Appendix E

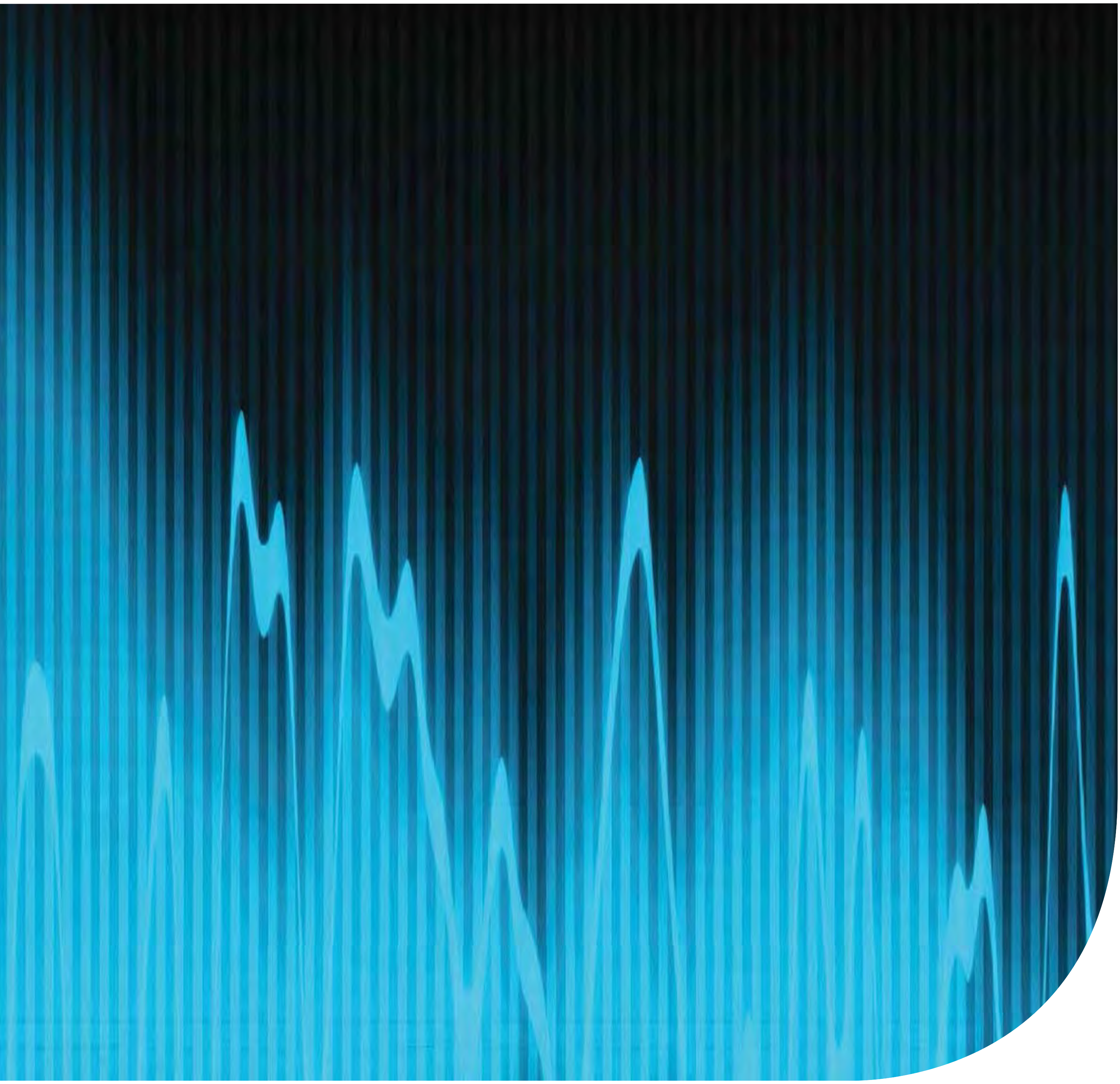
Noise and vibration assessment

E

Bringelly Concrete Batching Plant

Noise and Vibration Assessment

Prepared for Boral Resources (NSW) Pty Limited | 9 May 2016



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Noise and Vibration Assessment

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Bringelly Concrete Batching Plant

Final

Report J15110RP1 | Prepared for Boral Resources (NSW) Pty Limited | 9 May 2016

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1 Introduction

1.1 Overview

Boral Resources (NSW) Pty Limited (Boral) proposes to construct and operate a concrete batching plant in Bringelly, NSW (the project). This noise and vibration assessment supports a development application for the project under Part 4 of the *Environmental Planning and Assessment Act 1979*. Camden Council is the consent authority for the application. The proponent for the project is Boral, a wholly owned subsidiary of Boral Limited. Boral Limited is an international building and construction materials group, with around 12,000 full-time equivalent employees and over 430 operating sites in Australia.

The objectives of this noise assessment are to complete a concise review of operational, construction and road traffic noise and vibration emissions associated with the project. Where required, noise management or mitigation measures have been recommended to satisfy relevant criteria.

The noise assessment has been completed with reference to the following guidelines and policies:

- *NSW Industrial Noise Policy* (Environment Protection Authority (EPA) 2000) (INP);
- *Road Noise Policy* (EPA 2011) (RNP);
- *Voluntary Land Acquisition and Mitigation Policy* (NSW Government 2014);
- *Interim Construction Noise Guideline* (EPA 2009) (ICNG); and
- *Assessing Vibration: a technical guideline* (DEC 2006) (“the guideline”).

1.2 Secretary’s Environmental Assessment Requirements

Secretary’s Environmental Assessment Requirements (SEARs) were issued for the project (SEARs 961, September 2015). The relevant requirements and where they have been addressed in this assessment are provided in Table 1.1.

Table 1.1 SEARs

Key issue	Requirement	Section addressed
Noise and vibration	• a description of all potential noise and vibration sources during construction and operation, including road traffic noise.	4, 5 and 6
	• a noise and vibration assessment in accordance with the relevant Environment Protection Authority Guidelines.	7
	• a description and appraisal of noise and vibration mitigation and monitoring measures.	8

1.3 EPA requirements

The EPA presents key environmental impact assessment requirements in response the project's SEARs (27 August 2015). These are:

> **6. Noise Impact assessment:** The environmental outcome of the project should be to minimise adverse impacts due to noise from the project. The EA must clearly outline the noise mitigation, monitoring and management measures the proponent intends to apply to the project to minimise noise pollution.
>
> The assessment should be undertaken in accordance with the *NSW Industrial Noise Policy* (INP). In particular, the assessment should include, but not necessarily be limited to: the identification and assessment of all potential noise sources associated with the development, the location of all sensitive receptors, proposed hours of operation and proposed noise mitigation measures. The assessment should also take into account adverse weather conditions including temperature inversions. Sound power levels measured or estimated for all plant and equipment should be clearly stated and justifies. It should also include an assessment of cumulative noise impacts, having regard to existing surrounding industrial activities and development.
>
> The EIS must also identify the transport route(s) to be used, the hours of operation and assess potential road traffic noise impacts in accordance with the *"NSW Road Noise Policy"*.
>
> Any construction noise should also be assessed and any proposed noise mitigations measures identified and documented in the EIS in accordance with the Interim Construction Noise Guideline (DECC 2009).

1.4 Glossary of acoustic terms

A number of technical terms are required for the discussion of noise. These are explained in Table 1.2.

Table 1.2 Glossary of acoustic terms

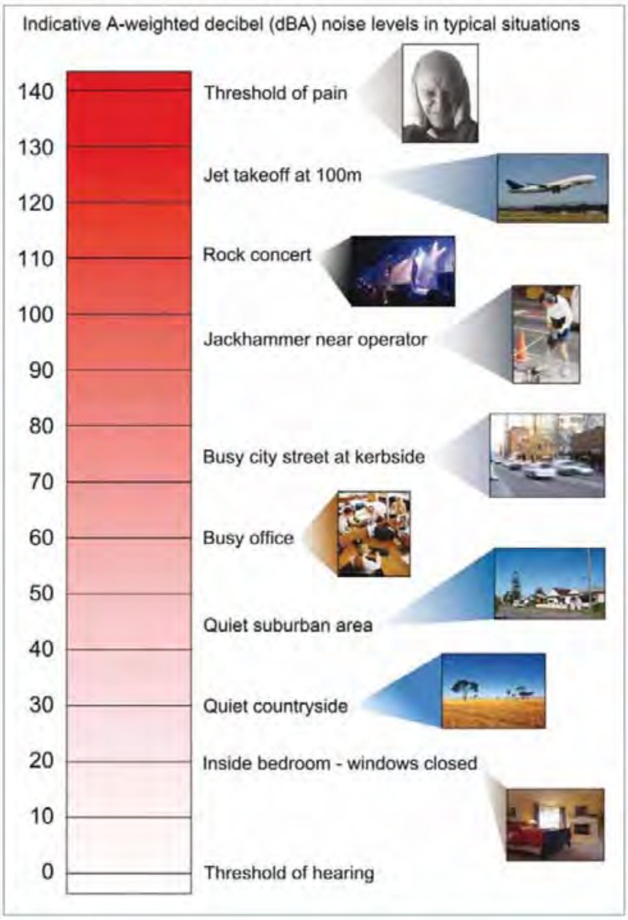
Term	Description
dB	Noise is measured in units called decibels (dB).
A-weighting	There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
L_{A1}	The A-weighted noise level exceeded for 1% of a measurement period.
L_{A10}	The A-weighted noise level which is exceeded 10% of the time. It is approximately equivalent to the average of maximum noise levels.
L_{A90}	Commonly referred to as the background noise, this is the A-weighted level exceeded 90% of the time.
L_{Aeq}	The A-weighted energy average noise from a source, and is the equivalent continuous sound pressure level over a given period. The $L_{eq,15min}$ descriptor refers to an L_{eq} noise level measured over a 15-minute period.
L_{Amax}	The maximum root mean squared A-weighted sound pressure level received at the microphone during a measuring interval.
RBL	The Rating Background Level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period.
Sound power level	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.
Temperature inversion	A positive temperature gradient. A meteorological condition where atmospheric temperature increases with altitude.

It is also useful to have an appreciation of decibels (dB), the unit of noise measurement. Table 1.3 gives an indication as to what an average person perceives about changes in noise levels:

Table 1.3 Perceived change in noise

Change in sound level (dB)	Perceived change in noise
1 to 2	typically indiscernible
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times as loud (or quarter) as loud

Examples of common noise levels are provided in Figure 1.1.



Source: Road Noise Policy (Department of Environment, Climate Change and Water (DECCW) 2011).

Figure 1.1 Common noise levels

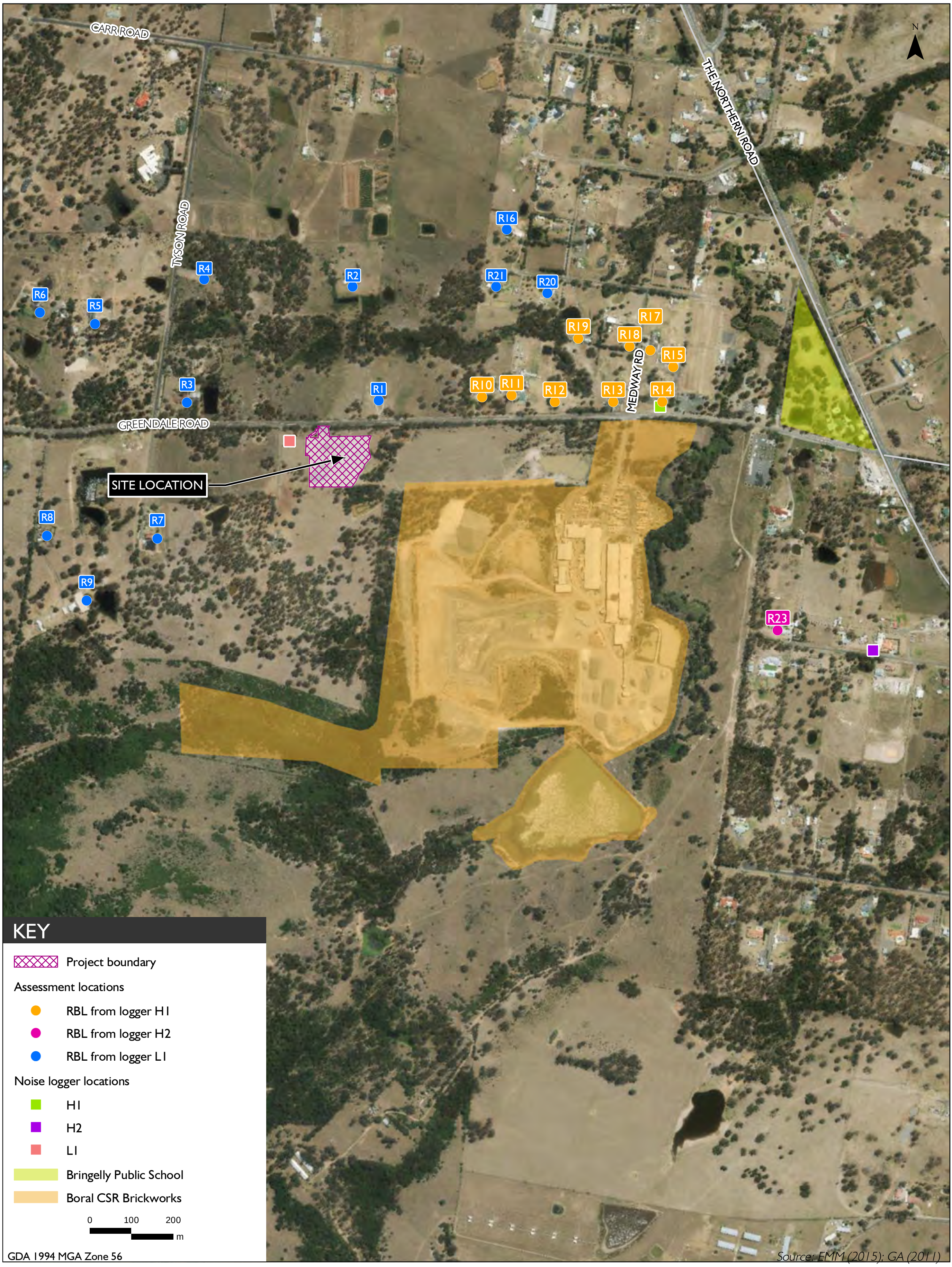
2 Project overview

The project is in the north-western corner of Lot 100 DP 1203966 on Greendale Road, Bringelly (see Figure 2.1). The indicative site layout is shown in Figure 2.2. The site is owned by Boral CSR Bricks Pty Ltd (now trading as PGH Bricks), a joint venture between Boral Limited and CSR Limited. The Boral CSR Bringelly Brickworks is also located on Lot 100 DP 1203966 approximately 200 m south-east of the project area. The project is intended to support the construction of local and regional infrastructure projects including local road upgrade works to Northern Road and Bringelly Road.

The key elements of the project are summarised in Table 2.1.

Table 2.1 Key project elements

Project element	Project description
Maximum processing rate	125,000 tonnes of concrete per annum 1,250 tonnes per day, 250 tonnes per hour Main components: • control room and amenities building; • 3 cement silos; • 4 hoppers; • 1 enclosed agitator load bay; • 2 enclosed slump stands; • 4 open aggregate stockpiles; • 1 bunded concrete admixtures container (modified 40 ft shipping container); • 2 water management pits (storage, sediment and first flush capture); • 1 operating front-end loader; • 4 m bund wall, consisting of a 2 m earth bund and 2 m Colourbond fence, to the north, east and west of the site; and • carpark area with 24 spaces.
Hours of operation	7 am–10 pm Monday to Saturday; 8 am–10 pm Sunday; and No deliveries after 6 pm.
Employment	13 full-time employees: 3 plant operators and 10 truck drivers
Disturbance footprint	1.7 ha
Transport and access	Access will be via a new driveway on Greendale Road. Average daily truck numbers: • Agitator trucks – 86; • Cement tankers – 7; and • Aggregate truck and dog – 20. Peak hour truck numbers: • Agitator trucks – 12; • Cement tankers – 1; and • Aggregate truck and dog – 2.
Construction timeframe	12 weeks construction period Construction hours: 7 am–6 pm Monday to Friday, 8 am–1 pm Saturday



Source: EMM (2015); GA (2011)

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Location of the project in relation to nearby land uses

Bringelly Concrete Batching Plant
Noise and Vibration Assessment
Figure 2.1

Source: EMM (2016); LPI (2011)

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Proposed indicative project layout plan

Bringelly Concrete Batching Plant
Noise and Vibration Assessment

Figure 2.2

3 Existing environment

3.1 Noise sensitive receivers

The closest residential properties to the site are on Greendale Road. Nearest representative noise sensitive receivers to the site have been defined in Table 3.1 and are further referred to in this report as assessment locations. The project in relation to assessment locations is shown in Figure 2.1. Bringelly public school, which is defined as a noise sensitive receiver type in the INP, is located in the outer vicinity of the project's assessment area.

Table 3.1 Assessment locations

ID	Receptor type[1]	Address
R1	Residential	31 Greendale Road
R2	Residential	33 Greendale Road
R3	Residential	162 Greendale Road
R4	Residential	5 Tyson Road
R5	Residential	37 Greendale Road
R6	Residential	39 Greendale Road
R7	Residential	Tyson Road South
R8	Residential	196A Greendale Road
R9	Residential	196 Greendale Road
R10	Residential	29 Greendale Road
R11	Residential	27 Greendale Road
R12	Residential	25 Greendale Road
R13	Residential	23 Greendale Road
R14	Residential	9 Greendale Road
R15	Residential	9A Greendale Road
R16	Residential	82 Medway Road
R17	Residential	25 Medway Road
R18	Residential	30 Medway Road
R19	Residential	52 Medway Road
R20	Residential	62 Medway Road
R21	Residential	72 Medway Road
R22	School	1205 The Northern Road
R23	Residential	54 Loftus Road
R24, Brickworks	Industrial	Boral CSR Bringelly Brickworks

Notes: 1. As defined in the NSW Industrial Noise Policy (EPA 2000).

3.2 Background and ambient noise levels

3.2.1 Unattended noise monitoring

In order to establish the existing ambient noise environment of the project area, noise monitoring was conducted. A noise logger was placed on the western boundary of Lot 100. The noise logger was placed approximately 40 m from Greendale road to represent the nearest residential assessment locations. Its position was selected after giving due consideration to noise sources which may extraneously influence the readings, the proximity of assessment locations to the proposed site, security issues for the noise monitoring device and gaining permission for access from the residents or landowners. Its location is shown in Figure 2.1.

The unattended measurements were carried out using an Acoustic Research Laboratoires Pty Ltd Ngara environmental noise logger (serial number 16-302-485). The logger was in place from 10 to 21 September 2015. The noise logger was programmed to record statistical noise level indices continuously in 15 minute intervals, including the L_{Amax}, L_{A1}, L_{A10}, L_{A50}, L_{A90}, L_{A99}, L_{Amin} and the L_{Aeq}. Calibration of all instrumentation was checked prior to and following measurements. No drift of more than plus or minus 0.5 dB was recorded. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

Weather data for the survey period was obtained from the Bureau of Meteorology weather station at Badgerys Creek Automatic Weather Station (Station No. 067108), located approximately 4.5 km from the project site. The wind speed and rainfall data was used to exclude noise data during periods of any rainfall and/or wind speed in excess of 5 m/s in accordance with INP methods. A summary of existing background and ambient noise levels is given in Table 3.2. Results are provided for each day and graphically in Appendix A.

Table 3.2 Summary of existing background and ambient noise levels, dB

Monitoring location	Period	RBL[1]	Measured existing L_{Aeq} noise level[2]
L1	Day	35	52
	Evening	35[3]	51
	Night	33	48

Notes: 1. The RBL is an INP term and is used to represent the background noise level.

2. The energy averaged noise level over the measurement period and representative of general ambient noise.

3. The EPA recommends where the evening RBL is above the daytime RBL, the daytime RBL should be taken to develop the intrusive noise criteria.

4. Day: 7am - 6pm. Evening: 6pm - 10pm. Night: 10pm - 7am.

3.2.2 Previous unattended noise monitoring

Unattended noise monitoring was conducted by Hyder Consulting (Hyder) in 2013 for the Boral Brickworks to the east of the site. The results from the unattended noise monitoring are presented in *Bringelly Brickworks and Quarry Expansion Environmental Impact Statement* (EIS) (Hyder 2013). Unattended noise monitoring was conducted at three locations, two of which are relevant to the project (refer to Figure 2.1). These are:

- 9 Greendale Road (H1); and
- 26 Loftus Road (H2).

The results from Hyder's unattended noise monitoring are presented in Table 3.3.

Table 3.3 Summary of existing background and ambient noise levels (Hyder 2013), dB

Monitoring location	Period	RBL[1]	Measured existing L_{Aeq} noise level
H1 (9 Greendale Road)	Day	41	57
	Evening	40	49
	Night	37	46
H2 (26 Loftus Road)	Day	41	51
	Evening	41	50
	Night	37	48

Notes: 1. Data published in Hyder 2013 was determined to satisfy the INP requirements although was not independently verified by EMM.

3.2.3 Attended noise monitoring

An operator attended measurement was also conducted by EMM on 10 September 2015 during noise logger deployment. This was done using a Brüel and Kjær Type 2250 integrating sound level meter (serial number 30-082-01) to both quantify and qualify the existing noise sources contributing to the ambient noise environment.

Field calibration of the instrument was completed using a Brüel and Kjær type 4230 calibrator (serial number 14-414-15). Attended measurements were undertaken in accordance with *AS 1055-1997 Description and Measurement of Environmental Noise, Parts 1, 2 and 3*. Meteorological conditions throughout the survey period were calm and clear with no influential wind or rain. Table 3.4 provides a summary of the attended measurement. There was no audible contribution from existing industrial noise sources during the attended measurement.

Table 3.4 Summary of attended noise measurement

Location	Date	Start time	Measured noise level dB			Comments
			L_{Aeq}	L_{A90}	L_{Amax}	
33 Greendale Road	10/09/15	11:45	52	34	71	Intermittent light plane activity present throughout, occasional heavy vehicle on Greendale Road.

3.3 Meteorology

Noise propagation over distance can be significantly affected by the prevailing weather conditions. Of most interest are source to receiver winds, the presence of temperature inversions and drainage flow effects, as these conditions can enhance received noise levels. To account for these phenomena, the INP specifies meteorological analysis procedures to determine the prevalent weather conditions.

3.3.1 Prevailing winds

The INP recommends consideration of wind effects if they are a "feature" of the area. The INP defines "feature" as the presence of source-to-receiver wind speed (measured at 10 m above ground level) of 3 m/s or less, occurring for 30% of the time in any assessment period and season.

This is further clarified by defining source-to-receiver wind direction as being the directional component of wind. The INP requires that where wind is identified to be a feature of the area then assessment of noise impacts should consider the highest wind speed below 3 m/s, which is considered to prevail for at least 30% of the time.

A thorough review of the vector components of five minute wind data from September 2014 to September 2015 was undertaken. The data was recorded by the Bureau of Meteorology's Badgerys Creek weather station (AWS 067108). Table 3.5 presents the prevailing winds that were identified using the INP analysis for the day and evening periods (i.e. the operating periods for the project). Refer to Appendix B for a detailed analysis.

Table 3.5 INP prevailing winds analysis

Period	Direction	Wind speed (m/s)
Day	68	2.4
Evening	45	2.1
Evening	90	2
Evening	113	1.9
Evening	135	1.9
Evening	158	1.9
Evening	180	2
Evening	203	2.2
Evening	315	1.8

3.3.2 Temperature Inversions

The INP states that the assessment of temperature inversion impacts be confined to the night-time noise assessment period where temperature inversions occur. The project is proposed to operate during daytime and evening hours only and, hence, assessment of inversions is not applicable.

4 Assessment criteria

4.1 Industrial noise

Noise from industrial sites or processes (e.g. onsite truck movements, concrete production etc) in NSW are regulated by the local council, Department of Planning and Environment (DP&E) and/or the (EPA), usually through a licence and/or approval conditions stipulating noise limits. These limits are normally derived from operational noise criteria applied at assessment locations. They are based on INP guidelines (EPA 2000) or noise levels that can be achieved at a specific site following the application of all feasible and reasonable noise mitigation.

The INP guidelines for assessing industrial facilities have been used for this assessment. With respect to the criteria, the INP states:

> They are not mandatory, and an application for a noise producing development is not determined purely on the basis of compliance or otherwise with the noise criteria. Numerous other factors need to be taken into account in the determination. These factors include economic consequences, other environmental effects and the social worth of the development.

The objectives of noise assessment criteria for industry are to protect the community from excessive intrusive noise and preserve amenity for specific land uses.

To ensure these objectives are met, the EPA provides two separate criteria: intrusiveness criteria and amenity criteria. The fundamental difference being intrusiveness criteria apply over 15 minutes in any period (day and evening), whereas the amenity criteria apply to the entire assessment period (day, evening or night).

4.1.1 Intrusiveness

The intrusiveness criteria require that $L_{Aeq,15\text{-}min}$ noise levels from the project during the relevant operational periods (i.e. day, evening and morning shoulder) do not exceed the RBL by more than 5 dB.

The intrusiveness criteria for the assessment locations was derived using EMM's unattended noise monitoring results and also from unattended noise monitoring results provided for the Boral Brickworks (Hyder 2013).

The unattended noise monitoring location L1 represents a similar ambient noise environment to most residential assessment locations. The RBL used to derive the intrusiveness criteria for assessment locations R1-R10, R16, R20 and R21 was taken from measured levels at L1.

Background noise levels from unattended noise monitoring locations at 9 Greendale Road (H1) and 26 Loftus Road (H2) were presented in an EIS that was written for the Boral Brickworks to the east of the project site (Hyder 2013). Background noise levels from 9 Greendale Road have been used to represent assessment locations R10-R15 and R17-R19. Background noise levels from 26 Loftus Road have been used to represent assessment location R23 (refer to Figure 2.1).

Table 4.1 presents the intrusive criteria for each of the assessment location.

Table 4.1 Intrusive noise criteria

Assessment location	Location of measured RBL	Period[1]	RBL, dB	Intrusive criteria dB, $L_{Aeq(15\text{-}min)}$
R1-R9	L1	Day	35	40
		Evening	35	40
R10	H1	Day	41	46
		Evening	40	45
R11	H1	Day	41	46
		Evening	40	40
R12	H1	Day	41	46
		Evening	40	45
R13	H1	Day	41	46
		Evening	40	45
R14	H1	Day	41	46
		Evening	40	45
R15	H1	Day	41	46
		Evening	40	45
R16	L1	Day	35	40
		Evening	35	40
R17	H1	Day	41	46
		Evening	40	45
R18	H1	Day	41	46
		Evening	40	45
R19	H1	Day	41	46
		Evening	40	45
R20	L1	Day	35	40
		Evening	35	40
R21	L1	Day	35	40
		Evening	35	40
R22, Bringelly Public School (internal)	H1	When in use	n/a	35-40 $L_{Aeq,1hr}$ (internal)
R23	H2	Day	41	46
		Evening	41	46
R24	Brickworks	When in use	n/a	n/a

Notes: *1. Day: 7 am - 6 pm Monday - Saturday; 8 am - 6 pm Sundays and public holidays; evening: 6 pm - 10 pm.*

2. RBL's from locations H1 (9 Greendale Road) and H2 (26 Loftus Road) were sourced from Hyder Consulting EIS 'Bringelly Brickworks and Quarry Expansion' 5 September 2013.

4.1.2 Amenity

The assessment of amenity is based on noise criteria specific to the land use. The criteria relate only to industrial noise and exclude road or rail noise. Where the measured existing industrial noise approaches recommended amenity criteria, it needs to be demonstrated that noise levels from new industry will not contribute to existing industrial noise such that criteria are exceeded.

Residential, industrial, and school assessment locations potentially affected by the project have been categorised in the INP suburban amenity category. The corresponding recommended amenity criteria for the subject site are given in Table 4.2.

Table 4.2 Amenity criteria

Assessment location	**Type of Receiver**	**Indicative area**	**Time period**	**Recommended noise level dB, $L_{Aeq,period}$**	
				Acceptable	**Maximum**
R1 -R21, R23	Residential	Suburban	Day[1]	55	60
			Evening	45	50
R22, Bringelly Public School	School classroom (internal)	All	Noisiest 1 hour period when in use	35	40
R24, Brickworks	Industrial	Industrial	When in use	70	75

Source: NSW INP (EPA 2000).

Notes: 1. Day: 7 am - 6 pm Monday - Saturday; 8 am - 6 pm Sundays and public holidays; Evening: 6 pm - 10 pm.

If existing industrial noise approaches the acceptable amenity criteria in Table 4.2, the criteria is to be adjusted to ensure the total industrial noise level, including project noise emissions, does not exceed the acceptable amenity criteria. This is achieved by applying modification factors in Table 4.3 based on existing industrial noise which are reproduced from Table 2.2 of the INP.

As described earlier, during attended noise monitoring at the site, existing industrial noise at the closest receivers was nil. However, this could differ at other times depending on operations at the neighbouring Boral Brickworks. Hence, predicted operational noise levels from the Brickworks were adopted (Hyder 2013). The resulting industrial noise levels were used to adjust the Acceptable Noise Level (ANL) where required, however, in most cases, no adjustment was needed.

Table 4.3 Modification to ANL to account for existing levels of industrial noise

Total existing L_{Aeq} noise level from industrial noise sources	**Maximum L_{Aeq} noise level for noise from new sources alone, dB**
≥ Acceptable noise level plus 2 dB	If existing noise level is likely to decrease in future acceptable noise level minus 10 dB If existing noise level is unlikely to decrease in future existing noise level minus 10 dB
Acceptable noise level plus 1 dB	Acceptable noise level minus 8 dB
Acceptable noise level	Acceptable noise level minus 8 dB
Acceptable noise level minus 1 dB	Acceptable noise level minus 6 dB
Acceptable noise level minus 2 dB	Acceptable noise level minus 4 dB
Acceptable noise level minus 3 dB	Acceptable noise level minus 3 dB
Acceptable noise level minus 4 dB	Acceptable noise level minus 2 dB

Table 4.3 Modification to ANL to account for existing levels of industrial noise

Total existing L_{Aeq} noise level from industrial noise sources	Maximum L_{Aeq} noise level for noise from new sources alone, dB
Acceptable noise level minus 5 dB	Acceptable noise level minus 2 dB
Acceptable noise level minus 6 dB	Acceptable noise level minus 1 dB
< Acceptable noise level minus 6 dB	Acceptable noise level

Notes: ANL = recommended acceptable L_{Aeq} noise level for the specific receiver, area and time of day from Table 4.2.

4.1.3 Project specific noise level

The project-specific noise level (PSNL) is the lower of the calculated intrusive or amenity criteria and is provided in Table 4.4 for all assessment locations.

Although no audible industrial noise was experienced during the attended measurement (10 September 2015), the results of attended noise monitoring conducted by Hyder (2013) show that industrial noise from the Brickworks is present for some assessment locations. It is most prominent around Loftus Road, and is generally more than 6 dB below the acceptable noise limit for assessment locations on Greendale Road. The amenity criteria presented in Table 4.4 have been adjusted where necessary (ie when the existing industrial noise level approaches the acceptable noise levels presented in Table 4.3).

Table 4.4 Project specific noise levels

Location	Period[1]	Intrusive criteria dB, $L_{Aeq,15min}$	Estimated existing industrial noise dB, $L_{Aeq,period}$	Amenity criteria dB, $L_{Aeq,period}$[2]	Project specific noise level (PSNL), dB
R1-R9	Day	40	<ANL -6[3]	55-60	40
	Evening	40	<ANL -6	45-50	40
R10	Day	46	<ANL -6	55-60	46
	Evening	45	<ANL -6	45-50	45
R11	Day	46	<ANL -6	55-60	46
	Evening	40	<ANL -6	45-50	40
R12	Day	46	<ANL -6	55-60	46
	Evening	45	<ANL -6	45-50	45
R13	Day	46	<ANL -6	55-60	46
	Evening	45	<ANL -6	45-50	45
R14	Day	46	<ANL -6	55-60	46
	Evening	45	<ANL -6	45-50	45
R15	Day	46	<ANL -6	55-60	46
	Evening	45	<ANL -6	45-50	45
R16	Day	40	<ANL -6	55-60	40
	Evening	40	<ANL -6	45-50	40
R17	Day	46	<ANL -6	55-60	46
	Evening	45	<ANL -6	45-50	45
R18	Day	46	<ANL -6	55-60	46
	Evening	45	<ANL -6	45-50	45

Table 4.4 Project specific noise levels

Location	Period[1]	Intrusive criteria dB, $L_{Aeq,15min}$	Estimated existing industrial noise dB, $L_{Aeq,period}$	Amenity criteria dB, $L_{Aeq,period}$[2]	Project specific noise level (PSNL), dB
R19	Day	46	<ANL -6	55-60	46
	Evening	45	<ANL -6	45-50	45
R20	Day	40	<ANL -6	55-60	40
	Evening	40	<ANL -6	45-50	40
R21	Day	40	<ANL -6	55-60	40
	Evening	40	<ANL -6	45-50	40
R22, Bringelly Public School	Noisiest 1 hour period when in use	n/a	<ANL -6	35-40	35-40 (internal)
R23	Day	46	47	55-60	46
	Evening	46	43	41	41 $L_{Aeq,evening}$ 46 $L_{Aeq,15min}$
R24, Brickworks	When in use	n/a	n/a	70-75	70

Notes: *1. Day: 7 am - 6 pm Monday - Saturday; 8 am - 6 pm Sundays and public holidays; evening: 6 pm - 10 pm.*

2. Amenity criteria have been adjusted where appropriate using predicted noise levels from Hyder (EIS 2013).

3. The existing industrial noise level is less than 6 dB below the acceptable noise level, and has therefore not been adjusted.

4.2 Construction noise

The ICNG (DECC 2009), provides guidelines for the assessment and management of noise from construction works. This assessment has adopted the ICNG quantitative approach, which is generally suited to longer-term construction.

i Noise management level

The ICNG suggests the following time restriction for construction activities where the noise is audible at residential premises:

- Monday to Friday 7 am - 6 pm;
- Saturday 8 am - 1 pm; and
- no construction work is to take place on Sundays or public holidays.

Table 4.5 is an extract from the ICNG and provides noise management levels for residential receivers for day and out of hours periods. These time restrictions are the primary management tool of the ICNG.

Table 4.5 ICNG residential noise management levels

Time of day	**Management level** $L_{Aeq,\ 15min}$	**How to apply**
Recommended standard hours: Monday - Friday 7 am - 6 pm Saturday 8 am - 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,15\text{-}min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • 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.
	Highly noise affected 75 dBA	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 relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: i) times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences; and ii) if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL +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 guidance on negotiating agreements see Section 7.2.2.

In summary, the ICNG noise management levels (NMLs) for activities during the standard hours are 10 dB above the existing background levels. For activities outside these hours, noise levels should be no more than 5 dB above the existing background levels. It is expected that construction activities for the project will occur during standard hours only.

The residential NMLs for construction and other sensitive land uses for the project are provided in Table 4.6. The NMLs for non-residences are as recommended in Table 3 of the ICNG.

Table 4.6 Construction noise management levels

Location	Day-time RBL, dB	Noise management level, $L_{Aeq,\ 15min,}$ dB
R1-R9	35	45
R10	41	51
R11	41	51
R12	41	51
R13	41	51
R14	41	51
R15	41	51
R16	35	45
R17	41	51
R18	41	51
R19	41	51
R20	35	45
R21	35	45
R22, Bringelly Public School (internal)	n/a	45
R23	41	51
R24, Brickworks	n/a	75

4.3 Road traffic noise

The potential impacts of traffic noise resulting from both the construction and operation of project related traffic on public roads are assessed against criteria defined in the RNP. The application of appropriate criteria for the project has followed the two step process identifying the assessment and relative increase criteria as outlined in Section 3.4.1 of the RNP.

Table 4.7 presents the road noise assessment criteria for residential land uses, reproduced from Table 3 of the RNP.

Table 4.7 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/development	Assessment criteria dB	
		Day (7 am–10 pm)	Night (10 pm–7 am)
Freeway/arterial/sub-arterial roads	Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors. Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors. Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments.	$L_{Aeq,15hr}$ 60 (external)	$L_{Aeq,9hr}$ 55 (external)

Additionally, the RNP states where existing road traffic noise criteria are already exceeded, any additional increase in total traffic noise level should be limited to 2 dB.

In addition to meeting the assessment criteria, any significant increase in total traffic noise at receptors due to a development must be considered. Receptors experiencing increases in total traffic noise levels above those presented in Table 4.8 should be considered for mitigation.

Table 4.8 Relative increase criteria for residential land uses

Road category	Type of project/development	Total traffic noise level increase, dB	
		Day (7 am - 10 pm)	Night (10 pm - 7 am)
Freeway/arterial/sub-arterial roads and transit ways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road.	Existing traffic $L_{Aeq,\ 15\text{-}hr}$+12 dB (external)	Existing traffic $L_{Aeq,9\text{-}hr}$+ 12 dB (external)

4.4 Operational and construction vibration

4.4.1 Human comfort

i General discussion on human perception of vibration

Humans are sensitive to vibration and they can detect vibration levels which are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not, in itself, be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2 1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in Table 4.9.

Table 4.9 Peak vibration levels and human perception of motion

Approximate vibration level	Degree of perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: *These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hz - 80 Hz.*

Source: *German Standard DIN 4150 Part 2 1975.*

Table 4.9 suggests that people will just be able to feel floor vibration at levels of about 0.15 mm/s and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

ii Assessing vibration a technical guideline

Environmental Noise Management – Assessing Vibration: a technical guideline (DEC 2006) is based on guidelines contained in *BS 6472 – 2008, Evaluation of human exposure to vibration in buildings (1-80Hz).*

The guideline BS 6472 – 2008 presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration levels below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration levels are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community member(s).

The guideline BS 6472 – 2008 defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 4.10.

Table 4.10 Examples of types of vibration

Continuous vibration	Impulsive vibration	Intermittent vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, eg occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990).	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is 3 or fewer these would be assessed against impulsive vibration criteria.

a. Intermittent vibration

Intermittent vibration (as defined in Section 2.1 of the guideline BS 6472 – 2008) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time. This is the most relevant type of vibration for the project.

Intermittent vibration is representative of activities such as impact hammering, rolling or general excavation work (such as an excavator tracking).

Section 2.4 of the guideline BS 6472 – 2008 provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted rms (root mean square) acceleration levels over the frequency range 1 Hz - 80 Hz. To calculate VDV the following formula is used (refer Section 2.4.1 of the guideline):

$$VDV = \left[\int_0^T a^4(t)dt \right]^{0.25}$$

Where VDV is the vibration dose value in m/s$^{1.75}$, *a (t)* is the frequency-weighted rms of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

The acceptable VDV for intermittent vibration are reproduced in 4.11 from Table 2.4.2 of *Assessing Vibration: a technical guideline* (DEC 2006).

Table 4.11 Acceptable vibration dose values for intermittent vibration

Location	Daytime		Night-time	
	Preferred value, m/s$^{1.75}$	Maximum value, m/s$^{1.75}$	Preferred value, m/s$^{1.75}$	Maximum value, m/s$^{1.75}$
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes: 1. Daytime is 7 am - 10 pm and night-time is 10 pm - 7 am.

2. These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration levels below the preferred values. Adverse comment or complaints may be expected if vibration levels approach the maximum values. The guideline states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

4.4.2 Structural vibration criteria

Most commonly specified "safe" structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure.

In terms of the most recent relevant vibration damage criteria, *Australian Standard (AS) 2187.2 - 2006 Explosives* - Storage *and Use - Use of Explosives* recommends the frequency dependent guideline values and assessment methods given in *BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2* be used as they are "applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 4.12 and graphically in Figure 3.1.

Table 4.12 Transient vibration guide values – minimal risk of cosmetic damage

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz - 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	N/A
2	Un-reinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

AS2187 states that the guide values in Table 4.12 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration gives rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 4.12 may need to be reduced by up to 50%.

Sheet piling activities (for example) are considered to have the potential to cause dynamic loading in some structures (eg residences) and it may, therefore, be appropriate to reduce the transient values by 50% for this activity.

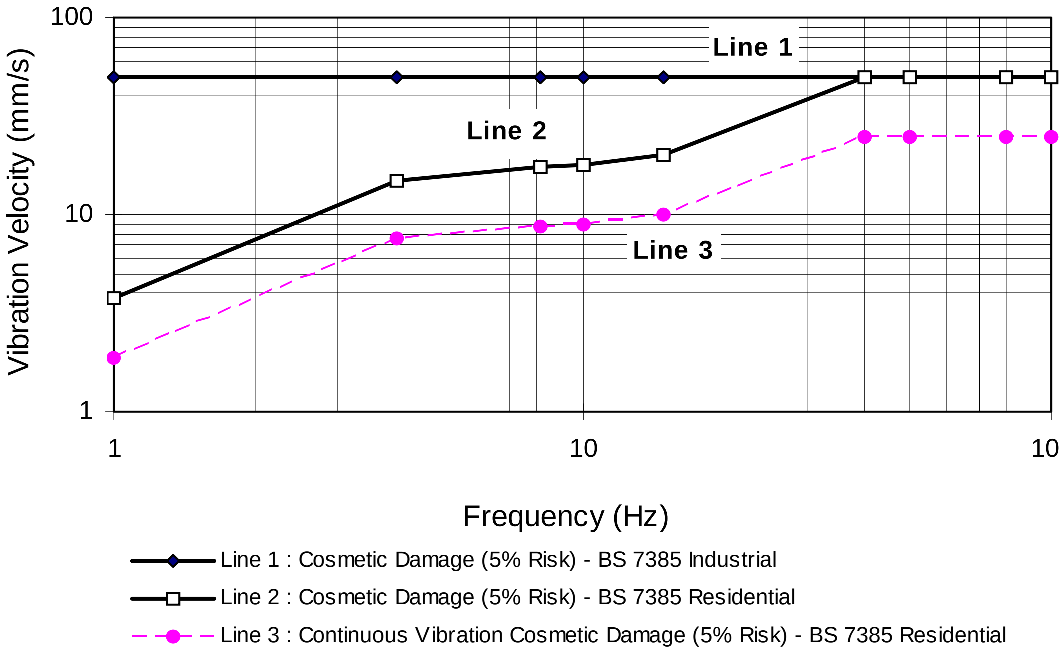


Figure 4.1 Graph of transient vibration guide values for cosmetic damage

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 4.12, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 4.12 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measurements should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Table 4.12.

It is noteworthy that, additional to the guide values nominated in Table 4.12, the standard states that:

> Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK.

Also that:

> A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

5 Noise modelling and assessment method

5.1 Operational noise assessment

5.1.1 Overview

This section presents the methods and base parameters used to model and assess the project's noise emissions.

Quantitative modelling of operational noise was undertaken using the ISO9613 algorithm with CONCAWE meteorology corrections within Brüel & Kjær Predictor Version 10.1 noise prediction software. This software calculates total noise levels at assessment locations from the concurrent operation of multiple noise sources. The model incorporates factors such as:

- the lateral and vertical location of plant and equipment;
- source-to-receiver distances;
- ground effects;
- atmospheric absorption;
- topography; and
- meteorological conditions.

Three-dimensional digitised ground contours of the site and surrounding land (supplied by Boral) were incorporated to model topographic effects. Equipment was modelled at locations and heights representative of potential operating scenarios for the project.

5.1.2 Modelled scenarios

Modelling was completed for day and evening periods (ie the operating periods for the project) for each meteorological condition presented in Table 5.1. Prevailing winds were identified for all source to receiver directions during the evening period (refer to Table 3.5). Therefore, wind effects were modelled to simulate downwind conditions for all assessment locations during the evening. The highest prevailing wind speed was chosen for all wind directions during the evening period.

Table 5.1 Modelled meteorological conditions

Assessment period	Meteorological condition	Air temperature °C	Relative humidity (%)	Wind speed (m/s)	Direction degrees from north
All periods	Calm	15	70	0	n/a
Day	Prevailing wind	15	70	2.4	68
Evening	Prevailing wind	10	90	2.2	All

5.1.3 Site generated heavy vehicle traffic

Heavy vehicle traffic associated with peak and average production scenarios considered in the assessment are presented in Table 5.2.

Table 5.2 Site generated heavy vehicle trips

Type of movements	Truck numbers
	Peak (hourly)
Concrete agitator	12
Cement tankers	1
Aggregate delivery truck (truck and dog)	2

5.1.4 Acoustically significant plant and equipment in noise model

Table 5.3 summarises the operational noise sources and associated sound power levels used in the noise model. The levels are based on measurements at similar Boral facilities, or otherwise have been supplemented using data taken from an EMM database of similar equipment.

Table 5.3 Plant and equipment sound power levels

Plant/equipment	Number in 15-min operating scenario	Sound power level, dB (Representative $L_{Aeq,15min}$)
Concrete agitator loading	1	113
Concrete agitator slumping	1	113
Aggregate delivery truck (truck and dog)[1]	1	102
Cement tanker (slow moving/idle)	1	102
Conveyor	3	73
Front end loader (<150 hp)[3]	1	98

Notes: *1. It is understood that aggregate deliveries and front end loader operation will not occur simultaneously. Aggregate delivery is 102 dB, and it operates for half of a 15 minute period. Aggregate delivery occurs up to 20 times a day, however, associated noise is relatively short in duration.*

2. Cement tanker deliver occurs no more than 7 times a day. Hence, modelling presented provides results with and without this source.

3. Front end loader <150 hp as per proponent's advice.

5.1.5 Operating assumptions

The main equipment operating assumptions for the model are as follows:

- conveyors operate continuously throughout the 15 minute assessment period;
- front end loader operates continuously throughout the 15 minute assessment period;
- concrete agitator trucks idle, load and slump for three minutes each throughout the 15 minute assessment period;
- onsite vehicle movements are under 20 km/hr;

- cement delivery trucks are modelled as a secondary scenario expected for up to seven times per day and, therefore, do not represent the norm;
- aggregate truck delivery operates for half of the 15 minute assessment period; and
- the front end loader does not operate when aggregate deliveries are taking place.

5.1.6 Noise mitigation

The following noise mitigation has been applied to the model:

- a 2 m high earth bund with a 2 m high solid wall/barrier is constructed around the northern and eastern perimeter of the project site;
- a 4 m high solid wall/barrier or along the western perimeter of the project site;
- reconfiguration of the site layout to maximise the effect of the perimeter barriers by placing plant close to and behind barriers;
- both the loading and slumping stands are partially enclosed in a clad building with 3 mm sheet metal, or standard 0.7 mm sheet metal with an internal lining (eg blue board), providing a minimum Rw of 36;
- the roofs of the slumping and loading enclosures are lined with acoustic absorption (minimum noise reduction coefficient of 0.6) to minimise reverberant noise and general noise breakout;
- mass loaded vinyl curtains with a density of at least 4 kg/m^2 are provided to the exit of the slump bay structure;
- slumping bay vinyl curtains remain closed during all slumping activity; and
- the slumping stand enclosure has dimensions of at least 19 m x 8 m x 5 m, with a volume of at least 760 m^3.

5.2 Construction assessment

Construction noise levels have been predicted at the nearest assessment locations outlined in Table 3.1 using the computerised acoustic model developed for the operational noise assessment using Brüel & Kjær Predictor Version 10.1 software.

Construction noise emissions have been modelled assuming an even distribution of construction equipment throughout the site over an ICNG 15 minute assessment period. The following construction scenarios have been modelled:

- Scenario 1: bulk earth works clearing trees;
- Scenario 2: concrete footings, water pits and other concreting works; and
- Scenario 3: plant install and commissioning.

It is understood that all scenarios are expected to last approximately one month.

5.2.1 Acoustically significant plant and equipment

The construction noise impact assessment has adopted equipment noise emission values obtained from the EMM noise database for similar equipment. Table 5.4 summarises typical equipment items for each scenario, assumed sound power levels, and quantities adopted in the noise modelling.

Table 5.4 Typical construction equipment

Scenario	Equipment	Quantity	Sound power level, dB(Representative $L_{Aeq,\ 15min}$)[1]
1	Excavator (20 tonne)	1	102
	Chainsaw	1	104
	Mobile wood chipper	1	115
2	Air powered nail gun	2	82
	Circular saw	2	101
	Concrete pump & agitator	1	104
	Concrete placing vibrators	3	79
3	Semi-trailer delivery of steel	1	103
	Crane (80 tonne)	1	104
	Power tools (eg angle grinder)	2	104

Notes: 1. The $L_{Aeq,15\ min}$ noise level is the energy average noise level over a 15 minute assessment period.

5.3 Road traffic noise assessment

The Calculation of Road Traffic Noise (CORTN) (UK Department of Transport) method was used to predict $L_{Aeq,15hr}$ and $L_{Aeq,1hr}$ noise levels at adjacent receptors from additional traffic travelling east and west along Greendale Road. CORTN, which was developed by the UK Department of Transport, considers traffic flow volume, average speed, percentage of heavy vehicles and road gradient to establish noise source strength. It also includes attenuation due to distance, ground and screening from buildings or barriers. The assessment locations assessed in the calculation were the residence with the nearest facade to Greendale Road and Bringelly Public School.

The nearest residential assessment locations to the proposed delivery haulage and agitator trucks will be located on Greendale Road. A great majority of the traffic from the project will be travelling to and from the east. Beyond Greendale Road, heavy vehicle traffic volumes will gradually distribute into other major roads and volumes will likely become relatively less significant. Greendale Road was considered as a sub-arterial road for the purpose of this assessment.

The existing traffic volumes using the road network in the locality of Bringelly has been determined by peak hour traffic surveys at two intersections undertaken in October 2015. In addition to the major road access intersection at Greendale Road, Bringelly Road and Northern Road, the peak hourly traffic volumes at the Brickworks access with Greendale Road were surveyed to determine the current traffic volumes for Greendale Road at the project site frontage and the Brickworks. Existing and project related traffic movements considered in the road traffic noise assessment are provided in Table 5.5.

Table 5.5 Summary of assessed existing and additional daily traffic movements

Location	Assessment location	Period	Existing average week day traffic [1]	Existing average week day heavy vehicles [2]	Additional future project site daily traffic	Additional future project site daily heavy vehicles
East of project site and west of the Brickworks	R1, R10, R11	Day	1521	75	113	100
		Night	169	9	0	0
		Total	1690	85	113	100
East of the Brickworks	R11-R14	Day	1881	195	113	100
		Night	209	22	0	0
		Total	2090	218	113	113
West of the project site	R3-R9	Day	1521	75	13	12
		Night	169	9	0	
		Total	1690	85	13	12
East of the Brickworks	R22, Bringelly Public School	When in use	206[3]	21	113	100

Note *1. Average daily traffic is estimated as 10.5 times the average peak hourly traffic for all roads. Daily heavy vehicle numbers and their % have been extrapolated from the am and pm peak period heavy vehicle traffic proportions. Road traffic volume data split 90% into day and 10% into night.*

2. Heavy vehicles: 5.4% west of the Brickworks, 10.4% east of the Brickworks.

3. This is a peak hour volume as required for assessment per the RNP.

6 Noise assessment

6.1 Operational noise modelling results

The $L_{Aeq,15min}$ noise levels have been predicted for calm and prevailing wind meteorological conditions for day and evening periods.

Modelling Scenarios 1 and 2 were developed to represent $L_{Aeq,15min}$ noise levels during peak production with and without a cement tanker delivery occurring, respectively. As cement tanker deliveries will only occur at a maximum of seven times per day, the $L_{Aeq,15min}$ noise level predictions for Scenario 1 are considered representative of worst case operations.

Scenario 2 is, therefore, a more appropriate representation of the project's average $L_{Aeq,15min}$ noise levels, as the predicted levels in Scenario 1 will only occur if a cement tanker delivery is occurring (maximum seven times a day) and all other proposed operations coincide with this (ie there are trucks loading, slumping, and transiting through the site, as well as the FEL operating and a cement tanker delivery occurring).

Table 6.1 presents the predicted noise levels for Scenarios 1 and 2. $L_{Aeq,15min}$ noise levels are predicted to comply with INP intrusive criteria for all assessment locations, during all periods and assessed meteorological conditions, except for assessment location R1. This is subject to the implementation of all feasible and reasonable operational noise mitigation (refer to Section 8.1). No further measures are considered feasible and the residue noise levels are not considered significant for R1.

It is evident that when the CBP is operating without a cement tanker delivery occurring, the impact on It is noted that the Bringelly Community Centre is located adjacent to the Bringelly Public School. The INP defines such a land use as a commercial receiver, and therefore is not considered as noise sensitive as Bringelly Public School. As predicted noise levels satisfy relevant noise criteria at Bringelly Public School, it is considered that they will also satisfy relevant (less onerous) noise criteria at the Bringelly Community Centre. surrounding receivers is reduced, by up to 3 dB at some assessment locations.

Table 6.1 Predicted operational noise levels

Assessment location	**Period**	**Predicted noise level, $L_{Aeq,15min}$, dB**				**PSNL, $L_{Aeq,15min}$, dB**
		Scenario 1		**Scenario 2**		
		Calm	**Prevailing wind**	**Calm**	**Prevailing wind**	
R1	Day	**44**	**43**	**44**	**43**	40
	Evening	**44**	**45**	**44**	**44**	40
R2	Day	37	34	35	32	40
	Evening	37	39	35	37	40
R3	Day	38	40	36	38	40
	Evening	38	40	36	38	40
R4	Day	36	39	33	36	40
	Evening	36	39	33	36	40
R5	Day	35	38	31	34	40
	Evening	35	38	31	34	40

Table 6.1 Predicted operational noise levels

Assessment location	Period	Predicted noise level, $L_{Aeq,15min}$, dB				PSNL, $L_{Aeq,15min}$, dB
		Scenario 1		Scenario 2		
		Calm	Prevailing wind	Calm	Prevailing wind	
R6	Day	33	36	<30	32	40
	Evening	33	36	<30	32	40
R7	Day	37	40	36	38	40
	Evening	37	40	36	38	40
R8	Day	33	36	31	34	40
	Evening	33	36	31	34	40
R9	Day	34	36	32	35	40
	Evening	34	36	32	35	40
R10	Day	35	32	34	32	46
	Evening	35	37	34	37	45
R11	Day	33	30	33	30	46
	Evening	33	35	33	35	40
R12	Day	30	<30	<30	<30	46
	Evening	30	33	<30	32	45
R13	Day	<30	<30	<30	<30	46
	Evening	<30	31	<30	30	45
R14	Day	<30	<30	<30	<30	46
	Evening	<30	30	<30	30	45
R15	Day	<30	<30	<30	<30	46
	Evening	<30	<30	<30	<30	45
R16	Day	31	<30	30	<30	40
	Evening	31	33	30	33	40
R17	Day	<30	<30	<30	<30	46
	Evening	<30	<30	<30	<30	45
R18	Day	<30	<30	<30	<30	46
	Evening	<30	30	<30	30	45
R19	Day	<30	<30	<30	<30	46
	Evening	<30	32	<30	31	45
R20	Day	31	<30	31	<30	40
	Evening	31	34	31	34	40
R21	Day	32	<30	32	<30	40
	Evening	32	35	32	35	40
R22, Bringelly Public School (internal)	When in use	<30	<30	<30	<30	46
R23	Day	<30	<30	<30	<30	39
	Evening	<30	<30	<30	30	39
R24, Brickworks	When in use	45	47	44	46	70

6.2 Construction noise

As discussed in Section 5.2, there are three construction assessment scenarios that have been modelled as follows:

- Scenario 1: bulk earth works clearing trees;
- Scenario 2: concrete footings, water pits and other concreting works; and
- Scenario 3: plant install and commissioning.

Table 6.2 presents the Scenario 1 minimum and maximum $L_{Aeq,15min}$ noise level predictions from construction, the relevant NML and exceedance level above the NML, which is 0 dB (or no exceedance) for all assessment locations, except R1-R5, R10 and R11. In Scenario 1 the mobile wood chipper is contributing largely to the exeedances at the aforementioned assessment locations. It is likely that the impacts from the mobile wood chipper will be temporary.

Table 6.2 Scenario 1 predicted operational noise levels for construction operations $L_{Aeq,15-min}$

Location	Period	Predicted minimum construction noise level, dB	Predicted maximum construction noise level, dB	NML, dB	Exceedance above NMLs, dB
R1	Day	52	64	45	7-19
R2	Day	46	52	45	1-7
R3	Day	43	50	45	0-4
R4	Day	41	48	45	0-3
R5	Day	39	47	45	0-2
R6	Day	37	45	45	0
R7	Day	38	44	45	0
R8	Day	36	38	45	0
R9	Day	34	40	45	0
R10	Day	45	54	51	0-3
R11	Day	43	52	51	0-1
R12	Day	41	44	51	0
R13	Day	39	46	51	0
R14	Day	37	41	51	0
R15	Day	36	43	51	0
R16	Day	40	46	45	0
R17	Day	37	44	51	0
R18	Day	38	45	51	0
R19	Day	47	39	51	0
R20	Day	40	47	45	0
R21	Day	41	49	45	0
R22, Bringelly Public School (internal)	When in use	32	38	45	0
R23	Day	32	34	51	0
R24, Brickworks	When in use	51	57	75	0

Table 6.3 presents the Scenario 2 minimum and maximum $L_{Aeq,15min}$ noise level predictions from construction, the relevant NML and exceedance level above the NML, which is 0 dB (or no exceedance) for all assessment locations, except assessment location R1. Construction operations in this Scenario are expected to vary, and it is highly unlikely that the worst-case noise levels that are predicted in the noise model would occur continuously throughout the daily construction period (ie 7 am-6 pm Monday-Friday and 8 am-1 pm Saturday).

Table 6.3 Scenario 2 predicted operational noise levels for construction operations $L_{Aeq,15\text{-}min}$

Location	Period	Predicted minimum construction noise level, dB	Predicted maximum construction noise level, dB	NML, dB	Exceedance above NMLs, dB
R1	Day	42	49	45	0-4
R2	Day	36	37	45	0
R3	Day	36	41	45	0
R4	Day	34	36	45	0
R5	Day	32	35	45	0
R6	Day	<30	32	45	0
R7	Day	30	37	45	0
R8	Day	<30	32	45	0
R9	Day	<30	32	45	0
R10	Day	35	38	51	0
R11	Day	34	36	51	0
R12	Day	32	34	51	0
R13	Day	<30	32	51	0
R14	Day	<30	30	51	0
R15	Day	<30	<30	51	0
R16	Day	<30	32	45	0
R17	Day	<30	<30	51	0
R18	Day	<30	<30	51	0
R19	Day	<30	32	51	0
R20	Day	<30	33	45	0
R21	Day	32	34	45	0
R22, Bringelly Public School (internal)	When in use	<30	<30	51	0
R23	Day	<30	<30	51	0
R24, Brickworks	When in use	41	45	75	0

Table 6.4 presents the Scenario 3 minimum and maximum $L_{Aeq,15min}$ noise level predictions from construction, the relevant NML and exceedance level above the NML, which is 0 dB (or no exceedance) for all assessment locations, except for assessment location R1. Again, construction operations in this Scenario are expected to vary, and it is highly unlikely that the worst-case noise levels that are predicted in the noise model would occur continuously throughout the daily construction period (ie 7 am-6 pm Monday-Friday and 8 am-1 pm Saturday).

Table 6.4 Scenario 3 predicted operational noise levels for construction operations $L_{Aeq,15\text{-}min}$

Location	Period	Predicted minimum construction noise level, dB	Predicted maximum construction noise level, dB	NML, dB	Exceedance above NMLs, dB
R1	Day	45	49	45	0-4
R2	Day	39	41	45	0
R3	Day	39	45	45	0
R4	Day	37	40	45	0
R5	Day	35	37	45	0
R6	Day	33	35	45	0
R7	Day	33	39	45	0
R8	Day	32	35	45	0
R9	Day	30	35	45	0
R10	Day	38	43	51	0
R11	Day	37	39	51	0
R12	Day	35	37	51	0
R13	Day	33	35	51	0
R14	Day	31	33	51	0
R15	Day	31	32	51	0
R16	Day	33	36	45	0
R17	Day	31	33	45	0
R18	Day	35	32	51	0
R19	Day	33	37	51	0
R20	Day	34	37	45	0
R21	Day	35	37	45	0
R22, Bringelly Public School (internal)	When in use	<30	<30	51	0
R23	Day	<30	<30	51	0
R24, Brickworks	When in use	38	43	75	0

In summary, maximum $L_{Aeq,15min}$ noise levels generated by the construction of the project are predicted to satisfy the ICNG NMLs for all assessment locations, except R1-R5, R10 and R11 in Scenario 1, and R1 in Scenario 1 and Scenario 2. None of the maximum noise levels predicted in the noise model exceed the ICNG highly affected noise criterion of 75 dB.

It is accepted that construction noise levels are constantly varying, and impacts are temporary. It is likely that if noise levels exceed the project's NML at an assessment location, it will be for a short-period of time. Further, the proponent will manage and minimise the potential for construction noise impacts from site, as discussed further in Section 8.2.

6.3 Road traffic noise

The predicted road traffic noise levels are presented in Table 6.5, which are based on traffic volumes in Table 5.5.

Table 6.5 Predicted road traffic noise levels

Location	Assessment location	Period	Distance from road to nearest façade (m)	RNP criteria	Predicted road traffic noise level, dB		
					Existing[1]	Proposed	Existing + proposed
East of project site, west of Brickworks	R1, R10, R11	Day	40	60 $L_{Aeq,15hr}$	53 $L_{Aeq,15hr}$	49 $L_{Aeq,15hr}$	54 $L_{Aeq,15hr}$
East of Brickworks	R11-R14	Day	25	60 $L_{Aeq,15hr}$	57 $L_{Aeq,15hr}$	54 $L_{Aeq,15hr}$	59 $L_{Aeq,15hr}$
West of project site	R3-R9	Day	25	60 $L_{Aeq,15hr}$	56 $L_{Aeq,15hr}$	46 $L_{Aeq,15hr}$	56 $L_{Aeq,15hr}$
East of Brickworks	Bringelly Public School	When in use	25	40 $L_{Aeq,1hr}$ (internal)	**Windows open**		
					50 $L_{Aeq,1hr}$	41 $L_{Aeq,1hr}$	51 $L_{Aeq,1hr}$
					Windows closed		
					40 $L_{Aeq,1hr}$	31 $L_{Aeq,1hr}$	41 $L_{Aeq,1hr}$

Notes: *1. Predictions were validated using the Logger L1 L_{Aeq} results for the 15 hour day period (refer to Appendix A).*

2. Predicted noise level at nearest facade locations to Greendale Road were taken at a representative worst case distance of 25m and 15m for the nearest residence on Greendale Road and Bringelly Public School, respectively.

3. Predicted noise levels include a 2.5 dB facade correction as required by the RNP.

4. Traffic volumes from the project were split 90% to the east and 10% to the west of the project site.

Road traffic noise level predictions demonstrate RNP criteria can be achieved for day periods (ie the operating periods of the project) for all residences. A marginal 1 dB increase is predicted for Bringelly Public School. The RNP states that "an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person" (RNP 2011). Therefore, the road traffic noise levels are expected to satisfy the RNP requirements.

Traffic volumes during the construction of the project are expected to be less than the operational phase and, therefore, road traffic noise impacts during construction are also considered highly unlikely.

6.4 Cumulative noise

The INP amenity criteria accounts for total industrial noise levels in the area including noise from the project (ie the Brickworks). At the time of writing, there were no other proposed developments, including proposed modifications, in the area surrounding the project. The assessment provided herein is representative of cumulative noise levels at nearest assessment locations which are shown to remain below INP amenity noise levels.

7 Vibration assessment

7.1 Construction

7.1.1 Ground-borne vibration (safe working distances)

As a guide, safe working distances for typical items of vibration intensive plant are listed in Table 7.1. The safe working distances are quoted for both “Cosmetic Damage” (refer British Standard BS 7385) and “Human Comfort” (refer British Standard BS 6472-1).

Table 7.1 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/description	Safe working distance	
		Cosmetic damage (BS 7385)	**Human response (BS 6472)**
Vibratory roller	<50kN (Typically 1-2 tonnes)	5 m	15 - 20 m
	<100kN (Typically 2-4 tonnes)	6 m	20 m
	<200kN (Typically 4-6 tonnes)	12 m	40 m
	<300kN (Typically 7-13 tonnes)	15 m	100 m
	>300kN (Typically 13-18 tonnes)	20 m	100 m
	>300kN (>18 tonnes)	25 m	100 m
Small hydraulic hammer	(300 kg -5 - 12t excavator)	2 m	7 m
Medium hydraulic hammer	(900 kg -12 - 18t excavator)	7 m	23 m
Large hydraulic hammer	(1600 kg -18 - 34t excavator)	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Source: Transport Infrastructure Development Corporation Construction Noise Strategy (Rail Projects), November 2007.

The safe working distances presented in Table 7.1 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

In relation to human comfort (response), the safe working distances in Table 7.1 relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed, as discussed in BS 6472-1.

7.1.2 Summary of potential vibration impacts

The nearest residential structure is approximately 120 m north-east of the project site. The nearest industrial building to the site is approximately 600 m south-east of the project site. It is, therefore, envisaged that vibration impacts on surrounding assessment locations are unlikely during the construction phase of the project.

7.2 Operation

The most significant source of vibration associated with the project would be heavy vehicle movements. Heavy vehicle movements on site would be classified as an intermittent source of vibration as the trucks come and go over the course of a day.

There is low risk in heavy vehicle movements within the boundaries of the site generating an adverse reaction to vibration. The US Federal Transport Authority (FTA) document "*Transit Noise and Vibration Impact Assessment* (May 2006) suggests that transport projects involving rubber tyred vehicles are unlikely to cause vibration impacts unless in unusual situations. Unusual situations could be where there are vibration sensitive buildings (eg theatres, research facilities) in proximity to the site. EMM understands that no such facilities are in proximity to the project site.

The RNP (EPA 2010) provides limited guidance on vibration assessment for heavy vehicle movements, but states that vehicles operating on a roadway are unlikely to cause a perceptible level of vibration, particularly if the receiver is more than 20 m from the road. This is the case for all residential locations surrounding the project which would be most sensitive to vibration.

Furthermore, as the human comfort criteria are more stringent than the building damage criteria, it is expected that there is even less risk of cosmetic damage criteria being exceeded.

On this basis, operational vibration impacts from the project are considered unlikely.

8 Management and mitigation

8.1 Operations noise

The proponent will implement the following noise mitigation measures at the project:

- construct a 2 m high earth bund with a 2 m high solid wall/barrier around the northern and eastern perimeter of the site;
- construct a 4 m high solid wall/barrier or 2 m high earth bund with a 2 m high solid wall along the western perimeter of the site, so that in conjunction with existing or modified topography, a continuous 4 m high solid object lines the western perimeter;
- reconfigure the fixed site plant layout to maximise the benefits of perimeter barriers;
- partially enclose both the loading and slumping bays in a clad building with 3 mm sheet metal, or standard 0.7 mm sheet metal with an internal lining (eg blue board), providing a minimum Rw of 36;
- ensure the slumping loading bay enclosures have a volume of at least 760 m^3 and 355 m^3, and dimensions of approximately 19 m x 8 m x 5 m and 9.5 m x 8 m x 5 m, respectively;
- line the roofs of the slumping and loading enclosures with acoustic absorption (minimum noise reduction coefficient of 0.6) to minimise reverberant noise and general noise breakout;
- install mass loaded vinyl curtains with a density of at least 4 kg/m^2 on the exit of the slump bay enclosure; and
- keep slumping bay vinyl curtains closed during all slumping activity.

8.2 Negotiation process

8.2.1 Residual noise impacts (INP Section 8.2.1)

Assessment location R1 is the only residence with residual noise impacts. The residual impacts exceed criteria by 5 dB during a worst case operational scenario and adverse weather conditions.

The most recent published qualitative guidance on noise impacts is in the Voluntary Land Acquisition and Mitigation Policy (VLAMP) (NSW Government 2014). The VLAMP describes these impacts, which have been reproduced in Table 8.1.

Table 8.1 Characterisation of noise impacts & potential treatments

Residual noise exceeds INP criteria by	Characterisation of impacts	Potential treatment
0-2dB(A) above the project specific noise level (PSNL)	Impacts are considered to be negligible	The exceedances would not be discernable by the average listener and therefore would not warrant receiver based treatments or controls
3-5dB(A) above the PSNL in the INP but the development would contribute less than 1dB to the total industrial noise level	Impacts are considered to be marginal	Provide mechanical ventilation / comfort condition systems to enable windows to be closed without compromising internal air quality / amenity.
3-5dB(A) above the PSNL in the INP and the development would contribute more than 1dB to the total industrial noise level	Impacts are considered to be moderate	As for marginal impacts but also upgraded façade elements like windows, doors, roof insulation etc. to further increase the ability of the building façade to reduce noise levels.
>5dB(A) above the PSNL in the INP	Impacts are considered to be significant	Provide mitigation as for moderate impacts and see voluntary land acquisition provisions below.

Source: Table 1 page 13 of VLAMP (NSW Government 2014).

According to Table 8.1, if residual noise exceeds the INP criteria by 3-5 dB (A), and the project would contribute more than 1 dB to the total industrial noise level, the impacts are considered to be moderate.

The VLAMP also provides potential treatments for the various levels of defined impacts.For moderate impacts these are (from VLAMP):

- provide mechanical ventilation/comfort condition systems to enable windows to without compromising internal air-quality/amenity; and
- upgraded façade elements like windows, doors, and roof insulation etc. to further increase the ability of the building façade to reduce noise levels.

Section 8.2.1 of the INP lists issues to be considered if predicted noise levels exceed the PSNLs after feasible and reasonable mitigation has been applied. It states that:

> Where proposed mitigation measures will not reduce noise levels to the project-specific noise levels, the proponent should seek to negotiate with the regulatory/consent authority to demonstrate that all feasible and reasonable mitigation measures have been applied.

And also:

> Where, in the final analysis, the level of impact would still exceed the project-specific noise levels, the economic and social benefits flowing from the proposed development to the community should be evaluated against the undesirable noise impacts.

Boral considers that all feasible and reasonable mitigation measures have been proposed for the site, as listed in Section 8.1 above. Considering that the project is aiding in The Northern Road and Bringelly Road upgrades, it is contributing to related benefits for the community.

8.3 Construction

8.3.1 Noise

Construction of the project is expected to take approximately three and a half months. Maximum noise levels generated by the proposed construction are predicted to satisfy the ICNG NMLs for all assessment locations, with exceptions being R1-R5, R10 and R11 in Scenario 1, and R1 in Scenario 1 and 2. It is unlikely that noise levels at assessment locations R1-R5, R10 and R11 will regularly exceed the NML for the project. However, by managing the order of construction events, such as building the 2 m high earth bund and 2 m high solid wall around the northern, eastern and western perimeters first, the noise impacts on relevant assessment locations will be largely reduced.

The proponent will also manage construction noise from the site by adopting universal work practices such as:

- constructing during ICNG standard hours only;
- regular reinforcement (such as at toolbox talks) of the need to minimise noise and vibration;
- regular identification of noisy activities and adoption of improvement techniques;
- avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby residents;
- developing routes for the delivery of materials and parking of vehicles to minimise noise;
- where possible, avoiding the use of equipment that generates impulsive noise;
- minimising the need for vehicle reversing for example, by arranging for one-way site traffic routes;
- use of broadband audible reverse alarms on vehicles and elevated work platforms used on site;
- minimising the movement of materials and plant and unnecessary metal-on-metal contact; and
- scheduling respite periods for intensive works.

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 site contact details.

8.3.2 Vibration

a. Vibration monitoring

As the safe working distances in Section 7.1 will not be encroached, vibration monitoring is not considered necessary at nearby structures.

9 Conclusion

EMM has completed a noise and vibration assessment for a proposed mobile concrete batching plant at Lot 100 DP 1203966 Greendale Road, Bringelly, NSW. The concrete batching plant has an intended production capacity of 125,000 tpa to service the Bringelly Road upgrade and other future road and infrastructure upgrades in the area.

The assessment found that operating noise from the project during peak production is predicted to satisfy INP intrusive noise criteria for day, evening, night and morning shoulder periods at most assessment locations, with the exception being assessment location R1. This is subject to the implementation of all feasible and reasonable operational noise mitigation provided in Section 8.1. No further measures are considered feasible and the residue noise levels are not considered significant for R1.

Noise levels from the project construction are predicted to satisfy the ICNG NMLs at all assessment locations for a large majority of the construction period. The proponent will nonetheless manage construction noise from the project by adopting the recommended noise management and mitigation measures.

Road traffic noise level predictions demonstrate that RNP criteria will be achieved for peak hour periods at all residences. A marginal 1 dB increase above existing road traffic noise levels is predicted for Bringelly Public School.

The assessment has also considered potential construction and operational vibration impacts from the project. The nearest residential building to the site is positioned 120 m north-east of the project. It is, therefore, envisaged, that vibration from the project is unlikely to impact any surrounding assessment locations.

References

Environment Protection Authority (EPA) 2000, *NSW Industrial Noise Policy* (INP)

NSW Department of Environment Climate Change and Water (DECCW) 2011, *Road Noise Policy* (RNP)

NSW Environmental Protection Authority (EPA) 2009, *The Interim Construction Noise Guideline* (ICNG)

NSW Government 2014 *Voluntary Land Acquisition and Mitigation Policy* (VLAMP)

Department of Environment and Conservation NSW 2006, *Assessing Vibration: a technical guideline*

Hyder Consulting Pty Ltd (Hyder) 2013, *Bringelly Brickworks and Quarry Expansion Environmental Impact Statement* (EIS)

Appendix A

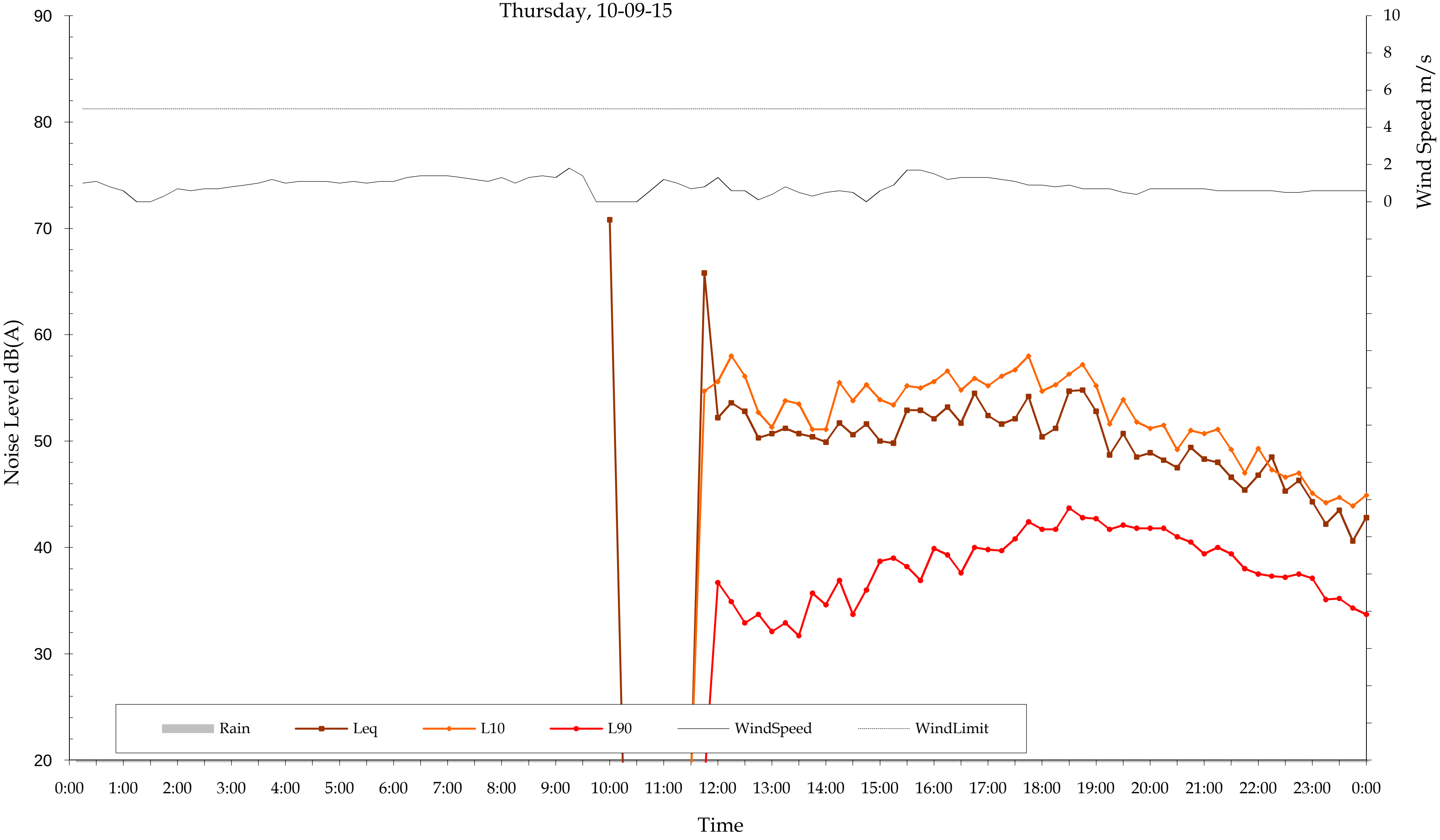
Noise logging daily results and charts

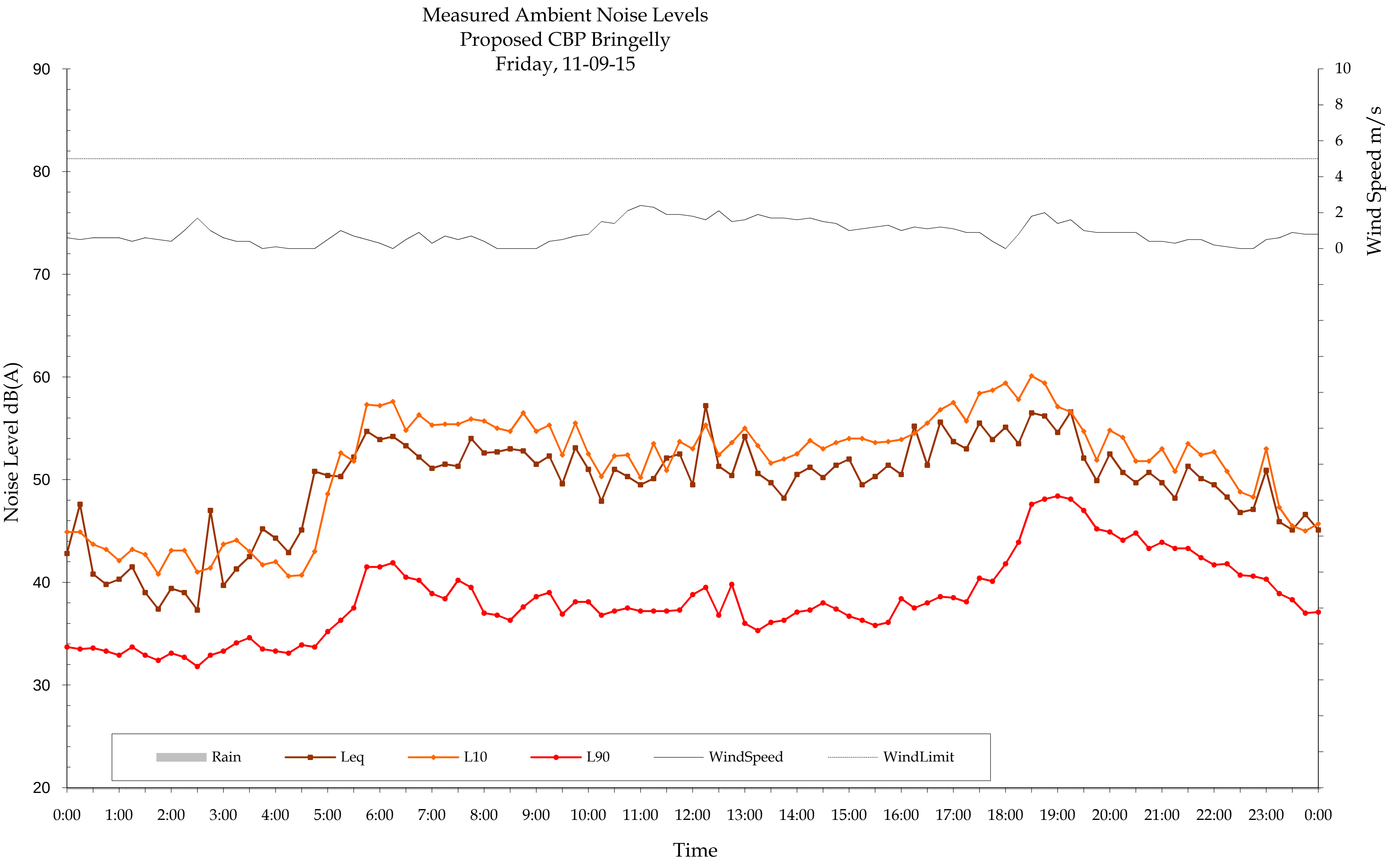
Table A.1 Summary of daily noise logging results Logger L1

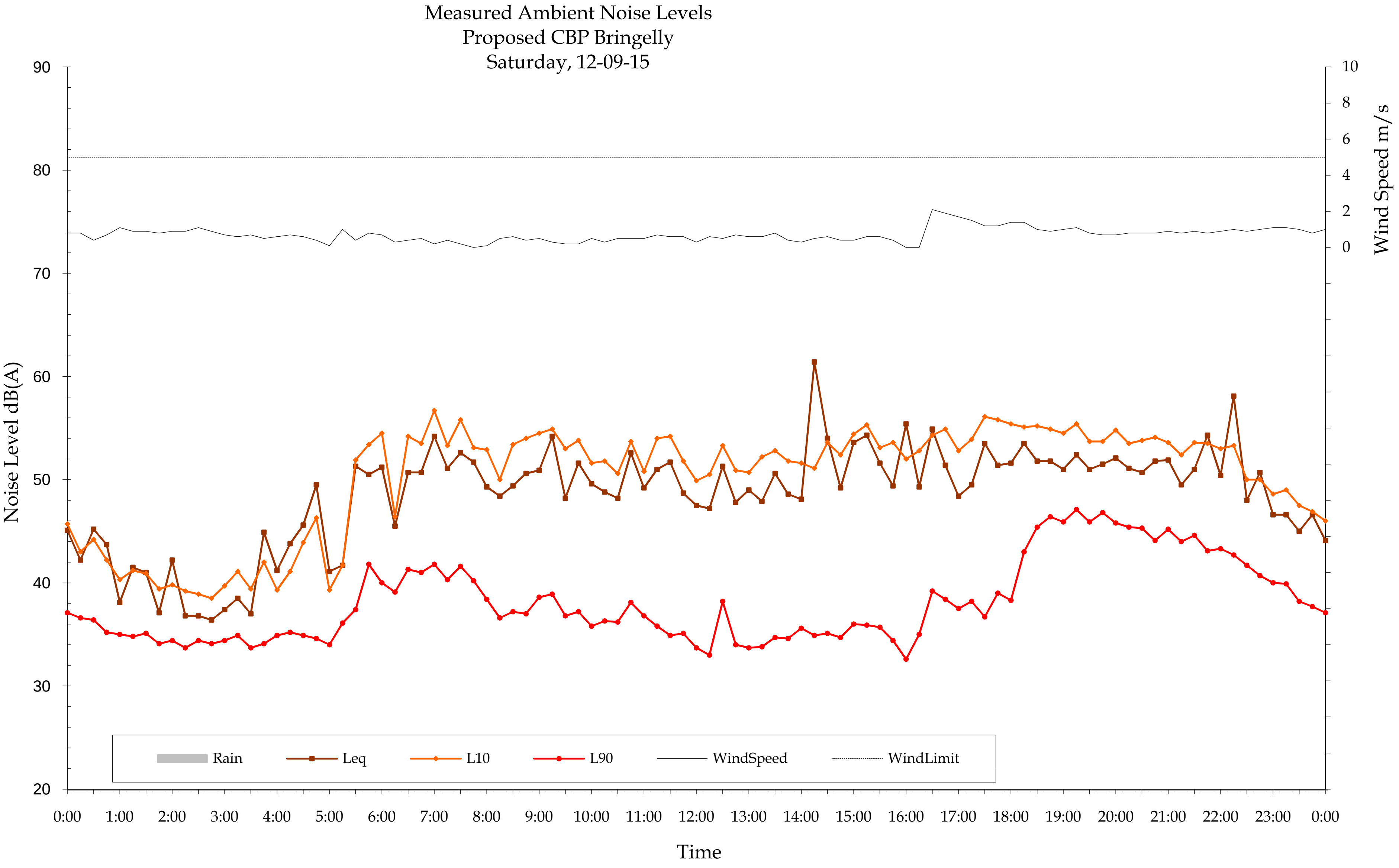
Date	ABL Day	ABL Evening	ABL Night	L_{eq} 11hr day	L_{eq} 4hr evening	L_{eq} 9hr night
Thursday, 10-09-15	0	38	33	0	50	48
Friday, 11-09-15	36	42	34	52	53	47
Saturday, 12-09-15	34	43	34	52	52	46
Sunday, 13-09-15	33	44	35	51	52	49
Monday, 14-09-15	36	46	35	52	52	50
Tuesday, 15-09-15	37	42	33	52	52	49
Wednesday, 16-09-15	34	37	32	52	49	48
Thursday, 17-09-15	34	0	31	51	0	49
Friday, 18-09-15	35	40	0	51	50	0
Saturday, 19-09-15	36	42	33	52	51	45
Sunday, 20-09-15	34	44	32	52	51	48
Monday, 21-09-15	0	0	0	0	0	0
Overall (RBL)	35	42	33	52	51	48

Notes: 1. '0' indicates insufficient data due to adverse weather conditions.

Measured Ambient Noise Levels
Proposed CBP Bringelly
Thursday, 10-09-15

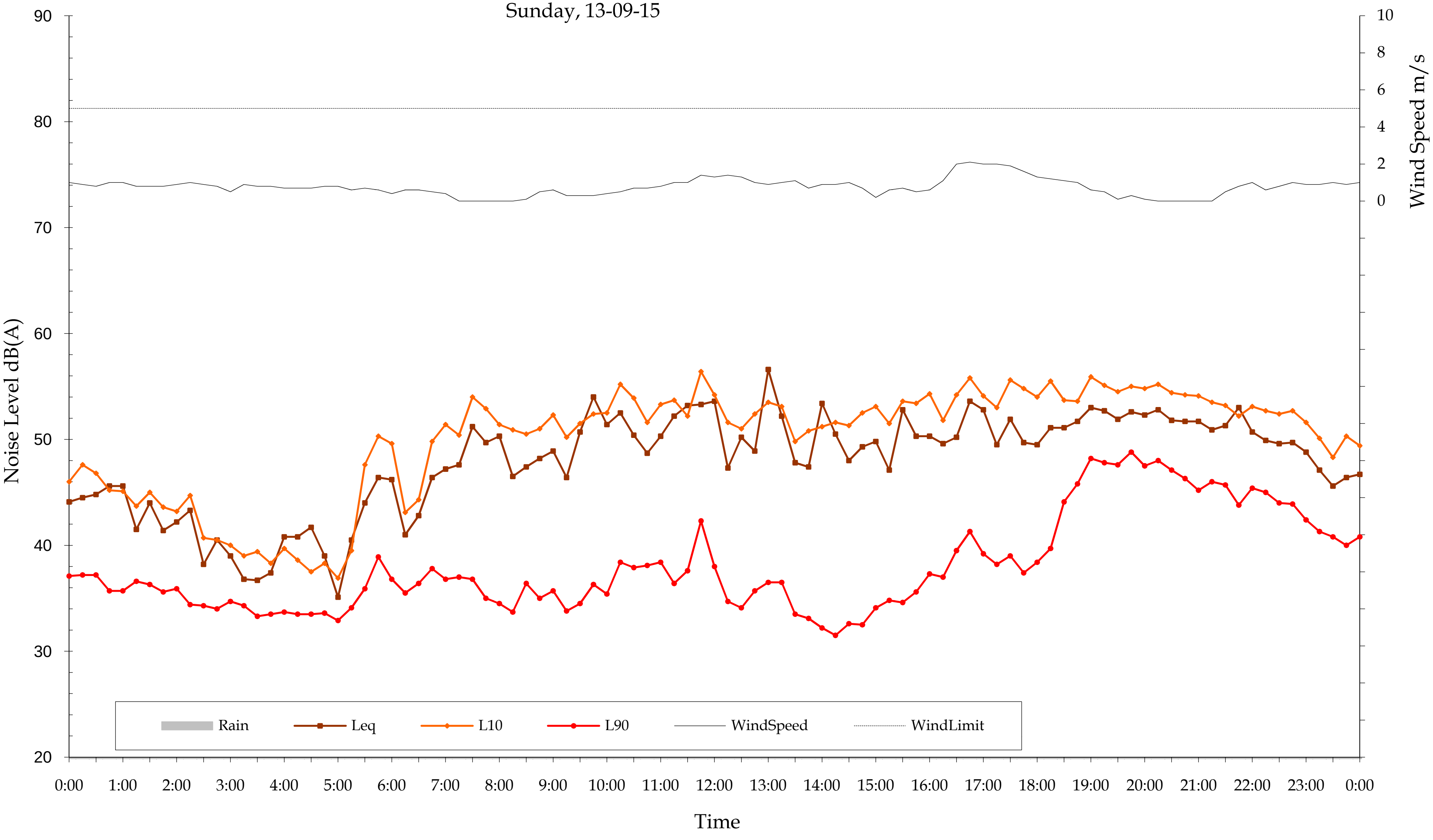


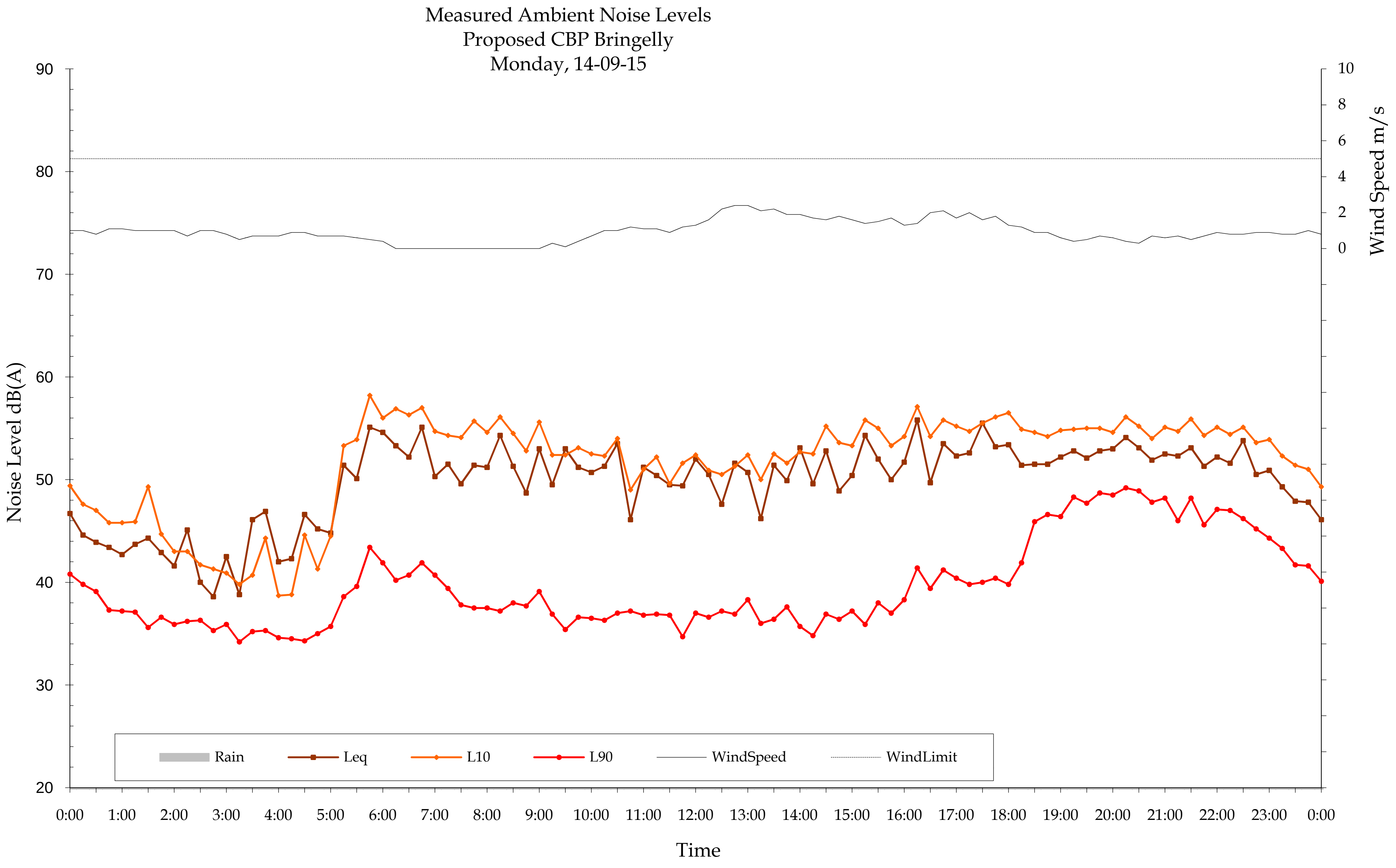

Measured Ambient Noise Levels
Proposed CBP Bringelly
Friday, 11-09-15
Noise Level dB(A)
90
80
70
60
50
40
30
20
Wind Speed m/s
10
8
6
4
2
0
Time
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00
Rain
Leq
L10
L90
WindSpeed
WindLimit



Measured Ambient Noise Levels
Proposed CBP Bringelly
Saturday, 12-09-15

Measured Ambient Noise Levels
Proposed CBP Bringelly
Sunday, 13-09-15





Measured Ambient Noise Levels
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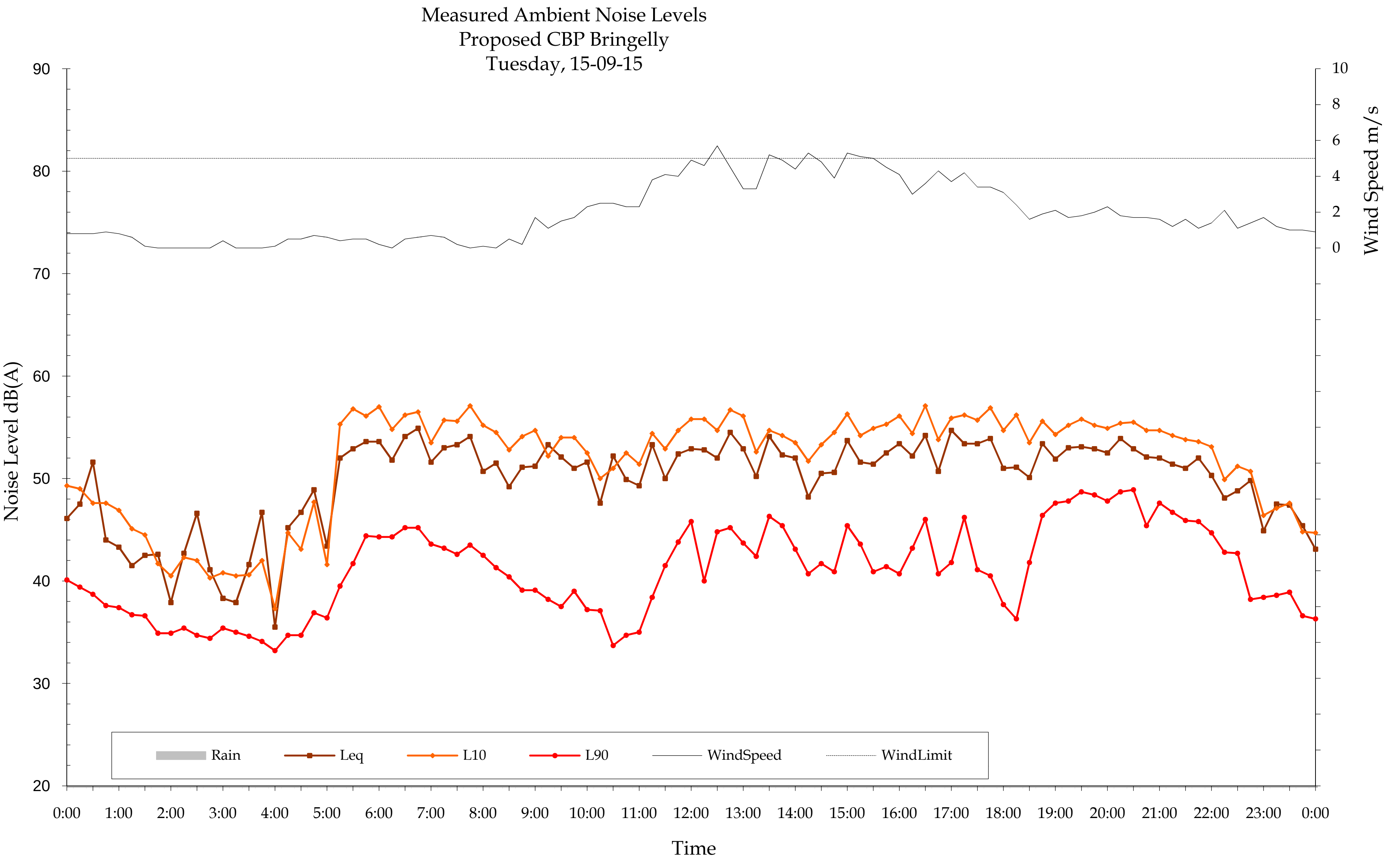
Monday, 14-09-15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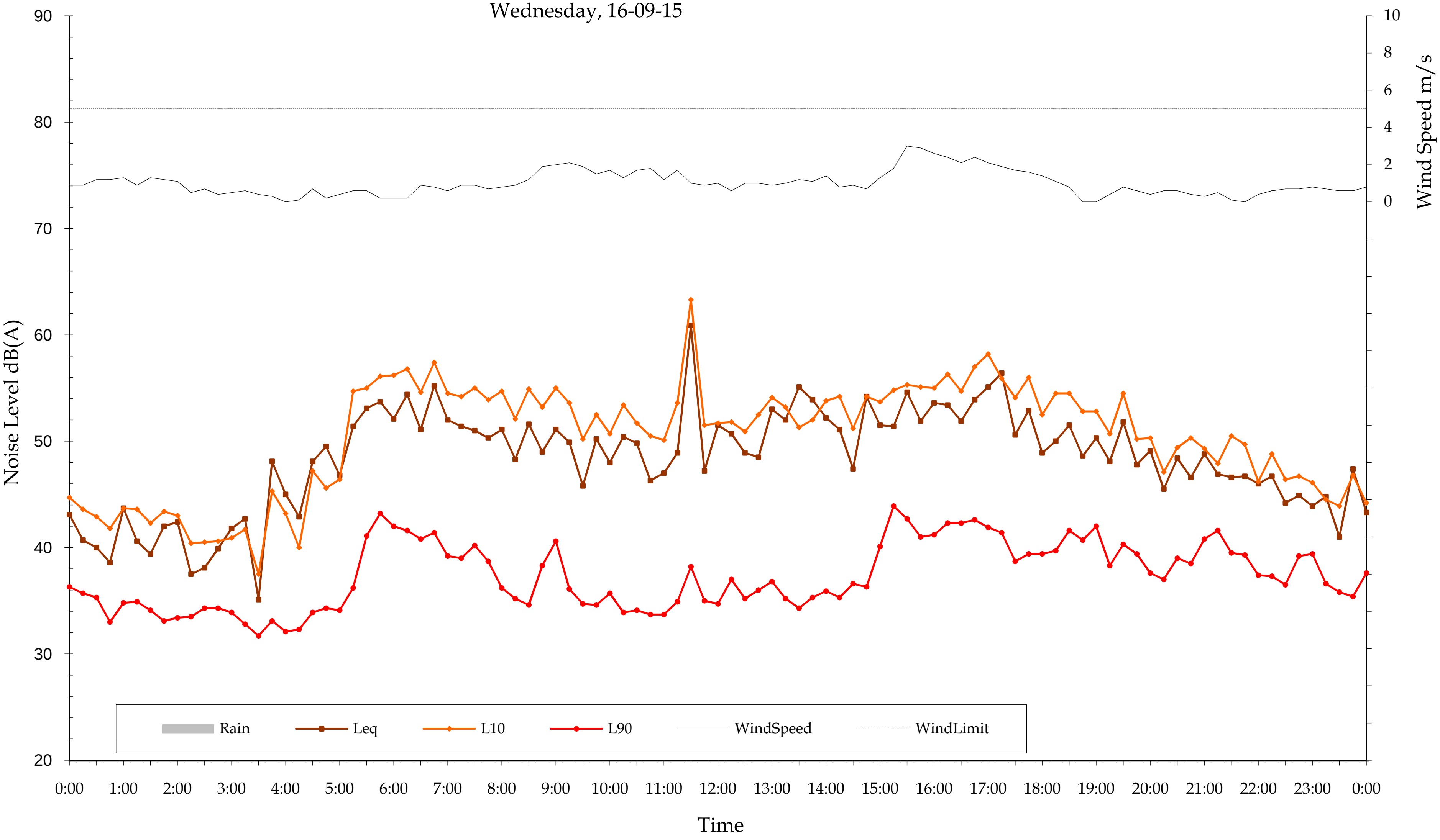
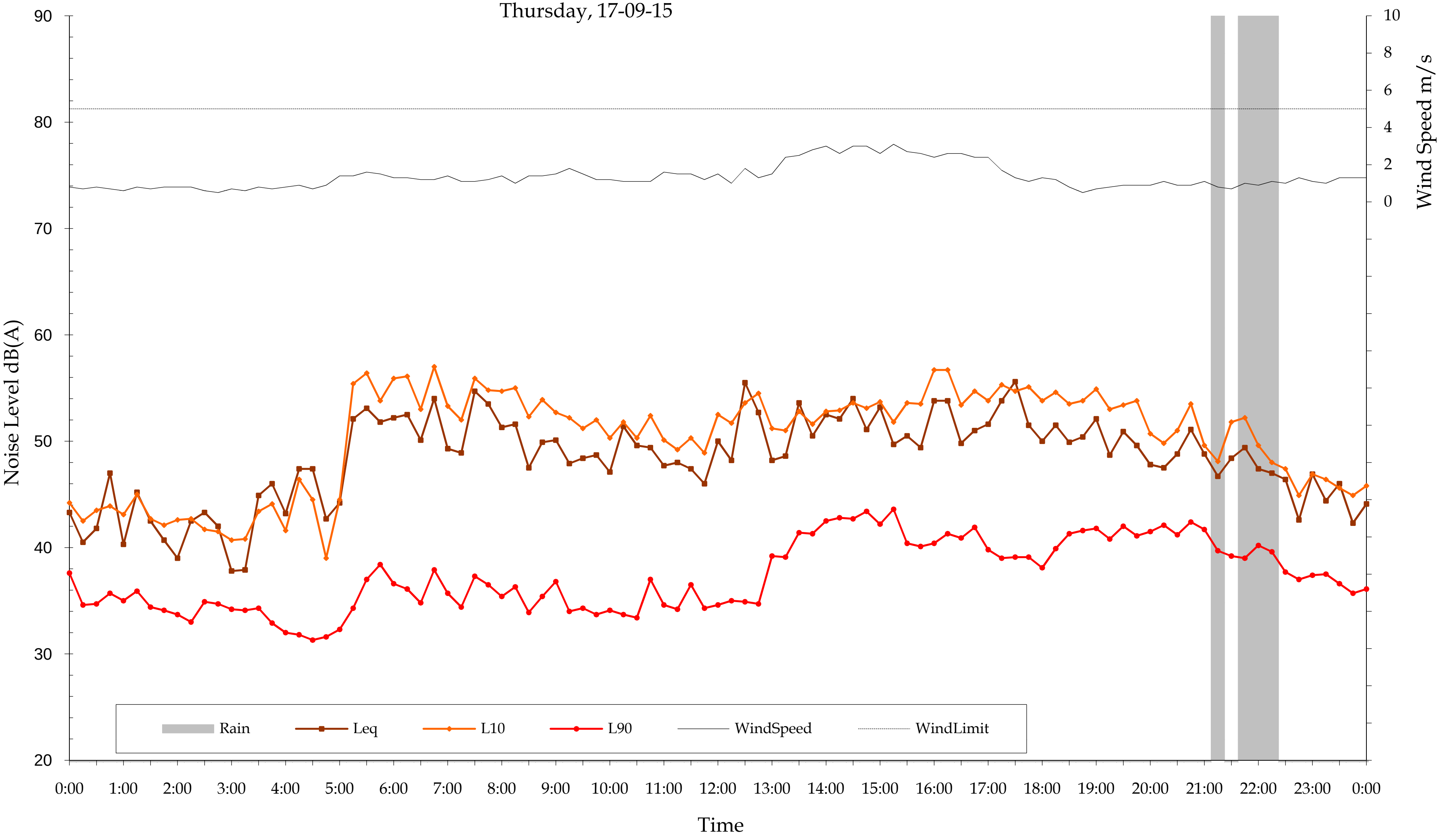
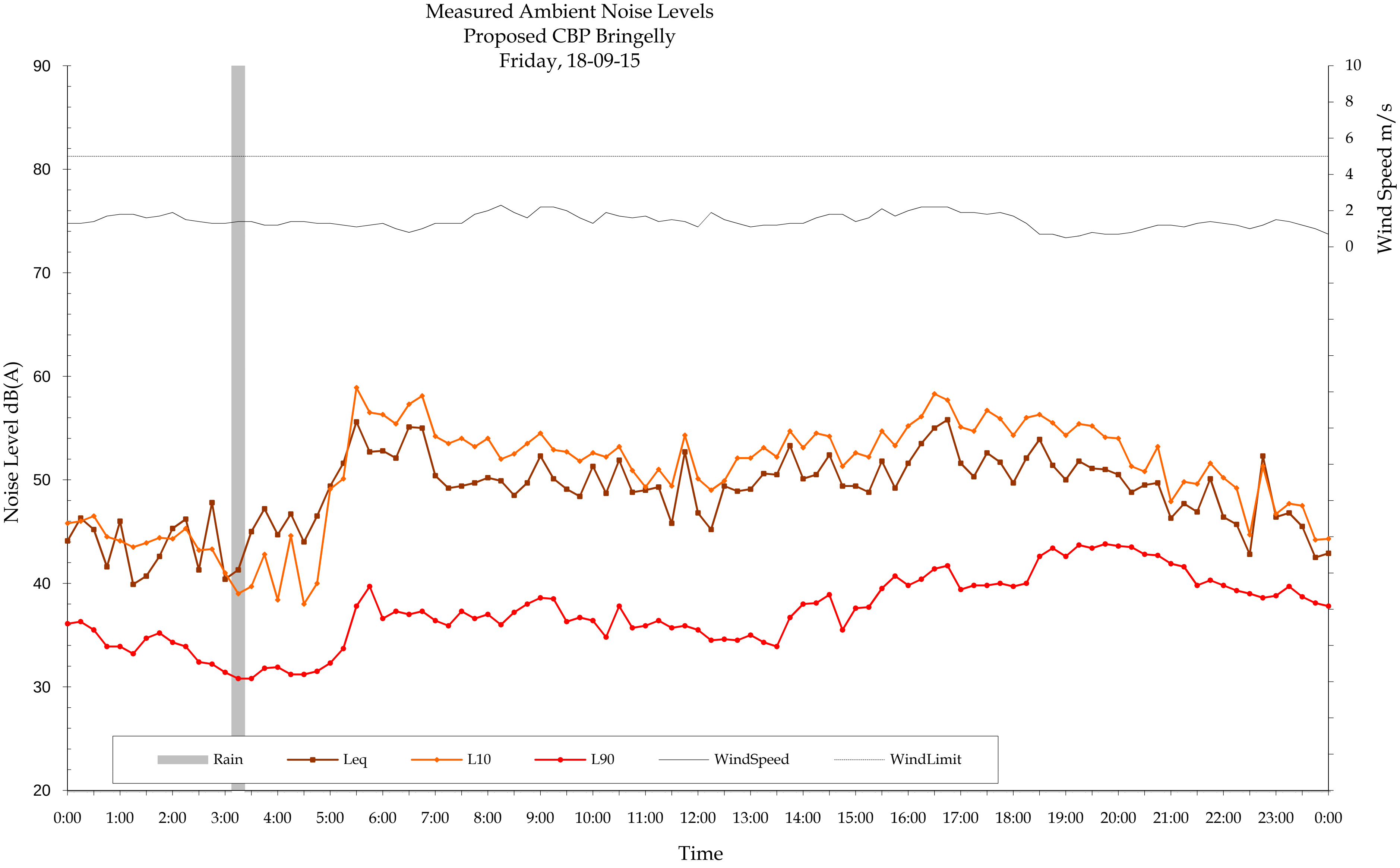
Proposed CBP Bringelly
Tuesday, 15-09-15

Measured Ambient Noise Levels
Proposed CBP Bringelly
Wednesday, 16-09-15



Measured Ambient Noise Levels
Proposed CBP Bringelly
Thursday, 17-09-15




Measured Ambient Noise Levels
Proposed CBP Bringelly
Friday, 18-09-15
Noise Level dB(A)
90
80
70
60
50
40
30
20
Wind Speed m/s
10
8
6
4
2
0
Rain
Leq
L10
L90
WindSpeed
WindLimit
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
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11:00
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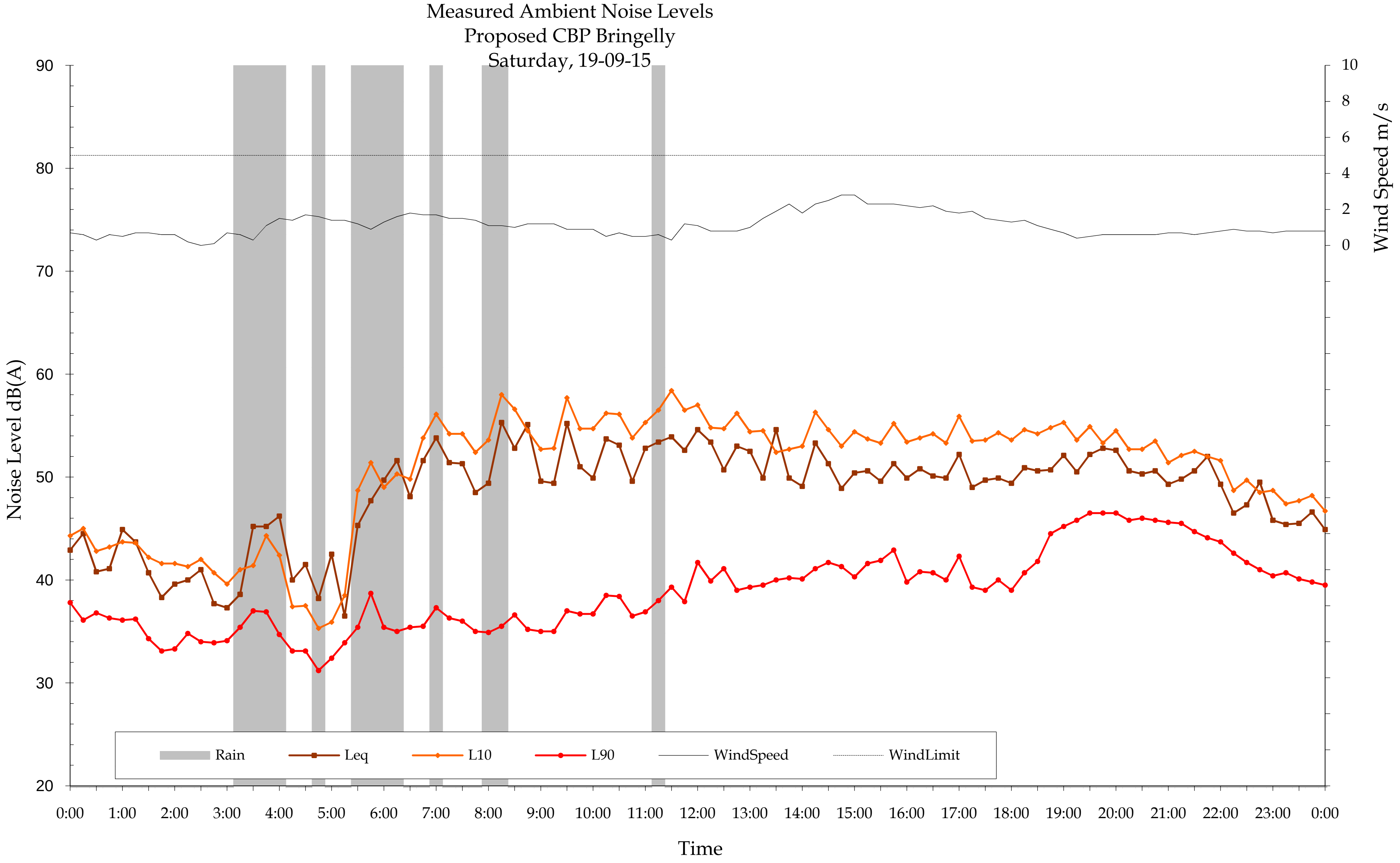
22:00
23:00
0:00
Time


Measured Ambient Noise Levels
Proposed CBP Bringelly
Saturday, 19-09-15
Noise Level dB(A)
90
80
70
60
50
40
30
20
Wind Speed m/s
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
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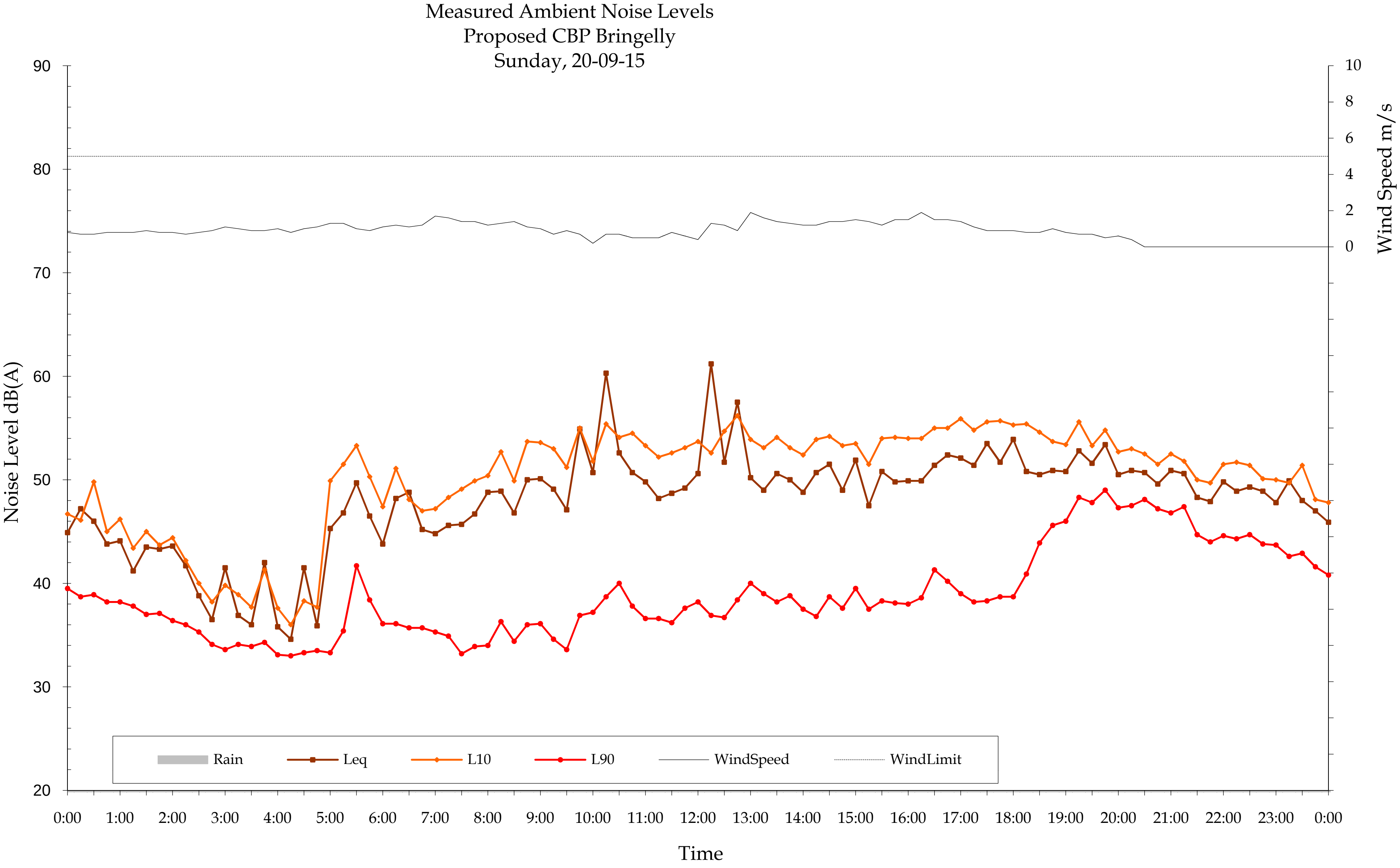
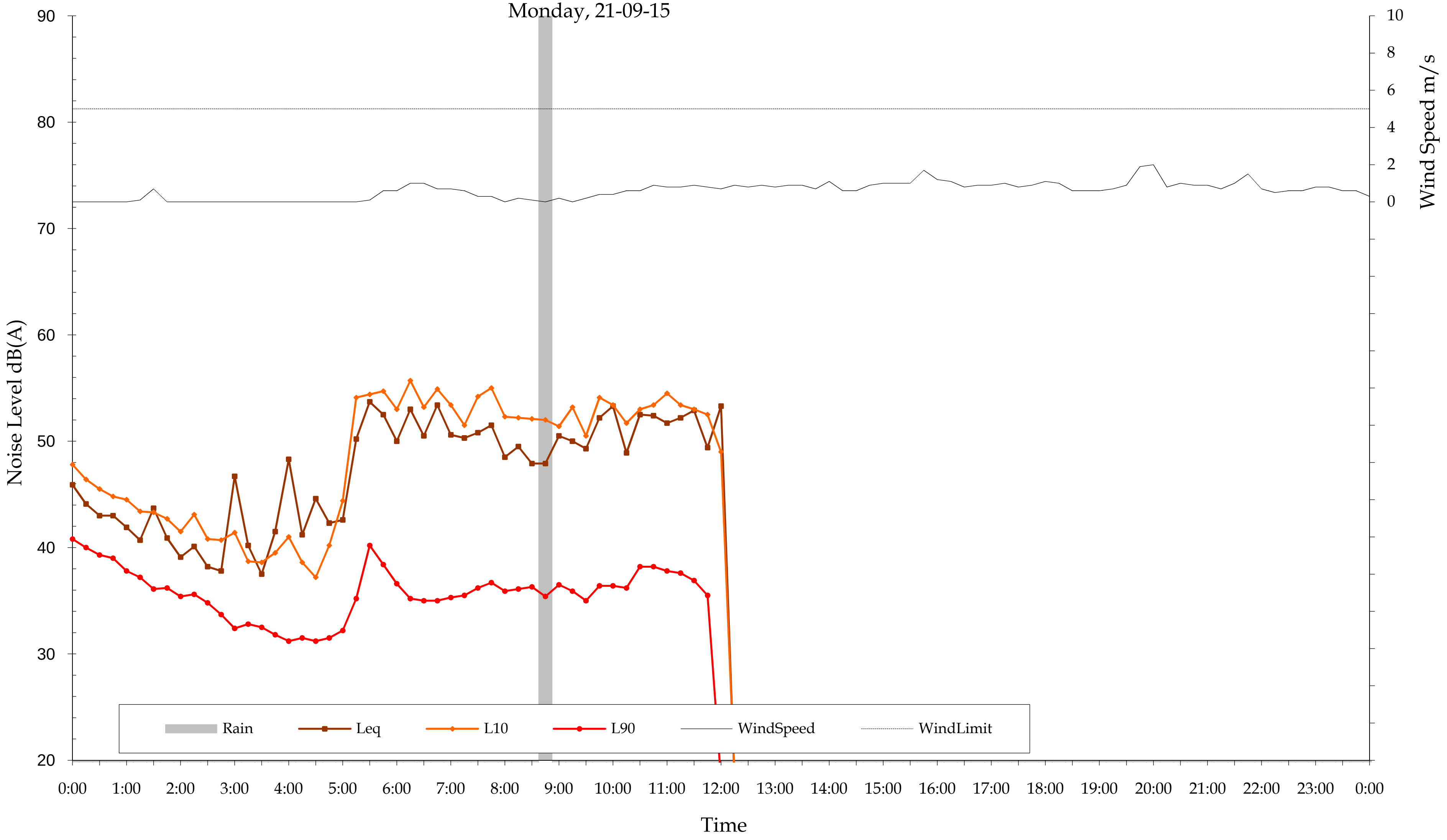
L10
L90
WindSpeed
WindLimit



Measured Ambient Noise Levels
Proposed CBP Bringelly
Sunday, 20-09-15

Measured Ambient Noise Levels
Proposed CBP Bringelly
Monday, 21-09-15



Appendix B

Wind analysis

Table B.1 Percentage occurrence of wind speeds between 0.5 to 3 m/s (vector at 22.5^{o} intervals)

Direction	**Day**				**Evening**				**Night**			
	Wint	**Aut**	**Spring**	**Sum**	**Wint**	**Aut**	**Spring**	**Sum**	**Wint**	**Aut**	**Spring**	**Sum**
NNE	28	22	24	24	21	17	13	18	18	12	12	14
NE	27	23	27	27	18	17	17	25	15	11	12	14
ENE	26	24	30	30	15	18	24	33	11	9	12	16
E	23	25	31	30	10	16	29	39	6	8	12	16
ESE	16	22	27	27	8	16	34	45	4	7	14	17
SE	11	20	23	24	8	19	38	48	4	10	15	21
SSE	11	20	20	21	11	22	37	45	5	14	18	27
S	14	22	18	19	21	31	38	43	17	29	27	35
SSW	19	22	16	17	39	37	40	38	36	45	44	45
SW	21	21	13	13	43	38	35	32	42	49	46	45
WSW	22	20	10	11	45	35	31	26	45	48	44	43
W	24	19	9	9	47	34	26	21	47	48	43	40
WNW	23	18	8	8	50	33	24	17	49	48	40	35
NW	26	17	11	11	48	27	20	13	47	42	35	28
NNW	28	19	16	15	33	19	12	9	28	21	18	16
N	27	20	20	20	22	15	9	10	21	13	12	13

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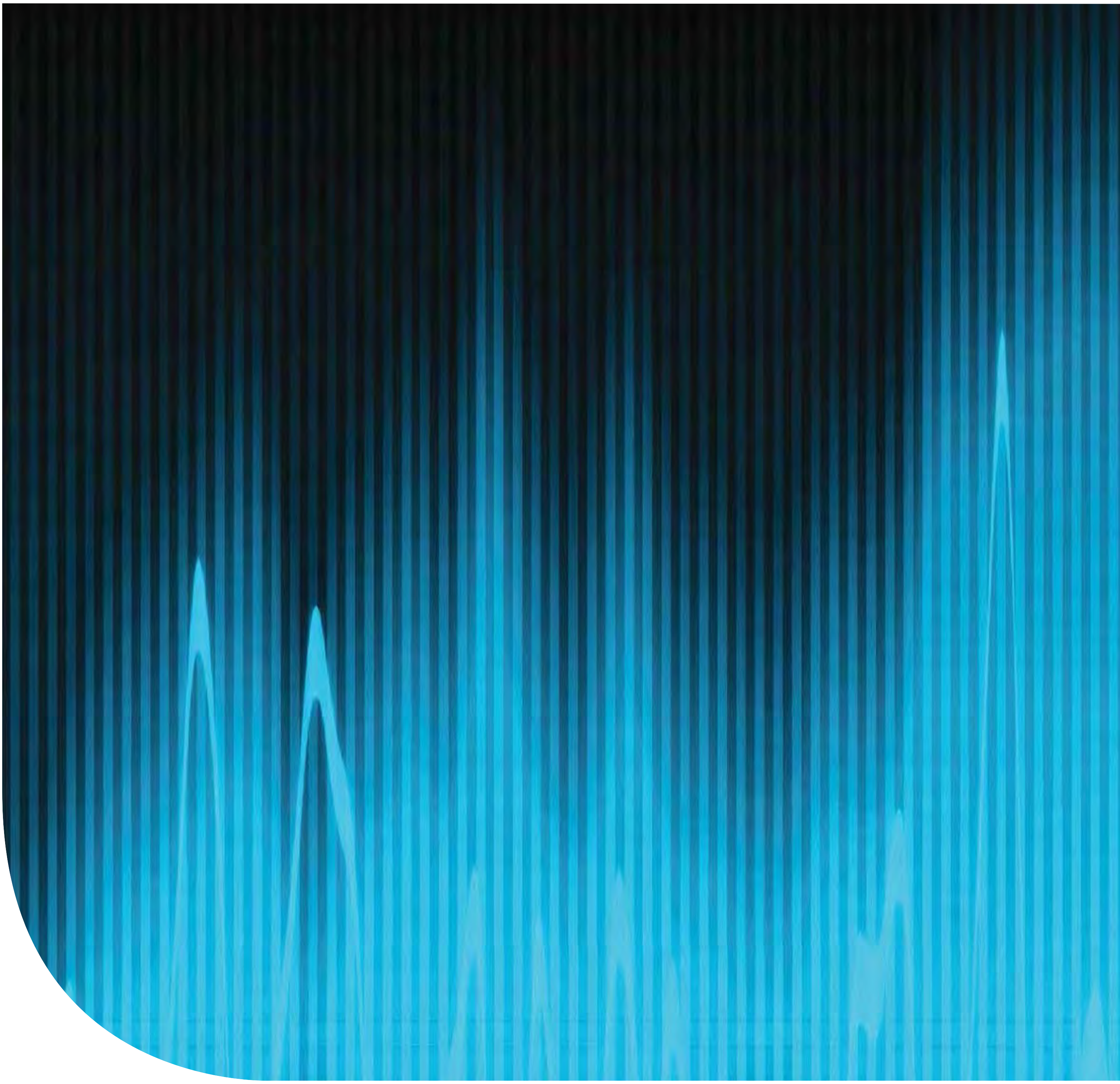
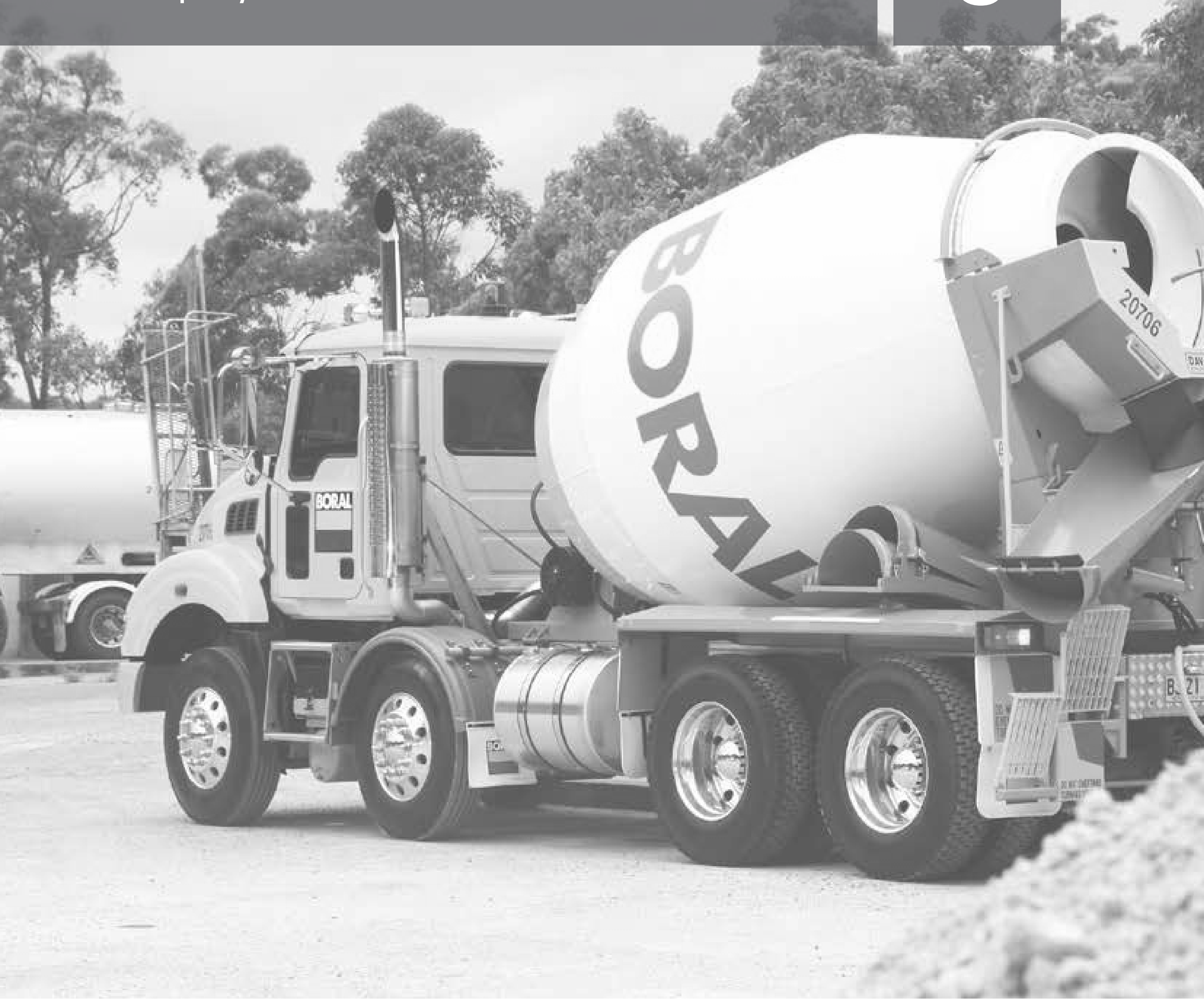


Appendix G

Air quality assessment

G



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PROPOSED BRINGELLY CONCRETE BATCHING PLANT

AIR QUALITY IMPACT ASSESSMENT

RAMBOLL ENVIRON

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AIR QUALITY IMPACT ASSESSMENT

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EXECUTIVE SUMMARY

Boral Resources (NSW) Pty Ltd (Boral) proposes to construct and operate a concrete batching plant (CBP) in Bringelly, NSW (the project). Ramboll Environ Australia Pty Ltd (Ramboll Environ) has been commissioned by EMM Consulting Pty Ltd (EMM) on behalf of Boral to conduct an air quality assessment of the project.

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated for peak proposed operations associated with the project using project-specific operational details and published emission estimation factors.

Existing air quality and meteorological conditions were analysed through a number of data resources, with particular weighting given to the NSW Office of Environment and Heritage (OEH) Bringelly air quality monitoring station.

Atmospheric dispersion modelling predictions of air pollution emissions for proposed operations were undertaken using the AERMOD dispersion model.

The results of the dispersion modelling conducted indicate that operation of the proposed project is unlikely to result in exceedances of the applicable NSW EPA assessment criteria for TSP, PM_{10} and dust deposition or the NEPM Goals for $PM_{2.5}$.

1. INTRODUCTION

Boral Resources (NSW) Pty Ltd (Boral), a wholly owned subsidiary of Boral Limited, proposes to construct and operate a concrete batching plant (CBP) in Bringelly, NSW (the project). Ramboll Environ Australia Pty Ltd (Ramboll Environ) has been commissioned by EMM Consulting Pty Ltd (EMM) on behalf of Boral to conduct an air quality assessment of the project.

This air quality impact assessment (AQIA) supports a development application for the project under Part 4 of the *Environmental Planning and Assessment Act 1979*. Camden Council is the consent authority for the application.

This air quality assessment provides:

- characterisation of the existing environment, specifically the existing air quality, prevailing meteorology and regulatory context;
- review of potential emission sources and mitigation measures;
- calculation of annual particulate matter emissions from the project; and
- atmospheric dispersion modelling of emissions for proposed operations at project site to predict potential particulate matter impacts at the surrounding sensitive receptor locations and determine the significance of the proposed project to ambient air quality.

The AQIA is guided by the NSW Environment Protection Authority (NSW EPA) document Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales ("the Approved Methods for Modelling", EPA 2005).

2. PROJECT DESCRIPTION AND LOCAL SETTING

2.1 Project Description

The project is in the north-western corner of Lot 100 DP 1203966 on Greendale Road, Bringelly (**Figure 2-1**). The indicative site layout is shown in **Figure 2-2**. The site is owned by Boral CSR Bricks Pty Ltd (now trading as PGH Bricks), a joint venture between Boral Limited and CSR Limited. The Boral CSR Bringelly Brickworks is also located on Lot 100 DP 1203966 approximately 200 m south-east of the project area. The project is intended to support the construction of local and regional infrastructure projects including local road upgrade works to Northern Road and Bringelly Road.

The key elements of the project are summarised in **Table 2-1**.

Table 2-1 Key project elements

Project element	Project description
Maximum processing rate	125,000 tonnes of concrete per annum 1,250 tonnes per day, 250 tonnes per hour
Site components	Main components: • control room and amenities building; • 3 cement silos; • 4 hoppers; • 1 enclosed agitator load bay; • 2 enclosed slump stands; • 4 open aggregate stockpiles; • 1 bunded concrete admixtures container (modified 40 ft shipping container); • 2 water management pits (storage, sediment and first flush capture); • 1 operating front-end loader; • 4 m bund wall, consisting of a 2 m earth bund and 2 m Colourbond fence, to the north, east and west of the site; and • carpark area with 24 spaces.
Hours of operation	7 am−10 pm Monday to Saturday; 8 am−10 pm Sunday; and No deliveries after 6 pm.
Employment	13 full-time employees: 3 plant operators and 10 truck drivers
Disturbance footprint	1.7 ha
Transport and access	Access will be via a new driveway on Greendale Road. Average daily truck numbers: • Agitator trucks − 86; • Cement tankers − 7; and • Aggregate truck and dog − 20. • Peak hour truck numbers: • Agitator trucks − 12; • Cement tankers − 1; and • Aggregate truck and dog − 2.
Construction timeframe	12 weeks construction period Construction hours: 7 am−6 pm Monday to Friday, 8 am−1 pm Saturday

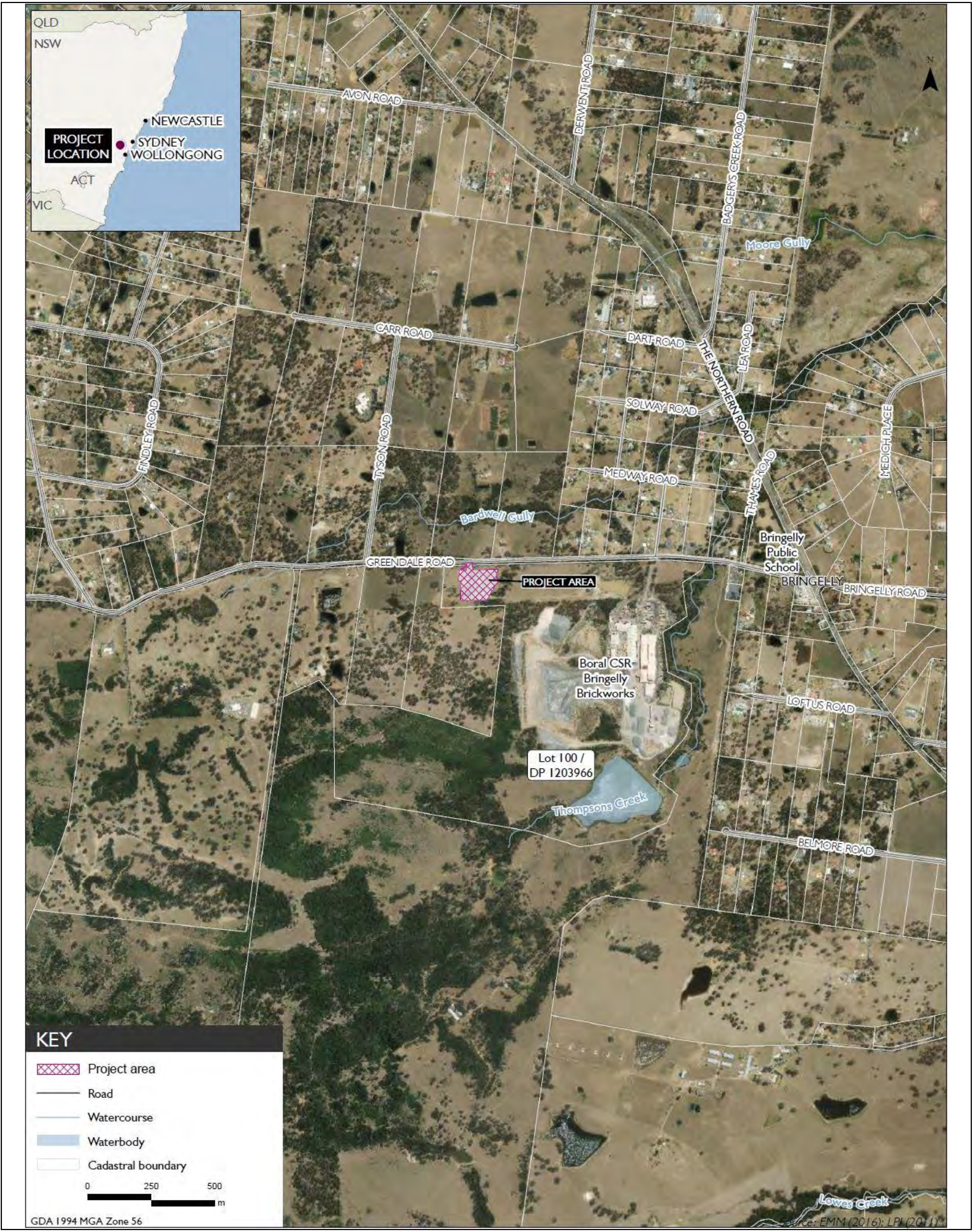

Figure 2-1: Site Location

Source: EMM (2016)

Figure 2-2: Proposed Site Layout

Source: EMM (2016)

2.2 Surrounding Receptor Locations

The project site is surrounded by scattered residential properties and the Boral CSR Brickworks site. A number of residential receptors have been selected from the neighbouring area at which to assess air quality impacts from the proposed project. The selected receptor locations are presented in **Table 2-2** and illustrated in **Figure 2-3**.

Table 2-2 Sensitive Receptor Locations Surrounding the Project Site

Receptor ID	Location (m, MGA56S)		Elevation (m, AHD)
	Easting	Northing	
1	289149	6242325	85
2	289088	6242596	84
3	288692	6242319	96
4	288733	6242613	90
5	288472	6242507	101
6	288340	6242534	105
7	288621	6241994	103
8	288357	6242002	112
9	288452	6241847	109
10	289396	6242333	89
11	289467	6242337	85
12	289571	6242321	82
13	289710	6242321	83
14	289827	6242322	84
15	289853	6242404	80
16	289456	6242733	84
17	289799	6242445	76
18	289749	6242453	76
19	289626	6242472	78
20	289552	6242581	76
21	289430	6242596	78
22	290222	6242258	85
23	290103	6241776	92

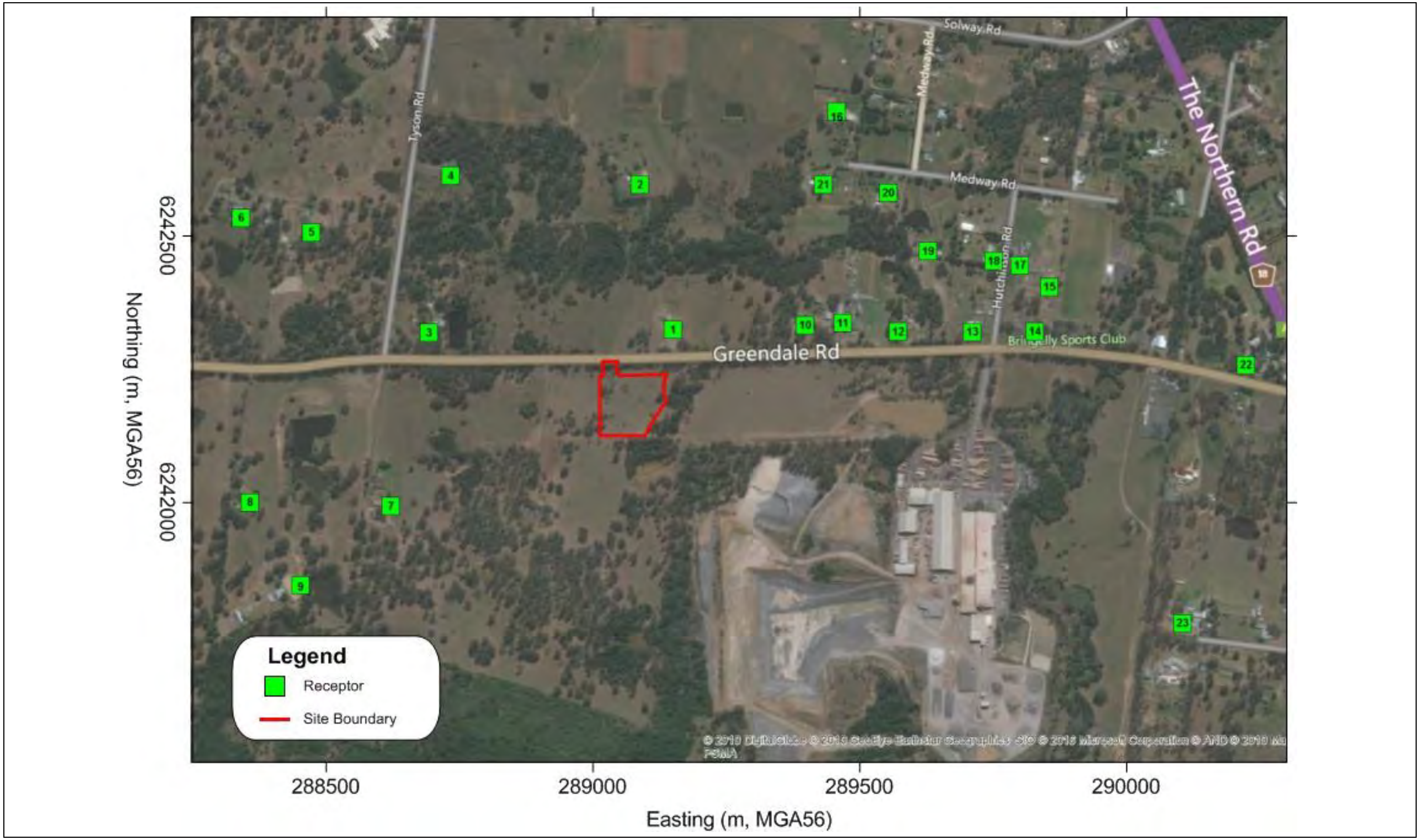

Figure 2-3: Surrounding Sensitive Receptor Locations

3. AIR QUALITY ASSESSMENT CRITERIA

The project must demonstrate compliance with the impact assessment criteria outlined in the Approved Methods for Modelling (EPA, 2005). The impact assessment criteria are designed to maintain ambient air quality that allows for the adequate protection of human health and well-being.

Relevant ambient air quality criteria applicable to the project are presented in the following sections.

3.1 Airborne particulate matter

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

Air quality criteria for PM in Australia are given for particle size metrics including TSP, PM_{10} and $PM_{2.5}$. Impact assessment criteria are prescribed by the NSW EPA for TSP and PM_{10}, however not for $PM_{2.5}$.

Under the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM), national reporting standards were initially prescribed for 24-hour average PM_{10} concentrations (NEPC, 1998). The AAQ NEPM was varied in 2003 to include 'advisory reporting standards' for $PM_{2.5}$ (NEPC, 2003) and again in 2015 to adopt these 'advisory reporting standards' as formal standards for $PM_{2.5}$ (NEPC, 2015). The latest variation also introduces an annual reporting standard for PM_{10} and establishes long term goals for $PM_{2.5}$, to be achieved by 2025 (NEPC, 2015).

It is noted that the purpose of the AAQ NEPM is to attain *'ambient air quality that allows for the adequate protection of human health and wellbeing',* and compliance with the AAQ NEPM is assessed through air quality monitoring data collected and reported by each state and territory. The AAQ NEPM standards are therefore not necessarily applicable to the assessment of impacts of emissions sources on individual sensitive receptors. For the purpose of this report, impacts are preferentially assessed against the NSW EPA's impact assessment criteria. In the case of $PM_{2.5}$, where impact assessment criteria do not exist, impacts are reported against the latest AAQ NEPM standards. The NSW EPA's impact assessment criteria and AAQ NEPM standards and goals for PM are presented in **Table 3-1**.

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

Table 3-1: Impact assessment criteria for PM

Pollutant	Averaging Period	Concentration (µg/m³)	Purpose of goal
TSP	Annual	90	NSW EPA impact assessment criteria
PM_{10}	24 hours	50	NSW EPA impact assessment criteria
		50	AAQ NEPM national reporting standard
	Annual	30	NSW EPA impact assessment criteria
		25	AAQ NEPM national reporting standard
$PM_{2.5}$	24 hours	25	AAQ NEPM national reporting standard
		20	AAQ NEPM long term goal for 2025
	Annual	8	AAQ NEPM national reporting standard
		7	AAQ NEPM long term goal for 2025

3.2 Dust deposition criteria

Nuisance dust deposition is regulated through the stipulation of maximum permissible dust deposition rates. The NSW EPA impact assessment goals for dust deposition are given in **Table 3-2** illustrating the allowable increment in dust deposition rates above ambient (background) dust deposition rates which would be acceptable so that dust nuisance could be avoided.

Table 3-2: Impact assessment criteria for dust deposition

Averaging Period	Maximum Increase in Deposited Dust Level	Maximum Total Deposited Dust Level
Annual	2 g/m^2/month	4 g/m^2/month

Source: Approved Methods for Modelling, EPA 2005

4. CLIMATE AND DISPERSION METEOROLOGY

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. Emission generation rates are particularly dependent on wind energy and on the moisture budget, which is a function of rainfall and evaporation rates.

In the absence of onsite meteorological monitoring data, a combination of local area observational data and meteorological modelling techniques were used. Details regarding the meteorological modelling are presented in **Section 4.1**.

The following data were used in the meteorological analysis:

- 1-hour average meteorological data from the NSW Office of Environment and Heritage (OEH) monitoring station at Bringelly, located 4.8km northeast of the project site.
- 1-hour average meteorological data and historical climate data from the BoM Automatic Weather Station (AWS) at Badgerys Creek (Station Number 067108) and Camden Airport (Station Number 067108) located 4.8km north and 11.3km south-southwest of the project site, respectively.

4.1 Meteorological Modelling

Section 4.1 of DEC (2005) specifies that meteorological data representative of a site can be used in the absence of suitable on-site observations. Data should cover a period of at least one year with a percentage completeness of at least 90%. Site representative data can be obtained from either a nearby meteorological monitoring station or synthetically generated using the CSIRO prognostic meteorological model The Air Pollution Model (TAPM).

As stated, hourly average meteorological data from the nearby NSW OEH Bringelly monitoring station and BoM Badgerys Creek and Camden Airport AWS locations were obtained in the absence of onsite monitoring at the project site. Data from the Bringelly station was used as the primary resource, with observations from the two BoM stations adopted only where data gaps exist (e.g. cloud observations only available at the Camden Airport AWS location).

To supplement these meteorological observation datasets, the CSIRO meteorological model TAPM was used to generate parameters not routinely measured, specifically the vertical temperature profile.

TAPM was configured and run in accordance with the Section 4.5 of the Approved Methods for Modelling, with the following refinements:

- Modelling to 300 m grid cell resolution (beyond 1 km resolution specified).
- Inclusion of high resolution (90 m) regional topography (improvement over default 250 m resolution data).

The TAPM vertical temperature profile for every hour was adjusted by first substituting the predicted 10 m above ground temperature with hourly recorded temperature at 10 m (sourced from the NSW OEH Bringelly station). The difference between the TAPM predicted temperature and the measured 10 m temperature was applied to the entire predicted vertical temperature profile. This modified vertical profile was used in combination with the ambient air temperature throughout the day to calculate convective mixing heights between sunrise and sunset.

4.2 Prevailing Wind Regime

A wind rose showing wind speed and direction data recorded at the NSW OEH Bringelly monitoring station is presented in **Figure 4-1**. The annual recorded wind pattern is dominated by southwesterly, northeasterly and easterly airflow. The highest wind speeds recorded are most frequently experienced from the south to west quadrant. The average recorded wind speed for 2014 was 1.9 m/s, with a frequency of calm conditions (wind speeds less than 0.5 m/s) occurring in the order of 23% of the time.

Additional inter-annual, seasonal and diurnal wind roses for Bringelly are provided in **Appendix 1**.

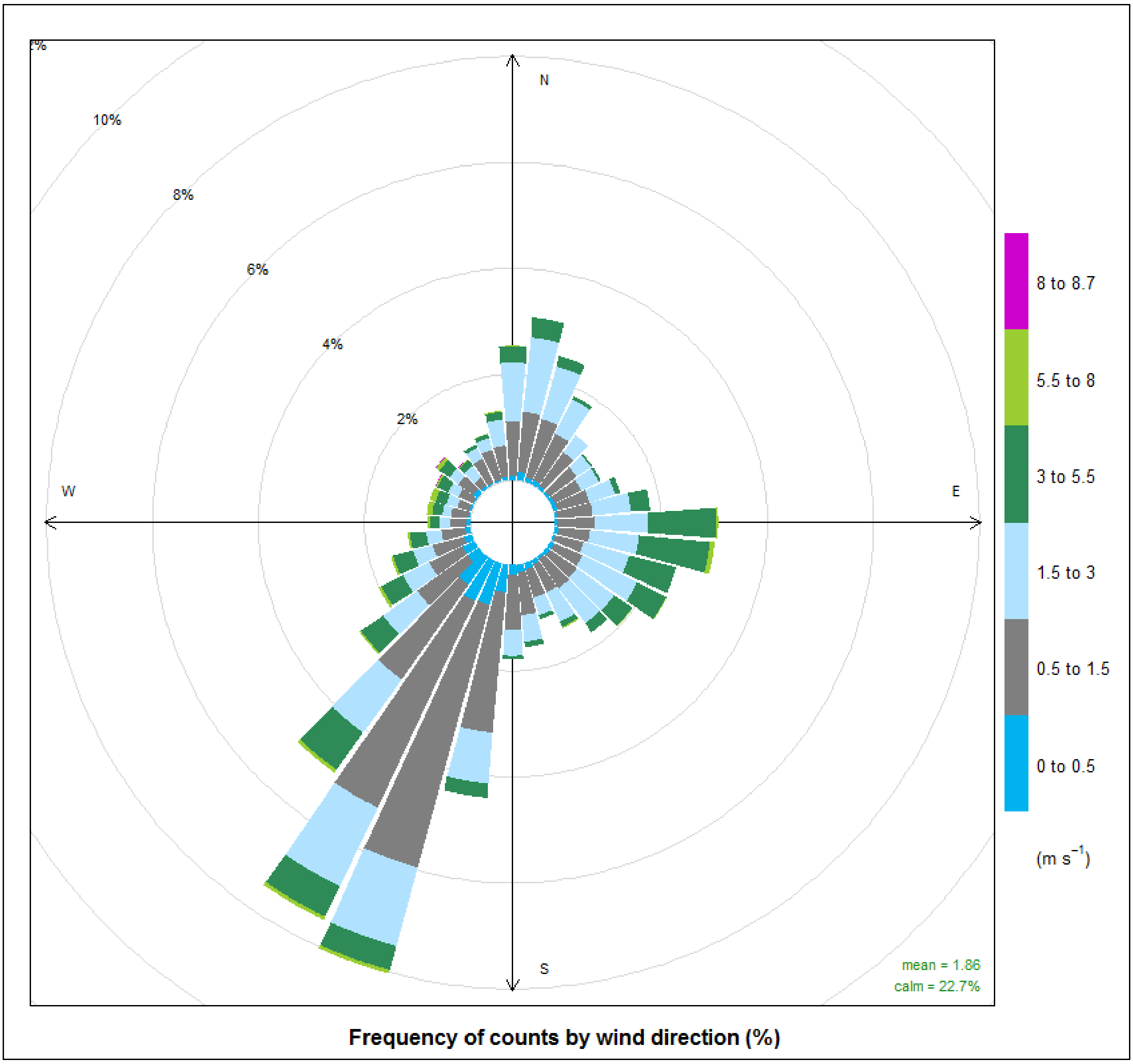

Figure 4-1: Annual Average Wind Rose – Bringelly OEH Station – 2014

Seasonal and diurnal (dividing the day into night and day) wind roses for the meteorological dataset are presented within **Appendix 1**.

Seasonal variation in wind speed and direction is evident in the recorded data from the NSW OEH Bringelly station. The southwesterly airflow is most dominant in autumn and winter, while the easterly and northeasterly airflow is most common in spring and summer. Wind speeds are typically lowest during the autumn months, with the lowest average wind speed and highest occurrence of calm conditions at this time. Wind speeds peak in the summer months.

Diurnal variation is most notable in both recorded wind speed and direction. Wind speeds are higher during the daylight hours than at night. Daylight hours experience a mixture of northeasterly, easterly and southwesterly air flow. Night time hours experience a dominance of southwesterly air flow.

4.3 Ambient Temperature

Monthly mean minimum temperatures are in the range of 4°C to 17°C, with mean maxima of 17°C to 30°C, based on the long-term average record from the BoM Badgerys Creek AWS. Peaks occur during summer months with the highest temperatures typically being recorded between November and February. The lowest temperatures are usually experienced between June and August.

The 2014 NSW OEH Bringelly temperature dataset has been compared with long-term trends recorded at the Badgerys Creek climate station to determine the representativeness of the dataset. **Figure 4-2** presents the monthly variation in recorded temperature during 2014 compared with the recorded station mean, minimum and maximum temperatures. There is good agreement between temperatures recorded during 2014 and the recorded historical trends, indicating that the dataset is representative of conditions likely to be experienced in the region.

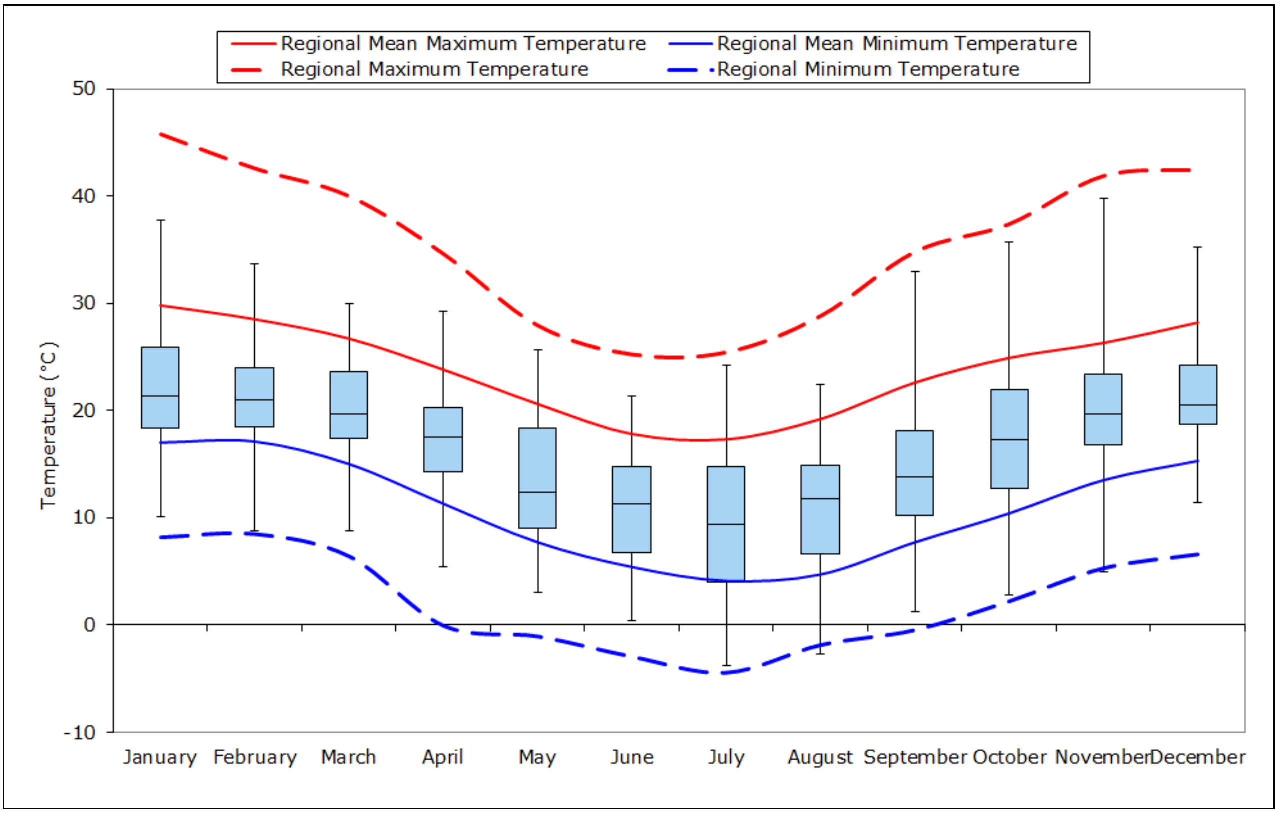

Figure 4-2: Temperature Comparison between Bringelly OEH 2014 dataset and Historical Averages (1995-2015) – Badgerys Creek BoM

Note: 2014 data from Bringelly are illustrated by the 'box and whisker' indicators. Boxes indicate 25th, median and 75th percentile temperature values while upper and lower whiskers indicate maximum and minimum values. Maximum and minimum temperatures from long-term measurements at Badgerys Creek are depicted as line graphs.

4.4 Rainfall

Precipitation is important to air pollution studies since it impacts on dust generation potential and represents a removal mechanism for atmospheric pollutants.

Based on historical data recorded at Bagerys Creek, the area is characterised by moderate to high rainfall, with a mean annual rainfall of approximately 1,090mm, and an annual rainfall range between 520mm and 2,025mm. Rainfall is most pronounced between summer and autumn, with lower rainfall during mid-winter to early spring. According to the long term records, an average of 129 rain days occur per year.

To provide a conservative (upper bound) estimate of the airborne particulate matter concentrations occurring due to the project, wet deposition (removal of particles from the air by rainfall) was excluded from the dispersion modelling simulations undertaken in this report.

4.5 Atmospheric Stability

Atmospheric stability refers to the degree of turbulence or mixing that occurs on the atmosphere and is a controlling factor in the rate of atmospheric dispersion of pollutants.

The Monin-Obukhov length (L) provides a measure of the stability of the surface layer (i.e. the layer above the ground in which vertical variation of heat and momentum flux is negligible; typically about 10 % of the mixing height). Negative L values correspond to unstable atmospheric conditions, while positive L values correspond to stable atmospheric conditions. Very large positive or negative L values correspond to neutral atmospheric conditions.

Figure 4-3 illustrates the seasonal variation of atmospheric stability derived from the Monin-Obukhov length calculated by AERMET for the project site. The diurnal profile presented illustrates that atmospheric instability increases during daylight hours as convective energy increases, whereas stable atmospheric conditions prevail during the night-time. This profile indicates that the potential for atmospheric dispersion of emissions would be greatest during day time hours and lowest during evening through to early morning hours.

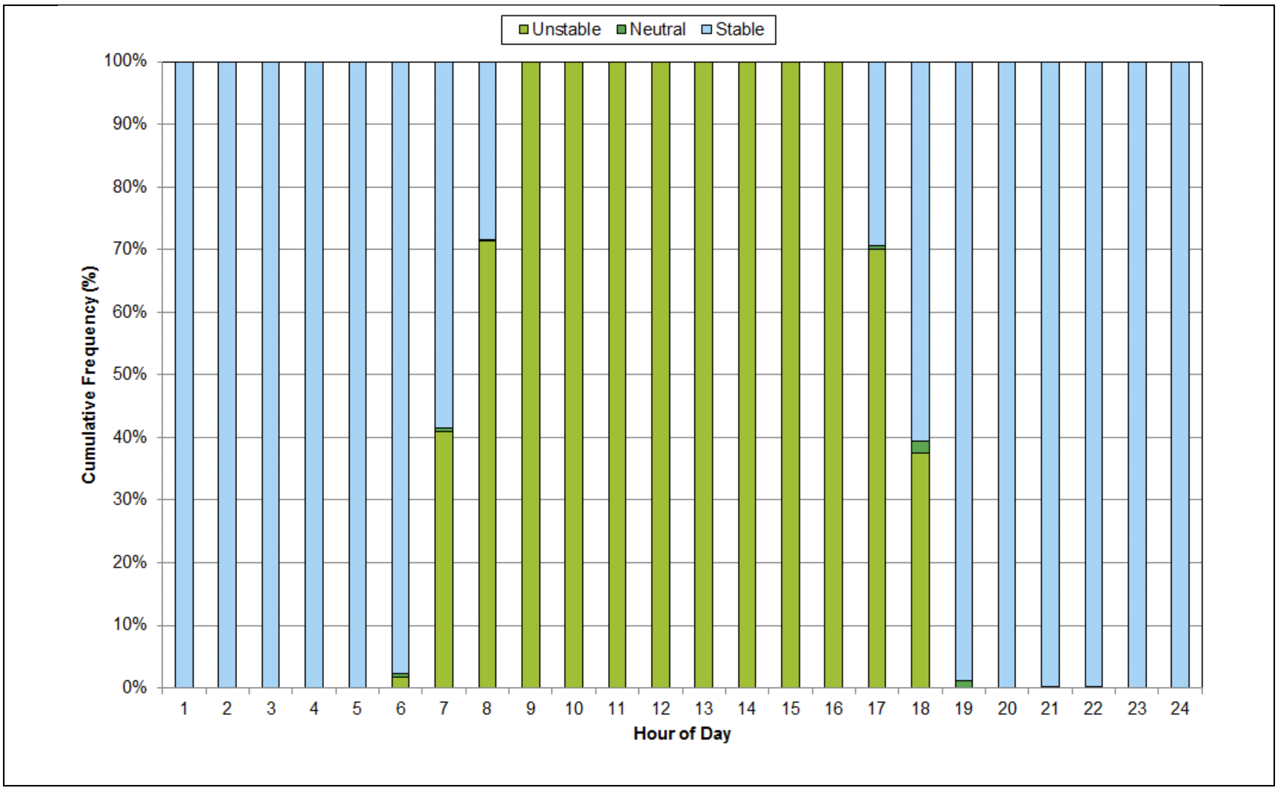

Figure 4-3: AERMET-Calculated Diurnal Variation in Atmospheric Stability– Project Site 2014

4.6 Mixing Depth

Hourly-varying atmospheric boundary layer depths were generated for the project site by AERMET, the meteorological processor for the AERMOD dispersion model (see **Section 7.1** for further information), using a combination of surface observations from the NSW OEH Bringelly station, sunrise and sunset times and adjusted TAPM-predicted upper air temperature profile.

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

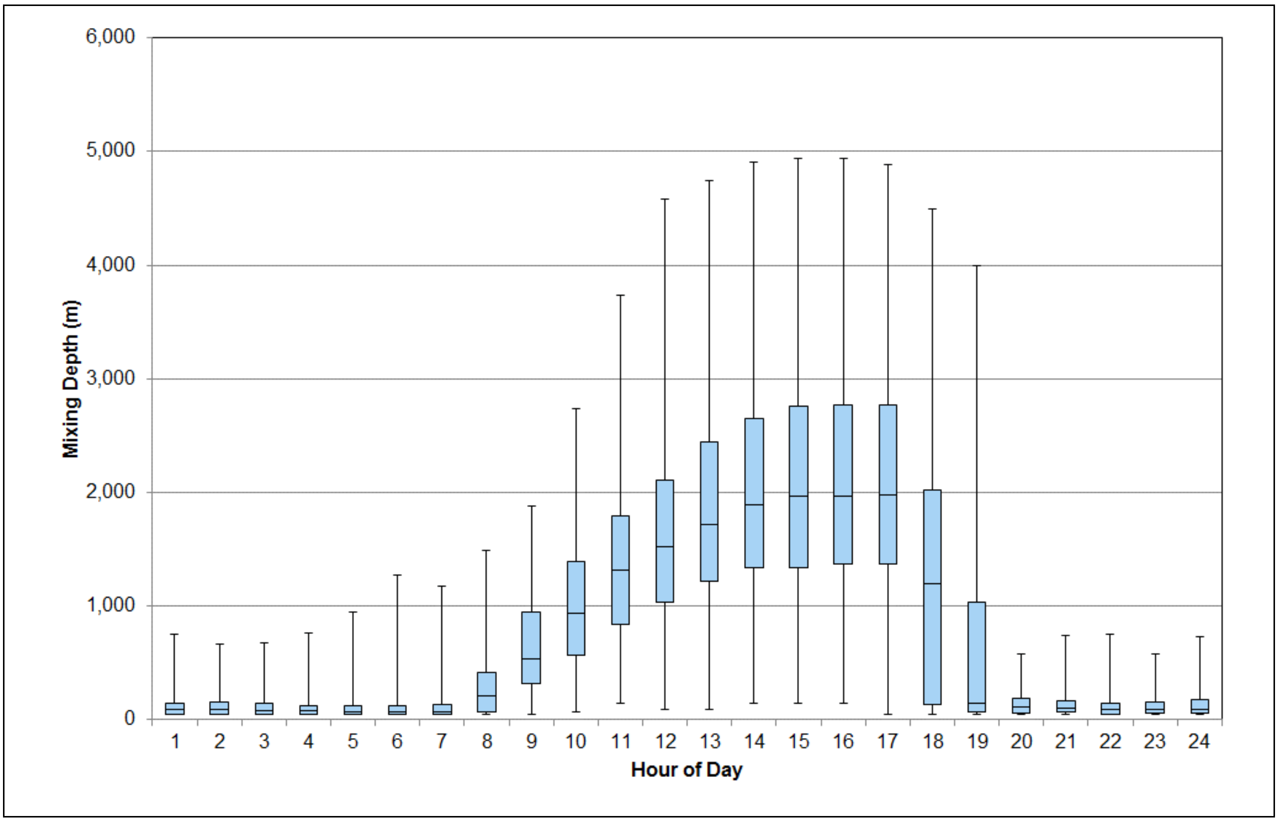

Figure 4-4: AERMET-Calculated Diurnal Variation in Atmospheric Mixing Depth – Project Site

Note: Boxes indicate 25th, Median and 75th percentile of AERMET-calculated mixing height data while upper and lower whiskers indicate maximum and minimum values.

5. EXISTING AIR QUALITY ENVIRONMENT

The quantification of cumulative air pollution concentrations and the assessment of compliance with ambient air quality limits necessitate the characterisation of baseline air quality. Given that particulate matter emissions represent the primary pollutant of concern generated by the proposed project, it is pertinent that existing sources and ambient air pollutant concentrations of these pollutants are considered.

5.1 Existing Local Sources of Atmospheric Emissions

The National Pollutant Inventory (NPI) database lists the following sources of PM in the surrounding 10km from the CPB site:

- Boral CSR Bringelly Brickworks – clay brick manufacturing;
- Jemena Eastern Gas Pipeline, Austral and Leppington – main gas pipeline valve;
- Inghams Badgerys Creek Farm – poultry farm operations;
- Sita Australia Elizabeth Drive Landfill, Badgerys Creek – Landfill operations;
- Australian Perlite Pty Limited - Production of expanded perlite and exfoliated vermiculite products;
- Baiada Poultry Facility, Luddenham - poultry farm operations; and
- A2 Dairy products plant, Smeaton Grange – milk and cream processing.

Of the above facilities, only the Boral CSR Brickworks at Bringelly is considered to have the potential for direct cumulative impacts with the proposed project due to the proximity of operations. Further discussion relating to the Boral CSR Brickworks is presented in **Section 5.1.1**.

In addition to the above operations, it is considered that the following sources contribute to particulate matter emissions in the vicinity of the project site:

- Dust entrainment and tyre and break wear due to vehicle movements along public roads;
- Agricultural practices;
- Petrol and diesel emission from vehicle movements along public roads;
- Wind generated dust from exposed areas within the surrounding region;
- Seasonal emissions from household wood burning fires;
- Sea salt contained in sea breezes.

More remote sources which contribute episodically to PM in the region include dust storms and bushfires. Whereas dust storms predominately contribute primary particles from mechanical attrition, bushfires are a source of fine particles including both primary and secondary particles formed by atmospheric gas to particle conversion processes.

5.1.1 Boral CSR Brickworks

As stated in **Section 2.1**, the project site is located in the northwestern corner of land owned by Boral CSR Bricks Pty Ltd, used for the primary purpose of the Boral CSR Brickworks. An AQIA was conducted for the Boral CSR Bringelly Brickworks in May 2013 (Wilkinson Murray, 2013). The assessment calculated particulate matter (TSP and PM_{10}) and combustion pollutant emissions and resultant air quality impacts for three operational scenarios at the site.

The 2013 AQIA identified that at all surrounding receptors, the predicted impacts would not adversely impact upon the neighbouring sensitive receptors for all pollutants and averaging periods.

The proposed project site is approximately 200m northwest of the closest activities at the Boral CSR Bringelly Brickworks. The dominant wind directions for the area (southwest, northeast and easterly as documented in **Section 4.2**) would limit the amount of time that emissions from both sites are combined to result in significant downwind cumulative impacts.

5.2 Background PM_{10}

Particulate matter concentrations recorded by the NSW OEH Bringelly station has been collected and analysed and is considered to be representative of ambient air quality conditions in the local environment, in the absence of onsite air quality monitoring.

The daily varying (24-hour average) PM_{10} concentrations recorded at the NSW OEH Bringelly monitoring station during 2014 are illustrated in **Figure 5-1**. It can be seen that the recorded 24-hour average PM_{10} concentrations fluctuate throughout 2014.

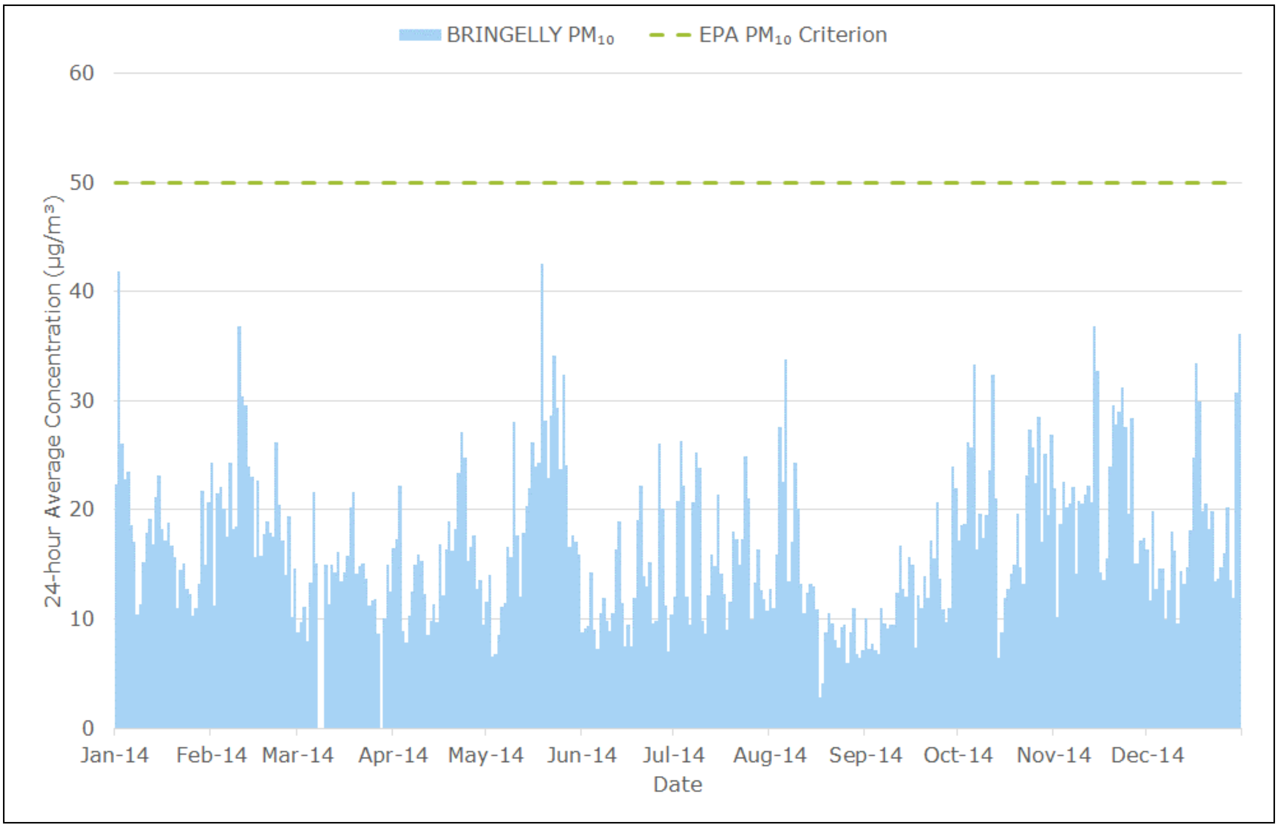

Figure 5-1: Time-series of 24-hour Average PM_{10} Concentrations recorded at OEH Bringelly – 2014

To assess the cumulative 24-hour average PM_{10} impacts of project emissions with ambient background PM_{10} concentrations, the maximum recorded concentration during 2014 (42.6µg/m^3) will be paired with the maximum predicted concentration at each receptor.

The annual average PM_{10} concentration to be adopted as background is 16.7µg/m^3.

5.3 Background $PM_{2.5}$

The NSW OEH Bringelly monitoring station does not record concentrations of $PM_{2.5}$. The closest NSW OEH $PM_{2.5}$ monitoring station to the project site is located at Camden, approximately 12km south-southwest of the project site. In the absence of $PM_{2.5}$ monitoring data at the Bringelly monitoring station, 24-hour average $PM_{2.5}$ concentrations recorded at Camden during 2014 will be adopted. A time series plot of 24-hour average $PM_{2.5}$ concentrations recorded at Camden during 2014 are illustrated in **Figure 5-2**.

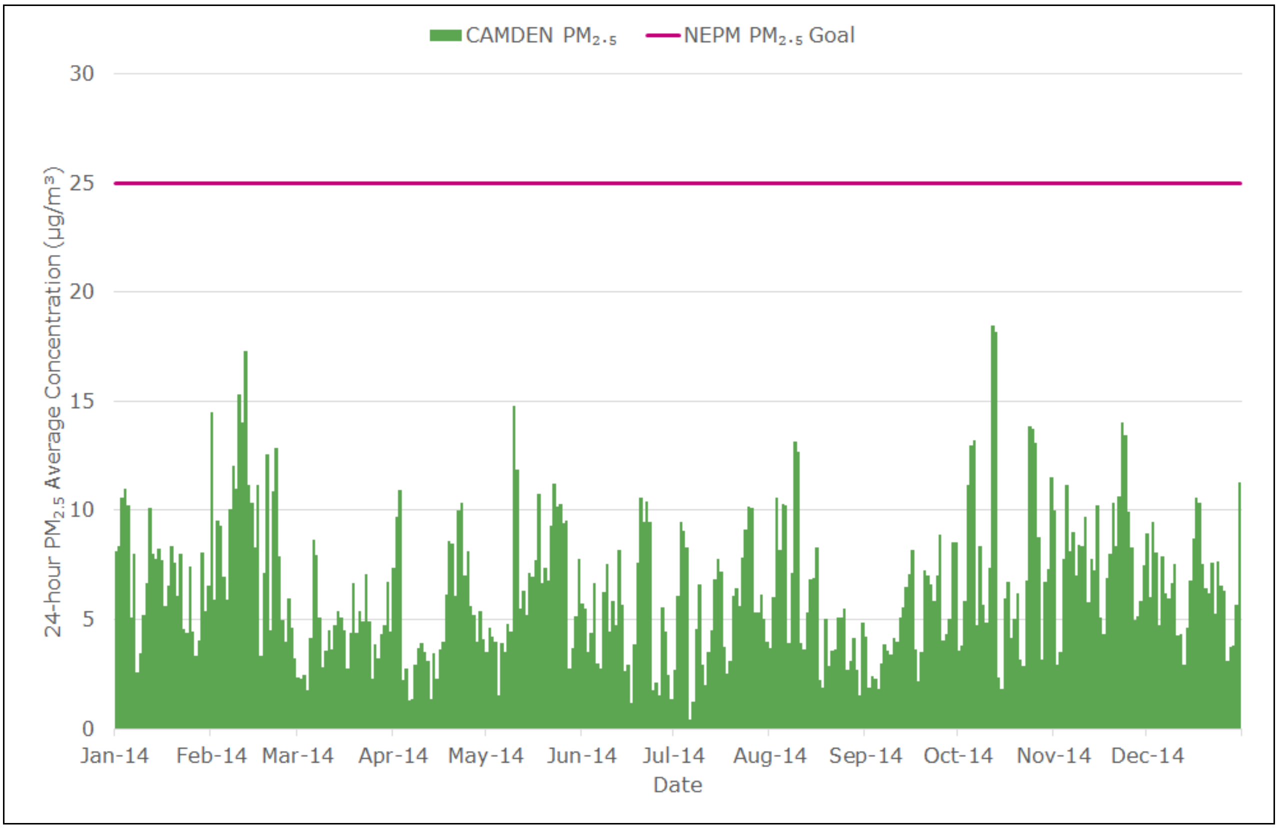

Figure 5-2: Time-series of 24-hour Average PM_{10} Concentrations recorded at OEH Camden – 2014

Maximum 24-hour average and annual average $PM_{2.5}$ concentrations for 2014 were 18.5µg/m^3 and 6.3µg/m^3 respectively.

5.4 Background TSP

Historically, the NSW OEH recorded concurrent 24-hour average TSP and PM_{10} concentrations on a one-in-six day sampling regime in the Sydney Metropolitan Region, with this monitoring discontinuing in 2004. NSW OEH quarterly air quality monitoring reports for 2003 and 2004 were reviewed for concurrent PM_{10} and TSP concentrations. This data highlighted that on average, the ratio of PM_{10} to TSP concentrations was approximately 0.48.

In the absence of local TSP monitoring data, the PM_{10}/TSP relationship from the 2003-2004 NSW OEH monitoring reports has been applied to the Bringelly PM_{10} monitoring data. The annual average TSP concentration adopted as background is therefore 34.7µg/m^3.

5.5 Background Dust Deposition

Dust deposition monitoring is undertaken for the Boral CSR Bringelly Brickworks site at four individual locations around the existing operations. Dust deposition gauge number 4 is located at the proposed project site. A review of dust deposition monitoring conducted at this location since 2011 was undertaken.

Annual average dust deposition levels at dust deposition gauge number 4 ranged from 1.9g/m^2/month to 3.2g/m^2/month between 2011 and 2015. The average of dust deposition monitoring conducted since 2011 is 2.5g/m^2/month. This value has been adopted as background dust deposition at the project site.

6. EMISSION ESTIMATION

Fugitive dust sources associated with the operation of the project were principally quantified through the application of NPI emission estimation techniques (specifically the Emission Estimation Technique Manual for Mining and United States Environmental Protection Agency (US-EPA) AP-42 emission factor equations). PM emissions were quantified for each particle size fraction, with the TSP size fraction also used to provide an indication of dust deposition rates. Fine particles (PM_{10} and $PM_{2.5}$) were estimated using ratios for the different particle size fractions available within the literature (principally the US-EPA AP-42).

6.1 Sources of Operational Emissions

Air emissions associated with the project would primarily comprise fugitive particulate matter releases. Potential sources of emission were identified as follows:

- Handling of aggregate and sand at storage bins and within the CBP;
- Transferring cement and cement supplement into silos from delivery trucks;
- CBP conveying and loading to agitator trucks;
- Wheel-generated dust from trucks and front end loader (FEL) movements across paved surfaces; and
- Wind erosion from material storage bins and adjacent paved surfaces.

6.2 Emission Scenario

A single emissions scenario, focusing on peak project operations, has been assessed in this report to quantify maximum potential impacts in the surrounding environment. Construction emissions would be short term and minor relative to operational emissions and have therefore not been considered further in this assessment.

Details on the assumptions made for the operational scenario are listed within **Appendix 2**.

6.3 Emission Reduction Factors

Based on information provided by Boral, the following emission reduction factors were applied to account for proposed controls at the project site:

- Paved roads / surfaces wheel dust – 9% reduction for monthly sweeping (Countess Environmental, 2006);
- Aggregate and sand unloading to storage area stockpiles - 50% reduction for water sprays (NPI, 2012);
- Wind erosion from material storage area stockpiles - 50% reduction for water sprays (NPI, 2012);
- Cement and cement supplement silo loading – Controlled emission factors applied to account for pneumatic loading of silos. Cement supplements are a liquid admixture;
- Weigh hopper loading and mixer activities - 50% reduction for carry-over of high moisture content from water sprays earlier in the process (NPI, 2012); and
- CBP material transfer points – 50% reduction for carry-over of high moisture content from water sprays earlier in the process (NPI, 2012).

6.4 Particulate Matter Emissions

A summary of project-related emissions by source type is presented in **Table 6-1** and illustrated in **Figure 6-1**. Control measures proposed for implementation, as documented in **Section 6.3**, have been taken into account in the emission estimates.

Table 6-1 and **Figure 6-1** highlight that, for both existing and proposed future operations, the most significant sources of emissions are associated with aggregate handling and transfer (including movement by FEL to hopper), weigh hopper and mixer activities, truck movements on paved surfaces, and diesel combustion emissions.

Further details regarding emission estimation factors and assumptions are provided in **Appendix 2**.

Table 6-1 Calculated Annual TSP, PM_{10} and $PM_{2.5}$ Emissions

Emissions Source	**Calculated Emissions (kg/annum) by Source**		
	TSP	**PM_{10}**	**$PM_{2.5}$**
Aggregate/Sand Delivery - Paved	60.9	11.7	3.4
Cement/Supplement/Admix Delivery - Paved	34.0	6.5	1.8
Aggregate Unloading	21.2	10.0	1.5
Sand Unloading	6.5	3.1	0.5
Cement unloading to silos	8.3	2.8	0.3
Supplement unloading to silos	4.5	2.4	0.2
Aggregate /Sand to Hopper	287.6	55.2	7.4
Aggregate transfer	21.2	10.0	1.5
Sand transfer	6.5	3.1	0.5
Weigh hopper loading	130.0	65.0	9.8
Mixer Loading (Central Mixer)	695.4	218.6	8.6
Agitator Truck Dispatch - Paved	99.7	19.1	4.5
Wind Erosion - Materials storage area	24.7	12.4	1.9
Diesel Combustion	166.1	166.1	161.3
Total	**1,566.5**	**586.0**	**203.2**

6.5 Metals Emissions

The US-EPA provide emission factors for various metals and metalloids associated with the handling and transfer of cement and cement additive at a CBP (US-EPA, 2006). However, given that the transfer of cement and cement additive will be conducted by transfer points fitted with reverse pulse filter systems, emissions of metals associated with this component of the project will be negligible. Emissions of metals and metalloids have not been considered further within this assessment.

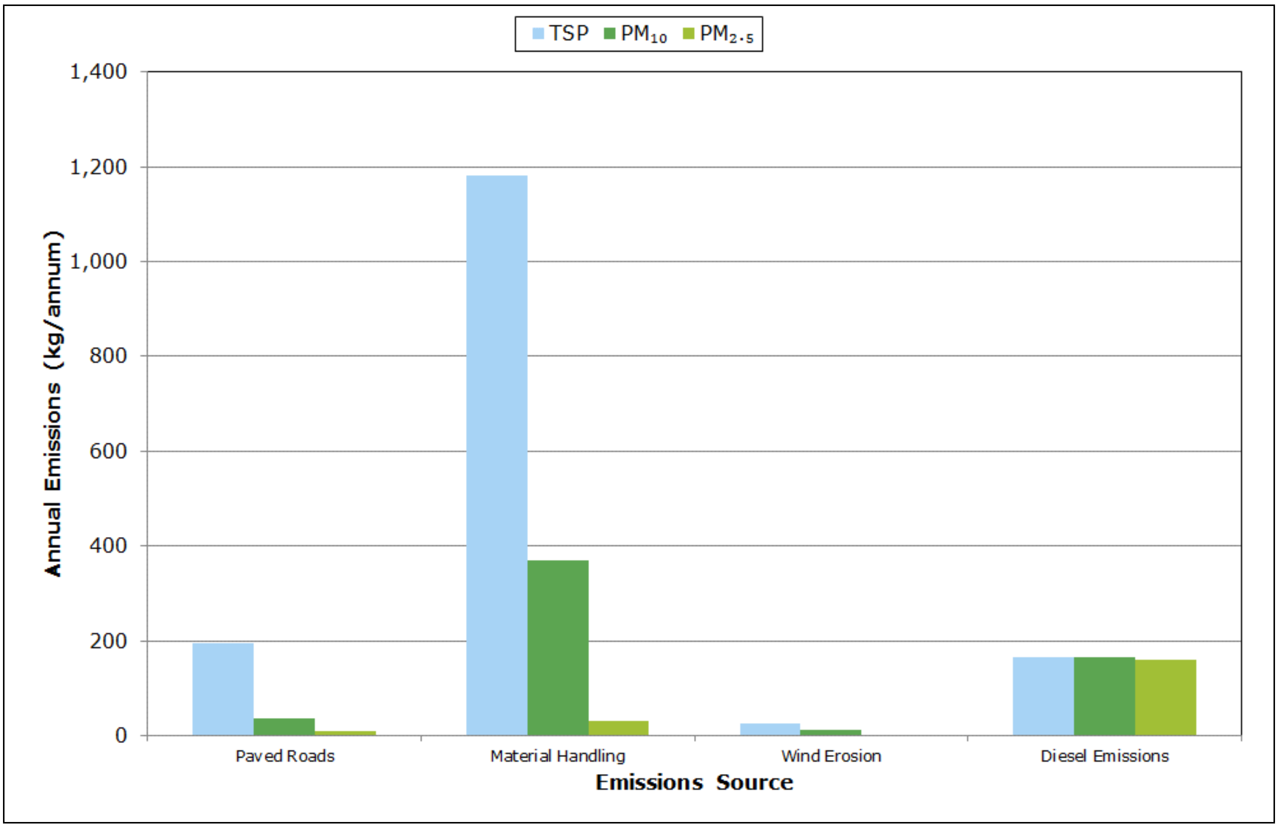

Figure 6-1: Comparison of Calculated Annual TSP, PM_{10} and $PM_{2.5}$ Emissions by Source Type

7. ASSESSMENT METHODOLOGY

7.1 Dispersion Model Selection and Application

The atmospheric dispersion modelling completed within this assessment used the AMS/US-EPA regulatory model (AERMOD) (US-EPA, 2004). AERMOD is designed to handle a variety of pollutant source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain. AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006 as it is considered to provide more realistic results with concentrations that are generally lower and more representative of actual concentrations compared to the ISC model. Compared to ISC, AERMOD represents an advanced new-generation model which requires additional meteorological and land-use inputs to provide more refined predictions.

Predicted concentrations were calculated for a regular Cartesian receptor grid covering a 3km by 3km computational domain centred over the project site, with a grid resolution of 100m applied. Additionally, concentrations were predicted at the sensitive receptor locations listed in **Table 2-2**.

Simulations were undertaken for the 12 month period of 2014 using the AERMET-generated file based largely on the Bringelly OEH meteorological monitoring dataset as input (see **Section 4** for description of input meteorology).

7.2 Modelling Scenarios

As identified in **Section 6.2**, a single emission scenario has been developed to estimate peak operational emissions of TSP, PM_{10} and $PM_{2.5}$ from the proposed project. The air dispersion modelling has predicted ground-level concentrations and deposition rates for this scenario.

7.3 Source and Emissions Data

The methodology and results of the emissions inventory developed for this study are presented in **Section 6** and **Appendix 2**. The spatial allocation of emissions was based on the layout of the project site presented in **Figure 2-2**. Material handling and wind erosion emissions were varied by wind speed, with higher emissions occurring during periods of higher wind speed.

7.4 Presentation of Model Results

Dispersion simulations were undertaken to predict the concentrations of TSP, PM_{10} and $PM_{2.5}$ and dust deposition. Incremental project-related concentrations and deposition rates occurring due to the proposed operations across the project site were modelled. Model results are expressed as the maximum predicted concentration for each averaging period at the selected assessment locations over the 2014 modelling period.

The results are presented in the following formats:

- Tabulated results of PM concentrations and dust deposition rates at the selected assessment locations are presented and discussed in **Section 8**.
- Isopleth plots, illustrating spatial variations in project-related incremental TSP, PM_{10} and $PM_{2.5}$ concentrations and dust deposition rates are provided in **Appendix 3**.

Note, the isopleth plots of the maximum 24-hour average concentrations presented in **Appendix 3** do not represent the dispersion pattern on any individual day, but rather illustrate the maximum daily concentration that was predicted to occur at each model calculation point given the range of meteorological conditions occurring over the 2014 modelling period.

8. DISPERSION MODELLING RESULTS

Incremental and cumulative TSP, PM_{10} and $PM_{2.5}$ concentrations and dust deposition rates predicted to occur under proposed project operations are presented in **Table 8-1** for each of the selected receptor locations.

Criteria applicable to the assessment of the predicted concentration are also presented in the tables. In the absence of impact assessment criteria for $PM_{2.5}$, reference is made to the NEPM standards for $PM_{2.5}$ to facilitate a screening assessment of predicted $PM_{2.5}$ concentrations.

Cumulative concentrations presented in these tables are the combination of the project-only increment and the adopted baseline air quality concentration (as per **Section 5**). In the case of maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations, the maximum predicted 24-hour average concentrations from project operations have been added to the maximum 24-hour average concentrations from local OEH monitoring stations. It is considered that this approach is conservative for assessing maximum cumulative impacts in the surrounding environment.

It can be seen from the results presented in **Table 8-1**, all pollutants and averaging periods are below the applicable NSW EPA assessment criterion and NEPM standards at all neighbouring receptors.

8.1 Cumulative Impacts with Boral CSR Brickworks

As discussed in **Section 5.1.1**, the neighbouring Boral CSR Bringelly Brickworks is located approximately 200m to the southeast of the project site. The 2013 Brickworks air quality impact assessment concluded that the emissions generated by the Boral CSR Bringelly Brickworks would not result in adverse impacts to the surrounding environment relative to impact assessment criteria.

Highest impacts from the Boral CSR Bringelly Brickworks were shown to occur at the receptors adjacent to the northern and eastern boundaries of that operation. These areas correlate approximately to receptors R10, R11, R12, R13, R14, R22 and R23. The predicted incremental concentrations and deposition rates from the proposed project at these receptors (as per **Table 8-1**) are negligible.

The magnitude of predicted incremental concentrations and deposition levels from the proposed project site are low at all neighbouring receptors, in particular at the receptors to the north and east of the Boral CSR Bringelly Brickworks. This is due to the dominant air flow (south-southwest, east and north-northeast) of the area.

Due to the east-west alignment of the two sites and the dominant air flow, the potential for the combined impact of emissions from the two operations is unlikely. It is therefore considered unlikely that the proposed project site would result in significant cumulative impacts that would change the conclusions of the 2013 Brickworks assessment.

Table 8-1 Incremental and Cumulative Particulate Matter Concentration/Deposition Results

Receptor ID	Incremental Concentration/Deposition due to project						Cumulative Concentration due to project + Background Air Quality					
	TSP Annual Average µg/m^3	PM$_{10}$ Maximum 24-hr µg/m^3	PM$_{10}$ Annual Average µg/m^3	PM$_{2.5}$ Maximum 24-hr µg/m^3	PM$_{2.5}$ Annual Average µg/m^3	Deposition Annual Average g/m^2/month	TSP Annual Average µg/m^3	PM$_{10}$ Maximum 24-hr µg/m$^{3(b)}$	PM$_{10}$ Annual Average µg/m^3	PM$_{2.5}$ Maximum 24-hr µg/m$^{3(b)}$	PM$_{2.5}$ Annual Average µg/m^3	Deposition Annual Average g/m^2/month
Criteria	**NA**	**NA**	**NA**	**NA**	**NA**	**2**	**90**	**50**	**30**	**25$^{(a)}$**	**8$^{(a)}$**	**4**
R1	1.6	3.7	0.6	1.0	0.2	0.2	38.7	46.3	17.3	19.5	6.5	2.7
R2	0.2	0.3	<0.1	<0.1	<0.1	<0.1	37.3	42.9	16.8	18.6	6.3	2.5
R3	0.2	0.4	<0.1	0.1	<0.1	<0.1	37.3	43.0	16.8	18.6	6.3	2.5
R4	0.1	0.2	<0.1	<0.1	<0.1	<0.1	37.2	42.8	16.7	18.6	6.3	2.5
R5	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	37.2	42.8	16.7	18.6	6.3	2.5
R6	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	37.2	42.8	16.7	18.5	6.3	2.5
R7	0.1	0.2	<0.1	<0.1	<0.1	<0.1	37.2	42.8	16.7	18.6	6.3	2.5
R8	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	37.2	42.7	16.7	18.5	6.3	2.5
R9	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	37.1	42.7	16.7	18.5	6.3	2.5
R10	0.2	0.7	<0.1	0.2	<0.1	<0.1	37.3	43.3	16.8	18.7	6.3	2.5
R11	0.2	0.4	<0.1	0.1	<0.1	<0.1	37.3	43.0	16.8	18.6	6.3	2.5
R12	0.1	0.3	<0.1	<0.1	<0.1	<0.1	37.2	42.9	16.7	18.6	6.3	2.5
R13	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	37.2	42.8	16.7	18.6	6.3	2.5
R14	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	37.2	42.8	16.7	18.5	6.3	2.5
R15	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	37.1	42.7	16.7	18.5	6.3	2.5

Table 8-1 Incremental and Cumulative Particulate Matter Concentration/Deposition Results

Receptor ID	Incremental Concentration/Deposition due to project						Cumulative Concentration due to project + Background Air Quality					
	TSP Annual Average µg/m³	PM_{10} Maximum 24-hr µg/m³	PM_{10} Annual Average µg/m³	$PM_{2.5}$ Maximum 24-hr µg/m³	$PM_{2.5}$ Annual Average µg/m³	Deposition Annual Average g/m²/month	TSP Annual Average µg/m³	PM_{10} Maximum 24-hr µg/m³ (b)	PM_{10} Annual Average µg/m³	$PM_{2.5}$ Maximum 24-hr µg/m³ (b)	$PM_{2.5}$ Annual Average µg/m³	Deposition Annual Average g/m²/month
Criteria	**NA**	**NA**	**NA**	**NA**	**NA**	**2**	**90**	**50**	**30**	**25(a)**	**8(a)**	**4**
R16	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	37.2	42.9	16.7	18.6	6.3	2.5
R17	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	37.2	42.7	16.7	18.5	6.3	2.5
R18	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	37.2	42.8	16.7	18.6	6.3	2.5
R19	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	37.2	42.9	16.7	18.6	6.3	2.5
R20	<0.1	0.4	<0.1	0.1	<0.1	<0.1	37.2	43.0	16.7	18.6	6.3	2.5
R21	0.1	0.3	<0.1	<0.1	<0.1	<0.1	37.2	42.9	16.7	18.6	6.3	2.5
R22	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	37.1	42.7	16.7	18.5	6.3	2.5
R23	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	37.1	42.6	16.7	18.5	6.3	2.5

NA – Not applicable. Criteria are applicable to cumulative concentrations.

a) The NEPM Reporting Goals for $PM_{2.5}$ are referenced for screening assessment purposes.

b) The maximum cumulative value is a sum of the maximum combined 24-hour average concentration from the project and the maximum baseline concentration.

9. CONCLUSIONS

Ramboll Environ was commissioned by EMM to undertake an AQIA for the proposed project at Bringelly on behalf of Boral.

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated for peak proposed operations associated with the project. Atmospheric dispersion modelling predictions of air pollution emissions for proposed operations were undertaken using the AERMOD dispersion model.

The results of the dispersion modelling conducted indicated that the operation of the proposed project was unlikely to result in exceedances of the applicable NSW EPA assessment criteria for TSP, PM_{10} and dust deposition or the NEPM standards for $PM_{2.5}$. Furthermore, the calculated cumulative concentrations were largely uniform at all receptors, indicating that the existing background air quality is dominant compared with impacts from the proposed operations.

10. REFERENCES

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US-EPA (2006c). AP42 Emission Factor Database, Chapter 11.12 Concrete Batching, United States Environmental Protection Agency, 2006.

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11. GLOSSARY OF ACRONYMS AND SYMBOLS

Approved Methods	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW
AHD	Australian Height Datum
BoM	Bureau of Meteorology
Boral	Boral Recycling Pty Ltd
CBP	Concrete batching plant
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EPA	Environmental Protection Authority
EMM	EMM Consulting Pty Limited
µg	Microgram (g x 10-6)
µm	Micrometre or micron (metre x 10-6)
m^3	Cubic metre
NPI	National Pollutant Inventory
OEH	NSW Office of Environment and Heritage
PM_{10}	Particulate matter less than 10 microns in aerodynamic diameter
$PM_{2.5}$	Particulate matter less than 2.5 microns in aerodynamic diameter
Ramboll Environ	Ramboll Environ Australia Pty Ltd
TAPM	"The Air Pollution Model"
TSP	Total Suspended Particulates
The project	Proposed Bringelly Concrete Batching Plant
US-EPA	United States Environmental Protection Agency
VKT	Vehicle Kilometres Travelled

APPENDIX 1
WIND ROSES

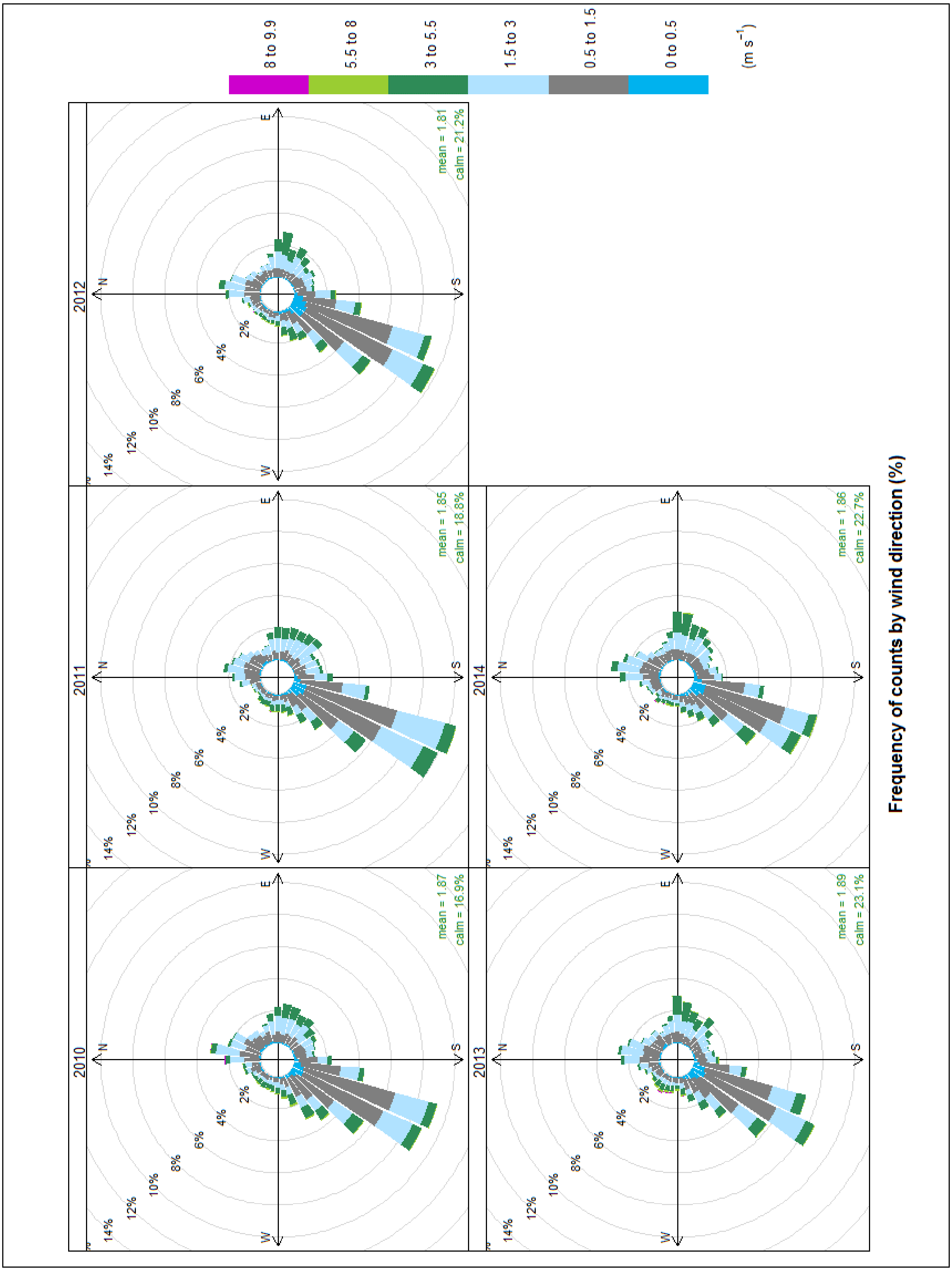

Figure A1.1 Annual Wind Roses – Bringelly OEH – 2010 - 2014

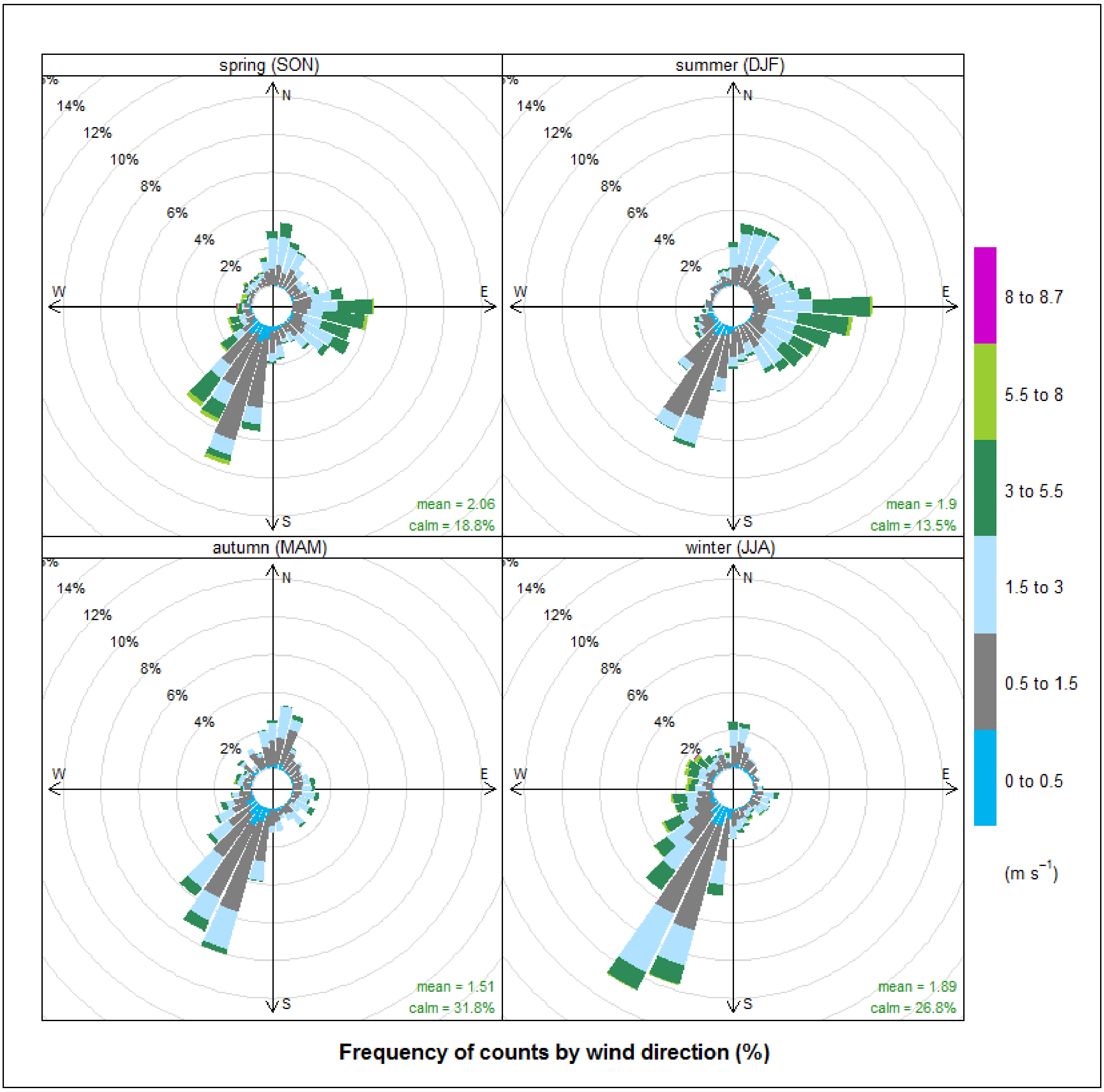

Figure A1.2 Seasonal Wind Roses – Bringelly OEH – 2014

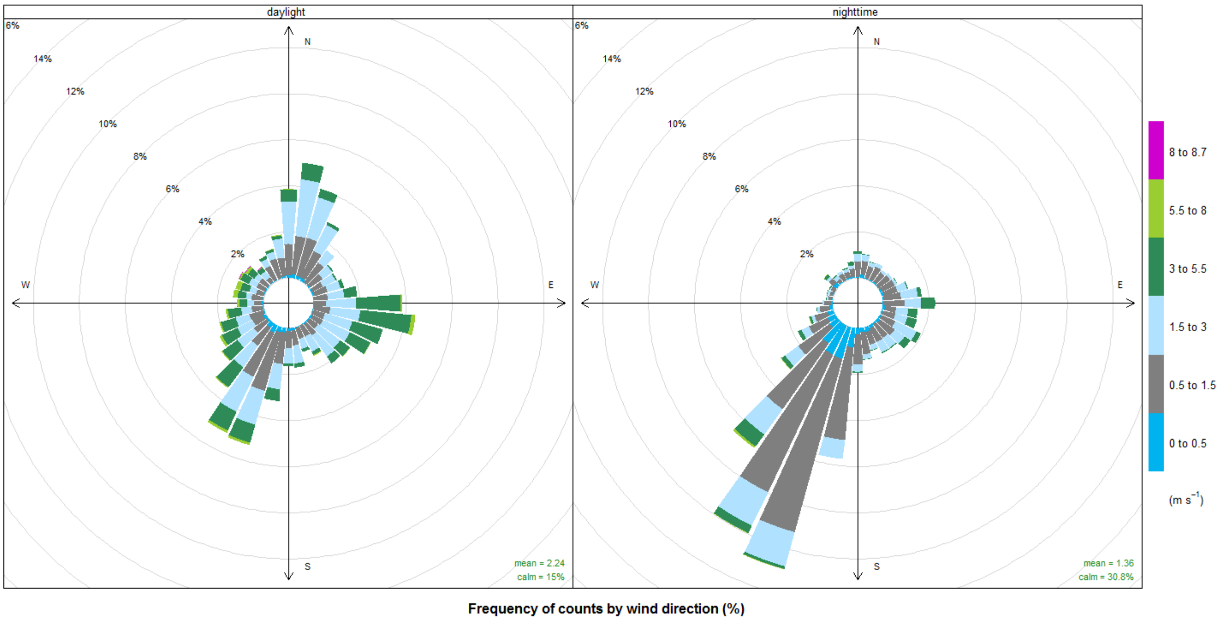

Figure A1.3 Diurnal Wind Roses – Bringelly OEH – 2014

APPENDIX 2EMISSIONS INVENTORY

Introduction

Air emission sources associated with the project were identified and quantified through the application of accepted published emission estimation factors, collated from a combination of United States Environmental Protection Agency (US-EPA) AP-42 Air Pollutant Emission Factors and NPI emission estimation manuals, including the following:

- NPI Emission Estimation Technique Manual for Mining (NPI, 2012);
- AP-42 Chapter 13.2.5 – Industrial Wind Erosion (US-EPA 2006a);
- AP-42 Chapter 13.2.4 – Aggregate Handling and Storage Piles (US-EPA 2006b);
- AP-42 Chapter 11.12 – Concrete Batching (US-EPA 2006c); and
- AP-42 Chapter 13.2.1 – Paved Roads (US-EPA 2011).

Sources of Particulate Matter Emissions

Air emissions associated with the project would primarily comprise of fugitive particulate matter releases. Key sources of emission were identified as follows:

- Handling of aggregate and sand at storage bins and within the CBP;
- Transferring cement and cement supplement into silos from delivery trucks;
- CBP conveying and loading to agitator trucks;
- Wheel-generated dust from trucks and front end loader (FEL) movements across paved surfaces;
- Diesel combustion; and
- Wind erosion from material storage bins and adjacent paved surfaces.

Operational Assumptions

To compile an emissions inventory for existing and proposed operations at the site, the following general assumptions were made:

- Operational activities occur between 7am and 10pm Monday to Saturday and 8am to 10pm Sunday. 300 operational days per year;
- Wind erosion area for material storage area and stockpiles of 0.175ha
- Average truck weights (average of loaded and unloaded weights);
  - Aggregate/sand truck – 26t;
  - Cement/supplement truck – 24t;
  - FEL – 9.5t; and
  - Agitator truck – 19.25t.
- Daily average truck movements;
  - Aggregate/sand truck – 20;
  - Cement/supplement truck – 12;
  - Agitator truck – 86.
- Front end loader equivalent to CAT930 adopted. Engine specifications of 115kW applied to diesel calculations.

Particulate Matter Emission Factors Applied

The emission factor equations applied within the assessment are documented in this subsection. **Table A2.1** lists the uncontrolled emission factors that were applied for the two emission scenarios, references the source of the listed factors and whether the factor is derived from a specific equation or a published default emission factor.

Table A2.1 Emission Estimation Factors Applied

Emission Source	TSP Emission Factor	PM_{10} Emission Factor	$PM_{2.5}$ Emission Factor	Emission Factor Unit	Source of Factor
Aggregate/Sand Delivery - Paved	0.04	0.01	0.00209	kg/Vehicle KM Travelled	AP-42 13.2.1 - Paved Road Equation
Cement/Supplement/Admix Delivery - Paved	0.03	0.01	0.00185	kg/Vehicle KM Travelled	AP-42 13.2.1 - Paved Road Equation
Aggregate Unloading	0.0008	0.0004	0.00006	kg/tonne aggregate	US-EPA AP42 13.2.4 - Materials Handling Equation
Sand Unloading	0.0003	0.0001	0.00002	kg/tonne sand	US-EPA AP42 13.2.4 - Materials Handling Equation
Cement unloading to silos	0.0005	0.0002	0.00002	kg/tonne cement	US-EPA AP42 11.12 - Cement unloading to elevated storage silos (controlled)
Supplement unloading to silos	0.0045	0.0024	0.00024	kg/tonne supplement	US-EPA AP42 11.12 - Cement supplement unloading to elevated storage silos (controlled)
Aggregate /Sand to Hopper	0.32	0.06	0.00818	kg/Vehicle KM Travelled	AP-42 13.2.1 - Paved Road Equation
Aggregate transfer	0.0008	0.0004	0.00006	kg/tonne aggregate	US-EPA AP42 13.2.4 - Materials Handling Equation
Sand transfer	0.0003	0.0001	0.00002	kg/tonne sand	US-EPA AP42 13.2.4 - Materials Handling Equation
Weigh hopper loading	0.0026	0.0013	0.00020	kg/tonne aggregate / sand	US-EPA AP42 11.12 - Weigh hopper loading
Mixer Loading (Central Mixer)	0.0795	0.0250	0.00099	kg/tonne cement/supplement	US-EPA AP42 11.12 - Truck loading (Central mix)
Agitator Truck Dispatch - Paved	0.03	0.01	0.00127	kg/Vehicle KM Travelled	AP-42 13.2.1 - Paved Road Equation
Aggregate/Sand Delivery - Paved	0.04	0.01	0.00209	kg/ha/year	AP-42 13.2.5 - Industrial Wind Erosion

Details relating to the emission equations referenced in **Table A2.1** are presented in the following sections.

Paved Roads Equation

The emissions factors for paved roads, as documented within AP42 Chapter 13.2.2 -"Paved Roads" (US-EPA 2011), was applied as follows:

$E = k (sL)^{0.91}(W)^{1.02}$

Where:

E = Emissions Factor (g/VKT)

sL = road surface silt loading (g/m^2)

W = mean vehicle weight (tonnes)

k = constant of 1.5 for PM_{10}

Material parameters are listed in **Table A2.2**.

Materials Handling

Particulate matter emissions from material transfer operations were calculated through the application of the US-EPA predictive emission factor equation for continuous and batch drop loading and tipping operations (AP42, Section 13.2.4), given as follows:

$$E = k(0.0016) * \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right)$$

where,

E =Emissions (kg/tonne transferred)

U = mean wind speed (m/s)

M = material moisture content (%)

k = 0.74 for TSP, 0.35 for PM_{10} and 0.053 for $PM_{2.5}$

Wind Erosion Sources

Wind-blown dust from storage bins and the materials storage area was estimated by applying the complex, predictive emission estimation procedure documented within AP-42 Chapter 13.2.5 "Industrial Wind Erosion" November 2006, as described below.

The predictive emission factor equation for industrial wind erosion is given as follows:

$$\mathrm{E} = \mathrm{k} \sum_{\mathrm{i}=1}^{\mathrm{N}} \mathrm{Pi}$$

Where,

k = particle size multiplier ($k = 1$ for TSP, 0.5 for PM_{10} and 0.075 for $PM_{2.5}$)

N = number of disturbances per year

Pi = erosion potential corresponding to the observed (or probable) fastest mile of wind for the i^{th} period between disturbances (g/m^2), calculated by:

$P = 58(u^* - ut^*) + 25(u^* - ut^*)$

$$P = 0 \text{ for } u^* \leq ut^*$$

Where,

u* = friction velocity (m/s)

ut* = threshold friction velocity (m/s)

Diesel Calculations

Diesel combustion emissions of $PM_{2.5}$ are described in the tables below. It is assumed that 97% of PM_{10} emissions from diesel combustion is $PM_{2.5}$, emissions have been up-scaled accordingly.

Table A2.3 Likely Onsite Diesel Equipment and Fleet and $PM_{2.5}$ Emissions

Equipment	Number	Make (or similar)	Power Rating (kW)	Operating Hours	$PM_{2.5}$ Emission Factor (g/kWh) – USEPA Tier 2	Load Factor	Annual Emissions (kg/year)
Front End Loader	1	CAT 930	115	4,500	0.4	0.5	103.5

Emission Factor Source: NSW EPA (2014) Reducing Emissions from Non-road Diesel Engines. Prepared by ENVIRON Australia Pty Ltd.

Load Factor Source:

Table A2.4 $PM_{2.5}$ Emissions – Trucks Moving Onsite

Equipment	PM Emission Factor (g/VKT) - 1996 ADR70/00	Annual VKT	Annual Emissions (kg/year)
Trucks moving on site	0.584	6,750	3.9

Emission Factor Source: NSW EPA (2012) Technical Report No. 7, Air Emissions Inventory for the Greater Metropolitan Region in New South Wales, 2008 Calendar Year,On-Road Mobile Emissions.

Table A2.5 $PM_{2.5}$ Emissions – Trucks Idling Onsite

Equipment	Trucks onsite at any hour	Emission Factor PM (g/hr) - USEPA	Hours per year	Annual Emissions (kg/year)
Trucks Idling on site	10	1.196	4,500	53.8

Emission Factor Source: NSW EPA (2012) Technical Report No. 7, Air Emissions Inventory for the Greater Metropolitan Region in New South Wales, 2008 Calendar Year, On-Road Mobile Emissions.

Project Related Input Data

Material property inputs used in the emission equations presented in **Table A2.1** are detailed in **Table A2.2**. It is noted that minimal details relating to the material properties were available at the time of reporting. To compensate, values were adopted from the literature.

Table A2.2 Material Property Inputs for Emission Estimation Factors Applied

Material Properties	Units	Value	Source of Information
Moisture Content of aggregate	%	1.77	Default value for aggregate – US-EPA AP42 (2006c)
Moisture Content of sand	%	4.14	Default value for Sand – US-EPA AP42 (2006c)
Silt Loading of Paved Roads – Material Deliveries and Product Dispatch	g/m^2	0.6	Default baseline loading for roads with traffic <500 vehicles per day - US-EPA AP42 (2011)
Silt Loading – FEL movements	g/m^2	12	Default loading for concrete batching plants- US-EPA AP42 (2011)

Key operational details by process used in the emission calculations are listed in **Table A2.3**.

Table A2.3 Emission Estimation Activity Rates Applied for Emission Calculations

Process	Unit	Scenario 1
Aggregate	Tonnes of material	50,000
Sand	Tonnes of material	50,000
Cement	Tonnes of material	16,500
Supplement	Tonnes of material	1,000
Aggregate / Sand delivery	Annual VKT (km)	1,800
Cement / Supplement delivery	Annual VKT (km)	1,080
Agitator Truck dispatch	Annual VKT (km)	3,870
FEL Transfer Movements	Annual VKT (km)	1,000
Wind Erosion – Material storage area and stockpiles	Area (ha)	0.175

APPENDIX 3INCREMENTAL ISOPLETH PLOTS

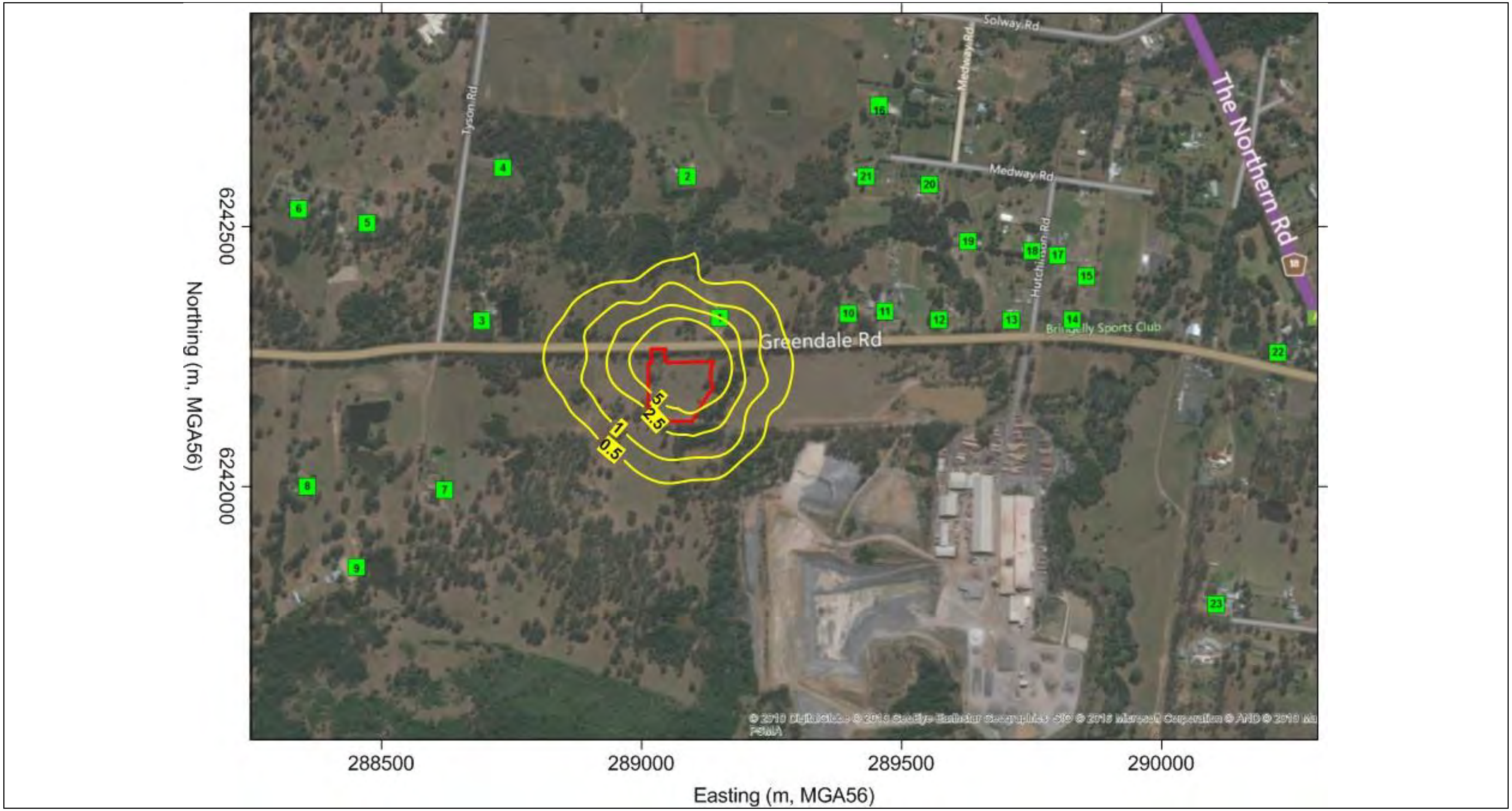

Figure A3.1 Predicted Incremental Annual Average TSP Concentrations (µg/m³)

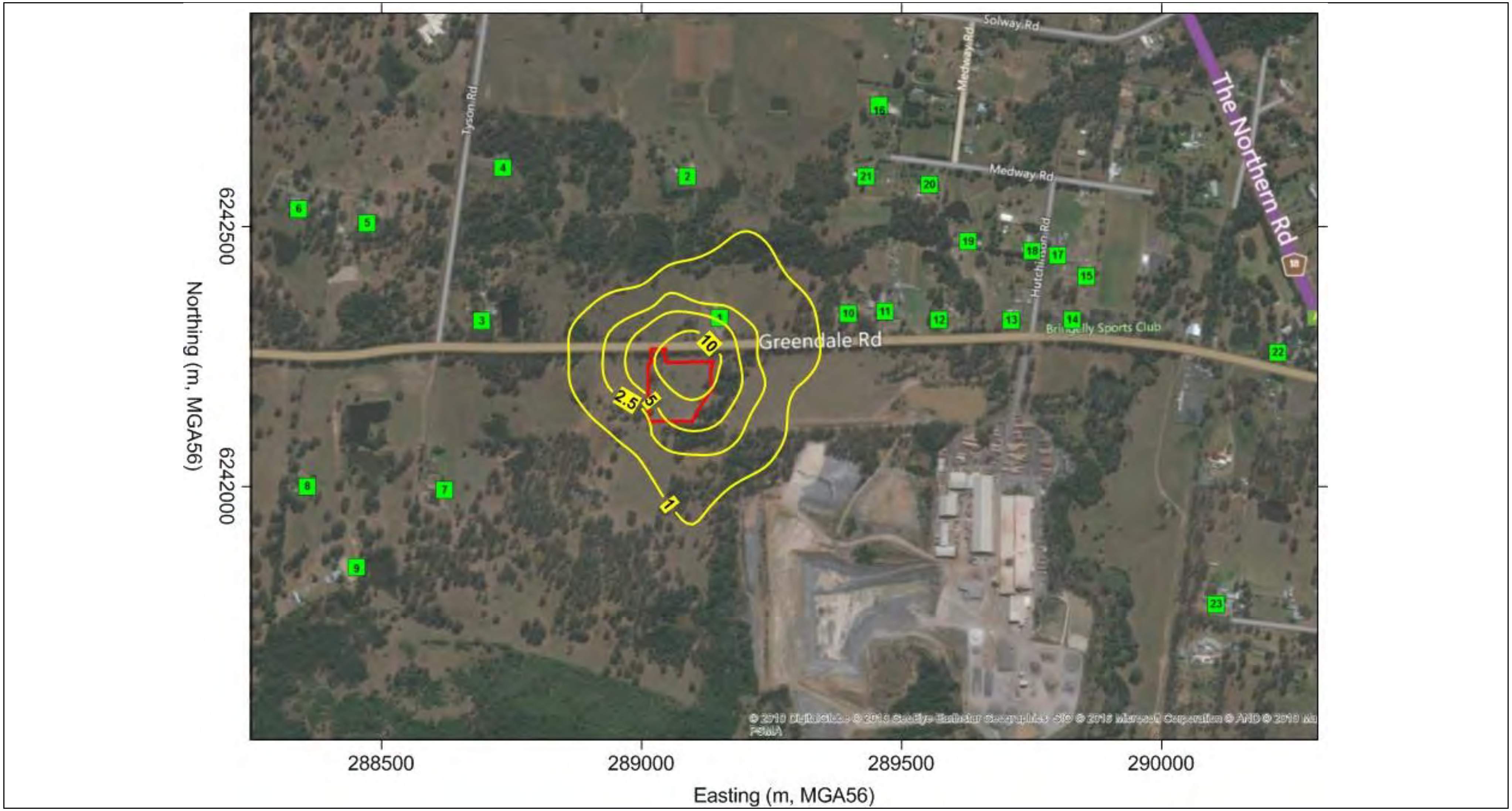

Figure A3.2 Predicted Incremental Maximum 24-hour Average PM_{10} Concentrations (µg/m³)

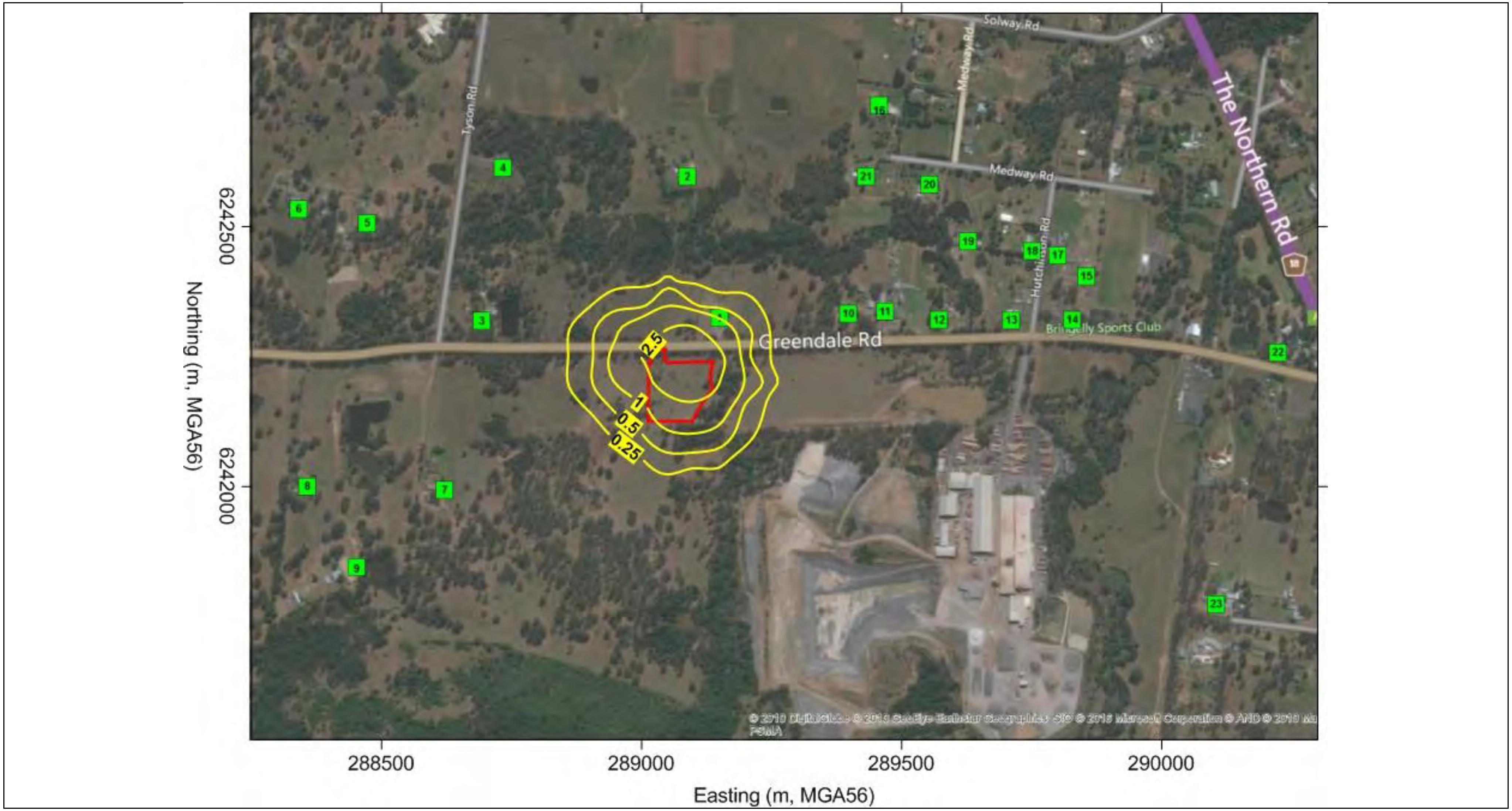

Figure A3.3 **Predicted Incremental Annual Average PM_{10} Concentrations (µg/m³)**

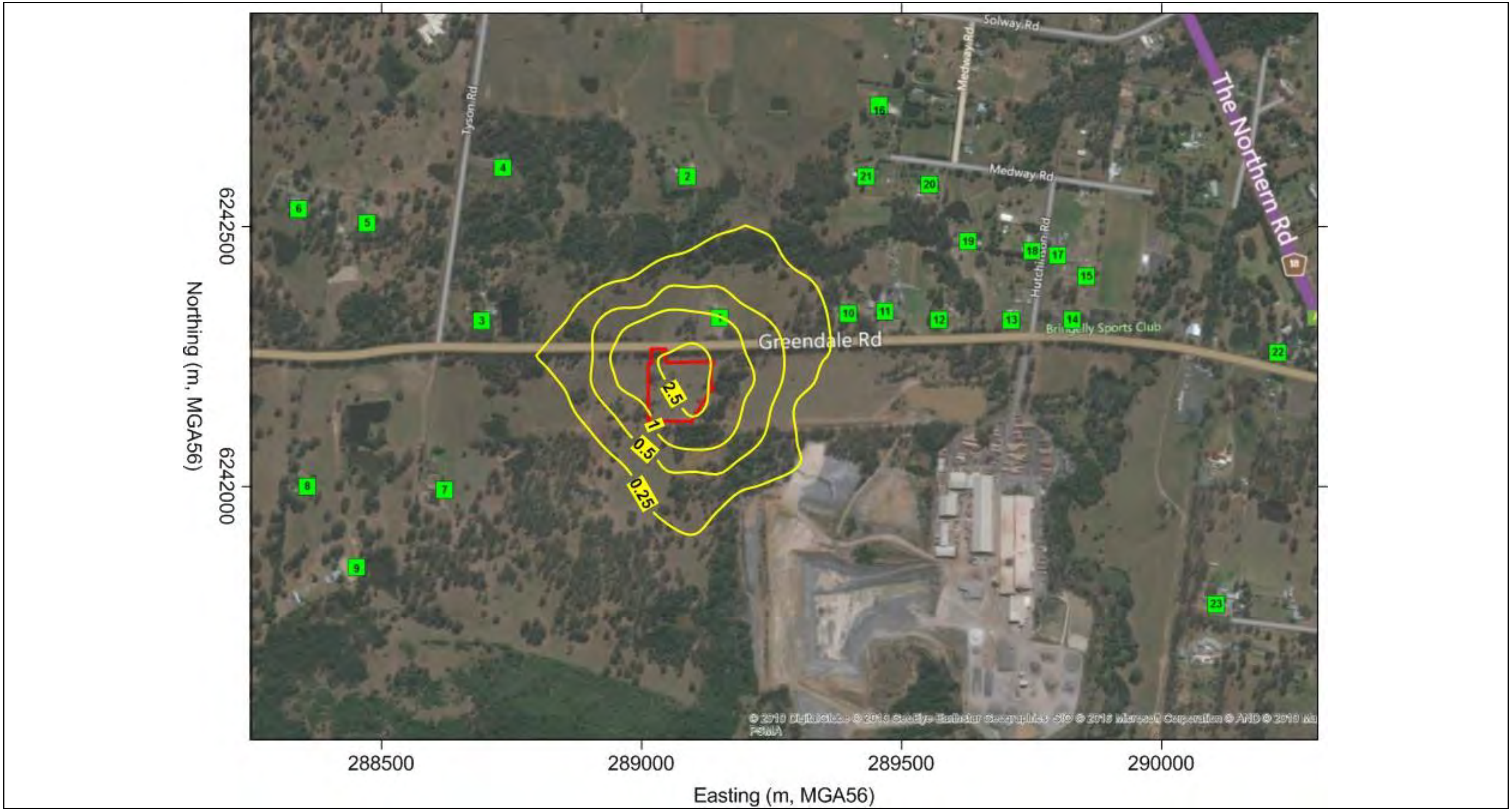

Figure A3.4 Predicted Incremental Maximum 24-hour Average $PM_{2.5}$ Concentrations (µg/m³)

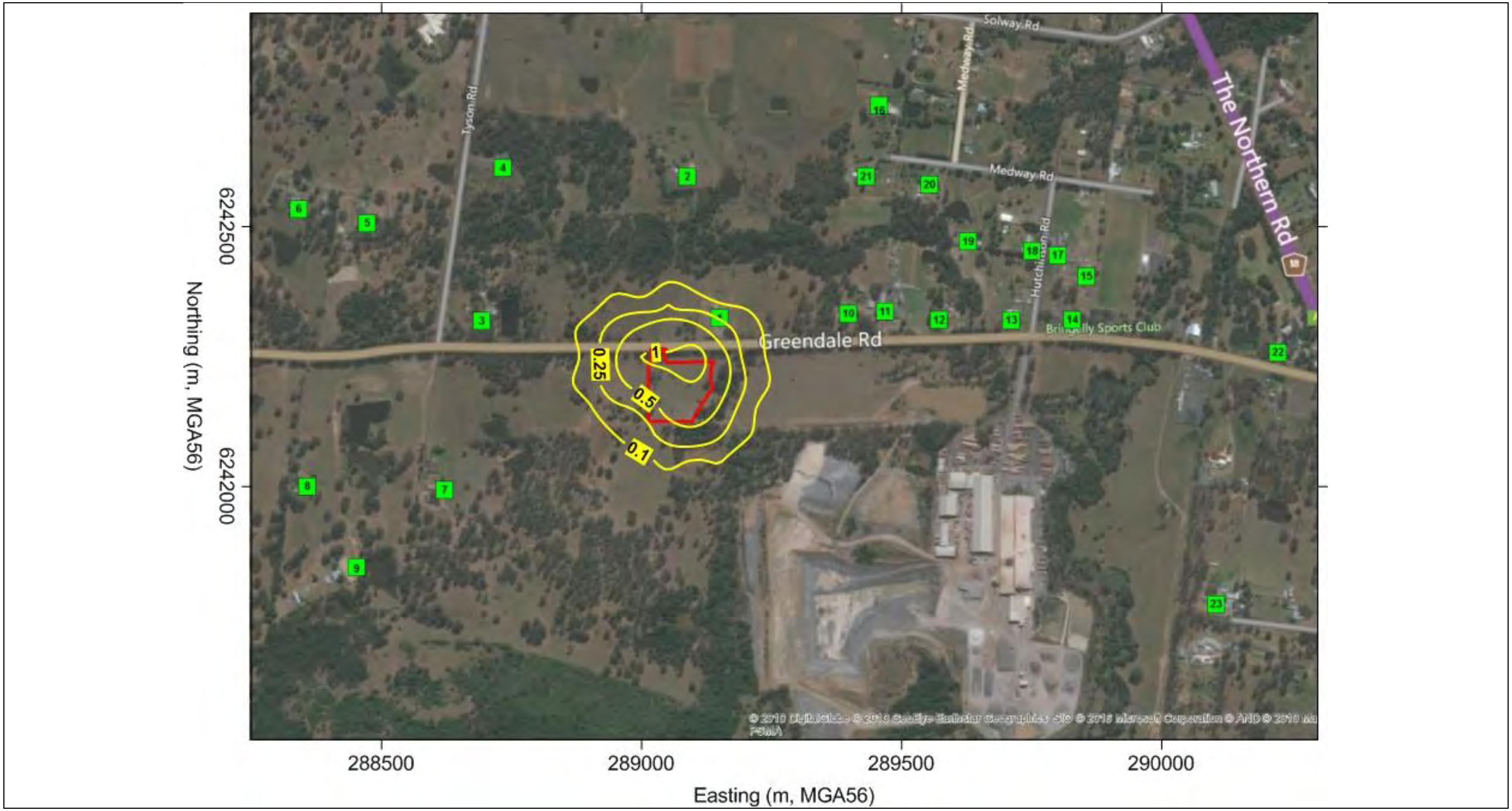

Figure A3.5 Predicted Incremental Annual Average $PM_{2.5}$ Concentrations (μg/m³)

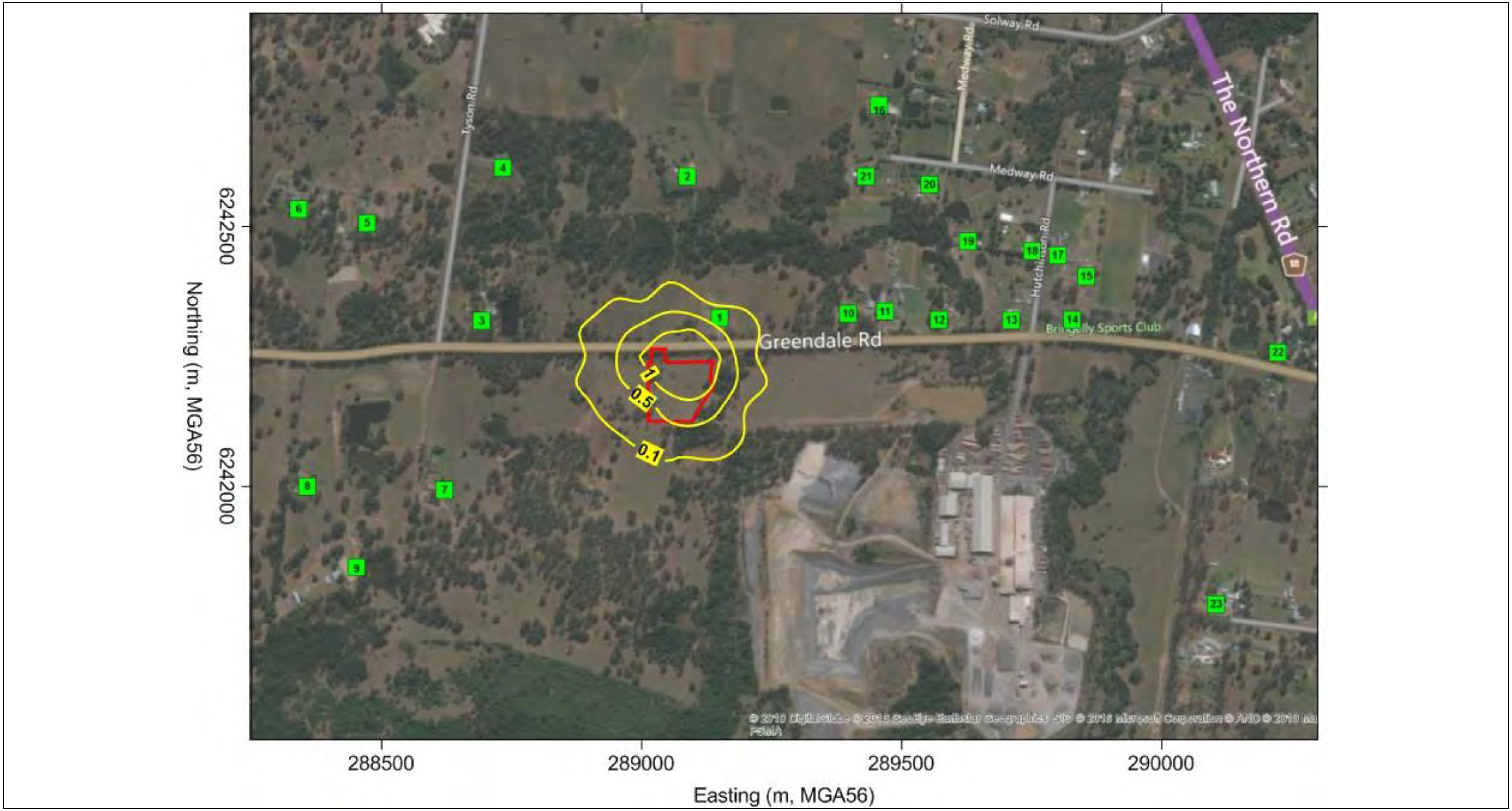

Figure A3.6 Predicted Incremental Annual Average Dust Deposition Levels (g/m^2/month)


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20706

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Re: Bringelly Concrete Batching Plant, revised road traffic assessment

1 Introduction

EMM Consulting Pty Limited recently completed a noise and vibration assessment for a proposed concrete batching plant in the north-western corner of Lot 100 DP 1203966 on Greendale Road, Bringelly, NSW (the project). The noise and vibration assessment was part of an Environmental Impact Statement (EIS) dated 9 May 2016.

In the original noise and vibration assessment (May 2016) the impacts of road traffic noise from the project were assessed by categorising Greendale Road as a sub-arterial road as per the 'Road Noise Policy' (EPA 2011) (RNP). Camden Council is the consent authority for the application and they have requested that Greendale Road be assessed as a 'rural collector road' as per the 'Environmental Criteria for Road Traffic Noise' (EPA 1999) (ECRTN) which was replaced by the RNP. This request has, therefore, been completed as provided in the following sections.

2 Criteria

The criteria for a rural collector road as per the ECTRN are provided below in Table 1.

Table 1 Environmental criteria for road traffic noise criteria, collector road

Type of development	**Criteria, $L_{Aeq\ (1\ hour)}$, dB**		**Where criteria are already exceeded**
	Day[1]	**Night**[1]	
Land use developments with potential to create additional traffic on collector road	60	55	Where feasible and reasonable, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB.

Notes: 1.The day is 7 am to 10 pm, the night is 10 pm to 7 am.

3 Existing and proposed road traffic volumes

The existing hourly road traffic volumes are presented below in Table 2. All values represent expected peak road traffic volumes.

Table 2 Existing and proposed road traffic volumes

Location	Distance to nearest façade (m)	Existing[1]			Proposed from the project		Other future developments[4]	
		Morning peak hour volume	Afternoon peak hour volume[2]	Percentage of heavy vehicles	Peak hour volume	Percentage of heavy vehicles[3]	Peak hour volume	Percentage of heavy vehicles
East of the project and west of the Brickworks	35	154	168	5.4	13	90	76	5
East of the Brickworks	25	192	206	10.4	13	90	76	5
West of the project	25	154	168	5.4	5	90	14	5
Bringelly Public School	25	192	206	10.4	13	90	76	5

Notes: *1 Sourced from EMM's traffic report 2016.*

2. These volumes were used as they are higher than morning peak hour volumes.

3. This assumes a highly conservative peak of 13 trucks per hour.

4. The traffic volumes for the proposed development at 41 Greendale Road were sourced from Liverpool City Council Joint Regional Planning Panel Report for DA-394/2011. Traffic volumes were split with 80% of road traffic heading east from the proposed development (ie towards The Northern Road and past the project).

4 Assessment

The results of the updated road traffic noise assessment are provided below in Table 3. Road traffic noise predictions demonstrate that ECTRN absolute criteria or the allowable 2 dB increase as per the ECTRN are achieved for the day period (ie the operating periods of the project) at all residences.

Table 3 Predicted road traffic noise levels

Location	Assessment location	Period	Distance from road to nearest façade (m)	ECTRN day criteria $L_{Aeq\ (1\ hour)}$, dB	Predicted road traffic noise level, $L_{Aeq\ (1\ hour)}$, dB					
					Existing[1]	Approved developments	Proposed from project	Existing + approved developments	Existing + proposed from project	Cumulative
East of project site, west of Brickworks	R1, R10, R11	Day	40	60	56	52	53	57	57	59
East of Brickworks	R11-R14	Day	25	60	60	54	55	61	61	62
West of project site	R3-R9	Day	25	60	58	52	50	59	59	60
East of Brickworks	Bringelly Public School	Day	25	40 (internal)	**Windows open[1]**					
					50	44	45	51	51	52
					Windows closed[2]					
					40	34	35	40	41	42

Notes: *1. 10 dB reduction has been assumed for windows open*

2. 20 dB reduction assumed for windows closed.

5 Conclusion

EMM has re-assessed road traffic noise impacts from the project as per Council's request. It was found that predicted road traffic noise levels satisfy absolute noise criteria or the allowable increase where 'existing' levels already exceed criteria.

Yours sincerely,

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26 April 2017

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William Jones, Town Planner

Camden Council
PO Box 183
Camden NSW 2570

Sent via email

Re: Proposed Bringelly CBP Access to Greendale Road, measurement of sight distances

Dear Will,

As is illustrated by the attached horizontal sight lines plan, I have verified by means of a measuring wheel and various sighting points, that the proposed site access driveway can meet the required Austroads safe intersection sight distance standard of 170 m for car access for an 80 km/hr travel speed on Greendale Road. For truck access, the higher sight distance standard of 181 m will also be able to be met due to the higher drivers eye height (2.4 m compared to 1.25 metres) for trucks.

In conjunction with the future road shoulder widening and road resurfacing/reconstruction for the Type BAR/BAL Austroads intersection design at the site access, the proposed clearance of a number of additional trees in the road reserve, within approximately 50 metres either side of the proposed access driveway centre line (eight trees in addition to the 38 trees identified in the EIS) will enable the standard Austroads 80 km/hr horizontal sight distance requirement to be met.

A vertical sight lines plan, showing compliance with the Austroads 80 km/hr vertical sight distance requirement, will be prepared as part of the future detailed intersection design plans for the Type BAR/BAL intersection at the site access.

Yours sincerely

Tim Brooker
Senior Transport Planner
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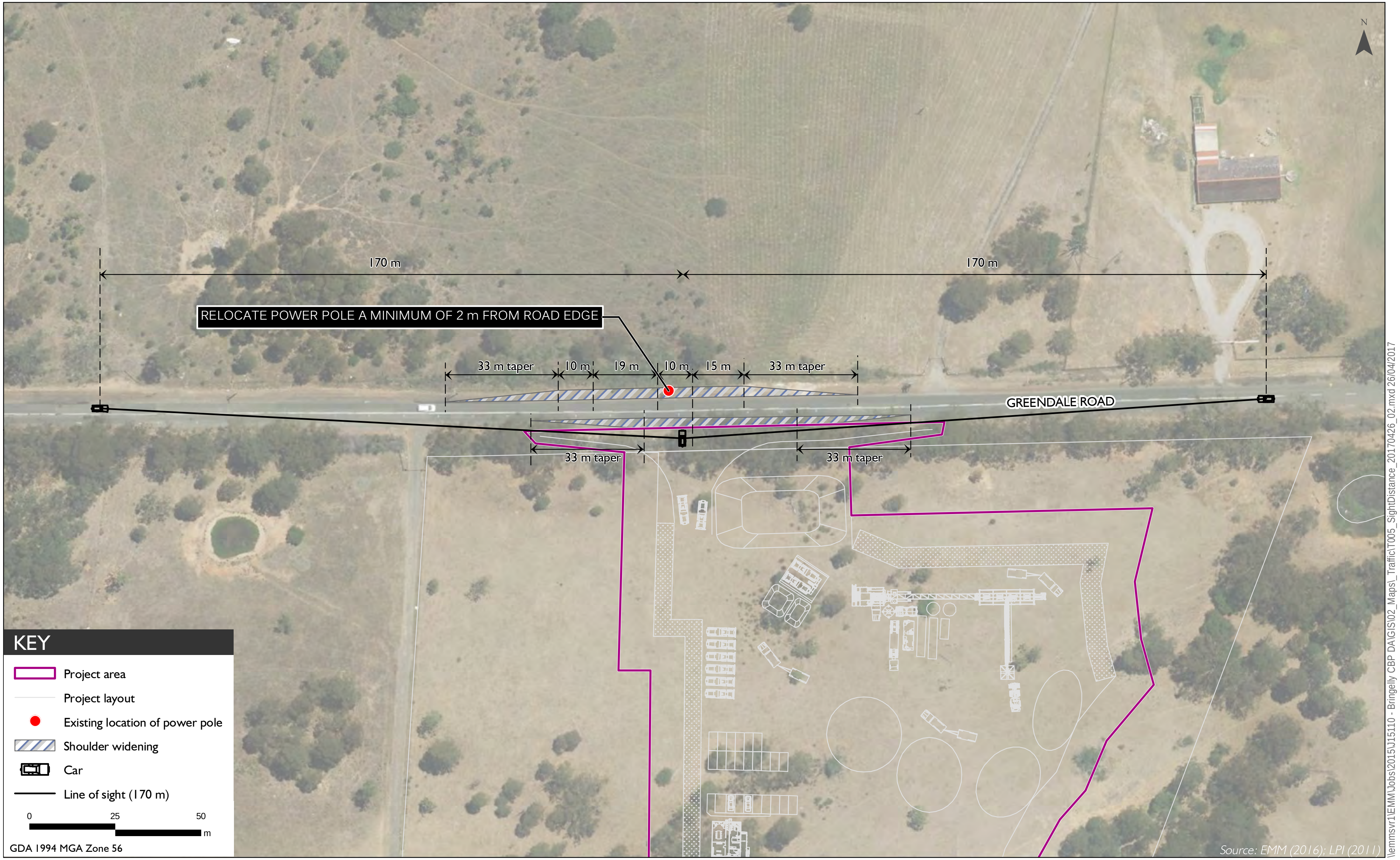


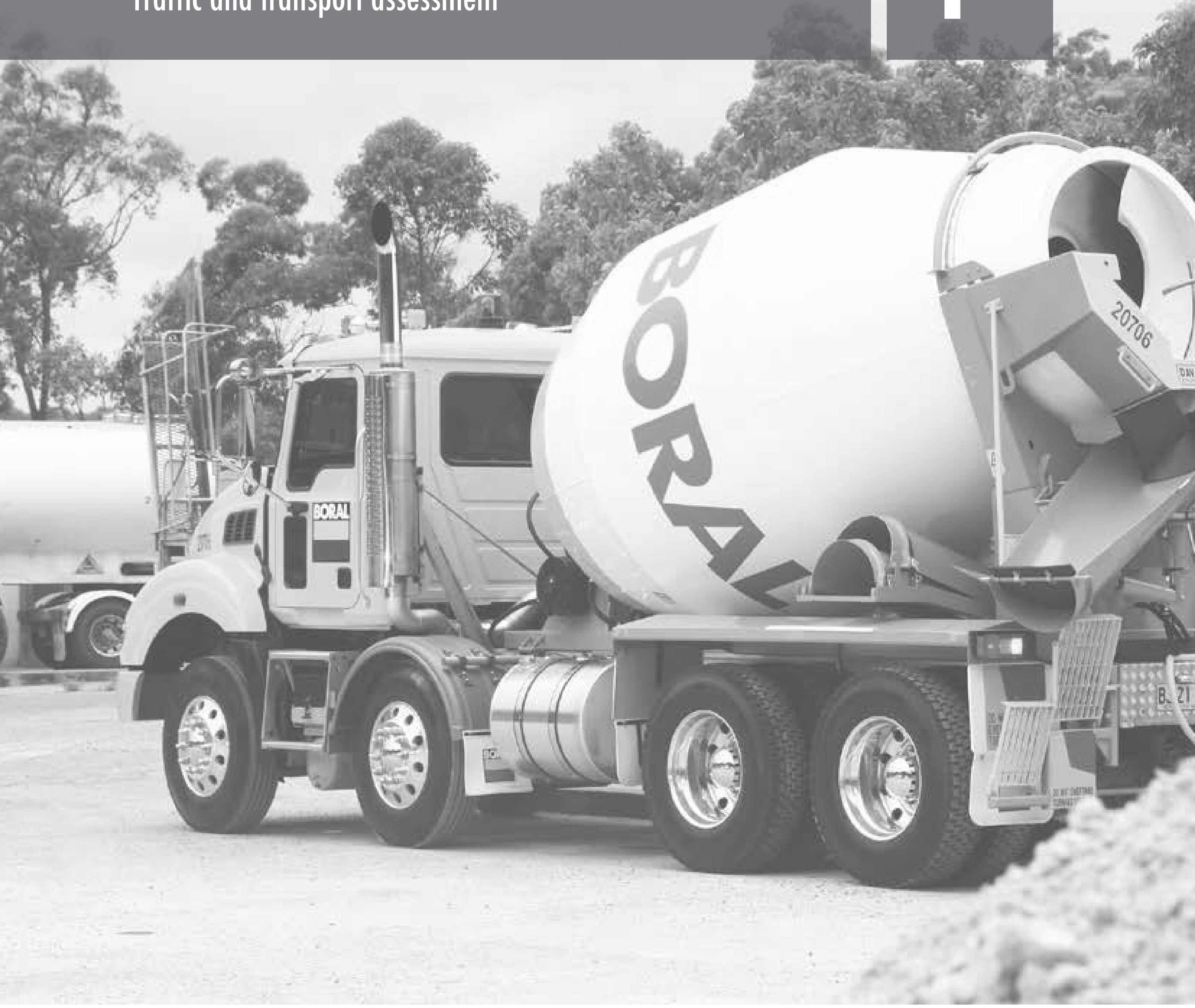
Proposed intersection - horizontal sight lines

Bringelly Concrete Batching Plant

Appendix F

Traffic and transport assessment

F



EMM

Bringelly Concrete Batching Plant

Traffic Impact Assessment

Prepared for Boral Resources (NSW) Pty Limited | 9 May 2016

Bringelly Concrete Batching Plant

Traffic Impact Assessment

Prepared for Boral Resources (NSW) Pty Limited | 9 May 2016

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Bringelly Concrete Batching Plant

Final

Report J15110RP1 | Prepared for Boral Resources (NSW) Pty Limited | 9 May 2016

Prepared by	**Tim Brooker**	Approved by	**Philip Towler**
Position	Senior Transport Planner	Position	Associate Director
Signature		Signature	
Date	9 May 2016	Date	9 May 2016

Document Control

Version	Date	Prepared by	Reviewed by
1	17 February 2016	Tim Brooker	Phil Towler
2	9 May 2016	Tim Brooker	Phil Towler

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1 Introduction

1.1 Purpose of report

Boral Resources (NSW) Pty Limited (Boral) proposes to construct and operate a concrete batching plant (CBP) in Bringelly, NSW (the project). This traffic impact assessment supports a development application (DA) for the project under Part 4 of the *Environmental Planning and Assessment Act 1979*. Camden Council is the consent authority for the application. The proponent for the project is Boral, a wholly owned subsidiary of Boral Limited. Boral Limited is an international building and construction materials group, with around 12,000 full-time equivalent employees and over 430 operating sites in Australia.

The project is in the north-western corner of Lot 100 DP 1203966 on Greendale Road, Bringelly (see Figure 1.2). The indicative site layout is provided in Appendix A. The site is owned by Boral CSR Bricks Pty Ltd(now trading as PGH Bricks), a joint venture between Boral Limited and CSR Limited. The Boral CSR Bringelly Brickworks is also located on Lot 100 DP 1203966 approximately 200 m south-east of the project area. The project is intended to support the construction of local and regional infrastructure projects including local road upgrade works to Northern Road and Bringelly Road.

This traffic impact assessment has been prepared in accordance with:

- the requirements identified by the Secretary's Environmental Assessment Requirements (SEAR 961) in consultation with the NSW government agencies and a pre DA consultation meeting with Council in November 2015; and

- the Roads and Traffic Authority (RTA), now Roads and Maritime Services (RMS) Guide to Traffic Generating Developments (2002), which is the relevant guidance for traffic impact assessments in NSW.

1.2 The proposal

1.2.1 Overview

The key elements of the project are summarised in Table 1.1.

Table 1.1 Key project elements

Project element	Project description
Maximum processing rate	125,000 tonnes of concrete per annum 1,250 tonnes per day, 250 tonnes per hour Main components: • control room and amenities building; • 3 cement silos; • 4 hoppers; • 1 enclosed agitator load bay; • 2 enclosed slump stands; • 4 open aggregate stockpiles; • 1 bunded concrete admixtures container (modified 40 ft shipping container); • 2 water management pits (storage, sediment and first flush capture); • 1 operating front-end loader; • 4 m bund wall, consisting of a 2 m earth bund and 2 m Colourbond fence, to the north, east and west of the site; and • carpark area with 24 spaces.
Hours of operation	7 am–10 pm Monday to Saturday; 8 am–10 pm Sunday; and No deliveries after 6 pm.
Employment	13 full-time employees: 3 plant operators and 10 truck drivers
Disturbance footprint	1.7 ha
Transport and access	Access will be via a new driveway on Greendale Road. Average daily truck numbers: • Agitator trucks – 86; • Cement tankers – 7; and • Aggregate truck and dog – 20. Peak hour truck numbers: • Agitator trucks – 12; • Cement tankers – 1; and • Aggregate truck and dog – 2.
Construction timeframe	12 weeks construction period Construction hours: 7 am–6 pm Monday to Friday, 8 am–1 pm Saturday

1.2.2 Site access

The site access routes and the regional and local road networks are shown in Figures 1.1 and 1.2. The future CBP site internal access and layout are shown in the site plans which are attached as Appendix A. The future traffic circulation paths are shown separately on the site plans in Appendix A for the concrete agitator trucks, the aggregate delivery trucks and the cement powder tanker trucks.

The site administration offices and car parking will be located in the south-western corner of the site, where an adjacent parking area will also be provided for the concrete agitator trucks based at the site.

The proposed site vehicular access will be via a rural type intersection (type BAL/BAR), incorporating sealed shoulder widening on Greendale Road, which will be designed to accommodate the vehicle swept paths for the largest vehicle (ie a B Double cement tanker truck) which is proposed to enter the site. The intersection will be designed in accordance with the current Austroads rural road and intersection design standards (Austroads, 2010).

The proposed site access driveway is located on the south side of Greendale Road, approximately 500 metres (m) west of the Bringelly Brickworks access driveway. The driveway will be used for both the project construction and operating phases and will be suitable for use by both heavy vehicle and car traffic.

1.2.3 Traffic generation

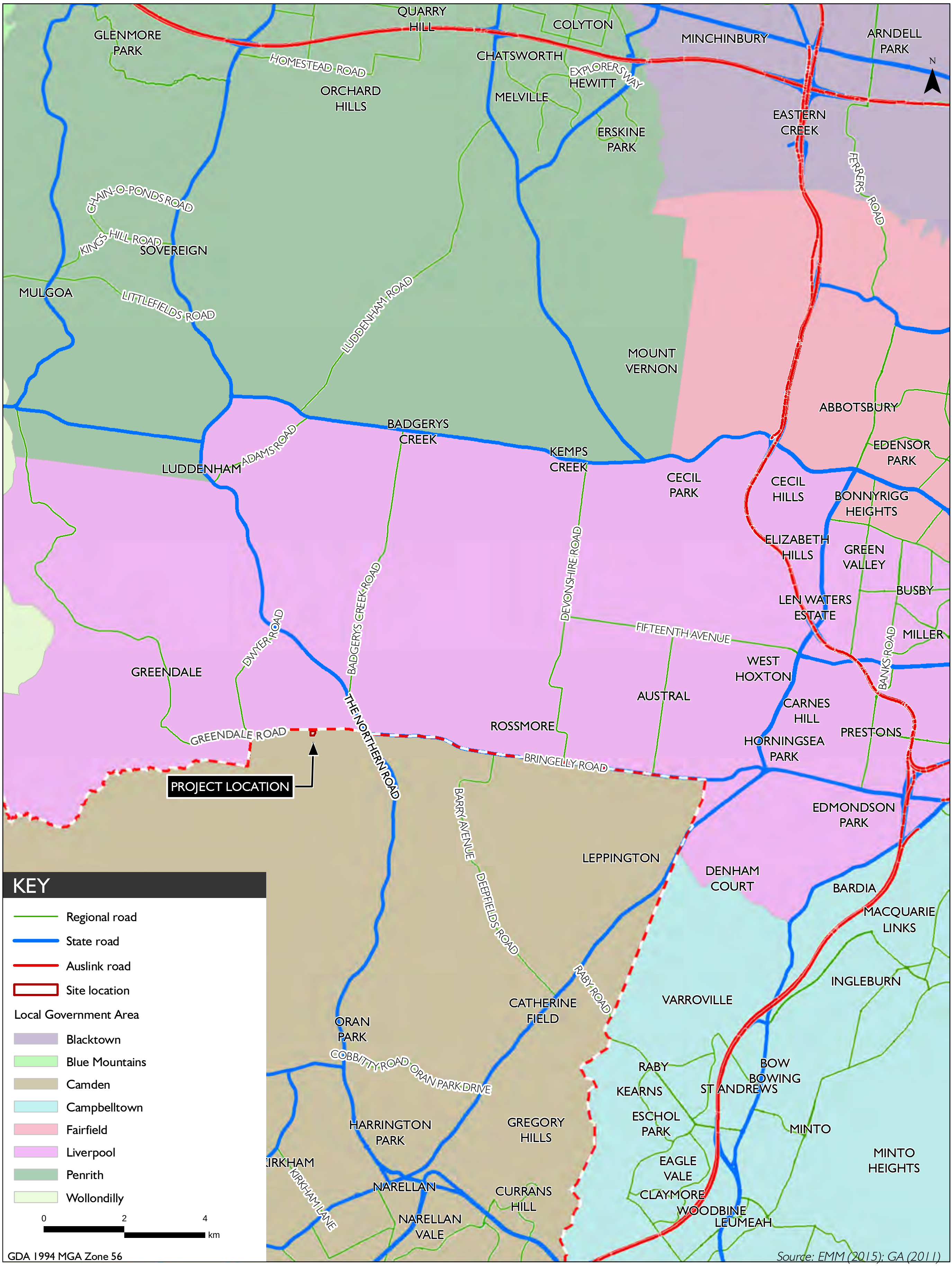
Approximately 13 full time operational staff will be employed at the site. Site staff will primarily be truck drivers (10 persons) who will not use their trucks to travel to and from work. Therefore, sufficient car parking will be provided at the site for all the site employees and visitors including the truck drivers' cars.

The raw materials for concrete production (aggregates, sand, cement, fly-ash and admixtures) would be primarily sourced from Boral's Peppertree Quarry (via the Maldon Terminal), Dunmore Quarry and St Peters rail terminal and Boral's Cement facility at Berrima. These deliveries would mostly utilise semi trailer or 'truck and dog' type vehicles with a typical payload capacity of 28 to 32 tonnes. The site raw materials delivery trucks (including B Double tanker vehicles for cement powder deliveries) would all generally travel via arterial road routes through the Narellan area and would generally approach the site from the south via Northern Road and continue via Greendale Road over the final kilometre of their journey to access the CBP site.

The site construction activities will take approximately 12 weeks and generally involve lower daily truck and car traffic movements than during the subsequent project operations and, therefore, the site traffic movements during the construction stage are not specifically analysed in this traffic impacts assessment. However, a construction stage traffic management plan will be required for the management of the project site access (including any access requirements for oversize vehicles) during the construction stage. This would be prepared subsequently to, and as a condition of, the development consent for the project.

The project's concrete delivery agitator trucks would generally supply larger infrastructure type projects within the Bringelly locality and surrounding areas and all travel via Greendale Road. On any given day, this traffic could all potentially travel either to or from the east, south or north of the Bringelly Road/Northern Road intersection to supply concrete to potential future work sites within the region. No trucks would travel west along Greendale Road from the site.

The associated site employee car traffic would not generally coincide with the peak periods of the site production traffic. The proposed site peak hourly raw materials and concrete production truck traffic are, therefore, assessed in this report assuming that this traffic could occur during either the existing morning or afternoon peak hour traffic periods. It is also assumed that the site workforce car traffic on weekdays (which would normally occur at the beginning and end of each working day) will not also occur during the same peak hourly traffic periods when the site is operating at peak production. Some site visitor car traffic movements may, however, occur during these times.



Source: EMM (2015); GA (2011)

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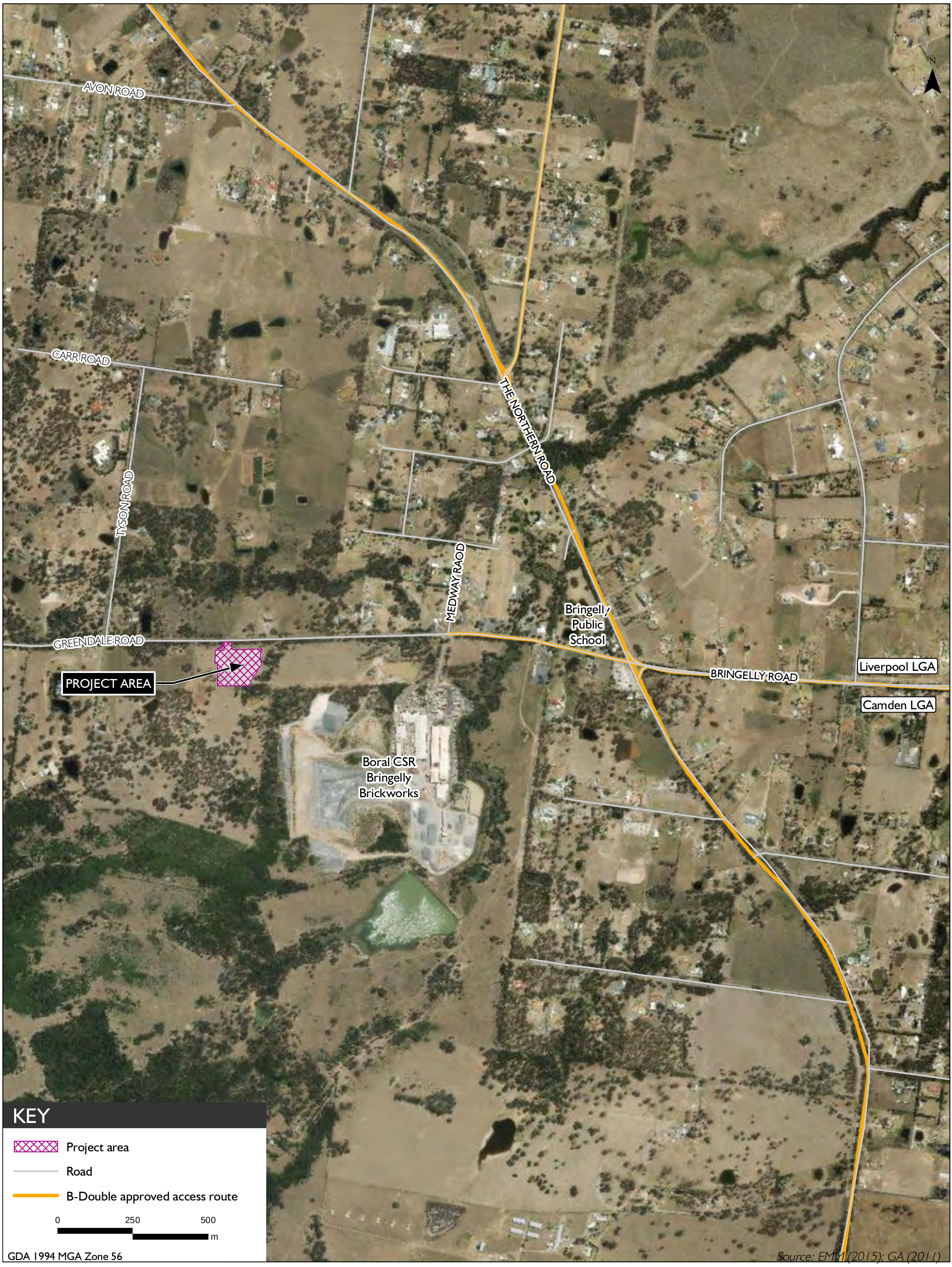
Regional road network

Bringelly Concrete Batching Plant
Traffic Impact Assessment

Figure 1.1



Source: EMM (2015); GA (2011)

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EMM

Local road network

Bringelly Concrete Batching Plant
Traffic Impact Assessment

Figure 1.2

2 Existing conditions

2.1 Site location and access

The site's location in relation to the regional and local road networks is shown on Figure 1.1 and Figure 1.2. The proposed layout of the site and corresponding truck circulation paths are shown in Appendix A.

The future site access will be located on the south side of Greendale Road, approximately 600 m west of the Brickworks site entry.

Views of Greendale Road at the site frontage, in the vicinity of the existing site driveway and the proposed site access are shown in Photograph 2.1 and Photograph 2.2. The existing site access driveway will not be utilised for any stage of the proposed CBP development, including the construction phase.

The current speed limit on Greendale Road at the site frontage is 80 km/hr. Approximately 280 m east of the site the speed limit changes to 60 km/hr (see Photograph 2.3).

The currently approved (RMS) B double access routes in the Bringelly area are shown in Figure 1.2. B Double access is currently only approved for Greendale Road east of the Brickworks access intersection. An extension to the approved B Double route will be required, to the proposed CBP site access intersection. The future site truck transport operations will generally utilise B Double trucks (at least for the cement powder tanker truck deliveries). Approval will be required from the relevant roads authority (which may include both the Camden Council and Liverpool City Council) for the future extension of the approved B Double access further to the west on Greendale Road.

2.2 Road network and intersections

2.2.1 Road network

The local and major road networks in the vicinity of the Bringelly CBP site are illustrated in Figure 1.1 and Figure 1.2. The key intersections which are likely to be used by the site traffic are also shown in Figure 1.2. The key roads in the locality are:

- Greendale Road – a two lane rural type road, west of Bringelly which continues through the Bringelly urban area to connect with Northern Road and Bringelly Road at a four way traffic signal controlled intersection.
- Bringelly Road – a significant arterial road which is currently undergoing upgrading from two lanes to either four or six lanes on most of the sections between Bringelly and the intersection with Camden Valley Way, east of Leppington. The upgrade works are currently occurring on the more easterly sections with the sections at the western end, in the vicinity of Bringelly, still mostly two lanes.
- Northern Road – a significant arterial road which is also undergoing upgrading from two lanes to either four or six lanes on most sections of the route between Narellan and the Penrith urban area. The road upgrade works for the route are currently occurring mainly on the northern and the southern sections with the central sections, in the vicinity of Bringelly, still mostly two lanes.

2.2.2 Intersections

The primary road intersection which will be used by most of the site traffic is at Greendale Road, Bringelly Road and Northern Road (see Figure 2.1). Some site employee car traffic and other light vehicle traffic may also potentially use other routes in the locality including Greendale Road west of the site and Medway Road which connects to other urban areas of Bringelly.

Photograph 2.1 Greendale Road near the proposed site entrance looking east

Photograph 2.2 Greendale Road near the proposed site entrance looking west

Source: EMM (2015); GA (2011)

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Intersection between The Northern Road, Greendale Road and Bringelly Road, Bringelly

Bringelly Concrete Batching Plant
Traffic Impact Assessment
Figure 2.1

Photograph 2.3 Greendale Road at the speed zone transition point (280 m east of the site entry)

Photograph 2.4 Northern Road looking north at the Greendale Road intersection (RMS Photo)

The lane configuration of the existing major road access intersection at Greendale Road, Bringelly Road and Northern Road in Bringelly, is shown in Figure 2.1.

The future CBP site access intersection, 600 m west of the Brickworks access, has no sealed shoulder widening currently (Photographs 2.1 and 2.2). The future site access intersection upgrade requirements to meet the minimum Austroads rural intersection design standards at this location are considered in this traffic assessment.

Plans have been recently exhibited (RMS 2015) for proposed upgrade works to Bringelly Road and Northern Road including a new grade separated intersection at Bringelly (see Section 2.2.3 below). These works will effectively replace the existing intersection (Photograph 2.4) when the works are completed in late 2019.

2.2.3 The Northern Road and Bringelly Road upgrades

The Federal and NSW Governments have funded the upgrading of Bringelly and The Northern roads as a part of the Western Sydney Infrastructure Plan, a 10 year, $3.6 billion road investment program. The upgrades are proposed to deliver new and upgraded roads to support integrated transport in the region and capitalise on economic benefits from developing a western Sydney airport at Badgerys Creek.

The upgrades include the following works:

- realigning The Northern Road to approximately 300m east of the existing alignment at the Bringelly Road intersection;
- widening of The Northern Road and Bringelly Road from two to four lanes with a central median to allow for six lanes in the future; and
- a grade separated interchange at the intersection to The Northern Road/Bringelly Road/Greendale Road.

Works on The Northern Road are due to commence in late 2017 with the road opening to traffic in late 2019, subject to project approval. The Bringelly Road upgrades (including the intersection upgrades) in the vicinity of the Northern Road are due to commence in early 2017 with the road and new intersection opening to traffic in mid-2019.

2.3 Traffic volumes

The existing traffic volumes using the road network in the locality of Bringelly has been determined by peak hour traffic surveys at two intersections in October 2015. In addition to the major road access intersection at Greendale Road, Bringelly Road and The Northern Road, the peak hourly traffic volumes at the Bringelly Brickworks access with Greendale Road were surveyed to determine the current traffic volumes for Greendale Road at the CBP site frontage, the Bringelly Brickworks access, and Medway Road.

The full intersection traffic survey details are shown in Appendix B and the hourly traffic volumes for each road are summarised in Table 2.1, including estimated daily traffic and heavy vehicle traffic proportions.

Table 2.1 Summary of existing traffic volumes from intersection traffic surveys

Road	Intersection survey location	Morning peak hour volume	Afternoon peak hour volume	Estimated daily traffic*	Average week day heavy vehicles*	% heavy vehicles
Greendale Road	CBP site entry	154	168	1,690	90	5.4
Greendale Road	East of the Brickworks	192	206	2,090	218	10.4
Medway Road	North of Greendale Road	17	9	140	18	12.0
Brickworks Access	South of Greendale Road	31	31	330	112	34.0
Greendale Road	West of Northern Road	136	225	1,900	238	12.5
Northern Road	North of Bringelly Road	1,691	1,820	18,400	810	4.4
Northern Road	South of Bringelly Road	1,369	1,557	15,400	646	4.2
Bringelly Road	East of Northern Road	538	652	6,250	344	5.5

Notes: **Average daily traffic is estimated as 10.5 times the average peak hourly traffic for all roads. Daily heavy vehicle numbers and their % have been extrapolated from the am and pm peak period heavy vehicle traffic proportions.*

The proportion of heavy vehicle traffic using Greendale Road between the Bringelly Brickworks access and Bringelly Road is relatively high (between 12% and 13%). This high proportion is currently influenced by the Bringelly Brickworks traffic which has 34% peak hourly heavy vehicle traffic movements. However, on the two major traffic routes in the locality (Northern Road and Bringelly Road) and on Greendale Road west of the Brickworks access, the surveyed proportions of heavy vehicles are generally lower and within the normal range for most roads, which is approximately 4% to 5%.

2.4 Intersection performance

The existing morning and afternoon peak hourly traffic operations and the levels of service at the Greendale Road, Bringelly Road and Northern Road intersection have been determined using the SIDRA intersection traffic model. The existing intersection's level of service (LoS) for the morning and afternoon peak hour periods have been measured according to RMS defined ranges (Table 2.2) which range from A (best) to F (worst).

Table 2.2 LoS definitions

Description	LoS	Average vehicle delay (sec)
Very good	A	<14.5
Good	B	14.5 to ≤28.5
Satisfactory	C	28.5 to ≤42.5
Near capacity	D	42.5 to ≤56.5
At capacity	E	56.5 to ≤70.5
Over capacity	F	≥70.5

The SIDRA intersection results for the existing local traffic during the two peak hours analysed are provided in Appendix C. The SIDRA analysis results for the existing traffic situation are summarised in Table 2.3.

Table 2.3 Existing traffic SIDRA intersection operations summary

Intersection	Peak hour	Degree of Saturation	LoS	Average delay for all traffic movements (secs)	Max queue (m)
Greendale Road, Bringelly Road and Northern Road	7.15 to 8.15 am	0.743	A	12.3	153
	4.30 to 5.30 pm	0.903	B	19.9	192

The traffic signal operations at the Greendale Road, Bringelly Road and Northern Road is currently operating under relatively uncongested morning and afternoon peak hour traffic conditions, with a degree of saturation between 0.74 and 0.90 and average intersection delays corresponding to LoS A or B.

There are currently significant peak hour traffic queues on the Northern Road northbound and southbound approaches to the intersection which extend for up to 153 m and 192 m respectively during the morning and the afternoon commuter traffic periods.

2.5 Existing site traffic and parking usage

The existing site daily traffic movements are minimal as the site is vacant currently and not used by traffic on a regular daily basis. No adjustment will need to be made to the predicted future CBP site traffic volumes to account for any existing site traffic usage.

2.6 Public transport

Bus routes in the Bringelly area are operated by Interline bus services under contract from Transport for NSW as part of the area 2 contract services for the Western Sydney region which covers all areas to the west and south west of the Liverpool, Glenfield, Minto, Leumeah and Leppington Rail Stations and also includes some services from these areas to Campbelltown Rail Station.

These routes are illustrated by the bus routes map in Figure 2.2. Route 856 connects Bringelly to the Leppington Rail Station and also continues to Liverpool proving access to the Liverpool CBD and rail services there. Journey times from Bringelly are approximately 20 minutes each way to Leppington Rail Station and 50 minutes each way to Liverpool Rail Station.

The bus services operate every day with seven daily bus services in each direction on Weekdays and four daily bus services in each direction on Saturdays and Sundays.

There are currently no public bus services which connect Bringelly to either the Penrith area to the north or the Campbelltown, Camden and Narellan areas to the south.

2.7 Pedestrian and cycling access

Within the locality of the site on Greendale Road and other roads within the Bringelly urban area, the unpaved road verges provide some hard surfaces suitable for pedestrian or cyclist access, as shown in Photographs 2.1 to 2.3.

Pedestrian and cyclist access to and from the proposed CBP site access driveway on Greendale Road is generally feasible to and from the east, which is the most likely direction from which persons may potentially travel to and from the site by either walking or cycling.

2.8 Safety and traffic management

Traffic safety at rural access intersections, such as the proposed CBP site access from Greendale Road, is primarily determined by the intersection sight lines for existing site traffic and the approaching traffic to or from the west or the east. These sight lines are shown in Photographs 2.1 and 2.2.

Although the proposed CBP site access intersection is located on a relatively straight and level section of road, there are significant undulations in the road surface both to the west and east of the intersection which could reduce the visibility for some traffic (mainly car traffic) approaching the intersection on Greendale Road from either direction.

Although the future intersection visibility will be generally acceptable for an 80 km/hr travel speed on Greendale Road at this location, consideration could be given to reducing the future speed limit at this location (ie extending the current 60 km/hr zone by about 280 m) in view of the undulations in the road surface alignment to the west of the proposed intersection location.

The four way traffic signal controlled intersection of Greendale Road, with Bringelly Road and Northern Road also has generally straight and level sections of road with good sight lines for turning traffic. This is important as the right turning traffic at the intersection does not have right turn “arrow” phases currently, and relies on filter right turn traffic movement across the opposing traffic stream. As discussed in Section 2.2.3, this intersection is scheduled for upgrading, with construction commencing in 2017. The upgrades will result in a graded interchange, improving the function of the intersection.

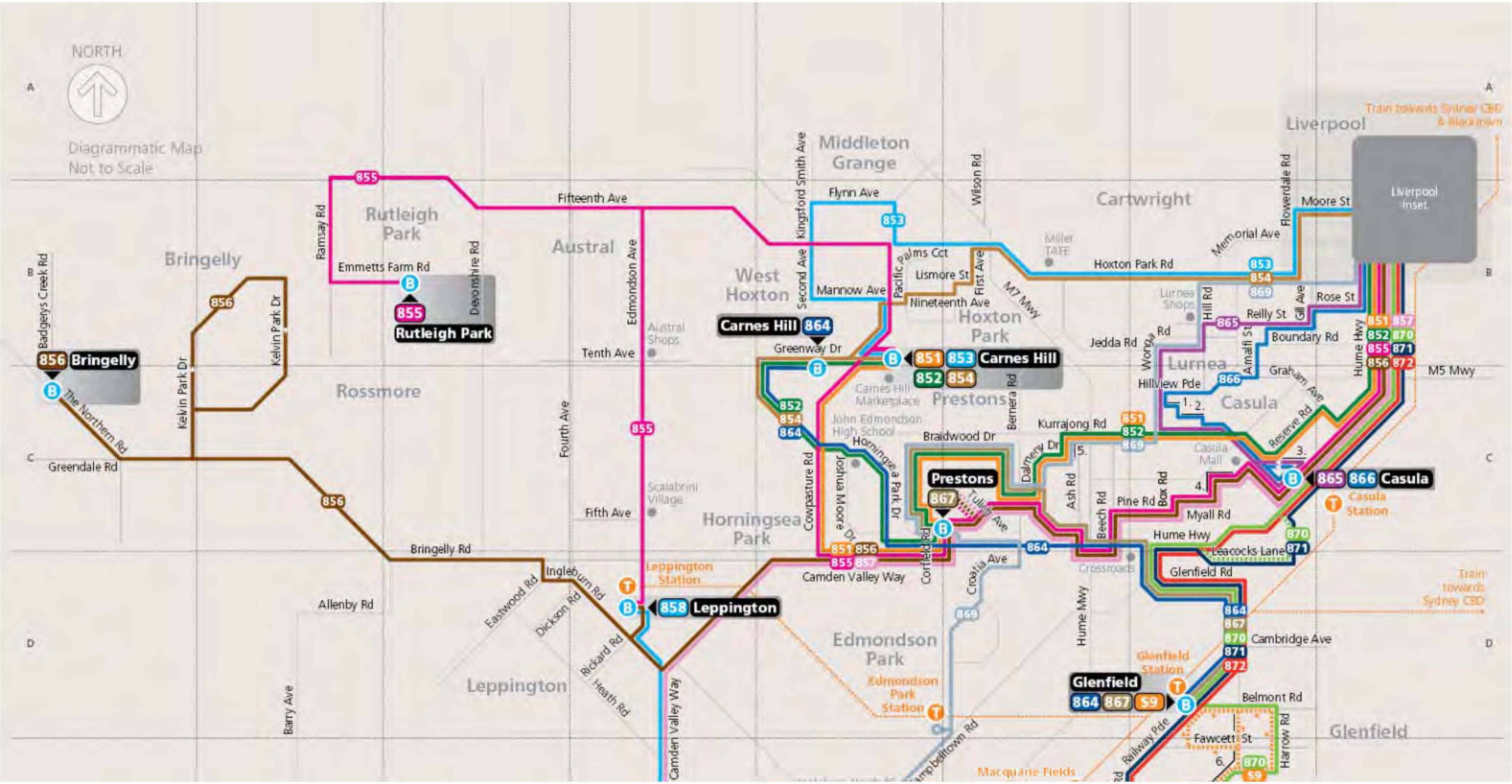


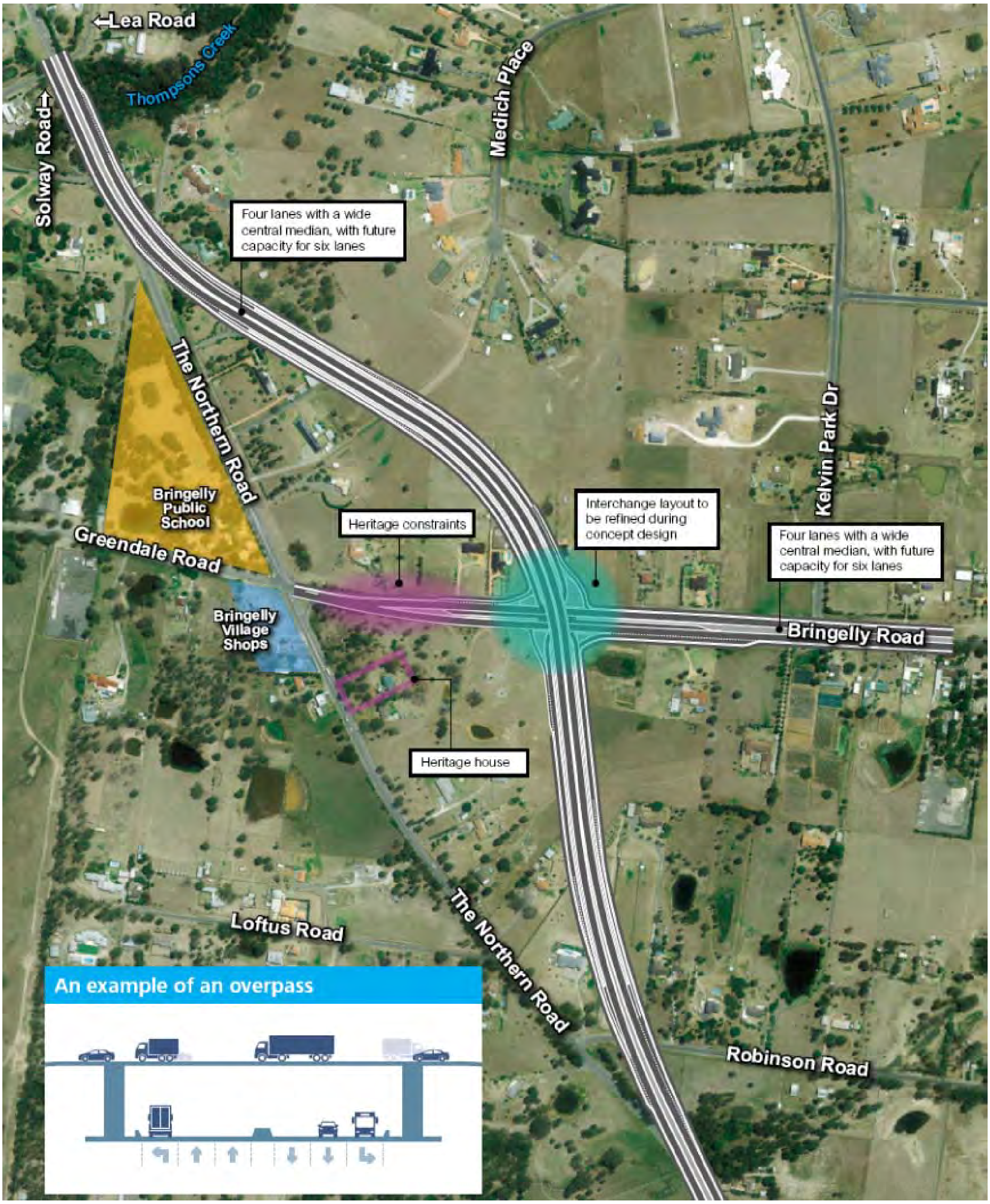
Figure 2.2 Existing Interline bus route map showing route 856 in the Bringelly area

2.9 Local traffic changes with RMS road upgrades

In July 2015 RMS exhibited their plan of the recommended option for the new intersection at Bringelly which will connect the respective road upgrades for the Bringelly Road and Northern Road routes.

The new interchange intersection plan, which is shown in Figure 2.3, will be located approximately 300 m east of the existing four way traffic signal intersection and will effectively replace the existing intersection in providing major road traffic access for traffic from the Bringelly area using Greendale Road.

In this assessment, the existing four-way traffic signal controlled intersection at Bringelly at Greendale Road, Bringelly Road and Northern Road is assessed for the interim future period (four years approximately) before the new interchange intersection becomes operational in late 2019, after which time, there will be improved traffic capacity on all the major roads in the locality.



Map Source: *RMS*

Figure 2.3 RMS exhibited plan of proposed interchange intersection at Bringelly

3 The project

3.1 Internal site layout and circulation

The proposed CBP internal site layout and traffic circulation are shown on the site plan in Appendix A. Key truck access and egress routes are shown for the incoming cement and aggregate raw materials delivery trucks and for the concrete agitator trucks travelling to and from their respective loading points within the site.

The truck loading areas within the site have been designed to current industrial site access standards, and will comply with the current requirements of AS 2890.2 for the internal site vehicle access movements for heavy vehicle traffic.

3.2 Haulage routes

The primary haulage routes for the truck raw materials (aggregate) deliveries and cement tanker deliveries to and from the site will be via Greendale Road, east of the site, continuing to and from the south via Northern Road from the four way intersection at Greendale Road and Bringelly Road.

The concrete agitator truck deliveries would also travel to and from the east of the site via Greendale Road and would not generally be using other local roads in the area, such as Greendale Road west of the site or Medway Road, other than where specific local deliveries will be required to sites within the areas served by these roads.

The primary site customers will be future infrastructure projects which will generally be located in areas east of the site eg via Bringelly Road, east of Greendale Road or via Northern Road, north or south of Bringelly. On any specific day, the entire site concrete production could potentially be directed towards sites in any of these three directions, so the potential future site traffic impacts are assessed on the basis that either of the three major traffic routes, north, east or south of Bringelly could potentially be used by all daily site agitator truck traffic.

Approximately 90% of the future site employee and site visitor car traffic is also anticipated to be either travelling to or from the north, east or south of Bringelly. Small proportions of the site car traffic (5% using each route approximately) could potentially use either Medway Road or Greendale Road west of the site, when travelling to or from the site.

3.3 Site car parking

On-site parking (24 car parking spaces and 15 agitator truck parking spaces) will be provided for the site based agitator truck fleet, site employees and occasional site visitors.

This parking provision will be more than adequate for the project. The agitator truck fleet will be parked at the site during non-operational hours and some of the future employees may live locally and be able to travel to the site by other means (either by walking, cycling or public transport) or may share car transport with other employees at the site.

The maximum number of site visitor cars requiring parking at the site would be typically low (a maximum of two or three cars at any one time) and this parking will be accommodated within the combined site employee/visitor car parking area at all times. One site disabled car parking space will be provided.

There are no current Council DCP car parking requirements which would be applicable to the CBP site as there are no significant industrial buildings with defined floor areas which could be used as the basis of an assessment. It is normally accepted for this type of industrial development that on site car and truck parking should be provided for all the actual site car and truck parking demand, which is the case for the project.

4 Traffic impact assessment

4.1 Predicted traffic generation and distribution

Daily and peak-hourly traffic generation rates for the site (for both car and truck traffic) have been calculated and assessed for the proposed annual production of up to 125,000 tonnes per annum of concrete at the site, with maximum production rates of 1,250 tonnes per day and 250 tonnes per hour.

For the site concrete production using standard agitator trucks with a typical capacity of up to 7.0 cubic metres, up to 86 loads of concrete could be produced per day, with a potential hourly maximum of 12 loads of concrete.

The corresponding average daily and maximum hourly numbers of raw materials deliveries which would be required to service concrete production are:

- 20 truck loads of aggregates on an average day;
- 7 tanker loads of cement powder on an average day;
- a maximum of 2 hourly truck loads of aggregates; and
- a maximum of 1 hourly tanker load of cement powder.

The site peak periods for concrete production could potentially coincide with both the normal morning commuter traffic peak hour (7.15 to 8.15 am) and the normal afternoon commuter traffic peak hour (4.30 to 5.30 pm) on the roads in the locality. During these periods, when the site is operating at maximum production, there will be no corresponding peak hourly site employee car traffic but there would potentially be some site visitor car trips. The site visitor car trips will be approximately two hourly vehicle trips travelling both to and from the site during the morning and afternoon commuter traffic peak hours (approximately 20 vehicle trips each way daily). The daily site employee car trips would be 13 trips per day each way (in and out of the site), but these trips would not occur during the same traffic peak hours as the site concrete production, if the site production was still continuing during the peak traffic hours.

4.2 External traffic impact at intersections

The calculated additional peak hourly traffic movements for the site are summarised in Table 4.1.

Table 4.1 Summary of additional local traffic movements for peak site production

Peak Traffic Period	Type of traffic	Hourly vehicles (in)	Hourly vehicles (out)	Distribution
Commuter am and pm peak hours	Site visitor cars	2	2	Assumed 90% east via Greendale Road
	Raw materials deliveries	3	3	Assumed 100% east via Greendale Road, then south
	Concrete agitator trucks	12	12	Assumed 100% east via Greendale Road, then north, east or south
Total hourly traffic	All vehicles	17	17	Between 95% -100% east via Greendale Road

The external road network impacts of the additional project traffic have been assessed at the future CBP site access intersection, and at the Greendale Road, Bringelly Road and Northern Road intersection.

The proposed CBP site future traffic impacts are assessed for the interim period comparable with the prevailing current local traffic volumes (surveyed in October 2015) as in the longer-term, the future locality traffic conditions will change significantly after the Greendale Road, Bringelly Road and Northern Road intersection works are completed in late 2019.

The SIDRA intersection program measures the intersection capacity and performance by calculating parameters such as average vehicle delay, maximum queue length, degree of saturation and level of service, based on the RTA/RMS Guide to traffic generating developments standards which were developed from the international Highway Capacity Manual standards.

The detailed SIDRA intersection analysis results are included in Appendix C and a summary of the results for each intersection is provided in Table 4.2 and Table 4.3.

Table 4.2 SIDRA intersection traffic operations at future CBP site access intersection

Intersection traffic conditions	Peak hour	Degree of saturation	LoS	Average delay for all traffic movements (secs)	Max queue (m)
With 95% site traffic travelling to/from the east	8.00 to 9.00 am	0.059	B	22.7	3
	4.15 to 5.15 pm	0.061	B	23.2	3

Note: ** Average vehicle delay and level of service are calculated for all vehicle movements at a signalised intersection.*

Table 4.3 Comparison of SIDRA intersection traffic operations at Bringelly Road intersection

Intersection traffic conditions	Peak hour	Degree of saturation	LoS	Average delay for all traffic movements (secs)	Max queue (m)
With 100% site agitator trucks travelling to/from the north	7.15 to 8.15 am	0.748	A	12.8	155
	4.30 to 5.30 pm	0.906	B	20.0	192
With 100% site agitator trucks travelling to/from the east	7.15 to 8.15 am	0.748	A	12.8	153
	4.30 to 5.30 pm	0.919	B	20.0	192
With 100% site agitator trucks travelling to/from the south	7.15 to 8.15 am	0.766	A	13.0	166
	4.30 to 5.30 pm	0.910	B	20.1	192

Note: ** Average vehicle delay and level of service are calculated for all vehicle movements at a signalised intersection.*

The future CBP site access intersection on Greendale Road would generally be operating at a very low degree of saturation 0.06 typically during the peak traffic hours (Table 4.2).

The future site access intersection operations will operate with a LoS B, with average traffic delays of 23 seconds for the right turning site traffic onto Greendale Road (primarily truck traffic). This delay is not the actual queuing traffic delay, which is minimal, but includes the additional intersection “geometric traffic delay” which is the time required for a truck to decelerate to a stop from normal traffic speed and then accelerate again to reach normal traffic speed.

During the normal morning and afternoon commuter traffic peak periods at the Greendale Road, Northern Road and Bringelly Road intersection, there will be only marginal changes to either the future traffic degrees of saturation or the average traffic delays with the future CBP site traffic. There will be no changes to the intersection LoS which would remain at 'A' during all the future morning peak hour traffic conditions assessed and 'B' during all the future afternoon peak hour traffic conditions assessed for the project.

During the morning peak hours, the intersection degree of saturation will increase from 0.743 without the CBP site traffic to between 0.748 and 0.766 with the project traffic (Table 2.3). Similarly the average intersection traffic delay will increase from 12.3 seconds without the CBP site traffic, to between 12.8 and 13.0 seconds with the project traffic.

During the afternoon peak hours, the intersection degree of saturation will increase from 0.903 without the CBP site traffic, to between 0.906 and 0.919 with the project traffic, depending on the directions which it would be travelling through the intersection. Similarly the average intersection traffic delay will increase from 19.9 seconds without the CBP site traffic, to between 20.0 and 20.1 seconds with the project traffic, depending on the directions which it would be travelling through the intersection.

There will be only minor and inconsequential changes to the maximum traffic queue lengths at the intersection with the future CBP site traffic during either of the peak hourly traffic periods.

4.3 External traffic impacts on local roads

The project's predicted daily traffic generation on the surrounding roads is presented in Table 4.4 along with the existing local traffic volumes which were surveyed in 2015.

The effects of the project generated daily traffic movements, including cars and heavy vehicle traffic, in 2015 are summarised in Table 4.5. These include additional local traffic generated from the site raw materials (54 daily truck movements), concrete production (172 daily truck movements), site employee traffic (26 daily car movements), and site visitor traffic (40 daily car movements), which would occur over a ten hour period typically each weekday.

Table 4.4 Summary of additional daily traffic movements on local roads surveyed

Road	Intersection survey location	Existing average weekday traffic*	Existing average weekday heavy vehicles*	Additional future site daily traffic movements	Additional future site daily heavy vehicle movements	% Daily traffic increase
Greendale Road	West of the site	1,690	90	3	0	0.2
Greendale Road	East of the Brickworks	2,090	218	286	226	13.7
Medway Road	North of Greendale Road	140	18	3	0	2.0
Greendale Road	West of Northern Road	1,900	238	286	226	15.1
Northern Road	North of Bringelly Road	18,400	810	192	172	1.0
Northern Road	South of Bringelly Road	15,400	646	246	226	1.6
Bringelly Road	East of Northern Road	6,250	344	192	172	3.1

*Notes: *Existing daily vehicle numbers have been determined from the am and pm peak period heavy vehicle traffic proportions.*

The additional site generated daily traffic is estimated to be 292 vehicle movements, comprising 66 light vehicle (car) traffic movements and 226 heavy vehicle traffic movements. The future effect of the additional site generated daily traffic movements is assessed in Table 4.4, for the major traffic routes north, east and south of Bringelly.

The estimated increases to the future average daily traffic movements would be proportionately greatest on the sections of Greendale Road between the site entry and the major intersection where Greendale Road meets Bringelly Road and Northern Road. The future CBP site generated daily traffic increases on these sections of Greendale Road would be between +13% and +15%. These sections of Greendale Road, have relatively high proportions of truck traffic currently (between 12% and 13% of all traffic in Table 2.2). The future additional site truck traffic movements would nevertheless also be noticeable and daytime site traffic management measures (including a code of conduct for the site truck drivers) should be adopted to help minimise the potential future noise and amenity effects of the future site truck traffic on Greendale Road, in particular in the vicinity of the Bringelly Public School.

On the other traffic routes, the future site generated traffic increases would be only marginally noticeable, and the existing design standard and the width of these roads (one traffic lanes in each direction generally) will continue to remain suitable prior to the RMS major road and intersection upgrade (due to be completed late 2019) and would not require any interim road widening or additional traffic controls.

At the future site access intersection on Greendale Road, an intersection consistent with the minimum Austroads Rural Roads intersection standards (Type BAR/BAL) would be required. The through traffic movements are currently less than 170 vehicles per hour two way (less than 100 vehicles per hour in either direction) and would not change with the site traffic. The relevant Austroads intersection design warrants for these traffic volumes (for an 80 km/hr intersection design) and the typical intersection designs for these types of intersection upgrades are provided in Appendix D.

As noted in Section 2.8, consideration should be given to lowering the future traffic speed limit from 80 km/hr to 60 km/hr on Greendale Road at the proposed site access (it is already 60 km/hr, 280 m further to the east) as there are some undulations in the road surface currently which affect the visibility for car traffic on Greendale Road to the west of the proposed intersection location.

4.4 Safety and traffic management

The future potential road safety related traffic impacts from the proposed operations have primarily been considered for Greendale Road, in the vicinity of the proposed site access intersection and at the existing Greendale Road, Bringelly Road and Northern Road intersection.

The recommended site access intersection would be a Austroads Rural type BAR/BAL standard, so truck traffic movements would have minimal effects on traffic safety at this intersection.

At the Greendale Road, Bringelly Road and Northern Road intersection the existing intersection visibility for turning traffic is considered to be good as the approach roads are all straight and level at the intersection. The intersection has also been approved for B-Double truck turning movements for the access via Greendale Road for the existing brickworks traffic. No additional traffic safety improvements will be required at the intersection for the proposed CBP site truck traffic movements.

The sections of Greendale Road between the site and Bringelly Road include a section which is adjacent to the Bringelly Public School. This section of Greendale Road already has the statutory ‘school peak hour’ morning and afternoon peak period 40 km/hr traffic speed restrictions (Photograph 2.4) which address the general ‘school zone’ traffic safety requirements for the school. However, additional daytime CBP site traffic management measures (including a code of conduct for the site truck drivers) should also be implemented to help minimise the potential future noise and amenity effects of the future site truck traffic in the vicinity of the Bringelly Public School.

4.5 Provision of car and truck parking

The proposed provision of the site car and truck parking for 24 car parking spaces (including one disabled space) and 15 truck parking spaces is considered to be more than adequate for the actual demand for this parking from the future total site employees (13) and visitor cars (two to three) and would meet any reasonable Council car parking requirement.

All the site car parking space dimensions and surfacing would be designed to comply with the requirements of the Australian Standard AS 2890.1.

For the site truck parking areas, the dimensions of the areas required for the parking of individual trucks will be based on the typical dimensions (with appropriate clearances between the vehicles) for the fleet of concrete agitator trucks which is to be based at the site.

4.6 Pedestrian, cycling and public transport access

The current arrangement for public transport, pedestrian and cyclist access to and from the site, which are summarised in Sections 2.6 and 2.7, are generally adequate for the future site access requirements. However, local public transport services are generally only available in the Liverpool direction (to and from the east) and there are generally no public transport services available for travel to and from the Penrith and Narellan/Campbelltown directions.

The CBP site would provide on-site car and truck parking for all the anticipated travel demand from either employees or visitors. The anticipated travel demand for persons travelling to or from the site, by either walking, cycling or public transport, will be minimal.

5 Summary and conclusions

This report has assessed the traffic impacts of Boral's proposed mobile CBP at the Greendale Road, Bringelly site, which is approximately 500 m west of the Bringelly Brickworks access. The proposal would supply ready mixed concrete products for infrastructure projects within the surrounding locality, to the north, east or south of Bringelly.

Production is proposed to be a maximum 125,000 tpa which corresponds to average daily production of approximately 1,250 tonnes and maximum hourly production of approximately 250 tonnes. Typically 86 loads of concrete would be produced on an average day when the site was operating. The corresponding maximum hourly production would be 12 loads.

The proposal's construction activities would generally involve much lower daily vehicular traffic movements (in particular for truck traffic) than during subsequent project operations. The project traffic impacts during operations are therefore the primary focus of this traffic report. A construction stage traffic management plan will nevertheless be prepared for the management of the site access and project traffic impacts during construction.

The external road network impacts of the additional project traffic have been assessed at the relevant intersections, which are at the future site access intersection from Greendale Road and at the Greendale Road/Bringelly Road/Northern Road intersection. The SIDRA analysis shows that there would be only minimal changes to the existing intersection operations with the future site traffic, and the future intersection operations at either level of service 'A' of 'B'.

Average daily traffic movements would increase on Greendale Road, east of the site entry and between the Brickworks access and Bringelly Road by +13% to +15%. The existing design standard and the width of the road (one traffic lane in each direction) will continue to remain suitable for this route and would not require any road widening or other traffic changes. However, daytime site traffic management measures (including a code of conduct for the site truck drivers) should be implemented to help minimise the potential future noise and amenity effects of the future site truck traffic in the vicinity of the Bringelly Public School.

Elsewhere within the Bringelly locality, on other routes such as Bringelly Road, Northern Road, Greendale Road west of the site and Medway Road, the future average daily traffic increases from the site traffic would be within the range +0.2% to +3.1%. These traffic increases would not generally be noticeable on these routes and would not result in any changes to the existing traffic flow conditions or the amenity of the route.

The future site truck traffic movements would have minimal effect on the traffic safety of the major roads and intersections in the Bringelly locality. The site access intersection on Greendale Road, will be designed according to the current (Austroads, 2010) rural roads intersection standard (Type BAR/BAL) which is appropriate for the proposed site truck access and the prevailing levels of through traffic movement using Greendale Road.

The future proposed on site car and truck parking areas and the existing site's accessibility for walking, cycling and public transport users have also been reviewed in this assessment and found to be satisfactory for the anticipated levels of usage by these travel modes.

References

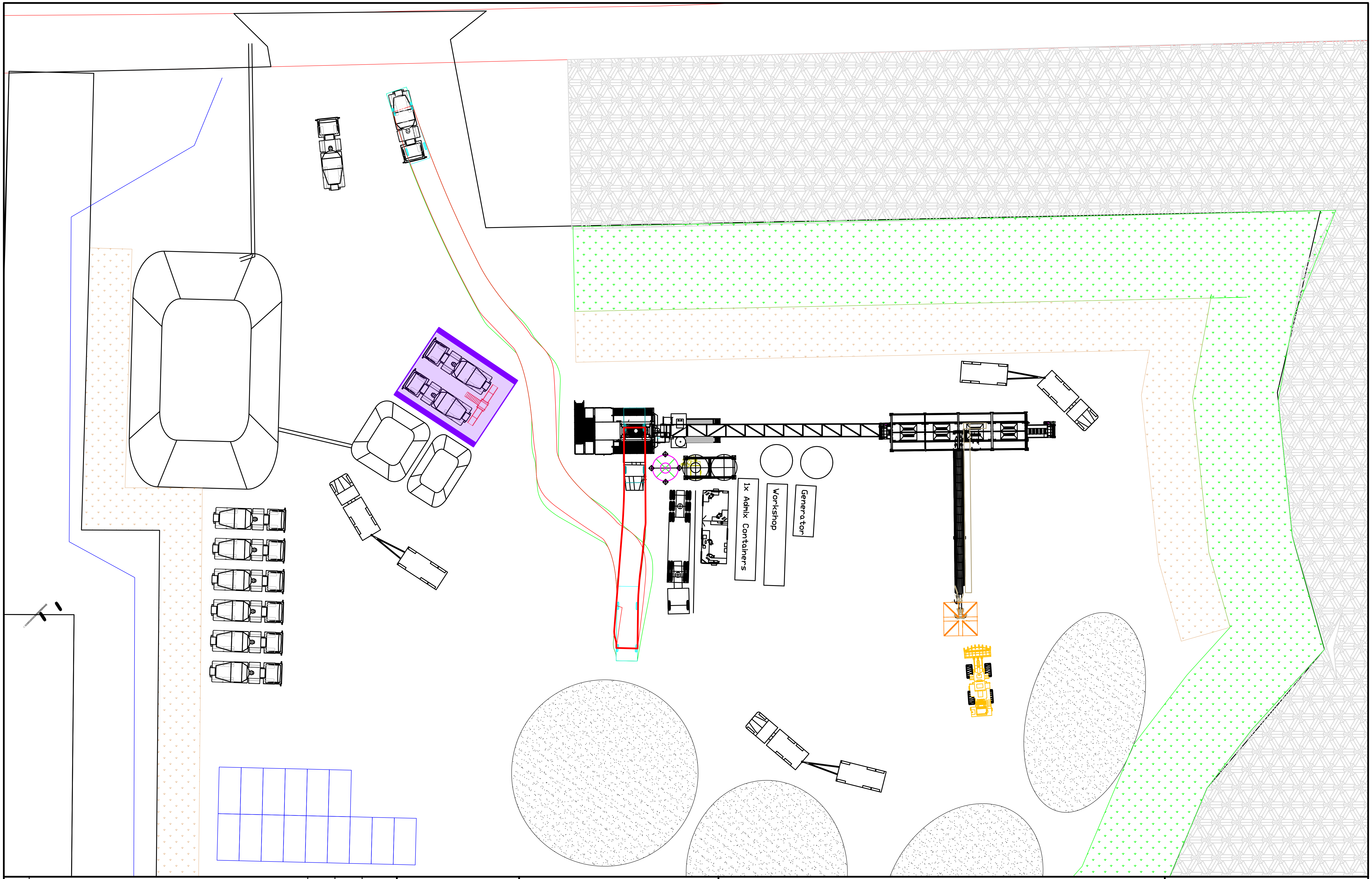
Austroads (2010) *Guide to Road Design*, Part 4A, Unsignalised and Signalised Intersections.

Roads and Traffic Authority (2002) *Guide to Traffic Generating Developments*.

Roads and Maritime Services (2015) *The Northern Road and Bringelly Road Interchange*, Community Update, July 2015.

Appendix A

Site Layout Plans



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SCALE 1:250 (A3)

	NAME	DATE
DRAWN	HC	23/05/16
APPROVED	JR	23/05/16

The Transport Planning Partnership
402/22 Atchison Street
St. Leonards
NSW 2065

PROJECT
Bringelly CPB

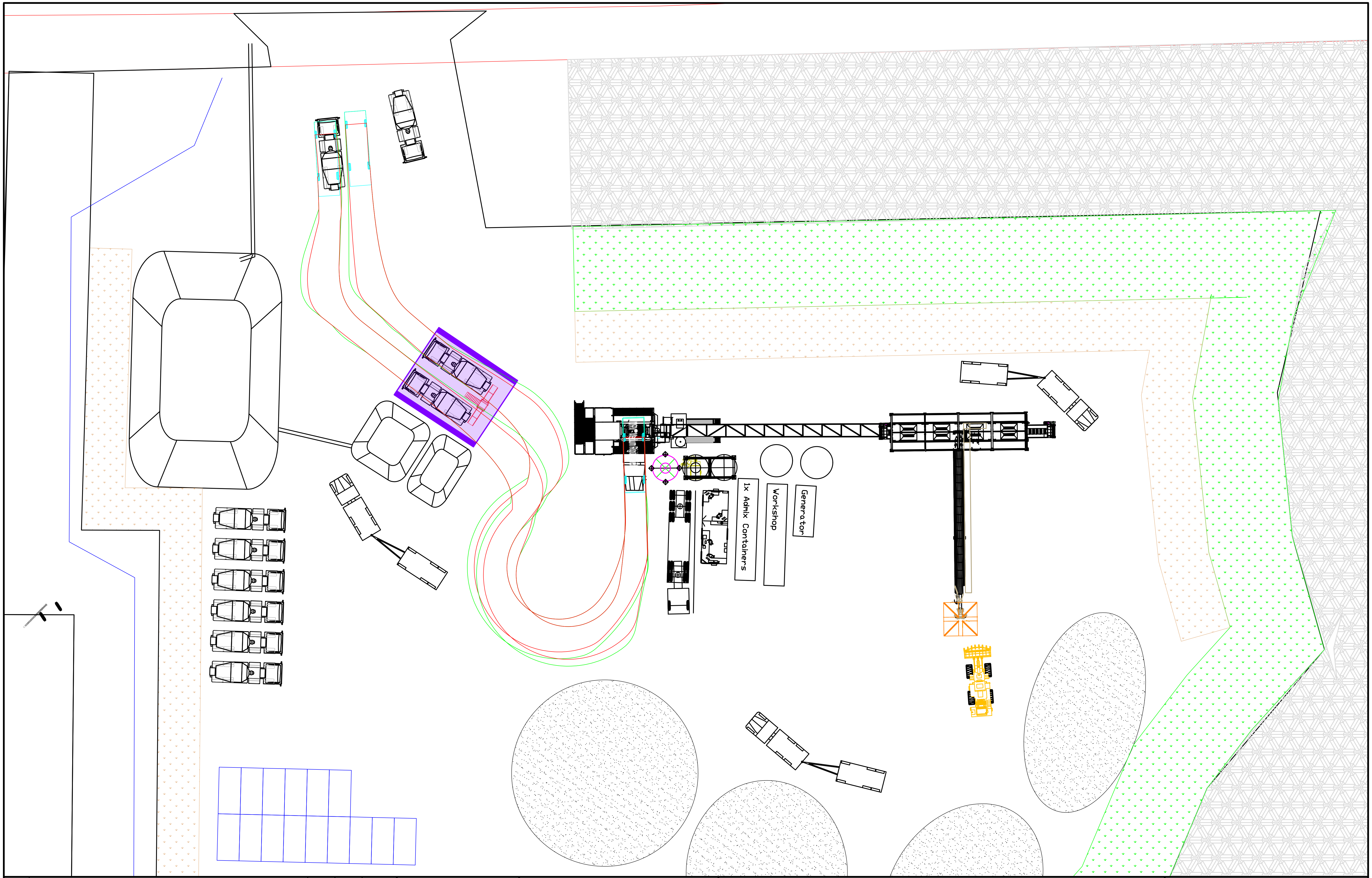
TITLE
Agitator (MRV) In - Swept Path

DWG No.
FIGURE 1

DATE STAMP
23 MAY 2016

PROJECT No.
16033

REV.
A



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SCALE 1:250 (A3)

	NAME	DATE
DRAWN	HC	23/05/16
APPROVED	JR	23/05/16

The Transport Planning Partnership
402/22 Atchison Street
St. Leonards
NSW 2065

PROJECT
Bringelly CPB

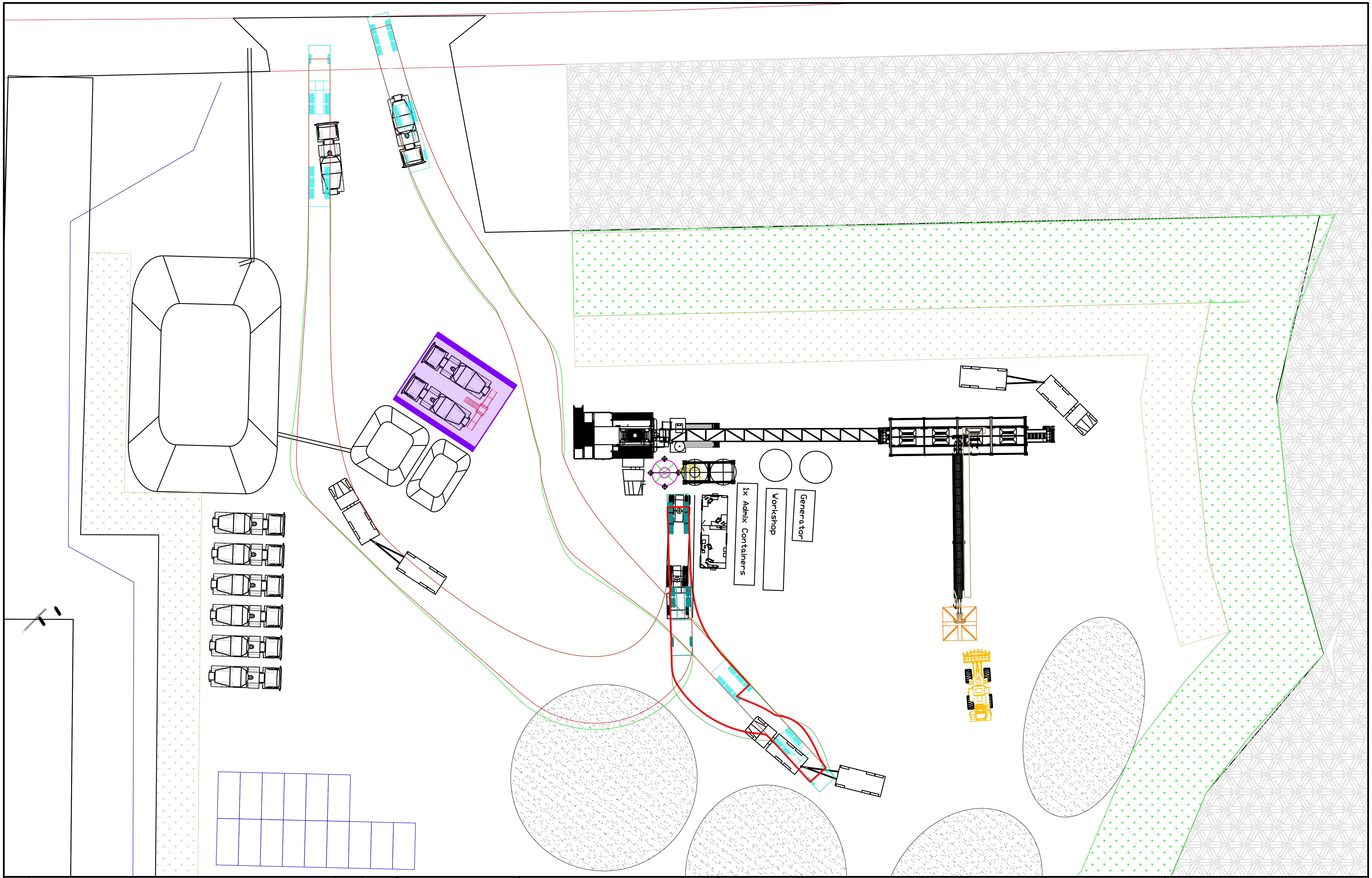
TITLE
Agitator (MRV) Out - Swept Path

DWG No.
FIGURE 2

DATE STAMP
23 MAY 2016

PROJECT No.
16033

REV.
A



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SCALE 1:250 (A3)

	NAME	DATE
DRAWN	HC	23/05/16
APPROVED	JR	23/05/16

The Transport Planning Partnership
402/22 Atchison Street
St. Leonards
NSW 2065

PROJECT
Bringelly CPB

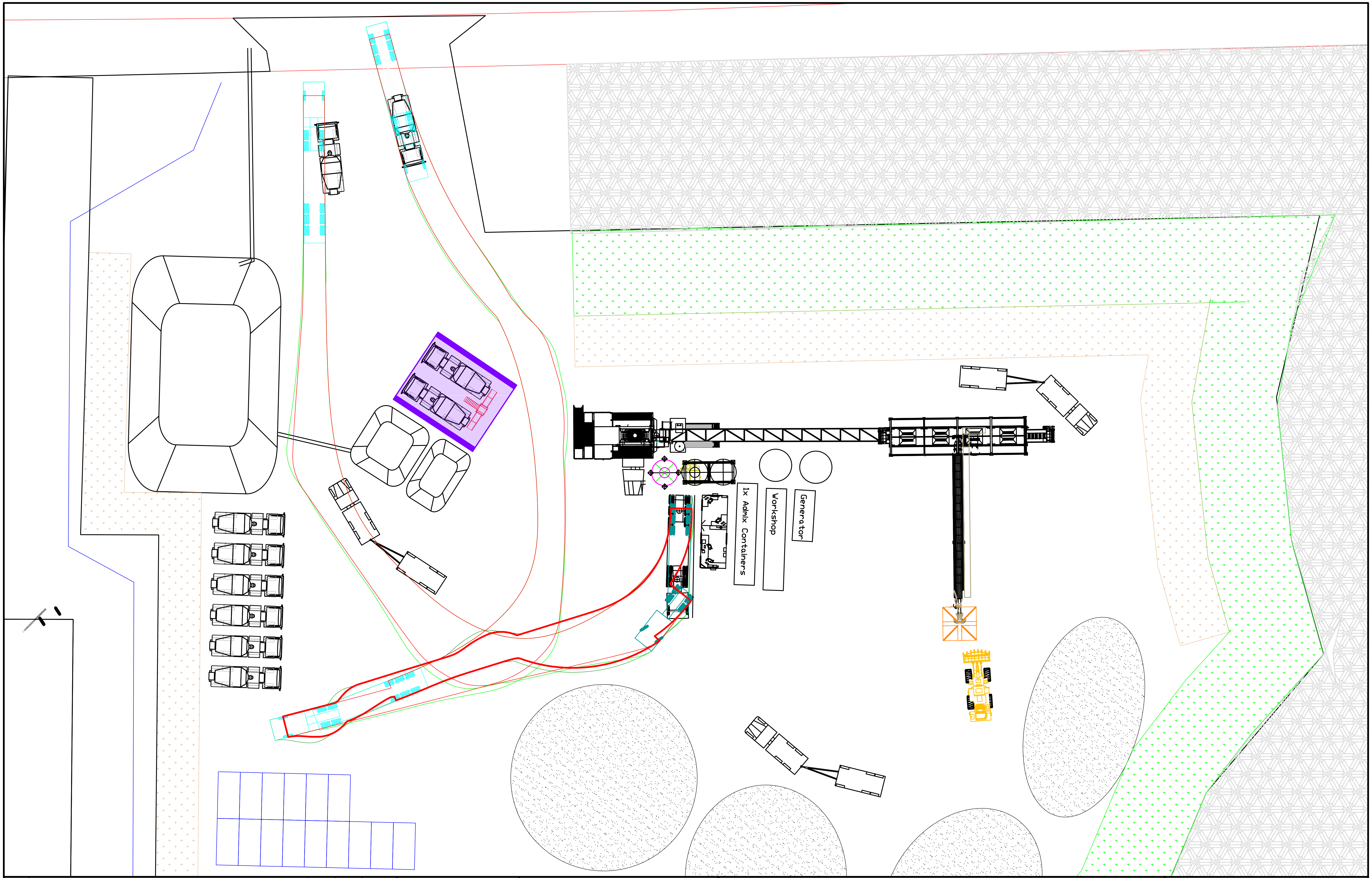
TITLE
Semi Trailer-Swept Path (Option 1)

DWG No.
FIGURE 3

DATE STAMP
23 MAY 2016

PROJECT No.
16033

REV.
A



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SCALE 1:250 (A3)

	NAME	DATE
DRAWN	HC	23/05/16
APPROVED	JR	23/05/16

The Transport Planning Partnership
402/22 Atchison Street
St. Leonards
NSW 2065

PROJECT
Bringelly CPB

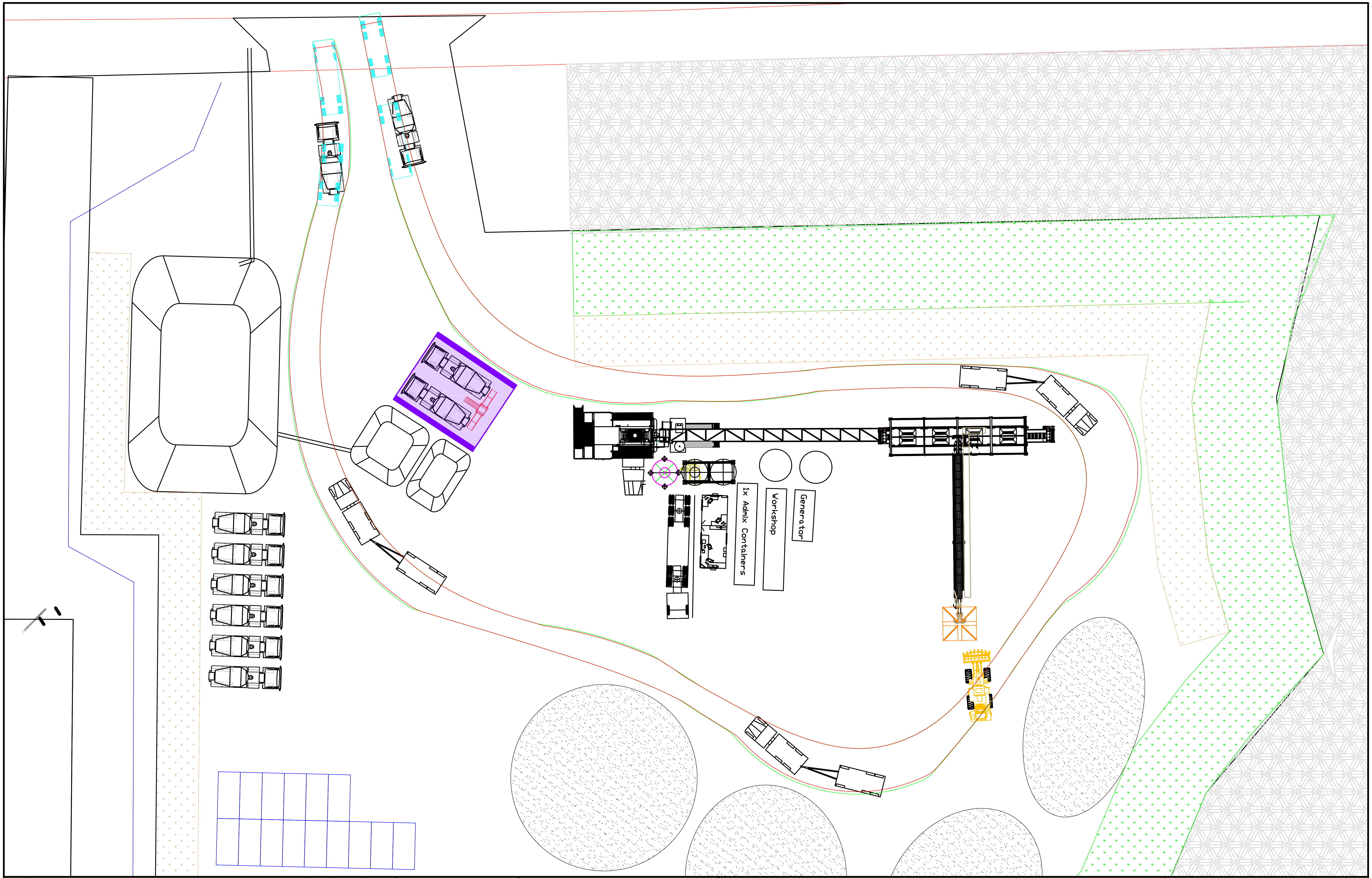
TITLE
Semi Trailer-Swept Path (Option 2)

DWG No.
FIGURE 4

DATE STAMP
23 MAY 2016

PROJECT No.
16033

REV.
A



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SCALE 1:250 (A3)

	NAME	DATE
DRAWN	HC	23/05/16
APPROVED	JR	23/05/16

The Transport Planning Partnership
402/22 Atchison Street
St. Leonards
NSW 2065

PROJECT
Bringelly CPB

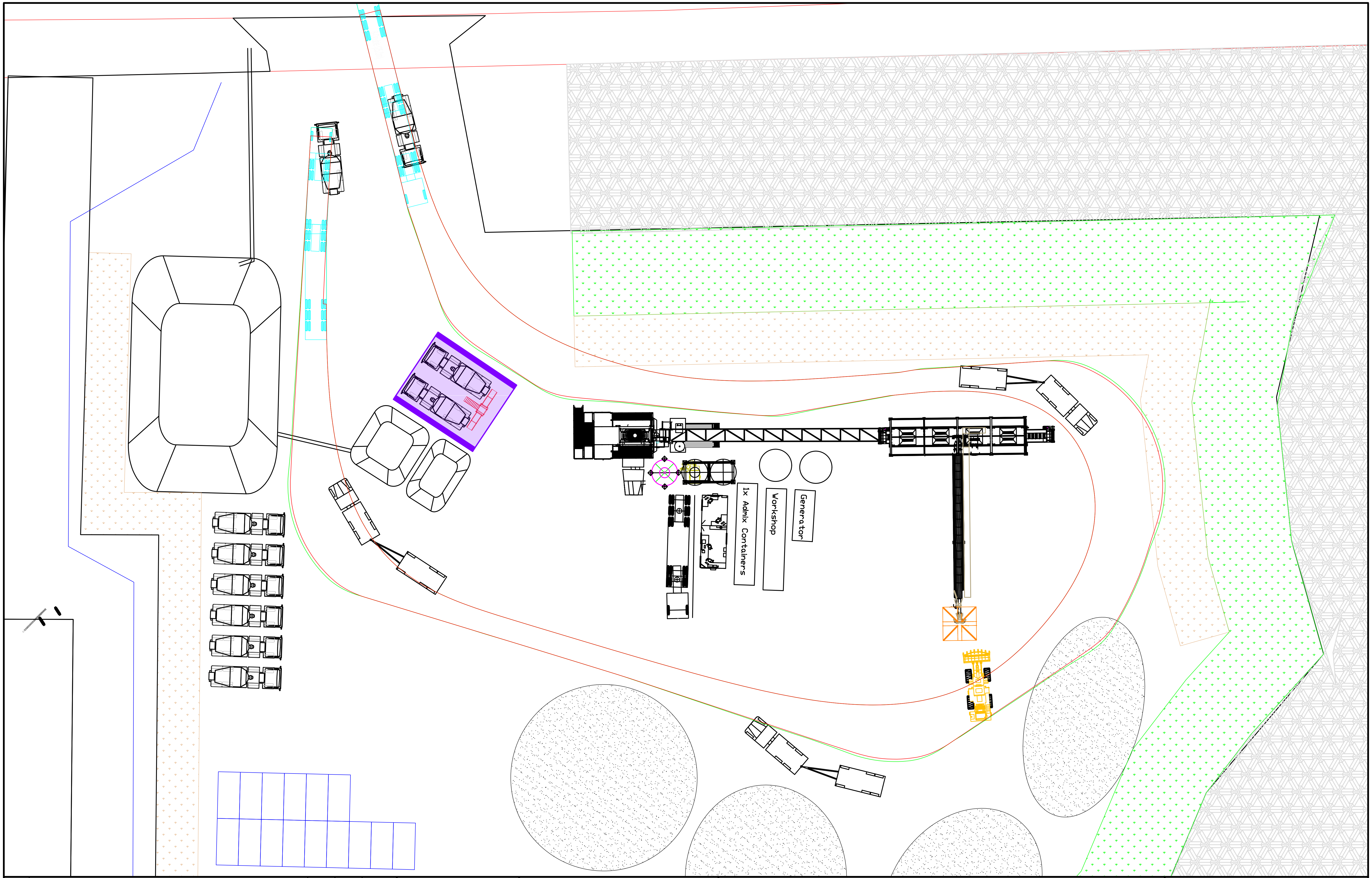
TITLE
Truck and Dog Trailer-Swept Path

DWG No.
FIGURE 5

DATE STAMP
23 MAY 2016

PROJECT No.
16033

REV.
A



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APPROVED	JR	23/05/16

The Transport Planning Partnership
402/22 Atchison Street
St. Leonards
NSW 2065

PROJECT
Bringelly CPB

TITLE
B-Double-Swept Path

DWG No.
FIGURE 6

DATE STAMP
23 MAY 2016

PROJECT No.
16033

REV.
A

Appendix B

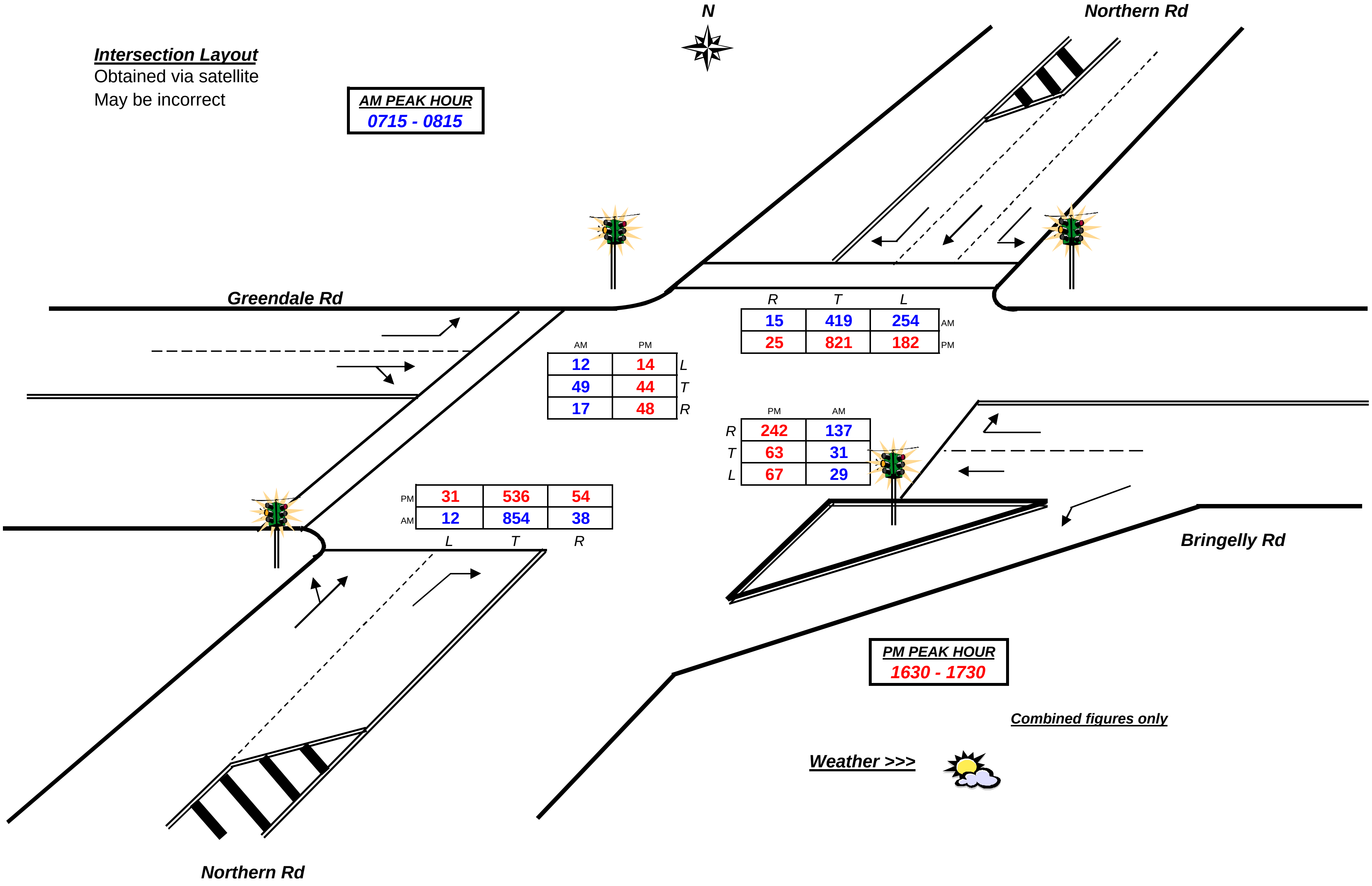
Intersection Traffic Counts

R.O.A.R. DATA
Reliable, Original & Authentic Results
Ph.88196847, Fax 88196849, Mob.0418-239019

Client : EMGA
Job No/Name : 5786 BRINGELLY Bringelly Rd
Day/Date : Wednesday / 7th October 2015

Intersection Layout
Obtained via satellite
May be incorrect

AM PEAK HOUR
0715 - 0815



Northern Rd (north approach)

	R	T	L
AM	15	419	254
PM	25	821	182

Greendale Rd

	AM	PM
L	12	14
T	49	44
R	17	48

Bringelly Rd

	PM	AM
R	242	137
T	63	31
L	67	29

Northern Rd (south approach)

	L	T	R
PM	31	536	54
AM	12	854	38

PM PEAK HOUR
1630 - 1730

Combined figures only

Weather >>>

R.O.A.R. DATA

Reliable, Original & Authentic Results

Ph.88196847, Fax 88196849, Mob.0418-239019

Client : EMGA
Job No/Name : 5786 BRINGELLY Bringelly Rd
Day/Date : Wednesday / 7th October 2015

Lights	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Time Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
0600 - 0615	59	75	1	4	5	4	0	130	3	4	7	19	**311**
0615 - 0630	51	97	0	6	7	6	0	158	2	2	3	31	**363**
0630 - 0645	60	179	3	2	5	4	3	155	5	5	12	24	**457**
0645 - 0700	61	146	1	1	7	4	1	138	5	9	4	40	**417**
0700 - 0715	59	103	2	1	10	2	3	160	6	4	6	38	**394**
0715 - 0730	70	91	1	1	12	2	1	178	13	3	6	35	**413**
0730 - 0745	57	110	1	2	7	4	2	250	9	11	8	38	**499**
0745 - 0800	55	99	1	3	10	3	4	221	6	4	4	30	**440**
0800 - 0815	62	86	6	2	17	4	4	178	5	8	8	29	**409**
0815 - 0830	26	91	3	3	8	14	8	138	3	8	6	37	**345**
0830 - 0845	35	94	6	3	10	12	15	111	8	10	8	23	**335**
0845 - 0900	21	92	7	5	20	12	10	99	9	16	17	29	**337**
Period End	**616**	**1263**	**32**	**33**	**118**	**71**	**51**	**1916**	**74**	**84**	**89**	**373**	**4720**

Lights	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Peak Time	L	T	R	L	T	R	L	T	R	L	T	R	TOT
0600 - 0700	231	497	5	13	24	18	4	581	15	20	26	114	**1548**
0615 - 0715	231	525	6	10	29	16	7	611	18	20	25	133	**1631**
0630 - 0730	250	519	7	5	34	12	8	631	29	21	28	137	**1681**
0645 - 0745	247	450	5	5	36	12	7	726	33	27	24	151	**1723**
0700 - 0800	241	403	5	7	39	11	10	809	34	22	24	141	**1746**
0715 - 0815	244	386	9	8	46	13	11	827	33	26	26	132	**1761**
0730 - 0830	200	386	11	10	42	25	18	787	23	31	26	134	**1693**
0745 - 0845	178	370	16	11	45	33	31	648	22	30	26	119	**1529**
0800 - 0900	144	363	22	13	55	42	37	526	25	42	39	118	**1426**
PEAK HOUR	**244**	**386**	**9**	**8**	**46**	**13**	**11**	**827**	**33**	**26**	**26**	**132**	**1761**

Heavies	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Time Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
0600 - 0615	4	12	2	3	0	1	0	2	0	1	5	1	**31**
0615 - 0630	4	11	2	3	2	2	0	3	0	0	0	1	**28**
0630 - 0645	11	10	0	0	2	0	0	3	1	0	0	0	**27**
0645 - 0700	2	15	0	2	1	0	0	2	1	2	1	2	**28**
0700 - 0715	4	8	3	0	3	0	0	5	0	0	1	1	**25**
0715 - 0730	5	12	2	2	0	0	0	6	0	1	3	1	**32**
0730 - 0745	2	9	0	0	1	0	0	8	4	0	1	0	**25**
0745 - 0800	1	7	2	1	1	3	0	10	1	2	1	2	**31**
0800 - 0815	2	5	2	1	1	1	1	3	0	0	0	2	**18**
0815 - 0830	3	4	0	3	1	0	0	7	0	0	0	0	**18**
0830 - 0845	1	7	3	0	0	1	2	8	2	0	2	3	**29**
0845 - 0900	2	8	2	1	0	0	1	5	1	2	0	4	**26**
Period End	**41**	**108**	**18**	**16**	**12**	**8**	**4**	**62**	**10**	**8**	**14**	**17**	**318**

Heavies	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Peak Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
0600 - 0700	21	48	4	8	5	3	0	10	2	3	6	4	**114**
0615 - 0715	21	44	5	5	8	2	0	13	2	2	2	4	**108**
0630 - 0730	22	45	5	4	6	0	0	16	2	3	5	4	**112**
0645 - 0745	13	44	5	4	5	0	0	21	5	3	6	4	**110**
0700 - 0800	12	36	7	3	5	3	0	29	5	3	6	4	**113**
0715 - 0815	10	33	6	4	3	4	1	27	5	3	5	5	**106**
0730 - 0830	8	25	4	5	4	4	1	28	5	2	2	4	**92**
0745 - 0845	7	23	7	5	3	5	3	28	3	2	3	7	**96**
0800 - 0900	8	24	7	5	2	2	4	23	3	2	2	9	**91**
PEAK HOUR	**10**	**33**	**6**	**4**	**3**	**4**	**1**	**27**	**5**	**3**	**5**	**5**	**106**

Combined	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Time Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
0600 - 0615	63	87	3	7	5	5	0	132	3	5	12	20	**342**
0615 - 0630	55	108	2	9	9	8	0	161	2	2	3	32	**391**
0630 - 0645	71	189	3	2	7	4	3	158	6	5	12	24	**484**
0645 - 0700	63	161	1	3	8	4	1	140	6	11	5	42	**445**
0700 - 0715	63	111	5	1	13	2	3	165	6	4	7	39	**419**
0715 - 0730	75	103	3	3	12	2	1	184	13	4	9	36	**445**
0730 - 0745	59	119	1	2	8	4	2	258	13	11	9	38	**524**
0745 - 0800	56	106	3	4	11	6	4	231	7	6	5	32	**471**
0800 - 0815	64	91	8	3	18	5	5	181	5	8	8	31	**427**
0815 - 0830	29	95	3	6	9	14	8	145	3	8	6	37	**363**
0830 - 0845	36	101	9	3	10	13	17	119	10	10	10	26	**364**
0845 - 0900	23	100	9	6	20	12	11	104	10	18	17	33	**363**
Period End	**657**	**1371**	**50**	**49**	**130**	**79**	**55**	**1978**	**84**	**92**	**103**	**390**	**5038**

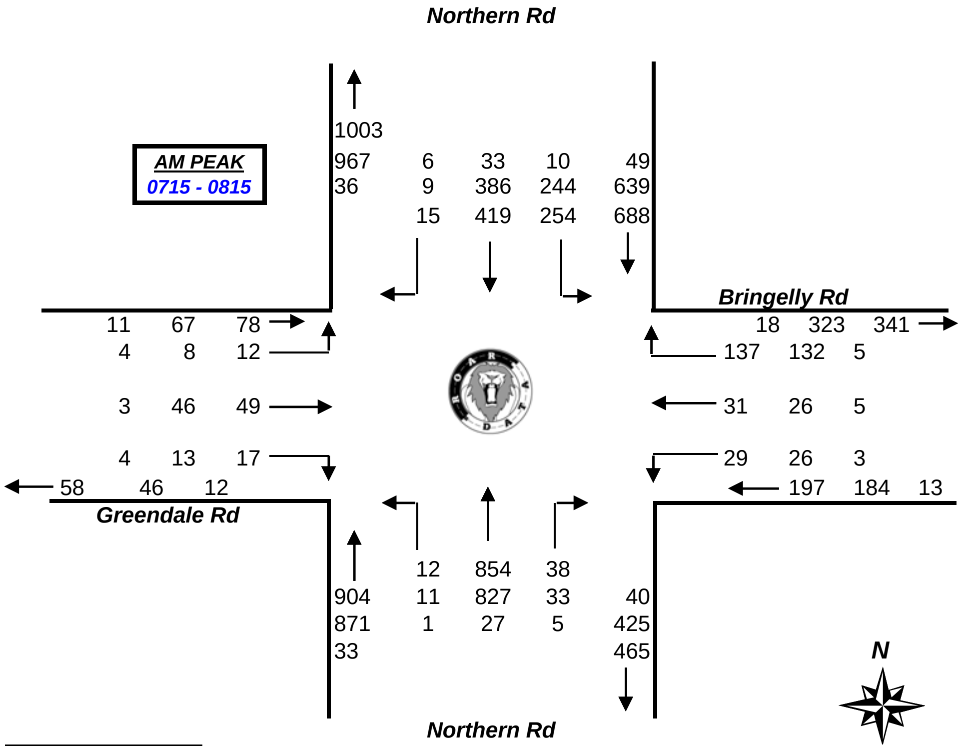
Combined	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Peak Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
0600 - 0700	252	545	9	21	29	21	4	591	17	23	32	118	**1662**
0615 - 0715	252	569	11	15	37	18	7	624	20	22	27	137	**1739**
0630 - 0730	272	564	12	9	40	12	8	647	31	24	33	141	**1793**
0645 - 0745	260	494	10	9	41	12	7	747	38	30	30	155	**1833**
0700 - 0800	253	439	12	10	44	14	10	838	39	25	30	145	**1859**
0715 - 0815	254	419	15	12	49	17	12	854	38	29	31	137	**1867**
0730 - 0830	208	411	15	15	46	29	19	815	28	33	28	138	**1785**
0745 - 0845	185	393	23	16	48	38	34	676	25	32	29	126	**1625**
0800 - 0900	152	387	29	18	57	44	41	549	28	44	41	127	**1517**
PEAK HOUR	**254**	**419**	**15**	**12**	**49**	**17**	**12**	**854**	**38**	**29**	**31**	**137**	**1867**

R.O.A.R DATA

Reliable, Original & Authentic Results

Ph.88196847, Fax 88196849, Mob.0418-239019

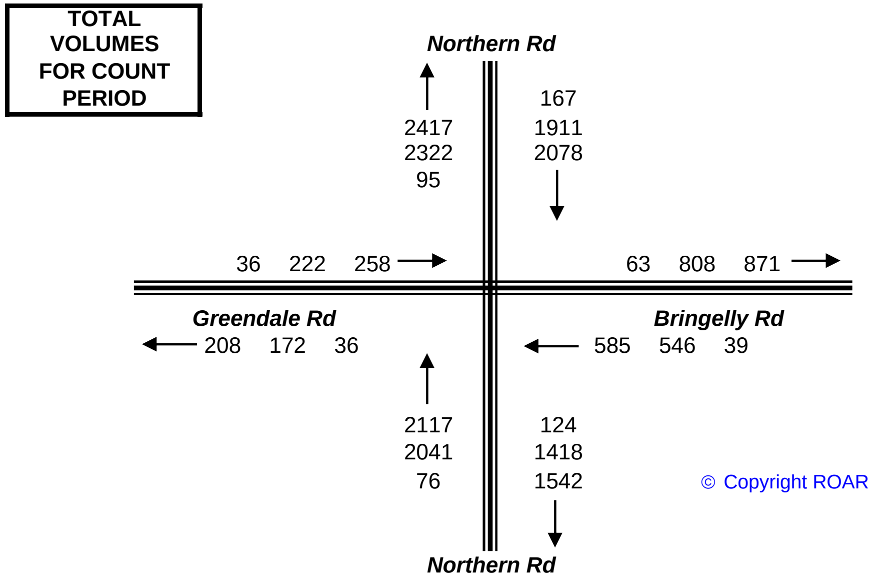
Client : EMGA
Job No/Name : 5786 BRINGELLY Bringelly Rd
Day/Date : Wednesday / 7th October 2015



Peds	**NORTH**	**WEST**	**SOUTH**	**EAST**	
	Northern Rd	***Greendale Rd***	***Northern Rd***	***Bringelly Rd***	
Time Per	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**TOT**
0600 - 0615					**0**
0615 - 0630					**0**
0630 - 0645					**0**
0645 - 0700		NOT	NOT		**0**
0700 - 0715		REQUIRED	REQUIRED		**0**
0715 - 0730					**0**
0730 - 0745					**0**
0745 - 0800					**0**
0800 - 0815					**0**
0815 - 0830					**0**
0830 - 0845					**0**
0845 - 0900					**0**
Period End	**0**	**0**	**0**	**0**	**0**

Peds	**NORTH**	**WEST**	**SOUTH**	**EAST**	
	Northern Rd	***Greendale Rd***	***Northern Rd***	***Bringelly Rd***	
Peak Per	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**TOT**
0600 - 0700	0	0	0	0	**0**
0615 - 0715	0	0	0	0	**0**
0630 - 0730	0	0	0	0	**0**
0645 - 0745	0	0	0	0	**0**
0700 - 0800	0	0	0	0	**0**
0715 - 0815	0	0	0	0	**0**
0730 - 0830	0	0	0	0	**0**
0745 - 0845	0	0	0	0	**0**
0800 - 0900	0	0	0	0	**0**

PEAK HR	**0**	**0**	**0**	**0**	**0**



R.O.A.R. DATA

Reliable, Original & Authentic Result

Ph.88196847, Fax 88196849, Mob.0418-239019

Client : EMGA
Job No/Name : 5786 BRINGELLY Bringelly Rc
Day/Date : Wednesday / 7th October 2015

Lights	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Time Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1515	38	131	3	1	14	12	6	132	14	13	15	38	**417**
1515 - 1530	34	124	3	1	10	10	4	110	17	12	10	41	**376**
1530 - 1545	39	126	2	0	10	5	3	123	11	10	13	51	**393**
1545 - 1600	38	173	3	3	7	6	9	141	7	14	19	37	**457**
1600 - 1615	43	132	5	1	16	13	10	109	11	15	15	65	**435**
1615 - 1630	39	179	3	2	14	12	10	130	10	17	16	44	**476**
1630 - 1645	43	183	3	0	11	13	7	136	10	10	20	59	**495**
1645 - 1700	52	213	5	4	8	11	11	113	11	19	15	50	**512**
1700 - 1715	29	197	5	5	17	15	7	132	16	19	10	69	**521**
1715 - 1730	49	215	6	2	6	6	4	131	12	17	16	50	**514**
1730 - 1745	45	206	1	3	8	8	3	128	14	8	10	70	**504**
1745 - 1800	38	176	3	3	12	10	3	91	11	21	12	40	**420**
Period End	**487**	**2055**	**42**	**25**	**133**	**121**	**77**	**1476**	**144**	**175**	**171**	**614**	**5520**

Lights	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Peak Time	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1600	149	554	11	5	41	33	22	506	49	49	57	167	**1643**
1515 - 1615	154	555	13	5	43	34	26	483	46	51	57	194	**1661**
1530 - 1630	159	610	13	6	47	36	32	503	39	56	63	197	**1761**
1545 - 1645	163	667	14	6	48	44	36	516	38	56	70	205	**1863**
1600 - 1700	177	707	16	7	49	49	38	488	42	61	66	218	**1918**
1615 - 1715	163	772	16	11	50	51	35	511	47	65	61	222	**2004**
1630 - 1730	173	808	19	11	42	45	29	512	49	65	61	228	**2042**
1645 - 1745	175	831	17	14	39	40	25	504	53	63	51	239	**2051**
1700 - 1800	161	794	15	13	43	39	17	482	53	65	48	229	**1959**
PEAK HOUR	**173**	**808**	**19**	**11**	**42**	**45**	**29**	**512**	**49**	**65**	**61**	**228**	**2042**

Heavies	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Time Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1515	2	5	1	1	0	0	1	7	2	2	1	1	**23**
1515 - 1530	0	10	1	1	0	0	1	8	0	2	0	0	**23**
1530 - 1545	0	6	3	2	1	2	2	6	1	1	1	1	**26**
1545 - 1600	2	11	1	1	0	0	1	9	2	3	2	2	**34**
1600 - 1615	4	8	0	0	0	0	0	14	3	3	1	2	**35**
1615 - 1630	1	9	0	0	1	0	0	9	2	1	1	2	**26**
1630 - 1645	4	4	0	2	0	1	0	9	2	1	2	6	**31**
1645 - 1700	1	3	1	0	0	0	1	3	2	1	0	1	**13**
1700 - 1715	2	3	5	0	1	1	1	5	0	0	0	5	**23**
1715 - 1730	2	3	0	1	1	1	0	7	1	0	0	2	**18**
1730 - 1745	1	2	1	0	2	0	1	1	0	1	1	1	**11**
1745 - 1800	3	5	2	1	0	0	0	2	0	0	0	2	**15**
Period End	**22**	**69**	**15**	**9**	**6**	**5**	**8**	**80**	**15**	**15**	**9**	**25**	**278**

Heavies	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Peak Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1600	4	32	6	5	1	2	5	30	5	8	4	4	**106**
1515 - 1615	6	35	5	4	1	2	4	37	6	9	4	5	**118**
1530 - 1630	7	34	4	3	2	2	3	38	8	8	5	7	**121**
1545 - 1645	11	32	1	3	1	1	1	41	9	8	6	12	**126**
1600 - 1700	10	24	1	2	1	1	1	35	9	6	4	11	**105**
1615 - 1715	8	19	6	2	2	2	2	26	6	3	3	14	**93**
1630 - 1730	9	13	6	3	2	3	2	24	5	2	2	14	**85**
1645 - 1745	6	11	7	1	4	2	3	16	3	2	1	9	**65**
1700 - 1800	8	13	8	2	4	2	2	15	1	1	1	10	**67**
PEAK HOUR	**9**	**13**	**6**	**3**	**2**	**3**	**2**	**24**	**5**	**2**	**2**	**14**	**85**

Combined	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Time Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1515	40	136	4	2	14	12	7	139	16	15	16	39	**440**
1515 - 1530	34	134	4	2	10	10	5	118	17	14	10	41	**399**
1530 - 1545	39	132	5	2	11	7	5	129	12	11	14	52	**419**
1545 - 1600	40	184	4	4	7	6	10	150	9	17	21	39	**491**
1600 - 1615	47	140	5	1	16	13	10	123	14	18	16	67	**470**
1615 - 1630	40	188	3	2	15	12	10	139	12	18	17	46	**502**
1630 - 1645	47	187	3	2	11	14	7	145	12	11	22	65	**526**
1645 - 1700	53	216	6	4	8	11	12	116	13	20	15	51	**525**
1700 - 1715	31	200	10	5	18	16	8	137	16	19	10	74	**544**
1715 - 1730	51	218	6	3	7	7	4	138	13	17	16	52	**532**
1730 - 1745	46	208	2	3	10	8	4	129	14	9	11	71	**515**
1745 - 1800	41	181	5	4	12	10	3	93	11	21	12	42	**435**
Period End	**509**	**2124**	**57**	**34**	**139**	**126**	**85**	**1556**	**159**	**190**	**180**	**639**	**5798**

Combined	NORTH			WEST			SOUTH			EAST			
	Northern Rd			*Greendale Rd*			*Northern Rd*			*Bringelly Rd*			
Peak Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1600	153	586	17	10	42	35	27	536	54	57	61	171	**1749**
1515 - 1615	160	590	18	9	44	36	30	520	52	60	61	199	**1779**
1530 - 1630	166	644	17	9	49	38	35	541	47	64	68	204	**1882**
1545 - 1645	174	699	15	9	49	45	37	557	47	64	76	217	**1989**
1600 - 1700	187	731	17	9	50	50	39	523	51	67	70	229	**2023**
1615 - 1715	171	791	22	13	52	53	37	537	53	68	64	236	**2097**
1630 - 1730	182	821	25	14	44	48	31	536	54	67	63	242	**2127**
1645 - 1745	181	842	24	15	43	42	28	520	56	65	52	248	**2116**
1700 - 1800	169	807	23	15	47	41	19	497	54	66	49	239	**2026**
PEAK HOUR	**182**	**821**	**25**	**14**	**44**	**48**	**31**	**536**	**54**	**67**	**63**	**242**	**2127**

R.O.A.R DATA

Reliable, Original & Authentic Results

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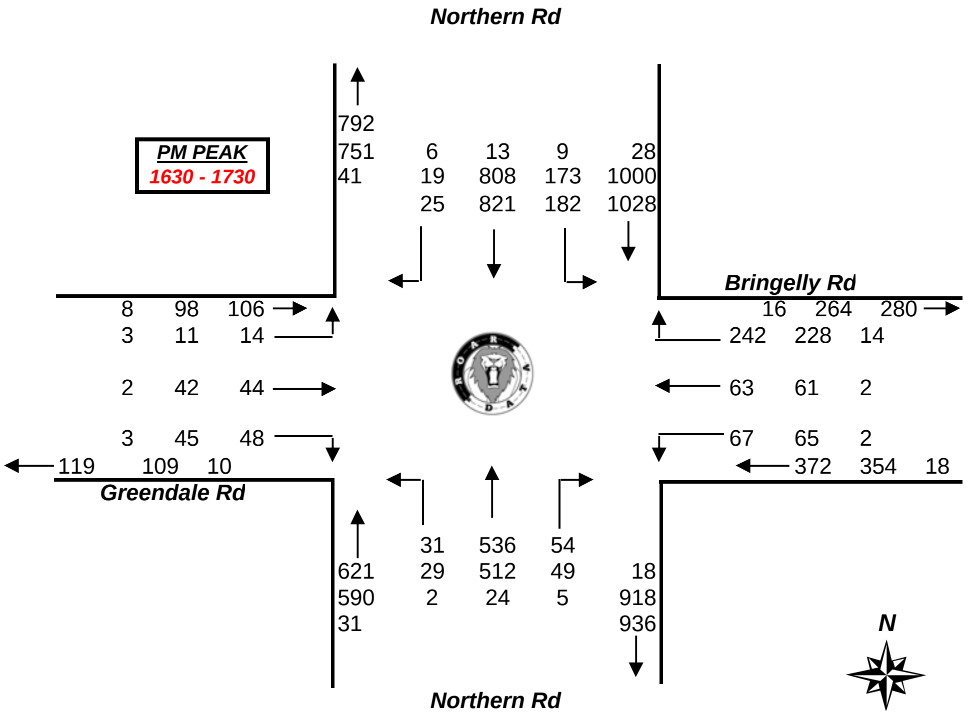
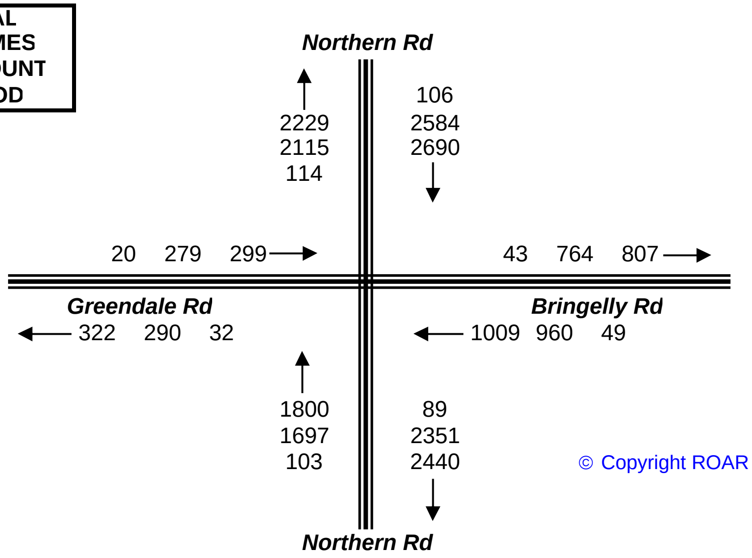
Client : EMGA
Job No/Name : 5786 BRINGELLY Bringelly Rc
Day/Date : Wednesday / 7th October 2015



Peds	**NORTH**	**WEST**	**SOUTH**	**EAST**	
	Northern Rd	***Greendale Rd***	***Northern Rd***	***Bringelly Rd***	
Time Per	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**TOT**
1500 - 1515					**0**
1515 - 1530					**0**
1530 - 1545					**0**
1545 - 1600		NOT	NOT		**0**
1600 - 1615		REQUIRED	REQUIRED		**0**
1615 - 1630					**0**
1630 - 1645					**0**
1645 - 1700					**0**
1700 - 1715					**0**
1715 - 1730					**0**
1730 - 1745					**0**
1745 - 1800					**0**
Period End	**0**	**0**	**0**	**0**	**0**

TOTAL VOLUMES FOR COUNT PERIOD



Peds	**NORTH**	**WEST**	**SOUTH**	**EAST**	
	Northern Rd	***Greendale Rd***	***Northern Rd***	***Bringelly Rd***	
Peak Per	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**TOT**
1500 - 1600	0	0	0	0	**0**
1515 - 1615	0	0	0	0	**0**
1530 - 1630	0	0	0	0	**0**
1545 - 1645	0	0	0	0	**0**
1600 - 1700	0	0	0	0	**0**
1615 - 1715	0	0	0	0	**0**
1630 - 1730	0	0	0	0	**0**
1645 - 1745	0	0	0	0	**0**
1700 - 1800	0	0	0	0	**0**

PEAK HR	**0**	**0**	**0**	**0**	**0**

R.O.A.R. DATA

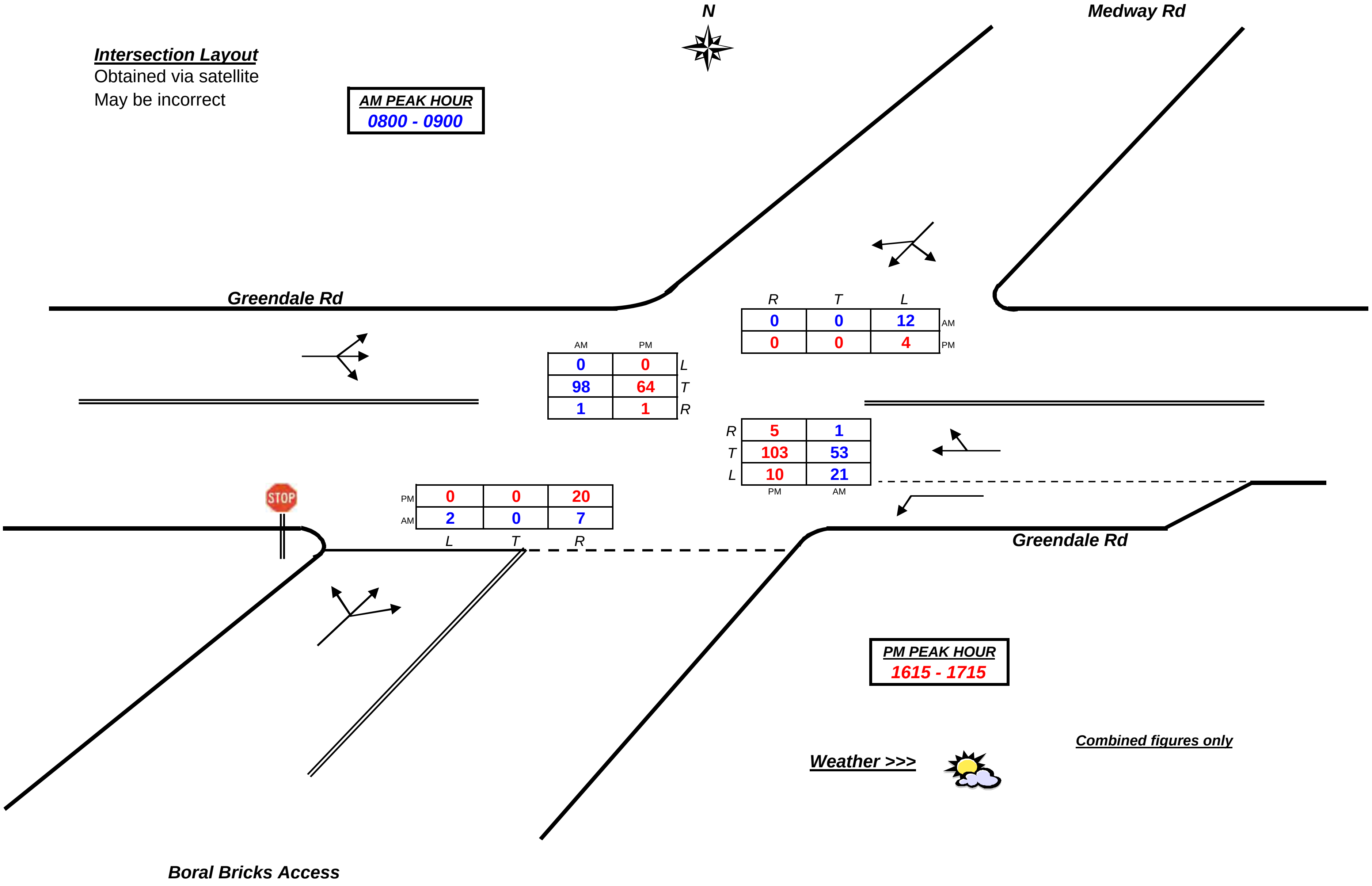
Reliable, Original & Authentic Results

Ph.88196847, Fax 88196849, Mob.0418-239019

Client : EMGA
Job No/Name : 5786 BRINGELLY Bringelly Rd
Day/Date : Wednesday / 7th October 2015

Intersection Layout
Obtained via satellite
May be incorrect

AM PEAK HOUR
0800 - 0900



Medway Rd approach:

	R	T	L
AM	0	0	12
PM	0	0	4

Greendale Rd (west) approach:

	AM	PM
L	0	0
T	98	64
R	1	1

Greendale Rd (east) approach:

	PM	AM
R	5	1
T	103	53
L	10	21

Boral Bricks Access approach:

	L	T	R
PM	0	0	20
AM	2	0	7

PM PEAK HOUR
1615 - 1715

Combined figures only

Weather >>>

R.O.A.R. DATA

Reliable, Original & Authentic Results

Ph.88196847, Fax 88196849, Mob.0418-239019

Client : EMGA
Job No/Name : 5786 BRINGELLY Bringelly Rd
Day/Date : Wednesday / 7th October 2015

Lights	**NORTH**			**WEST**			**SOUTH**			**EAST**			
	Medway Rd			***Greendale Rd***			***Boral Bricks***			***Greendale Rd***			
Time Per	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**TOT**
0600 - 0615	0	0	0	0	11	0	0	0	0	1	2	0	**14**
0615 - 0630	0	0	0	0	16	0	0	0	0	1	2	0	**19**
0630 - 0645	1	0	0	0	11	0	0	0	1	2	13	0	**28**
0645 - 0700	1	0	0	0	11	0	0	0	0	2	4	0	**18**
0700 - 0715	0	0	0	0	18	0	0	0	1	0	10	0	**29**
0715 - 0730	2	0	0	0	12	0	0	0	0	2	9	1	**26**
0730 - 0745	1	0	0	0	15	0	0	0	0	1	10	0	**27**
0745 - 0800	4	0	0	0	18	1	0	0	0	2	7	0	**32**
0800 - 0815	5	0	0	0	21	0	0	0	0	3	10	1	**40**
0815 - 0830	3	0	0	0	23	0	0	0	0	3	7	0	**36**
0830 - 0845	1	0	0	0	25	1	1	0	0	4	12	0	**44**
0845 - 0900	0	0	0	0	26	0	1	0	2	3	17	0	**49**
Period End	**18**	**0**	**0**	**0**	**207**	**2**	**2**	**0**	**4**	**24**	**103**	**2**	**362**

Lights	**NORTH**			**WEST**			**SOUTH**			**EAST**			
	Medway Rd			***Greendale Rd***			***Boral Bricks***			***Greendale Rd***			
Peak Time	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**TOT**
0600 - 0700	2	0	0	0	49	0	0	0	1	6	21	0	**79**
0615 - 0715	2	0	0	0	56	0	0	0	2	5	29	0	**94**
0630 - 0730	4	0	0	0	52	0	0	0	2	6	36	1	**101**
0645 - 0745	4	0	0	0	56	0	0	0	1	5	33	1	**100**
0700 - 0800	7	0	0	0	63	1	0	0	1	5	36	1	**114**
0715 - 0815	12	0	0	0	66	1	0	0	0	8	36	2	**125**
0730 - 0830	13	0	0	0	77	1	0	0	0	9	34	1	**135**
0745 - 0845	13	0	0	0	87	2	1	0	0	12	36	1	**152**
0800 - 0900	9	0	0	0	95	1	2	0	2	13	46	1	**169**
PEAK HOUR	**9**	**0**	**0**	**0**	**95**	**1**	**2**	**0**	**2**	**13**	**46**	**1**	**169**

Heavies	**NORTH**			**WEST**			**SOUTH**			**EAST**			
	Medway Rd			***Greendale Rd***			***Boral Bricks***			***Greendale Rd***			
Time Per	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**TOT**
0600 - 0615	0	0	0	0	3	0	0	0	2	7	0	0	**12**
0615 - 0630	1	0	0	0	3	0	0	0	1	0	0	0	**5**
0630 - 0645	0	0	0	0	1	0	0	0	2	0	0	0	**3**
0645 - 0700	0	0	0	0	1	0	0	0	2	0	1	0	**4**
0700 - 0715	0	0	0	0	0	0	0	0	1	3	0	0	**4**
0715 - 0730	0	0	0	0	0	0	0	0	3	3	3	0	**9**
0730 - 0745	0	0	0	0	0	0	0	0	1	0	1	1	**3**
0745 - 0800	0	0	0	0	2	0	0	0	3	2	1	0	**8**
0800 - 0815	0	0	0	0	1	0	0	0	1	2	1	0	**5**
0815 - 0830	0	0	0	0	1	0	0	0	3	0	0	0	**4**
0830 - 0845	0	0	0	0	1	0	0	0	0	4	4	0	**9**
0845 - 0900	3	0	0	0	0	0	0	0	1	2	2	0	**8**
Period End	**4**	**0**	**0**	**0**	**13**	**0**	**0**	**0**	**20**	**23**	**13**	**1**	**74**

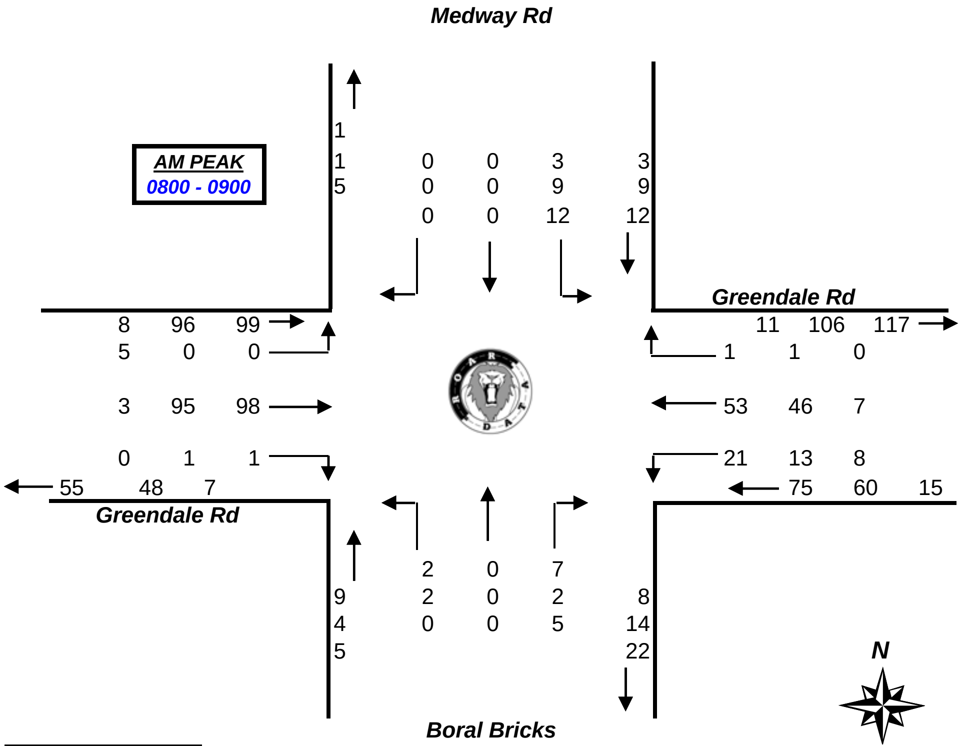
Heavies	**NORTH**			**WEST**			**SOUTH**			**EAST**			
	Medway Rd			***Greendale Rd***			***Boral Bricks***			***Greendale Rd***			
Peak Per	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**TOT**
0600 - 0700	1	0	0	0	8	0	0	0	7	7	1	0	**24**
0615 - 0715	1	0	0	0	5	0	0	0	6	3	1	0	**16**
0630 - 0730	0	0	0	0	2	0	0	0	8	6	4	0	**20**
0645 - 0745	0	0	0	0	1	0	0	0	7	6	5	1	**20**
0700 - 0800	0	0	0	0	2	0	0	0	8	8	5	1	**24**
0715 - 0815	0	0	0	0	3	0	0	0	8	7	6	1	**25**
0730 - 0830	0	0	0	0	4	0	0	0	8	4	3	1	**20**
0745 - 0845	0	0	0	0	5	0	0	0	7	8	6	0	**26**
0800 - 0900	3	0	0	0	3	0	0	0	5	8	7	0	**26**
PEAK HOUR	**3**	**0**	**0**	**5**	**3**	**0**	**0**	**0**	**5**	**8**	**7**	**0**	**26**

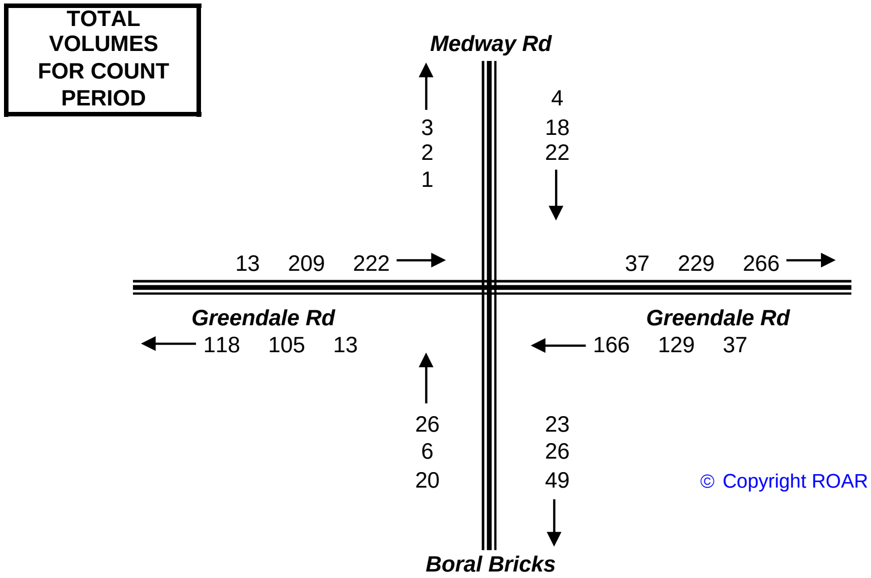
Combined	**NORTH**			**WEST**			**SOUTH**			**EAST**			
	Medway Rd			***Greendale Rd***			***Boral Bricks***			***Greendale Rd***			
Time Per	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**TOT**
0600 - 0615	0	0	0	0	14	0	0	0	2	8	2	0	**26**
0615 - 0630	1	0	0	0	19	0	0	0	1	1	2	0	**24**
0630 - 0645	1	0	0	0	12	0	0	0	3	2	13	0	**31**
0645 - 0700	1	0	0	0	12	0	0	0	2	2	5	0	**22**
0700 - 0715	0	0	0	0	18	0	0	0	2	3	10	0	**33**
0715 - 0730	2	0	0	0	12	0	0	0	3	5	12	1	**35**
0730 - 0745	1	0	0	0	15	0	0	0	1	1	11	1	**30**
0745 - 0800	4	0	0	0	20	1	0	0	3	4	8	0	**40**
0800 - 0815	5	0	0	0	22	0	0	0	1	5	11	1	**45**
0815 - 0830	3	0	0	0	24	0	0	0	3	3	7	0	**40**
0830 - 0845	1	0	0	0	26	1	1	0	0	8	16	0	**53**
0845 - 0900	3	0	0	0	26	0	1	0	3	5	19	0	**57**
Period End	**22**	**0**	**0**	**0**	**220**	**2**	**2**	**0**	**24**	**47**	**116**	**3**	**436**

Combined	**NORTH**			**WEST**			**SOUTH**			**EAST**			
	Medway Rd			***Greendale Rd***			***Boral Bricks***			***Greendale Rd***			
Peak Per	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**TOT**
0600 - 0700	3	0	0	0	57	0	0	0	8	13	22	0	**103**
0615 - 0715	3	0	0	0	61	0	0	0	8	8	30	0	**110**
0630 - 0730	4	0	0	0	54	0	0	0	10	12	40	1	**121**
0645 - 0745	4	0	0	0	57	0	0	0	8	11	38	2	**120**
0700 - 0800	7	0	0	0	65	1	0	0	9	13	41	2	**138**
0715 - 0815	12	0	0	0	69	1	0	0	8	15	42	3	**150**
0730 - 0830	13	0	0	0	81	1	0	0	8	13	37	2	**155**
0745 - 0845	13	0	0	0	92	2	1	0	7	20	42	1	**178**
0800 - 0900	12	0	0	0	98	1	2	0	7	21	53	1	**195**
PEAK HOUR	**12**	**0**	**0**	**0**	**98**	**1**	**2**	**0**	**7**	**21**	**53**	**1**	**195**

R.O.A.R DATA
Reliable, Original & Authentic Results
Ph.88196847, Fax 88196849, Mob.0418-239019

Client : EMGA
Job No/Name : 5786 BRINGELLY Bringelly Rd
Day/Date : Wednesday / 7th October 2015





Peds	**NORTH**	**WEST**	**SOUTH**	**EAST**	
	Medway Rd	***Greendale Rd***	***Boral Bricks***	***Greendale Rd***	
Time Per	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**TOT**
0600 - 0615					**0**
0615 - 0630					**0**
0630 - 0645					**0**
0645 - 0700		NOT	NOT		**0**
0700 - 0715		REQUIRED	REQUIRED		**0**
0715 - 0730					**0**
0730 - 0745					**0**
0745 - 0800					**0**
0800 - 0815					**0**
0815 - 0830					**0**
0830 - 0845					**0**
0845 - 0900					**0**
Period End	**0**	**0**	**0**	**0**	**0**

Peds	**NORTH**	**WEST**	**SOUTH**	**EAST**	
	Medway Rd	***Greendale Rd***	***Boral Bricks***	***Greendale Rd***	
Peak Per	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**TOT**
0600 - 0700	0	0	0	0	**0**
0615 - 0715	0	0	0	0	**0**
0630 - 0730	0	0	0	0	**0**
0645 - 0745	0	0	0	0	**0**
0700 - 0800	0	0	0	0	**0**
0715 - 0815	0	0	0	0	**0**
0730 - 0830	0	0	0	0	**0**
0745 - 0845	0	0	0	0	**0**
0800 - 0900	0	0	0	0	**0**
PEAK HR	**0**	**0**	**0**	**0**	**0**

R.O.A.R. DATA

Reliable, Original & Authentic Result

Ph.88196847, Fax 88196849, Mob.0418-239019

Client : EMGA
Job No/Name : 5786 BRINGELLY Bringelly Rc
Day/Date : Wednesday / 7th October 2015

Lights	NORTH			WEST			SOUTH			EAST			
	Medway Rd			*Greendale Rd*			*Boral Bricks*			*Greendale Rd*			
Time Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1515	2	0	0	0	16	0	0	0	2	0	23	0	**43**
1515 - 1530	0	0	0	0	10	0	0	0	0	1	18	0	**29**
1530 - 1545	11	0	0	0	12	0	0	0	0	1	14	0	**38**
1545 - 1600	4	0	0	0	10	0	0	0	1	0	21	2	**38**
1600 - 1615	1	0	0	0	22	0	0	0	4	2	22	3	**54**
1615 - 1630	2	0	0	0	15	1	0	0	2	3	22	2	**47**
1630 - 1645	0	0	0	0	17	0	0	0	1	3	25	1	**47**
1645 - 1700	2	0	0	0	15	0	0	0	2	0	25	1	**45**
1700 - 1715	0	0	0	0	16	0	0	0	11	0	25	1	**53**
1715 - 1730	0	0	0	0	9	0	0	0	2	1	20	0	**32**
1730 - 1745	1	0	0	0	20	0	0	0	1	0	16	2	**40**
1745 - 1800	2	0	0	0	11	0	0	0	4	1	17	0	**35**
Period End	**25**	**0**	**0**	**0**	**173**	**1**	**0**	**0**	**30**	**12**	**248**	**12**	**501**

Lights	NORTH			WEST			SOUTH			EAST			
	Medway Rd			*Greendale Rd*			*Boral Bricks*			*Greendale Rd*			
Peak Time	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1600	17	0	0	0	48	0	0	0	3	2	76	2	**148**
1515 - 1615	16	0	0	0	54	0	0	0	5	4	75	5	**159**
1530 - 1630	18	0	0	0	59	1	0	0	7	6	79	7	**177**
1545 - 1645	7	0	0	0	64	1	0	0	8	8	90	8	**186**
1600 - 1700	5	0	0	0	69	1	0	0	9	8	94	7	**193**
1615 - 1715	4	0	0	0	63	1	0	0	16	6	97	5	**192**
1630 - 1730	2	0	0	0	57	0	0	0	16	4	95	3	**177**
1645 - 1745	3	0	0	0	60	0	0	0	16	1	86	4	**170**
1700 - 1800	3	0	0	0	56	0	0	0	18	2	78	3	**160**
PEAK HOUR	**4**	**0**	**0**	**0**	**63**	**1**	**0**	**0**	**16**	**6**	**97**	**5**	**192**

Heavies	NORTH			WEST			SOUTH			EAST			
	Medway Rd			*Greendale Rd*			*Boral Bricks*			*Greendale Rd*			
Time Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1515	0	0	0	0	0	0	0	0	1	1	2	0	**4**
1515 - 1530	0	0	0	0	0	0	0	0	3	2	0	0	**5**
1530 - 1545	0	0	0	0	4	0	0	0	1	1	5	0	**11**
1545 - 1600	0	0	0	0	0	0	0	0	0	2	3	0	**5**
1600 - 1615	0	0	0	0	0	0	0	0	0	0	1	0	**1**
1615 - 1630	0	0	0	0	1	0	0	0	0	0	1	0	**2**
1630 - 1645	0	0	0	0	0	0	0	0	3	0	2	0	**5**
1645 - 1700	0	0	0	0	0	0	0	0	0	2	0	0	**2**
1700 - 1715	0	0	0	0	0	0	0	0	1	2	3	0	**6**
1715 - 1730	0	0	0	0	1	0	0	0	2	0	0	0	**3**
1730 - 1745	0	0	0	0	1	0	0	0	1	0	3	0	**5**
1745 - 1800	0	0	0	0	0	0	0	0	0	1	1	0	**2**
Period End	**0**	**0**	**0**	**0**	**7**	**0**	**0**	**0**	**12**	**11**	**21**	**0**	**51**

Heavies	NORTH			WEST			SOUTH			EAST			
	Medway Rd			*Greendale Rd*			*Boral Bricks*			*Greendale Rd*			
Peak Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1600	0	0	0	0	4	0	0	0	5	6	10	0	**25**
1515 - 1615	0	0	0	0	4	0	0	0	4	5	9	0	**22**
1530 - 1630	0	0	0	0	5	0	0	0	1	3	10	0	**19**
1545 - 1645	0	0	0	0	1	0	0	0	3	2	7	0	**13**
1600 - 1700	0	0	0	0	1	0	0	0	3	2	4	0	**10**
1615 - 1715	0	0	0	0	1	0	0	0	4	4	6	0	**15**
1630 - 1730	0	0	0	0	1	0	0	0	6	4	5	0	**16**
1645 - 1745	0	0	0	0	2	0	0	0	4	4	6	0	**16**
1700 - 1800	0	0	0	0	2	0	0	0	4	3	7	0	**16**
PEAK HOUR	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**6**	**0**	**15**

Combined	NORTH			WEST			SOUTH			EAST			
	Medway Rd			*Greendale Rd*			*Boral Bricks*			*Greendale Rd*			
Time Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1515	2	0	0	0	16	0	0	0	3	1	25	0	**47**
1515 - 1530	0	0	0	0	10	0	0	0	3	3	18	0	**34**
1530 - 1545	11	0	0	0	16	0	0	0	1	2	19	0	**49**
1545 - 1600	4	0	0	0	10	0	0	0	1	2	24	2	**43**
1600 - 1615	1	0	0	0	22	0	0	0	4	2	23	3	**55**
1615 - 1630	2	0	0	0	16	1	0	0	2	3	23	2	**49**
1630 - 1645	0	0	0	0	17	0	0	0	4	3	27	1	**52**
1645 - 1700	2	0	0	0	15	0	0	0	2	2	25	1	**47**
1700 - 1715	0	0	0	0	16	0	0	0	12	2	28	1	**59**
1715 - 1730	0	0	0	0	10	0	0	0	4	1	20	0	**35**
1730 - 1745	1	0	0	0	21	0	0	0	2	0	19	2	**45**
1745 - 1800	2	0	0	0	11	0	0	0	4	2	18	0	**37**
Period End	**25**	**0**	**0**	**0**	**180**	**1**	**0**	**0**	**42**	**23**	**269**	**12**	**552**

Combined	NORTH			WEST			SOUTH			EAST			
	Medway Rd			*Greendale Rd*			*Boral Bricks*			*Greendale Rd*			
Peak Per	L	T	R	L	T	R	L	T	R	L	T	R	TOT
1500 - 1600	17	0	0	0	52	0	0	0	8	8	86	2	**173**
1515 - 1615	16	0	0	0	58	0	0	0	9	9	84	5	**181**
1530 - 1630	18	0	0	0	64	1	0	0	8	9	89	7	**196**
1545 - 1645	7	0	0	0	65	1	0	0	11	10	97	8	**199**
1600 - 1700	5	0	0	0	70	1	0	0	12	10	98	7	**203**
1615 - 1715	4	0	0	0	64	1	0	0	20	10	103	5	**207**
1630 - 1730	2	0	0	0	58	0	0	0	22	8	100	3	**193**
1645 - 1745	3	0	0	0	62	0	0	0	20	5	92	4	**186**
1700 - 1800	3	0	0	0	58	0	0	0	22	5	85	3	**176**
PEAK HOUR	**4**	**0**	**0**	**0**	**64**	**1**	**0**	**0**	**20**	**10**	**103**	**5**	**207**

R.O.A.R DATA

Reliable, Original & Authentic Results

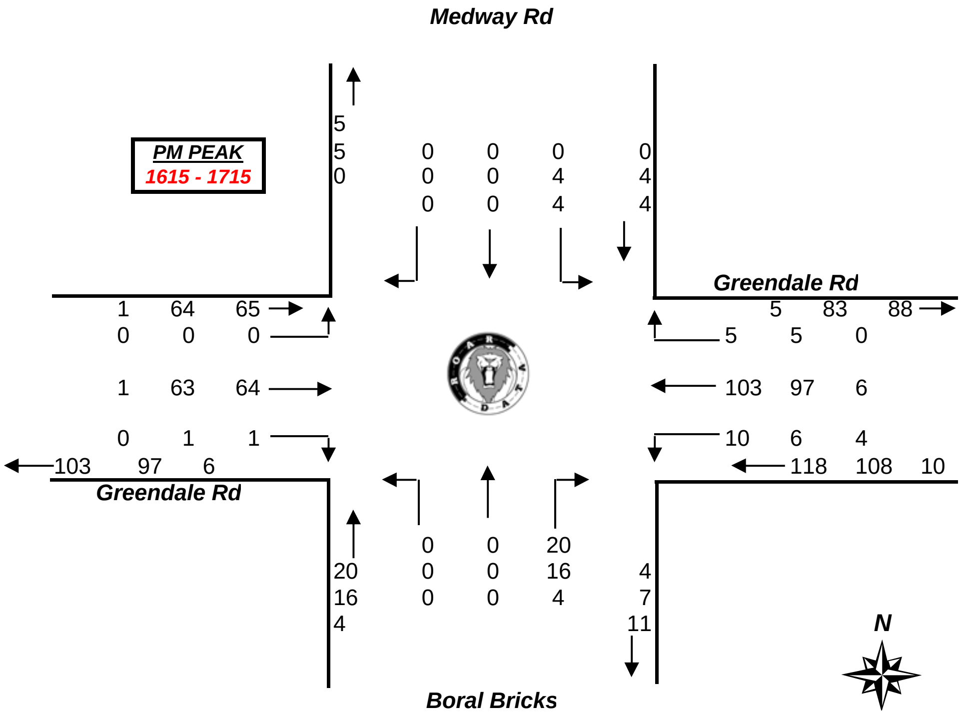
Ph.88196847, Fax 88196849, Mob.0418-239019

Client : EMGA
Job No/Name : 5786 BRINGELLY Bringelly Rc
Day/Date : Wednesday / 7th October 2015

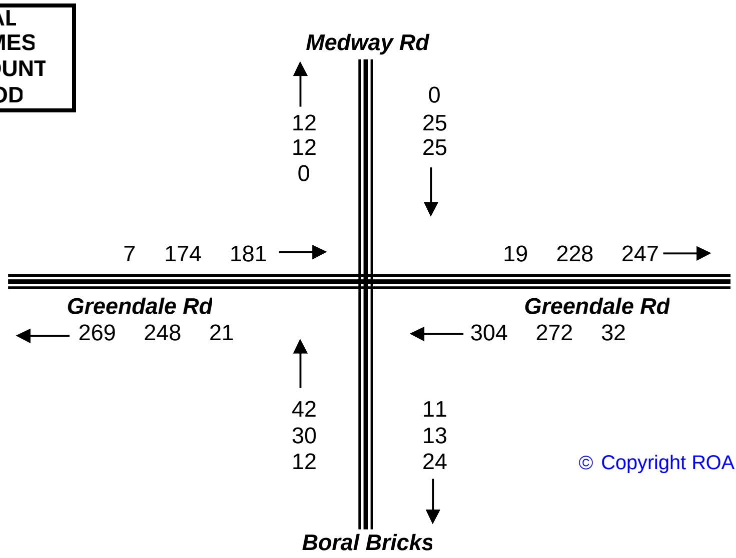
Peds	**NORTH**	**WEST**	**SOUTH**	**EAST**	
	Medway Rd	***Greendale Rd***	***Boral Bricks***	***Greendale Rd***	
Time Per	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**TOT**
1500 - 1515					**0**
1515 - 1530					**0**
1530 - 1545					**0**
1545 - 1600		NOT	NOT		**0**
1600 - 1615		REQUIRED	REQUIRED		**0**
1615 - 1630					**0**
1630 - 1645					**0**
1645 - 1700					**0**
1700 - 1715					**0**
1715 - 1730					**0**
1730 - 1745					**0**
1745 - 1800					**0**
Period End	**0**	**0**	**0**	**0**	**0**

Peds	**NORTH**	**WEST**	**SOUTH**	**EAST**	
	Medway Rd	***Greendale Rd***	***Boral Bricks***	***Greendale Rd***	
Peak Per	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNCLASSIFIED**	**TOT**
1500 - 1600	0	0	0	0	**0**
1515 - 1615	0	0	0	0	**0**
1530 - 1630	0	0	0	0	**0**
1545 - 1645	0	0	0	0	**0**
1600 - 1700	0	0	0	0	**0**
1615 - 1715	0	0	0	0	**0**
1630 - 1730	0	0	0	0	**0**
1645 - 1745	0	0	0	0	**0**
1700 - 1800	0	0	0	0	**0**

PEAK HR	**0**	**0**	**0**	**0**	**0**

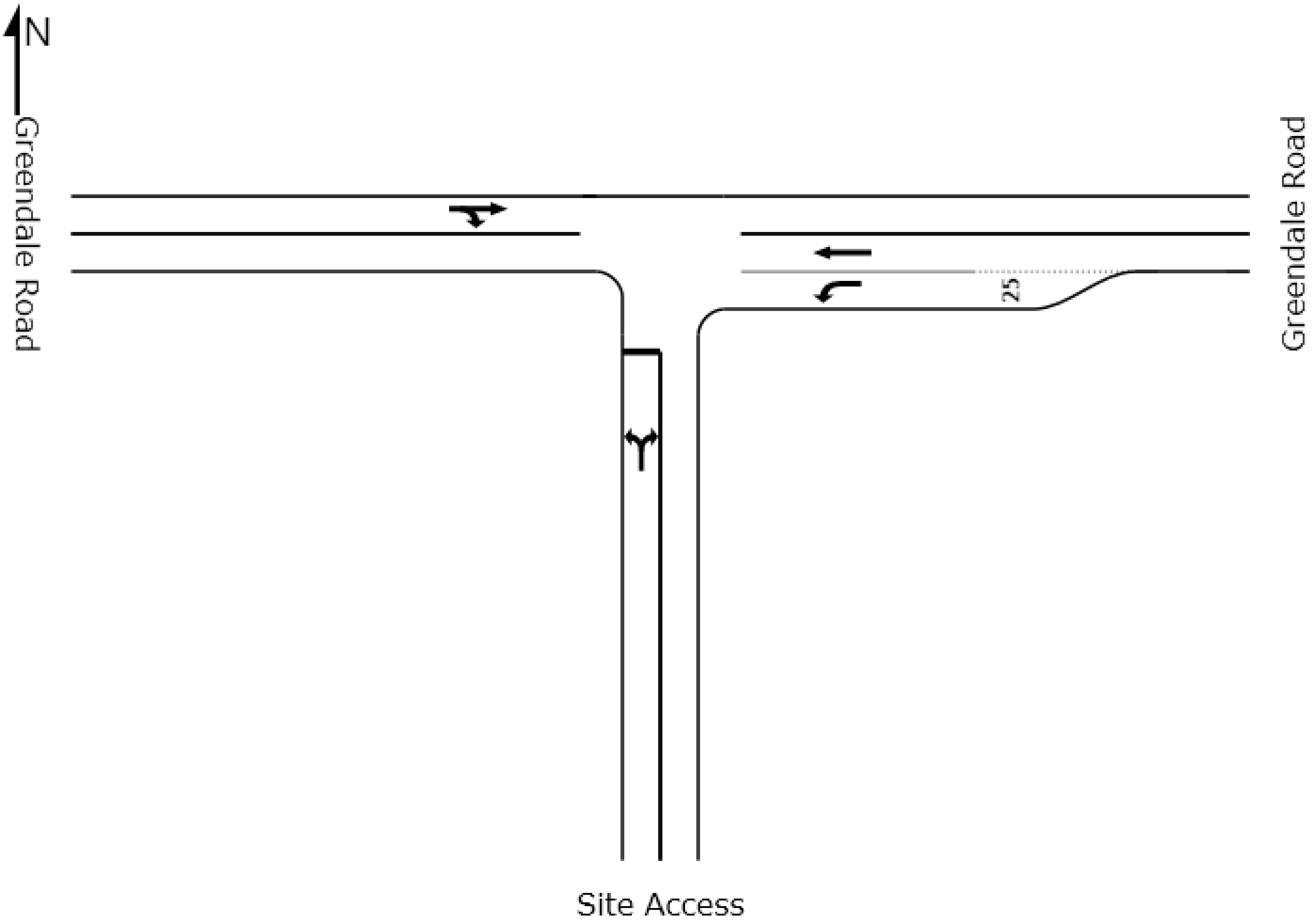


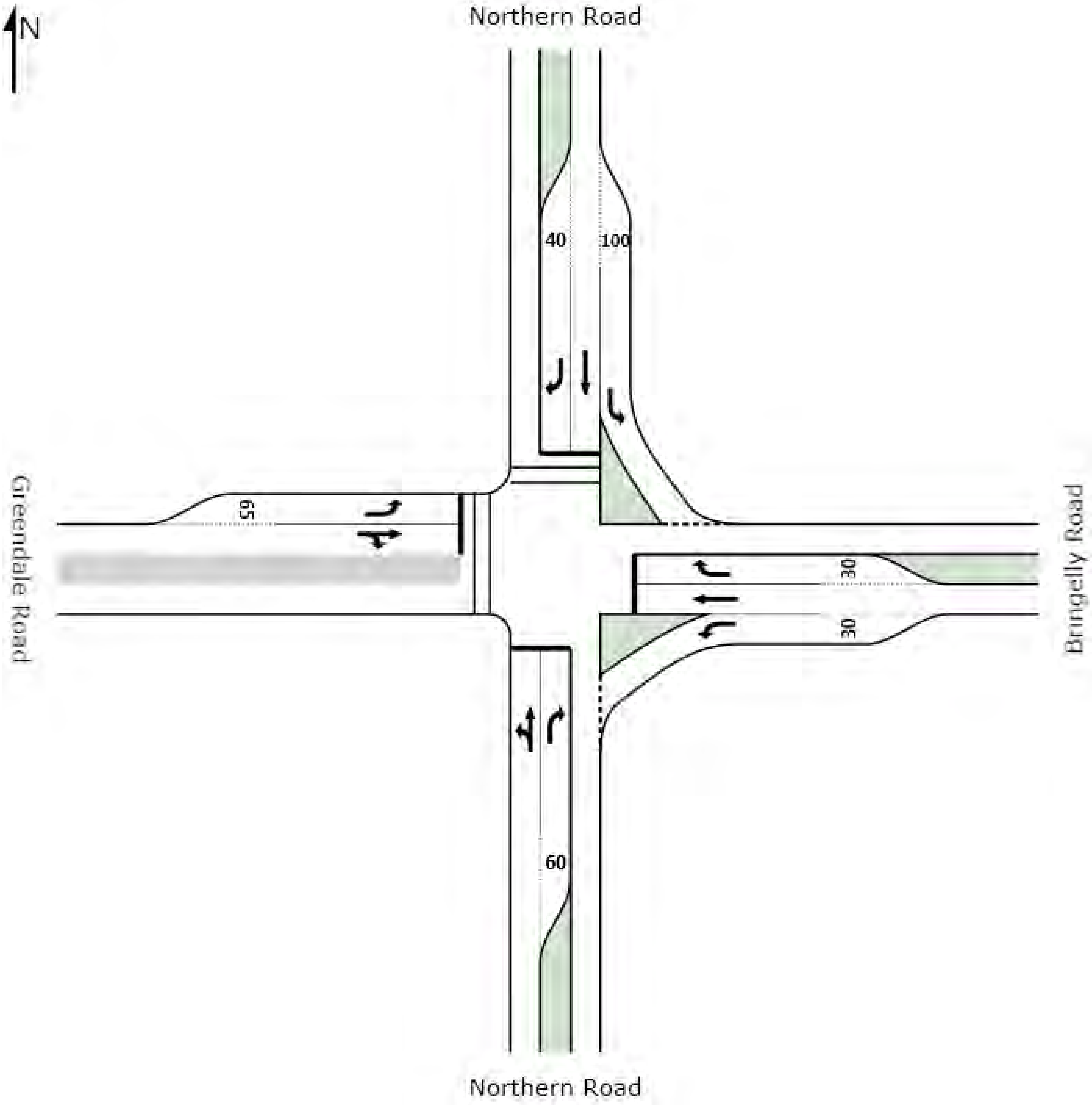
TOTAL VOLUMES FOR COUNT PERIOD



Appendix C

SIDRA Intersection Analysis Results


N
Greendale Road
Greendale Road
25
Site Access


N
Northern Road
40
100
Greendale Road
65
Bringelly Road
30
30
60
Northern Road

MOVEMENT SUMMARY

Site: CBP Site Access Intersection
AM Peak

Stop Sign Site Access Intersection
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Site Access											
1	L	1	0.0	0.059	17.1	LOS B	0.2	2.7	0.46	0.72	39.7
3	R	17	93.8	0.059	22.7	LOS B	0.2	2.7	0.46	0.91	39.9
Approach		18	88.2	0.059	22.3	LOS B	0.2	2.7	0.46	0.90	39.8
East: Greendale Road											
4	L	17	93.8	0.015	13.8	LOS A	0.0	0.0	0.00	0.71	57.1
5	T	58	12.7	0.032	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
Approach		75	31.0	0.032	3.1	NA	0.0	0.0	0.00	0.16	74.2
West: Greendale Road											
11	T	104	3.0	0.055	0.3	LOS A	0.3	2.3	0.22	0.00	72.5
12	R	1	0.0	0.055	10.6	LOS A	0.3	2.3	0.22	1.25	58.0
Approach		105	3.0	0.055	0.4	NA	0.3	2.3	0.22	0.01	72.4
All Vehicles		198	21.3	0.059	3.4	NA	0.3	2.7	0.16	0.15	68.0

Level of Service (LOS) Method: Delay (RTA NSW).

Vehicle movement LOS values are based on average delay per movement

Minor Road Approach LOS values are based on average delay for all vehicle movements.

NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model used.

Processed: Friday, 22 January 2016 4:16:38 PM
SIDRA INTERSECTION 5.1.13.2093
Project: R:\Transport Planning\SIDRA RESULTS\Boral Bringelley CBP\Bringelly Road Intersection.sip
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SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: CBP Site Access Intersection
PM Peak

Stop Sign Site Access Intersection
Stop (Two-Way)

Movement Performance - Vehicles											
Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Site Access											
1	L	1	0.0	0.061	17.6	LOS B	0.2	2.8	0.48	0.75	39.4
3	R	17	93.8	0.061	23.2	LOS B	0.2	2.8	0.48	0.91	39.6
Approach		18	88.2	0.061	22.8	LOS B	0.2	2.8	0.48	0.90	39.5
East: Greendale Road											
4	L	17	93.8	0.015	13.8	LOS A	0.0	0.0	0.00	0.71	57.1
5	T	108	5.8	0.058	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
Approach		125	17.6	0.058	1.9	NA	0.0	0.0	0.00	0.10	76.5
West: Greendale Road											
11	T	68	1.5	0.036	0.5	LOS A	0.2	1.5	0.27	0.00	70.9
12	R	1	0.0	0.036	10.8	LOS A	0.2	1.5	0.27	1.20	58.3
Approach		69	1.5	0.036	0.7	NA	0.2	1.5	0.27	0.02	70.7
All Vehicles		213	18.3	0.061	3.2	NA	0.2	2.8	0.13	0.14	69.2

Level of Service (LOS) Method: Delay (RTA NSW).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: Bringelly Road Intersection
AM Peak

Traffic Signal Intersection
Signals - Fixed Time   Cycle Time = 70 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Northern Road											
1	L	13	8.3	0.743	17.7	LOS B	21.3	153.1	0.74	0.97	43.1
2	T	899	3.2	0.743	9.2	LOS A	21.3	153.1	0.74	0.68	45.2
3	R	40	13.2	0.097	17.0	LOS B	0.7	5.2	0.50	0.72	41.2
Approach		952	3.7	0.743	9.6	LOS A	21.3	153.1	0.73	0.68	45.0
East: Bringelly Road											
4	L	31	10.3	0.060	9.5	LOS A	0.2	1.5	0.29	0.64	47.8
5	T	33	16.1	0.100	26.2	LOS B	1.0	7.6	0.86	0.63	33.3
6	R	144	3.6	0.728	41.0	LOS C	5.0	36.3	0.96	0.89	28.2
Approach		207	6.6	0.728	34.0	LOS C	5.0	36.3	0.85	0.81	30.9
North: Northern Road											
7	L	267	3.9	0.215	8.5	LOS A	1.1	8.2	0.23	0.66	48.5
8	T	441	7.9	0.370	6.3	LOS A	7.0	52.5	0.50	0.44	49.1
9	R	16	40.0	0.121	29.3	LOS C	0.4	3.9	0.73	0.74	34.0
Approach		724	7.1	0.370	7.6	LOS A	7.0	52.5	0.41	0.53	48.4
West: Greendale Road											
10	L	13	33.3	0.045	35.3	LOS C	0.4	3.3	0.85	0.69	30.9
11	T	52	6.1	0.232	27.2	LOS B	2.1	16.1	0.89	0.69	32.2
12	R	18	23.5	0.232	36.4	LOS C	2.1	16.1	0.89	0.80	31.6
Approach		82	14.1	0.232	30.4	LOS C	2.1	16.1	0.88	0.71	31.8
All Vehicles		1965	5.7	0.743	12.3	LOS A	21.3	153.1	0.63	0.64	43.3

Level of Service (LOS) Method: Delay (RTA NSW).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P5	Across N approach	53	29.3	LOS C	0.1	0.1	0.91	0.91
P7	Across W approach	53	7.3	LOS A	0.0	0.0	0.46	0.46
All Pedestrians		106	18.3	LOS B			0.69	0.69

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

Processed: Monday, 18 January 2016 1:59:57 PM
SIDRA INTERSECTION 5.1.13.2093

Project: R:\Transport Planning\SIDRA RESULTS\Boral Bringelley CBP\Bringelly Road Intersection.sip
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MOVEMENT SUMMARY

Site: Bringelly Road Intersection
PM Peak

Traffic Signal Intersection
Signals - Fixed Time   Cycle Time = 50 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Northern Road											
1	L	33	6.5	0.632	18.5	LOS B	10.9	79.0	0.78	0.92	42.5
2	T	564	4.5	0.632	10.0	LOS A	10.9	79.0	0.78	0.69	44.2
3	R	57	9.3	0.344	33.4	LOS C	1.4	10.8	0.97	0.74	31.4
Approach		654	5.0	0.632	12.5	LOS A	10.9	79.0	0.80	0.71	42.6
East: Bringelly Road											
4	L	71	3.0	0.145	16.3	LOS B	1.0	7.3	0.69	0.71	41.5
5	T	66	3.2	0.133	15.7	LOS B	1.3	9.2	0.80	0.61	39.7
6	R	255	5.8	0.903	32.3	LOS C	6.7	49.0	0.94	0.93	31.8
Approach		392	4.8	0.903	26.6	LOS B	6.7	49.0	0.87	0.84	34.5
North: Northern Road											
7	L	192	4.9	0.139	8.6	LOS A	0.7	4.8	0.28	0.66	48.2
8	T	864	1.6	0.895	24.6	LOS B	27.0	191.8	0.98	1.13	33.9
9	R	26	24.0	0.111	24.7	LOS B	0.5	4.3	0.77	0.73	36.2
Approach		1082	2.7	0.895	21.8	LOS B	27.0	191.8	0.85	1.04	35.8
West: Greendale Road											
10	L	15	21.4	0.035	24.2	LOS B	0.3	2.3	0.77	0.70	36.4
11	T	46	4.5	0.237	16.4	LOS B	2.0	14.3	0.83	0.65	37.7
12	R	51	6.3	0.237	25.0	LOS B	2.0	14.3	0.83	0.80	36.6
Approach		112	7.5	0.237	21.3	LOS B	2.0	14.3	0.82	0.72	37.1
All Vehicles		2239	4.0	0.903	19.9	LOS B	27.0	191.8	0.84	0.89	37.4

Level of Service (LOS) Method: Delay (RTA NSW).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P5	Across N approach	53	19.4	LOS B	0.1	0.1	0.88	0.88
P7	Across W approach	53	10.2	LOS B	0.0	0.0	0.64	0.64
All Pedestrians		106	14.8	LOS B			0.76	0.76

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

MOVEMENT SUMMARY

Site: Bringelly Road Intersection
AM Peak Project Traffic North

Traffic Signal Intersection
Signals - Fixed Time   Cycle Time = 70 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Northern Road											
1	L	16	26.7	0.748	18.4	LOS B	21.5	155.0	0.74	0.97	43.1
2	T	899	3.2	0.748	9.3	LOS A	21.5	155.0	0.74	0.68	45.2
3	R	40	13.2	0.097	17.0	LOS B	0.7	5.2	0.50	0.72	41.2
Approach		955	4.0	0.748	9.7	LOS A	21.5	155.0	0.73	0.69	44.9
East: Bringelly Road											
4	L	31	10.3	0.060	9.5	LOS A	0.2	1.5	0.29	0.64	47.8
5	T	34	15.6	0.102	26.2	LOS B	1.0	7.8	0.86	0.63	33.3
6	R	144	3.6	0.731	41.1	LOS C	5.1	36.5	0.96	0.89	28.2
Approach		208	6.6	0.731	34.1	LOS C	5.1	36.5	0.85	0.81	30.8
North: Northern Road											
7	L	267	3.9	0.215	8.5	LOS A	1.1	8.2	0.23	0.66	48.5
8	T	441	7.9	0.370	6.3	LOS A	7.0	52.5	0.50	0.44	49.1
9	R	28	66.7	0.297	33.2	LOS C	0.8	9.2	0.79	0.77	32.5
Approach		737	8.7	0.370	8.1	LOS A	7.0	52.5	0.42	0.53	48.0
West: Greendale Road											
10	L	25	66.7	0.108	37.3	LOS C	0.8	8.3	0.86	0.73	30.6
11	T	53	6.0	0.259	27.4	LOS B	2.3	17.7	0.89	0.69	32.0
12	R	21	35.0	0.259	37.1	LOS C	2.3	17.7	0.89	0.80	31.4
Approach		99	27.7	0.259	32.0	LOS C	2.3	17.7	0.89	0.72	31.5
All Vehicles		1999	7.2	0.748	12.8	LOS A	21.5	155.0	0.64	0.65	43.0

Level of Service (LOS) Method: Delay (RTA NSW).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P5	Across N approach	53	29.3	LOS C	0.1	0.1	0.91	0.91
P7	Across W approach	53	7.3	LOS A	0.0	0.0	0.46	0.46
All Pedestrians		106	18.3	LOS B			0.69	0.69

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: Bringelly Road Intersection
AM Peak Project Traffic East

Traffic Signal Intersection
Signals - Fixed Time   Cycle Time = 70 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Northern Road											
1	L	16	26.7	0.748	18.4	LOS B	21.5	155.0	0.74	0.97	43.1
2	T	899	3.2	0.748	9.3	LOS A	21.5	155.0	0.74	0.68	45.2
3	R	40	13.2	0.097	17.0	LOS B	0.7	5.2	0.50	0.72	41.2
Approach		955	4.0	0.748	9.7	LOS A	21.5	155.0	0.73	0.69	44.9
East: Bringelly Road											
4	L	31	10.3	0.060	9.5	LOS A	0.2	1.5	0.29	0.64	47.8
5	T	46	38.6	0.160	26.8	LOS B	1.4	12.9	0.87	0.66	33.0
6	R	144	3.6	0.739	42.1	LOS C	5.1	37.0	0.97	0.90	27.8
Approach		221	11.9	0.739	34.4	LOS C	5.1	37.0	0.86	0.81	30.6
North: Northern Road											
7	L	267	3.9	0.219	8.6	LOS A	1.3	9.4	0.25	0.66	48.4
8	T	441	7.9	0.370	6.3	LOS A	7.0	52.5	0.50	0.44	49.1
9	R	16	40.0	0.122	30.1	LOS C	0.4	4.0	0.74	0.74	33.5
Approach		724	7.1	0.370	7.7	LOS A	7.0	52.5	0.41	0.53	48.4
West: Greendale Road											
10	L	13	33.3	0.045	35.3	LOS C	0.4	3.3	0.85	0.69	30.9
11	T	65	24.2	0.325	28.0	LOS B	2.7	23.2	0.91	0.71	31.8
12	R	21	35.0	0.325	37.6	LOS C	2.7	23.2	0.91	0.81	31.3
Approach		99	27.7	0.325	31.0	LOS C	2.7	23.2	0.90	0.73	31.5
All Vehicles		1999	7.2	0.748	12.8	LOS A	21.5	155.0	0.64	0.65	42.9

Level of Service (LOS) Method: Delay (RTA NSW).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P5	Across N approach	53	29.3	LOS C	0.1	0.1	0.91	0.91
P7	Across W approach	53	7.3	LOS A	0.0	0.0	0.46	0.46
All Pedestrians		106	18.3	LOS B			0.69	0.69

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

Processed: Friday, 22 January 2016 4:00:37 PM
SIDRA INTERSECTION 5.1.13.2093

Project: R:\Transport Planning\SIDRA RESULTS\Boral Bringelley CBP\Bringelly Road Intersection.sip
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MOVEMENT SUMMARY

Site: Bringelly Road Intersection
AM Peak Project Traffic South

Traffic Signal Intersection
Signals - Fixed Time   Cycle Time = 70 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Northern Road											
1	L	28	59.3	0.766	20.3	LOS B	22.7	165.7	0.76	0.99	42.5
2	T	899	3.2	0.766	10.0	LOS A	22.7	165.7	0.76	0.71	44.4
3	R	40	13.2	0.097	17.0	LOS B	0.7	5.2	0.50	0.72	41.2
Approach		967	5.2	0.766	10.6	LOS A	22.7	165.7	0.75	0.72	44.2
East: Bringelly Road											
4	L	31	10.3	0.060	9.5	LOS A	0.2	1.5	0.29	0.64	47.8
5	T	34	15.6	0.102	26.2	LOS B	1.0	7.8	0.86	0.63	33.3
6	R	144	3.6	0.729	41.0	LOS C	5.0	36.4	0.96	0.89	28.2
Approach		208	6.6	0.729	34.0	LOS C	5.0	36.4	0.85	0.81	30.9
North: Northern Road											
7	L	267	3.9	0.215	8.5	LOS A	1.1	8.3	0.23	0.66	48.5
8	T	441	7.9	0.370	6.3	LOS A	7.0	52.5	0.50	0.44	49.1
9	R	16	40.0	0.126	31.0	LOS C	0.4	4.1	0.76	0.74	33.1
Approach		724	7.1	0.370	7.6	LOS A	7.0	52.5	0.41	0.53	48.4
West: Greendale Road											
10	L	13	33.3	0.045	35.3	LOS C	0.4	3.3	0.85	0.69	30.9
11	T	53	6.0	0.350	28.3	LOS B	2.7	23.4	0.91	0.72	31.3
12	R	34	59.4	0.350	38.9	LOS C	2.7	23.4	0.91	0.80	30.9
Approach		99	27.7	0.350	32.8	LOS C	2.7	23.4	0.90	0.74	31.1
All Vehicles		1999	7.2	0.766	13.0	LOS A	22.7	165.7	0.64	0.66	42.7

Level of Service (LOS) Method: Delay (RTA NSW).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P5	Across N approach	53	29.3	LOS C	0.1	0.1	0.91	0.91
P7	Across W approach	53	7.3	LOS A	0.0	0.0	0.46	0.46
All Pedestrians		106	18.3	LOS B			0.69	0.69

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

Processed: Friday, 22 January 2016 4:02:05 PM
SIDRA INTERSECTION 5.1.13.2093
Project: R:\Transport Planning\SIDRA RESULTS\Boral Bringelley CBP\Bringelly Road Intersection.sip
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SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: Bringelly Road Intersection
PM Peak Project Traffic North

Traffic Signal Intersection
Signals - Fixed Time   Cycle Time = 50 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Northern Road											
1	L	36	14.7	0.638	18.8	LOS B	11.0	80.2	0.79	0.93	42.4
2	T	564	4.5	0.638	10.1	LOS A	11.0	80.2	0.79	0.70	44.1
3	R	57	9.3	0.344	33.4	LOS C	1.4	10.8	0.97	0.74	31.4
Approach		657	5.4	0.638	12.6	LOS A	11.0	80.2	0.80	0.71	42.5
East: Bringelly Road											
4	L	71	3.0	0.145	16.3	LOS B	1.0	7.3	0.69	0.71	41.5
5	T	67	3.1	0.136	15.7	LOS B	1.3	9.3	0.80	0.61	39.7
6	R	255	5.8	0.906	32.3	LOS C	6.7	49.0	0.95	0.93	31.9
Approach		393	4.8	0.906	26.6	LOS B	6.7	49.0	0.88	0.83	34.5
North: Northern Road											
7	L	192	4.9	0.139	8.6	LOS A	0.7	4.8	0.28	0.66	48.2
8	T	864	1.6	0.895	24.6	LOS B	27.0	191.8	0.98	1.13	33.9
9	R	39	48.6	0.216	26.6	LOS B	0.8	8.0	0.80	0.76	35.6
Approach		1095	3.8	0.895	21.9	LOS B	27.0	191.8	0.85	1.04	35.8
West: Greendale Road											
10	L	27	57.7	0.080	26.0	LOS B	0.5	5.5	0.78	0.72	36.2
11	T	47	4.4	0.256	16.6	LOS B	2.1	15.4	0.83	0.66	37.6
12	R	54	11.8	0.256	25.3	LOS B	2.1	15.4	0.83	0.80	36.5
Approach		128	18.9	0.256	22.3	LOS B	2.1	15.4	0.82	0.73	36.8
All Vehicles		2273	5.3	0.906	20.0	LOS B	27.0	191.8	0.84	0.89	37.3

Level of Service (LOS) Method: Delay (RTA NSW).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P5	Across N approach	53	19.4	LOS B	0.1	0.1	0.88	0.88
P7	Across W approach	53	10.2	LOS B	0.0	0.0	0.64	0.64
All Pedestrians		106	14.8	LOS B			0.76	0.76

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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SIDRA INTERSECTION 5.1.13.2093

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SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: Bringelly Road Intersection
PM Peak Project Traffic East

Traffic Signal Intersection
Signals - Fixed Time   Cycle Time = 50 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
							Vehicles veh	Distance m			
South: Northern Road											
1	L	36	14.7	0.638	18.8	LOS B	11.0	80.2	0.79	0.93	42.4
2	T	564	4.5	0.638	10.1	LOS A	11.0	80.2	0.79	0.70	44.1
3	R	57	9.3	0.344	33.4	LOS C	1.4	10.8	0.97	0.74	31.4
Approach		657	5.4	0.638	12.6	LOS A	11.0	80.2	0.80	0.71	42.5
East: Bringelly Road											
4	L	71	3.0	0.145	16.3	LOS B	1.0	7.3	0.69	0.71	41.5
5	T	80	18.4	0.177	16.0	LOS B	1.6	12.7	0.81	0.63	39.5
6	R	255	5.8	0.919	32.5	LOS C	6.7	49.0	0.96	0.92	31.7
Approach		405	7.8	0.919	26.4	LOS B	6.7	49.0	0.88	0.82	34.5
North: Northern Road											
7	L	192	4.9	0.141	8.8	LOS A	0.8	5.6	0.31	0.67	48.1
8	T	864	1.6	0.895	24.6	LOS B	27.0	191.8	0.98	1.13	33.9
9	R	26	24.0	0.112	24.7	LOS B	0.5	4.3	0.77	0.73	36.2
Approach		1082	2.7	0.895	21.8	LOS B	27.0	191.8	0.85	1.04	35.8
West: Greendale Road											
10	L	15	21.4	0.035	24.2	LOS B	0.3	2.3	0.77	0.70	36.4
11	T	60	24.6	0.308	16.9	LOS B	2.4	19.1	0.84	0.67	37.5
12	R	54	11.8	0.308	25.7	LOS B	2.4	19.1	0.84	0.81	36.5
Approach		128	18.9	0.308	21.4	LOS B	2.4	19.1	0.84	0.73	36.9
All Vehicles		2273	5.3	0.919	20.0	LOS B	27.0	191.8	0.84	0.89	37.3

Level of Service (LOS) Method: Delay (RTA NSW).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue		Prop. Queued	Effective Stop Rate per ped
					Pedestrian ped	Distance m		
P5	Across N approach	53	19.4	LOS B	0.1	0.1	0.88	0.88
P7	Across W approach	53	10.2	LOS B	0.0	0.0	0.64	0.64
All Pedestrians		106	14.8	LOS B			0.76	0.76

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

MOVEMENT SUMMARY

Site: Bringelly Road Intersection
PM Peak Project Traffic South

Traffic Signal Intersection
Signals - Fixed Time   Cycle Time = 50 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Northern Road											
1	L	48	37.0	0.661	19.8	LOS B	11.4	84.7	0.80	0.93	42.2
2	T	564	4.5	0.661	10.3	LOS A	11.4	84.7	0.80	0.71	43.8
3	R	57	9.3	0.344	33.4	LOS C	1.4	10.8	0.97	0.74	31.4
Approach		669	7.2	0.661	12.9	LOS A	11.4	84.7	0.82	0.73	42.3
East: Bringelly Road											
4	L	71	3.0	0.145	16.3	LOS B	1.0	7.3	0.69	0.71	41.5
5	T	67	3.1	0.136	15.7	LOS B	1.3	9.3	0.80	0.61	39.7
6	R	255	5.8	0.910	32.7	LOS C	6.7	49.0	0.95	0.93	31.7
Approach		393	4.8	0.910	26.8	LOS B	6.7	49.0	0.88	0.83	34.3
North: Northern Road											
7	L	192	4.9	0.139	8.8	LOS A	0.8	5.6	0.31	0.67	48.1
8	T	864	1.6	0.895	24.6	LOS B	27.0	191.8	0.98	1.13	33.9
9	R	26	24.0	0.117	25.6	LOS B	0.5	4.5	0.79	0.73	35.7
Approach		1082	2.7	0.895	21.8	LOS B	27.0	191.8	0.85	1.04	35.8
West: Greendale Road											
10	L	15	21.4	0.035	24.2	LOS B	0.3	2.3	0.77	0.70	36.4
11	T	47	4.4	0.323	17.1	LOS B	2.4	19.3	0.85	0.68	37.1
12	R	66	28.6	0.323	26.5	LOS B	2.4	19.3	0.85	0.81	36.2
Approach		128	18.9	0.323	22.7	LOS B	2.4	19.3	0.84	0.75	36.5
All Vehicles		2273	5.3	0.910	20.1	LOS B	27.0	191.8	0.85	0.90	37.3

Level of Service (LOS) Method: Delay (RTA NSW).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P5	Across N approach	53	19.4	LOS B	0.1	0.1	0.88	0.88
P7	Across W approach	53	10.2	LOS B	0.0	0.0	0.64	0.64
All Pedestrians		106	14.8	LOS B			0.76	0.76

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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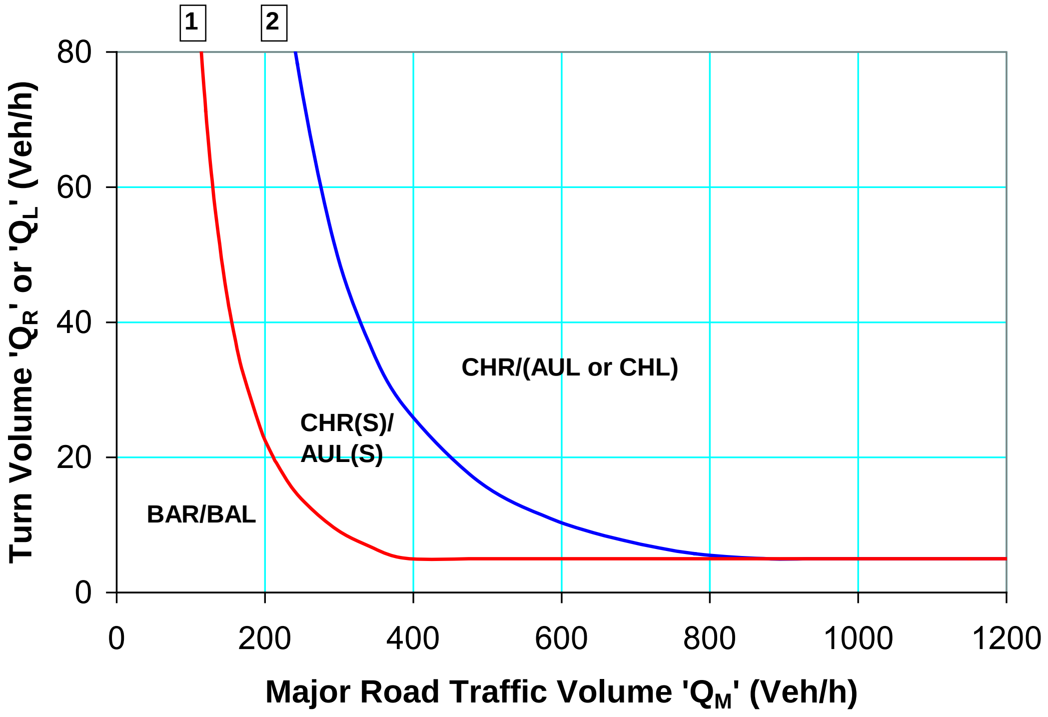
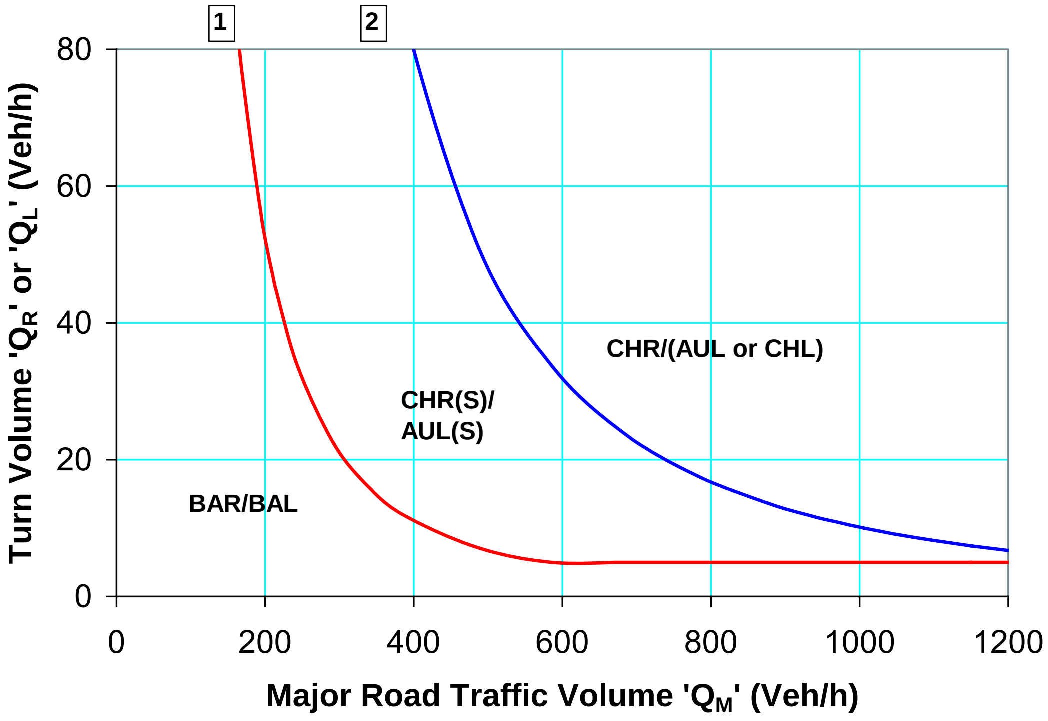
Appendix D

Austroads Intersection Design Standards



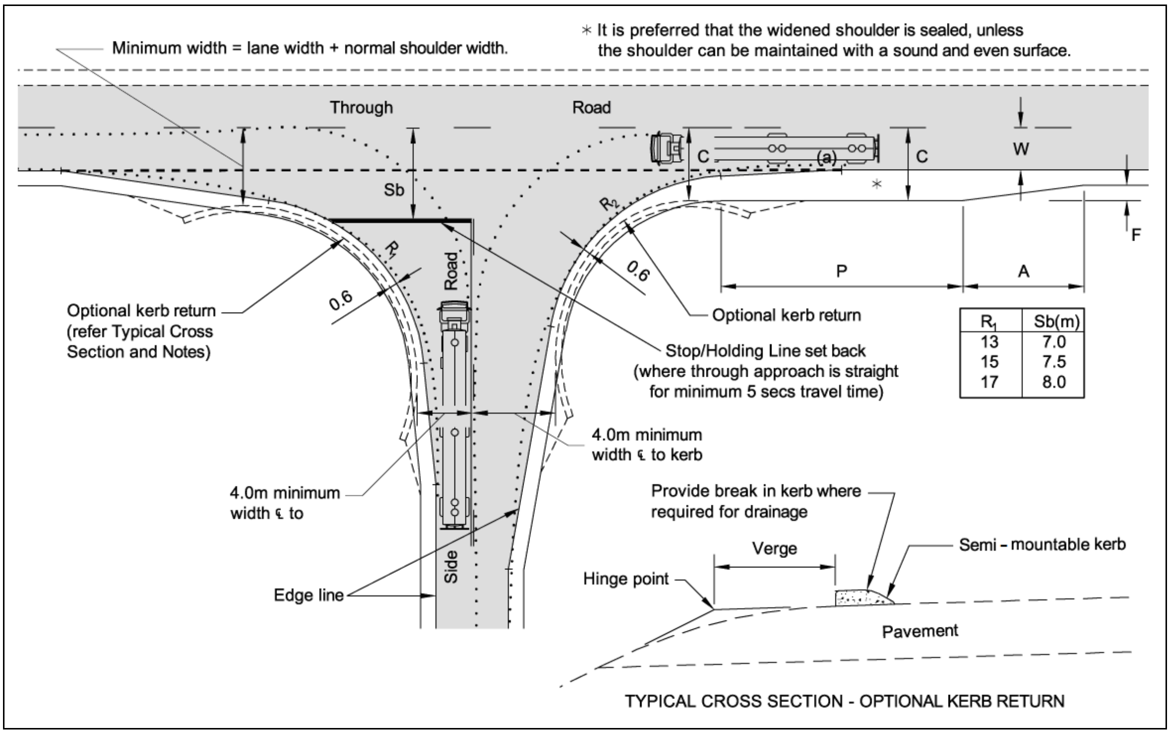
(a) Design speed ≥100 km/h



(b) Design speed < 100 km/h

Source: Arndt and Troutbeck (2006).

Figure 4.9: Warrants for turn treatments on the major road at unsignalised intersections



Notes:

1. R1 and R2 are determined by the swept path of the design vehicle.
2. The dimensions of the treatment are defined thus:

W = Nominal through lane width (m) (including widening for curves).

C = On straights – 6.0 m minimum.

On curves – 6.0 m plus curve widening (based on widening for the design turning vehicle plus widening for the design through vehicle).

A = $\frac{0.5VF}{3.6}$

V = Design speed of major road approach (km/h).

F = Formation/carriageway widening (m).

P = Minimum length of parallel widened shoulder (Table 8.1).

Source: QDMR (2006).

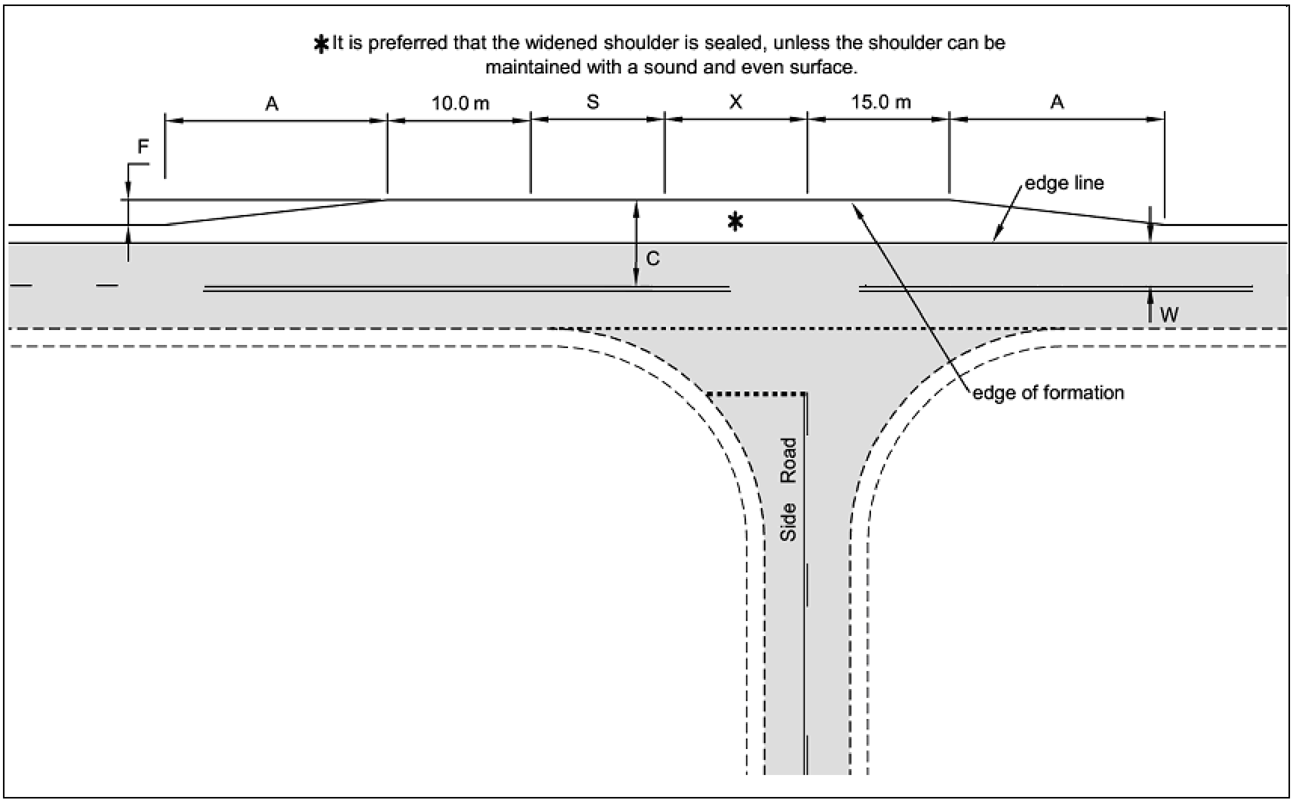
Figure 8.2: Rural basic left-turn treatment (BAL)

Table 8.1: Minimum length of widened parallel shoulder

Design speed of major road approach (km/h)	Minimum length of parallel widened shoulder P (m)
50	0
60	5
70	10
80	15
90	20
100	25
110	35
120	45

Note: Adjust the length for grade using the ‘correction to grade’ factor in Table 5.3

Source: QDMR (2006).



✱ It is preferred that the widened shoulder is sealed, unless the shoulder can be maintained with a sound and even surface.

Notes:

1. This treatment applies to the right turn from a major road to a minor road.
2. The dimensions of the treatment are defined thus:

W = Nominal through lane width (m) (including widening for curves). Width to be continuous through the intersection.

C = On straights – 6.5 m minimum

7.0 m minimum for Type 1 & Type 2 road trains

On curves – widths as above + curve widening (based on widening for the design turning vehicle plus widening for the design through vehicle).

A = $\frac{0.5VF}{3.6}$

Increase length A on tighter curves (e.g. those with a side friction demand greater than the maximum desirable). Where the design through vehicle is larger than or equal to a 19 m semi-trailer the minimum speed used to calculate A is 80 km/h.

V = Design speed of major road approach (km/h).

F = Formation/carriageway widening (m).

S = Storage length to cater for one design turning vehicle (m) (minimum length 12.5 m).

X = Distance based on design vehicle turning path, typically 10–15 m.

Source: QDMR (2006).

Figure 7.5: Basic right (BAR) turn treatment on a two-lane rural road

7.5.2 Rural Channelised T-junction – Short Lane Type CHR(S)

The CHR(S) turn treatment shown in Figure 7.6 is a more desirable treatment than the BAR treatment because it provides greater protection for vehicles waiting to turn right from the centre of the road. This treatment is suitable where there are low to moderate through and turning volumes. For higher volume sites, a full-length CHR turn treatment (Figure 7.7) is preferred.

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