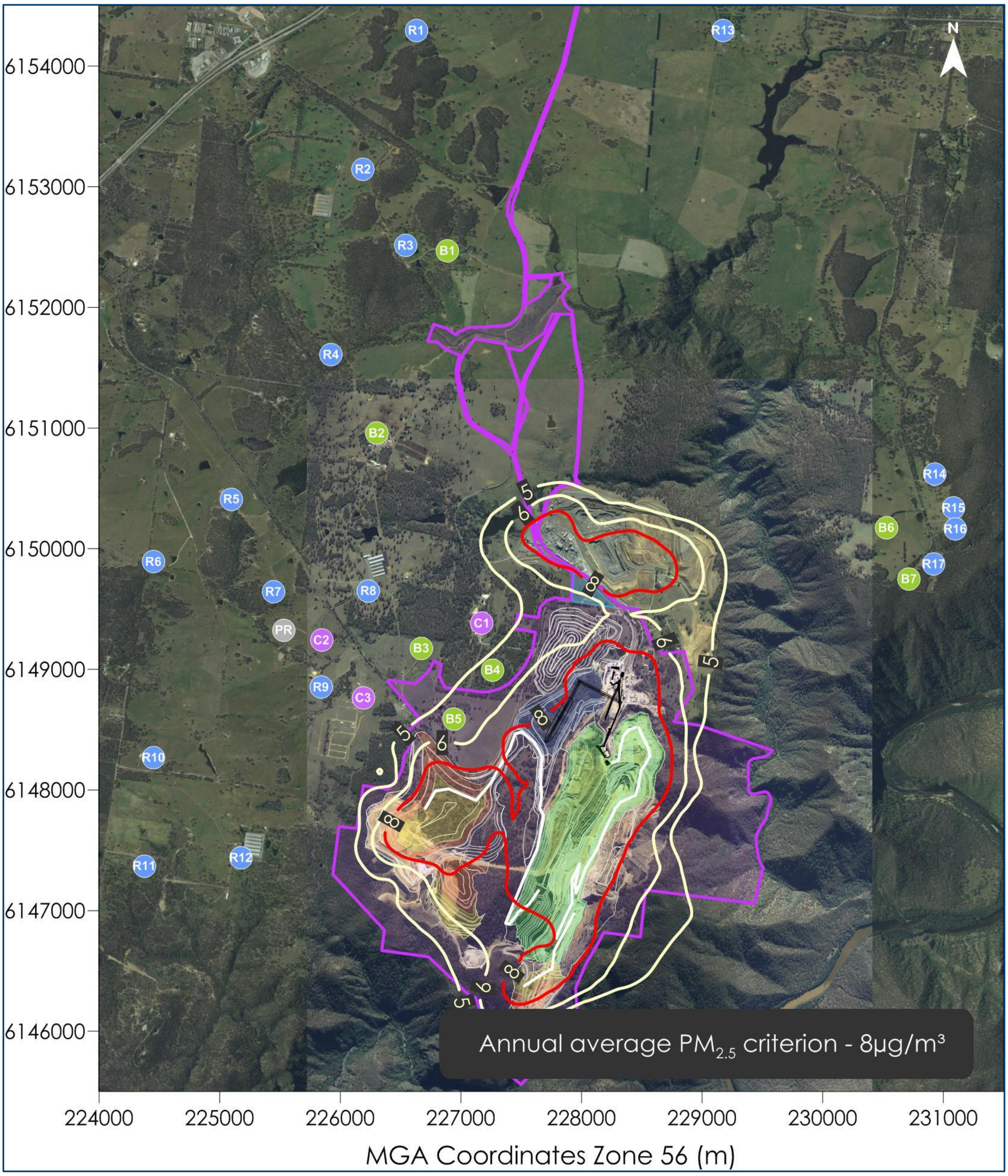


Figure D-17: Predicted cumulative annual average $PM_{2.5}$ concentrations (µg/m³) – Stage 2

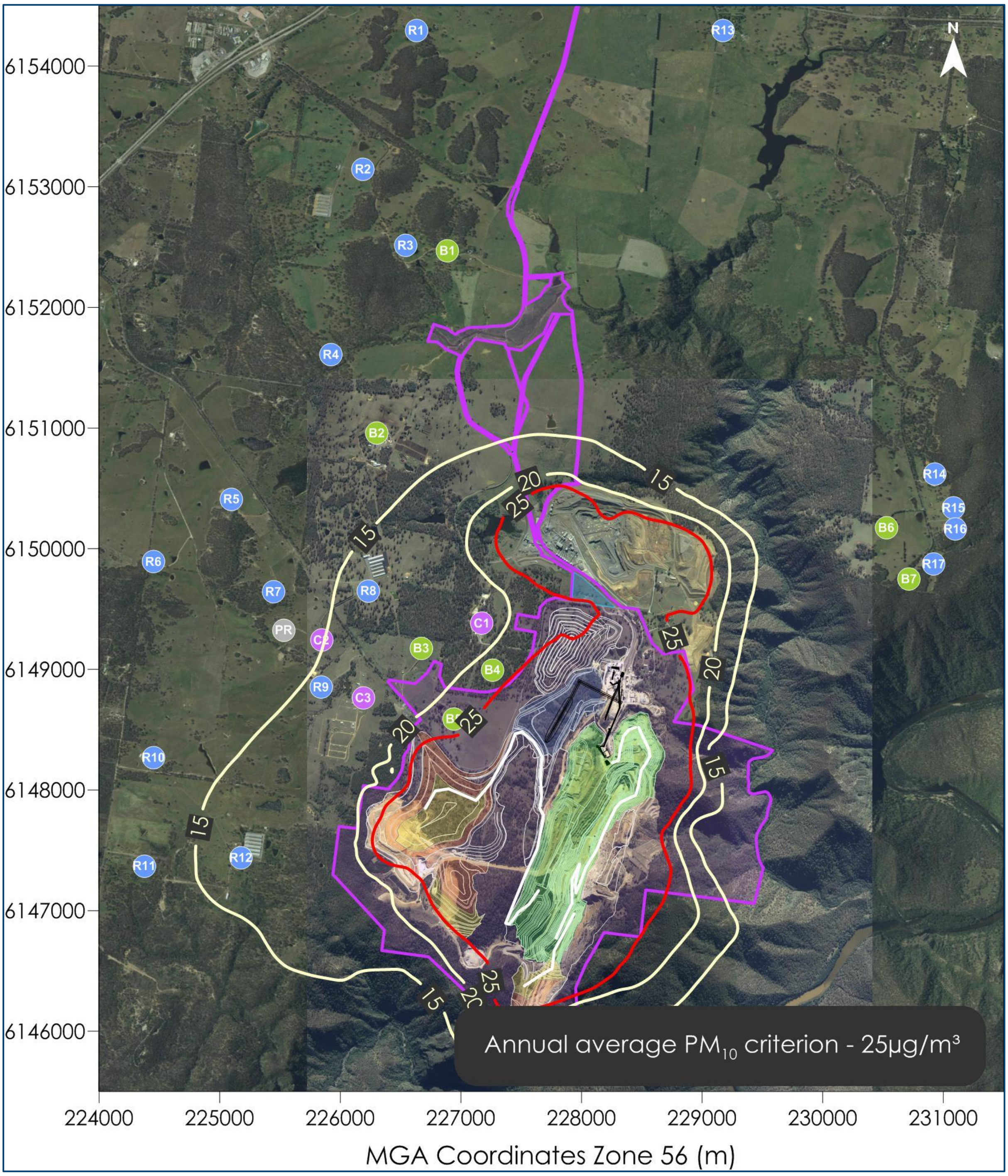


Figure D-18: Predicted cumulative annual average PM_{10} concentrations (µg/m³) – Stage 2

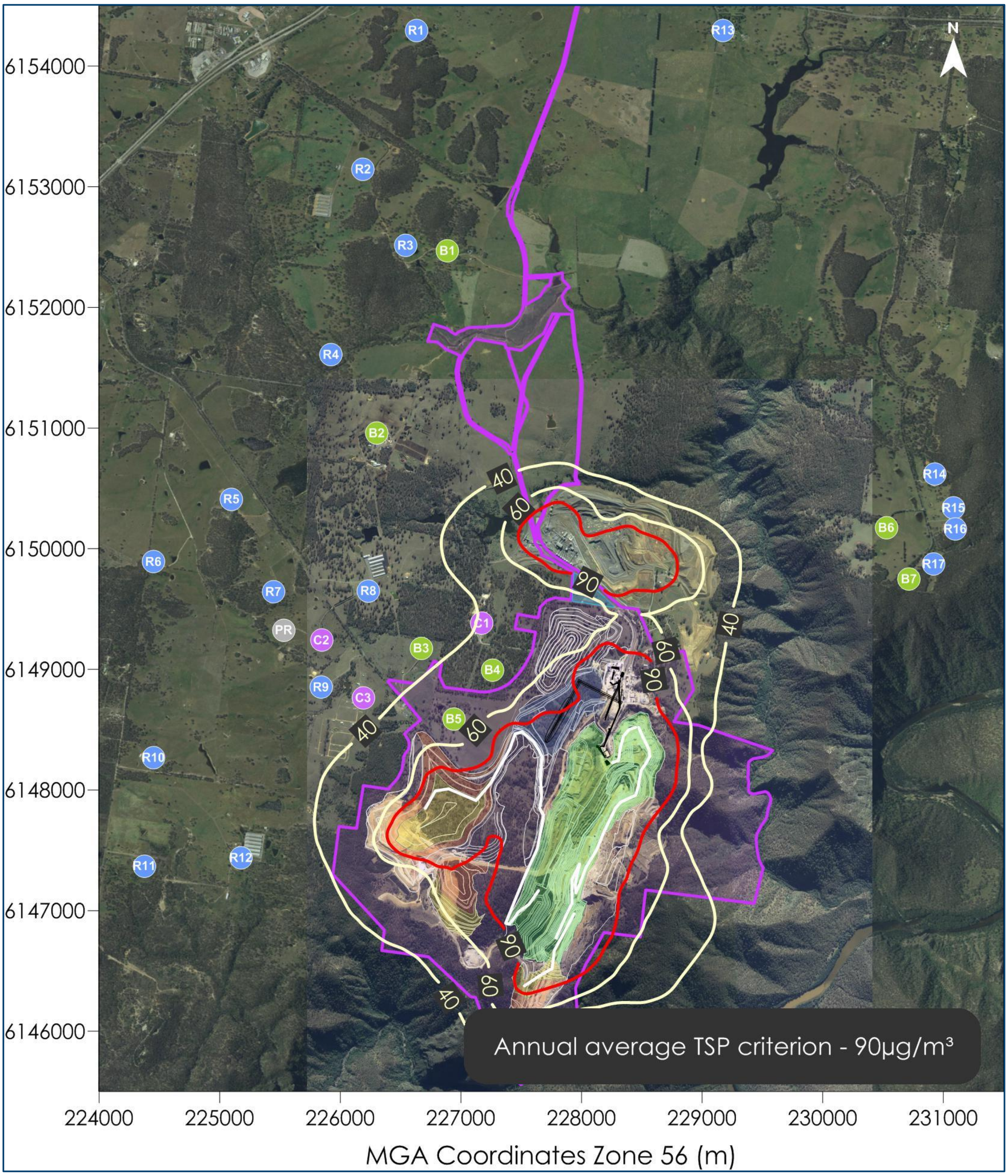


Figure D-19: Predicted cumulative annual average TSP concentrations (µg/m³) – Stage 2

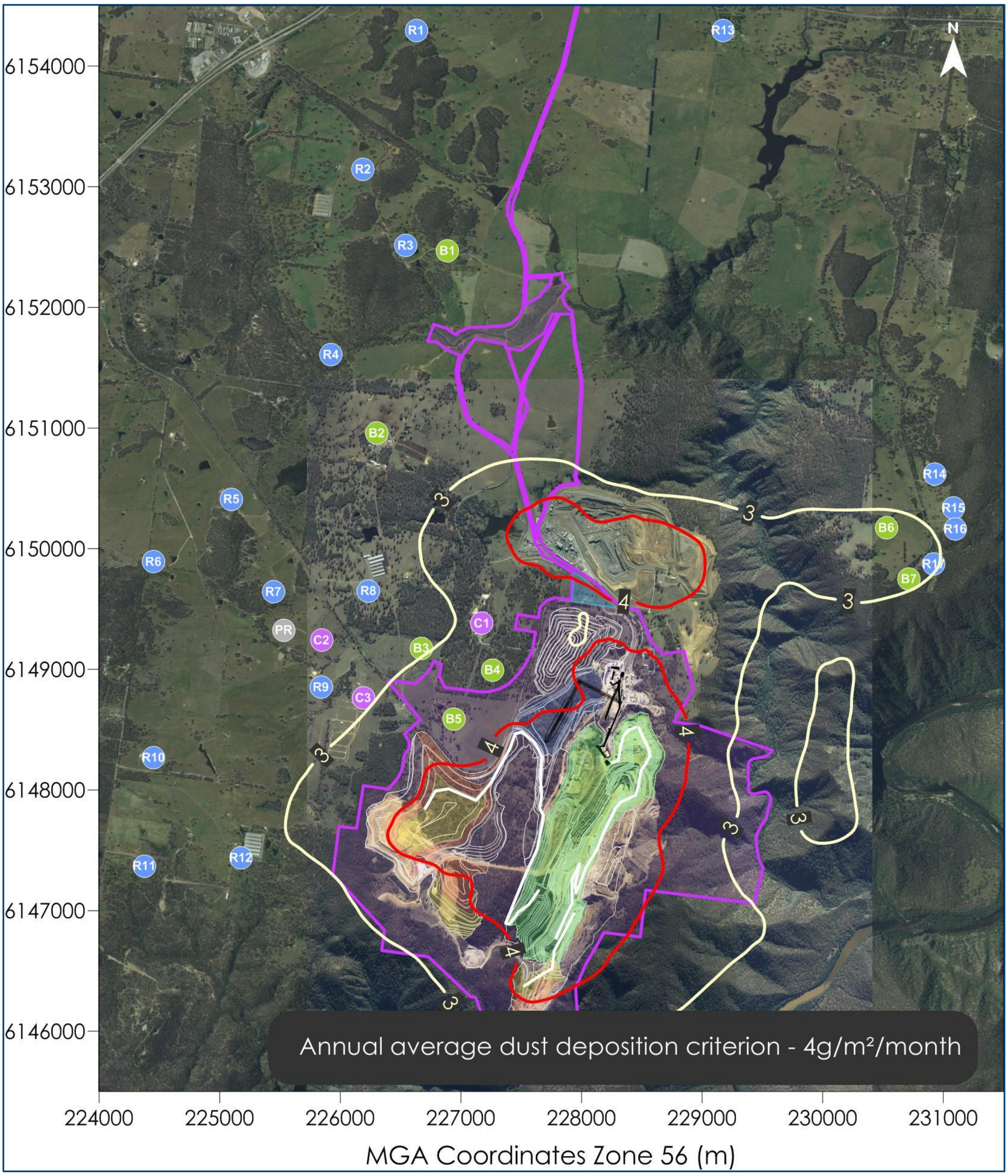


Figure D-20: Predicted cumulative annual average dust deposition levels (g/m²/month) – Stage 2

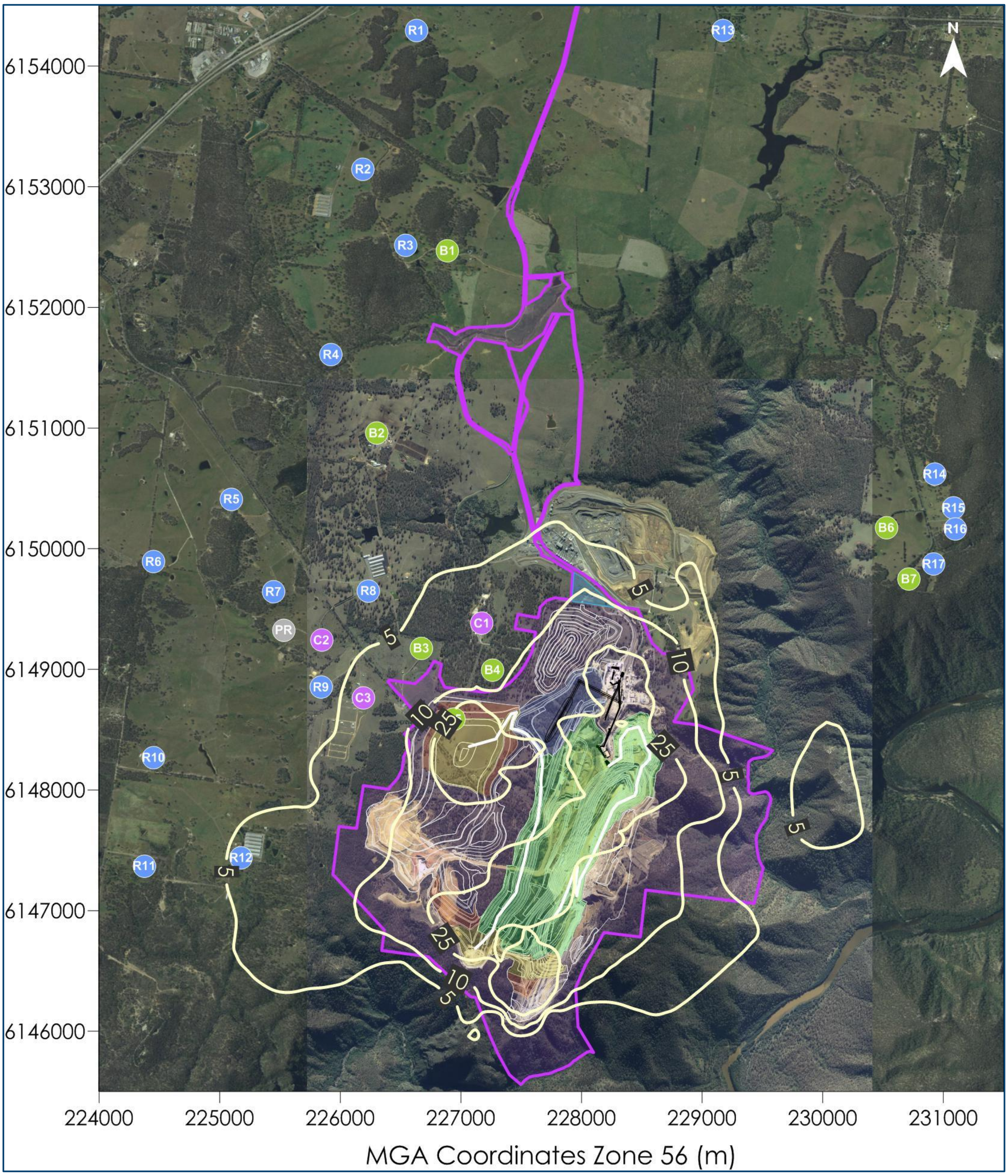


Figure D-21: Predicted maximum incremental 24-hour average $PM_{2.5}$ concentrations (µg/m³) – Stage 3

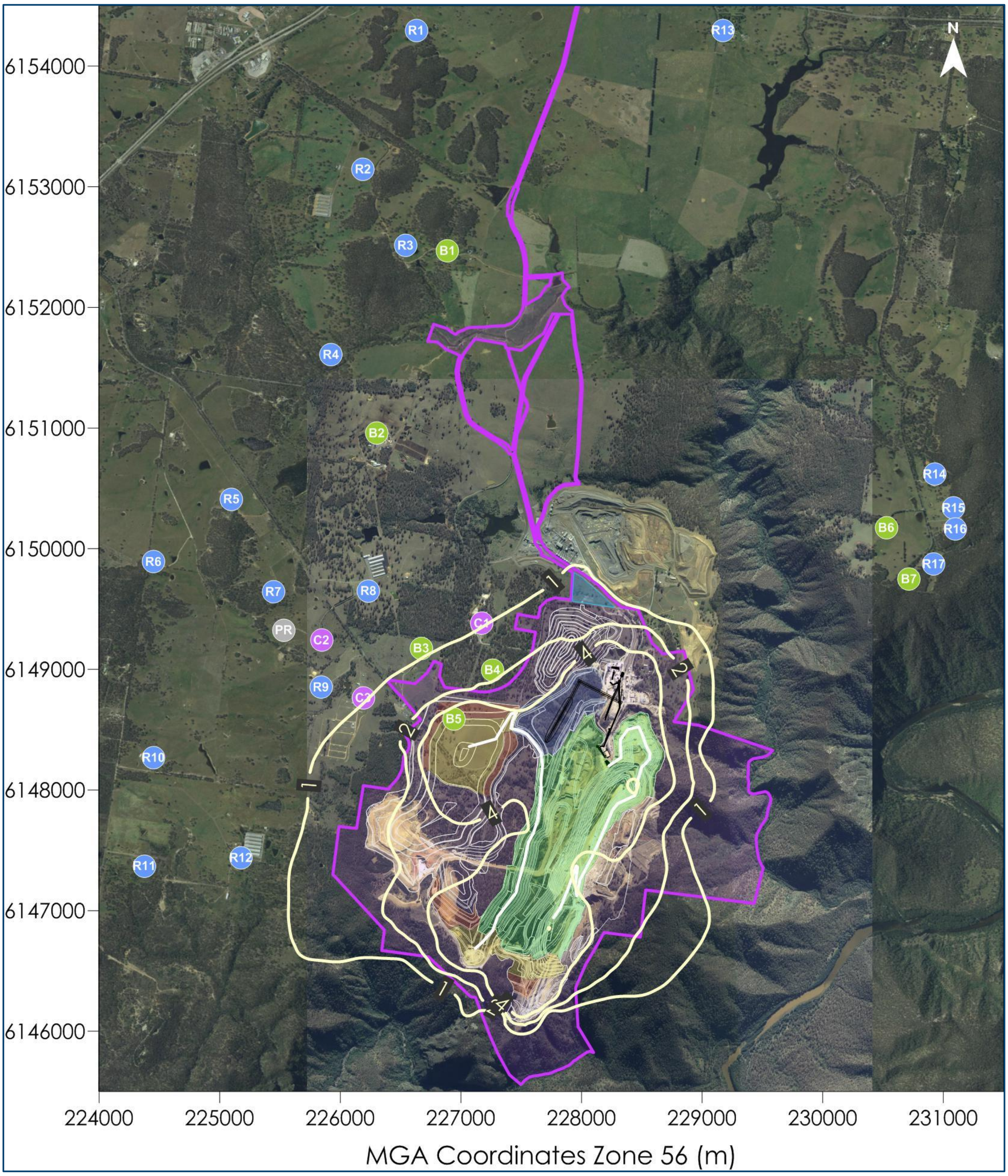


Figure D-22: Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³) – Stage 3

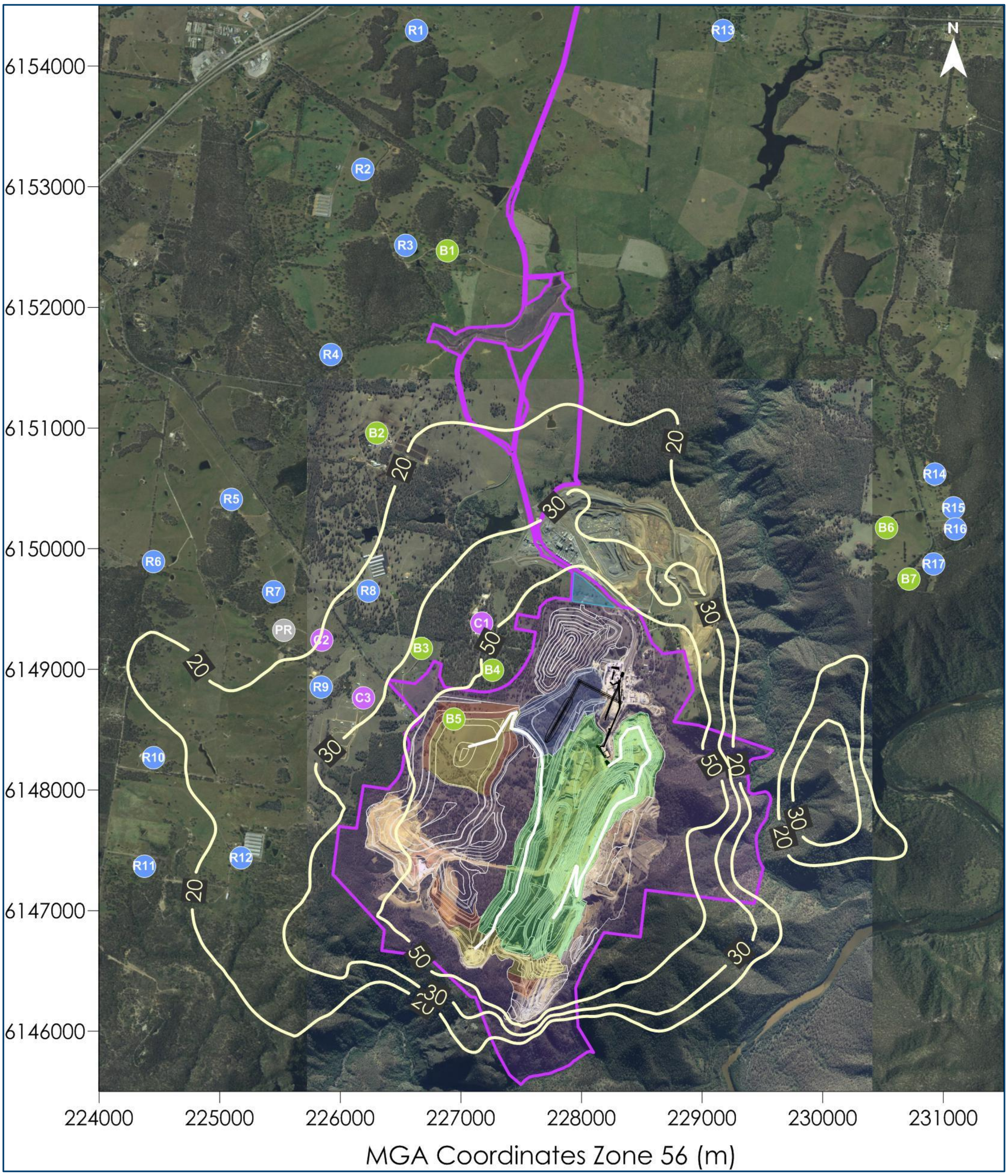


Figure D-23: Predicted maximum incremental 24-hour average PM_{10} concentrations (µg/m³) – Stage 3

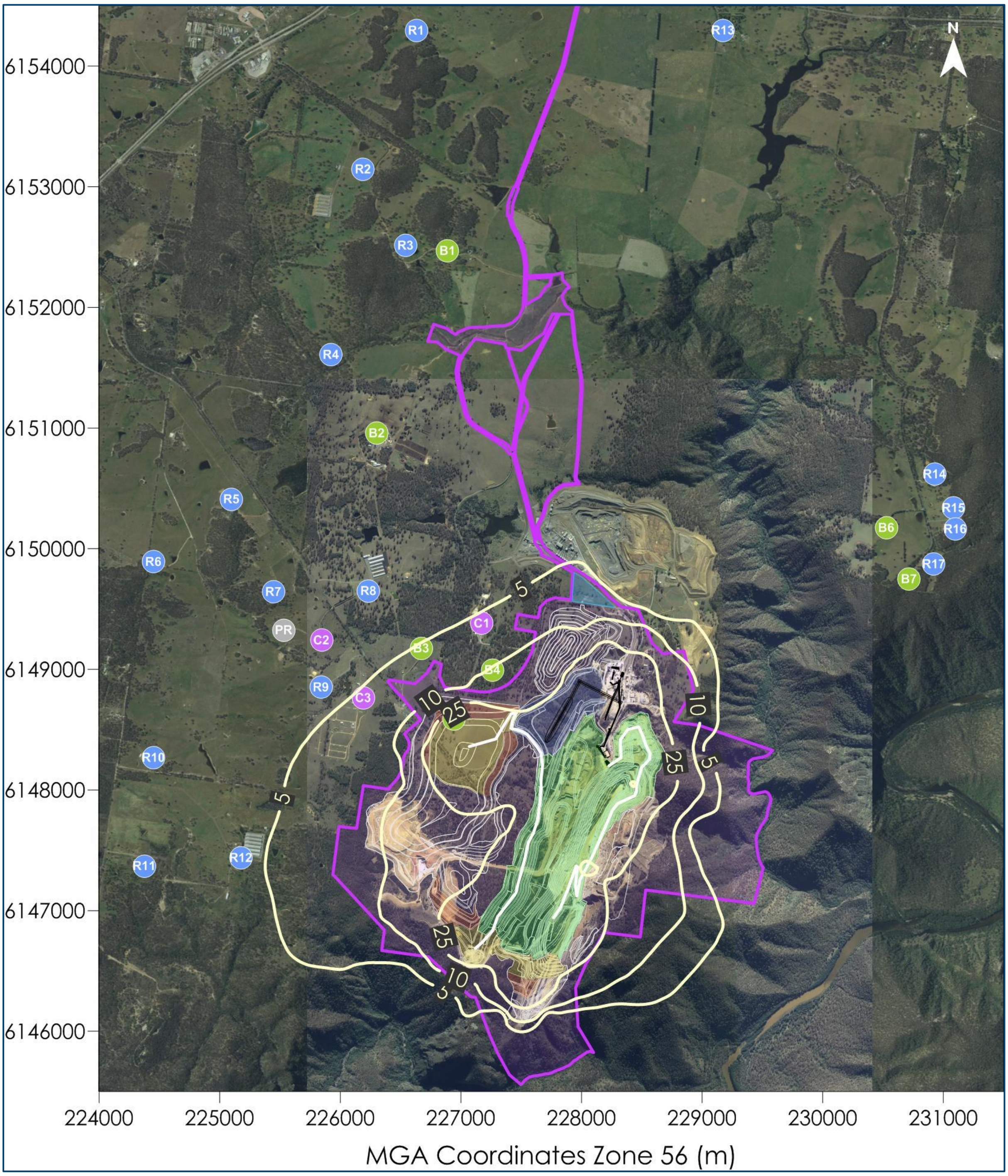


Figure D-24: Predicted incremental annual average PM_{10} concentrations (µg/m³) – Stage 3

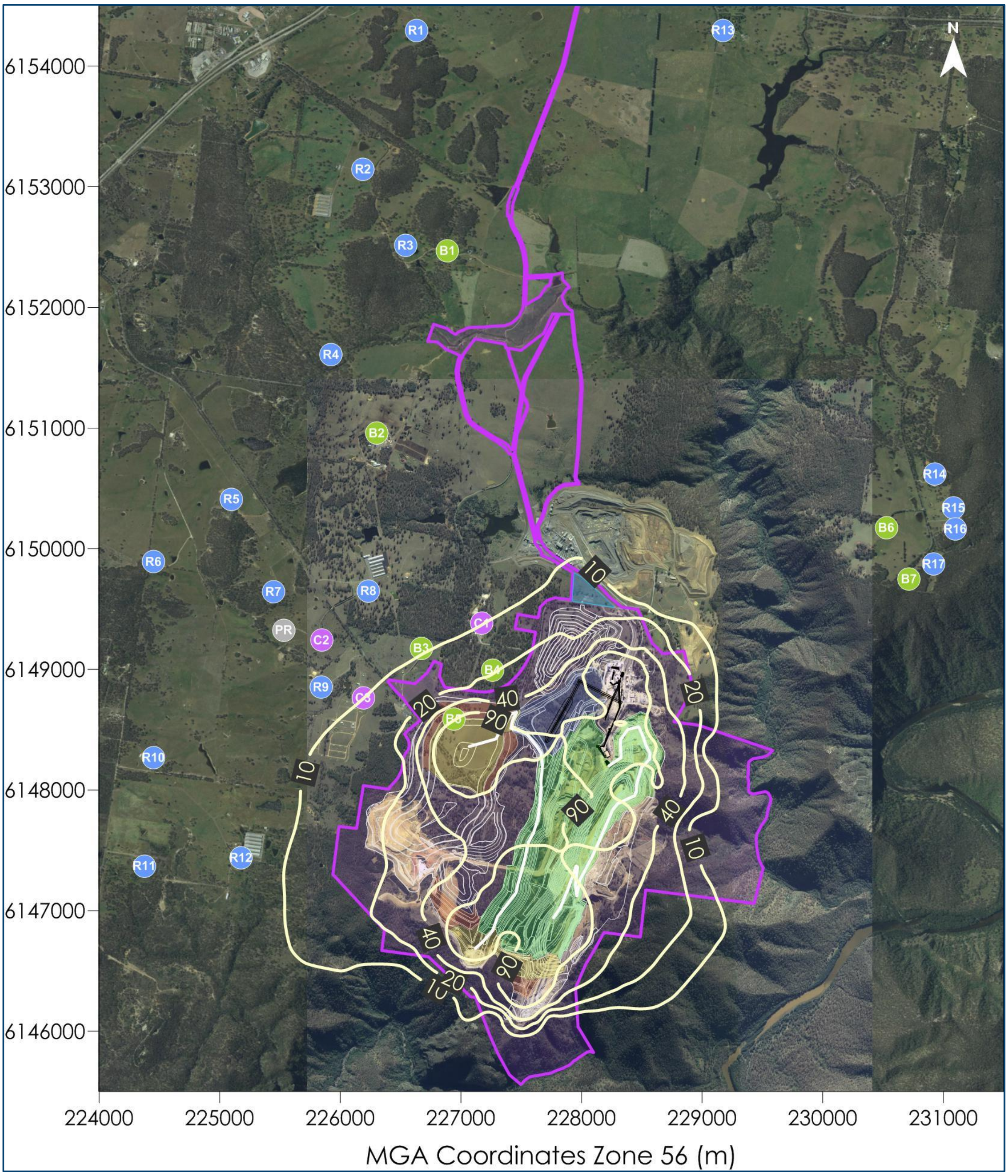


Figure D-25: Predicted incremental annual average TSP concentrations (µg/m³) – Stage 3

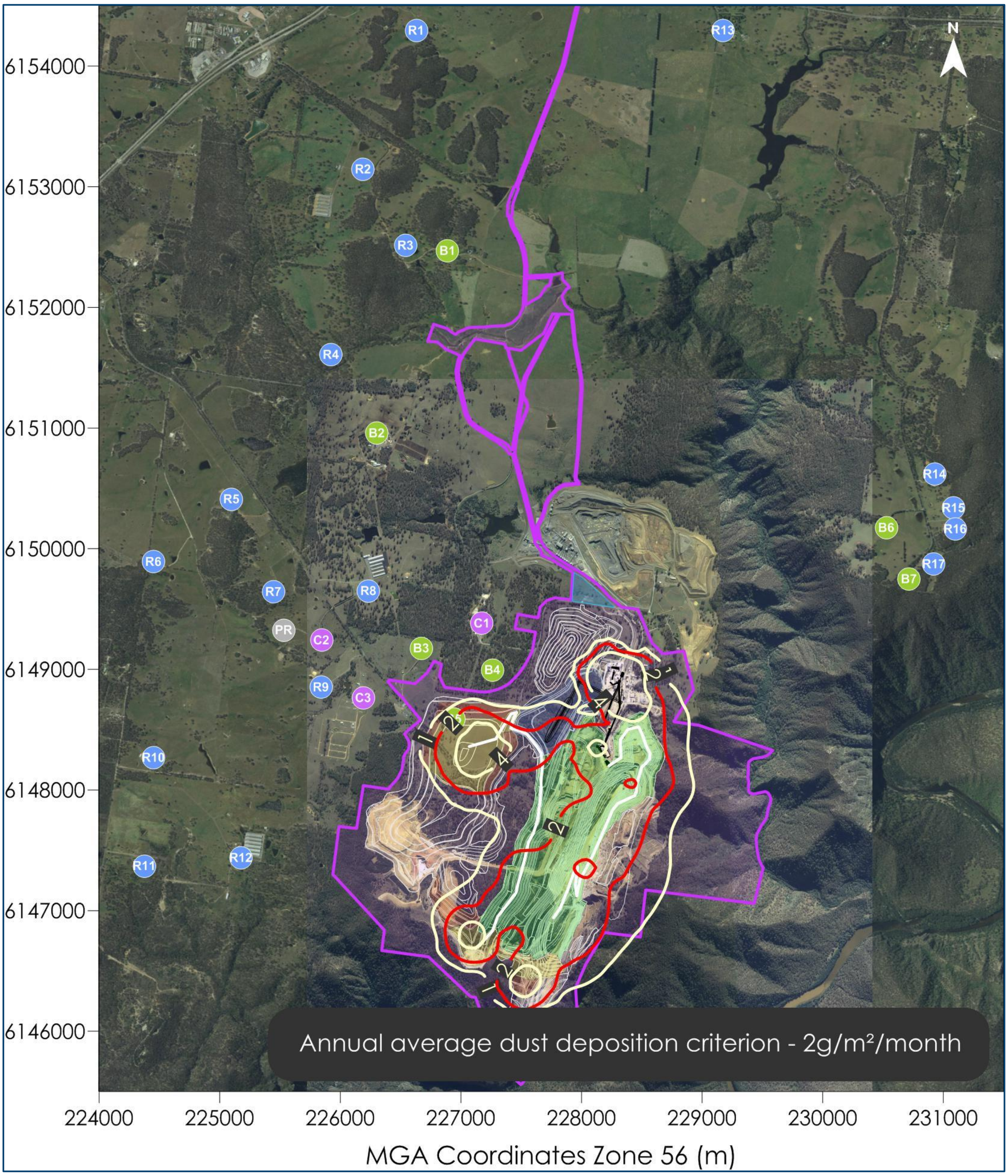


Figure D-26: Predicted annual average dust deposition levels (g/m²/month) – Stage 3

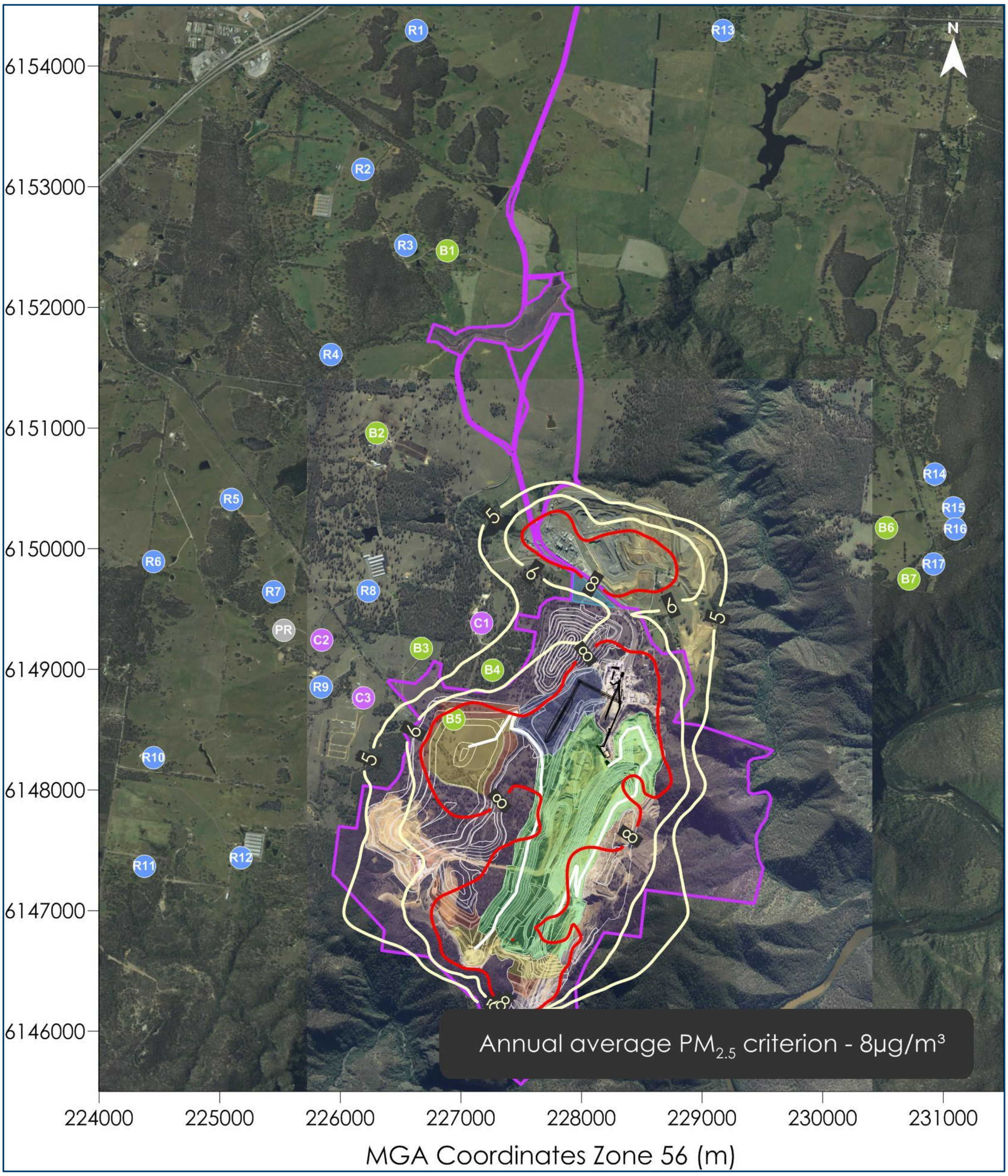


Figure D-27: Predicted cumulative annual average $PM_{2.5}$ concentrations (µg/m³) – Stage 3

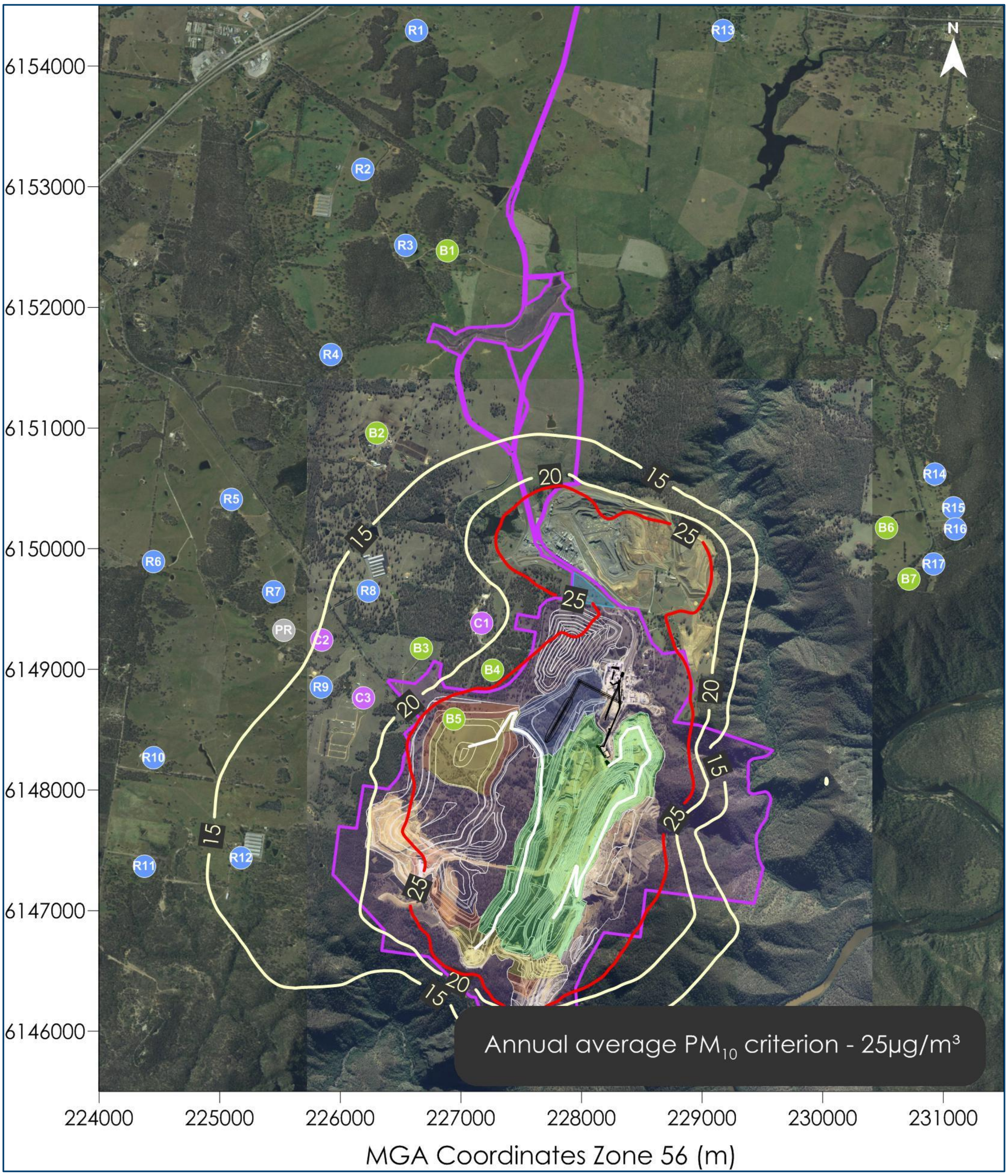


Figure D-28: Predicted cumulative annual average PM_{10} concentrations (µg/m³) – Stage 3

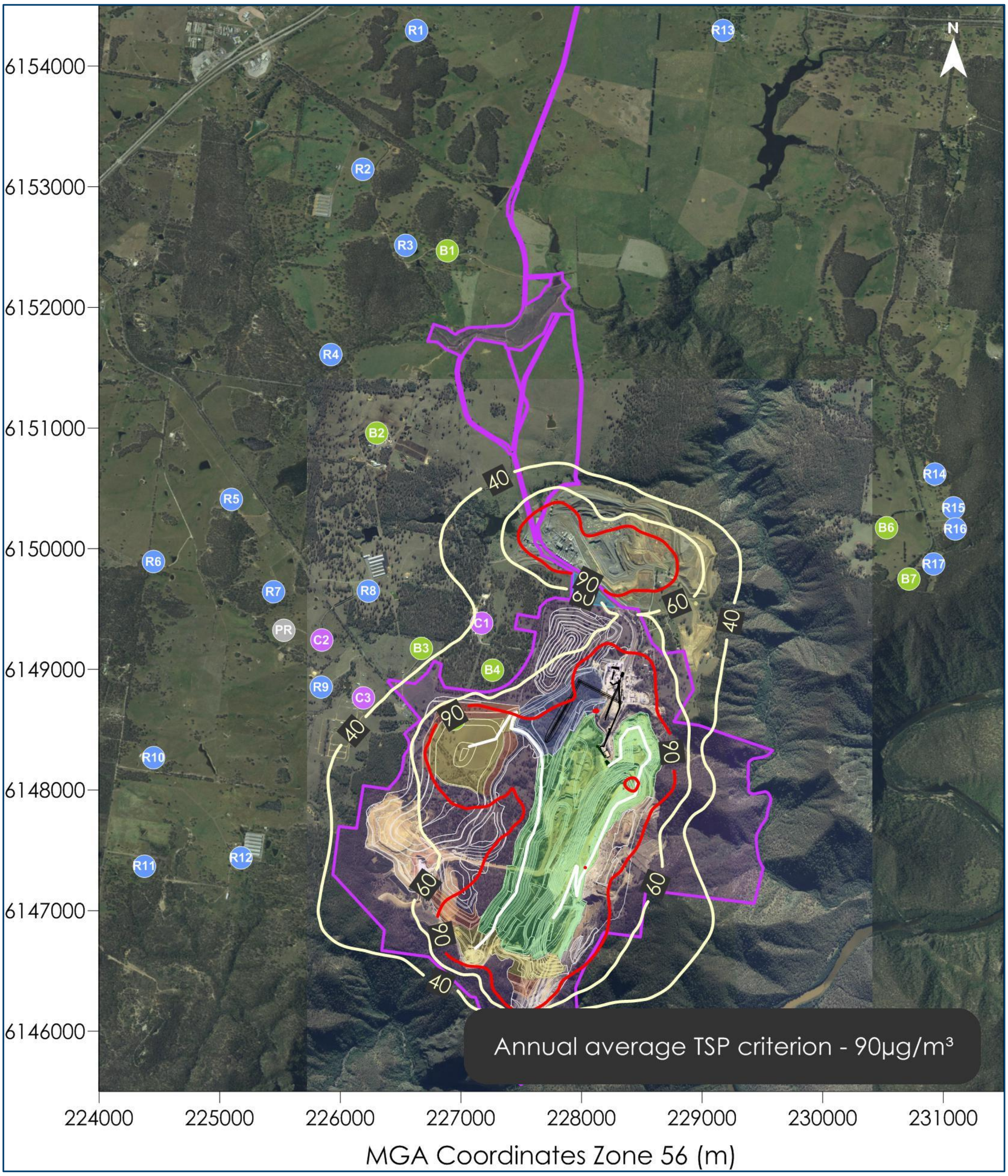


Figure D-29: Predicted cumulative annual average TSP concentrations (µg/m³) – Stage 3

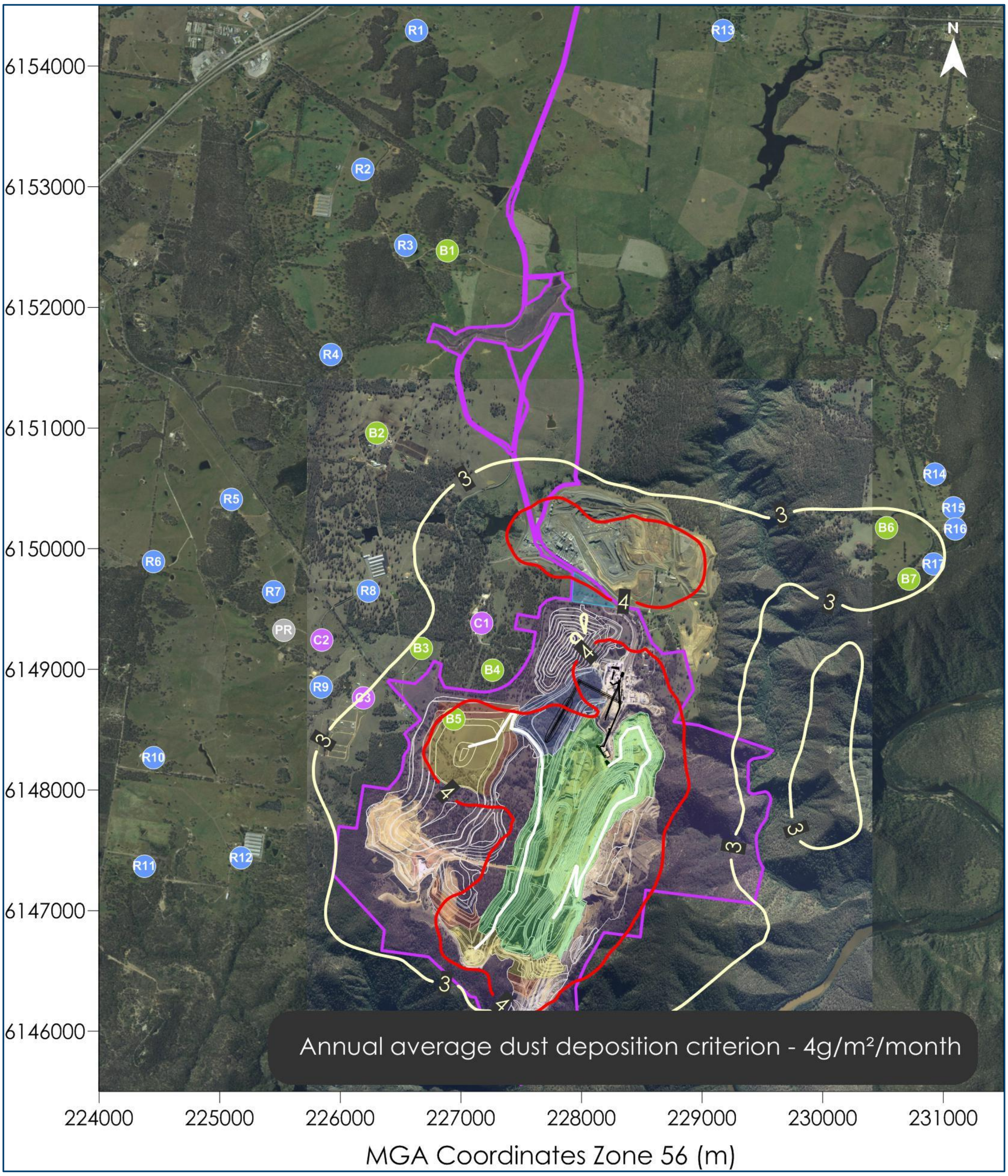


Figure D-30: Predicted cumulative annual average dust deposition levels (g/m²/month) – Stage 3

Appendix E

Further detail regarding 24-hour PM_{10} analysis

Further detail regarding 24-hour PM_{10} analysis

The analysis below provides a cumulative 24-hour PM_{10} impact assessment in accordance with the NSW EPA Approved Methods; refer to the worked example on Page 46 to 47 of the Approved Methods (**NSW EPA, 2017**).

The background level is the estimated ambient level at the nearest monitoring station (HVAS) excluding the contribution from the Project and the Peppertree Quarry.

The predicted increment is the predicted level to occur at the receiver due to the Project and the Peppertree Quarry.

The total is the sum of the background level and the predicted level. The totals may have minor discrepancies due to rounding.

Each table assesses one receiver. The left half of the table examines the cumulative impact during the periods of highest background levels and the right half of the table examines the cumulative impact during the periods of highest contribution from the Project and the Peppertree Quarry.

The green shading represents days ranked per the highest background level but below the criteria.

The blue shading represents days ranked per the highest predicted increment level but below the criteria.

Tables E-1 to **E-18** show the predicted maximum cumulative levels at each receiver surrounding the Project.

Please note that the 70th percentile of the measured HVAS level (20.7µg/m^3) is used on days when there is no monitoring data, hence this number appears frequently in the background levels in the tables.

Table E-1: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 1 – Receiver R3

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	0.0	42.8	19/08/2014	20.7	18.5	39.2
2/04/2014	41.9	0.1	42.0	24/03/2014	20.7	15.9	36.6
7/02/2014	41.5	0.1	41.6	6/06/2014	20.7	13.3	34.0
26/04/2014	28.1	0.0	28.1	9/06/2014	20.7	10.8	31.5
13/02/2014	25.5	0.3	25.8	5/04/2014	20.7	10.6	31.3
29/09/2014	25.0	0.0	25.0	30/08/2014	11.0	10.2	21.3
23/10/2014	25.0	0.1	25.1	4/09/2014	20.7	9.0	29.7
1/02/2014	24.9	0.4	25.3	29/08/2014	20.7	8.9	29.6
20/04/2014	21.1	0.0	21.1	14/04/2014	18.4	8.5	26.9
25/02/2014	20.7	0.0	20.7	28/08/2014	20.7	8.1	28.8

Table E-2: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 1 – Receiver R4

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	0.0	42.8	6/06/2014	20.7	15.0	35.7
2/04/2014	41.9	0.1	42.0	5/06/2014	20.7	12.0	32.7
7/02/2014	41.5	0.2	41.7	25/03/2014	20.7	11.5	32.2
26/04/2014	28.1	0.0	28.1	24/03/2014	20.7	11.2	31.9
13/02/2014	25.5	0.5	26.0	9/06/2014	20.7	11.0	31.7
29/09/2014	25.0	0.0	25.0	22/08/2014	20.7	10.4	31.1
23/10/2014	25.0	1.3	26.3	21/08/2014	20.7	10.1	30.8
1/02/2014	24.9	1.0	25.9	19/08/2014	20.7	9.7	30.4
20/04/2014	21.1	0.0	21.1	13/04/2014	20.7	9.5	30.2
25/02/2014	20.7	0.0	20.7	14/04/2014	18.4	9.5	27.9

Table E-3: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 1 – Receiver R8

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured backgrou nd level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	1.2	44.0	28/02/2014	20.7	25.2	45.9
2/04/2014	41.9	0.2	42.1	1/03/2014	20.7	24.7	45.4
7/02/2014	41.5	4.0	45.5	22/08/2014	20.7	23.1	43.8
26/04/2014	28.1	0.0	28.1	7/04/2014	20.7	22.7	43.4
13/02/2014	25.5	7.7	33.2	25/03/2014	20.7	21.1	41.8
29/09/2014	25.0	0.1	25.2	5/06/2014	20.7	19.7	40.4
23/10/2014	25.0	6.8	31.8	13/03/2014	20.7	18.4	39.1
1/02/2014	24.9	13.1	37.9	2/03/2014	20.7	18.1	38.8
20/04/2014	21.1	0.1	21.2	30/05/2014	20.7	17.9	38.6
25/02/2014	20.7	0.4	21.1	9/03/2014	11.0	17.6	28.7

Table E-4: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 1 – Receiver R9

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured backgrou nd level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	1.5	44.3	13/03/2014	20.7	22.0	42.7
2/04/2014	41.9	0.2	42.2	28/02/2014	20.7	22.0	42.7
7/02/2014	41.5	4.9	46.5	7/04/2014	20.7	21.5	42.2
26/04/2014	28.1	0.0	28.1	25/03/2014	20.7	19.2	39.9
13/02/2014	25.5	8.9	34.4	10/11/2014	6.1	19.2	25.3
29/09/2014	25.0	0.1	25.2	22/01/2014	20.7	18.8	39.5
23/10/2014	25.0	8.1	33.1	30/05/2014	20.7	18.5	39.2
1/02/2014	24.9	15.4	40.2	20/01/2014	11.0	18.4	29.5
20/04/2014	21.1	0.1	21.2	1/03/2014	20.7	17.7	38.4
25/02/2014	20.7	1.0	21.6	9/03/2014	11.0	17.6	28.7

Table E-5: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 1 – Receiver R12

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	3.2	46.0	10/11/2014	6.1	25.9	32.0
2/04/2014	41.9	0.2	42.2	27/12/2014	20.7	25.0	45.7
7/02/2014	41.5	6.0	47.5	12/09/2014	20.7	24.9	45.6
26/04/2014	28.1	0.0	28.1	13/01/2014	20.7	23.9	44.6
13/02/2014	25.5	9.1	34.5	23/02/2014	20.7	23.4	44.1
29/09/2014	25.0	0.1	25.1	27/04/2014	20.7	22.6	43.3
23/10/2014	25.0	6.8	31.8	11/02/2014	20.7	22.5	43.2
1/02/2014	24.9	15.0	39.8	20/12/2014	20.7	22.3	43.0
20/04/2014	21.1	0.0	21.1	12/02/2014	20.7	22.1	42.8
25/02/2014	20.7	1.5	22.2	9/12/2014	20.7	21.5	42.2

Table E-6: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 1 – Receiver R17

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	0.3	43.1	25/06/2014	3.8	13.6	17.4
2/04/2014	41.9	3.3	45.3	16/06/2014	20.7	12.6	33.3
7/02/2014	41.5	0.1	41.6	26/06/2014	20.7	12.4	33.1
26/04/2014	28.1	6.3	34.4	4/05/2014	20.7	12.4	33.1
13/02/2014	25.5	0.4	25.9	10/07/2014	20.7	11.9	32.6
29/09/2014	25.0	1.0	26.0	30/06/2014	20.7	11.2	31.9
23/10/2014	25.0	0.4	25.3	1/08/2014	20.7	11.1	31.8
1/02/2014	24.9	0.1	24.9	18/07/2014	20.7	11.0	31.7
20/04/2014	21.1	3.7	24.9	17/07/2014	20.7	10.8	31.5
25/02/2014	20.7	0.0	20.7	17/06/2014	20.7	10.5	31.2

Table E-7: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 2 – Receiver R3

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured backgrou nd level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	0.0	42.8	19/08/2014	20.7	15.9	36.6
2/04/2014	41.9	0.0	42.0	24/03/2014	20.7	14.4	35.1
7/02/2014	41.5	0.1	41.6	6/06/2014	20.7	11.8	32.5
26/04/2014	28.1	0.0	28.1	30/08/2014	11.0	9.5	20.5
13/02/2014	25.5	0.2	25.7	5/04/2014	20.7	8.6	29.3
29/09/2014	25.0	0.0	25.0	14/04/2014	18.4	8.2	26.6
23/10/2014	25.0	0.1	25.1	9/06/2014	20.7	8.0	28.7
1/02/2014	24.9	0.4	25.2	4/09/2014	20.7	7.7	28.4
20/04/2014	21.1	0.0	21.1	29/08/2014	20.7	7.7	28.4
1/01/2014	20.7	0.1	20.8	28/08/2014	20.7	7.1	27.8

Table E-8: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 2 – Receiver R4

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured backgrou nd level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	0.0	42.8	6/06/2014	20.7	13.6	34.3
2/04/2014	41.9	0.1	42.0	24/03/2014	20.7	12.5	33.2
7/02/2014	41.5	0.1	41.6	19/08/2014	20.7	11.1	31.8
26/04/2014	28.1	0.0	28.1	25/03/2014	20.7	10.1	30.8
13/02/2014	25.5	0.4	25.9	22/08/2014	20.7	9.9	30.6
29/09/2014	25.0	0.0	25.0	9/06/2014	20.7	9.8	30.5
23/10/2014	25.0	1.1	26.1	30/08/2014	11.0	9.0	20.0
1/02/2014	24.9	0.9	25.8	26/08/2014	20.7	8.9	29.6
20/04/2014	21.1	0.0	21.1	5/06/2014	20.7	8.8	29.5
1/01/2014	20.7	0.3	21.0	14/04/2014	18.4	8.5	26.9

Table E-9: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 2 – Receiver R8

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	1.2	44.0	22/08/2014	20.7	21.5	42.2
2/04/2014	41.9	0.2	42.1	25/03/2014	20.7	20.5	41.2
7/02/2014	41.5	3.6	45.1	28/02/2014	20.7	17.7	38.4
26/04/2014	28.1	0.0	28.1	24/03/2014	20.7	16.9	37.6
13/02/2014	25.5	5.6	31.1	1/03/2014	20.7	16.8	37.5
29/09/2014	25.0	0.1	25.1	14/04/2014	18.4	16.8	35.2
23/10/2014	25.0	5.0	30.0	7/04/2014	20.7	16.3	37.0
1/02/2014	24.9	9.6	34.4	6/06/2014	20.7	16.2	36.9
20/04/2014	21.1	0.1	21.2	6/03/2014	20.7	15.2	35.9
1/01/2014	20.7	3.8	24.5	9/03/2014	11.0	15.0	26.1

Table E-10: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 2 – Receiver R9

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	1.3	44.1	21/01/2014	20.7	20.9	41.6
2/04/2014	41.9	0.2	42.1	20/01/2014	11.0	20.2	31.2
7/02/2014	41.5	2.7	44.2	1/03/2014	20.7	20.0	40.7
26/04/2014	28.1	0.0	28.1	22/01/2014	20.7	18.4	39.1
13/02/2014	25.5	8.2	33.7	28/02/2014	20.7	18.0	38.7
29/09/2014	25.0	0.1	25.1	7/04/2014	20.7	16.7	37.4
23/10/2014	25.0	6.4	31.4	25/03/2014	20.7	16.6	37.3
1/02/2014	24.9	12.1	36.9	9/03/2014	11.0	15.0	26.0
20/04/2014	21.1	0.0	21.2	26/08/2014	20.7	14.9	35.6
1/01/2014	20.7	3.1	23.8	13/03/2014	20.7	14.4	35.1

Table E-11: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 2 – Receiver R12

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured backgrou nd level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	2.4	45.1	10/11/2014	6.1	32.4	38.5
2/04/2014	41.9	0.2	42.1	27/04/2014	20.7	27.9	48.6
7/02/2014	41.5	5.5	47.0	9/12/2014	20.7	26.8	47.5
26/04/2014	28.1	0.0	28.1	13/01/2014	20.7	26.4	47.1
13/02/2014	25.5	9.3	34.8	23/02/2014	20.7	24.4	45.1
29/09/2014	25.0	0.1	25.1	12/09/2014	20.7	23.7	44.4
23/10/2014	25.0	6.7	31.7	20/12/2014	20.7	23.5	44.2
1/02/2014	24.9	17.8	42.7	11/02/2014	20.7	23.3	44.0
20/04/2014	21.1	0.0	21.1	27/12/2014	20.7	23.0	43.7
1/01/2014	20.7	4.3	25.0	2/03/2014	20.7	21.6	42.3

Table E-12: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 2 – Receiver R17

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured backgrou nd level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	0.2	43.0	25/06/2014	3.8	12.3	16.1
2/04/2014	41.9	2.6	44.5	26/06/2014	20.7	12.2	32.9
7/02/2014	41.5	0.1	41.6	10/07/2014	20.7	12.2	32.9
26/04/2014	28.1	4.6	32.7	1/08/2014	20.7	11.2	31.9
13/02/2014	25.5	0.4	25.9	4/05/2014	20.7	11.0	31.7
29/09/2014	25.0	1.1	26.2	16/06/2014	20.7	10.7	31.4
23/10/2014	25.0	0.3	25.3	11/07/2014	20.7	10.2	30.9
1/02/2014	24.9	0.1	24.9	17/07/2014	20.7	10.0	30.7
20/04/2014	21.1	2.9	24.0	3/05/2014	20.7	9.6	30.3
1/01/2014	20.7	0.8	21.5	29/06/2014	20.7	8.8	29.5

Table E-13: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 3 – Receiver R3

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured backgrou nd level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	0.0	42.8	19/08/2014	20.7	17.4	38.1
2/04/2014	41.9	0.1	42.0	24/03/2014	20.7	15.0	35.7
7/02/2014	41.5	0.1	41.6	6/06/2014	20.7	12.1	32.8
26/04/2014	28.1	0.0	28.1	30/08/2014	11.0	9.8	20.9
13/02/2014	25.5	0.2	25.7	5/04/2014	20.7	8.7	29.4
29/09/2014	25.0	0.0	25.0	14/04/2014	18.4	8.2	26.6
23/10/2014	25.0	0.1	25.1	9/06/2014	20.7	8.0	28.7
1/02/2014	24.9	0.4	25.2	4/09/2014	20.7	7.9	28.6
20/04/2014	21.1	0.0	21.1	29/08/2014	20.7	7.6	28.3
1/01/2014	20.7	0.1	20.8	12/04/2014	20.7	7.4	28.1

Table E-14: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 3 – Receiver R4

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured backgrou nd level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	0.0	42.8	6/06/2014	20.7	13.6	34.3
2/04/2014	41.9	0.1	42.0	24/03/2014	20.7	13.2	33.9
7/02/2014	41.5	0.1	41.6	19/08/2014	20.7	11.1	31.8
26/04/2014	28.1	0.0	28.1	9/06/2014	20.7	10.3	31.0
13/02/2014	25.5	0.4	25.9	25/03/2014	20.7	10.2	30.9
29/09/2014	25.0	0.0	25.0	22/08/2014	20.7	10.1	30.8
23/10/2014	25.0	1.1	26.1	30/08/2014	11.0	9.7	20.7
1/02/2014	24.9	0.9	25.8	26/08/2014	20.7	9.2	29.9
20/04/2014	21.1	0.0	21.1	14/10/2014	20.7	8.9	29.6
1/01/2014	20.7	0.3	21.0	5/06/2014	20.7	8.6	29.3

Table E-15: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 3 – Receiver R8

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	1.2	44.0	22/08/2014	20.7	22.4	43.1
2/04/2014	41.9	0.2	42.1	25/03/2014	20.7	21.5	42.2
7/02/2014	41.5	3.6	45.1	24/03/2014	20.7	17.8	38.5
26/04/2014	28.1	0.0	28.1	28/02/2014	20.7	17.6	38.3
13/02/2014	25.5	5.6	31.1	6/06/2014	20.7	17.5	38.2
29/09/2014	25.0	0.1	25.1	14/04/2014	18.4	17.4	35.8
23/10/2014	25.0	5.0	29.9	1/03/2014	20.7	17.1	37.8
1/02/2014	24.9	9.7	34.5	7/04/2014	20.7	16.1	36.8
20/04/2014	21.1	0.1	21.2	9/06/2014	20.7	16.0	36.7
1/01/2014	20.7	3.7	24.4	6/03/2014	20.7	15.9	36.6

Table E-16: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 3 – Receiver R9

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	1.4	44.1	21/01/2014	20.7	21.1	41.8
2/04/2014	41.9	0.2	42.1	20/01/2014	11.0	21.0	32.0
7/02/2014	41.5	2.8	44.3	22/01/2014	20.7	19.8	40.5
26/04/2014	28.1	0.0	28.1	25/03/2014	20.7	19.0	39.7
13/02/2014	25.5	9.2	34.7	1/03/2014	20.7	18.9	39.6
29/09/2014	25.0	0.1	25.1	11/02/2014	20.7	18.4	39.1
23/10/2014	25.0	7.0	32.0	28/02/2014	20.7	18.3	39.0
1/02/2014	24.9	13.2	38.0	7/04/2014	20.7	17.2	37.9
20/04/2014	21.1	0.1	21.2	26/08/2014	20.7	17.2	37.9
1/01/2014	20.7	2.9	23.6	11/11/2014	20.7	16.2	36.9

Table E-17: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 3 – Receiver R12

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	3.9	46.7	27/12/2014	20.7	23.6	44.3
2/04/2014	41.9	0.2	42.1	12/09/2014	20.7	22.9	43.6
7/02/2014	41.5	4.9	46.4	11/02/2014	20.7	22.3	43.0
26/04/2014	28.1	0.0	28.1	20/01/2014	11.0	22.1	33.2
13/02/2014	25.5	9.1	34.6	13/01/2014	20.7	21.3	42.0
29/09/2014	25.0	0.1	25.1	10/11/2014	6.1	20.9	27.0
23/10/2014	25.0	6.1	31.1	11/11/2014	20.7	20.7	41.4
1/02/2014	24.9	13.1	37.9	21/01/2014	20.7	19.9	40.6
20/04/2014	21.1	0.0	21.1	12/02/2014	20.7	19.9	40.6
1/01/2014	20.7	4.6	25.3	27/04/2014	20.7	19.5	40.2

Table E-18: Cumulative 24-hour average PM_{10} concentration (µg/m³) Stage 3 – Receiver R17

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
4/11/2014	42.8	0.3	43.0	25/06/2014	3.8	12.5	16.3
2/04/2014	41.9	2.6	44.5	10/07/2014	20.7	12.4	33.1
7/02/2014	41.5	0.1	41.6	26/06/2014	20.7	12.3	33.0
26/04/2014	28.1	4.9	33.0	1/08/2014	20.7	11.5	32.2
13/02/2014	25.5	0.3	25.8	4/05/2014	20.7	11.1	31.8
29/09/2014	25.0	1.1	26.2	16/06/2014	20.7	10.8	31.5
23/10/2014	25.0	0.3	25.3	30/06/2014	20.7	10.5	31.2
1/02/2014	24.9	0.1	24.9	11/07/2014	20.7	10.2	30.9
20/04/2014	21.1	3.0	24.1	17/07/2014	20.7	10.0	30.7
1/01/2014	20.7	0.9	21.6	3/05/2014	20.7	9.6	30.3

Appendix Q

Greenhouse gas assessment

VOLUME 6

Report for Boral Cement Limited

Marulan South Limestone Mine Continued Operations Greenhouses Gas Emissions Assessment

August 2018

EDGE

Project Delivered for:

Element Environment

Project Delivered by:

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Revision	Revision Details	Author	Approved by	Date Approved
v1		Joel Clayton	Ken Lunty	21/07/15
v2		Joel Clayton	Ken Lunty	22/07/15
v3		Joel Clayton	Ken Lunty	18/03/16
v4	GHG calculations updated to match Project changes	Nicole Thompson	Joel Clayton	16/03/18
V5	Updated according to comments	Nicole Thompson	Ken Lunty	19/06/18
V6	Updated according to comments	Nicole Thompson	Ken Lunty	22/08/18

Executive Summary

Boral Cement Limited (Boral) owns and operates the Marulan South Limestone Mine (the mine). It is a long standing open cut mine that has produced up to 3.38 million tonnes of limestone and lime products per year for the cement, steel, agricultural, construction and commercial markets.

An Environmental Impact Statement (EIS) has been prepared by Element Environment, on behalf of Boral for submission to the Department of Planning and Environment (DP&E) to satisfy the provisions of Part 4 of the EP&A Act. Boral is seeking approval for continued operations at the site through a development application for a State Significant Development including a 30-year mine plan, associated overburden emplacement areas and a mine water supply dam (hereafter referred to as 'the Project')

Edge Environment (Edge) has prepared this Greenhouse Gas (GHG) assessment on behalf of Boral to assess the GHG emissions associated with the Project to comply with the Secretary's environmental assessment requirements (SEARs).

The scope of this GHG assessment is to undertake an assessment of projected GHG emissions from the Project. The assessment will be used to identify actions for mitigating or reducing emissions, where possible. The scope of works for this assessment is to:

- Identify the main sources of emissions during construction and operational stages of the Project;
- Scope and calculate the emissions from each source using factors and methods outlined in the National Greenhouse Accounts (NGA) Factors, published by the Australian Government Department of Climate Change and Energy Efficiency (2017), the GHG Protocol published by the World Business Council for Sustainable Development (2001) and the BPIC/ICIP Project's Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database; and
- Investigate and recommend strategies for emissions mitigation to reduce GHG emissions associated with Project development and operation.

Table 6 illustrates the estimated emissions from the construction and operational activities associated with the continuation of mining operations.

Table 1 - Overall Emission Summary

Period	Scope 1 Estimated emissions (tCO2-e)	Scope 2 Estimated emissions (tCO2-e)	Scope 3 Estimated emissions (tCO2-e)	Total Estimated emissions (tCO2-e)
Construction	13,972	8	202	14,182
Operation	94,660	15,780	12,264	122,703

The total estimated emissions from construction activities associated with the continued operation of the mine are 14,182 tCO_2e, which are approximately 11.3% of the estimated annual operational emissions of 122,703 tCO_2e.

Actions have been recommended to further reduce emissions throughout the Project development. GHG emissions reduction actions should ideally be prioritised according to the carbon management principles.

Avoid: Actions which avoid emissions, in the first instance, should be considered as a priority;

Reduce: Actions which result in a reduction of emissions should be considered next;

Switch: Actions which switch energy sources to reduce emissions should be the next considered;

Sequester: Actions which sequester GHG emissions do not reduce emissions but store them; and

Offset: Offsetting of emissions through the purchase of offsets. This should be considered as a last resort.

Possible GHG management actions could include:

- Reducing idling time of haul trucks and mobile equipment;
- Energy efficiency lighting lamp replacements and day/night sensors for lighting control;
- Potentially utilising conveyors for some of the overburden emplacement, substituting for haul trucks where possible;
- Continuous improvement program in fixed production plant whereby efficiencies continue to be improved resulting in shorter running time required;
- Regular monitoring of emissions throughout the Project to assess the effectiveness of emissions mitigation actions;
- Use locally sourced construction materials to reduce emissions associated with transport;
- Recycle/compost waste wherever possible;
- Plan construction and operational works to avoid double handling of materials and minimise haulage distances, thereby minimising the use of fuel;
- Train both on-site and product transportation staff on efficient driving practices for example throttling down and switching off machinery when not in use;
- Make use of recycled or low impact materials to reduce emissions associated with embodied energy (not estimated in this report);
- Investigate the procurement of energy efficient equipment for the site (e.g. office and floodlighting, front end loaders and trucks etc.). Consider the procurement of equipment that uses lower GHG intensive fuel (e.g. gas, ethanol);
- Sourcing electricity and fuels with low GHG intensity, where practical;
- Maximise efficiency of operations through logistical planning;
- Regular maintenance of equipment to maintain optimum operations and fuel efficiency; and
- Incorporate energy efficiency design aspects into existing buildings wherever possible to reduce energy demand. Examples could include energy efficient lighting systems, natural ventilation, insulation and other renewable forms of energy.

Contents

1 Introduction

Boral Cement Limited (Boral) owns and operates the Marulan South Limestone Mine (the mine). It is a long standing open cut mine that has produced up to 3.5 million tonnes of limestone and lime products per year for the cement, steel, agricultural, construction and commercial markets.

The mine is a strategically important asset for Boral, as it supplies the main ingredient for the manufacture of cement at Boral's Berrima Cement Works. This is also a strategically important operation for Sydney based consumers of these products as this represents around 60% of the cement sold in NSW and feeds into more than 30% of concrete sold in Sydney.

The mine operates under Consolidated Mining Lease No. 16 (CML 16), Environment Protection Licence (EPL) 944, a combination of development consents issued by Goulburn Mulwaree Council (Council) and continuing use rights.

Due to changes between the Mining Act 1992 and the *Environmental Planning & Assessment Act 1979* (EP&A Act), when mining moves beyond the area covered by the current Mining Operations Plan (MOP), a development consent under the EP&A Act will need to be in place.

An Environmental Impact Statement (EIS) has been prepared by Element Environment, on behalf of Boral for submission to the Department of Planning and Environment (DP&E) to satisfy the provisions of Part 4 of the EP&A Act. Boral is seeking approval for continued operations at the site through a development application for a State Significant Development including a 30-year mine plan, associated overburden emplacement areas and a mine water supply dam (hereafter referred to as 'the Project').

Edge Environment (Edge) has prepared this Greenhouse Gas (GHG) assessment for Boral to assess the GHG emissions associated with the Project.

1.1 Site Location and Context

The mine is located in Marulan South, 10 kilometres (km) southeast of Marulan village and 35 km east of Goulburn, within the Goulburn Mulwaree Local Government Area (LGA) in the Southern Tablelands of NSW (Figure 1). Access is via Marulan South Road, which connects the mine and Boral's Peppertree Hard Rock Quarry (Peppertree Quarry) with the Hume Highway approximately 9 km to the northwest. Boral's private rail line connects the mine and Peppertree Quarry with the Main Southern Railway approximately 6 km to the north.

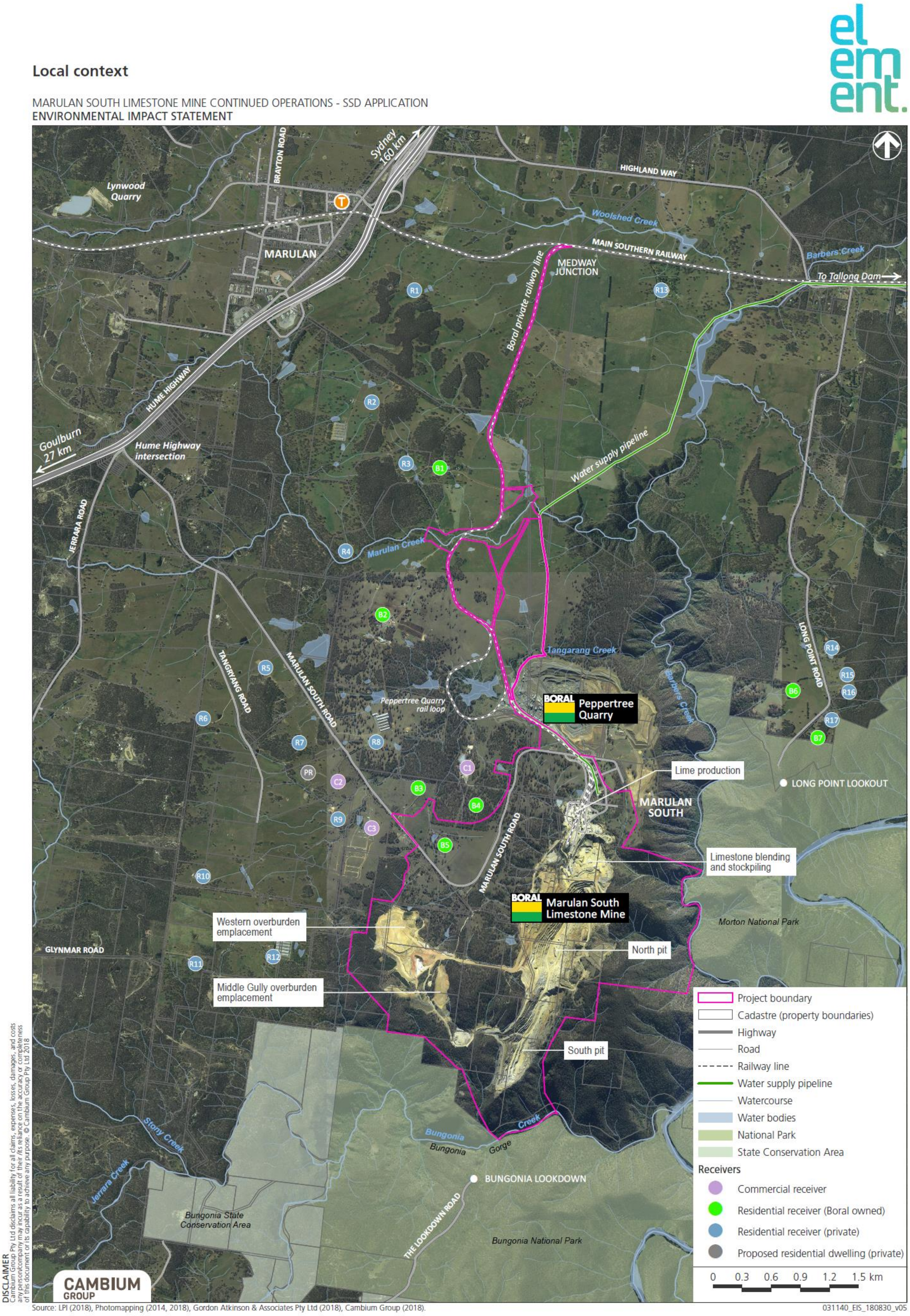

Figure 1 - Regional Locality (Element 2018)

1.2 Land Use and Ownership

CML 16 under which the mine operates, covers an area of 616.5 hectares (ha), which includes land owned by Boral (approximately 475 ha), Crown Land (adjoining to the south and east) and five privately owned titles (Figure 2). There is also Boral owned land surrounding the mine that does not fall within CML 16.

Land use surrounding the mine is a mixture of extractive industry, grazing, rural residential, commercial/industrial and conservation.

The mine is separated from the Bungonia State Conservation Area to the south by Bungonia Creek and is separated from the Shoalhaven River and Morton National Park to the east by Barbers Creek.

Peppertree Quarry, owned by Boral Resources (NSW) Pty Limited, borders the mine to the north. The site of the former village of Marulan South is located between the mine and Peppertree Quarry on land owned by Boral. The village was established principally to service the mine but has been uninhabited since the late 1990's. The majority of the village's infrastructure has been removed and only a village hall and former bowling club remains. The bowling club has been converted into administration offices for the mine and the hall is used by the mine services team.

A small number of rural landholdings surround the Boral properties to the north and west, including an agricultural lime manufacturing facility, fireworks storage facility, turkey farm and rural residential (a number of these properties are actively grazed). The main access for these properties is via Marulan South Road. Rural residential properties are also located to the northeast of the mine along Long Point Road. These properties are separated from the mine by the deep Barbers Creek gorge.

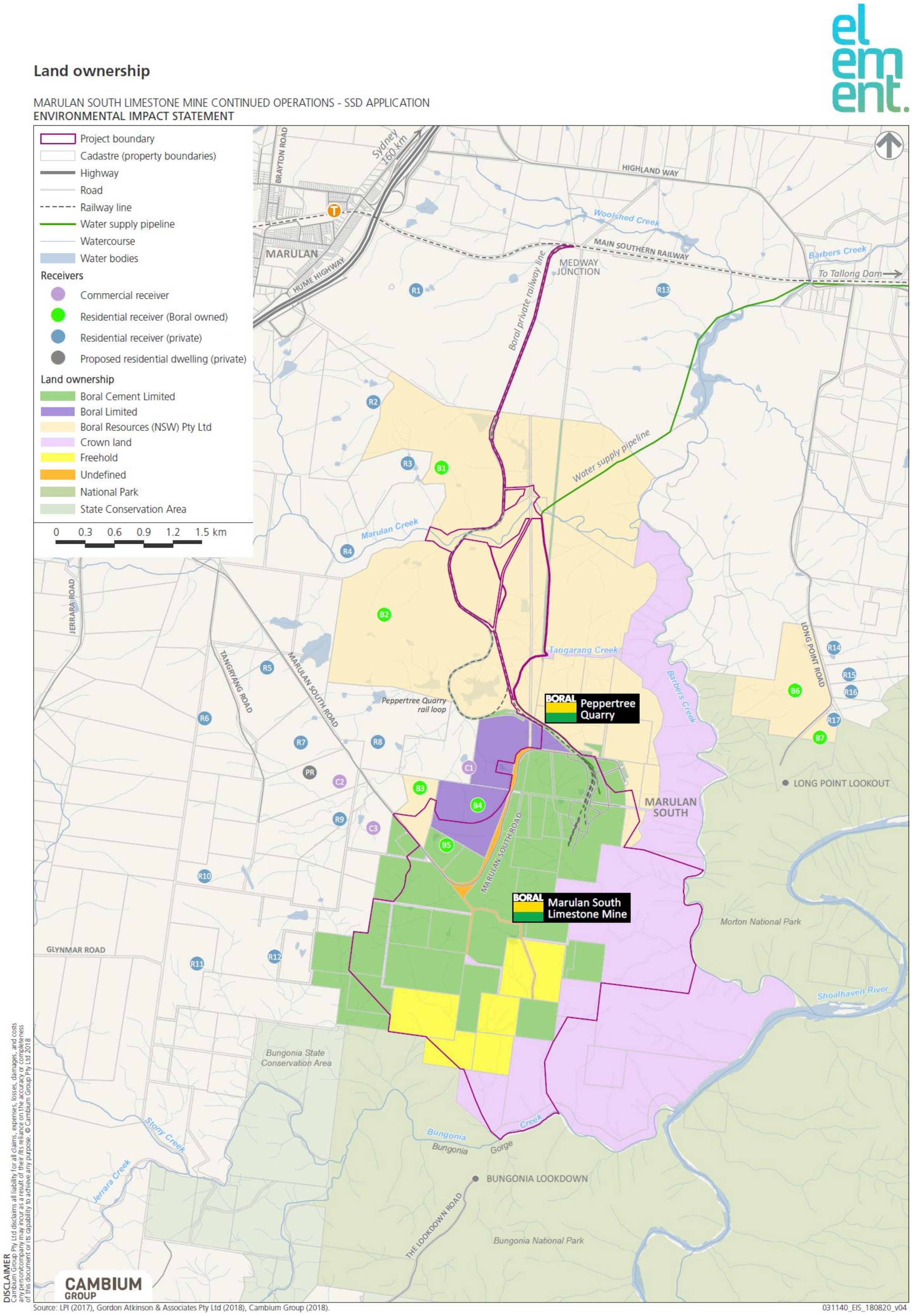

Figure 2 – Land ownership (Element 2018)

1.3 Existing Operations

The Marulan South Limestone Mine is sited on a high-grade limestone resource. Subject to market demand the mine has typically produced 3 to 3.3 million tonnes of limestone and 120,000 to 200,000 tonnes of shale per annum.

The mine currently produces a range of limestone products for internal and external customers in the Southern Highlands/Tablelands, the Illawarra and Metropolitan Sydney markets for use primarily in cement and lime manufacture, steel making, agriculture and other commercial uses. Products produced at the mine are despatched by road and rail, with the majority despatched by rail

Limestone and shale are extracted using open-cut hard rock drill and blast techniques. Material is loaded using front end loaders and hauled either to stockpiles or the processing plant using haul trucks. Oversized material is stockpiled and reduced in size using a hydraulic hammer attached to an excavator.

Limestone processing facilities including primary and secondary crushing, screening, conveying and stockpiling plant and equipment located in the northern section of the North Pit. Kiln stone grade limestone is also processed on site through the existing lime plant comprising kiln stone stockpiles, rotary lime kiln, hydration plant and associated auxiliary conveying, processing, storage, despatch plant and equipment. Overburden from stripping operations is emplaced in the Western Overburden Emplacement, west of the open cut pits.

The current operations are 24 hour, 7 days per week with personnel employed on a series of 8 to 12 hour shifts to cover the different operational aspects of the mine. Blasting is restricted to daylight hours and on weekdays, excluding public holidays.

1.4 The Proposed Project

1.4.1 Mining Operations

Boral proposes to continue mining limestone from the mine at a rate of up to 4 million tonnes per annum (mtpa) for a period of up to 30 years. This represents an increase in extraction rate from historic levels (peak of 3.38 mtpa) due to forecast increased demand from the construction industry. Shale will continue to be extracted at a rate of up to 200,000 tonnes per annum (tpa).

The proposed 30 year mine plan accesses approximately 120 million tonnes of limestone down to a depth of 335 m AHD. The mine footprint focuses on an expansion of the North Pit westwards to mine the Middle Limestone and to mine deeper into the Eastern Limestone. As the Middle Limestone lies approximately 70 m to 150 m west of the Eastern Limestone, the 30 year mine plan avoids mining where practical the interburden between these two limestone units thereby creating a smaller second, north-south oriented West Pit with a ridge remaining between. The North Pit will also be expanded southwards, encompassing part of the South Pit, leaving the remainder of the South Pit for overburden emplacement and a visual barrier (Figure 3).

In addition to mining approximately 5 million tonnes of shale, the extraction of the limestone requires the removal of approximately 108 million tonnes of overburden over the 30 year period. This material will be emplaced within existing and proposed overburden emplacement areas (Figure 3).

Limestone will continue to be mined using drilling and blasting methods. Shale will continue to be mined by excavator/front end loader. Limestone, shale and overburden will be transported to the primary crusher, stockpile areas and overburden emplacements respectively, using the load and haul fleet of trucks.

Products produced at the mine will continue to be despatched by road and rail, with the majority despatched by rail.

The limestone sand plant, produces a crushed and air classified limestone sand for use in concrete. The mine currently produces 500,000 tpa for Peppertree Quarry and propose to increase production of manufactured sand to approximately 1 million tpa.

Boral's adjoining Peppertree Quarry currently has approval to emplace some of its overburden in the South Pit mine void. As the South Pit is required for the emplacement of over 30 million tonnes of overburden from the mine after the removal of accessible limestone, Boral proposes to emplace up to 15 million tonnes of overburden from Peppertree Quarry within the Northern Overburden Emplacement (Figure 3).

1.4.2 Associated Infrastructure

Processing

The existing facilities for processing limestone will continue to be utilised to produce a series of graded and blended limestone products that are despatched from site for use primarily in cement manufacture, steel making, commercial and agricultural applications.

Limestone processing facilities (Figure 3) include primary and secondary crushing, screening, conveying and stockpiling plant and equipment located north-west of the North Pit and extending to the tertiary crushing, screening, bin storage and despatch (rail and road) systems that form part of the main processing facilities.

Kiln stone grade limestone will also continue to be processed on site through the existing lime plant comprising kiln stone stockpiles, rotary lime kiln, hydration plant and associated auxiliary conveying, processing, storage, despatch plant and equipment.

Processing infrastructure and the reclaim and stockpile area at the northern end of the North Pit will be relocated during the life of the 30 year pit to enable full development of the mine plan. The timing and location of this is presented in the EIS.

Shale and white clay will not be processed and will be stockpiled directly from the pit, ready for dispatch by road to the Berrima and Maldon cement operations.

Water Supply

Water supply for the Project, including dust suppression, processing activities and some non-potable amenities will be from existing and new on-site dams and a proposed new water supply dam on Marulan Creek (Figures 3 and 4). This dam would be located on Boral owned land north of Peppertree Quarry and utilises Boral's adjoining Tallong water pipeline to transfer water to the mine. This dam would require the purchase of water entitlements.

Mine water demand will also be supplemented by Tallong Weir via the Tallong water pipeline.

Rail

No changes are proposed to the existing rail infrastructure. A 1.2 km long passing line was constructed at Medway Junction during construction of the Peppertree Quarry, which will also be used by the mine to enhance access to the Main Southern Railway.

Road

Road access from the mine to the Hume Highway is via Marulan South Road. The proposed Western Overburden Emplacement extends northwards over Marulan South Road. Boral propose to realign a section of Marulan South Road, to accommodate the northern portion of the proposed Western Overburden Emplacement (Figure 3).

All public roads within the former village of Marulan South as well as the section of Marulan South Road between Boral's operations and the entrance to the agricultural lime manufacturing facility will be de-proclaimed.

Power

Power supply to the mine is via a high voltage power line that commences at a sub-station on the southern side of Marulan South Road, immediately west of the Project boundary. A section of this power line will be relocated to accommodate the proposed Northern Overburden Emplacement (Figure 3).

1.4.3 Transport

The majority of limestone products will continue to be transported to customers by rail for cement, steel, commercial and agricultural uses. Boral seeks no limitation on the volume of products transported by rail.

Manufactured sand will continue to be transported by truck along a dedicated internal road, across Marulan South Road and into Peppertree Quarry for blending and dispatch by rail.

Agricultural lime, quick lime and fine limestone products will continue to be transported by powder tanker, bulk bags on trucks or open tipper trucks along Marulan South Road.

Shale, limestone aggregates, sand and tertiary crushed products will be transported by predominantly truck and dog along Marulan South Road.

The adjoining Peppertree Quarry is currently approved to transport all products by rail. Boral will seek to transport approximately 150,000 tpa of Peppertree Quarry's products from the mine to customers via Marulan South Road. This could be achieved by back loading to a new shared road sales product stockpile area by the trucks carrying the limestone sand to Peppertree Quarry. A new shared road sales product stockpile area is proposed on the northern side of Marulan South Road, immediately west of the mine and Peppertree Quarry entrances (Figure 3). This shared finished product stockpile area, includes a weighbridge and wheel wash and will service both the mine and Peppertree Quarry.

In total, Boral is seeking to transport up to 600,000 tpa of limestone and hard rock products along Marulan South Road to the Hume Highway, as well as 120,000 tpa of limestone products to the agricultural lime manufacturing facility.

1.4.4 Construction

Of all the Project Activities outlined above, those that are considered to be construction activities for the purposes of this GHG assessment include:

1. Marulan Creek Dam;
2. Marulan South Road Realignment;
3. HV Powerline Relocation;
4. Road Sales Stockpile Area; and
5. Stockpile Reclaim Area.

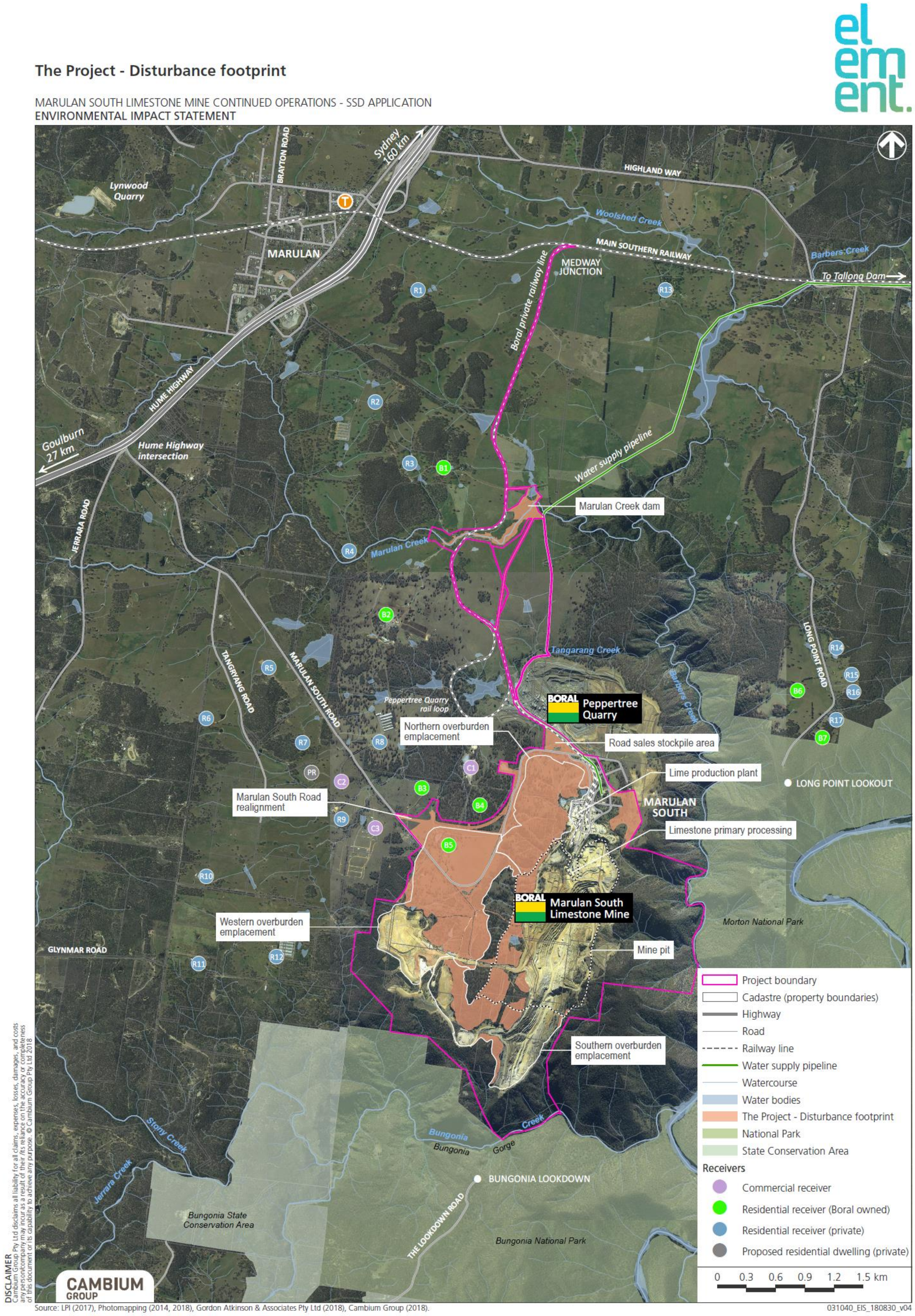

Figure 3 - Proposed Project (Element 2018)

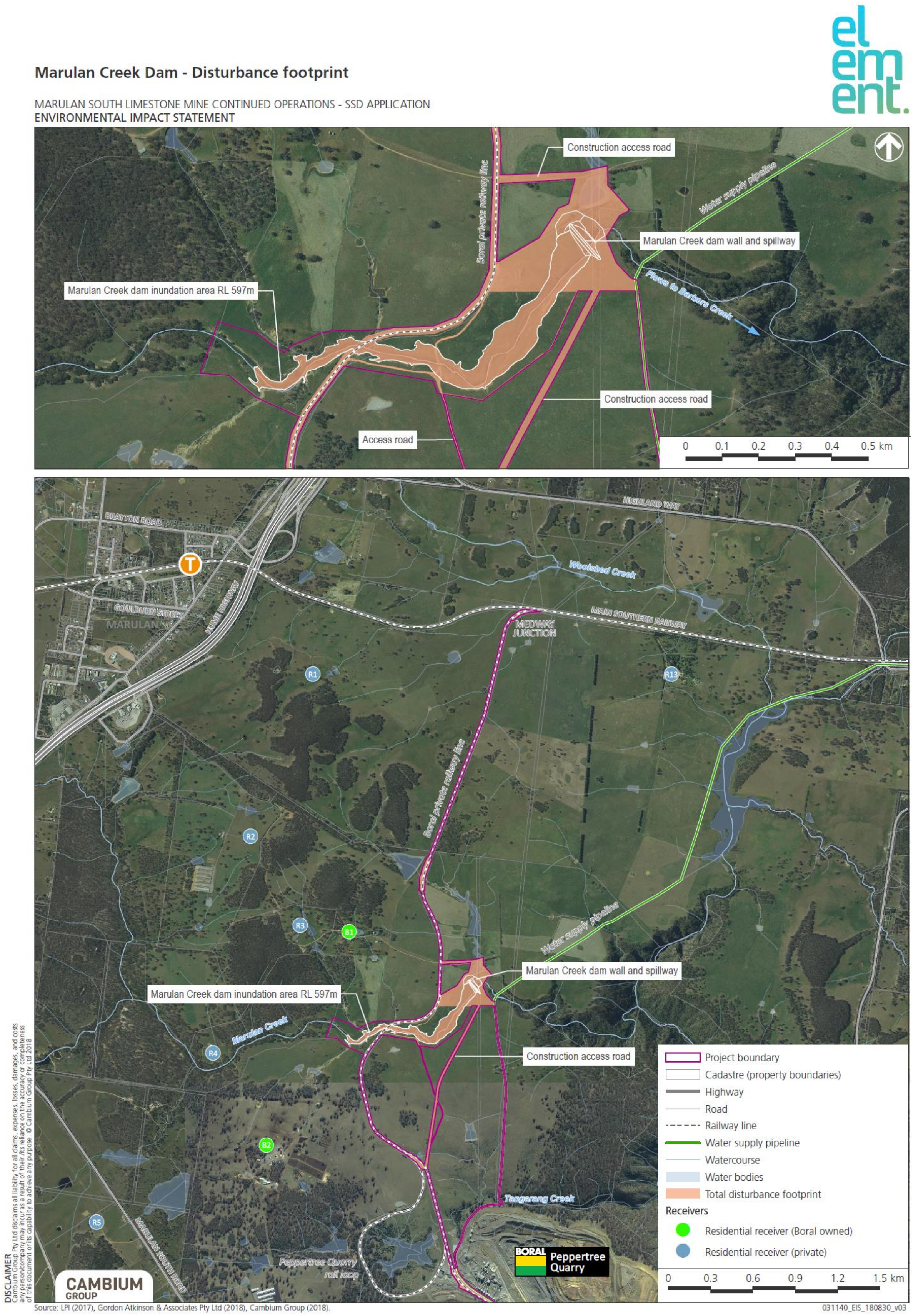

Figure 4 – Marulan Creek Dam (Element 2018)

1.5 Context of Greenhouse Gas

In 2007, the Intergovernmental Panel on Climate Change (IPCC) released its fourth assessment report (AR4) on climate change. It stated that warming of the climate system is unequivocal, as is evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. It also states that most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas (GHG) concentrations (IPCC 2007). In 2013, the IPCC released its fifth assessment report (AR5), which states that annual global GHG emissions have continued to grow since AR4. AR5 (2013) further states that human influence, through the emission of greenhouse gases, has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes. Based on AR5 evidence for human influence has grown since AR4. 'It is extremely likely that human influence has been the dominant cause of the observed warming since the mid 20th century' (IPCC 2013).

In Australia and NSW, there are a number of policies, guidelines and regulations, which have been developed to manage and reduce GHG emissions. These include the following:

- The Australian Government has committed to reduce its emissions by between 5 and 15 or 25 per cent below 2000 levels by 2020. The five per cent target is unconditional. The up to 15 per cent and 25 per cent targets are conditional on the extent of international action. It has also committed to a long-term emissions reduction target of 80 per cent below 2000 levels by 2050;
- The National Greenhouse and Energy Reporting (NGER) Act was introduced in 2007 and requires corporations to register and report emissions, energy consumption or production that meets certain thresholds every year. For GHG emissions, thresholds are currently set at 25,000 tonnes carbon dioxide equivalent (tCO2e) for a facility under a corporation and 50,000 tCO2e for a corporation as a whole for 2010-2011 (DCC 2008);
- The NSW Department of Infrastructure, Planning and Natural Resources – Department of Energy, Utilities and Sustainability Guidelines for Energy and Greenhouse in EIA provides guidance on the consideration of energy and greenhouse issues when developing projects and when undertaking environmental impact assessment (EIA) under the Environmental Planning and Assessment Act 1979 (EP&A Act); and
- The Commonwealth Department of Environment publishes National, State and Territory Greenhouse Gas Inventories annually. This provides an overview of the latest available estimates of GHG emissions for the Australian States and Territories based on a Kyoto accounting basis.

Table 2 outlines the best available emissions estimates for Australia broken down by economic sector. This GHG assessment will estimate the CO_2 emissions associated with the construction and operation of the Project and identify actions to manage and minimise these emissions where feasible.

Table 2 - National emissions by economic sector in 1990, 2015 and 2016.

ANZSIC code	Industry Classification	Emissions (Mt CO_2-e)			Change in emissions (per cent)	
		1990	2015	2016	1990 to 2016	2015 to 2016
Div A	**Agriculture, forestry and fishing**	**247.0**	**73.5**	**64.3**	**-74.0%**	**-12.5%**
Div B	**Mining**	**41.5**	**76.0**	**82.3**	**98.3%**	**8.3%**
06	Coal mining	23.1	34.8	35.2	52.5%	1.3%
07	Oil and gas extraction	14.4	26.6	32.4	124.3%	21.8%
08-10	Metal ore and non-metallic mineral mining and quarrying	4.0	14.7	14.8	269.1%	0.5%
Div C	**Manufacturing**	**69.3**	**62.7**	**60.0**	**-13.5%**	**-4.3%**
11-12	Food, beverages, tobacco	5.2	4.6	4.8	-8.5%	4.0%
13	Textile, clothing, footwear and leather	0.6	0.5	0.5	-15.9%	0.4%
14-16	Wood, paper and printing	2.1	1.7	1.7	-17.2%	1.8%
17-19	Petroleum, coal and chemical	15.6	18.2	16.0	2.3%	-11.9%
20	Non-metallic mineral products	10.1	9.6	9.3	-8.1%	-3.6%
21-22	Metal products	34.9	27.6	27.2	-22.2%	-1.4%
24	Machinery and equipment	0.8	0.5	0.5	-37.9%	-5.9%
25	Other manufacturing	0.1	0.1	0.1	41.2%	5.5%
Div D	**Electricity, gas and water**	**136.9**	**194.8**	**201.2**	**47.0%**	**3.3%**
Div E-H, J-Q	**Commercial services and construction**	**34.6**	**34.4**	**34.9**	**0.9%**	**1.5%**
Div I	**Transport and storage**	**12.7**	**28.4**	**29.4**	**130.9%**	**3.6%**
	Residential	**40.6**	**60.5**	**60.9**	**49.7%**	**0.6%**
	Residential (non transport)	8.5	13.1	13.3	56.4%	1.9%
	Residential (transport)	32.1	47.4	47.5	48.0%	0.2%
Total	All Sectors	582.7	530.3	533.0	-8.5%	0.5%

Source: Australian Greenhouse Emissions Information System:
http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/ageis

The Project contributes to the "Metal ore and non-metallic mineral mining and quarrying" sector for construction and operational emissions.

1.6 Scope of Works

The scope of this GHG assessment is to undertake an assessment of projected GHG emissions from the Project. The assessment will be used to identify actions for mitigating or reducing emissions, where possible. The scope of works for this assessment is to:

- Identify the main sources of emissions during construction and operational stages of the Project;
- Meet the Secretary's Environmental Assessment Requirements for State Significant Development for Air Quality which states that an assessment of the likely greenhouse gas impacts of the development, having regard to the EPA's requirements;
- Scope and calculate the emissions from each source using factors and methods outlined in the National Greenhouse Accounts (NGA) Factors, published by the Australian Government Department of Climate Change and Energy Efficiency (2012), the GHG Protocol published by the World Business Council for Sustainable Development (2001) and the BPIC/ICIP Project's Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database; and
- Investigate and recommend strategies for emissions mitigation to reduce GHG emissions associated with Project development and operation.

Figure 5 illustrates the measurement boundaries and emissions sources investigated in this GHG assessment.

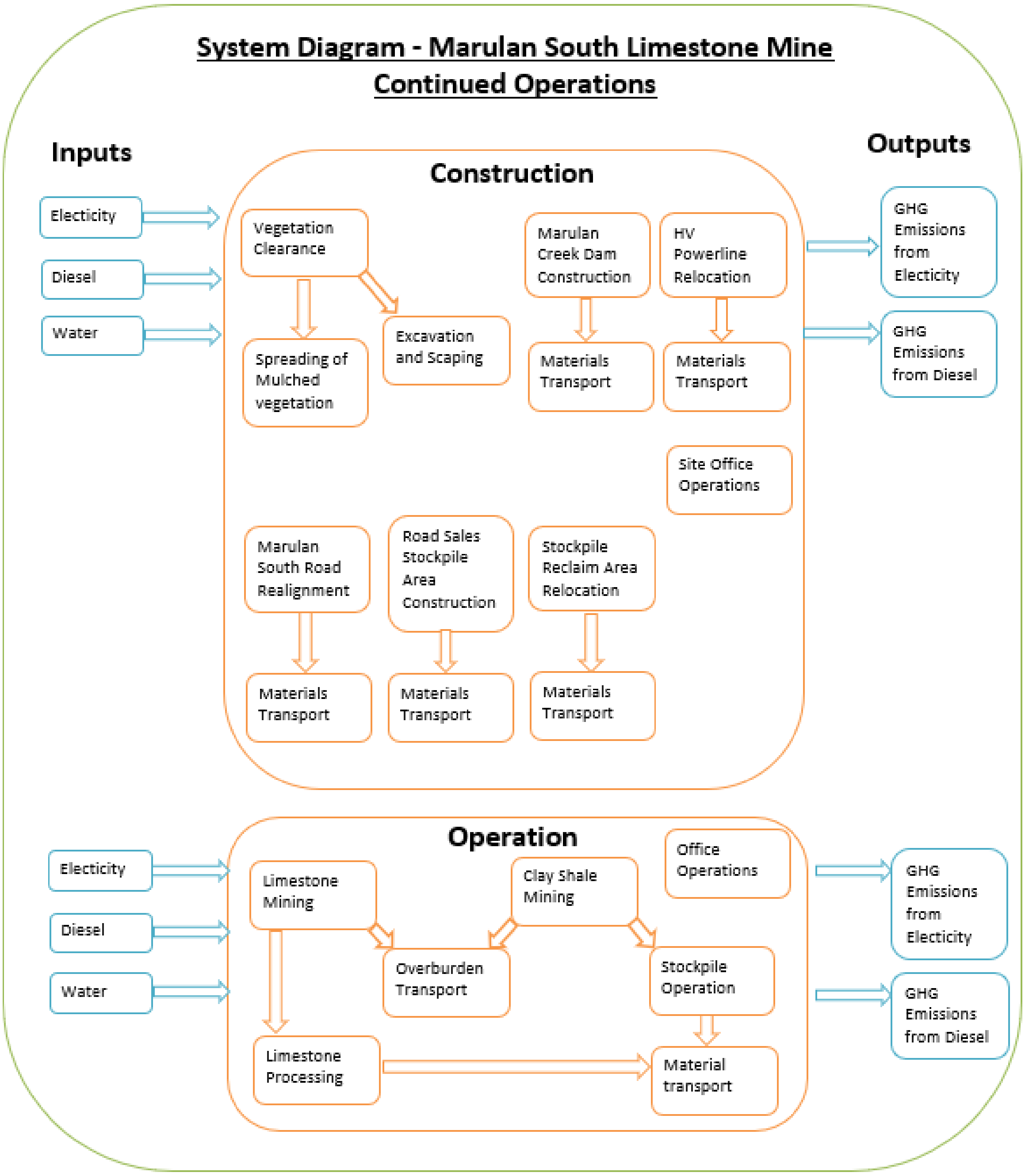

Figure 5 - GHG emissions boundary for the Project

The scoping processes used within this report for the operation of the facility are adapted from the 'The Greenhouse Gas Protocol' (WBCSD 2001). Under this protocol, the Projects direct and indirect emissions sources can be delineated into three 'Scopes' (Scope1, Scope 2 and Scope 3) for GHG accounting and reporting purposes. This method of scoping helps to improve transparency, and assists in setting emissions reduction objectives.

The GHG protocol definitions for each Scope are presented in Figure 6 and described in further detail below.

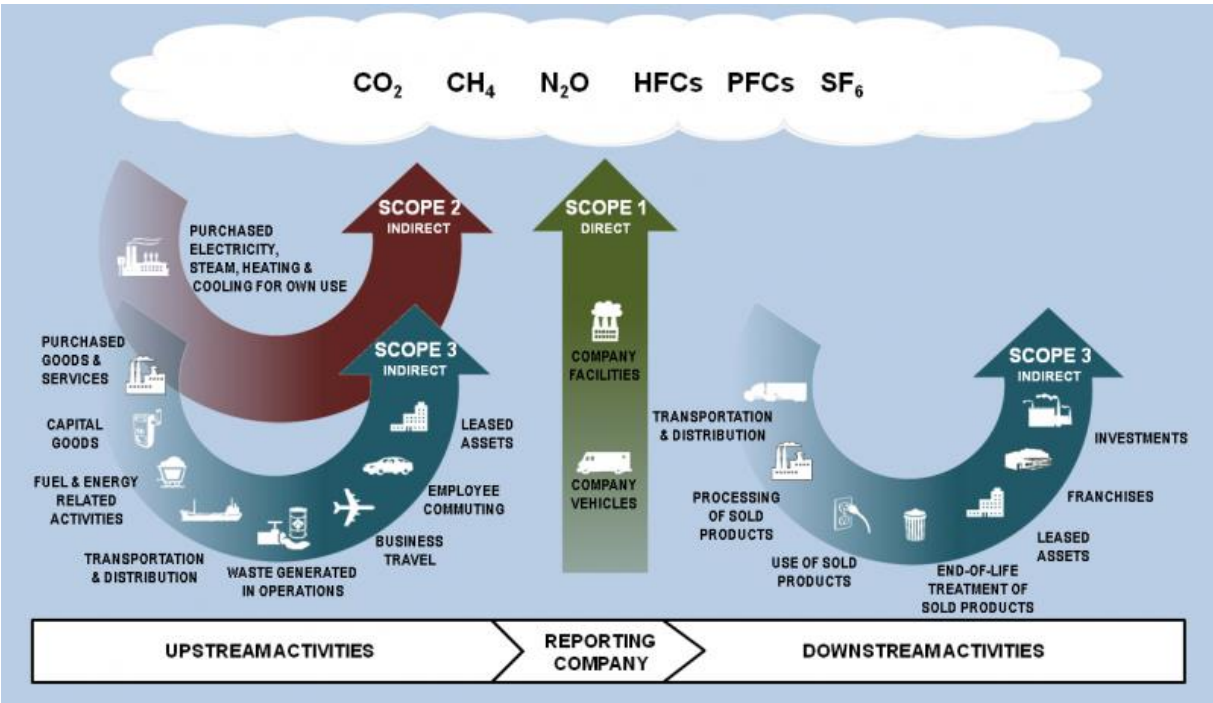

Figure 6 - Overview of Scopes and emission sources (Source: World Business Council for Sustainable Development, 2001)

- **Scope 1 – Direct GHG emissions:** Scope 1 emissions are direct emissions that occur from sources on site. This would include emissions arising from the combustion of fuels in equipment on-site (e.g. generators, vehicles, machinery, fugitive emissions etc.);
- **Scope 2 – Electricity indirect GHG emissions:** Scope 2 emissions account for GHG emissions arising from the generation of purchased electricity consumed on-site. Scope 2 emissions are considered indirect as they occur at an off-site facility where electricity is generated; and
- **Scope 3 – Other indirect GHG emissions:** Scope 3 emissions are an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities on, but occur away from the development site and are not under Boral's control.

This assessment has been undertaken using the best available current and historical data. Assumptions have been outlined, where appropriate to maintain transparency.

2 Construction Based GHG Inventory

The construction activities associated with the Project will include the transport of materials to and from site, decomposition of vegetation waste and the use of machinery and vehicles for preparation of the site and civil and construction works. These activities require the use of fuels and electricity, which will result in the release of associated GHG emissions.

Accurately quantifying these emissions at this stage requires a number of assumptions to be made including distances travelled and hours of use for vehicles and machinery. Other factors which will affect GHG emissions during the construction phase include construction methods, time table, materials sources and transport methods.

Emissions were calculated by estimating fuel use, electricity consumption and vegetation decomposition using available data. Emissions in tonnes CO_2 equivalent were calculated using factors and methods from the Australian Government National Greenhouse Accounts Methods and Factors Workbook. Specific assumptions made with regard to fuel use, electricity consumption, construction schedules, material quantities, material transport and waste decomposition are outlined in detail in the following sections. These assumptions are based on Edge's experience in similar construction projects. General assumptions and calculations are provided in the report.

2.1 Construction Activities

The total estimated emissions from construction activities is ***14,182tCO₂e***. The breakdown of these emissions is detailed in the following sections. This includes emissions from the following construction activities:

- Vegetation clearing to prepare the site for construction;
- Spreading of mulched vegetation;
- Lost carbon sink due to land clearing;
- Site office operations;
- Marulan Creek Dam;
- Marulan South Road Realignment;
- HV Powerline Relocation;
- Road Sales Stockpile Area; and
- Stockpile Reclaim Area Relocation

Table 3 - Summary of GHG emissions from construction by construction activity

Construction activity	Scope 1 Emissions (tCO_2e)	Scope 2 Emissions (tCO_2e)	Scope 3 Emissions (tCO_2e)	Total Emissions (tCO_2e)
Land Clearing – Low condition vegetation	175.17		12.88	188
Land Clearing – Moderate condition vegetation	1,832		135	1,967
Land Clearing - Access Road Realignment	70		5	75
Spreading Mulched Vegetation	6		0	6
Disturbed vegetation removal - lost carbon sink	11,240			11,240
Site Office - Site Preparation		1	0	1
Marulan Creek Dam - Wall Fill	139		10	150
Marulan Creek Dam - Rip Rap	45.70		3.36	49.06

Marulan Creek Dam - Spillway Excavation	41		3	44
Marulan Creek Dam - Spillway surface Area (Concrete)	55		4	59
Marulan South Road Realignment - Cut and Fill	111		8	119
Marulan South Road Realignment - Road Construction	196		14	211
Marulan South Road Realignment - Drainage Construction	1		0	1
Road Sales Stockpile Area - Weighbridge & Wheel Wash Area Construction	4.40		0	5
Stockpile Reclaim Area Relocation - Concrete footings	13.19		1	14
Stockpile Reclaim Area Relocation - Tunnel	5.49		0	6
Stockpile Reclaim Area Relocation - Crane	32.64		2	35
Stockpile Reclaim Area Relocation - Elevated Work Platform		2.65	0	3
Site Office - Construction		4.16	1	5
HV Powerline Relocation - Concrete foundations	3.85			4
HV Powerline Relocation - Stringing of Cables	0.20			0
TOTAL	13,972	8	202	14,182

Assumptions used in calculating the above emissions are set out below:

- Site preparation works are expected to take 2 months in total;
- The area of cleared land is detailed below and is sourced from the Niche Environment and Heritage Biodiversity Assessment Report (2018).
  - Land Clearing - High shrubs and medium dense trees 32.2 ha
  - Land Clearing – Low shrubs - 168.4 ha
  - Land Clearing – Grasslands – 25.7 ha
- The following vegetation mass factors are assumed based on Niche Environment and Heritage Biodiversity Assessment Report (14th March 2018).
  - 90t/ha – Mature Forest
  - 20t/ha - High shrubs and medium dense trees < 10m
  - 5t/ha - Low shrubs
- The following fuel consumption estimates were assumed for vegetation removal. This factor assumes vegetation removal will be conducted using conventional plant (i.e. graders and dozers);
  - 4 kL/ha – Mature Forest
  - 2 kL/ha - High shrubs and medium dense trees < 10m
  - 1 kL/ha – Low shrubs

- It was assumed that all cleared vegetation was mulched and spread on site;
- A fuel consumption factor of 0.004kL/m^3 was assumed for spreading of mulched vegetation. This factor assumes conventional plant (i.e. graders and dozers);
- Vegetation Removal – lost carbon sink emissions, were calculated by multiplying the average annual rainfall (541mm) by the area of land cleared (~226ha disturbed) by the disturbed (0.09 t CO2-e/ha) vegetation sequestration factors.
- The above factors and methods of calculation are taken from Greenhouse Gas Assessment Workbook for Road Projects, Transport Authorities Greenhouse Group, June 2011.
- Construction works are expected to be complete within the following timelines:
    - Marulan Creek Dam construction – 3 months
    - Marulan South Road Realignment – 4 months
    - Road Sales Stockpile Area construction – 2 months
    - Stockpile Reclaim Area Relocation – 2 months
    - HV Powerline Relocation – 2 months
- Areas and volumes of the main components of each construction activity are summarized below:
    - Marulan Creek Dam construction - Wall Fill – 14,650 m^3
    - Marulan Creek Dam construction - Rip Rap – 4,000 m^2
    - Marulan Creek Dam construction - Spillway Excavation – 15,000 m^3
    - Marulan Creek Dam construction - Spillway surface Area (Concrete) – 5,000 m^2
    - Realignment of Marulan South Road - Cut and Fill – 11,643 m^3
    - Realignment of Marulan South Road - Road Construction – 9,061 m^2
    - Realignment of Marulan South Road - Drainage Construction – 550 m^2
    - Road Sales Stockpile Area - Weighbridge & Wheel Wash Area Construction – 400 m^2
    - Stockpile Reclaim Area Relocation – Concrete footings – 168m^3
    - Stockpile Reclaim Area Relocation – Tunnel – 50m^3
    - Stockpile Reclaim Area Relocation – Crane and Elevated work platform use (2 Cranes for 2 months)
    - HV Powerline Relocation – Concrete foundations – 35m^3
    - HV Powerline Relocation – Stringing Power cables – 5.4km
- The following fuel use factors and methods are taken from Greenhouse Gas Assessment Workbook for Road Projects, Transport Authorities Greenhouse Group, June 2011.
    - Marulan Creek Dam construction - Wall Fill – 3.5L/m^3
    - Marulan Creek Dam construction - Rip Rap – 3.5L/m^3
    - Marulan Creek Dam construction - Spillway Excavation – 1L/m^3
    - Marulan Creek Dam construction - Spillway Surface Area (Concrete) – 4.04L/m^2
    - Realignment of Marulan South Road - Cut and Fill – 3.5L/m^3
    - Realignment of Marulan South Road - Road Construction – 8L/m^2
    - Realignment of Marulan South Road - Drainage Construction – 0.4L/m
    - Road Sales Stockpile Area - Earth Bund Wall Construction – 3.5L/m^3
    - Road Sales Stockpile Area - Weighbridge & Wheel Wash Area Construction – 4.04L/m^2
    - Stockpile Reclaim Area Relocation – Concrete footings – 40.4 L/m^3

- Stockpile Reclaim Area Relocation – Tunnel – 40.4 L/m^3
- Stockpile Reclaim Area Relocation – Crane and Elevated work platform use (1-2months) – 200L/day and 35.52kWh/day respectively

- 5.4km of powerline to be strung
- Powerline strung at 1.05km/hr
- Hydraulic puller and tensioner diesel consumption 14L/hour

2.2 Summary of Construction Based GHG Emissions

Figure 7 illustrates the breakdown of total GHG emissions from construction activities for the Project. It can be seen that lost carbon sink from vegetation for disturbed land is estimated to be the most significant GHG emission contributor associated with the construction activities. Emissions from land clearing and the realignment of Marulan South Road are the next most significant emissions sources.

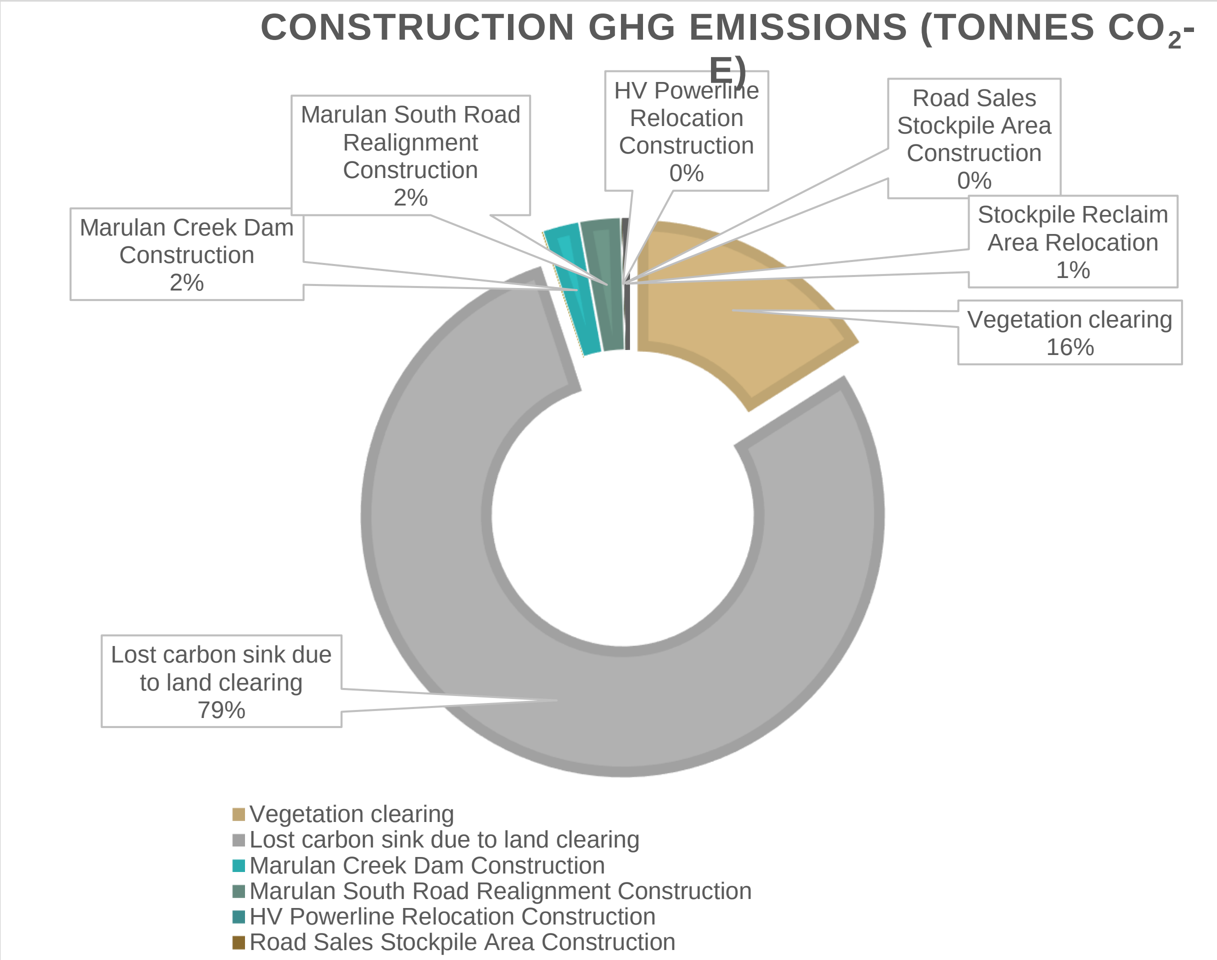

Figure 7 - Emissions breakdown by construction activity

The National Greenhouse Accounts Methods and Factors workbook (DCCEE 2012) also provides guidance on estimating Scope 3 emissions associated with fuel and electricity use. Scope 3 emissions are the indirect emissions associated with fuel or electricity being used on site. The Scope 1, 2 and 3 emissions associated with all fuel and electricity used during construction are outlined in Table 4 below.

Table 4 - Emissions associated with fuel and electricity use in construction activities

Construction activity	Elec Consumption (kWh)	Diesel Consumption (L)	Scope 1 Estimated emissions (tCO2-e)	Scope 2 Estimated emissions (tCO2-e)	Scope 3 Estimated emissions (tCO2-e)
Site preparation		765,861	2,083		153.17
Vegetation Removal - Lost Carbon Sink			11,019		
Construction	3,197	238,341	648	2.65	48.05
Site Office	6,266			5.20	0.75
Total	9,462	1,004,202	13,750	8	202

3 Operations Based GHG Inventory

This section outlines the GHG emissions associated with the key mining operations. This section will include a quantitative assessment of Scope 1, 2 and 3 emissions associated with the continued operation of the mine.

3.1 On Site Operations

The main emissions sources from continued operation of the mine are expected to be from electricity and fuel use. These emissions sources are the result of the following activities:

- Overburden removal
- Limestone mining
- Clay shale mining
- Hauling of limestone and clay shale to processing/stockpile facility
- Hauling of overburden to emplacements
- Limestone processing
- Kiln stone grade limestone processing
- Clay shale and white clay processing
- Water use
- Transport to customers by rail and road (External to Site

3.2 Operations Based GHG Emissions

Table 5, below illustrates projected GHG emissions based on predicted consumption of electricity, diesel and other sources. Figure 8 shows the total GHG emissions by the different sources in a graphical view.

Table 5 - Projected operational electricity and fuel use and GHG emissions

Operation source	Annual Elec Consumption (kWh)	Annual Fuel Consumption (L or GJ)	Scope 1 Estimated emissions (tCO2-e)	Scope 2 Estimated emissions (tCO2-e)	Scope 3 Estimated emissions (tCO2-e)
Electricity	19,011,934			15,780	2,281
Natural Gas (GJ)		664,979	34,180		9,443
Sub-bituminous Coal		210	3,918		
Diesel – Automotive (L)		2,697,000	7,336		539
Lime Production			49,226		
Total	19,011,934	N/R	94,660	15,780	12,264

Note: N/R = Not Relevant

Figure 8 shows that Lime Production is estimated to be the most significant emissions source during the operation of the Project, followed by emissions from natural gas use and electricity use.

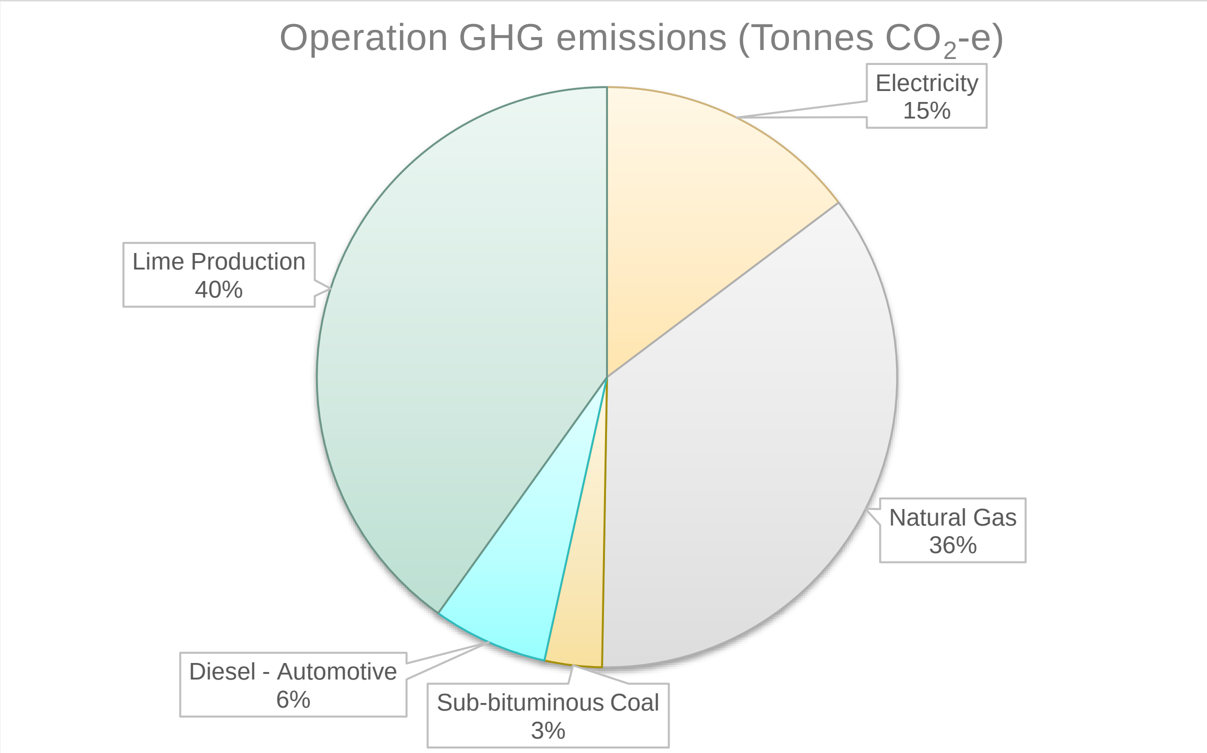

Figure 8 - Emissions breakdown by operation source

Assumptions used in calculating the above operational emissions are set out below:

- All fuel, electricity and GHG emission calculations are taken from the NGERs reporting for the 2016-2017 financial year for the Project. As this is an assessment of the continued operations of the mine it was deemed acceptable to use the existing NGERs information.
- National Greenhouse Account Factors for electricity from August 2017.

4 Project GHG Impact Assessment

Table 6 illustrates the estimated emissions from the construction and operational activities associated with the continuation of mining operations.

Table 6 - Overall Emission Summary

Period	Scope 1 Estimated emissions (tCO_2-e)	Scope 2 Estimated emissions (tCO_2-e)	Scope 3 Estimated emissions (tCO_2-e)	Total Estimated emissions (tCO_2-e)
Construction	13,972	8	202	14,182
Operation	94,660	15,780	12,264	122,704

The total estimated emissions from construction activities associated with the continued operation of the mine are 14,182tCO_2e, which is 11.4% of the estimated annual operational emissions of 122,704 tCO_2e as further illustrated in Figure 9.

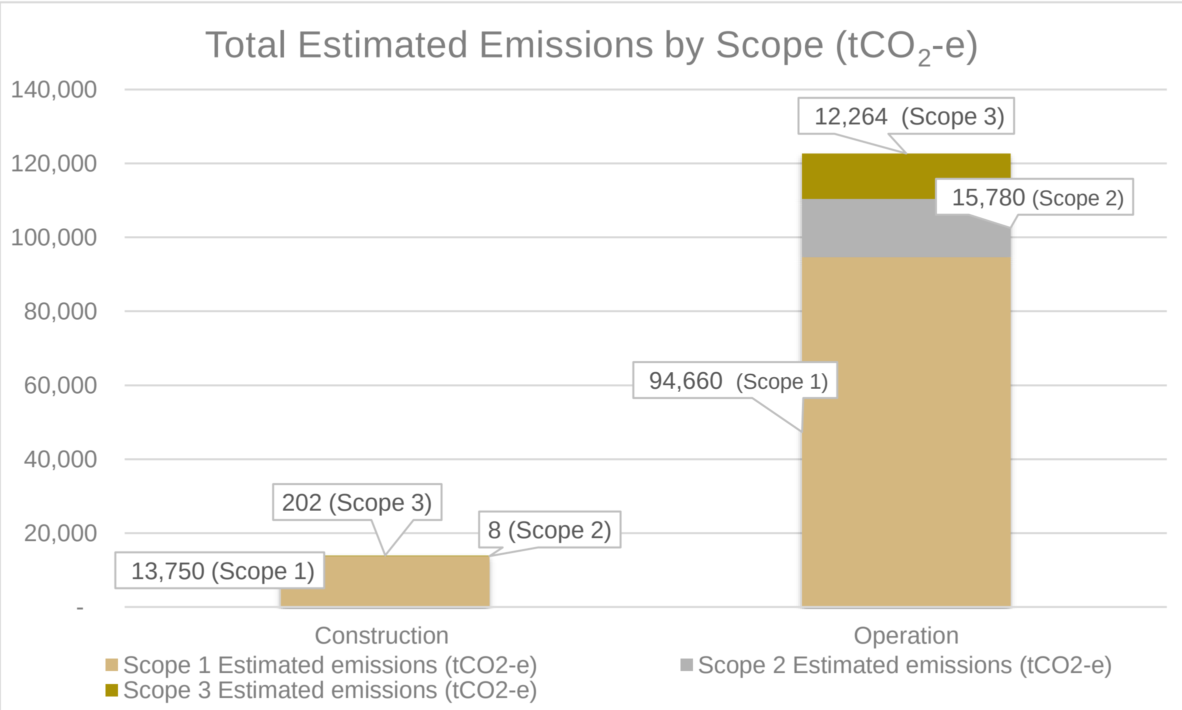

Figure 9 - Estimated Construction and Operational CO_2-e Emissions

5 GHG Management and Mitigation Options

The carbon management principles (shown in Figure 10) provide a robust framework for the management and reduction of GHG emissions.

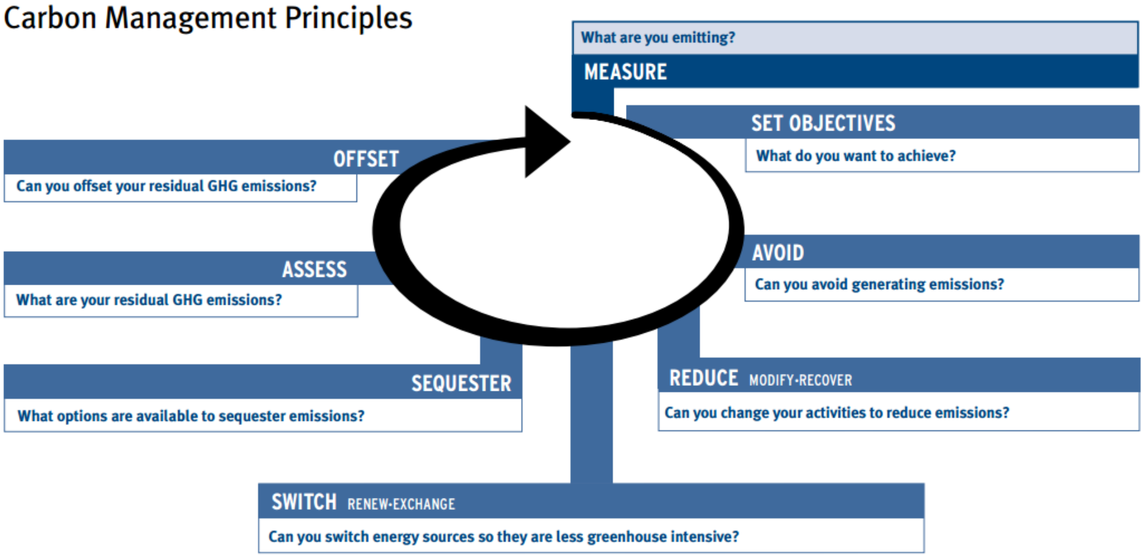

Figure 10 - Carbon management principles for emissions reduction (Victorian EPA)

The earlier sections in this assessment represent the emissions measurement and objectives setting components of the carbon management principles. This section recommends actions to further reduce emissions throughout the Project development. GHG emissions reduction actions should ideally be prioritised according to the carbon management principles.

Avoid: Actions which avoid emissions, in the first instance, should be considered as a priority;

Reduce: Actions which result in a reduction of emissions should be considered next;

Switch: Actions which switch energy sources to reduce emissions should be the next considered;

Sequester: Actions which sequester GHG emissions do not reduce emissions but store them; and

Offset: Offsetting of emissions through the purchase of offsets. This should be considered as a last resort.

Marulan Mine Management current reduction strategy includes:

1. A program to reduce idling time for HME through timer based automatic shut off of the engines
2. Replacement of lighting throughout site with energy efficient lighting
3. Over the last 4 years, through efficiency improvements in fixed crushing equipment have reduced the operating hours from 96 per week to 62
4. Training programs for operators of heavy equipment, particularly Front End Loaders and Haul trucks to minimise movement of the equipment in the loading area to reduce fuel consumption by between 5 and 11% and improve loading times with the added benefit of idling time reduction
5. Full planned maintenance program for all plant, fixed and mobile to maintain a level of efficiency and serviceability

Other Possible GHG management actions could include:

- Day/night sensors for lighting control;
- Potentially utilising conveyors for some of the overburden emplacement, substituting for haul trucks where possible;
- Regular monitoring of emissions throughout the Project to assess the effectiveness of emissions mitigation actions;
- Use locally sourced construction materials to reduce emissions associated with transport;
- Recycle/compost waste wherever possible;
- Plan construction and operational works to avoid double handling of materials and minimise haulage distances, thereby minimising the use of fuel;
- Make use of recycled or low impact materials to reduce emissions associated with embodied energy (not estimated in this report);
- Investigate the procurement of energy efficient equipment for the site (e.g. office and floodlighting, front end loaders and trucks etc.). Consider the procurement of equipment that uses lower GHG intensive fuel (e.g. gas, ethanol);
- Sourcing electricity and fuels with low GHG intensity, where practical;
- Maximise efficiency of operations through logistical planning;
- Incorporate energy efficiency design aspects into existing buildings wherever possible to reduce energy demand. Examples could include energy efficient lighting systems, natural ventilation, insulation and other renewable forms of energy.

5.1 Conclusion

The Project's total construction GHG emissions of 14,182tCO_2e equates to less than 0.1% of the national "Metal ore and non-metallic mineral mining and quarrying" sectors 14.8 MtCO_2e of annual GHG emissions.

The Project's annual operational GHG emissions of 122,704tCO_2e equates to less than 1% of the national "Metal ore and non-metallic mineral mining and quarrying" sectors 14.8 MtCO_2e of annual GHG emissions.

Following the proposed GHG management actions will result in emission reductions in both construction and operation and are recommended to minimise GHG impacts from the continued operation of the Marulan South Limestone Mine.

It's recommended that any future GHG emission reduction initiatives implemented at the mine focus on lime production, natural gas consumption and electricity consumption in operations, as these are the largest GHG emission sources.

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Appendix R

Noise and blasting assessment

VOLUME 6

A C O U S T I C S A N D A I R

MARULAN SOUTH LIMESTONE MINE CONTINUED OPERATIONS PROJECT MARULAN SSD

NOISE & BLASTING ASSESSMENT

REPORT NO. 14099-A
VERSION F

MARCH 2019

PREPARED FOR

ELEMENT ENVIRONMENT
ON BEHALF OF BORAL CEMENT LIMITED

WILKINSON MURRAY

DOCUMENT CONTROL

Version	Status	Date	Prepared By	Reviewed By
A	Draft	30 July 2015	George Jenner	John Wassermann
B	Draft	3 December 2015	Roman Haverkamp	John Wassermann
C	Draft	27 April 2018	George Jenner	John Wassermann
D	Draft	4 September 2018	George Jenner	John Wassermann
D	Final	10 October 2018	John Wassermann	John Wasserman
E	Final	23 October 2018	John Wassermann	John Wasserman
E	Final	1 March 2019	John Wassermann	John Wasserman
F	Final	12 March 2019	John Wassermann	John Wassermann

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GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

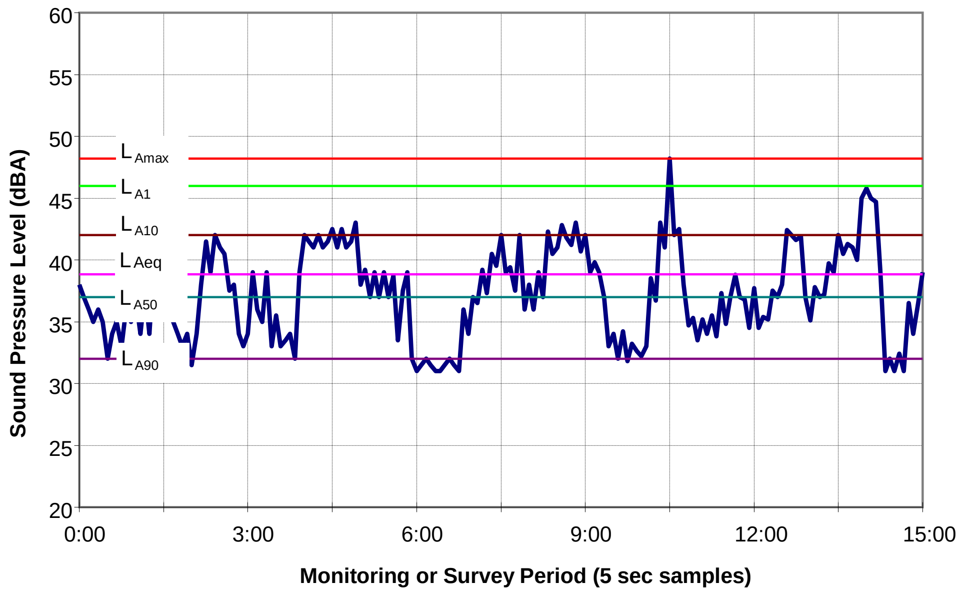
L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

Typical Graph of Sound Pressure Level vs Time



EXECUTIVE SUMMARY

Boral Cement Limited (Boral) owns and operates the Marulan South Limestone Mine (the mine). It is a long-standing open cut mine that has produced up to 3.38 million tonnes of limestone and lime-based products per year for the cement, steel, agricultural, construction and commercial markets.

Boral proposes to continue mining limestone from the mine at a rate of up to 4 million tonnes per annum (mtpa) for a period of up to 30 years. This represents a modest increase in extraction rate from historic levels (peak of 3.38 mtpa). Shale will continue to be extracted at a rate of up to 200,000 tonnes per annum (tpa).

Noise from ongoing operations, construction, blasting and traffic generation has been assessed against the latest guidelines promulgated by NSW authorities. The NSW EPA has recently released the *Noise Policy for Industry (NPfI)* which sets appropriate noise trigger levels for operational noise assessment.

Noise trigger levels at surrounding residential receivers have been derived from a review of all noise monitoring undertaken to date around the mine, as well as available data from the nearby Peppertree Quarry.

The NPfI requires detailed assessment of prevailing meteorological conditions. Five years of data from the Peppertree Quarry weather station was analysed to show that noise enhancing meteorological conditions are not a feature of the area. This applies to both wind and night time temperature inversions. Therefore, noise was assessed under standard meteorological conditions described in the *NPfI*.

Noise modelling was done based on the typical worst-case equipment locations provided by Boral for five stages during the life of the mine. Noise source levels were based in part on extensive noise surveys at the mine.

The predicted noise levels were less than the project noise trigger levels at all sensitive receiver locations for all stages of the proposed 30-year mine operations. As such, it is considered that the mine would have no significant noise impacts on neighbouring communities. The modelled scenarios presented in this report represent the culmination of several iterative noise modelling investigations designed to determine feasible and reasonable noise mitigation measures.

Overpressure and vibration levels from blasting were assessed. Criteria presented in the ANZECC blasting guideline (ANZECC, 1990) can be achieved.

Noise from the construction was predicted to comply with the EPA's *Interim Construction Noise Guideline*. (ICNG)

Noise from traffic generated by the proposal was predicted to comply with EPA's *Road Noise Policy (RNP)*.

Rail noise has been reviewed and deemed to comply with the EPA's *Rail Infrastructure Noise Guideline* (RING).

1 INTRODUCTION

Boral Cement Limited (Boral) owns and operates the Marulan South Limestone Mine (the mine). It is a long-standing open cut mine that has produced up to 3.38 million tonnes of limestone-based products per year for the cement, steel, agricultural, construction and commercial markets.

The mine is a strategically important asset for Boral, as it supplies the main ingredient for the manufacture of cement at Boral's Berrima Cement Works. This is also a strategically important operation for Sydney based consumers of these products as this represents around 60% of the cement sold in NSW and feeds into more than 30% of concrete sold in Sydney.

The mine operates under Consolidated Mining Lease No. 16 (CML 16), Mining Lease No. 1716, Environment Protection Licence (EPL) 944 and a combination of development consents issued by Goulburn Mulwaree Council and continuing use rights.

Due to changes between the *Mining Act 1992* and the *Environmental Planning & Assessment Act 1979* (EP&A Act), when mining moves beyond the area covered by the current Mining Operations Plan, a development consent under the EP&A Act will need to be in place.

An Environmental Impact Statement has been prepared by Element Environment Pty Ltd on behalf of Boral for submission to the Department of Planning and Environment to satisfy the provisions of Part 4 of the EP&A Act. Boral is seeking approval for continued operations at the site through a development application for a State Significant Development including a 30-year mine plan, associated overburden emplacement areas and a mine water supply dam (hereafter referred to as 'the Project').

This report presents a noise and blasting assessment of the proposed continued operations at the site. The New South Wales Environment Protection Authority (EPA) has released the Noise Policy for Industry (NPfI). The noise assessment evaluates potential noise impacts associated with the Project in accordance with the NPfI. Traffic noise, construction noise and blasting impacts have also been considered.

1.1 Authority Requirements

This report has been prepared in accordance with the *Secretary's Environmental Assessment Requirements (SEARs*) (ref: SSD 14-6766 and dated December 2014). Table 1-1 provides a summary of the *SEARs* and the section where they have been addressed in this report.

Table 1-1 *SEARs* (SSD 14-6766) Compliance Table

SEARs	Where Addressed
The EIS must address the following specific issues: ***Noise & Blasting – including:***	
• *an assessment of the likely operational noise impacts of the development (including construction noise) under the NSW Industrial Noise Policy, including the obligations in chapters 8 and 9 of the policy, and having regard to the NSW Government's Voluntary Land Acquisition and Mitigation Policy: For State Significant Mining, Petroleum and Extractive Industry Developments;*	Chapters 7, 8, 9 and 10
• *if a claim is made for specific construction noise criteria for certain activities, then this claim must be justified and accompanied by an assessment of the likely construction noise impacts of these activities under the Interim Construction Noise Guideline;*	Chapters 7, 8, 9 and 109
• *an assessment of the likely road noise impacts of the development under the NSW Road Noise Policy;*	Chapter 12
• *an assessment of the likely rail noise impacts of the development under the Rail Infrastructure Noise Guideline; and*	Note 1
• *an assessment of the likely blasting impacts of the development on people, livestock, buildings, infrastructure, and significant natural features, having regard to the relevant ANZECC guidelines;*	Chapter 14

2 SITE DESCRIPTION

2.1 Site Location

The mine is in Marulan South, 10 km southeast of Marulan village and 35 km east of Goulburn, within the Goulburn Mulwaree Local Government Area in the Southern Tablelands of NSW (Figure 2-1). Access is via Marulan South Road, which connects the mine and Boral's Peppertree Hard Rock Quarry (Peppertree Quarry) with the Hume Highway approximately 9 km to the northwest (Figure 2-2). Boral's private rail line connects the mine and Peppertree Quarry with the Main Southern Railway approximately 6 km to the north (Figure 2-2).

2.2 Land Use and Ownership

CML 16 (which encompasses ML 1716) covers an area of 616.5 hectares (ha), which includes land owned by Boral (approximately 475 ha), Crown Land (adjoining to the south and east) and five privately owned titles (Figure 2-3). There is also Boral owned land surrounding the mine that does not fall within CML 16.

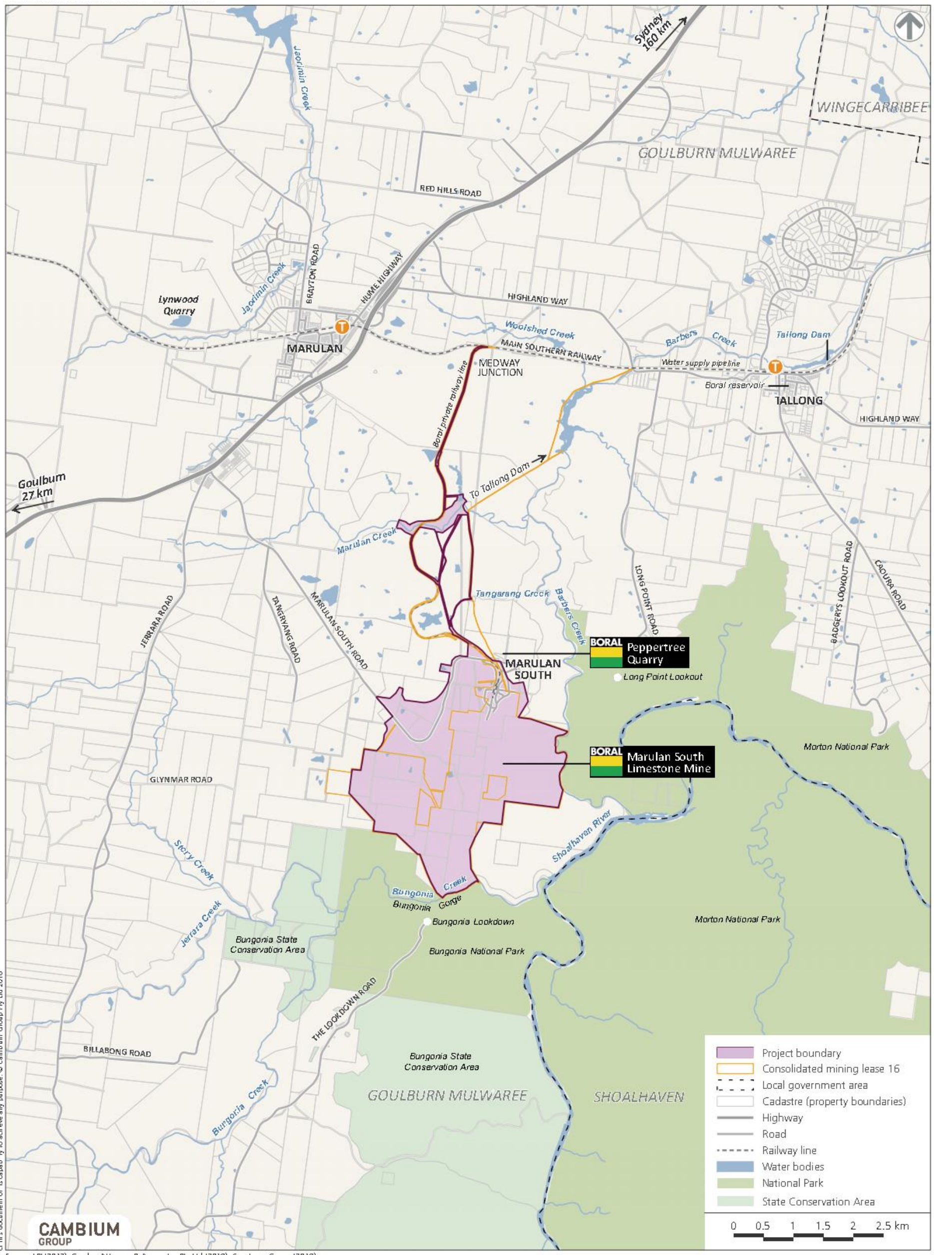
Land use surrounding the mine is a mixture of extractive industry, grazing, rural residential, commercial/industrial and conservation.

The mine is separated from the Bungonia State Conservation Area to the south by Bungonia Creek and is separated from the Shoalhaven River and Morton National Park to the east by Barbers Creek.

Peppertree Quarry, owned by Boral Resources (NSW) Pty Limited, borders the mine to the north. The site of the former village of Marulan South is between the mine and Peppertree Quarry on land owned by Boral. The village was established principally to service the mine but has been uninhabited since the late 1990's. The majority of the village's infrastructure has been removed and only a village hall and former bowling club remains. The bowling club has been converted into administration offices for the mine and the hall is used by the mine services team.

A small number of rural landholdings surround the Boral properties to the north and west, including an agricultural lime manufacturing facility, fireworks storage facility, turkey farm and rural residential (a number of these properties are actively grazed). The main access for these properties is via Marulan South Road. Rural residential properties are also located to the northeast of the mine along Long Point Road. These properties are separated from the mine by the deep Barbers Creek gorge. Sensitive receivers are shown in Figure 2-3.

Figure 2-1 Regional Context



Source: LPI (2017), Gordon Atkinson & Associates Pty Ltd (2018), Cambium Group (2018).

Figure 2-2 Local Context

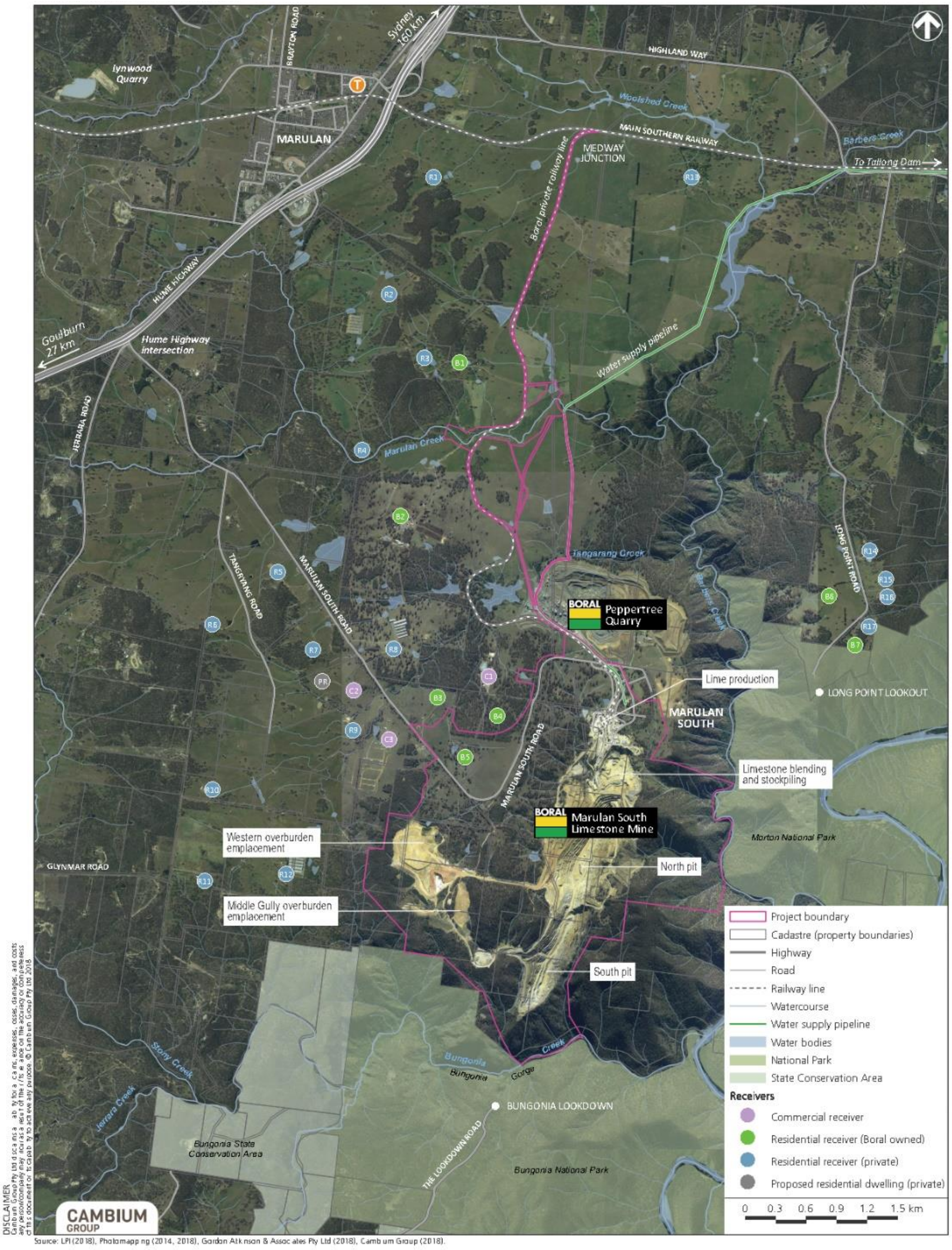
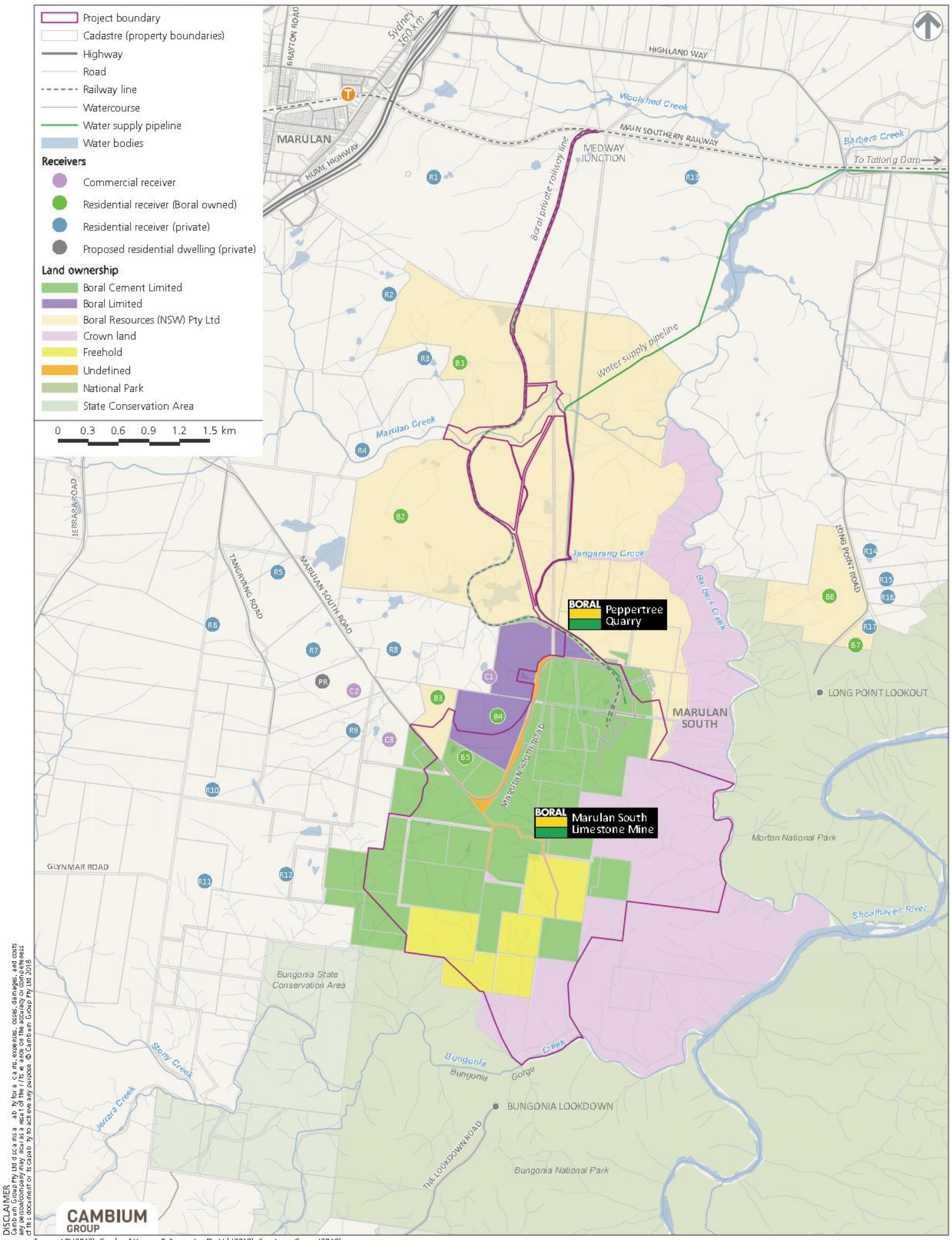


Figure 2-3 Land ownership



Source: LPI (2017), Gordon Atkinson & Associates Pty Ltd (2018), Cambium Group (2018).

2.3 Zoning

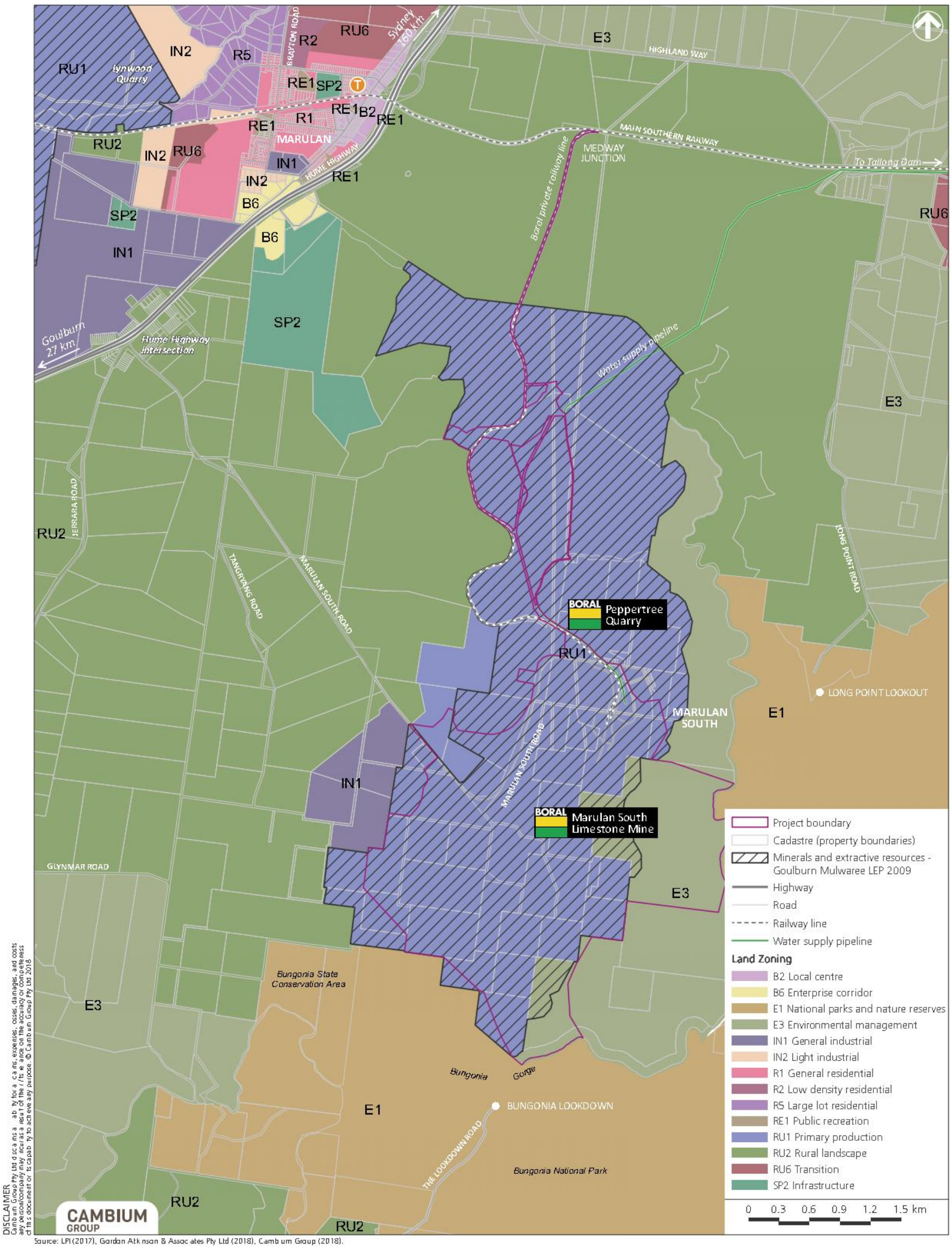
The majority of the site is zoned RU1 - Primary Production zone under the Goulburn Mulwaree Local Environmental Plan (LEP) 2009. Mining and extractive industries are permissible in this zone with consent (Figure 2-4).

The remaining area is zoned E3 - Environmental Management. Under this zone mining and extractive industries are prohibited development, although historically mining has occurred within these areas under "existing use rights" as mining and processing operations commenced well before the commencement of the Mulwaree Planning Scheme Ordinance (PSO) on 15 May 1970. Notwithstanding that both mining and extractive industries are prohibited in the E3 zone, these activities are permissible pursuant to State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007. In accordance with Clause 7(1)(b)(i) of this SEPP mining can be carried out with consent in any zone which has agriculture as a permissible land use (with or without consent). Agriculture is permitted with consent in the E3 - Environmental Management zone under the Goulburn Mulwaree LEP 2009. Similarly, Clause 7(3)(a) of this SEPP makes it clear that extractive industries can be carried out with consent in any zone which has agriculture as a permissible land use (with or without consent). Therefore, both mining and extractive industries are land uses which can be carried out provided development consent is granted.

Boral operates the mine pursuant to Section 109 of the EP&A Act and the continuance of an existing use and its expansion is possible provided the necessary approvals are in place. Therefore, there are no environmental planning issues that would prohibit approval of expanded operations at the mine.

Importantly, the Project aims to improve the stability of existing overburden emplacements and improve rehabilitation outcomes over the entire site.

Figure 2-4 Local zoning



3 EXISTING OPERATIONS

The mine is sited on a high-grade limestone resource. Subject to market demand, the mine has typically produced 3 to 3.38 million tonnes of limestone and 120,000 to 200,000 tonnes of shale per annum.

The mine currently produces a range of limestone products for internal and external customers in the Southern Highlands/Tablelands, the Illawarra and Metropolitan Sydney markets for use primarily in cement and lime manufacture, steel making, agriculture and other commercial uses. Products produced at the mine are despatched by road and rail, with the majority despatched by rail.

Historically limestone mining was focused on the approximately 200-300 m wide Eastern Limestone and was split between a North Pit and a South Pit. A limestone wall (referred to by the mine as the 'centre ridge') rising almost to the original land surface, divided the two pits. The North and South Pits were recently joined in 2016/2017 by mining the centre ridge to form a single contiguous pit, approximately 2 km in length. However, the North Pit/South Pit nomenclature remains important as current mining operation locations continue to be reported with respect to one or other of the old pits.

Limestone and shale are extracted using open-cut hard rock drill and blast techniques. Material is loaded using front end loaders and hauled either to stockpiles or the processing plant using haul trucks. Oversized material is stockpiled and reduced in size using a hydraulic hammer attached to an excavator.

Limestone processing facilities including primary and secondary crushing, screening, conveying and stockpiling plant and equipment are in the northern end of the North Pit. Kiln stone grade limestone is also processed on site through the existing lime plant comprising kiln stone stockpiles, rotary lime kiln, hydration plant and associated auxiliary conveying, processing, storage, despatch plant and equipment. Overburden from stripping operations is emplaced in the Western Overburden Emplacement, west of the open cut pits.

The current operations are 24 hour, 7 days per week with personnel employed on a series of 8, 10 and 12 hour shifts to cover the different operational aspects of the mine. Blasting is restricted to daylight hours and on weekdays, excluding public holidays.

4 THE PROPOSED PROJECT

4.1 Mining Operations

Boral proposes to continue mining limestone from the mine at a rate of up to 4 million tonnes per annum (mtpa) for a period of up to 30 years. This represents an increase in extraction rate from historic levels (peak of 3.38 mtpa) due to forecast increased demand from the construction industry. Shale will continue to be extracted at a rate of up to 200,000 tonnes per annum (tpa).

The proposed 30-year mine plan accesses approximately 120 million tonnes of limestone down to a depth of 335 m AHD. The mine footprint focuses on an expansion of the North Pit westwards to mine the Middle Limestone and to mine deeper into the Eastern Limestone. As the Middle Limestone lies approximately 70 m to 150 m west of the Eastern Limestone, the 30-year mine plan avoids mining where practical the interburden between these two limestone units thereby creating a smaller second, north-south oriented West Pit with a ridge remaining between. The North Pit will also be expanded southwards, encompassing part of the South Pit, leaving the remainder of the South Pit for overburden emplacement and a visual barrier.

In addition to mining approximately 5 million tonnes of shale, the extraction of the limestone requires the removal of approximately 108 million tonnes of overburden over the 30-year period. This material will be emplaced within existing and proposed overburden emplacement areas.

Limestone will continue to be mined using drilling and blasting methods. Shale will continue to be mined by excavator/front end loader. Limestone, shale and overburden will be transported to the primary crusher, stockpile areas and overburden emplacements respectively, using the load and haul fleet of trucks.

Products produced at the mine will continue to be despatched by road and rail, with the majority despatched by rail.

The limestone sand plant produces a crushed and air classified limestone sand for use in concrete. The mine currently produces 500,000 tpa for Peppertree Quarry and propose to increase production of manufactured sand to approximately 1 million tpa.

Boral's adjoining Peppertree Quarry currently has approval to emplace some of its overburden in the South Pit mine void. As the South Pit is required for the emplacement of over 30 million tonnes of overburden from the mine after the removal of accessible limestone, Boral proposes to emplace up to 15 million tonnes of overburden from Peppertree Quarry within the Northern Overburden Emplacement (Figure 4-1).

4.2 Associated Infrastructure

4.2.1 Processing

The existing facilities for processing limestone will continue to be utilised to produce a series of graded and blended limestone products that are despatched from site for use primarily in cement manufacture, steel making, commercial and agricultural applications.

Limestone processing facilities (Figure 4-1) include primary and secondary crushing, screening, conveying and stockpiling plant and equipment located north-west of the North Pit and extending to the tertiary crushing, screening, bin storage and despatch (rail and road) systems that form part of the main processing facilities.

Kiln stone grade limestone will also continue to be processed on site through the existing lime plant comprising kiln stone stockpiles, rotary lime kiln, hydration plant and associated auxiliary conveying, processing, storage, despatch plant and equipment.

Processing infrastructure and the reclaim and stockpile area at the northern end of the North Pit will be relocated during the life of the 30-year pit to enable full development of the mine plan. The timing and location of this is presented in the EIS.

Shale and white clay will not be processed and will be stockpiled directly from the pit, ready for dispatch by road to the Berrima and Maldon cement operations.

4.2.2 Water Supply

Water supply for the Project, including dust suppression, processing activities and some non-potable amenities will be from existing and new on-site dams and a proposed new water supply dam on Marulan Creek (Figure 4-3 and Figure 4-4). This dam would be located on Boral owned land north of Peppertree Quarry and utilises Boral's adjoining Tallong water pipeline to transfer water to the mine. This dam would require the purchase of water entitlements.

Mine water demand will also be supplemented by Tallong Weir via the Tallong water pipeline.

4.2.3 Rail

No changes are proposed to the existing rail infrastructure. A 1.2 km long passing line was constructed at Medway Junction during construction of the Peppertree Quarry, which will also be used by the mine to enhance access to the Main Southern Railway.

4.2.4 Road

Road access from the mine to the Hume Highway is via Marulan South Road. The proposed Western Overburden Emplacement extends northwards over Marulan South Road. Boral propose to realign a section of Marulan South Road, to accommodate the northern portion of the proposed Western Overburden Emplacement (Figure 4-2).

All public roads within the former village of Marulan South as well as the section of Marulan South Road between Boral's operations and the entrance to the agricultural lime manufacturing facility will be de-proclaimed.

4.2.5 Power

Power supply to the mine is via a high voltage power line that commences at a sub-station on the southern side of Marulan South Road, immediately west of the Project boundary. A section of this power line will be relocated to accommodate the proposed Northern Overburden Emplacement.

4.2.6 Transport

The majority of limestone products will continue to be transported to customers by rail for cement, steel, commercial and agricultural uses. Boral seeks no limitation on the volume of products transported by rail.

Manufactured sand will continue to be transported by truck along a dedicated internal road, across Marulan South Road and into Peppertree Quarry for blending and dispatch by rail.

Agricultural lime, quick lime and fine limestone products will continue to be transported by powder tanker, bulk bags on trucks or open tipper trucks along Marulan South Road.

Shale, limestone aggregates, sand and tertiary crushed products will be transported by predominantly truck and dog along Marulan South Road.

The adjoining Peppertree Quarry is currently approved to transport all products by rail. Boral will seek to transport approximately 150,000 tpa of Peppertree Quarry's products from the mine to customers via Marulan South Road. This could be achieved by back loading to a new shared road sales product stockpile area by the trucks carrying the limestone sand to Peppertree Quarry. A new shared road sales product stockpile area is proposed on the northern side of Marulan South Road, immediately west of the mine and Peppertree Quarry entrances. This shared finished product stockpile area, includes a weighbridge and wheel wash and will service both the mine and Peppertree Quarry.

In total, Boral is seeking to transport up to 600,000 tpa of limestone and hard rock products along Marulan South Road to the Hume Highway, as well as 120,000 tpa of limestone products to the agricultural lime manufacturing facility.

Figure 4-1 The Limestone Mine – Total disturbance footprint

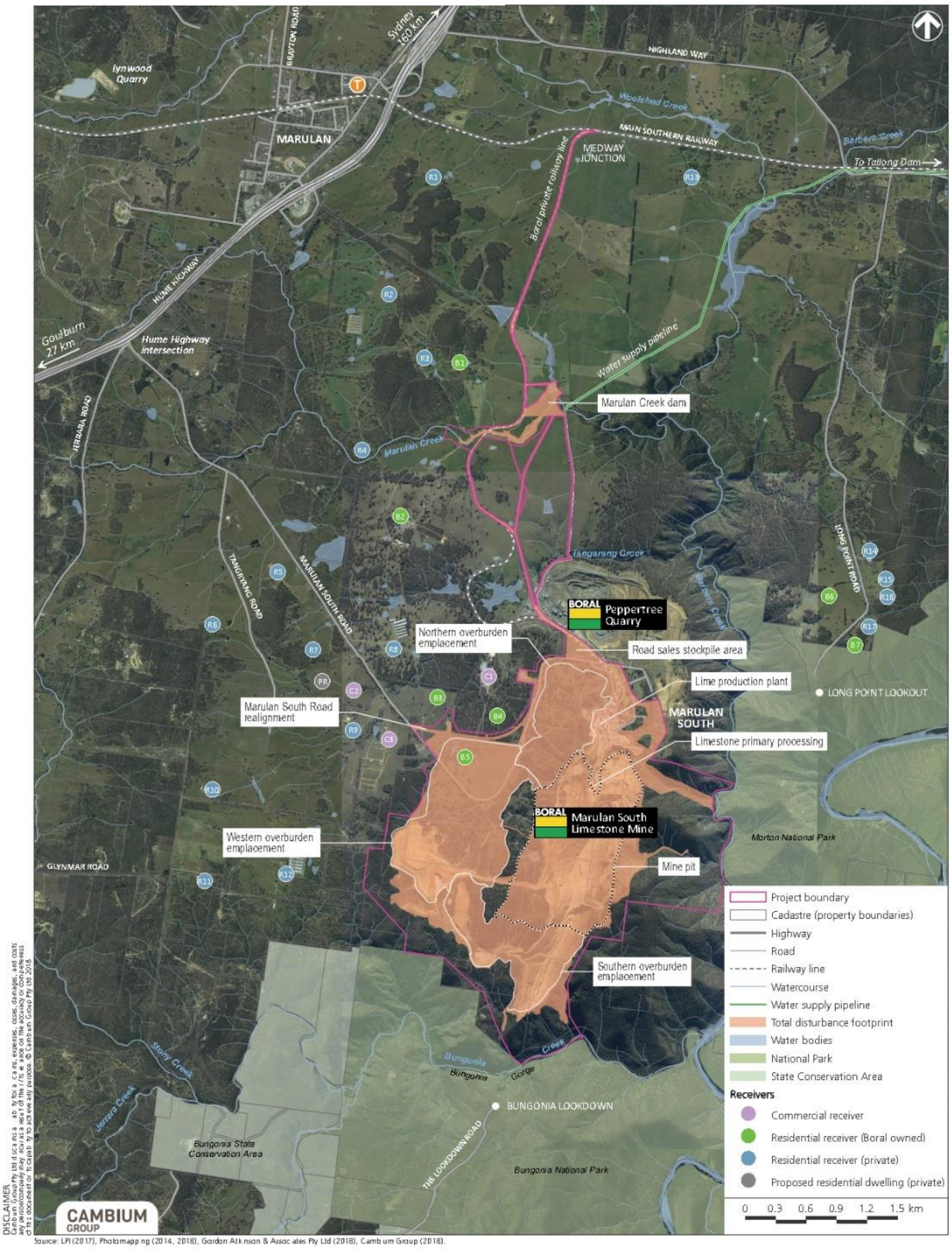
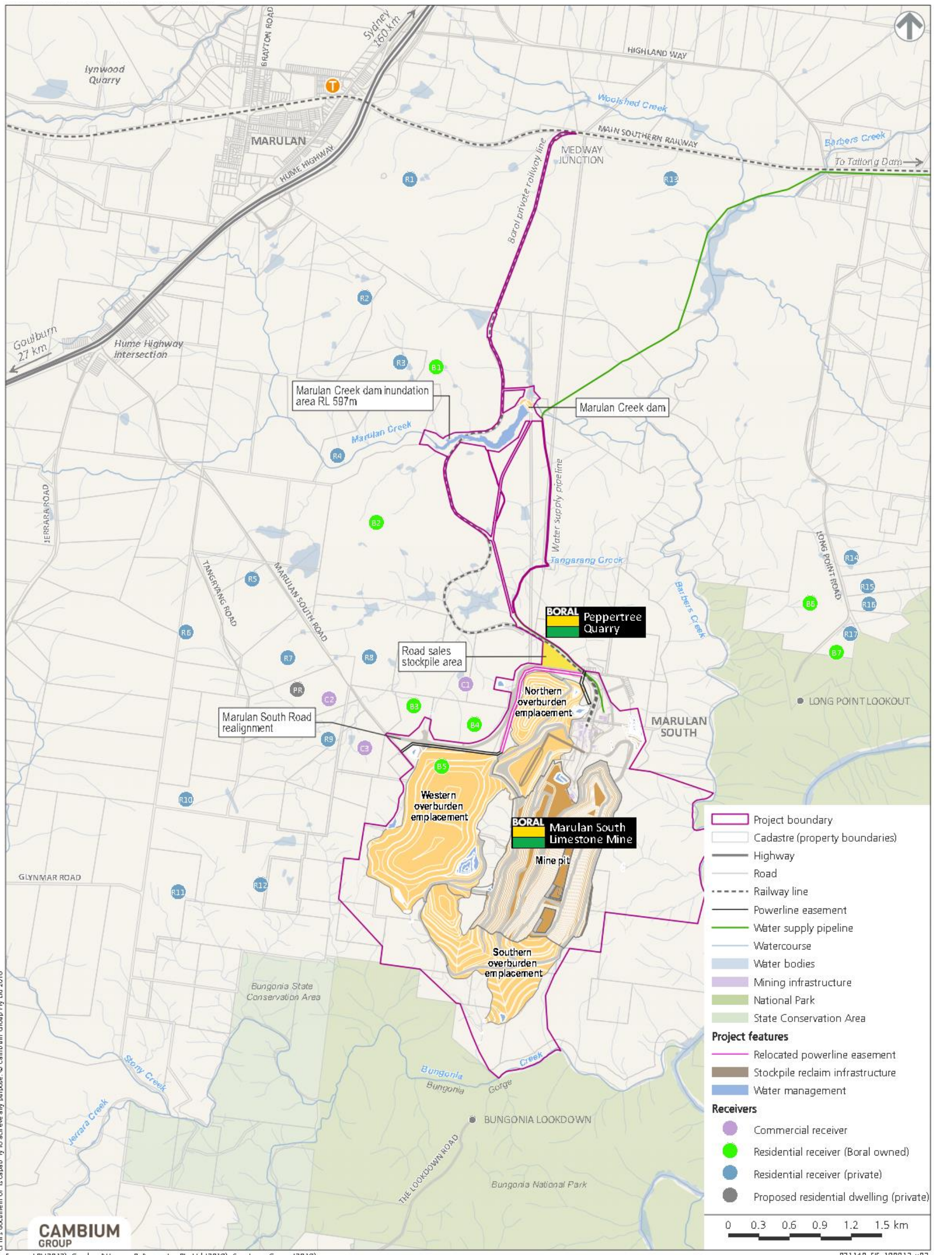


Figure 4-2 The Project



Source: LPI (2017), Gordon Atkinson & Associates Pty Ltd (2018), Cambium Group (2018).

Figure 4-3 Marulan Creek Dam – Disturbance footprint

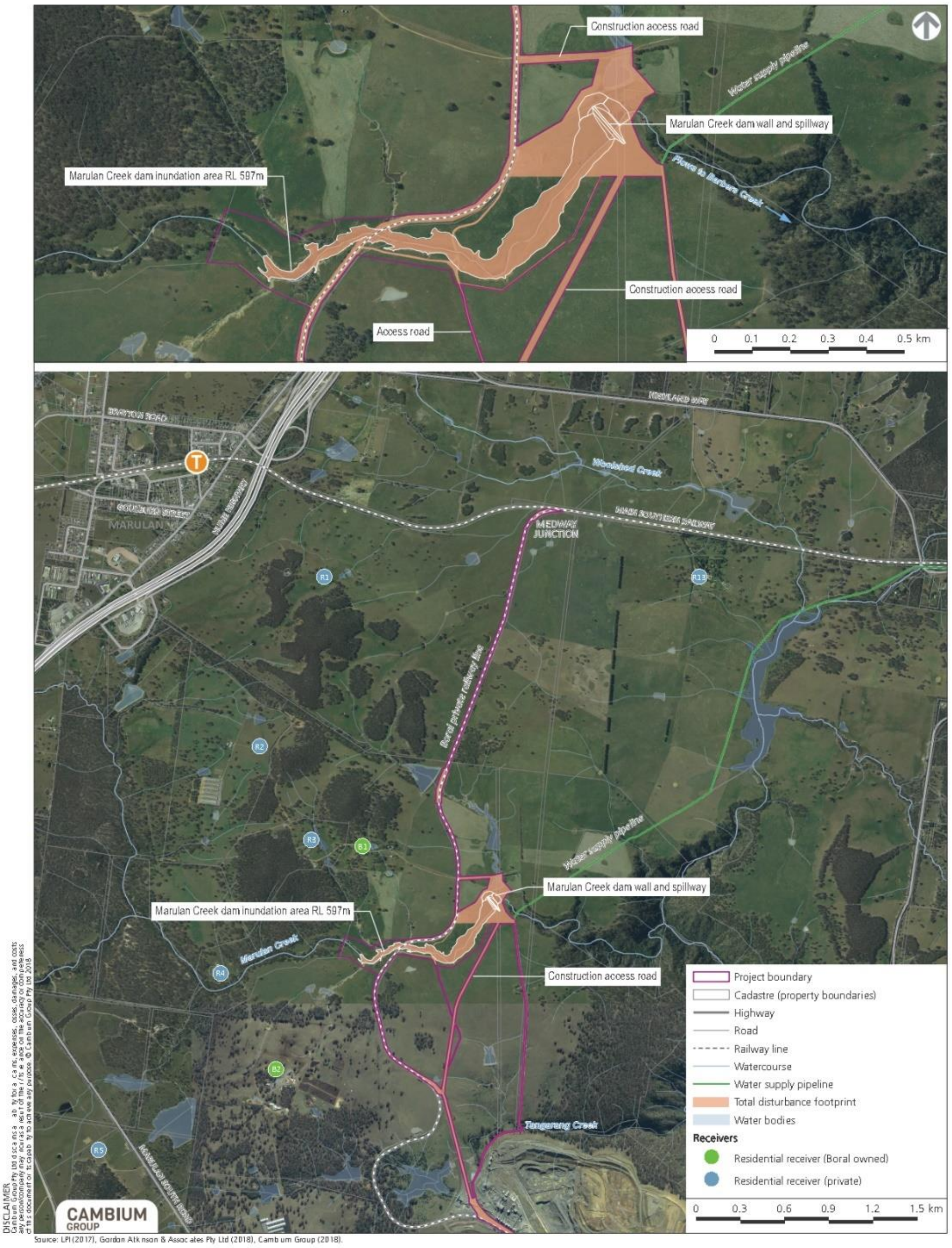
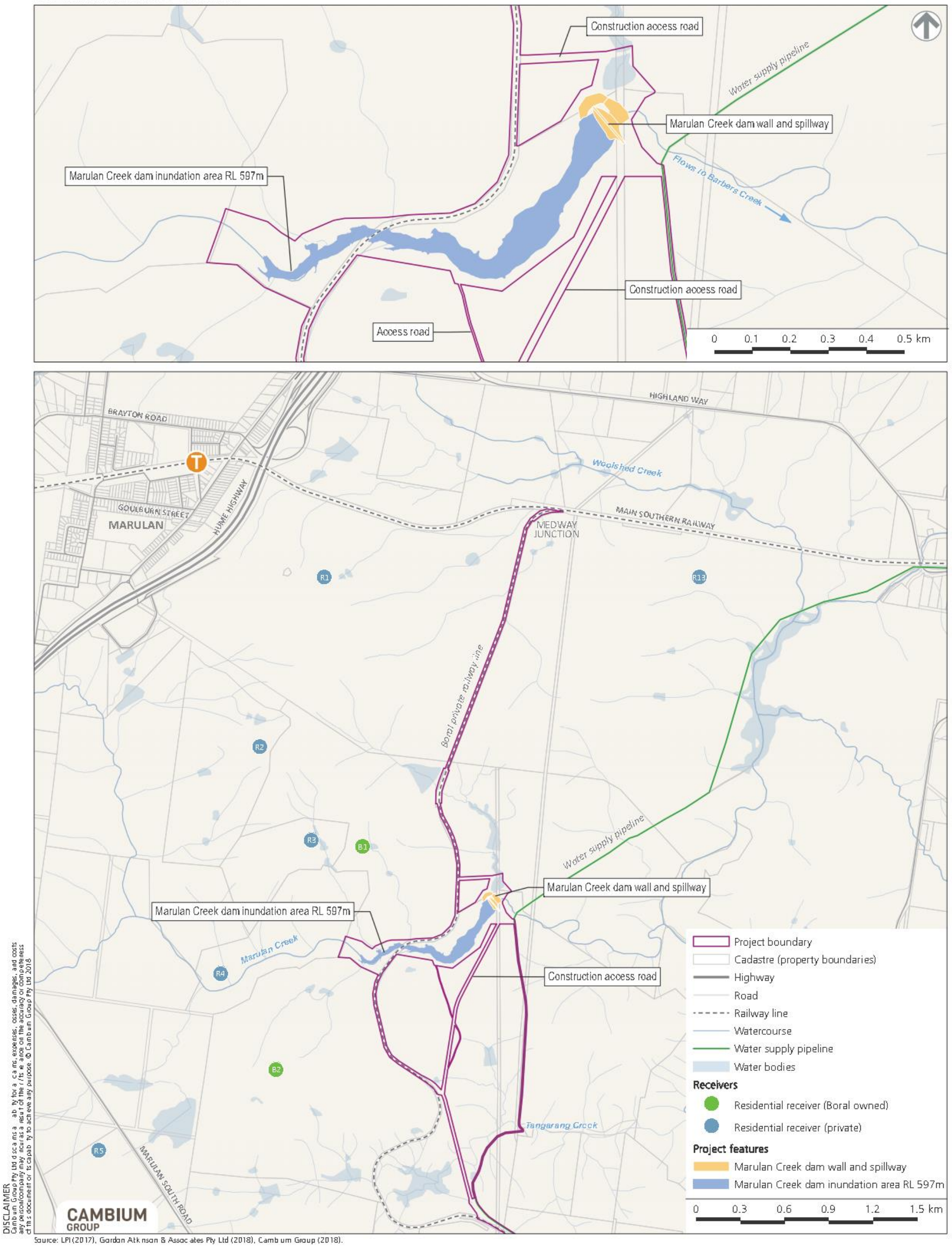


Figure 4-4 The Project (Marulan Creek Dam)

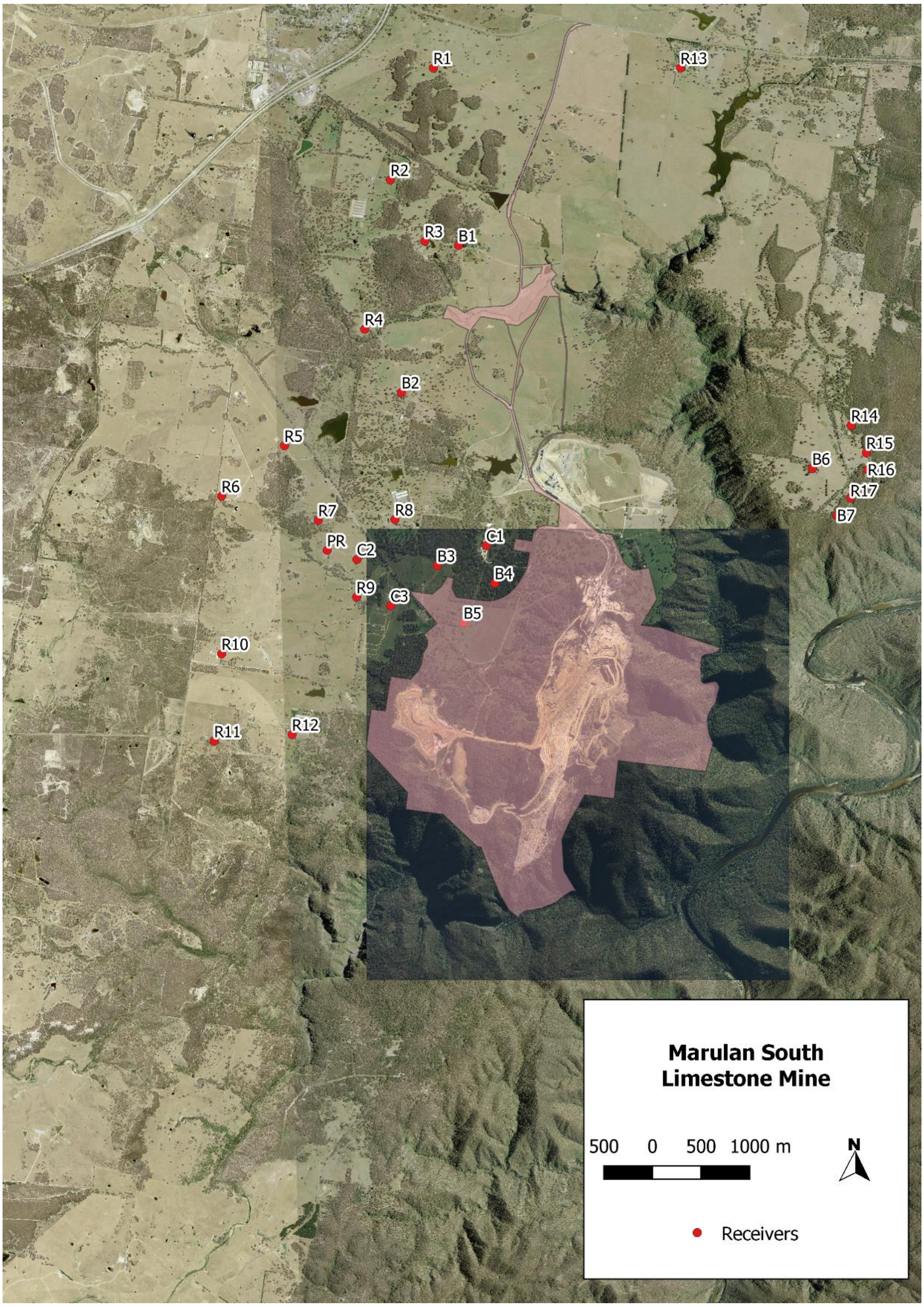


5 IDENTIFICATION OF SENSITIVE RECEIVERS

Surrounding land uses include mining, grazing, rural properties, including an agricultural lime manufacturing facility, fireworks storage facility, turkey farm and rural residential. The main access for these properties is via Marulan South Road. Rural residential properties are also located to the northeast of the mine along Long Point Road. These properties are separated from the mine by the deep Barbers Creek gorge. Figure 5-1 presents the location of the mine in relation to sensitive receivers of relevance to this assessment.

Receivers prefixed with 'R' are residential locations that are assessed in this report. There are 17 residential locations assessed (R1-R17). The receiver prefixed "PR" is a potential new private residence.

Figure 5-1 Receiver Locations



6 BACKGROUND NOISE LEVELS

This section discusses the Rating Background Levels (RBL) to be used in the assessment.

Determining ambient background levels in the absence of noise from the Limestone Mine or Peppertree Quarry is complicated by their continued operations, which only cease for a period of 3-days over the Christmas break.

To set appropriate RBLs for this assessment this report considers historical monitoring data for Peppertree, as monitoring carried out for the Marulan South Mine Continued Operations assessment.

6.1 Measurements during Christmas Shutdown, 2014

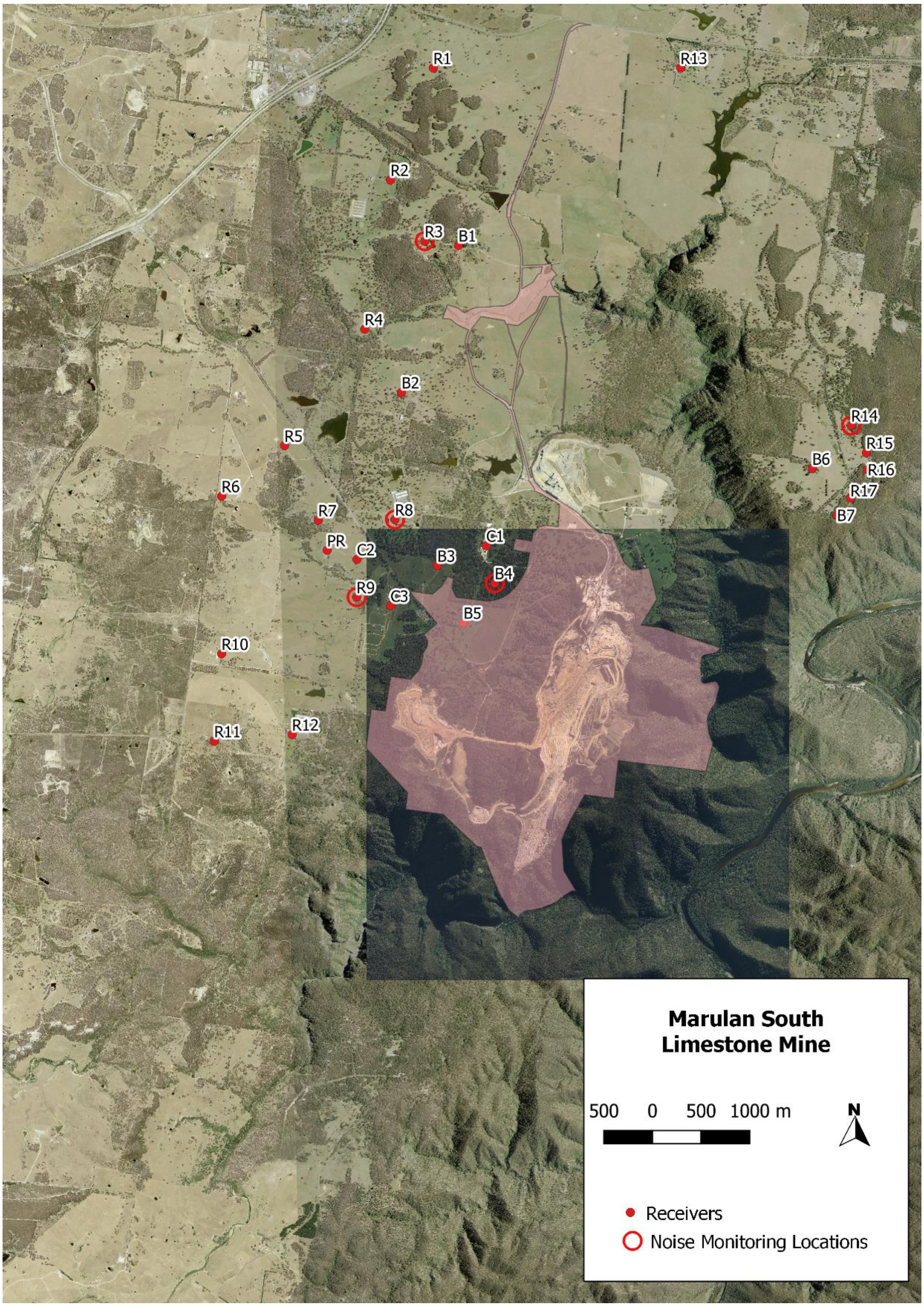
Background noise levels were measured by unattended noise loggers at five (5) locations during the Christmas break of 2014 for the Marulan South Mine Continued Operations assessment.

As the measurements were compromised by adverse weather, the background levels used in the assessment are determined from an analysis of the Christmas 2014 monitoring, ongoing quarterly monitoring for Peppertree Quarry, and other previously published RBLs in Peppertree Quarry environmental assessments.

6.1.1 Monitoring Locations

Noise monitoring locations are shown on Figure 6-1.

Figure 6-1 Noise Monitoring Locations



6.1.2 Equipment

The noise monitoring equipment used for background noise measurements consisted of environmental noise loggers set to A-weighted, fast response, continuously monitoring over 15-minute sampling periods. This equipment is capable of remotely monitoring and storing noise level descriptors for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift was noted.

The logger determines L_{A1}, L_{A10}, L_{A90} and L_{Aeq} levels of the ambient noise. L_{A1}, L_{A10} and L_{A90} are the levels exceeded for 1%, 10% and 90% of the sample time respectively (see Glossary of Acoustic Terms for definitions). The L_{A1} is indicative of maximum noise levels due to individual noise events, such as the occasional pass-by of a heavy vehicle. This is used for the assessment of sleep disturbance. The L_{A90} level is normally taken as the background noise level during the relevant period.

6.1.3 Measurement Results

Due to adverse weather conditions, no complete sets of daytime measurements were taken; however, there are two (2) complete evening and night time background noise measurements. For daytime background, noise was estimated from the measurement charts. As there were only two days of data, and some of it affected by meteorology, the Rating Background Levels or RBLs for this measurement period were estimated from the result charts. The results of the background noise measurements are shown in Table 6-1, and the result charts in Appendix A. The charts show the measured noise level throughout at 15-minute intervals throughout the monitoring period. RBLs are determined from the set of 15-minute L_{A90} levels for day, evening and night on any day. The charts also show other standard noise descriptors such as $L_{Aeq,15min}$ and the L_{Amax} for the 15-minute periods.

At the eastern noise monitoring location (on the eastern side of Barbers Creek gorge (R14), the evening period measurement is higher than the daytime period. In accordance with the *NPfI* recommendations, the evening RBL will be set to the daytime level for these measurement results.

Because the monitoring period was limited, and site observations indicated that the long-term RBL is not influenced by noise from Peppertree Quarry and Marulan South Mine, the results shown in Table 6-1 will be considered in the context of previous monitoring and ongoing compliance monitoring at Peppertree Quarry.

That analysis shows that while the measured levels during the Christmas shutdown are slightly lower than the adopted long-term RBL, they are within the range of RBLs measured over many years.

Table 6-1 Measured Rating Background Levels, December 2014

Location	RBL, dB(A)		
	Daytime	Evening	Night
(B4) Mine Manager Property	34	31	30
(R8) Turkey Farm	35	32	32
(R9) Western Location	35	32	32
(R3) Northern Location	35	31	31
(R14) Eastern Location	31	33	27

Notes:
1 Day: the period from 7.00am to 6.00pm.
2 Evening: the period from 6.00pm to 10.00pm.
3 Night: the period from 10.00pm to 7.00am.

6.2 Other RBL Data

Additional background noise levels have been measured around the mine as part of the Peppertree Quarry noise compliance monitoring program. Daytime attended background ($L_{A90,15min}$) noise monitoring results from 2011 to 2014 are presented in Table 6-3. Unattended background ($L_{A90,period}$) noise monitoring results from 2011 to 2017 are presented in Table 6-4.

Background noise levels were measured for the environmental assessment of the Peppertree Quarry Modification 2 in 2011. The relevant measured levels are shown in Table 6-2 (only daytime and night time periods are reported in the Environmental Assessment).

Table 6-2 Background Noise Levels

Receiver	Period	RBL
R2	Daytime	30
	Night time	30
R8	Daytime	34
	Night time	34

To view the long-term trend in RBL, Table 6-4 includes:

- RBL from Peppertree Compliance Monitoring;
- RBL from Peppertree Environmental Assessment; and
- RBL from Wilkinson Murray Measurements, December 2014.

Table 6-3 Daytime Attended Background Levels Measured during Compliance Measurements Monitoring, $L_{A90,15min}$ – dB(A)

ID	5 & 6 Oct 2011	L_{A90}	12 Oct 2012	L_{A90}	12 Jan 2012	L_{A90}	13 Jan 2012	L_{A90}	21 Nov 2012	L_{A90}	22 Nov 2012	L_{A90}	16 Jan 2013	L_{A90}	17 Jan 2013	L_{A90}	
R8	11.12am	34	12.51pm	38	3.20pm	42.5	9.18am	37.1	11.22am	35	12.31pm	39	10.50am	36	11.33am	35	
B2	2.31pm	38	12.39pm	40	12.46pm	35.4	12.45pm	34.3	4.26pm	38	8.26am	34	14.44pm	27	7.49am	35	
B3	3.27pm	37	12.50pm	38	2.08pm	33.0	8.10am	37.6	2.56pm	39	9.34am	42	15.18pm	39	7.20am	40	
B5	0.59pm	38	2.22pm	37	2.44pm	30.6	8.43pm	37.0	2.20pm	29	9.02am	41	10.07am	32	12.05pm	33	
B6	0.43pm	31	3.36pm	39	10.22am	32.3	10.12am	34.1	11.22am	35	10.30am	29	13.55pm	36	9.05am	37	
R3	10.11am	38	4.43pm	38	4.00pm	30.3	10.58am	32.9	1.20pm	40	11.51am	34	11.48am	32	10.12am	35	
R2	10.49am	37	4.16pm	35	11.21am	33.3	11.26am	39.2	12.34pm	41	11.17am	34	12.30pm	41	10.50am	44	
ID	**8 Aug 2013**	**L_{A90}**	**9 Aug 2013**	**L_{A90}**	**22 Oct 2013**	**L_{A90}**	**24 Oct 2013**	**L_{A90}**	**22 Jan 2013**	**L_{A90}**	**22 Jan 2013**	**L_{A90}**	**22 Oct 2014**	**L_{A90}**	**23 Oct 2014**	**L_{A90}**	**Median**
R8	12.25pm	40	11.20am	33	-	-	11.11am	52	3.03pm	43	1.13pm	42	12.30pm	32	9.45am	28	**37**
B2	1.53pm	39	10.16am	44	14.59pm	32	9.20am	48	12.53pm	38	11.26am	39	-	-	-	-	**38**
B3	1.22pm	40	-	-	-	-	-	-	12.15pm	42	11.55am	41	-	-	-	-	**39**
B5	12.55pm	39	10.54am	41	14.22pm	34	10.12am	51	11.22am	42	8.45am	38	12.00pm	36	9.15am	30	**36**
B6	12.42pm	37	9.11am	37	-	-	7.41am	45	1.46pm	32	9.38am	27	-	-	-	-	**36**
R3	11.31am	41	12.20pm	41	-	-	8.33am	47	4.14pm	36	10.34am	33	2.00pm	31	1.02pm	28	**35**
R2	10.56am	41	11.59am	45	-	-	8.58am	54	3.53pm	34	10.13am	39	1.15pm	40	12.30pm	35	**37**

Table 6-4 Combined Background Levels Measured during Various Studies from Peppertree Quarry and Marulan Mine, $L_{A90,period}$ – dBA

Date	R4			R2			R8			B6			B5		
	Day	Eve	Night	Day	Eve	Night	Day	Eve	Night	Day	Eve	Night	Day	Eve	Night
Peppertree EA	-	-	-	30	30	30	34	34	34	-	-	-	-	-	-
25 July 2012	36	37	46	-	-	-	32	32	32	33	33	33	-	-	-
22 November 2012	36	34	30	30	37	33	36	34	35	-	-	-	-	-	-
17 January 203	33	31	30	34	30	30	-	-	-	-	-	-	33	38	34
22 August 2013	34	38	40		38	40	35	35	38	-	-	-	40	36	35
October 2013	34	34	33	35	38	36	35	33	30	-	-	-	32	30	30
January 1014	30	30	30	31	30	30	35	34	32	-	-	-	38	36	34
August 2014	40	40	38				36	35	34	-	-	-	34	33	33
October 2014	34	32	32	34	32	32	32	32	32	-	-	-	30	31	30
December 2014 (WM)	34	31	31				35	32	32	-	-	-	-	-	-
April 2015	33	33	33	34	36	34	37	33	29	-	-	-	33	35	25
July 2015	36		38				34	38	36	-	-	-	-	-	-
February 2016	30	31	37	35	32	36	36	35	35	-	-	-	31	38	36
May 2016	-	-	-	-	-	-				-	-	-	-	39	-
August 2016	37	45	-	-	-	40	34	31	30	-	-	-	34	35	34
October 2016	37	38	-	-	-	40	35	34	31	-	-	-	-	-	-
February 2017	40	-	-	40	37	38	36	32	40	-	-	-	-	-	-
May 2017	30	31	30	37	37	39	31	30	33	-	-	-	-	-	-
July 2017	27	29	29	29	28	33	31	31	30	-	-	-	-	-	-
December 2017	32	34	38	38	38		38	35	37	-	-	-	-	-	-
Median	**34**	**33**	**33**	**34**	**36**	**35**	**35**	**34**	**33**	**33**	**33**	**33**	**33**	**36**	**34**

	Wind affected	-	No Data

6.3 Adopted RBL Values

Based on site observations and attended monitoring reports, it is considered that the long-term RBL at the receiver locations is not caused by noise emission from either Peppertree Quarry or the Limestone Mine. As the limited data collected during Christmas shutdown was not sufficient to set RBLs for the assessment, it has been considered with previously collected data.

The reported background noise levels measured around the Limestone Mine as part of the Peppertree Quarry noise compliance monitoring program were typically low and therefore it is unlikely that the L_{A90} levels would have been influenced by quarry or mine noise. This is confirmed by site Noise levels measured when the Limestone Mine and quarry was shut down (Table 6-1) and noise levels measured for Peppertree Quarry compliance purposes (Table 6-3 and Table 6-4), which show similar trends with the daytime levels being higher than evening and night.

While the RBL is usually the median of separate assessment periods, for a conservative assessment, measurements greater than RBL 40 dBA were excluded. While there is no requirement to do this under the *NPfI*, those levels were judged atypically high for a rural setting and may be impacted by extraneous noise, for example from insects. Combining these results, the RBL at each receiver are shown in Table 6-5.

Table 6-5 Rating Background Levels – dB(A)

Receiver	Intrusive Criteria		
	Daytime	Evening	Night
R1	34	34	34
R2	34	34	34
R3	34	34	34
R4	34	33	33
R5	34	33	33
R6	34	33	33
R7	34	33	33
R8	35	34	33
R9	35	34	33
R10	35	34	33
R11	35	34	33
R12	35	34	33
R13	31	31	30
R14	31	31	30
R15	31	31	30
R16	31	31	30
R17	31	31	30

Notes:
1 Day: the period from 7.00am to 6.00pm.
2 Evening: the period from 6.00pm to 10.00pm.
3 Night: the period from 10.00pm to 7.00am.

6.4 Existing Noise Levels of the Mine

Noise levels were measured in recent years to assess the impact of low-frequency noise. The mine has been operational for many years and the proposed operations are generally the continuation of the same processes.

To receivers east of the mine, ongoing work would not change noise impact significantly.

Monitoring was done at 97 Longpoint Road in 2015 (Wilkinson Murray Report 14119). This residence is north of the sensitive receivers included in the noise modelling, and therefore receives less noise from Marulan South Limestone Mine. The monitoring showed that noise from Marulan South Limestone mine was less than 30 dBA at this residence.

Noise levels were measured at Receiver 17, 471 Longpoint Road in 2016 in response to a complaint about low frequency noise (Wilkinson Murray Report 14119-NM-01). Noise levels were measured using the BarnOwl directional monitoring system in order to differentiate noise from Marulan and Peppertree. During the daytime periods, the noise levels from the Limestone mine ranged between 26 and 38dBA. In the evening periods, a range of 21 to 36dBA was measured from the Limestone mine and at night it ranged between 15 to 35dBA.

Noise levels were measured at Receiver R3, 113 Green Hills Road in 2017 (Wilkinson Murray Report 14119-NM-02), however as these receivers are more impacted by Peppertree Quarry than Marulan South Limestone Mine, the noise level from Marulan South Limestone Mine cannot be extracted from the data.

At receivers west of the mine there may be some change in noise from Marulan South Limestone Mine due to the increasing height of the overburden emplacement. While no noise measurements have been done at any of the potentially most impacted receivers, it is noted that Boral has never received a complaint from any receiver West of the mine. This indicates that it is likely that noise levels at those receivers are not intrusive.

7 NOISE POLICY FOR INDUSTRY

7.1 Overview

The NSW *NPfI* provides a framework and process for deriving noise criteria for consents and licences that enable the EPA and others to regulate premises that are scheduled under the *Protection of the Environment Operations Act 1997*.

The *NPfI* documents a procedure for assessment and management of industrial noise which involves the following steps:

- Determining the project noise trigger levels for a development. The project noise trigger level is a benchmark level above which noise management measures are required to be considered and is not intended as a mandatory requirement. They are derived by considering short-term intrusiveness due to changes in the existing noise environment (applicable to residential receivers only) and maintaining noise level amenity for particular land uses for residents and other sensitive receivers;
- Predicting or measuring noise produced by the development (having regard to any associated annoying characteristics and prevailing meteorological effects);
- Comparing the predicted or measured noise level with the project noise trigger level and assessing impacts and the need for noise mitigation and management measures;
- Considering any residual noise impacts following the application of feasible and reasonable noise mitigation measures;
- Setting statutory compliance levels that reflect the best achievable and agreed noise limits for development; and
- Monitoring and reporting environmental noise levels from the development.

7.1.1 Intrusiveness Noise Trigger Levels

For assessing intrusiveness, the background noise level (L_{A90}) is measured and the Rating Background Level (RBL) determined (refer to Section 6). The NPfI states that where the daytime RBL was measured at less than 35 dBA, then a minimum daytime RBL of 35 dBA must be used. Therefore, the daytime RBL for all sensitive receivers has been adjusted to 35 dBA as the measured RBL at all receivers was 35 dBA or lower.

The intrusiveness of an industrial noise source may generally be considered acceptable if the equivalent continuous noise level (L_{Aeq}) of the source (measured over a 15-minute period) does not exceed the background noise level (RBL) by more than 5 dBA. Therefore, the Project intrusiveness noise trigger levels are calculated by adding 5 dBA to the RBL.

Table 7-1 summarises the minimum assumed RBLs and the intrusiveness noise levels relevant to the Project.

Table 7-1 Project Intrusiveness Noise Trigger Levels, dBA

Receiver	RBL			Intrusiveness Noise Level		
	Daytime	Evening	Night	Daytime	Evening	Night
R1	35	34	34	40	39	39
R2	35	34	34	40	39	39
R3	35	34	34	40	39	39
R4	35	33	33	40	38	38
R5	35	33	33	40	38	38
R6	35	33	33	40	38	38
R7	35	33	33	40	38	38
R8	35	34	33	40	39	38
R9	35	34	33	40	39	38
R10	35	34	33	40	39	38
R11	35	34	33	40	39	38
R12	35	34	33	40	39	38
R13	35	31	30	40	36	35
R14	35	31	30	40	36	35
R15	35	31	30	40	36	35
R16	35	31	30	40	36	35
R17	35	31	30	40	36	35

Note 1: Daytime 7.00am–6.00pm; Evening 6.00pm–10.00pm; Night 10.00pm-7.00am.

7.1.2 Amenity Noise Level

The *NPfI* amenity noise level is specific to the type of land use and associated activities. The amenity noise levels relate only to industrial-type noise and do not include transportation noise (when on public transport corridors), noise from motor sport, construction noise, community noise, blasting, shooting ranges, occupational workplace noise, wind farms and, amplified music/patron noise.

The amenity noise level aims to limit continuing increases in noise levels which may occur if the intrusiveness level alone is applied to successive development within an area.

The recommended amenity noise level represents the objective for total industrial noise at a receiver location. The project amenity noise level represents the objective for noise from a single industrial development at a receiver location.

To prevent increases in industrial noise due to the cumulative effect of several developments in an area, the project amenity noise level for each new source of industrial noise is set at 5 dBA below the recommended amenity nose level. For comparison to the intrusiveness level, the project amenity noise trigger level is converted from a period level (day, evening or night time periods) to a 15-minute level by adding 3 dBA.

Amenity noise levels are not used directly as regulatory limits. They are used in combination with the project intrusiveness noise level to assess the potential impact of noise, assess mitigation options and determine achievable noise requirements.

The *NPfI* amenity noise trigger levels are presented in Table 7-2.

Table 7-2 Amenity Noise Levels, dBA

Receiver	Noise Amenity Area	Time of Day[1]	Recommended Amenity Noise Level $L_{Aeq,period}$ (dBA)	Project Amenity Trigger Level $L_{Aeq,15min}$ dBA
Residence	Rural	Day	50	48
		Evening	45	43
		Night	40	38
Commercial	All	When in use	65	63

Note 1: Daytime 7.00am–6.00pm; Evening 6.00pm–10.00pm; Night 10.00pm-7.00am.

At commercial receivers, the $L_{Aeq,15min}$ project amenity noise level is 63 dBA.

7.1.3 Project Noise Trigger Levels

In determining the project noise trigger levels, a comparison needs to be made between the amenity and intrusiveness noise levels, and the lowest noise level needs to be selected for each period (day, evening and night). As outlined in Table 7-2, for 24 hour operations, the highest amenity noise level for a rural receiver at night time can be 38 dBA. Therefore, for those residential receivers where the night time intrusiveness noise trigger level is 39 dBA (refer to Table 7-1) an adjusted project noise trigger level of 38 dBA needs to be adopted. The resulting project trigger levels are shown in Table 7-3.

Table 7-3 Project Noise Trigger Levels

Receiver	Project Noise Trigger Level (*NPfI*)		
	Daytime	Evening	Night
R1	40	39	38
R2	40	39	38
R3	40	39	38
R4	40	38	38
R5	40	38	38
R6	40	38	38
R7	40	38	38
R8	40	39	38
R9	40	39	38
R10	40	39	38
R11	40	39	38
R12	40	39	38

Receiver	Project Noise Trigger Level (*NPfI*)		
	Daytime	Evening	Night
R13	40	36	35
R14	40	36	35
R15	40	36	35
R16	40	36	35
R17	40	36	35
All Commercial	63	63	63

Note 1: Daytime 7.00am–7.00pm; Evening 7.00pm–10.00pm; Night 10.00pm-7.00am.

7.2 Low Frequency Noise

Where a noise source contains certain characteristics, such as tonality, intermittency, irregularity or dominant low-frequency content, the noise may cause greater annoyance. The *NPfI* refers to these potentially annoying characteristics as "modifying factors". The *NPfI* recommends correction factors to be applied to the source noise level at the receiver before comparison with the criteria to account for the additional annoyance caused by these modifying factors.

The only relevant characteristic for noise from the mine is the potential for dominant low-frequency content.

The *NPfI* recommends investigating whether a modifying factor for low-frequency noise is applicable based on an analysis of third octave band levels where there is a difference between C- and A- weighting levels of more than 15 dB. The factor to be applied depends on comparison of the third octave spectrum of the noise against the threshold spectrum in Table 7-4 (Table C2 from *NPfI*).

Table 7-4 Low Frequency Noise Thresholds (Table C2 from *NPfI*)

Threshold & Predicted Level	One-Third Octave Centre Frequency, Hz												
	10	12	16	20	25	31	40	50	63	80	100	125	160
$L_{Zeq,15min}$ threshold level	92	89	86	77	69	61	54	50	50	48	48	46	44

The following corrections apply where the measured dBC minus dBA level is 15 dB or more:

- where any of the one-third octave noise levels in *NPfI* Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a 2 dBA positive adjustment to measured/predicted A-weighted levels applies for the evening/night period.
- where any of the one-third octave noise levels in *NPfI* Table C2 are exceeded by more than 5 dB and cannot be mitigated, a 5 dBA positive adjustment to measured/predicted A-weighted levels applies for the evening/night period and a 2 dBA positive adjustment applies for the daytime period.

7.3 Residual Noise Impacts

The *NPfI* recognises that where all source and pathway feasible and reasonable noise mitigation measures have been applied a proposed development might give rise to residual noise impacts.

Table 4.1 of the *NPfI*, which interprets the significance of any potential noise exceedances, is reproduced below in Table 4-4. These significance categories (i.e. negligible, marginal, moderate and significant) are generally consistent with Table 1 of the *Voluntary Land Acquisition and Mitigation Policy* (*VLAMP*) (DP&E, 2018) which addresses noise and air quality impacts from State significant mining, petroleum and extractive industry developments.

Table 7-5 Significance of Residual Noise Impacts

If the predicted noise level minus the project noise trigger level is:	And the total cumulative industrial noise level is:	Then the significance of residual noise level is:
<=2 dBA	Not applicable	Negligible
>= 3 but <=5 dBA	< recommended amenity noise level or > recommended amenity noise level, but the increase in total cumulative industrial noise level resulting from the development is less than or equal to 1dB	Marginal
>= 3 but <=5 dBA	> recommended amenity noise level and the increase in total cumulative industrial noise level resulting from the development is more than 1dB	Moderate
>5 dBA	=< recommended amenity noise level	Moderate
>5 dBA	> recommended amenity noise level	Significant

The *NPfI* also gives examples of noise mitigation measures addressing residual noise impacts in Table 4.2 of the Policy. Table 4.2 of the *NPfI* is reproduced in Table 7-6.

Table 7-6 Examples of Receiver-Based Treatment to Mitigate Residual Noise Impacts

Significance of Residual Noise Level	Example of Potential Treatment
Negligible	The exceedance would not be discernible by the average listener and therefore would not warrant receiver-based treatment or controls.
Marginal	Provide mechanical ventilation/comfort condition systems to enable windows to be closed without compromising internal air quality/amenity.
Moderate	As for 'marginal', but also upgraded façade elements, such as windows, doors or roof insulation, to further increase the ability of the building façade to reduce noise levels.
Significant	May include suitable commercial agreement where considered feasible and reasonable.

Table 7-7 presents the methodology for assessing noise levels which may exceed the *NPfI* Project noise trigger levels at privately-owned residences.

Table 7-7 Project Noise Impact Assessment Methodology

Noise Management Zone		Noise Affectation Zone
1-2 dB above Project noise trigger levels	3-5 dB above Project noise trigger levels	> 5 dB Project noise trigger levels
No treatment/controls required	• Voluntary mitigation rights applicable. • Architectural treatment required if requested (incl. ventilation & upgraded façade elements).	• Voluntary mitigation rights applicable. • Architectural treatment required if requested (incl. ventilation & upgraded façade elements). • Voluntary land acquisition rights applicable.

7.4 Maximum Noise Level Events

Noise sources of short duration and high level may cause disturbance to sleep if occurring during the night time and therefore need to be considered.

The approach recommended by the *NPfI* is to apply the following initial screening noise levels:

- L_{AFmax} 52 dBA or the prevailing RBL + 15 dB, whichever is the **greater**; and
- $L_{Aeq,15min}$ 40 dBA or the prevailing RBL + 5 dB, whichever is the **greater**.

The sleep disturbance screening noise levels apply outside bedroom windows during the night time period (10.00pm to 7.00am).

Where the screening noise levels cannot be met, a detailed maximum noise level event assessment should be undertaken.

The L_{Afmax} screening levels based on RBL + 15 dB and $L_{Aeq,15min}$ screening level based on RBL + 5 dB are below L_{Afmax} 52 dBA and $L_{Aeq,15min}$ 40 dBA, respectively, when considering the RBL levels in Table 6-5. Therefore, the project specific maximum event screening levels at all receivers are:

- L_{AFmax} 52 dBA; and
- $L_{Aeq,15min}$ 40 dBA.

The maximum noise level (sleep disturbance) criteria are presented in Table 7-8 for all receivers.

Table 7-8 Maximum Noise Event Screening Levels, dBA

Receiver	*NPfI*	
	$L_{Aeq,15min}$	L_{AFMax}
R1	40	52
R2	40	52
R3	40	52
R4	40	52
R5	40	52
R6	40	52
R7	40	52
R8	40	52
R9	40	52
R10	40	52
R11	40	52
R12	40	52
R13	40	52
R14	40	52
R15	40	52
R16	40	52
R17	40	52

7.5 Construction Noise Goals

The *Interim Construction Noise Guidelines (ICNG)* (DECC, 2009) recommends noise management levels (NMLs) to reduce the likelihood of noise impacts arising from construction activities. The NML recommended for residential receivers are presented in Table 7-9.

Table 7-9 Noise at Receivers using Quantitative Assessment

Time of Day	Management Level $L_{Aeq,(15min)}$ *	How to Apply
Recommended Standard Hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public Holidays	Noise affected RBL + 10dB(A)	• The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
Recommended Standard Hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public Holidays	Highly noise affected 75dB(A)	• The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. • If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside standard hours	Noise affected + 5dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

For industrial receivers the *ICNG* recommends 75 dB(A) $L_{Aeq,15min}$ as the NML.

The *ICNG* recommended standard construction hours are:

- 7.00am to 6.00pm Monday to Friday;
- 8.00am to 1.00pm Saturday; and,
- No work on Sunday or public holidays.

Outside these hours, the NMLs are the same as the project noise trigger levels.

The construction NMLs recommended for this Project are presented in Table 7-10.

Table 7-10 Construction Noise Criteria, LAeq,15min – dB(A)

Receiver	Standard Hours	Outside Standard Hours		
	Daytime	Daytime	Evening	Night Time
R1	45	40	39	38
R2	45	40	39	38
R3	45	40	39	38
R4	45	40	38	38
R5	45	40	38	38
R6	45	40	38	38
R7	45	40	38	38
R8	45	40	39	38
R9	45	40	39	38
R10	45	40	39	38
R11	45	40	39	38
R12	45	40	39	38
R13	45	40	36	35
R14	45	40	36	35
R15	45	40	36	35
R16	45	40	36	35
R17	45	40	36	35
All Commercial	75	75	75	75

8 NOISE MODELLING PROCEDURE

8.1 Noise Modelling Methodology

Operational noise levels at nearby receivers have been calculated using the Environmental Noise Model (ENM) a proprietary computer program from RTA Technology Pty Ltd. This modelling software is recommended by the *NPfI* and has been previously accepted by the EPA for use in environmental noise assessments. The assessment models the total noise at each receiver from the operation of the Project. Total predicted operational noise levels are then compared with the project noise trigger levels presented in Section 7.

The following information was provided by the mine in order to facilitate noise modelling:

- Mine plans for relevant modelled stages.
- Topographic information covering the general area and including all relevant noise-sensitive receivers.
- Location of existing and future fixed infrastructure, such as crushers and conveyors.
- Location of existing and future mobile fleet and haul routes for both emplacement of overburden or cartage of material to the production area of the mine.
- A selection of operating scenarios likely to result in the greatest levels of noise emissions from the Project.
- Meteorological data for the site obtained from the Peppertree weather station (see Appendix D).

8.2 Noise Assessment Scenarios

The development of the mine over the proposed 30 years of continued operations has been presented in four stages namely:

- Stage 1 – commencing in July 2019, approximately 5 years;
- Stage 2 – approximately 7-8 years;
- Stage 3 – approximately 6-7 years; and
- Stage 4 – approximately 11 years.

Modelling was done for the worst-case conditions at the end of each stage (when the dozer and haul routes are at their highest and most exposed locations), as well as the beginning of Stage 1, so typical worst-case conditions over the life of the mine are presented.

For each stage two (2) operational scenarios were addressed:

1. use of haulage fleet and other associated plant for overburden removal, overburden emplacement and limestone mining – this option is referred to as '4+2' as there are four (4) haul trucks transporting product to the crusher and two (2) haul trucks transporting overburden material to the active overburden emplacement area; and

2. the use of haulage fleet and other associated plant for overburden removal and overburden emplacement only – this option is referred to as '6' as there are six (6) haul trucks transporting overburden material to the active overburden emplacement area.

The assessment found that the six (6) haul trucks transporting overburden material resulted in higher noise impacts than the four (4) haul trucks transporting product to the crusher and two (2) haul trucks transporting overburden material to the active overburden emplacement area. Therefore, to show the typical noise source locations for the operating scenarios the source locations for the six (6) haul trucks transporting overburden material to the active overburden emplacement area are presented diagrammatically in Appendix D.

8.3 Daily Equipment Profile Noise Modelling Assumptions

The following assumptions have been made when developing the worst-case operating scenarios for noise modelling purposes:

- All fixed and mobile equipment is assumed to be operating 24hours.
- For both of the two worst-case operating scenarios developed for each stage, there are 6 haul trucks operating. It was assumed that at all times, four of those would be travelling on haul roads, and two would be at the loading points within the pit. The two haul trucks being loaded were assumed to be idling for approximately two minutes, and their sound power level for the 15-minute assessment period was set at $L_{Aeq,15min}$ 113 dBA (rather than 114 dBA for full power for 15 minutes).

8.4 Equipment & Sound Power Levels

In order to assign sound power levels (SWLs) to the mobile mine equipment/machinery, attended noise measurements of the site infrastructure were conducted at the mine site. The SWL of most of the mobile plant machinery that couldn't be measured at the mine site, have been based on the WM's database and other noise assessments where the same or very similar machinery SWLs have been measured.

The SWL and location of the mobile equipment modelled is provided in Table 8-1.

Table 8-1 Equipment Sound Power Levels

Fleet Item	Description	Location	Sound Power Level L_{Aeq}, dB(A)	Reference
Haul Trucks	CAT 777C	Haul roads	114	WM database
	CAT 777D	Haul roads	114	WM database
	Articulated Truck	Haul roads	110	Wilkinson Murray database + Peppertree EIS
Dozer	Komatsu D375A-5	Overburden emplacement	116	Site survey
Excavators	CAT 235 (40t) with hydraulic hammer attachment	Limestone removal in pit	122	Site survey

Fleet Item	Description	Location	Sound Power Level L_{Aeq}, dB(A)	Reference
	65t CAT Exc	Overburden removal in pit	115	Site survey
Loaders	CAT 993K	Limestone & overburden removal in pit	113	Site survey
	CAT 988G	Product sales at Processing Area	112	Site survey
	CAT 980	Shared Road Sales Stockpile Area	110	Site survey
	Kawasaki YR2012	Despatcher's loader at Processing Area	110	Site survey
	CAT 980	Mobile Screen / Crusher	110	Site survey
	CAT 993	Reclaim Stockpile Area	113	Site survey
Drill	Cubex QXR920	Limestone in pit	114	Site survey
Grader	CAT 140H	Haul roads	108	Site survey
Watercart	CAT 777	Haul roads	114	WM database
Mobile Crane	Tadano	Near Primary Crusher	106	Site survey
Forklift	Mitsubishi FD50	Processing Area	91	Site survey
Kanga Loader	Ford UF MAY 96	Processing Area	93	Site survey
Backhoe Loader	CAT 432D	Processing Area	101	Site survey
ANFO Truck	Iveco Acco 2350G	Limestone in pit	104	Site survey
Skid Steer Bobcat	Bobcat S220	Processing Area	102	Site survey
Maintenance Transport	Isuzu NPS250	Processing Area	102	Site survey
Service Truck	Hinto GT8 JKMA	Processing Area	102	Site survey
Road Sweeper	Tennant 830	Internal sealed roads	111	Site survey
Mower	Kubota BX2230	Processing Area	92	Site survey
Mobile Crusher	Kleeman Mobile Jaw	Reclaim Stockpile Area	115	Site survey
Mobile Hopper/Multi-Screen	Kleeman MS19	Reclaim Stockpile Area	110	Site survey
Mobile Transfer Conveyor	Ezystak Conveyor Belt Feeder	Reclaim Stockpile Area	100	Site survey
Road Trucks	Truck & Dog	Sealed road between Shared Road Sales Stockpile Area / Processing Area and site entrance and between Sand Plant and Peppertree Quarry Processing Plant	102	WM database
	Tanker Truck	Sealed road between Processing Area and site entrance	102	WM database
	Flatbed Truck	Sealed road between Processing Area and site entrance	102	WM database

8.5 Environment for Noise Assessment Process

8.5.1 Accounting for Different Meteorological Conditions

Fact Sheet D of the *NPfI* defines standard meteorological conditions and noise-enhancing meteorological conditions to be considered for the assessment. The definition of those conditions is provided in Table D1 of Fact Sheet D which is reproduced in Table 8-2.

Table 8-2 Standard and noise-enhancing meteorological conditions.

Meteorological conditions	***Meteorological parameters***
Standard meteorological conditions	*Day/evening/night: stability categories A-D with wind speed up to 0.5m/s at 10m AGL*
Noise-enhancing meteorological conditions	*Day/evening: stability categories A-D with light winds (up to 3m/s at 10m AGL)* *Night: stability categories A-D with light winds (up to 3m/s at 10m AGL) and/or stability category F with winds up to 2m/s at 10m AGL*

Notes: *m/s = metres per second; m = metres; AGL = above ground level; where a range of conditions is nominated, the meteorological condition delivering the highest predicted noise level should be adopted for assessment purposes. However, feasible and reasonable noise limits in consents and licences derived from this process would apply under the full range of meteorological conditions nominated under standard or noise-enhancing conditions as relevant. All wind speeds are referenced to 10m AGL. Stability categories are based on the Pasquill-Gifford stability classification scheme.*

Fact Sheet D provides two options when considering meteorological effects:

- Conservatively adopt noise-enhancing meteorological conditions without processing meteorological data local to the site; or
- Determine the significance of noise-enhancing meteorological conditions based on meteorological data local to the site and:
  1) adopt significant noise-enhancing conditions for the assessment where noise-enhancing meteorological conditions are deemed significant; or
  2) adopt non-significant, standard meteorological conditions for the assessment where noise-enhancing meteorological conditions are not deemed significant may be adopted.

As Boral maintains two weather stations (one on the Limestone Mine site and one at Peppertree Quarry), an analysis of the meteorological data was undertaken to determine the significance of noise-enhancing meteorological conditions at the site. The Peppertree meteorological data was primarily used for the analysis as it is considered the most reliable.

8.5.2 Analysis of Meteorology

Five years of meteorological data from the Peppertree Quarry weather station was provided by Boral. The data included the Pasquill-Gifford stability category. The *NPfI* states: "Where the sum total of F and G Pasquill-Gifford stability category occur for at least 30% of the total night-time in winter, the project area is considered to be significantly affected by inversions warranting noise assessment."

Table 8-3 presents the results of the analysis of the occurrence of temperature inversions on winter nights and shows that F and G class Pasquill-Gifford stability category are not considered a feature of the area according to the NPfI, that is temperature inversions occur for less than 30% of winter nights.

Table 8-3 Percent Occurrence of F & G Pasquil-Gifford Stability Category's on Winter Nights

Year	Winter
2013	25.6
2014	29.8
2015	28.7
2016	24.5
2017	27.2
Average	**27.2**

The assessment of the significance of wind needs to consider both the wind speed and direction.

The NPfI recommends consideration of wind effects if they are a "feature" of the area. The NPfI defines "feature" as the presence of source-to-receiver winds at speeds up to 3 m/s (measured at 10 m above ground level) and occurring for 30% of the time or more in any assessment period and season.

Five years of meteorological data from the Peppertree Quarry weather station was analysed and wind roses for each season and assessment period are presented in Appendix C. A summary of the prevailing weather analysis is presented in Table 8-4.

Table 8-4 Prevailing wind analysis results

Wind Direction	Assessment Period											
	Summer Day	Summer Evening	Summer Night	Autumn Day	Autumn Evening	Autumn Night	Winter Day	Winter Evening	Winter Night	Spring Day	Spring Evening	Spring Night
N	9.1	7.4	15	10	9.5	13.2	7.6	6.6	8	7.2	7.6	14.1
NNE	9.1	10.6	10.6	7.3	8.2	5.6	4.5	3.3	1.4	6.2	7.4	8.2
NE	10.4	18.5	14.6	8.5	12.6	5.5	4.2	4.1	0.6	7.1	16.1	10
ENE	15.8	29	21.5	14.5	18.8	7.4	7.2	6.8	0.7	10.4	22.5	12.6
E	18.4	29.3	26.1	18.5	22.9	10.1	10.2	8.7	1.4	12.3	23.6	14.2
ESE	18.2	28.2	26.4	20.8	25.2	13.2	13.2	11.2	3.1	13.2	22.4	14.5
SE	15.9	19.5	20.3	20.6	20.4	13.8	15.4	10.8	5.5	12	13.4	12.1
SSE	7.9	7.3	11.1	14.2	13.2	11.7	12.9	8.5	6.8	7.9	6	8.1
S	3.6	2.9	5	9.7	8.1	9	10.8	7.3	7.4	5.3	3.7	5.3
SSW	2.5	1.8	2.7	7.4	4.7	6.1	8.7	5.2	7.6	4.4	3.5	4.2
SW	2.8	3.6	2.2	5.9	6.6	5.8	6.9	7.2	8.8	4.4	4.9	5
WSW	3.4	5.2	3.9	6.9	10.7	9	8.1	13.6	13.6	4.8	9.2	9

Wind Direction	Assessment Period											
	Summer Day	Summer Evening	Summer Night	Autumn Day	Autumn Evening	Autumn Night	Winter Day	Winter Evening	Winter Night	Spring Day	Spring Evening	Spring Night
W	4.3	6.7	8.5	9.4	17.6	18.9	10.2	24.5	26	5.7	16	22.1
WNW	5.6	7.2	14.9	12.1	19.8	26.4	12.4	27.6	29.4	6.7	17.5	28.7
NW	6.3	6.3	17.6	12.7	18.3	26.3	12.2	25.1	27.9	7.1	16.5	28.5
NNW	8.3	6.3	18.1	12	15.4	23.2	10.5	18.4	21.8	7.4	13	26

The analysis shows that the frequency of occurrence of winds up to 3 m/s did not triggered the 30% NPfI assessment requirement for any assessment periods (ie day, evening and night).

8.5.3 Adopted Meteorological Parameters for Noise Assessment Model

Given these results, standard meteorological conditions as described above were used for assessment of noise emissions.

Temperature and humidity make small differences to prediction using ENM. The parameters used were:

- for daytime – 70% relative humidity, 20^{o} degrees Celsius; and
- for evening and night time – 90% relative humidity, 10^{o} degrees Celsius.

9 OPERATIONAL NOISE ASSESSMENT

9.1 Predicted Noise Levels

The predicted daytime, evening and night noise levels from the proposed continuation of mining operations for each stage of the 30 year mine life daytime, evening and night are shown in Table 9-1, Table 9-2, and Table 9-3 respectively.

The tables show that the predicted noise levels from two worst-case operating scenarios comply with the noise trigger levels at all stages and during all time periods.

Table 9-1 Predictions Noise Levels – Daytime ($L_{Aeq,15min}$ dBA)

Rec.	Overburden Removal, Overburden Emplacement & Limestone Mining ('4+2')					Overburden Removal & Emplacement ('6')					Noise Trigger Level	Complies (Yes/ No)
	Stage					Stage						
	1 Start	1 End	2	3	4	1 Start	1 End	2	3	4		
R1	17	16	17	16	16	18	18	17	17	16	40	Yes
R2	24	22	23	22	22	25	24	24	23	22	40	Yes
R3	29	24	26	26	24	29	26	27	27	24	40	Yes
R4	25	21	23	23	21	25	24	25	24	21	40	Yes
R5	26	22	25	24	22	27	27	27	27	21	40	Yes
R6	25	21	25	23	20	26	28	28	26	20	40	Yes
R7	29	24	29	28	24	30	31	31	30	24	40	Yes
R8	31	26	30	31	26	32	32	32	34	26	40	Yes
R9	30	27	32	29	26	33	36	34	32	26	40	Yes
R10	26	23	27	25	23	29	30	30	27	23	40	Yes
R11	27	24	27	23	22	31	30	30	26	22	40	Yes
R12	29	26	30	26	24	33	33	32	29	24	40	Yes
R13	23	23	23	23	23	24	23	23	23	22	40	Yes
R14	31	31	31	31	31	31	31	31	31	30	40	Yes
R15	31	31	32	31	31	32	32	32	32	31	40	Yes
R16	30	30	31	30	30	31	31	31	31	30	40	Yes
R17	29	29	29	29	29	29	30	30	29	29	40	Yes
C1	35	31	34	36	31	35	35	35	38	31	63	Yes
C2	30	26	31	29	26	32	34	33	31	25	63	Yes
C3	32	29	34	31	28	35	38	36	33	28	63	Yes

Table 9-2 Predicted Noise Levels – Evening – ($L_{Aeq,15min}$ dBA)

Rec.	Overburden Removal, Overburden Emplacement & Limestone Mining ('4+2')					Overburden Removal & Emplacement ('6')					Noise Trigger Level	Complies (Yes/ No)
	Stage					Stage						
	1 Start	1 End	2	3	4	1 Start	1 End	2	3	4		
R1	18	17	18	17	17	19	18	18	17	17	39	Yes
R2	25	23	25	23	23	26	24	25	24	23	39	Yes
R3	30	26	30	27	26	31	27	28	28	26	39	Yes
R4	26	22	26	23	22	27	24	25	25	22	38	Yes
R5	28	23	28	26	23	29	27	28	28	23	38	Yes
R6	26	22	26	25	22	27	28	29	27	21	38	Yes
R7	30	25	30	29	25	31	31	32	31	25	38	Yes
R8	32	27	32	32	27	33	32	33	35	27	39	Yes
R9	31	28	31	30	27	34	36	35	33	27	39	Yes
R10	28	25	28	26	25	31	30	31	28	25	39	Yes
R11	28	25	28	25	24	32	30	31	27	24	39	Yes
R12	30	27	30	27	25	34	33	33	30	25	39	Yes
R13	24	24	24	24	24	25	25	25	25	24	36	Yes
R14	32	32	32	32	32	33	33	33	33	32	36	Yes
R15	33	33	33	33	32	33	33	33	33	32	36	Yes
R16	32	32	32	32	32	32	32	32	32	31	36	Yes
R17	30	30	30	30	30	30	30	30	30	30	36	Yes
C1	36	31	36	36	32	36	35	36	39	31	63	Yes
C2	31	27	31	30	27	33	34	34	32	26	63	Yes
C3	33	30	33	32	29	35	37	37	34	29	63	Yes

Table 9-3 Predicted Noise Levels - Night Time – ($L_{Aeq,15min}$ dBA)

Rec.	Overburden Removal, Overburden Emplacement & Limestone Mining ('4+2')					Overburden Removal & Emplacement ('6')					Noise Trigger Level	Complies (Yes/ No)
	Stage					Stage						
	1 Start	1 End	2	3	4	1 Start	1 End	2	3	4		
R1	18	17	18	17	17	19	18	18	17	17	38	Yes
R2	25	23	25	23	23	26	24	25	24	23	38	Yes
R3	30	26	30	27	26	31	27	28	28	26	38	Yes
R4	26	22	26	23	22	27	24	25	25	22	38	Yes
R5	28	23	28	26	23	29	27	28	28	23	38	Yes
R6	26	22	26	25	22	27	28	29	27	21	38	Yes
R7	30	25	30	29	25	31	31	32	31	25	38	Yes
R8	32	27	32	32	27	33	32	33	35	27	38	Yes
R9	31	28	31	30	27	34	36	35	33	27	38	Yes
R10	28	25	28	26	25	31	30	31	28	25	38	Yes
R11	28	25	28	25	24	32	30	31	27	24	38	Yes
R12	30	27	30	27	25	34	33	33	30	25	38	Yes
R13	24	24	24	24	24	25	25	25	25	24	35	Yes
R14	32	32	32	32	32	33	33	33	33	32	35	Yes
R15	33	33	33	33	32	33	33	33	33	32	35	Yes
R16	32	32	32	32	32	32	32	32	32	31	35	Yes
R17	30	30	30	30	30	30	30	30	30	30	35	Yes
C1	36	31	36	36	32	36	35	36	39	31	63	Yes
C2	31	27	31	30	27	33	34	34	32	26	63	Yes
C3	33	30	33	32	29	35	37	37	34	29	63	Yes

9.2 Noise Contour Maps

Noise Contour Maps representing predicted noise levels for worst case operational scenarios from all overburden emplacement areas are presented in Appendix C. The equipment assumed to be operating was assumed to be the same for the day, evening and night time scenarios. The only difference in the models are higher humidity and lower temperature assumed for evening and night time, which leads to slightly higher predictions at the receiver locations (generally less than 1 dBA higher). Therefore, as the results are nearly identical for all three periods, only the contours for evening and night are presented as they are the worst case by a small margin.

9.3 Proposed Residential Dwelling

Boral were advised during consultation with the community that a new residential dwelling is proposed to the northwest of the mine site on the same property and to the west of C2 (see receiver identified as PR in Figure 5-1).

Although this noise assessment has focused on existing noise-sensitive receivers surrounding the Project site, as the proposed residence will be located further away from the site than a number of other residences identified within this assessment, potential impacts on this proposed residence can be assumed to have been fully assessed.

9.4 Residual Noise Impacts

The concept of "residual noise impact" was introduced in the *NPfI*. They describe the situation where the best-achievable noise level from a development exceeds the project noise trigger level when assessed at a sensitive receiver location.

Residual noise impacts are identified after all source and pathway feasible and reasonable noise mitigation measures have been considered. The significance of the residual impact and the need to assess receiver-based treatment options may need to be considered as part of an authority's determination/approval process.

There are no predicted residual noise impacts at any receiver, therefore *Voluntary Land Acquisition and Mitigation Policy* (*VLAMP*) (DP&E, 2018) does not need to be considered any further.

However, the Project is subject to voluntary land acquisition when the acceptable noise levels plus 5dB in Table 2.2 of the NPfI is exceeded on more than 25% of any privately-owned land at night where there is an existing dwelling or where a dwelling could be built under existing planning controls.

The recommended voluntary land acquisition criteria is:

- Night time – 45 $L_{Aeq,period}$.

Wilkinson Murray has reviewed potential impacts on privately-owned land. Review of the noise contours in Appendix E established that the night time 45 dBA $L_{Aeq,period}$ remain within lands owned by Boral. The noise contours used for this review are based on $L_{Aeq,15min}$ predictions and therefore should be considered conservative as the minus 3 dB conversion from a 15-minute to period level has not been considered.

9.5 Maximum Noise level Assessment

The noise model was also used to analyse potential L_{AFMax} likely to arise from the Project's night time operations.

Sleep disturbance can be caused by high-level, short-term noise caused by such things as rock on metal impacts or tipping rock on an overburden emplacement. These events cause short-term spikes in noise, expressed as L_{AFMax}. For a short time, the noise rises above the L_{Aeq} level that is used for the intrusiveness assessment, but the elevated level does not last long enough to increase the L_{Aeq} significantly.

The instantaneous noise sources and their typical L_{AFMAX} SWL that may have the potential to disturb sleep can be summarised as follows:

- Trucks tipping on the overburden emplacements at the closest point to receivers, 120 dBA L_{AFMax}.
- Infrastructure area impact noise near crusher (e.g. rock falling into metal bin) 122 dBA L_{AFMax}.

The most potentially impacted receivers are Receiver 9 and Receiver 12, and the impact would arise when tipping occurs at the western extents of the WOE. The worst case for those two receivers would occur for the start of Stage 1. Table 9-4 summarises the predicted L_{AFMax} levels at all sensitive receivers for the start of Stage 1. Noise is predicted to be less than the *NPfI* Screening level at all receivers for all stages of the mine operations. Therefore, the Project is not predicted to result in sleep disturbance at sensitive receivers.

Table 9-4 Night Time Impact Noise Predictions L_{AFMax} dBA

Receiver	Stage 1 Start		Screening Level
	Trucks Tipping	Infrastructure Area	
R1	29	29	52
R2	32	32	52
R3	38	38	52
R4	35	35	52
R5	40	40	52
R6	40	40	52
R7	43	43	52
R8	46	46	52
R9	49	49	52
R10	42	42	52
R11	42	42	52
R12	48	48	52
R13	32	32	52
R14	39	39	52
R15	39	39	52
R16	39	39	52
R17	36	36	52

9.6 Operational Noise from proposed Marulan Creek Dam

The potential noise impacts associated with the construction of the proposed Marulan Creek Dam are discussed in Section 0.

During operation, the only equipment operating at the Marulan Creek Dam would be a submersible pump. No noise emissions are expected from the submersible pump that would be perceptible at the closest receivers.

10 LOW FREQUENCY NOISE IMPACTS

Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level. For this project there is the possibility that low frequency noise might be audible.

The *NPfI* recommends correction factors to be applied to the source noise level at the receiver before comparison with the trigger levels to account for the additional annoyance caused by these modifying factors.

The *NPfI* recommends investigating whether modifying factors are applicable based on an analysis of third octave band levels where there is a difference between C- and A-weighting levels of more than 15 dB. The factor to be applied depends on the third octave spectrum of the noise.

At the most-affected receiver west of the mine noise (R9), predicted night time noise levels up to 36 dBA were predicted. East of the mine the most-affected receivers are (R14 and R15) have predicted noise levels up to 33 dBA. The predicted differences between C- and A-weighting levels are typically 12 dB. While the difference is less than the 15dB recommended by the *NPfI*, it is noted that the noise modelling data used for the predictions was in octaves. And that data below 63 Hz, and third octave source data, is generally not available. Therefore, the uncertainty of the calculation of the difference between C- and A-weighting levels would appear to be quite large. In reality, potential sources of low frequency noise are unknown at this stage, and experience suggests that such impacts have only occasionally been noted at similar operations.

Wilkinson Murray did noise monitoring at receivers R17 and R3 in 2016. At R17 there were some occasions where the C-weighted level was more than 15 dBA above the A-weighted level; however, this occurred for less than 1% of the monitoring period. Further, there were no periods where the threshold levels were exceeded in any 3rd octave band. At R3 the C-weighted level exceeded the A-weighted level by more than 15 dB for approximately 2.5% of the time, but there was only one 15-minute measurement period out of 3 weeks of monitoring where the threshold was exceeded.

To further assess further the risk of low-frequency noise emissions from the mine impacting sensitive receivers' impacts presenting, the following analysis is based on the recommendations of the further analysis has been undertaken in accordance with the *NPfI*.

Table 10-1 shows the results of a low-frequency analysis calculated to at the most impacted receivers under noise-enhancing meteorological conditions during night time. The third octave spectrum as based on the BarnOwl monitoring results at R3 has been applied to the worst-case noise predictions. The results are presented in Table 10-1.

It was found that the predicted low-frequency noise levels are below the low-frequency noise threshold. The low-frequency noise assessment indicates that it is unlikely that any of the receivers surrounding the Project would be subject to low-frequency noise. Therefore, no modifying factor correction for low-frequency noise is warranted for the Project.

Boral is committed to ameliorating any low frequency noise issues if they arise for the Project consistent with the most recent low frequency noise assessment process from the *NPfI*.

Table 10-1 Low Frequency Noise Analysis at Receivers

Threshold & Predicted Level	Overall		One-Third Octave Centre Frequency, Hz												
	A	C	10	12	16	20	25	31	40	50	63	80	100	125	160
$L_{Zeq,15min}$ Threshold Level			92	89	86	77	69	61	54	50	50	48	48	46	44
Predicted Level, Worst-Case West (Receiver 9)	36	53	45	50	49	42	42	42	41	42	39	40	38	35	30
Predicted Level, Worst-Case East (Receivers 14, 15)	33	51	42	47	46	40	36	36	33	32	32	35	32	32	22

11 CONSTRUCTION NOISE

11.1 Description of Construction Projects

Four (4) construction projects are proposed to support the continued operation of the mine, all of which will generally be conducted during recommended standard construction hours. Some out of hours work may be considered where predicted noise levels comply with the noise management levels.

The construction projects are described in Table 11-1.

Table 11-1 Construction Projects & Equipment

Location	Construction Project	Approx. Year	Approx. Duration	Description of Noisiest Activity	Construction Plant Used
Outside Mine Site	Marulan Creek Dam Wall and vehicle access track	Year 1 (Stage 1)	3 months	Earthworks	• 3x 40t dump trucks • CAT 980 FEL • 30t excavator • Sheep foot roller • road truck • water cart
Within Mine Site	Relocation of Stockpile Reclaim Area	Year 5 (Stage 1)	3 months	Excavation (cut and fill)	Use of existing mining fleet (loaders, dump trucks, grader, dozer etc.)
	Road Sales Stockpile Area	Year 1 (Stage 1)	2 months	Earthworks	Use of existing mining fleet (loaders, dump trucks, grader, dozer etc.)
	Marulan South Road Realignment and Relocation of the HV powerline	Year 1-5 (Stage 1)	4 months	Earthworks (cut and fill)	• 4x 30t road trucks • CAT 980 FEL • D14 Grader • sheep foot roller • road truck watercart • Cranes

11.2 Construction Noise Predictions

The Marulan Creek dam wall and vehicle access track project takes place outside the operational mining area and a detailed analysis follows. The other three (3) construction projects take place within the mine and equipment to be used is typical of the activity that would take place in those areas during operation. Noise emission from those construction activities will be generally indistinguishable from normal operation; however, further assessment has been conducted of those other construction projects and is presented in Table 11-3.

The location of the Marulan Creek Dam and the construction access roads are shown in Figure 4-4. Materials for the construction of the dam wall and spillway will be hauled either from the mine and/or the Peppertree Quarry along the southern construction access road. The equipment listed in Table 11-1, was used to predict the noise levels at all receivers as presented in Table 11-2. Noise emissions from the construction of the Marulan Creek Dam Wall are predicted to comply with the relevant construction noise criteria during standard construction hours at all identified receivers.

Table 11-2 Marulan Creek Dam Construction Noise Predicted Levels, $L_{Aeq,15min}$ – dB(A)

Receiver	Marulan Creek Dam	Criterion	Complies (Yes/No)
R1	<25	45	Yes
R2	26	45	Yes
R3	31	45	Yes
R4	<25	45	Yes
R5	<25	45	Yes
R6	<25	45	Yes
R7	28	45	Yes
R8	31	45	Yes
R9	27	45	Yes
R10	<25	45	Yes
R11	<25	45	Yes
R12	<25	45	Yes
R13	<25	45	Yes
R14	<25	45	Yes
R15	<25	45	Yes
R16	<25	45	Yes
R17	<25	45	Yes
C1	35	75	Yes
C2	27	75	Yes
C3	27	75	Yes

A realignment of Marulan South Road and the relocation of the HV powerline, earthworks on the Road Sales Stockpile Area and relocation of the Stockpile Reclaim Area has been proposed.

The equipment listed in Table 11-1 were used to predict noise levels at all receivers as presented in Table 11-3. Noise emissions from the construction are predicted to comply with the relevant construction noise criteria during standard construction hours at all identified receivers.

Table 11-3 General Construction Noise Predicted Levels, $L_{Aeq,15min}$ – dB(A)

Receiver	Realignment of Marulan South Road and the relocation of the HV powerline	Earthworks Road Sales Stockpile Area	Earthworks Stockpile Reclaim Area	Criterion	Complies (Yes/No)
R1	<25	<25	<25	45	Yes
R2	28	<25	<25	45	Yes
R3	30	<25	<25	45	Yes
R4	27	<25	<25	45	Yes
R5	35	<25	<25	45	Yes
R6	29	<25	<25	45	Yes
R7	38	<25	<25	45	Yes
R8	43	<25	<25	45	Yes
R9	38	<25	<25	45	Yes
R10	32	<25	<25	45	Yes
R11	32	<25	<25	45	Yes
R12	34	<25	<25	45	Yes
R13	<25	<25	<25	45	Yes
R14	26	<25	<25	45	Yes
R15	26	<25	<25	45	Yes
R16	26	<25	<25	45	Yes
R17	27	<25	<25	45	Yes
C1	48	<25	<25	75	Yes
C2	44	<25	<25	75	Yes
C3	45	<25	<25	75	Yes

12 TRAFFIC NOISE ASSESSMENT

12.1 Traffic Noise Criteria

The NSW *Road Noise Policy (RNP)* sets out criteria for assessment of noise from vehicles on public roads. The *RNP* sets out noise criteria for 'arterial', 'sub-arterial' and 'local roads'.

Criteria for "existing residences affected by additional traffic" are shown in Table 12-1.

For traffic noise assessment according to the RNP, Marulan South Road would be considered a sub-arterial road due to its historical and current use as a heavy vehicle finished product transport route from the mine.

Table 12-1 *RNP* Traffic Noise Criteria

Road Category	Type of Project / Land Use	Assessment Criteria – dB(A)	
		Day (7am–10pm)	Night (10pm–7am)
Freeway / arterial / sub-arterial roads	Existing residences affected by additional traffic on existing arterial / sub-arterial roads generated by land use developments	$L_{Aeq15hr}$, 60 (external)	$L_{Aeq,9hr}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	L_{Aeq1hr}, 55 (external)	$L_{Aeq,1hr}$ 50 (external)

The *RNP* also states that where predicted noise levels exceed the traffic noise criteria, an assessment of all feasible and reasonable mitigation options should be considered. The *RNP* states that an increase of up to 2dB represents a minor impact that is considered barely perceptible to the average person.

12.2 Existing & Future Traffic Volumes

Traffic noise predictions were provided in the "Traffic impact assessment for continued operations of Marulan South Limestone Mine, June 2015" by Transport and Urban Planning Pty Limited (the Traffic Report). Based on the figures provided in that report, the existing and future traffic volumes are shown in Table 12-2. The most significant change is the addition of extra heavy vehicles. The Traffic Report states: "While Boral seeks approval to continue to transport product from the mine and Road Sales Stockpile area, by road over a 24-hour period, for the purpose of this assessment and to take into account the worst-case operating scenario, it is assumed that the transport of the additional products will occur over a 12-hour period generally between 6.00am and 6.00pm." From this the Traffic Report concludes that the increase in traffic volumes during an average hour in that 12-hour period would be 10 heavy vehicles per hour in either direction.

Table 4.3 and Table 4.4 of the Traffic Report give hourly traffic counts on Marulan South Road between the mine and the Hume Highway. Based on this, and the increase of 10 heavy vehicles per hour over the 6.00am to 6.00pm period, traffic volumes for noise prediction were derived and are presented in Table 12-2. Note that the "Hourly Volumes for Noise Prediction" values will lead to daily volumes which exceed the daily volumes from the top part of Table 12-3. This is because the Traffic Report does not do not give the light/heavy vehicle split for all hours, so conservative values have been assumed.

Table 12-2 Traffic Volumes (5-day Average)

Weekday		Light	Heavy	Total
Daily Volumes				
Existing		348	190	538
Future		348	306	654
Hourly Volumes for Noise Prediction				
Daytime, 15-hr	Existing	29	11	40
	Future	29	17	46
Night Time, 9-hr	Existing	12	2	13
	Future	12	3	15

12.3 Predicted Traffic Noise Levels

The predicted traffic noise levels in Table 12-3 were calculated using the *Calculation of Road Traffic Noise* (CoRTN) algorithm based on the traffic volumes given in Table 12-2.

Typically, residential houses are set well back (on average, approximately 180 m) from Marulan South Road. The nearest residential house to Marulan South Road between the mine and the Hume Highway is 75 m from the road. Therefore, traffic noise has been predicted at both the 'worst case' affected residence and the 'typical' affected residence, so the table presents results for the worst-case house and a typical house.

During the daytime, the traffic noise is predicted to increase by up to 2 dBA at both the worst affected and typical residence but will still comply with the traffic noise criterion at all receivers.

During night time the traffic noise is predicted to increase by up to 1 dBA at both the worst affected and typical residences and as such will comply with the traffic noise criterion at all receivers.

Table 12-3 Predicted Traffic Noise, $L_{Aeq,period}$ dBA

Location	Period	Predicted Level		Criterion	Compliance
		Existing	Future		
Worst Case (75m from road)	Daytime, $L_{Aeq,15hr}$ dBA	51	53	55	Yes
	Night time, $L_{Aeq,9hr}$ dBA	47	48	50	Yes
Typical (180m from road)	Daytime, $L_{Aeq,15hr}$ dBA	47	49	55	Yes
	Night time, $L_{Aeq,9hr}$ dBA	44	45	50	Yes

13 RAIL NOISE ASSESSMENT

Products produced at the mine are despatched by road and rail, with the majority despatched by rail. Boral's non-network rail line connects the Marulan Limestone Mine and Peppertree Quarry with the Main Southern Railway approximately 6 km to the north (Figure 2-2).

No changes are proposed to the existing rail infrastructure or train numbers. The 1.2 km long passing line was constructed at Medway Junction during construction of the Peppertree Quarry, which will also be used by the mine to enhance access to the Main Southern Railway.

Noise from train movements along the non-network rail line and along the Main Southern Railway Line was considered in the Peppertree (Marulan South) Quarry original Environmental Assessment Report (ERM, 2006) and Peppertree (Marulan South) Quarry Modification 2 – Infrastructure and Site Layout Changes (ERM, 2011).

It was stated that at peak production Peppertree Quarry would require up to 3-4 trains per day and that Marulan Limestone Mine operates with up to 5-6 trains per day.

The Peppertree Quarry environmental assessments concluded that the Boral rail movements generated by the quarry and the mine would result in a marginal 1dB increase along the existing Southern Railway Line.

The Peppertree Quarry environmental assessments conducted a specific noise assessment for the non-network rail line. The predicted noise levels from the noise assessment are presented in Table 13-1.

Table 13-1 Predicted rail noise levels from the non-network rail line.

Receiver Locations	Distance (m)	$L_{Aeq\ (15min)}$	Industrial Noise Policy Criteria
R2	1220	29	35
R3	960	31	35
B2	800	33	36
B6	2280	23	35

It was concluded in the noise assessments that the train pass-by levels alone do not cause an exceedance of the then applicable *Industrial Noise Policy* (INP) day, evening and night time noise criteria.

The EPA released the *Rail Infrastructure Noise Guideline* (RING) in 2013. Appendix 3 of the *RING* deals with non-network rail lines on or those exclusively servicing industrial sites.

Where a non-network rail line exclusively servicing one or more industrial sites extends beyond the boundary of the industrial premises, noise from this section of track should be assessed against the recommended acceptable L_{Aeq} noise level from industrial noise sources for the relevant receiver type and indicative noise amenity area, as shown in Table 2.1 of the *INP* reproduced below.

INP Table 2.1 Recommended L_{Aeq} noise levels from industrial noise sources

Type of Receiver	*Indicative Noise Amenity*	*Time of Day*	*Acceptable L_{Aeq} Noise Level – dB(A)*
Residence	*Rural*	*Day (11hrs)*	*50*
		Evening (4hrs)	*45*
		Night (9hrs)	*40*

To contemporise the original noise assessments to consider the new policy for the non-network rail line noise, the original noise predictions have been adjusted assuming that a maximum of 10 trains per day (20 movements) would occur during the following times:

- Daytime – 10 movements;
- Evening – 3 movements; and
- Night time – 7 movements.

The estimated noise levels with additional estimates for R1 and R13 compared to the *RING* criteria are presented in Table 13-2 utilising the predicted values presented in Table 13-1.

Table 13-2 Estimated rail noise levels from the non-network rail line.

Receiver Locations	Distance (m)	Daytime $L_{Aeq, (11hrs)}$	Evening $L_{Aeq, (11hrs)}$	Night time $L_{Aeq, (11hrs)}$	RING Noise Criteria
R1	1250	23	22	22	50/45/40
R2	1220	23	22	22	50/45/40
R3	960	25	24	24	50/45/40
R13	1220	23	22	22	50/45/40
B2	800	27	26	26	50/45/40
B3	820	26	25	25	50/45/40
B5	1340	22	21	21	50/45/40
B6	2280	17	16	16	50/45/40

As can be seen from Table 13-2 the estimated L_{Aeq} day, evening and night time noise levels from the freight trains using the Boral rail line are below the *RING* noise criteria for non-network rail lines.

14 BLASTING ASSESSMENT

14.1 Annoyance & Discomfort Criteria

For assessment of annoyance due to blasting, the EPA (and most similar authorities in Australia) adopt guidelines produced by the Australian and New Zealand Environment Council (ANZEC, 1990). The fundamental criteria are that at any residence or other sensitive location:

- The maximum overpressure due to blasting should not exceed 115 dBLin for more than 5% of blasts in any year, and should not exceed 120 dBLin for any blast; and
- The maximum peak particle ground velocity should not exceed 5 mm/sec for more than 5% of blasts in any year and should not exceed 10 mm/sec for any blast.

Additionally, the ANZEC guideline recommends a long-term regulatory target of 2mm/sec maximum peak particle ground velocity.

14.2 Structural Damage Criteria

At sufficiently high levels, blast overpressure may in itself cause structural damage to some building elements, such as windows. However, this occurs at peak overpressure levels of about 133dBLin and above, well in excess of criteria for annoyance.

For assessment of damage due to ground vibration, Australian Standard *AS2187.2-1993 Explosives – Storage, Transport and Use* contains an appendix specifying recommended levels for peak particle vibration velocity to protect typical buildings from damage. These are:

- "Structures that may be particularly susceptible to ground vibration" – 5 mm/sec;
- "Houses and low-rise residential buildings; commercial buildings not included below" – 10 mm/sec; and
- "Commercial and industrial buildings or structures of reinforced concrete or steel construction" – 25 mm/sec.

The Standard notes that there may be special cases including high-rise buildings, reservoirs and buildings housing sensitive equipment where alternative criteria may be appropriate.

14.3 Prediction of Noise & Vibration Levels

The most important factors influencing the peak overpressure and vibration levels from blasting are the Maximum Instantaneous Charge (MIC) used in the blast and the distance to the receiving location. Other factors, such as stemming depth, type of initiation and meteorological conditions also affect these values and result in variation above or below the predicted overpressure and peak particle velocity values.

Predictive equations have been developed based on a large number of blasts (Terrock, 2000). These predict both the overpressure and peak particle velocity (ppv) levels. Values predicted from these equations are expected to be conservative, because more recent blast practices generally provide greater control over blasting parameters. The prediction equations used are:

PVS = 500*(R/Q^1/2)^ -1.6

SPL = 165 – 24*(log(R) - ⅓ log(Q))

where,

PVS = PVS vibration velocity (mm/s)

SPL = Peak airblast noise level (dBLin)

R = Distance between charge and receiver (m)

Q = Charge mass per delay (kg)

Based on review of the last three years of data the following is considered a blast at Marulan Limestone Mine:

1. On average, each blast is 20 holes (15m x 165mm hole);
2. On average each hole contains 220kg of explosives; and
3. On average, the maximum number of holes detonated simultaneously within a blast would be 8.

The mine currently monitors its blasts near B5. Monitoring data between 2014 and 2018 has been reviewed as part of this assessment. The mine has not received any complaints due to blasting.

The monitoring data indicated that no blast exceeded the 120dBLin maximum over pressure criterion and the 2mm/s long-term regulatory target. The 5% exceedance level for overpressure was 111dBLin which is below the 115dBLin criterion.

As the B5 location is significantly closer to the mine than the closest residential receiver it indicates compliance with the blasting criteria.

Table 13-1 shows calculated overpressure and vibration levels at relevant sensitive receivers due to blasting from the mine site. It is assumed that the MIC for the blast would be 1,760 (8x220)kg.

The predicted blast vibration and overpressure levels are well below the building damage criteria of 10mm/s and 133 dB(Lin) respectively at all dwellings of sensitive receivers.

The predicted blast vibration and overpressure levels are below the human annoyance and discomfort criteria of 2mm/s and 115 dB(Lin) respectively at all dwellings of sensitive receivers.

Table 13-1 Predicted Overpressure and Vibration Levels for Blasting Stage 1 & Stage 2 (1,760kg MIC)

Receiver No	Stage 1 (Yr 2)		Stage 2 (Yr 7)	
	Peak Overpressure, dB(Lin)	PPV, mm/sec	Peak Overpressure, dB(Lin)	PPV, mm/sec
R1	100	0.18	98	0.13
R2	102	0.23	100	0.16
R3	104	0.30	101	0.20
R4	105	0.35	103	0.25
R5	106	0.40	104	0.33
R6	105	0.35	105	0.34
R7	108	0.57	107	0.46
R8	110	0.83	108	0.57
R9	110	0.83	110	0.77
R10	105	0.39	107	0.51
R11	105	0.35	108	0.57
R12	107	0.51	111	0.89
R13	100	0.18	98	0.12
R14	106	0.40	102	0.22
R15	106	0.40	102	0.22
R16	106	0.42	102	0.23
R17	108	0.54	103	0.25
B1	104	0.31	101	0.20
B2	107	0.51	104	0.33
B3	114	1.47	110	0.83
B4	119	3.13	111	0.95
B5	117	2.34	113	1.34
B6	108	0.54	103	0.27
B7	108	0.54	103	0.28
C1 (Aglime)	116	2.06	109	0.72
C2	110	0.77	109	0.64
C3	112	1.12	111	0.95

14.4 Blasting Impacts on Livestock

There are no generally accepted guidelines for the impact of blasting noise and vibration on livestock or other animals.

In a study by Casaday and Lehmann (1967) (Responses of Farm Animals to Sonic Booms) animal installations were selected for observations on animal behaviour under sonic boom conditions. The number of animals observed in this study included approximately 10,000 commercial feedlot beef cattle, 100 horses, 150 sheep and 320 lactating dairy cattle. Booms during the test period were scheduled at varying intervals during the morning hours Monday to Friday of each week.

Results of the study showed that the reactions of the sheep and horses to sonic booms were slight. Dairy cattle were little affected by sonic booms (125dBLin to 136 dBLin). Only 19 of 104 booms produced even a mild reaction, as evidenced by a temporary cessation of eating, rising of heads, or slight startle effects in a few of those being milked. Milk production was not affected during the test period, as evidenced by total and individual milk yield. The researchers developed a summary by species and farms indicating that the few abnormal behavioural changes observed were well within the range of activity variation within a group of animals. They defined these changes as horses jumping up and galloping around the paddock, bellowing of dairy cattle, and increased activity by beef cattle (Casaday and Lehmann, 1967). In order to provide for a conservative assessment, the lowest airblast exposure studied (125 dBLin) was adopted as a criterion for the purposes of assessment of livestock impacts.

With regard to vibration impacts on livestock from blasting there appears to be little research available. As a worst case the human comfort vibration criterion will be adopted for the purposes of assessment of livestock impacts. Information concerning the location of grazing land is not available. An assessment has been done based on the location of the nearest cleared lands to the mine, both Boral owned land (to west of the mine) and privately-owned land (to west of the mine). The results are shown in Table 13-2.

The predicted vibration levels comply with the guidelines for human comfort (5mm/s) and the overpressure level of 125dBLin at the nearest grazing land.

Table 13-2 Predicted Blasting Impact on Grazing Land

Closest Grazing Land	Stage 1 (Yr 2)		Stage 2 (Yr 7)	
	Peak Overpressure, dB(Lin)	PPV, mm/sec	Peak Overpressure, dB(Lin)	PPV, mm/sec
Criteria	125	5	125	5
Boral Owned Land	120	3.7	115	1.8
Private Land	113	1.2	113	1.2

14.5 Impact of Blasting on Infrastructure & Natural Features

There are no sensitive infrastructure or significant natural features in the close proximity of the 30 year mine plan where elevated overpressure or vibration levels could occur from blasting. The vibration from blasting will be below the structural damage criterion at all non-mine-owned infrastructure, including Jemena gas pipeline that delivers gas to the site.

15 RECOMMENDED MANAGEMENT AND MONITORING PROGRAM

The operations environment management plan for Marulan South Limestone Mine will include noise and blast management and mitigation measures.

The noise management will include:

- A compliance noise monitoring program to confirm the operational noise levels of the project that specifically addresses:
  - Compliance with the noise trigger levels;
  - Measurements and assessment of any maximum noise levels (L_{AFmax});
- The noise monitoring would be based around an attended monitoring program that:
  - Measures $L_{A90,15minutes}$ and $L_{Aeq15minute}$ noise levels;
  - Measures and /or calculates the contributed noise level from the operation of the mine;
  - Records weather conditions at the monitoring site.

The results of the monitoring program would be reviewed by the management team of the mine to assess compliance with the trigger levels and will be reported in accordance with any requirements of the development consent and/ or the EPL.

Should compliance not be achieved, all reasonable and feasible noise mitigation measures would be identified and implemented.

The blast management will include:

- Continued restriction of blasting to daylight hours and on weekdays, excluding public holidays;
- Sounding warning sirens prior to blasting events;
- Standard safe blasting procedures and additional procedures followed prior to any blasting event that may affect the public utilising the adjacent recreational reserves;
- A compliance blast monitoring program to confirm the blast vibration and overpressure levels of the project that specifically address compliance with the ANZACC blasting criteria. The blast monitoring data should collect:
  - Measured vibration levels;
  - Measured overpressure levels;
  - Maximum instantaneous charge;
  - Number of holes;
  - Blast type; and
  - Meteorological conditions.
- Continuation and possible refinement of the existing blast monitoring program.

16 CONCLUSION

This report details noise emissions from all construction and operational phases of the Project -, the ongoing continued operation of Marulan South Limestone Mine.

Noise from ongoing operations, construction, blasting, rail and traffic generation has been assessed against the latest guidelines promulgated by NSW authorities. The NSW EPA has recently released the *Noise Policy for Industry (NPfI)* which sets appropriate noise trigger levels for operational noise assessment.

Noise trigger levels at surrounding residential receivers have been derived from a review of all noise monitoring undertaken to date around the mine, as well as available data from the nearby Peppertree Quarry.

The *NPfI* requires detailed assessment of prevailing meteorological conditions. Five years of data from the Peppertree Quarry weather station was analysed to show that noise enhancing meteorological conditions are not a feature of the area. This applies to both wind and night time temperature inversions. Therefore, noise was assessed under standard meteorological conditions described in the *NPfI*.

Noise modelling was done based on the typical worst-case equipment locations provided by Boral for four stages during the life of the mine. Noise source levels were based in part on extensive noise surveys at the mine.

The predicted noise levels were less than the project noise trigger levels at all sensitive receiver locations for all stages of the proposed 30-year mine operations. As such, it is considered that the mine would have no significant noise impacts on neighbouring communities. The modelled scenarios presented in this report represent the culmination of several iterative noise modelling investigations designed to determine feasible and reasonable noise mitigation measures.

Overpressure and vibration levels from blasting were assessed. Criteria presented in the ANZECC blasting guideline (ANZECC, 1990) can be achieved.

Noise from the construction was predicted to comply with the EPA's *Interim Construction Noise Guideline*. (ICNG)

Noise from traffic generated by the proposal was predicted to comply with EPA's *Road Noise Policy (RNP)*.

Rail noise has been reviewed and deemed to comply with the EPA's *Rail Infrastructure Noise Guideline* (RING).

17 REFERENCES

- Environment Protection Authority (2000) *NSW Industrial Noise Policy (INP).*
- Environment Protection Authority (2017) *NSW Noise Policy for Industry (NPfI).*
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- Office of Environment and Heritage (2011) *Application Notes – NSW Industrial Noise Policy*. Website: http://www.epa.nsw.gov.au/noise/applicnotesindustnoise.htm Accessed 5 October 2011.
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- Department of Environment, Food and Rural Affairs (2005) Update of Noise Database for Prediction of Noise on Construction and Pen Sites.
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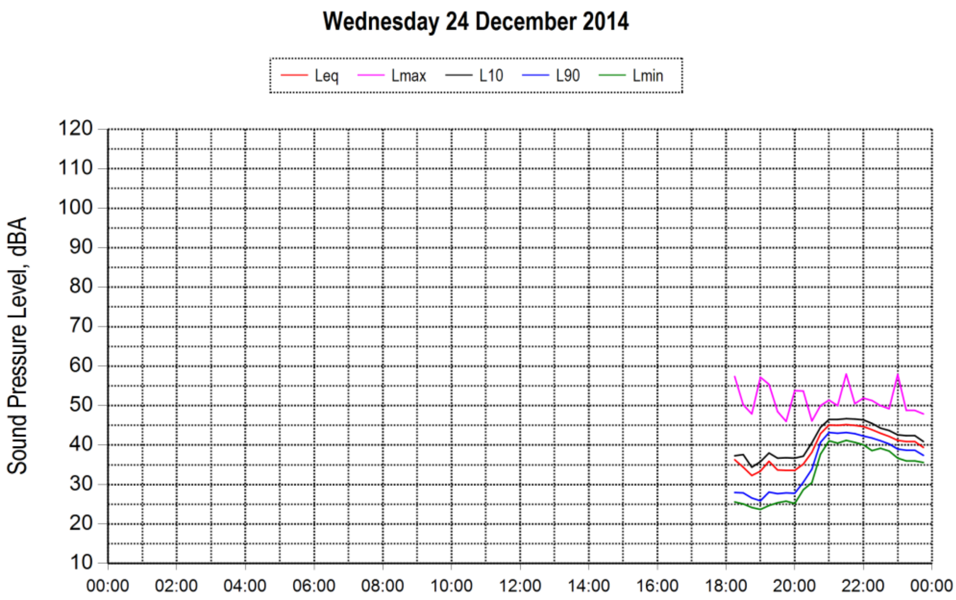
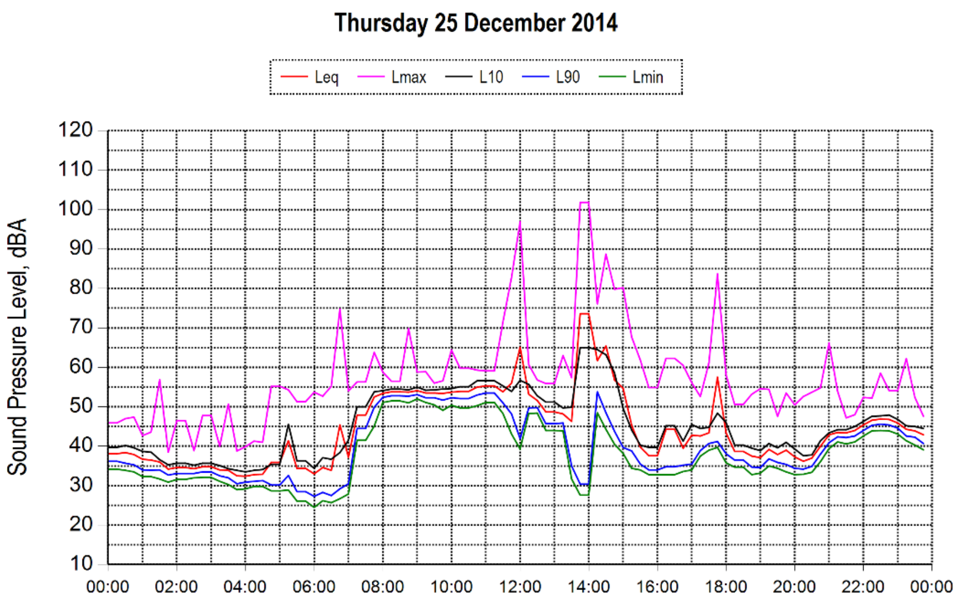
- Health Council 2004, The health effects of environmental noise – other than hearing loss, Health Council, Perth.
- ANZECC (1990) *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration .*
- ICI Australia (1990) 'Environmental Effects of Blasting' in Handbook of Blasting Tables, pp 33-35.
- Standards Association of Australia, AS.2187.2-1993. *Explosives – Storage Transport and Use – Part 2 – Use of Explosives.*
- Terrock, (2000) Blast Vibration Course, Measurement – Assessment – Control
- ERM (2006) Marulan South Quarry Environmental Assessment Report.
- ERM (2011) Boral Peppertree Quarry Section 75w Modification.

APPENDIX A

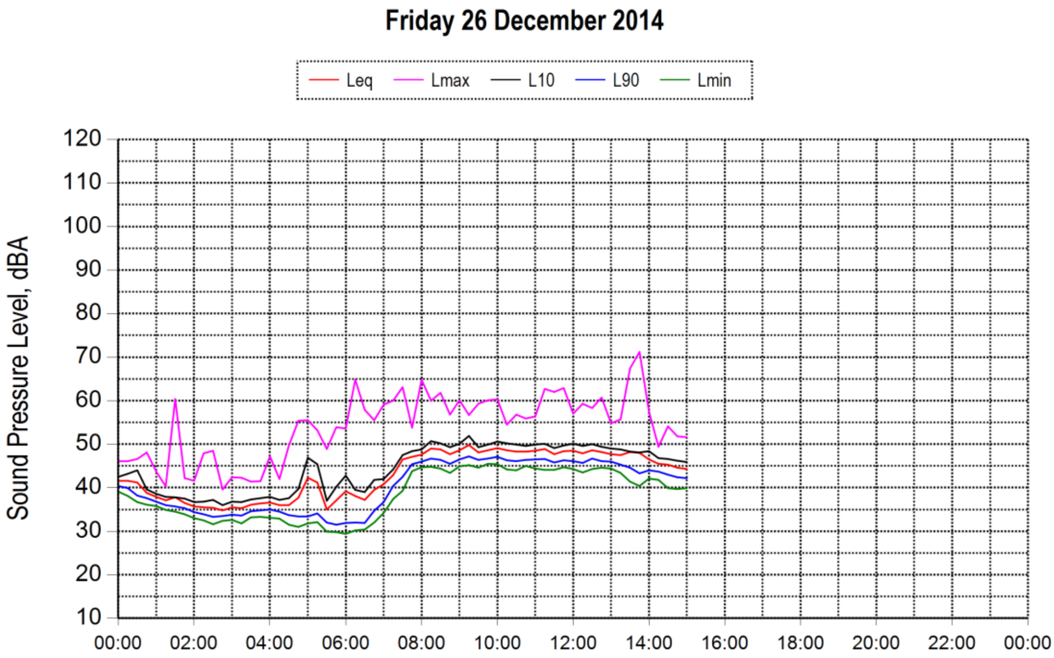
NOISE MEASUREMENT RESULTS

(B4) Mine Manager Property

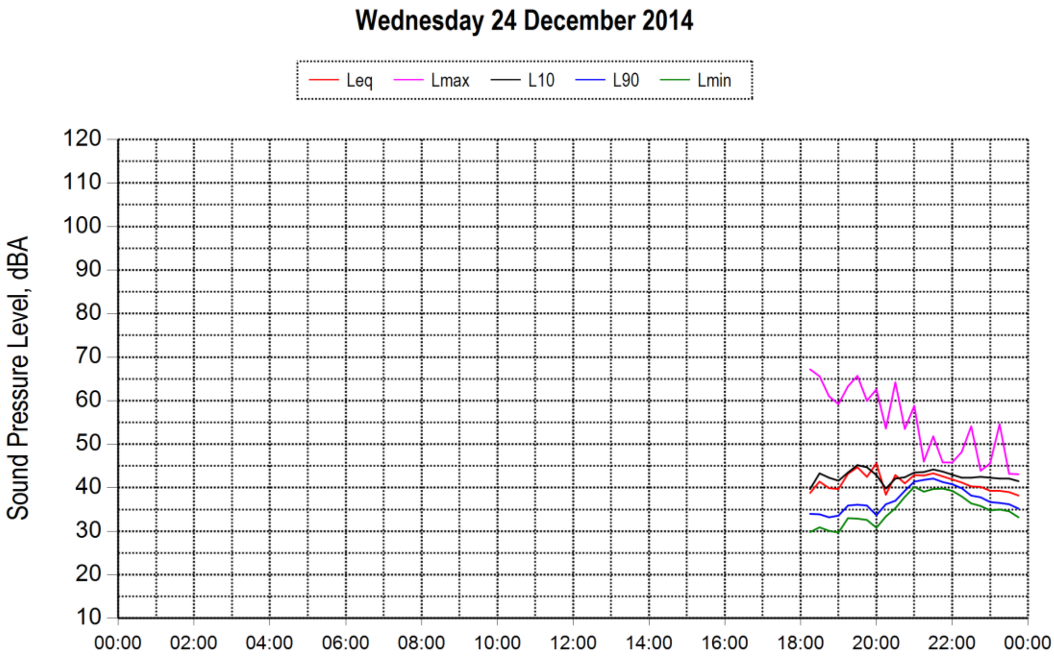


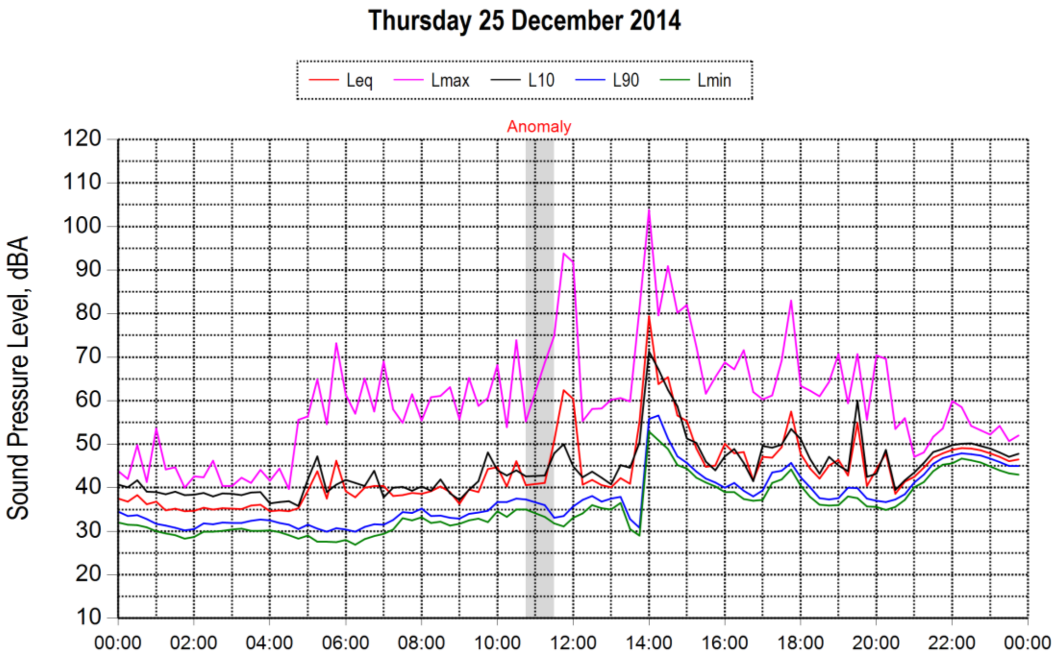


(B4) Mine Manager Property

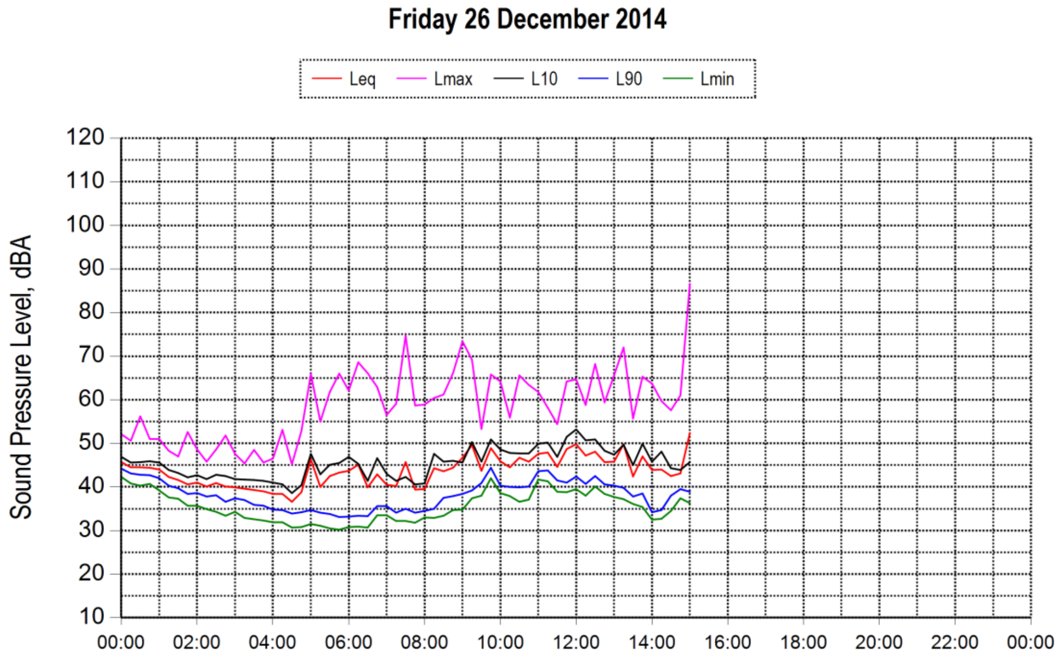


(R8) Turkey Farm

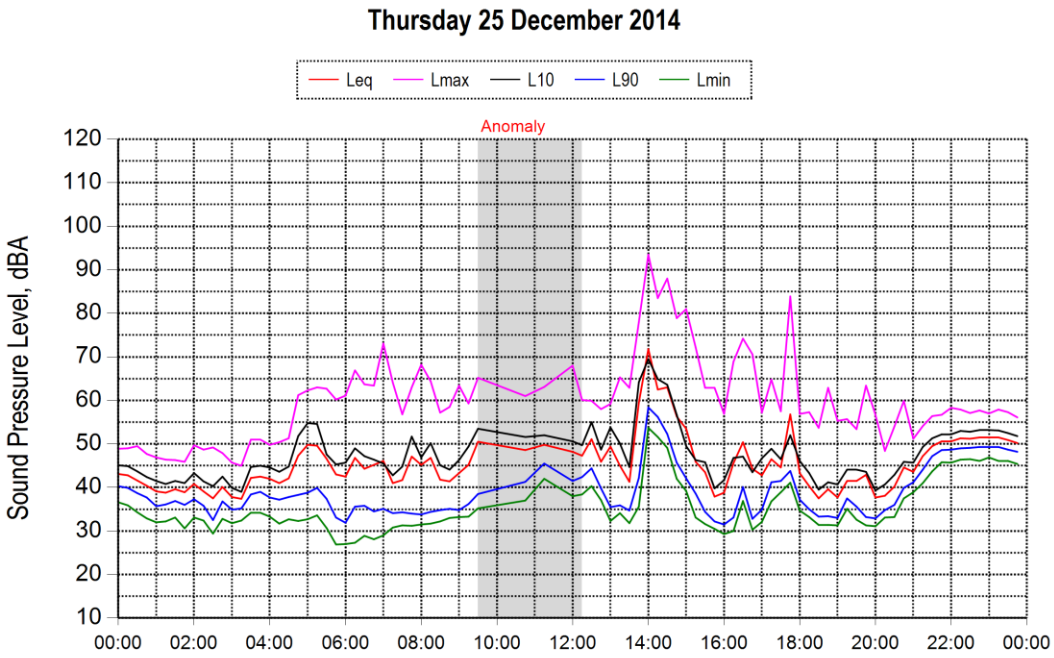


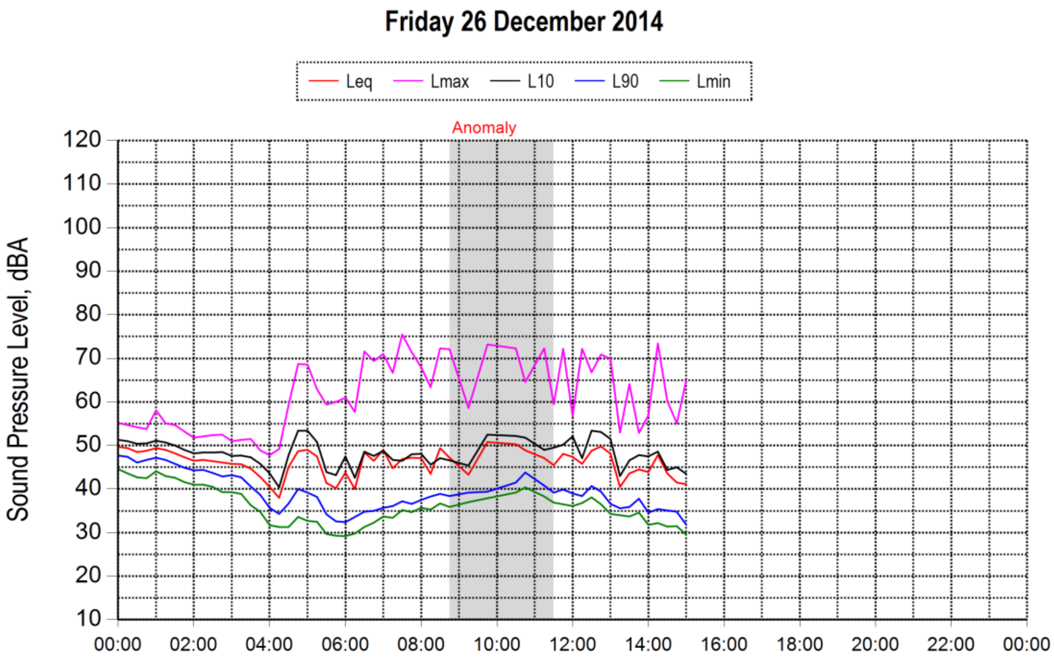


(R8) Turkey Farm

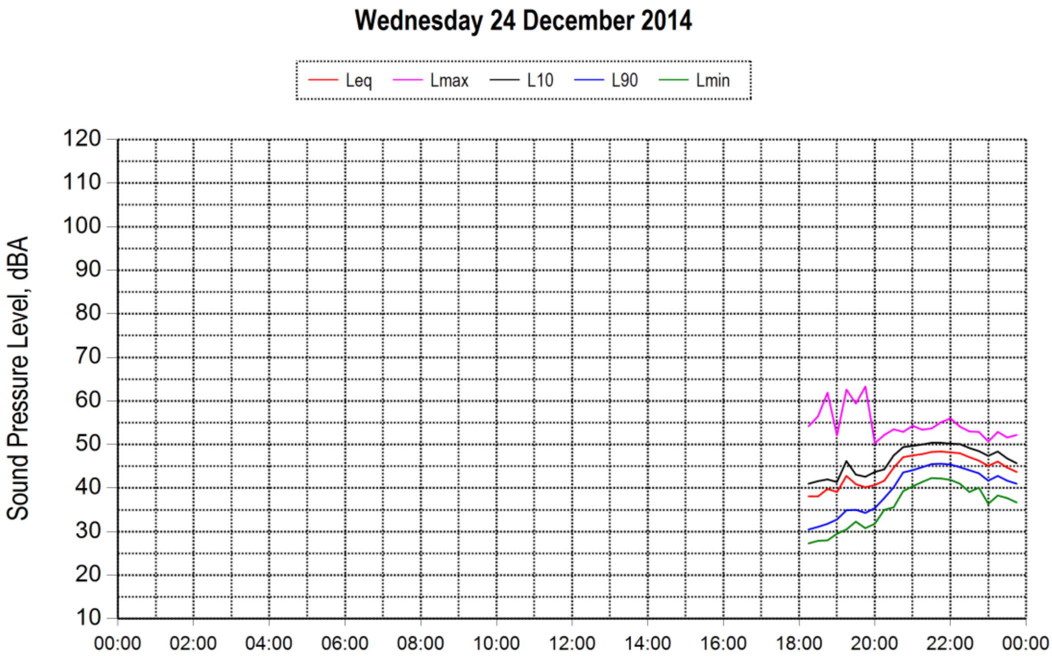


(R9) Western Location

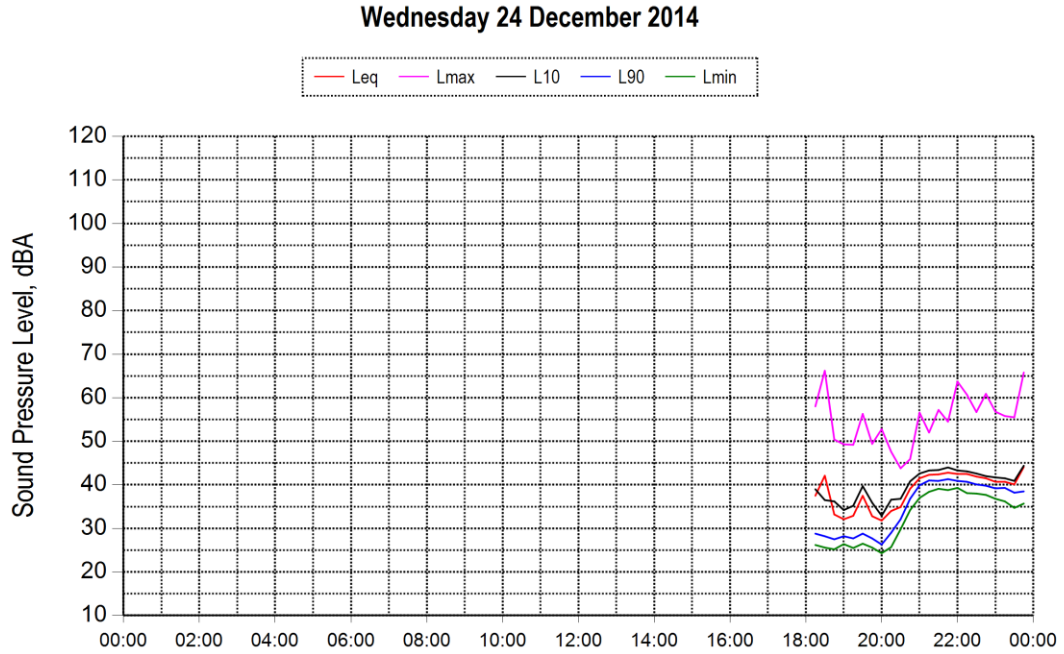


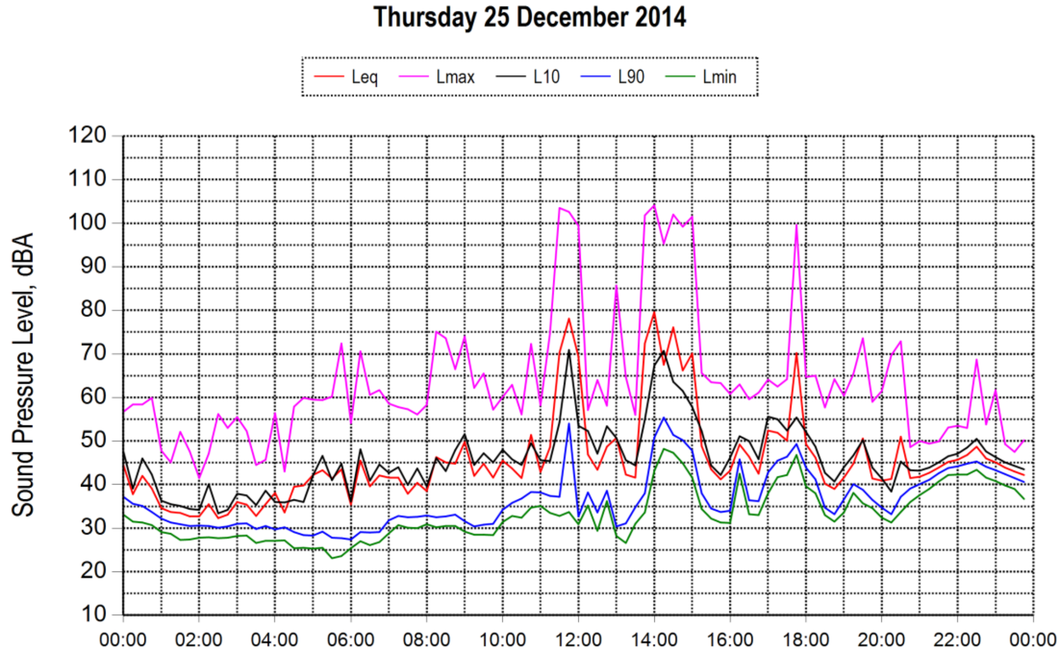


(R9) Western Location

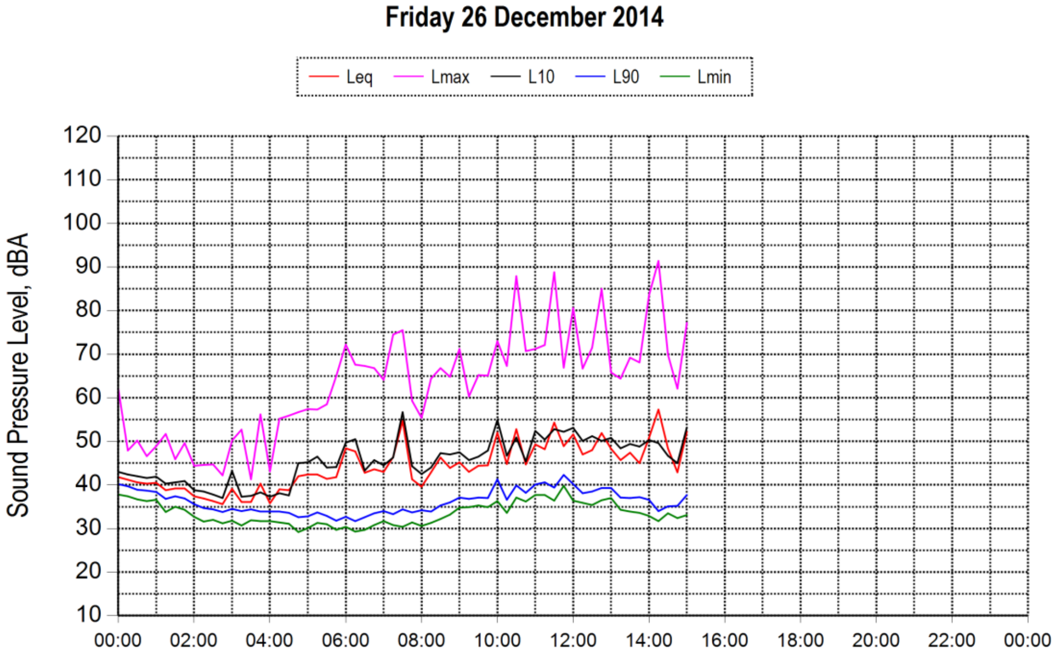


(R3) Northern Location

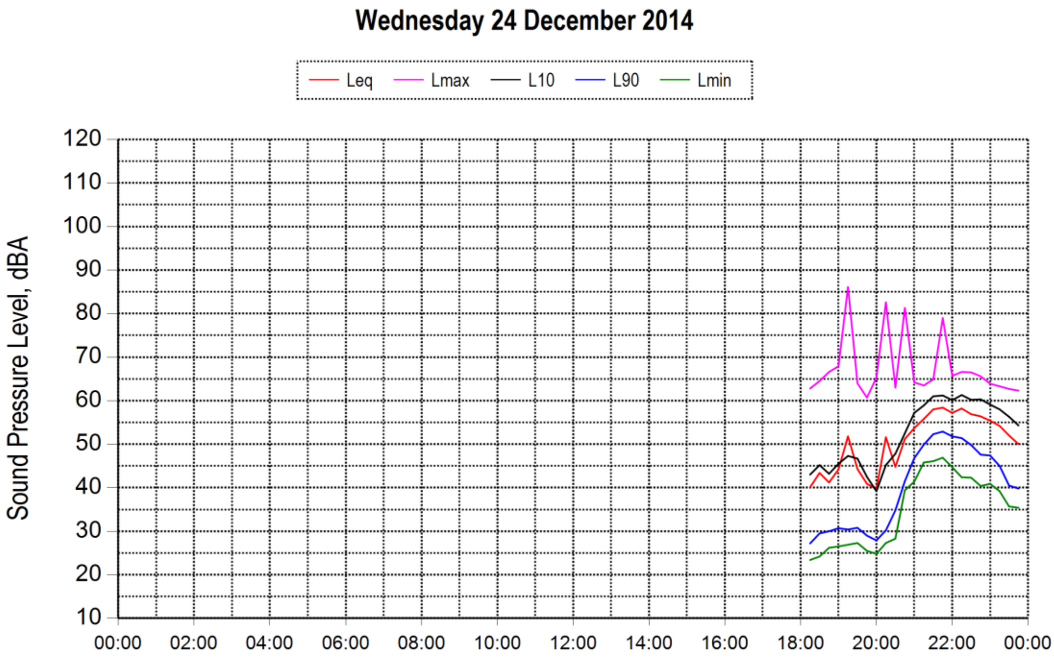


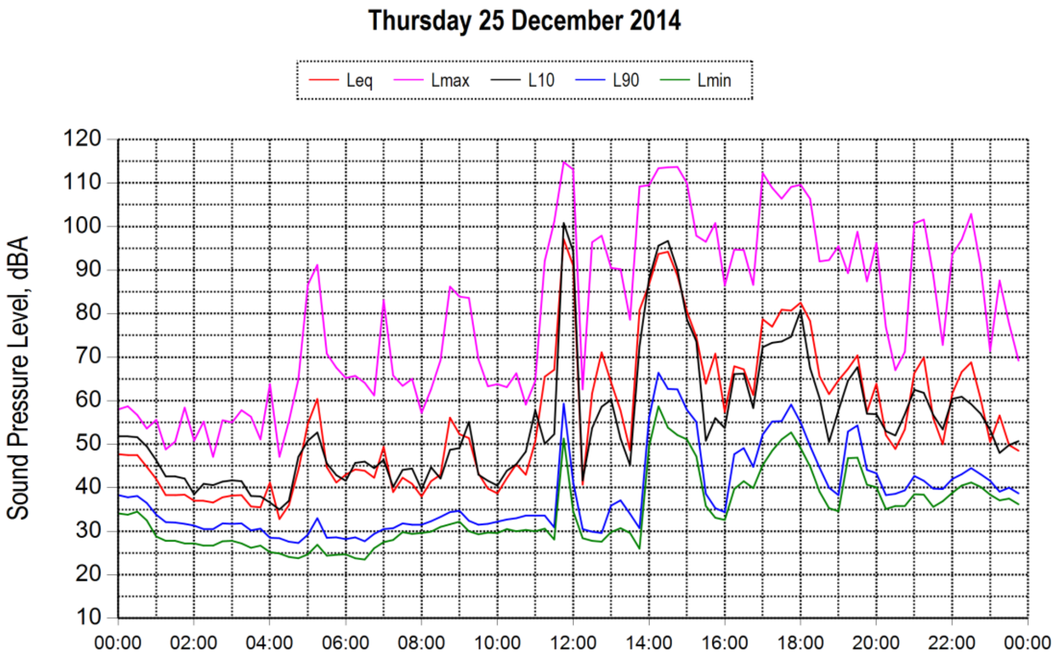


(R3) Northern Location

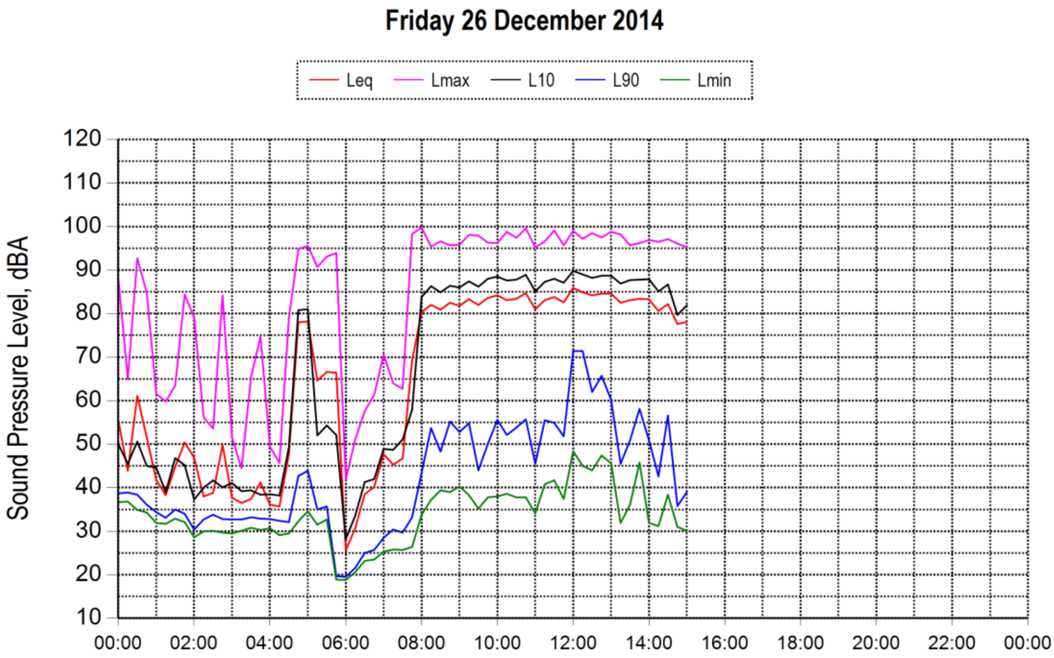


(R14) Eastern Location



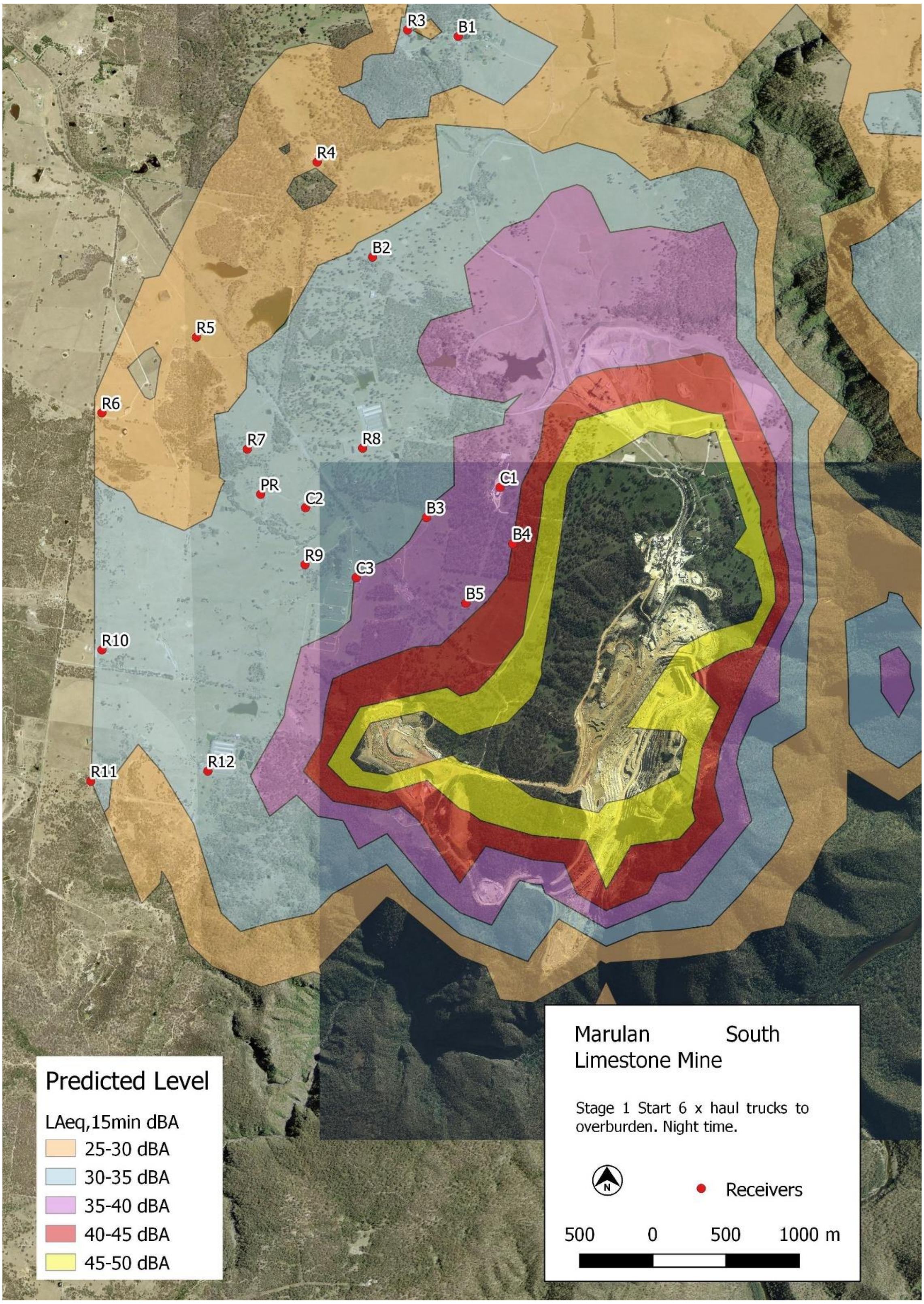


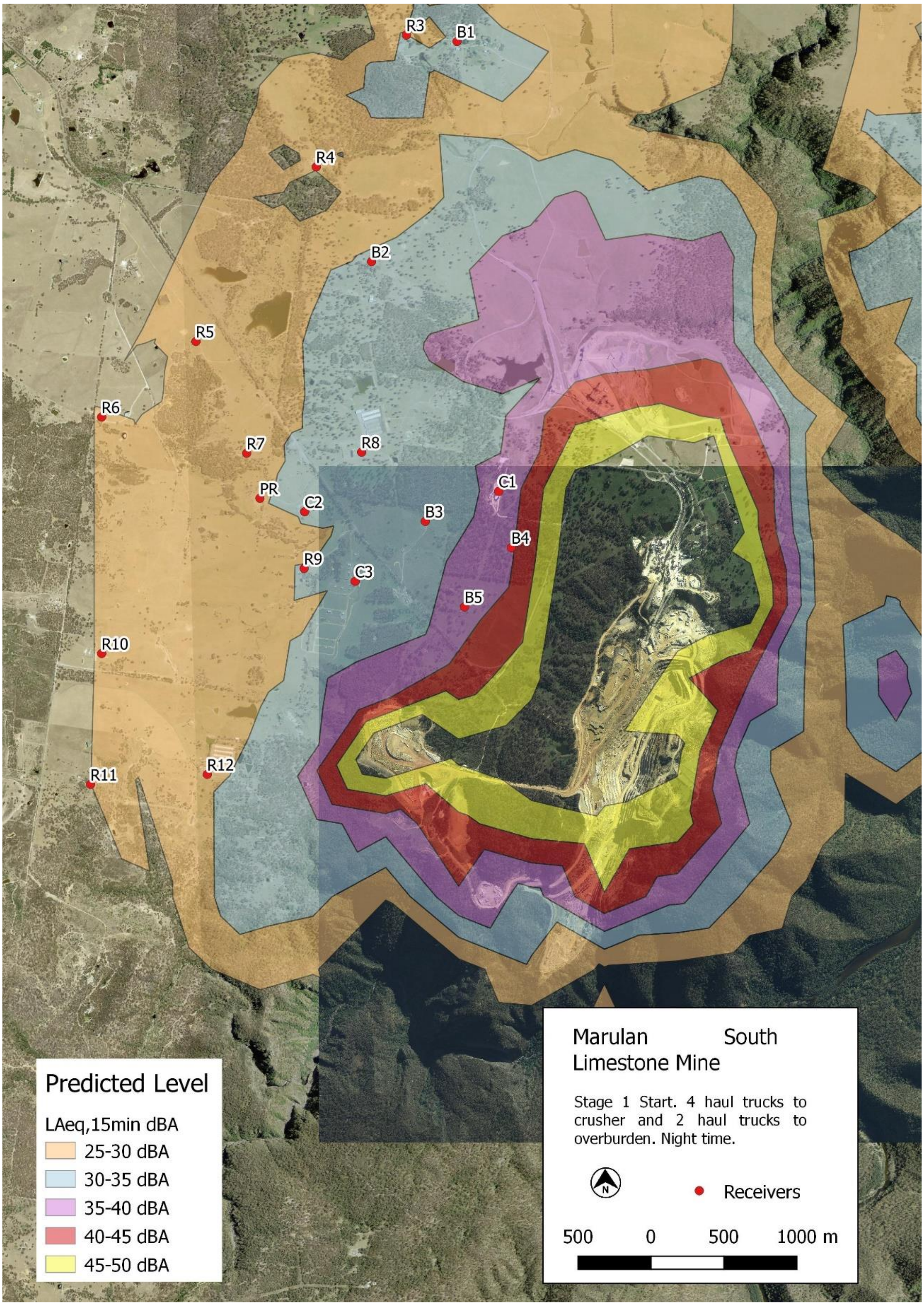
(R14) Eastern Location



APPENDIX B

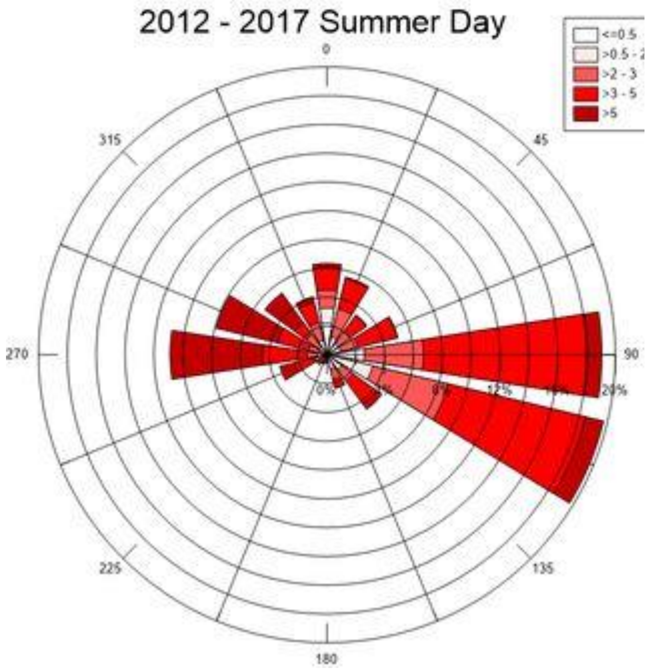
NOISE CONTOUR MAPS

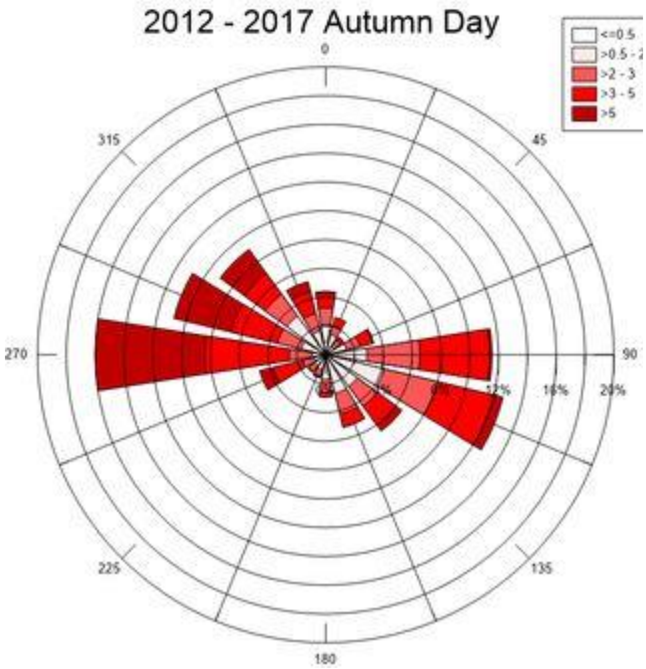

R3
B1
R4
B2
R5
R6
R7
R8
PR
C2
C1
B3
B4
R9
C3
B5
R10
R11
R12
Predicted Level
LAeq,15min dBA
25-30 dBA
30-35 dBA
35-40 dBA
40-45 dBA
45-50 dBA
Marulan South Limestone Mine
Stage 1 Start 6 x haul trucks to overburden. Night time.
Receivers
500
0
500
1000 m

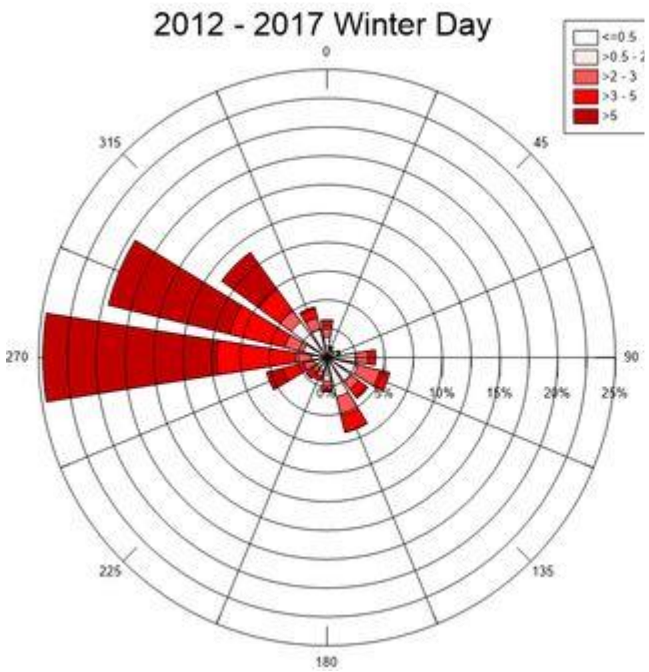

R3
B1
R4
B2
R5
R6
R7
R8
C1
PR
C2
B3
B4
R9
C3
B5
R10
R12
R11
Predicted Level
LAeq,15min dBA
25-30 dBA
30-35 dBA
35-40 dBA
40-45 dBA
45-50 dBA
Marulan South Limestone Mine
Stage 1 Start. 4 haul trucks to crusher and 2 haul trucks to overburden. Night time.
N
Receivers
500 0 500 1000 m

APPENDIX C

WIND ROSES


2012 - 2017 Summer Day
<=0.5
>0.5 -
>2 - 3
>3 - 5
>5
0
45
90
135
180
225
270
315


2012 - 2017 Autumn Day
<=0.5
>0.5 -
>2 - 3
>3 - 5
>5
0
45
90
135
180
225
270
315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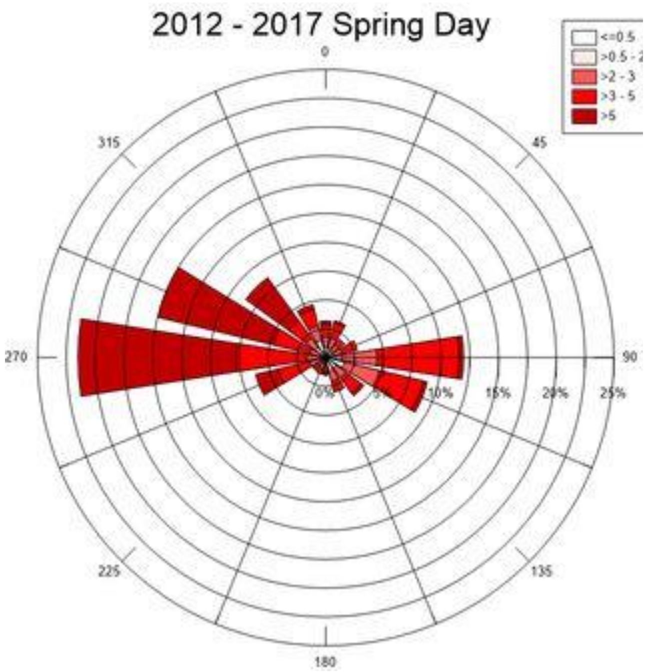
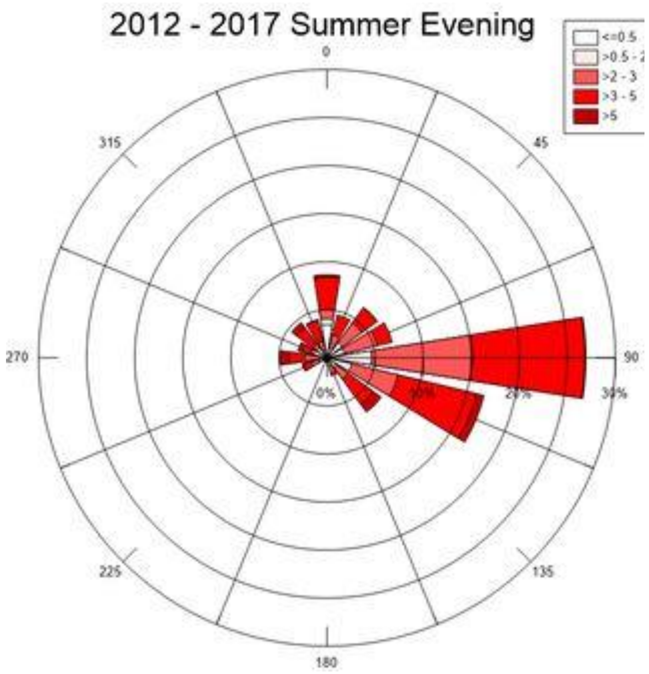
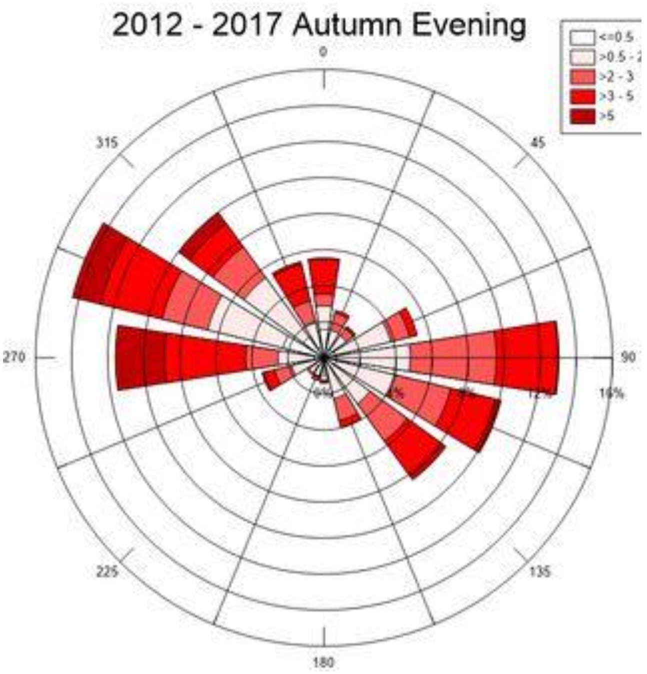
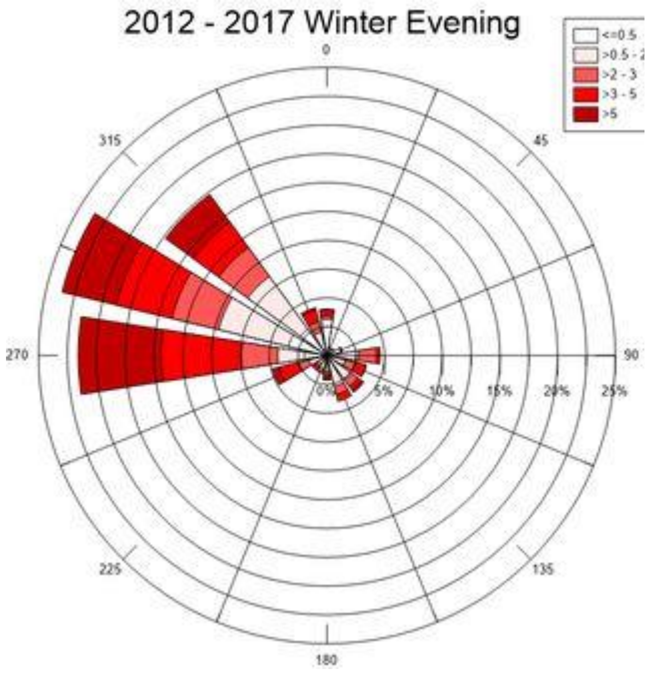
>0.5 -
>2 - 3
>3 - 5
>5
0
45
90
135
180
225
270
315


2012 - 2017 Spring Day
<=0.5
>0.5 -
>2 - 3
>3 - 5
>5
0
45
90
135
180
225
270
315


2012 - 2017 Summer Evening
<=0.5
>0.5 -
>2 - 3
>3 - 5
>5
0
45
90
135
180
225
270
315
0%
10%
20%
30%


2012 - 2017 Autumn Evening
<=0.5
>0.5 -
>2 - 3
>3 - 5
>5
0
45
90
135
180
225
270
315
0%
12%
16%


2012 - 2017 Winter Evening
<=0.5
>0.5 -
>2 - 3
>3 - 5
>5
0
45
90
135
180
225
270
315
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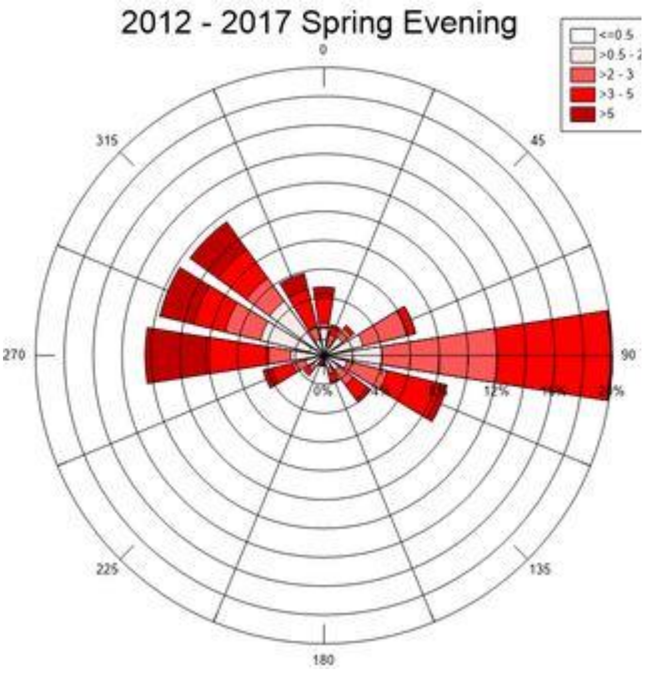
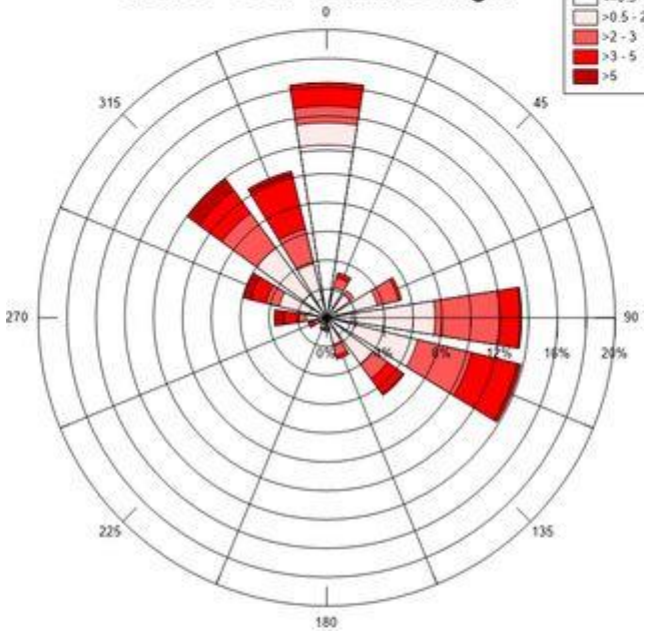
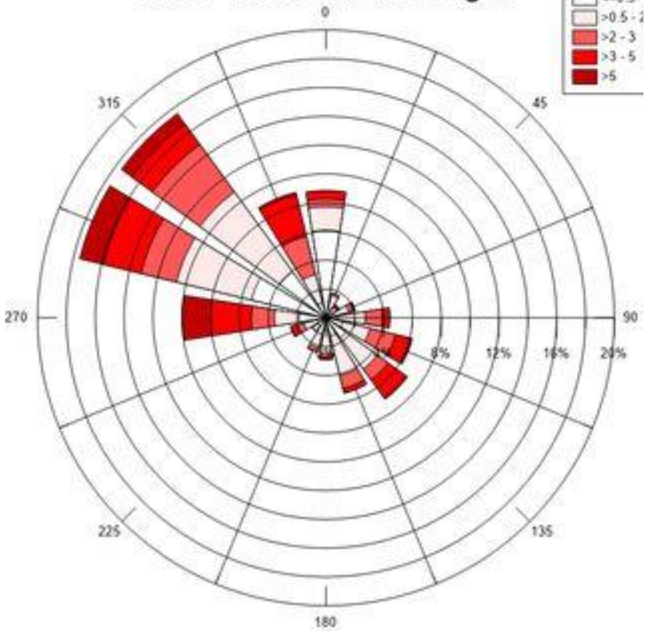
5%
10%
15%
20%
25%


2012 - 2017 Spring Evening
<=0.5
>0.5 -
>2 - 3
>3 - 5
>5
0
45
90
135
180
225
270
315
0%
12%

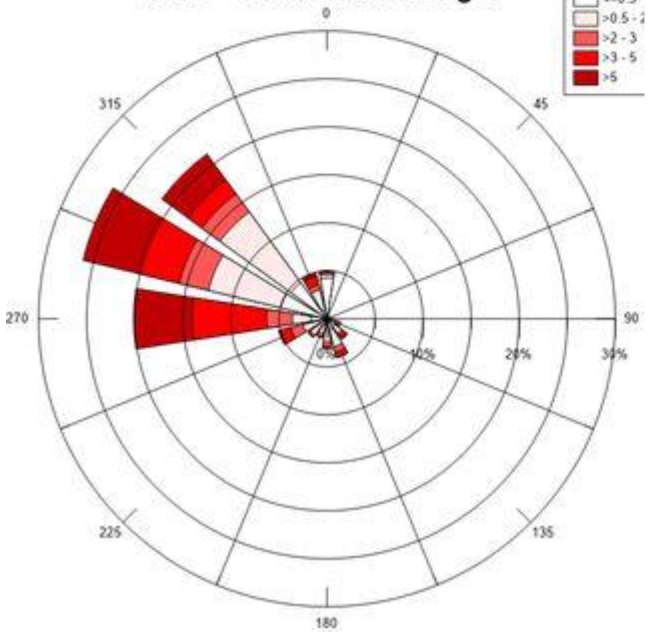
2012 - 2017 Summer Night



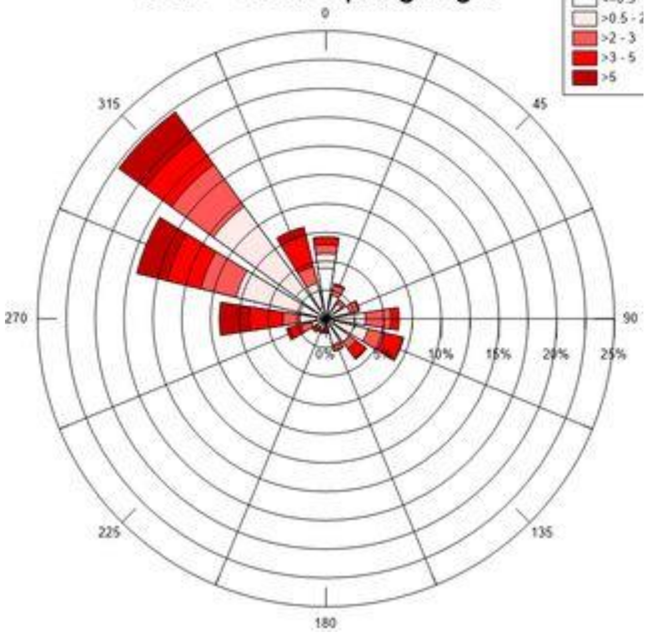
2012 - 2017 Autumn Night

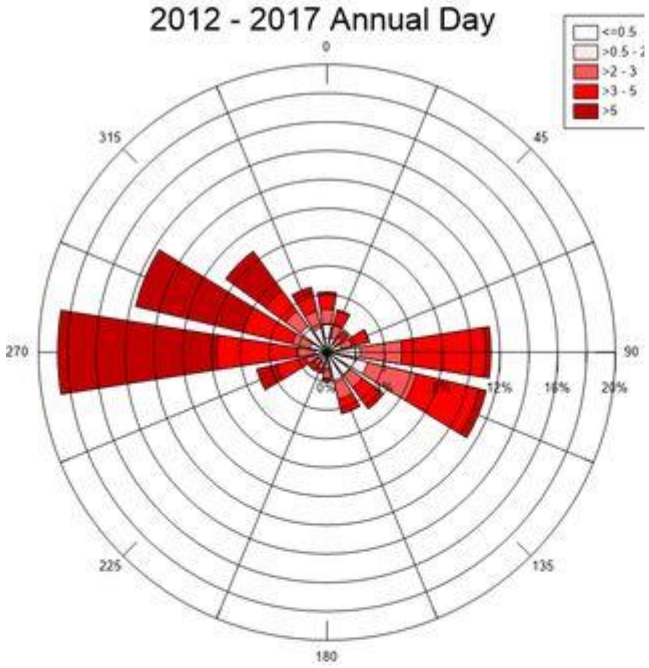


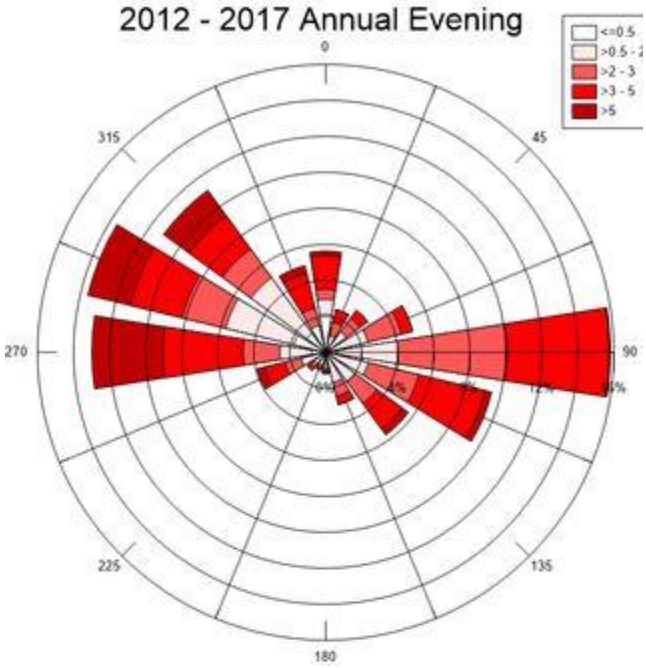
2012 - 2017 Winter Night

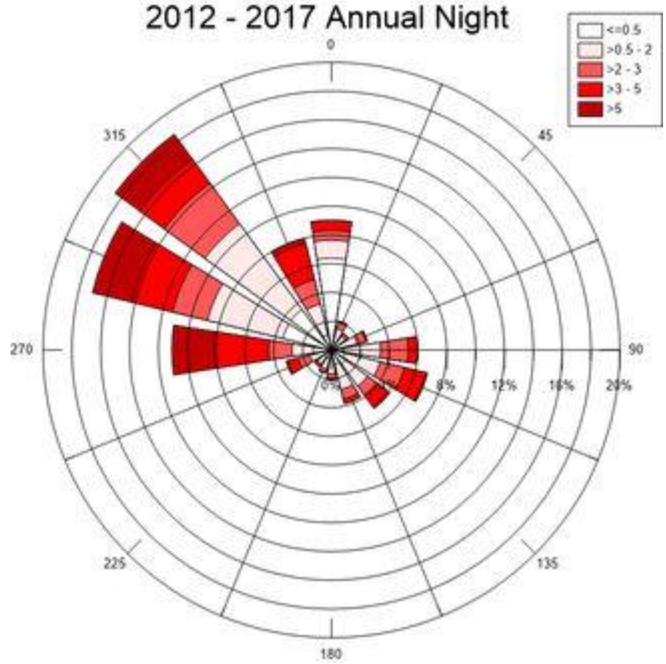


2012 - 2017 Spring Night




2012 - 2017 Annual Day
0
45
90
135
180
225
270
315
0%
12%
16%
20%

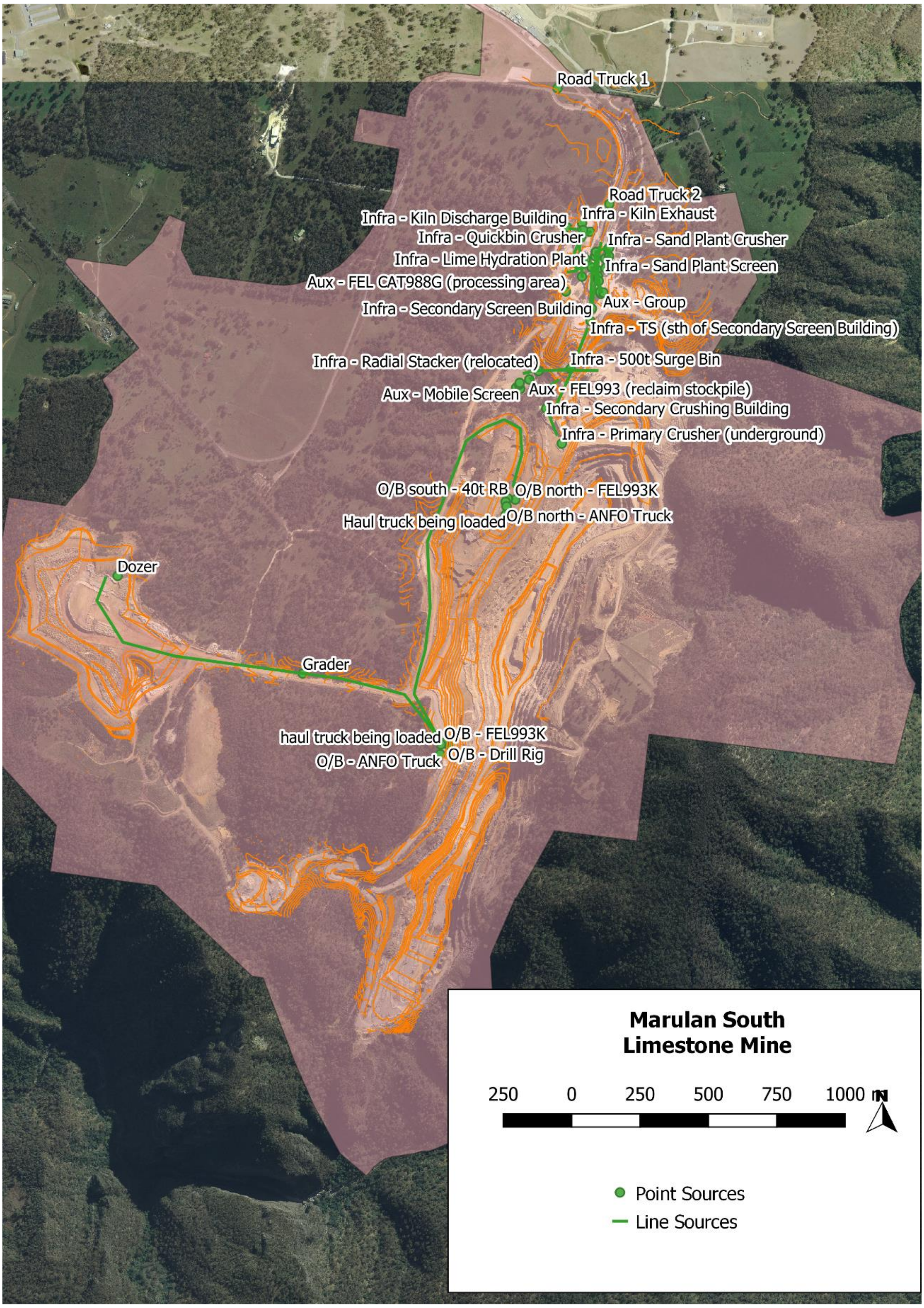

2012 - 2017 Annual Evening
0
45
90
135
180
225
270
315


2012 - 2017 Annual Night
<=0.5
>0.5 - 2
>2 - 3
>3 - 5
>5
0
45
90
135
180
225
270
315
0%
8%
12%
16%
20%

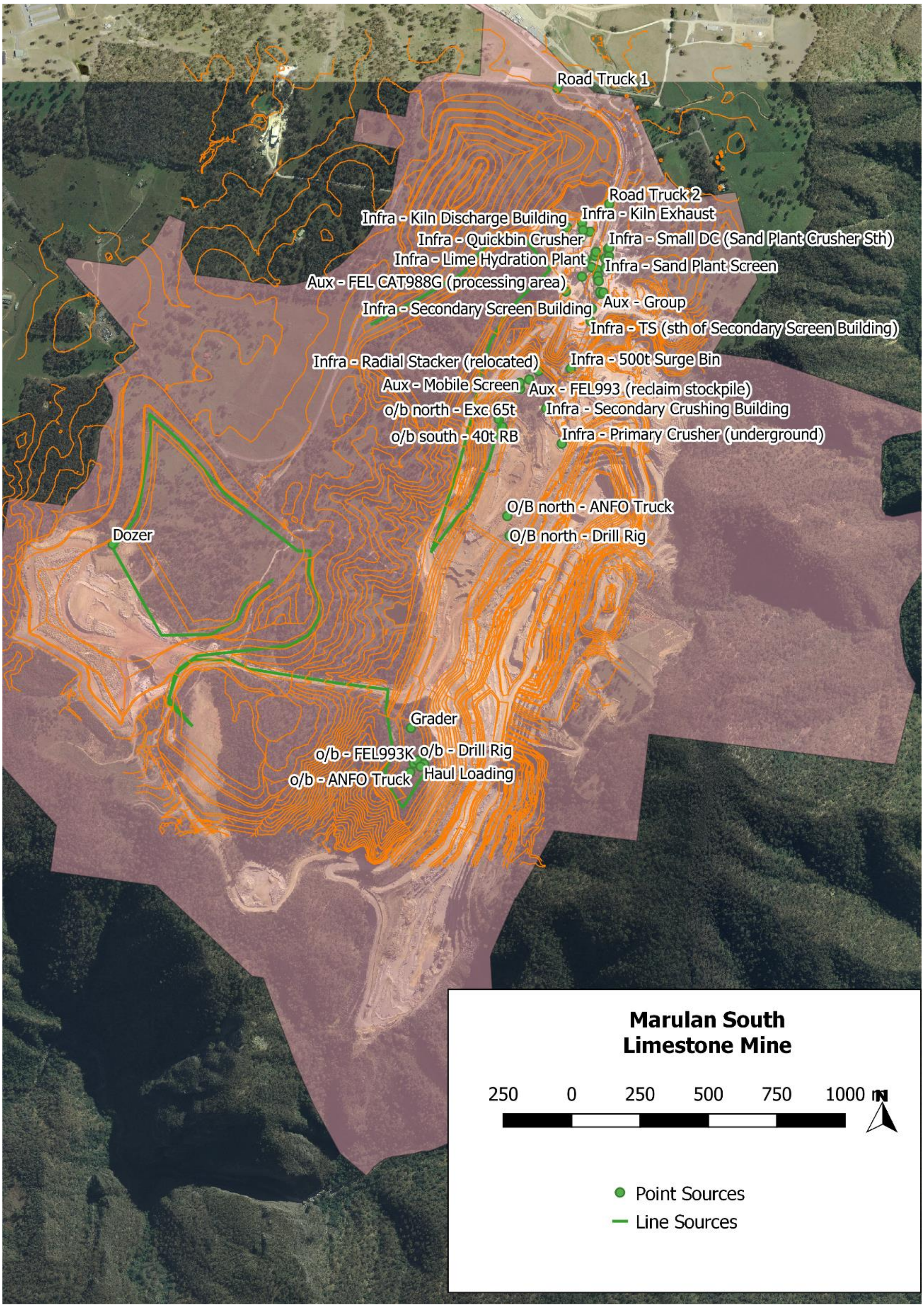
APPENDIX D

SOURCE LOCATIONS

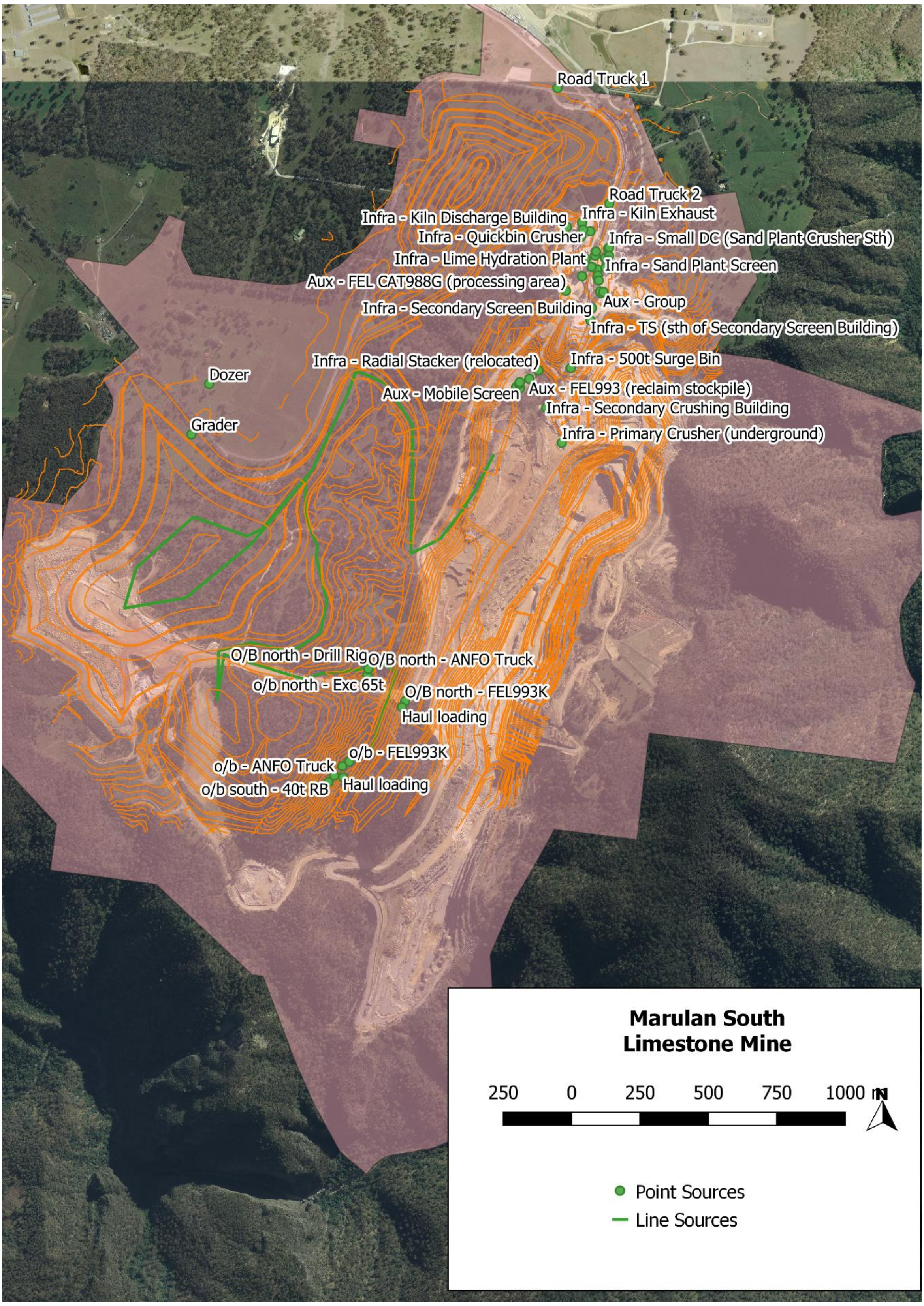
Stage 1 – Beginning – 6 Haul Trucks



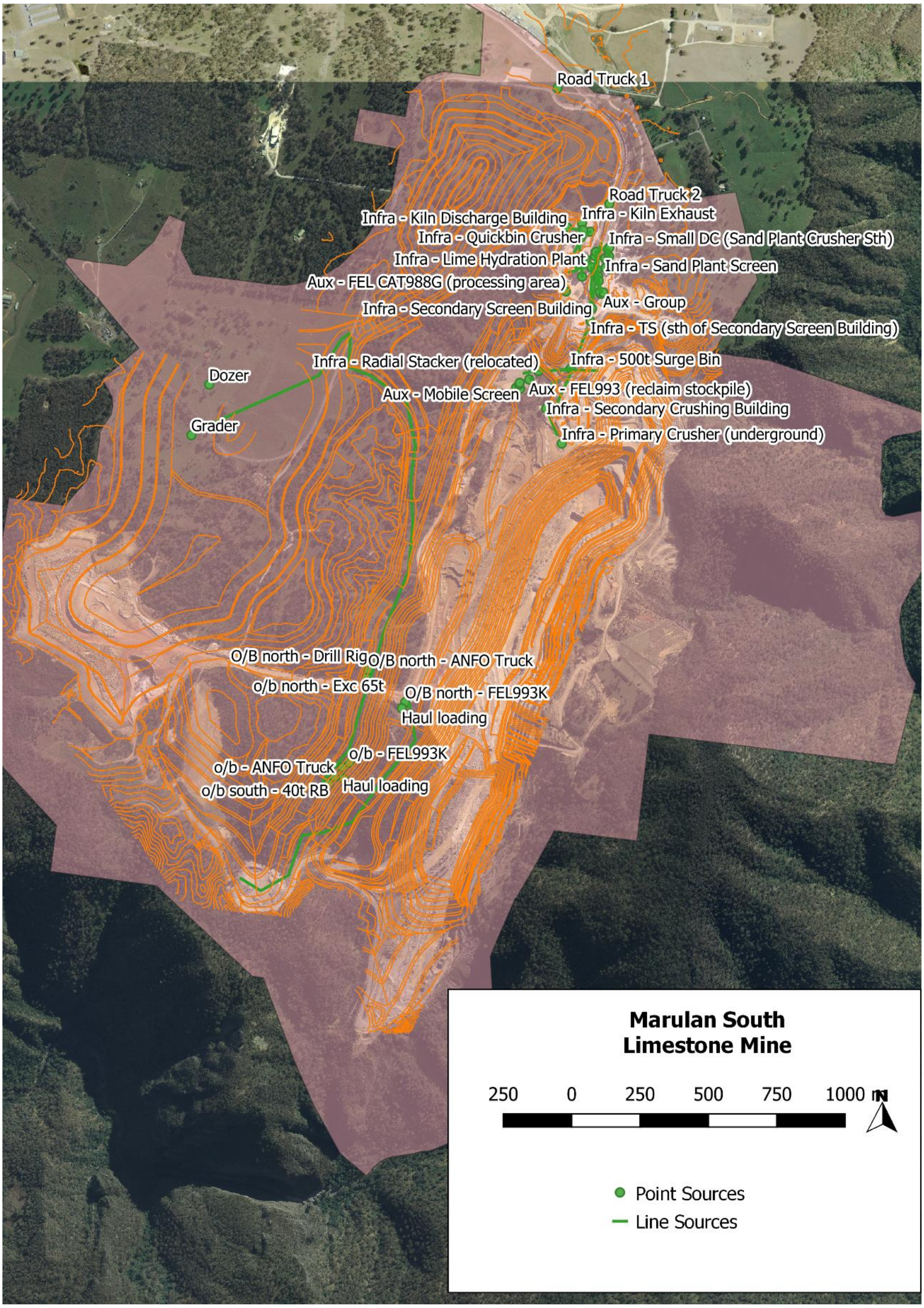
Stage 1 – End – 6 Haul Trucks



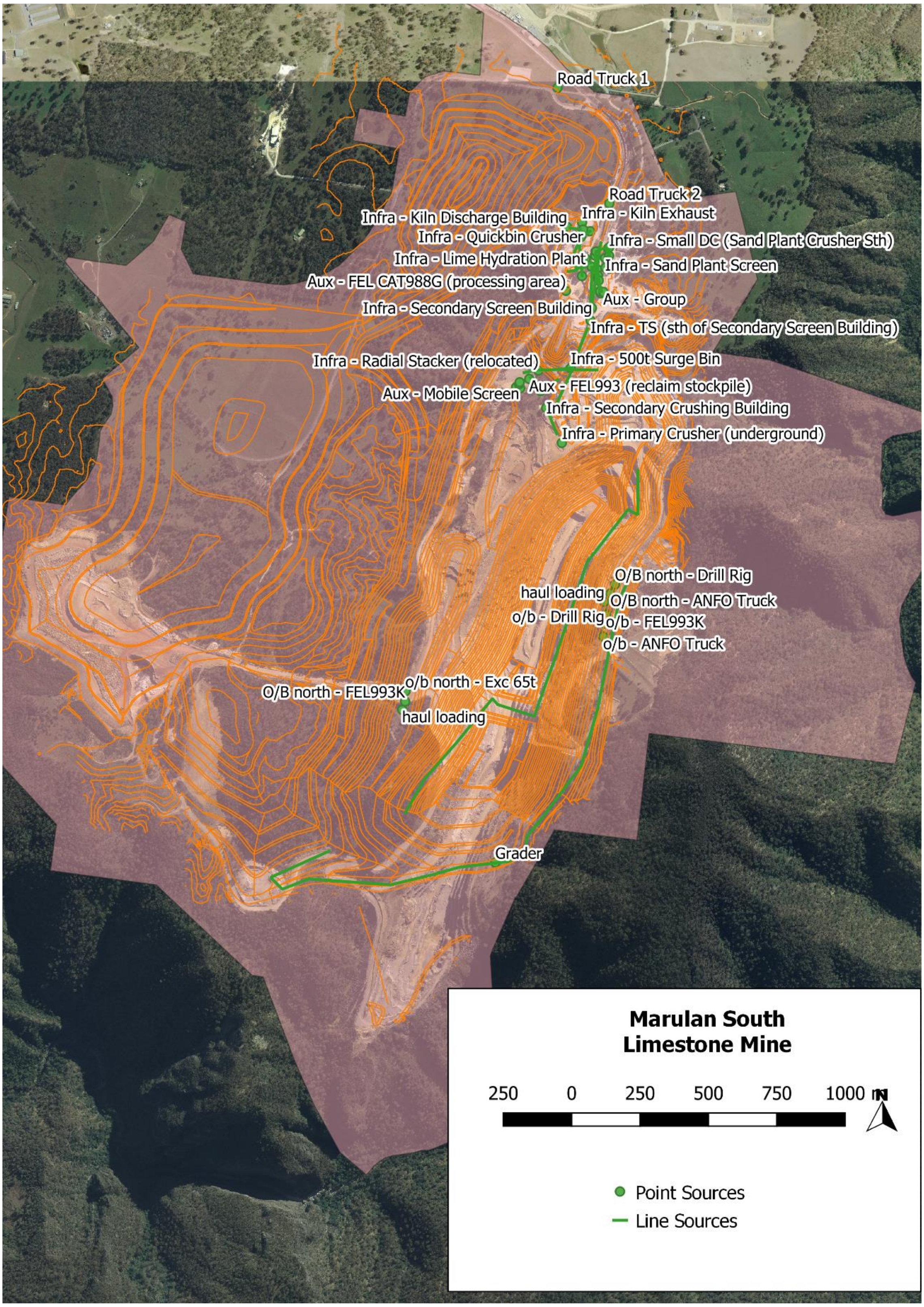
Stage 2 – 6 Haul Trucks



Stage 3 – 6 Haul Trucks

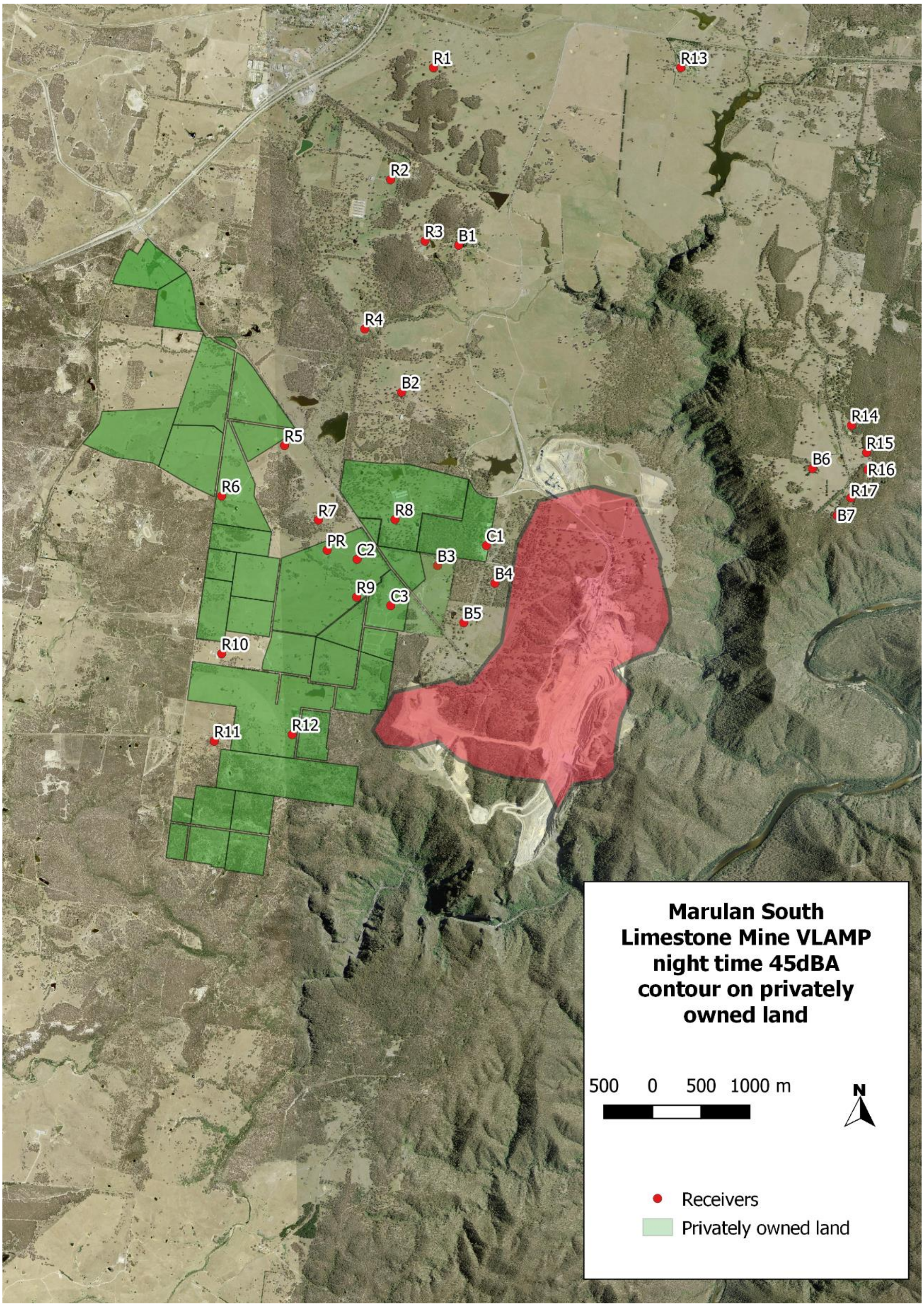


Stage 4 – 6 Haul Trucks



APPENDIX E

VLAMP CONTOUR


R1
R13
R2
R3
B1
R4
B2
R14
R15
B6
R16
R17
B7
R5
R6
R7
R8
PR
C2
C1
B3
B4
R9
C3
B5
R10
R11
R12
Marulan South Limestone Mine VLAMP night time 45dBA contour on privately owned land
500 0 500 1000 m
N
Receivers
Privately owned land

CAMBIUM
GROUP