APPENDIX B

NOISE IMPACT ASSESSMENT

Noise Assessment

Narrabri to Turrawan Line Upgrade Project
Narrabri, NSW

Prepared for: Element Environment Pty Ltd
March 2022
MAC211422-02RP1V2

Muller Acoustic Consulting

Document Information

Noise Assessment

Narrabri to Turrawan Line Upgrade Project

Narrabri, NSW

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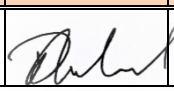
MAC211422-02RP1V2	Final	4 March 2022	Dale Redwood		Oliver Muller	

CONTENTS

1 Introduction

Muller Acoustic Consulting Pty Ltd (MAC) has been commissioned by Element Environment Pty Ltd (Element) on behalf of Australian Rail Track Corporation Limited (ARTC) to complete a Noise Assessment (NA) for the proposed Narrabri to Turrawan Line Upgrade Project (N2TLU) (the 'project'), Narrabri, NSW.

This report presents the results, findings and recommendations of the NA for the proposed construction and operation of the project on the surrounding community. It has been prepared to accompany the project's Review of Environmental Factors (REF) being prepared by Element.

The NA has been undertaken in general accordance with the following policies and guidelines:

- NSW Environment Protection Authority (EPA), Rail Infrastructure Noise Guideline (RING), 2013;
- NSW Environment Protection Authority (EPA), Noise Policy for Industry (NPI) 2017;
- NSW Department of Environment and Climate Change (DECC), Interim Construction Noise Guideline (ICNG), 2009;
- Australian Standard AS 1055:2018 - Acoustics - Description and measurement of environmental noise - General Procedures;
- Australian Standard AS 2436-2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites;
- British Standard BS 7385: Part 2-1993 "Evaluation and measurement for vibration in buildings Part 2";
- German Institute for Standardisation – DIN 4150 (1999-02) Part 3 (DIN4150-3) – Structural Vibration - Effects of Vibration on Structures; and
- NSW Department of Environment and Conservation – NSW Environmental Noise Management – Assessing Vibration: a Technical Guideline (the NSW vibration guideline), February 2006.

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

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2 Project Description

2.1 Background

The Narrabri to Turrawan Line Upgrade Project proposes to upgrade approximately 35km of existing railway from the Whitehaven Coal Junction (south of Turrawan) to Narrabri North. Approximate chainages of the project are from 540.38km to 575.00km (refer **Figure 1**).

The project scope comprises two sections of track that will be upgraded as described below:

- ARTC Zone 3 Narrabri Coal Junction to Turrawan is 8.1 kilometres in length between the Whitehaven Coal Balloon Loop Junction (540.38km) and 52 points at the northern end of Turrawan passing loop (548.490km). The main scope for this section is to upgrade existing track to 25TAL and 60kg rail.
- ARTC Central North West (CNW) Turrawan to Narrabri North is around 26.7 kilometres in length between 52 points at the northern end of Turrawan passing loop (548.490km) and future Inland Rail interface at Narrabri North (approximately 575.00km). The main scope for this section is to upgrade existing track to 25TAL and cascaded 53kg rail.

The upgrade of each section of the project would generally comprise the following construction activities:

- Replacement of existing steel and timber sleepers with Heavy Duty concrete sleepers;
- Replacement of the existing 47kg/m and 53kg/m rail with 53kg/m rail cascaded from rerailing projects on the Hunter Valley Coal Network (Turrawan to Narrabri North) and new 60kg/m rail (Narrabri Coal Junction to Turrawan);
- Lifting of the track by approximately by 50-200mm, where required, to accommodate 100mm of new ballast below the new concrete sleepers;
- Track formation works at bridge ends, where required; and
- Partial level crossing upgrades (including new concrete sleepers, steel crossing panels and partial track lift or lifting of level crossing level, where feasible).

Please note that the construction phase will deliver the above scope of works in separate packages of work that do not necessarily align (longitudinally) with the above track sections. The delivery of the project and associated staging will be confirmed once the successful contractor has been appointed.

2.1.1 Receiver Review

The project site extends approximately 35km from the rural area of Turrawan in the south to the urban environment of Narrabri in the north. Residential receivers adjacent to the project alignment are categorised into three broad noise catchment areas (NCAs). The NCAs are described as follows:

- NCA 1 – Residential receivers located within the urban centre of Narrabri. Residential receivers are characterised by medium density urban/suburban lots, close to transport routes, and commercial and industrial premises. The noise environment in NCA 1 is typically dominated by urban hum and transport noise. Natural noise sources may be more noticeable during the evening and night periods;
- NCA 2 – Residential receivers on the peri-urban fringe of Narrabri between the Narrabri Triangle and Narrabri Creek. Receivers are typically rural receivers adjacent to road, rail or industrial sources, and isolated communities surrounded by rural lands. The noise environment has local traffic with some limited industry during the day period but is dominated by natural sounds during the evening and night periods; and
- NCA 3 – Rural receivers between the southern limit of works to the suburban fringe of Narrabri to the south of the Narrabri Triangle and from the northern fringe of Narrabri to the northern limit of works. The noise environment within the rural area is characterised by low background noise levels dominated by natural sounds.

The locality plan identifying the noise catchment areas is provided in **Figure 2**.

FIGURE 1

LOCALITY PLAN

MAC211422-01

Narrabri to Turrawan Line Upgrade

KEY

Narrabri Coal to Turrawan

Turrawan to Narrabri North

0 1000 2000 3000 4000 5000 m

N

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FIGURE 2

Noise Catchment Areas

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Narrabri to Turrawan Line Upgrade

KEY

Narrabri Coal to Turrawan

Turrwan to Narrabri North

NCA 1

NCA 2

NCA 3

0 1000 2000 3000 4000 5000 m

N

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2.1.2 Construction period and Proposed Construction Hours

The construction period is estimated at 18 months, to be completed between early 2022 and the end of September 2023.

The project construction hours have yet to be confirmed. The preferred option is a roster arrangement (i.e. similar to 10 days on and 4 days off) with construction activities predominantly undertaken between 6am and 6pm daily (including weekend working). Additionally, certain project scope would be constructed during the six annual Hunter Valley Planned Possessions, which are typically three (3) to four (4) days long and would involve construction activities during the day, evening and night periods.

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3 Noise Policy and Guidelines

The noise conditions from Environment Protection Licence (EPL) 3142 for railway maintenance activities apply to this project. It is noted that condition O9 of EPL 3142 is based on the provisions of the Interim Construction Noise Guideline (ICNG), including the identification of standard and out of hours work periods and the relevant noise management levels. The following sections detail the policies and guidelines that underpin the assessment requirements.

3.1 Interim Construction Noise Guideline

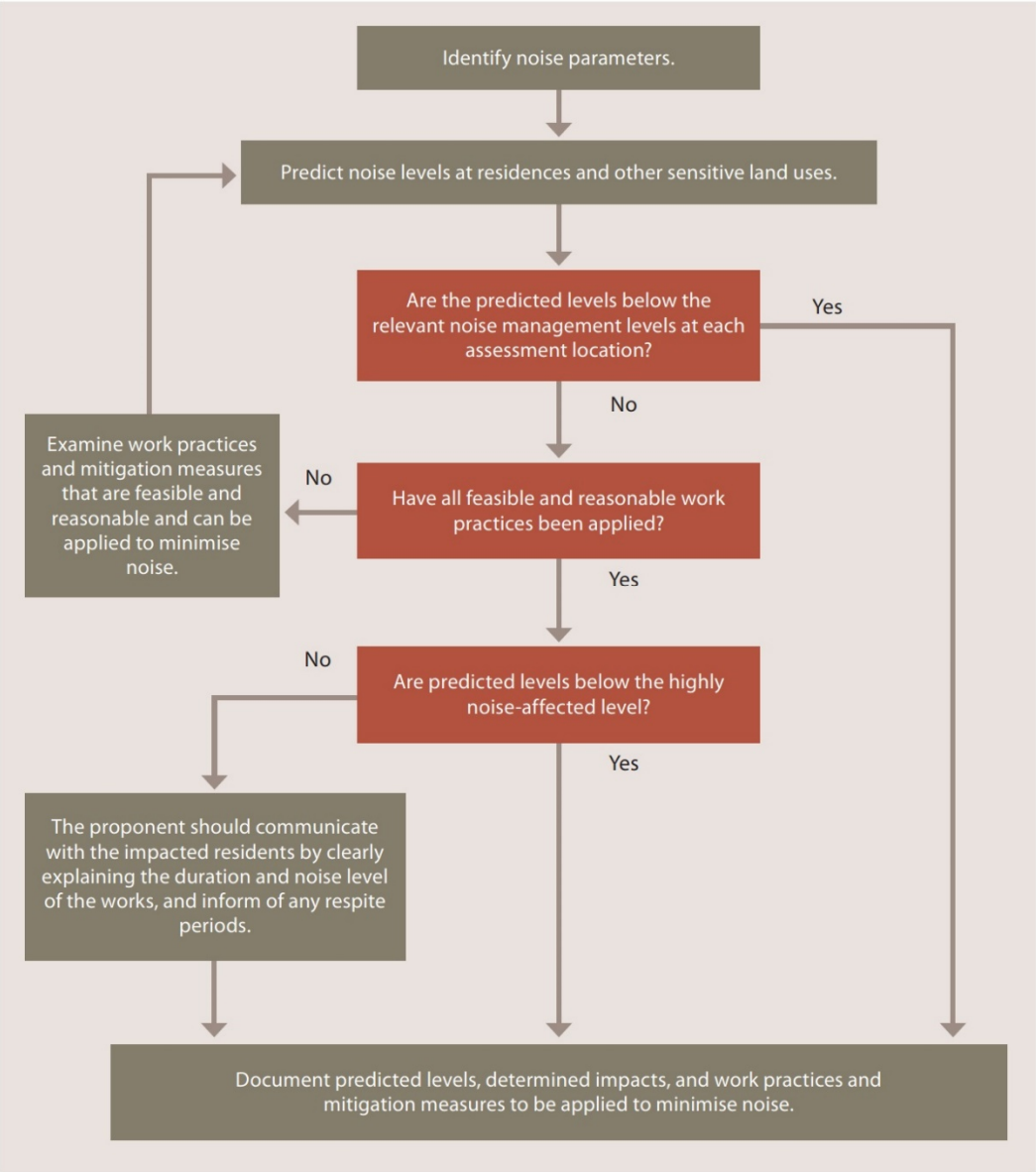
The ICNG sets out procedures to identify and address the impacts of construction noise on residences and other sensitive land uses. This section provides a summary of noise objectives that are applicable to the assessment.

The ICNG provides two methodologies for the assessment of construction noise emissions:

- Quantitative, which is suited to major construction projects with typical durations of more than three weeks; and
- Qualitative, which is suited to short term infrastructure maintenance (< three weeks).

The qualitative assessment methodology is a more simplified approach that relies on noise management strategies. This NA has adopted a quantitative assessment approach which is summarised in **Figure 3.** The quantitative approach includes identification of potentially affected receivers, derivation of the construction noise management levels, quantification of potential noise impact at receivers via predictive modelling and, provides management and mitigation recommendations.

Figure 3 Quantitative Assessment Processes for Assessing and Managing Construction Noise



Source: Department of Environment and Climate Change, 2009.

3.1.1 Standard Hours for Construction

Table 1 presents the recommended standard hours for construction works as detailed in the ICNG and Condition O9.1 of EPL 3142.

Table 1 Recommended Standard Hours for Construction

Daytime	Construction Hours
Monday to Friday	7am to 6pm
Saturdays	8am to 1pm
Sundays or Public Holidays	No construction

These recommended hours do not apply in the event of direction from police, or other relevant authorities, for safety reasons or where required in an emergency to avoid the loss of lives, property and/or to prevent environmental harm.

3.1.2 Out of Hours Construction

Works conducted outside of recommended standard hours are considered out of hours work (OOH). The ICNG suggests that any request to vary the hours of construction activities as identified above shall be:

- considered on a case by case basis or activity-specific basis;
- accompanied by details of the nature and need for activities to be undertaken during the varied construction hours;
- accompanied by written evidence that activities undertaken during the varied construction hours are strongly justified;
- appropriate consultation with potentially affected receivers and notification of the relevant regulatory authorities has occurred; and
- all practicable and reasonable mitigation measures will be put in place.

The extent of OOH construction activities is not known at this stage; however, it is understood that there will be activities undertaken during the six Hunter Valley Planned Possessions, which would involve construction activities during standard and OOH periods over approximately 3 to 4 days per possession. Therefore, each construction activity has been assessed to occur during OOH periods and the relevant mitigation measures required if they were to be undertaken.

3.1.3 Construction Noise Management Levels

Section 4 of the ICNG details the quantitative assessment method involving predicting noise levels and comparing them with the Noise Management Level (NML) and are important indicators of the potential level of construction noise impact. **Table 2** reproduces the ICNG Noise Management Level (NML) for residential receivers, while **Table 3** reproduces the ICNG management levels for other receiver types.

Table 2 Noise Management Levels

Time of Day	Management Level LAeq(15min)[1]	How to Apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays.	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq(15min) 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 work to be carried out, the expected noise levels and duration, as well as contact details.
	Highly Noise Affected 75dBA (HNA)	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 times identified by the community when they are less sensitive to noise such as before and after school for work near schools, or mid-morning or mid-afternoon for work near residences; and 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 work 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 5dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see Section 7.2.2 of the ICNG.

Note 1: The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the construction noise management levels for noise assessment purposes and is the median of the ABL's.

Table 3 Noise Management Levels for Other Noise Sensitive Receivers		
Land use	Where objective applies	Management Level $LA_{eq(15min)}$[1]
Classrooms at schools and other educational institutions	Internal noise level	45dB
Hospital wards and operating theatres	Internal noise level	45dB
Places of worship	Internal noise level	45dB
Active recreation areas	External noise level	65dB
Passive recreation areas	External noise level	60dB
Commercial premises	External noise level	70dB
Industrial premises	External noise level	75dB

Note 1: Noise management levels apply when receiver areas are in use only.

Where the predicted or measured $LA_{eq(15min)}$ noise level is greater than the NML, the proponent should apply all feasible and reasonable work practices to meet the relevant NML.

3.1.4 Construction Sleep Disturbance

Condition O9.3 of EPL 3142 states that the licensee may undertake maintenance activities outside of the hours specified in Condition O9.1, if the activities do not exceed:

- 15dBA (LA1, 1min or LAmax) above the relevant rating background level at night, as determined at the nearest noise sensitive receiver as assessed by acoustic investigation.

3.2 Vibration Assessment Guidelines

3.2.1 Structural Damage Criteria

For structural damage, vibration should be assessed at the foundation of a building or structure. In the absence of an Australian Standard, German Standard DIN 4150 - Part 3: 1999 provides the strictest guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, or maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in **Table 4** and shown graphically in **Figure 4** in the case of foundation levels. For residential and commercial type structures, the standard recommends safe limits as low as 5mm/s and 20mm/s respectively, while for sensitive structures such as heritage items, the recommended safe limits start at 3mm/s. These limits increase with frequency values above 10Hz as shown in **Figure 4**.

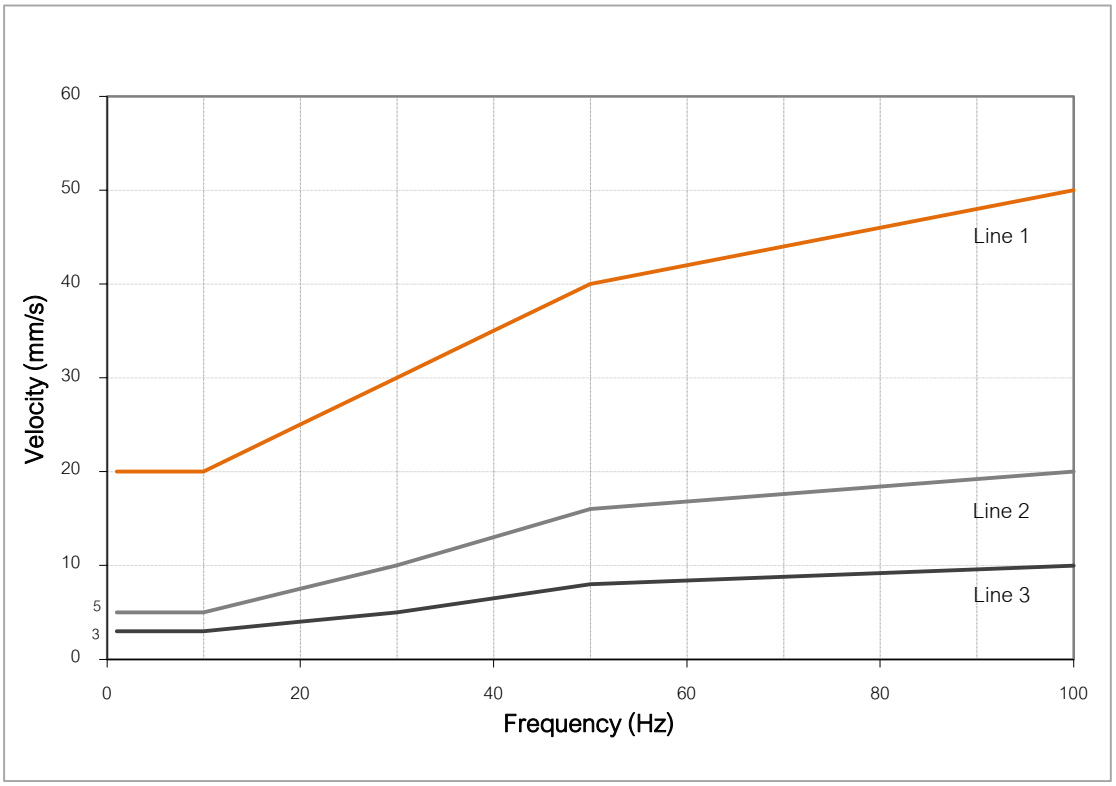
Table 4 Structural Damage Guideline – DIN4150					
Line	Type of Structure	Vibration Velocity in mm/s			
		At Foundation at a Frequency of			Plane of Floor of Uppermost Storey
		Less than 10Hz	10Hz to 50 Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

These levels are “safe limits”, for which damage due to vibration effects is unlikely to occur. “Damage” is defined in DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls. Should such damage be observed without vibration levels exceeding the “safe limits” then it is likely to be attributable to other causes. DIN 4150 also states that when vibration levels higher than the “safe limits” are present, it does not necessarily follow that damage will occur.

For sensitive buildings such as heritage structures, the guideline vibration values are typically half of those for dwellings. Therefore, based on the DIN 4150 structural damage guidelines, the minimum working distance for heritage structures that are found to be structurally unsound would be approximately equal to twice the minimum working distance for other building types. Human Comfort – Assessing Vibration a Technical Guideline

As indicated by the criteria from DIN 4150 in **Table 4**, high frequency vibration has less potential to cause damage than lower frequencies. Furthermore, the “point source” nature of vibration from excavation and construction equipment causes the vibratory disturbances to arrive at different parts of nearby large structures in an out-of-phase manner, thereby reducing its potential to excite in-phase motion of the low order modes of vibration in such structures.

Figure 4 DIN4150 Structural Vibration Safe Limits



3.2.2 Human Comfort – Assessing Vibration a Technical Guideline

Humans are highly sensitive to vibration and may detect vibration levels which are well below levels that may cause damage to buildings or structures. Assessing vibration: a technical guideline was published in February of 2006 by the Department of Environment and Conservation (DEC) and provides guidance on assessing vibration against human comfort.

The guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values 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 values are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community.

The guideline 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 5.

Table 5 Examples of types of vibration (from Table 2.1 of the guideline)		
Continuous Vibration	Impulsive Vibration	Intermittent Vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery)	Infrequent: Activities that create up to three distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.	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 three or fewer these would be assessed against impulsive vibration criteria.

Continuous and Impulsive Vibration

Appendix C of the guideline outlines acceptable criteria for human exposure to continuous and impulsive vibration (1Hz to 80Hz), the criteria are dependent on both the time of activity (usually daytime or night-time) and the occupied place being assessed. **Table 6** reproduces the preferred and maximum criteria relating to measured peak velocity.

Table 6 Criteria for Exposure to Continuous and Impulsive Vibration (Peak Velocity (mm/s)[1, 2])

Place	Time	Continuous		Impulsive	
		Preferred	Maximum	Preferred	Maximum
Critical working Areas (e.g. hospital operating theatres, precision laboratories)	Day or Night	0.14	0.28	0.14	0.28
Residences	Day	0.28	0.56	8.6	17
	Night	0.20	0.40	2.8	5.6
Offices	Day or Night	0.56	1.1	18	36
Workshops	Day or Night	1.1	2.2	18	36

Note 1: rms velocity (mm/s) and vibration velocity value (dB re 10^{-9} mm/s).

Note 2: values given for most critical frequency >8Hz assuming sinusoidal motion.

Intermittent Vibration

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

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 provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted root mean square (RMS) acceleration levels over the frequency range 1Hz to 80Hz.

To calculate VDV the following formula (refer section 2.4.1 of the guideline) was used:

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

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 is reproduced in **Table 7**.

Table 7 Acceptable Vibration Dose Values (VDV) for Intermittent Vibration ($m/s^{1.75}$)

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

Note: Daytime is 7am to 10pm and Night-time is 10pm to 7am.

Note: 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 values below the preferred values. Adverse comment or complaints may be expected if vibration values 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.

3.3 Rail Infrastructure Noise Guideline

The Rail Infrastructure Noise Guideline Policy (RING) provides a procedure for the consideration of feasible and reasonable noise mitigation measures that form part of a Noise Impact Assessment (NIA) to be used by planning authorities to assess rail projects. The purpose of the RING is to specify noise and vibration trigger levels for heavy and light rail projects to protect the community from the adverse effects of noise and vibration from rail infrastructure projects.

The RING is used to determine changes in operational rail noise and applies to heavy rail infrastructure projects including new rail line, redeveloped rail line and other rail works (i.e. crossovers, sidings, turnouts, loops, refuges, relief lines, straightening curves or the installation of track signalling devices).

According to Section 1.4.1.2 of the RING projects of this nature are considered to fall into the category of 'redeveloped rail line' where works on an existing rail line are proposed that will increase its capacity to carry rail traffic.

3.3.1 RING Noise Trigger Levels

Operational rail noise can have a significant effect on noise-sensitive receivers near a rail line. The RING specifies noise and vibration trigger levels, and if exceeded by the proposed rail development, mitigation measures need to be considered to reduce emissions. The noise and vibration triggers apply to existing noise-sensitive receivers and future sensitive receivers associated with any planned developments.

All RING Noise Trigger Levels (NTLs) differentiate between noise impacts during the day and at night. A more stringent noise trigger is applied for night-time. It is widely accepted that noise is generally more disturbing at night because more noise-sensitive activities occur at that time (e.g. listening activities and sleep). Also, most residents are at home and noise is more intrusive due to lower background levels at night.

To evaluate predicted rail noise, NTLs are provided for both $L_{Aeq(period)}$ (the level of average noise energy over the day or night period including maximum noise events from individual train pass-bys) and L_{Amax} (the maximum noise level not exceeded by 95 per cent of individual train pass-bys).

For non-residential noise-sensitive land uses, only the L_{Aeq} parameter is applied, as the focus is on speech interference and to provide adequate acoustic protection to conduct the activities associated with those land uses.

Trigger levels in this guideline that apply to heavy rail projects relate to:

- the absolute level of rail noise associated with all rail transportation services, and
- the increase in the predicted rail noise due to the proposed rail infrastructure project in the case of redevelopments.

In addition, the RING also requires that if the Noise Impact Assessment undertaken for the infrastructure proposal indicates that the trigger levels are likely to be exceeded, a detailed study must be made to evaluate the predicted noise and vibration levels. The predicted levels should then be compared to the noise and vibration trigger levels and it is then necessary to consider feasible and reasonable mitigation measures. If the triggers are not exceeded, mitigation considerations are not required under this guideline.

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4 Existing Environment

In accordance with the ICNG, the NMLs are determined through quantification of the existing background noise environment using the methodologies detailed in Fact Sheets A and B of the NPI. In circumstances where the noise environment is described as a low noise environment (e.g. rural environments), the minimum assumed RBLs as per Section 2.3 of the NPI are adopted in lieu of undertaking a detailed background noise assessment.

A review of the project locality identified that the rail corridor passes through both suburban and rural areas. For suburban areas (NCA 1 and NCA 2), a detailed background noise assessment was undertaken to determine the RBLs and hence NMLs. For the rural noise catchment (NCA 3), the minimum assumed RBLs were used in lieu of undertaking a background noise assessment.

4.1 Background Noise levels – Rural Receivers (NCA 3)

Residential receivers located within NCA 3 are described as rural residential receivers within a low noise environment. Due to the rural setting, for residential receivers within NCA 3, minimum assumed RBLs have been adopted in lieu of a detailed background noise assessment, as per Section 2.3 of the NPI. The minimum assumed RBLs are reproduced in **Table 8.**

Table 8 Minimum Assumed RBLs

Period[1]	Adopted RBL, dB L_{A90}
Day	35
Evening	30
Night	30

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

4.2 Unattended Noise Monitoring

To quantify the existing background noise environment of the area, unattended noise monitoring was conducted at two locations representative of the ambient environment within NCA 1 and NCA 2. The selected monitoring locations are shown in **Figure 5** and are considered representative of residential receivers within those NCAs as per Fact Sheet B1.1 of the NPI.

The unattended noise survey was conducted in general accordance with the procedures described in Australian Standard AS 1055:2018, "Acoustics – Description and Measurement of Environmental Noise".

The measurements were carried out using two Svantek 977 noise analyser from Wednesday 6 October 2021 to Friday 15 October 2021. The acoustic instrumentation used carries current NATA calibration and complies with AS/NZS IEC 61672.1-2019-Electroacoustics - Sound level meters - Specifications. Calibration of all instrumentation was checked prior to and following measurements. Drift in calibration did not exceed ±0.5dBA. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

Observations on-site identified the surrounding locality at both monitoring locations were typical of a suburban environment, with local road noise dominant. Other noise sources audible in the surrounding locality included bird noise and dogs barking.

Data affected by adverse meteorological conditions have been excluded from the results in accordance with methodologies provided in Fact Sheet A4 of the NPI. Residential receivers situated in the surrounding area have been classified under the EPA's suburban amenity category. These criteria are used in conjunction with the intrusiveness criteria to determine the limiting criteria. The results of long-term unattended noise monitoring are provided in **Table 9**. The noise monitoring charts for the background monitoring assessment are provided in **Appendix B**.

Table 9 Background Noise Monitoring Summary

Date	Measured Background Noise Level (LA_{90}) dB ABL[1,2,3,4]			Measured dB $LA_{eq(period)}$		
	Day	Evening	Night	Day	Evening	Night
Location 1 (NCA 2) – Hillam Avenue						
Wednesday - 6 October 2021	(30.2)	35.2	30.1	(40.0)	44.8	43.1
Thursday - 7 October 2021	40.8	37.6	27.6	55.6	55.1	39.9
Friday - 8 October 2021	33.2	40.6	31.5	50.6	46.5	44.3
Saturday - 9 October 2021	37.5	38.7	(31.6)	47.0	46.1	(47.0)
Sunday - 10 October 2021	(41.2)	38.6	(38.8)	(54.2)	47.9	(47.6)
Monday - 11 October 2021	33.2	40.6	31.1	49.8	52.5	46.8
Tuesday - 12 October 2021	31.3	39.2	27.1	50.6	46.2	44.8
Wednesday - 13 October 2021	33.1	50.5	37.5	50.1	61.8	50.0
Thursday - 14 October 2021	44.2	45.7	36.8	59.5	50.6	47.9
Friday - 15 October 2021	(42.1)	n/a	n/a	(46.4)	n/a	n/a
Location 1 – RBL / Leq Overall	**33**	**39**	**31**	**54**	**54**	**46**
Location 2 (NCA 1) – Logan Street						
Wednesday - 6 October 2021	(27.5)	29.2	25.8	(44.5)	45.3	43.3
Thursday - 7 October 2021	36.7	29.2	23.9	50.3	52.1	37.5
Friday - 8 October 2021	32.4	33.7	26.7	51.7	46.7	41.0
Saturday - 9 October 2021	34.5	33.1	(30.0)	49.4	58.7	(44.1)
Sunday - 10 October 2021	(38.9)	36.2	(29.4)	(54.1)	52.2	(50.5)
Monday - 11 October 2021	32.1	33.3	31.7	52.5	50.7	49.6
Tuesday - 12 October 2021	34.7	33.8	28.5	53.0	47.6	49.0
Wednesday - 13 October 2021	33.8	36.9	30.3	53.0	51.2	52.1
Thursday - 14 October 2021	40.2	38.8	31.2	56.6	46.0	50.2
Friday - 15 October 2021	(37.7)	n/a	n/a	(50.7)	n/a	n/a
Location 2 – RBL / Leq Overall	**35**	**34**	**30 (29)[5]**	**53**	**52**	**48**

Note 1: Assessment background level (ABL) – the single-figure background level representing each assessment period day, evening and night as per NPI Fact Sheet A.

Note 2: Excludes periods of wind or rain affected data. Meteorological data obtained from the Bureau of Meteorology weather station Narrabri Airport AWS (station ID: 054038).

Note 3: Day - the period from 7am to 6pm Monday to Saturday or 8am to 6pm on Sundays and public holidays; Evening - the period from 6pm to 10pm; Night - the remaining periods.

Note 4: Bracketed data excluded from calculation of RBLs due to insufficient data following data exclusion rules.

Note 5: Where noise levels are measured at below the minimum background noise levels, the RBL is set to the minimum assumed RBL as per Section 2.3 of the NPI.

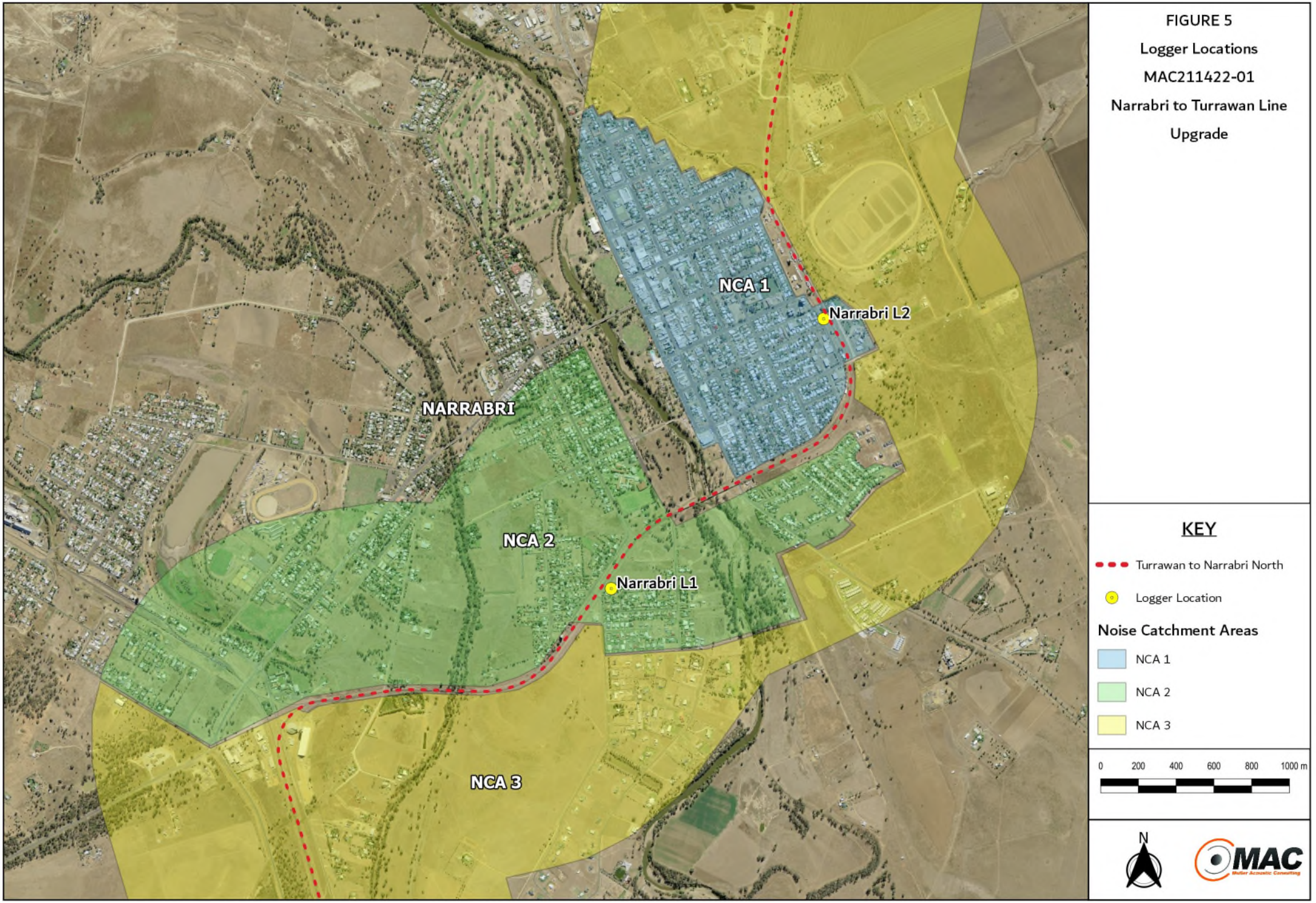

FIGURE 5

Logger Locations

MAC211422-01

Narrabri to Turrawan Line Upgrade

KEY

Turrawan to Narrabri North

Logger Location

Noise Catchment Areas

NCA 1

NCA 2

NCA 3

0 200 400 600 800 1000 m

N

MAC

4.3 Attended Noise Monitoring

To supplement the unattended noise assessment and to inform the identification and occurrence of ambient noise sources in the community surrounding the project, 15 minute attended measurements were completed at each of the unattended noise logging locations.

The attended noise survey was conducted in general accordance with the procedures described in Australian Standard AS 1055:2018, "Acoustics – Description and Measurement of Environmental Noise".

The acoustic instrumentation used carries current NATA calibration and complies with AS/NZS IEC 61672.1-2019-Electroacoustics - Sound level meters - Specifications. Calibration of all instrumentation was checked prior to and following measurements. Drift in calibration did not exceed ±0.5dBA. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

The attended noise monitoring was conducted using a Svantek 971 noise analyser at Location 1 (NCA 2) and Location 2 (NCA 1) on Wednesday 6th October 2021 to quantify ambient background noise levels.

The attended measurements were completed during calm and clear meteorological conditions and confirmed that ambient traffic and environmental noise dominated the surrounding environment. The results of the short-term noise measurement and observations are summarised in **Table 10**.

Table 10 Operator-Attended Noise Survey Results

Location	Date/ Time (hrs)	Noise Descriptor (dBA re 20 µPa)			Meteorology	Description and SPL, dBA
		L_{Amax}	L_{Aeq}	L_{A90}		
Location 1	06/10/2021 16:24	58	39	32	WD: NW WS: 0.5m/s 23°C	Birds <30-51 Traffic <30-40 Dog Barking 40-58 Residential Noise <30-36
Location 2	06/10/2021 17:07	62	43	32	WD: W WS: 0.5m/s 23°C	Birds <30-45 Traffic <30-62

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5 Assessment Criteria

5.1 Construction Noise Management Levels

Construction NMLs for residential receivers are established from the representative noise environment for each of the NCAs. The NMLs for standard and out of hours work periods are summarised in **Table 11** for residential receivers and **Table 12** for applicable non-residential receivers.

Table 11 Construction NMLs – Residential Receivers

Location	Assessment Period	RBL, dBA	NML dB $L_{Aeq(15min)}$	Highly noise affected NML[1] dB $L_{Aeq(15min)}$
NCA 1	Day (Standard Hours)	35[2]	45 (RBL+10dBA)	75
	Evening	33	38 (RBL+5dBA)	
	Night	31	36 (RBL+5dBA)	
NCA 2	Day (Standard Hours)	35	45 (RBL+10dBA)	75
	Evening	34	39 (RBL+5dBA)	
	Night	30[2]	35 (RBL+5dBA)	
NCA 3	Day (Standard Hours)	35	45 (RBL+10dBA)	75
	Evening	30	35 (RBL+5dBA)	
	Night	30	35 (RBL+5dBA)	

Note 1: The highly noise affected NML is a hypothetical level that is adopted to ensure the avoidance of strong community reaction. Should this level be exceeded the construction methodology is to be reviewed to reduce the impact on surrounding sensitive receivers.

Note 2: Where RBLs were measured to be below the minimum assumed RBLs, the minimum assumed RBLs have been adopted.

Table 12 Construction NMLs – Non-Residential Receivers			
Location	Assessment Period	Where NML Applies	NML dB $LA_{eq(15min)}$
Educational institutions	When in use	Internal noise level	45
		External noise level[1]	70
Hospital wards and operating theatres	When in use	Internal noise level	45
		External noise level[1]	70
Places of Worship	When in use	Internal noise level	45
		External noise level[1]	70
Passive Recreation	When in use	External noise level	60
Active Recreation	When in use	External noise level	65
Commercial Receivers	When in use	External noise level	70
Industrial Premises	When in use	External noise level	75
Community Centres	When in use	Refer to AS2107 for maximum internal levels and specific use	

Note 1: External noise level assumes a 25dB transmission loss for a masonry building with single glazing (windows closed) as per the ENMM (RTA, 2001).

5.1.1 Sleep Disturbance Criteria

The sleep disturbance criteria shown in **Table 13** are based on night time RBLs and trigger levels as per Condition O9.3 of EPL 3142. The trigger levels will be applied to transient noise events that have the potential to cause sleep disturbance.

Table 13 Sleep Disturbance Criteria		
Location	RBL, dBA	Criteria dB $LA_{1(1min)}$
NCA 1	46	45 (RBL+15dBA)
NCA 2	45	38 (RBL+15dBA)
NCA 3	45	36 (RBL+15dBA)

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

5.2 Construction Vibration

The Construction Noise and Vibration Strategy (CNVS) (TfNSW, 2019) provides guidance on minimum working distances from sensitive receivers for typical items of vibration intensive plant (see **Table 14**). The minimum distances are quoted for "cosmetic" damage in accordance with British Standard BS7385.2-1993, sensitive structures in accordance with DIN 4150 - Part 3: 1999, and human comfort in accordance with the Department of Environment and Conservation (2006) Assessing Vibration: a technical guideline.

Table 14 Minimum Working Distances or Vibratory Plant (m)

Plant item	Rating / Description	Minimum working distance		
		Cosmetic damage (BS 7385)	Heritage Item (DIN 4150)	Human response (OH&E)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5m	10m	15m to 20m
	< 100 kN (Typically 2-4 tonnes)	6m	12m	20m
	< 200 kN (Typically 4-6 tonnes)	12m	24m	40m
	< 300 kN (Typically 7-13 tonnes)	15m	30m	100m
	> 300 kN (Typically 13-18 tonnes)	20m	40m	100m
	> 300 kN (> 18 tonnes)	25m	50m	100m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2m	4m	7m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7m	14m	23m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22m	44m	73m
Vibratory Pile Driver	Sheet piles	2m to 20m	up to 40m	20m
Pile Boring	≤ 800 mm	2m (nominal)	4m	4m
Jackhammer	Hand held	1m (nominal)	2m	2m

Note: Source, CNVG (Roads and Maritime, 2016).

Note: More stringent conditions may apply to heritage or other sensitive structures.

5.3 Operational Noise Criteria

5.3.1 RING Noise Trigger Levels

The project falls into the category of “redeveloped rail line” in accordance with RING Section 1.4.1.2. This category includes works on an existing rail line that will increase its capacity to carry rail traffic. Therefore the applicable NTLs for the project are reproduced from Table 1 of the RING and presented in **Table 15**.

Table 15 RING Noise Trigger Levels (External) for Residential Land Uses

Type of Development	Day (7am-10pm)	Night (10pm-7am)
Redevelopment of existing rail line	Development increases existing LAeq(period)[1] rail noise levels by 2 dB or more, or existing LAmax rail noise levels by 3 dB or more and predicted rail noise levels exceed:	
	65dB $LA_{eq(15hr)}$ OR 85dB LA_{max}	60dB $LA_{eq(9hr)}$ OR 85dB LA_{max}

Note 1: $LA_{eq(period)}$ means $LA_{eq(15h)}$ for the day-time period and $LA_{eq(9h)}$ for the night-time period.

6 Noise Assessment

6.1 Assessment Methodology

The noise emissions from each representative construction scenario were calculated to several distances, representative of buffer distances to receivers surrounding the project, using a simple loss for distance calculation method, with general corrections for ground and atmospheric effects, and terrain and partial barrier effects.

6.2 Construction Methodology

The construction methodology will be finalised during the detailed design planning and engagement of the contractor(s). The construction methodology would generally involve the following construction stages:

- Stage 1 – Site Establishment – would involve the erection of temporary barriers, and delivery of equipment to site.
- Stage 2 – Formation Reconstruction – would involve the removal of existing track (rail, sleepers and ballast), excavation to required depth to install new structural layers and capping, and reconstruction of track with new ballast, concrete sleepers and new 60kg rail or cascaded 53kg rail.
- Stage 3 – Concrete Re-sleepering – would involve the replacement of existing steel and timber sleepers with heavy duty concrete sleepers using side insertion.
- Stage 4 – Re-railing – would involve replacing the existing rail with new 60kg rail or cascaded 53kg rail.
- Stage 5 – Resurfacing – would involve completion of track horizontal and vertical alignment.

Proposed equipment to be used during each construction scenario of the project are listed in **Table 16** along with their sound power level (SWL). The total fleet SWL is the total combined SWL for each construction scenario with consideration of equipment usage (i.e. not all equipment would operate simultaneously throughout the entirety of the assessment period).The SWLs for plant assessed in this report were sourced from manufacturers specifications or from the MAC database.

All calculations take into account moderate levels (up to 8dB) of attenuation due to ground attenuation and air absorption and an additional 5dB to account for general terrain effects and partial barrier effects.

Table 16 Acoustically Significant Sources – Sound Power Levels (*re 10^{-12} Watts*).

Item	Sound Power Levels dB $LA_{eq(15min)}$	Construction Scenario				
		Site Establishment	Formation Reconstruction	Concrete Re-sleepering	Re-railing	Resurfacing
Excavators 30t	110		✓			
Front-end loaders	106		✓	✓	✓	✓
Pozitrack or Grader	110		✓			
Vibratory rollers	109		✓			
Hydrema dump truck	108		✓	✓		✓
Track tools	104		✓		✓	
Welding and oxy cutting	110		✓		✓	
Flash-butt welding truck	107		✓		✓	
Hi-rail excavator	105		✓		✓	✓
Ballast trains	106	✓	✓			✓
Tamper / regulator	116		✓	✓		
Ballast hoppers and shunt engine	106		✓	✓		✓
Hi-rail excavator c/w tamping banks	109		✓	✓		
Rail saw	107		✓		✓	✓
Generators	93	✓	✓	✓	✓	✓
Mobile crane	105	✓				
Water cart	101	✓	✓	✓	✓	✓
Road truck	103	✓	✓	✓	✓	
Total Fleet SWL		110	118	118	115	112
Sleep disturbance assessment (LA_{max})						
Impact noise[1]	119	Night time periods (10pm to 7am), all activities				

Note 1: Sleep disturbance assessment based on general impact noise such as metal on metal or excavator bucket on rock.

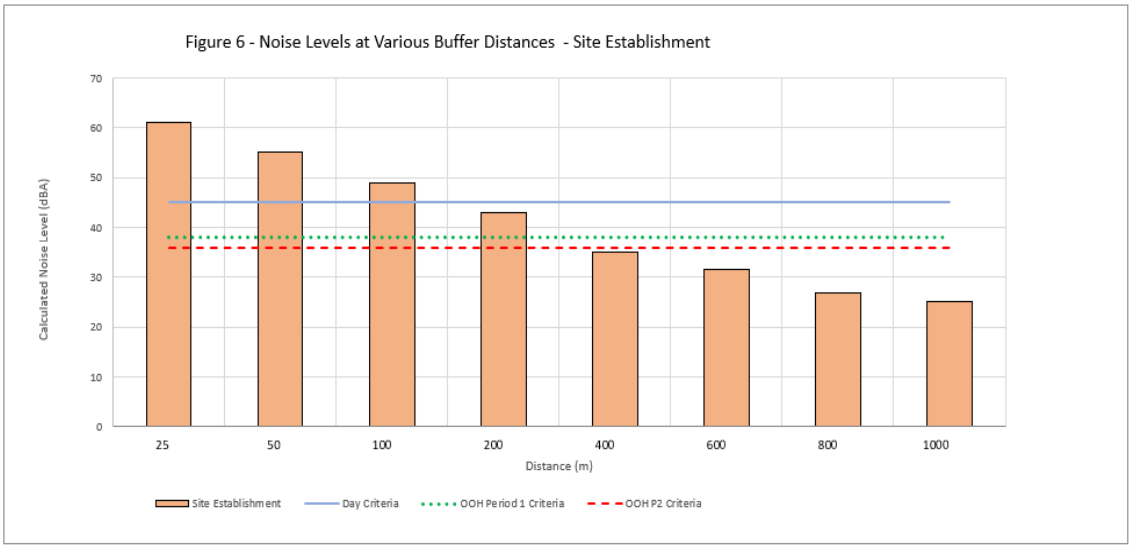
6.3 Construction Noise Assessment Results

Construction scenarios considered to have the greatest potential noise impact at nearby receivers were provided by ARTC and have formed the basis of this assessment. Predictions have quantified noise levels from each nominated construction scenario for the project. Predicted noise levels for each activity are plotted against criteria for several buffer distances and results are presented in **Section 6.3.1** for residential receivers within NCA 1, **Section 6.3.2** for residential receivers within NCA 2, and **Section 6.3.3** for residential receivers within NCA 3. Detailed mapping of affected distances for the construction scenarios with the greatest potential for noise impacts, identified as formation reconstruction and concrete re-sleepering is provided in **Appendix C**.

Additionally, an analysis of affected distances for non-residential receivers is provided in **Section 6.3.4** and a maximum noise level assessment is provided in **Section 6.3.5**.

6.3.1 Construction Noise Buffer Distances – NCA 1

Predicted noise levels for each construction scenario are plotted against criteria for several buffer distances and results are presented in **Figure 6** to **Figure 10** for receivers within NCA 1.



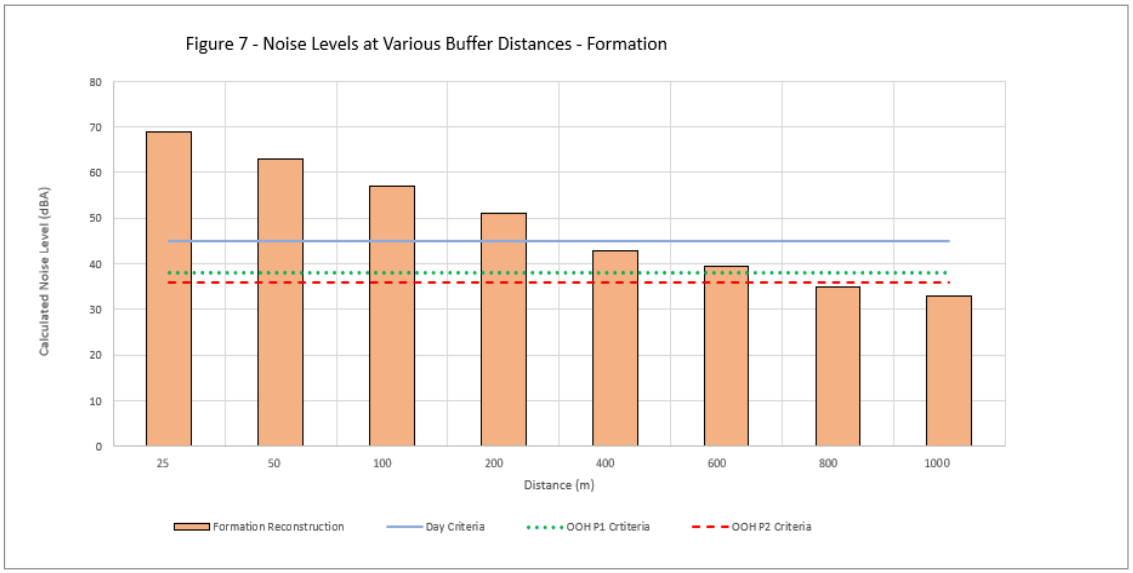


Figure 8 - Noise Levels at Various Buffer Distances - Concrete Re-sleepering

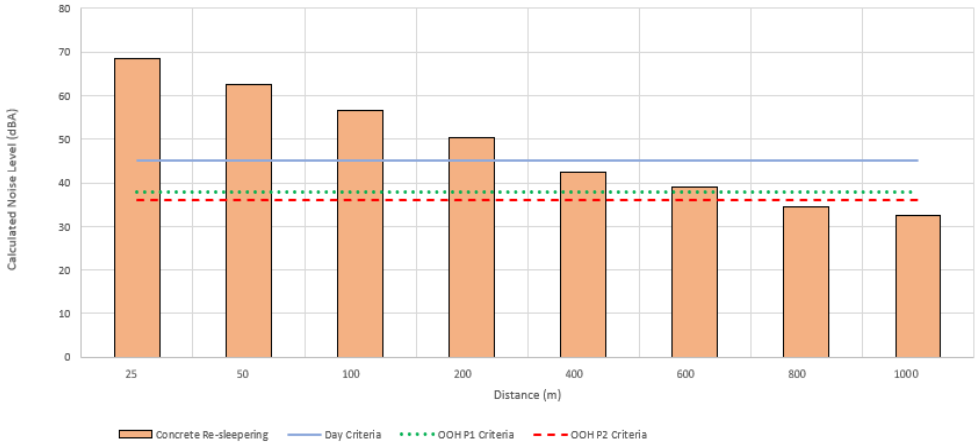


Figure 9 - Noise Levels at Various Buffer Distances - Re-railing

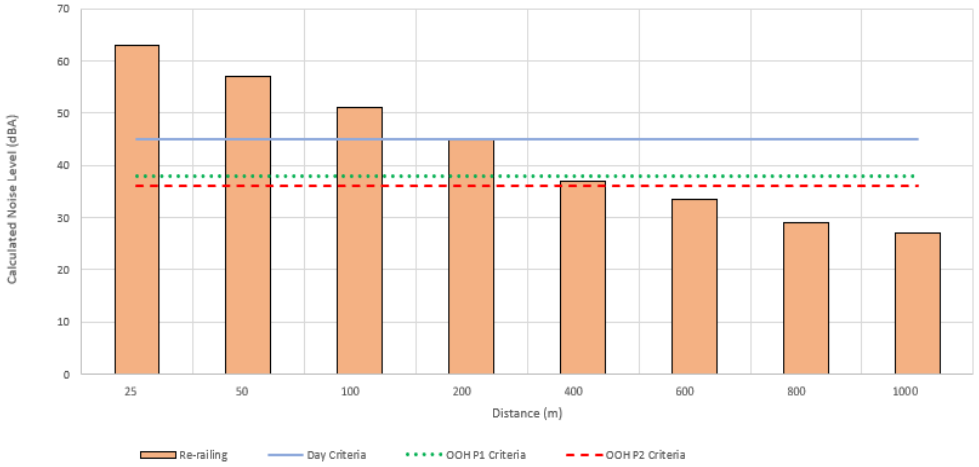
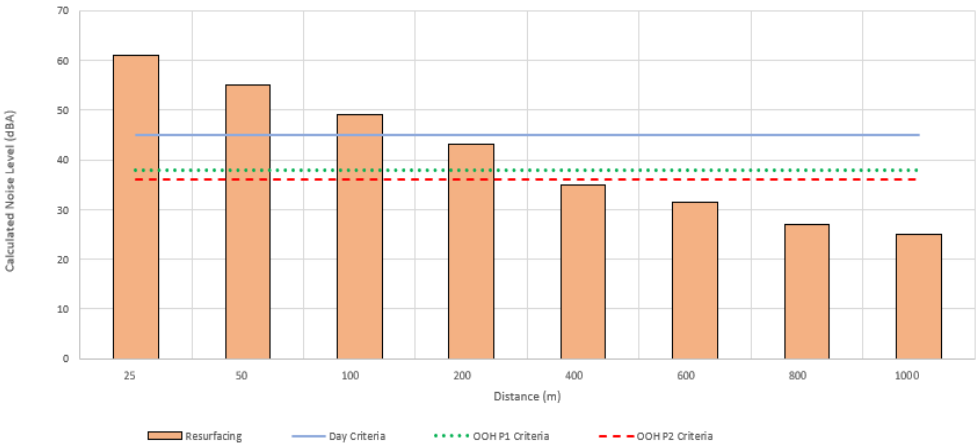


Figure 10 - Noise Levels at Various Buffer Distances - Resurfacing



The results of the analysis demonstrate that predicted $LA_{eq(15min)}$ noise emissions are anticipated to exceed the day period (standard hours) criterion for residential receivers within NCA 1 to approximately 350m from the Project Area with a maximum exceedance of the NML of up to 27dB $LA_{eq(15min)}$. It is predicted that up to 290 residential receivers may experience noise levels above the day period NML during formation reconstruction and concrete re-sleepering.

During the evening and night periods residential receivers to approximately 650m and 750m respectively are predicted to experience construction noise levels above the relevant NMLs, with up to 580 residential receivers anticipated to experience construction noise levels above the evening period NML and up to 610 residential receivers anticipated to experience construction noise levels above the night period NML. The highest exceedance of the NMLs is predicted to be on the order of 33dB and 37dB $LA_{eq(15min)}$ during the evening and night periods respectively.

A summary of the highest predicted construction noise levels at the nearest residential receivers, affected distances, number of potentially affected receivers is provided in **Table 17**.

Table 17 Summary of Construction Affected Distances and Number of Affected Receivers – NCA 1

Construction Scenario	Highest Predicted Noise Level[1] dBA	Day Period		Evening Period		Night Period	
		Affected Distances (m)	Affected receivers	Affected Distances (m)	Affected receivers	Affected Distances (m)	Affected receivers
Site Establishment	64	175	~110	300	~290	375	~360
Formation Reconstruction	72	350	~290	650	~580	750	~610
Concrete Re-sleepering	72	350	~290	650	~580	750	~610
Re-railing	69	200	~200	375	~360	450	~430
Resurfacing	66	190	~130	315	~310	390	~380

Note 1: Denotes the predicted noise level at the nearest residential receiver.

6.3.2 Construction Noise Buffer Distances – NCA 2

Predicted noise levels for each construction scenario are plotted against criteria for several buffer distances and results are presented in **Figure 11** to **Figure 15** for receivers within NCA 2.

Figure 11 - Noise Levels at Various Buffer Distances - Site Establishment

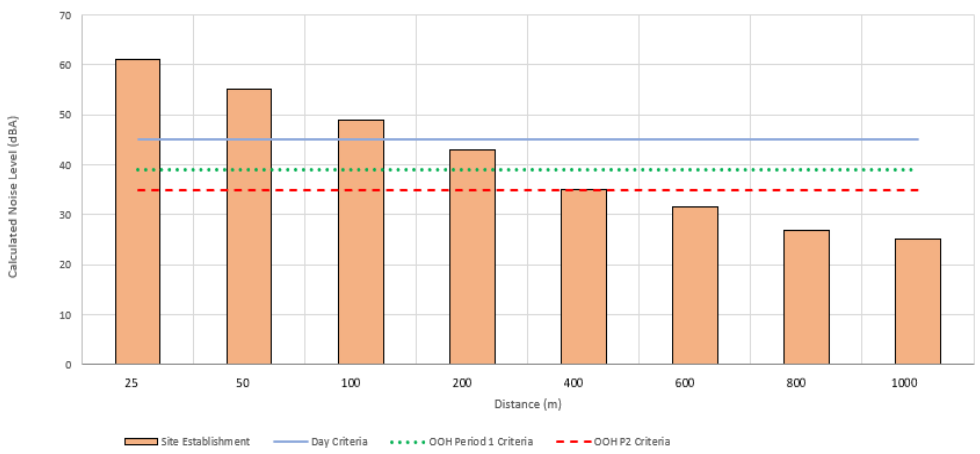


Figure 12 - Noise Levels at Various Buffer Distances - Formation Reconstruction

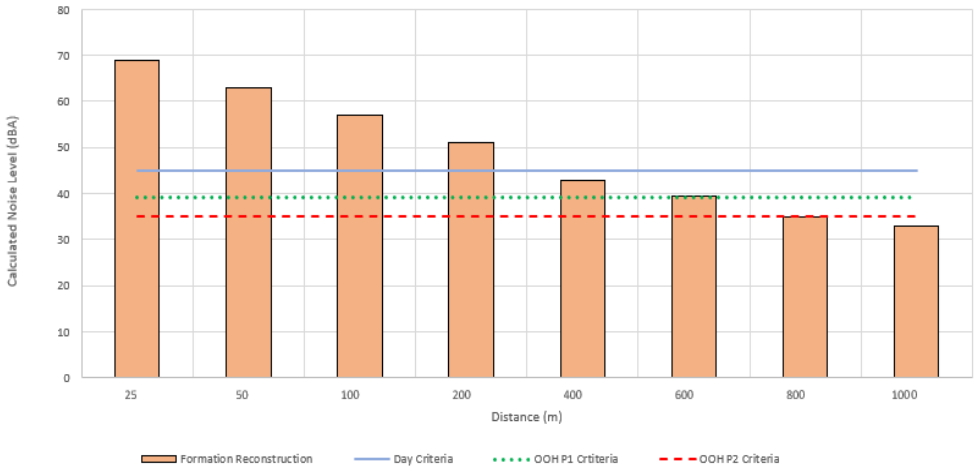


Figure 13 - Noise Levels at Various Buffer Distances - Concrete Re-sleepering

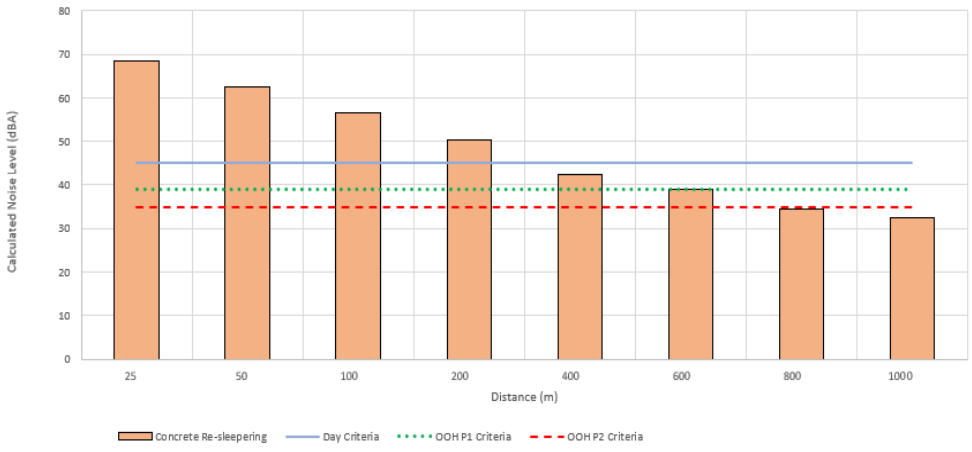


Figure 14 - Noise Levels at Various Buffer Distances - Re-railing

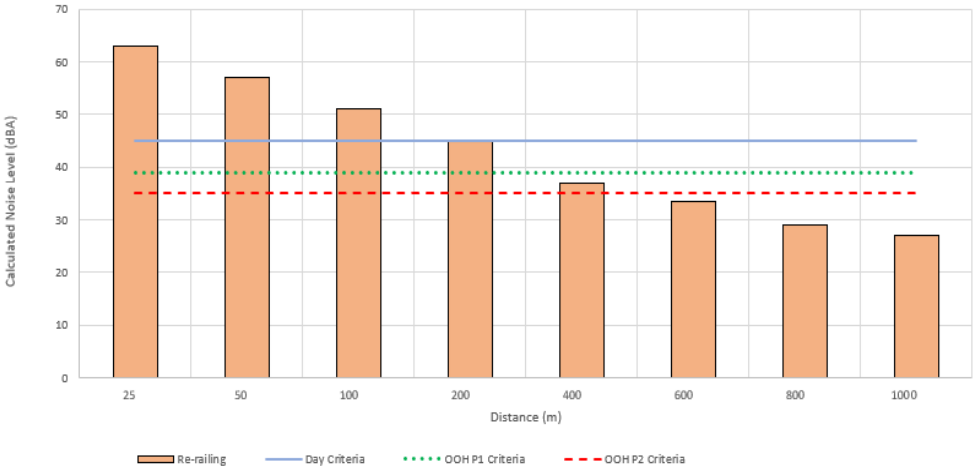
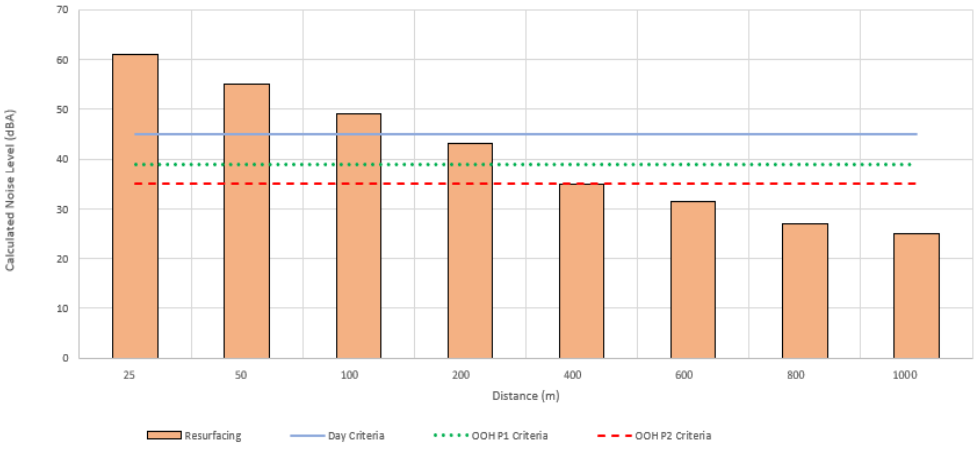


Figure 15 - Noise Levels at Various Buffer Distances - Resurfacing



The results of the analysis demonstrate that predicted $LA_{eq(15min)}$ noise emissions are anticipated to exceed the day period (standard hours) criterion for residential receivers within NCA 2 to approximately 350m from the Project Area with a maximum exceedance of the NML of up to 27dB $LA_{eq(15min)}$. It is predicted that up to 375 residential receivers may experience noise levels above the day period NML during formation reconstruction and concrete re-sleepering.

During the evening and night periods residential receivers to approximately 600m and 800m respectively are predicted to experience construction noise levels above the relevant NMLs, with up to 560 residential receivers anticipated to experience construction noise levels above the evening period NML and up to 710 residential receivers anticipated to experience construction noise levels above the night period NML. The highest exceedance of the NMLs is predicted to be on the order of 33dB and 37dB $LA_{eq(15min)}$ during the evening and night periods respectively.

A summary of the highest predicted construction noise levels at the nearest residential receivers, affected distances, number of potentially affected receivers is provided in **Table 18**.

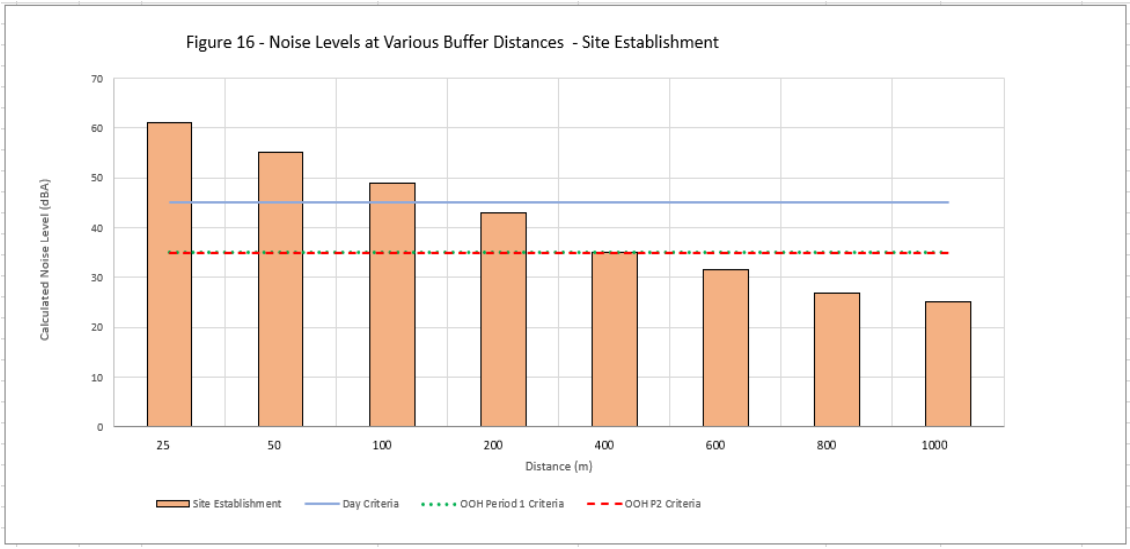
Table 18 Summary of Construction Affected Distances and Number of Affected Receivers – NCA 2

Construction Scenario	Highest Predicted Noise Level[1] dBA	Day Period		Evening Period		Night Period	
		Affected Distances (m)	Affected receivers	Affected Distances (m)	Affected receivers	Affected Distances (m)	Affected receivers
Site Establishment	64	175	~170	300	~315	400	~415
Formation Reconstruction	72	350	~375	600	~560	800	~710
Concrete Re-sleepering	72	350	~375	600	~560	800	~710
Re-railing	69	200	~195	350	~375	500	~475
Resurfacing	66	190	~180	315	~330	415	~430

Note 1: Denotes the predicted noise level at the nearest residential receiver.

6.3.3 Construction Noise Buffer Distances – NCA 3

Predicted noise levels for each construction scenario are plotted against criteria for several buffer distances and results are presented in **Figure 16** to **Figure 20** for receivers within NCA 3.



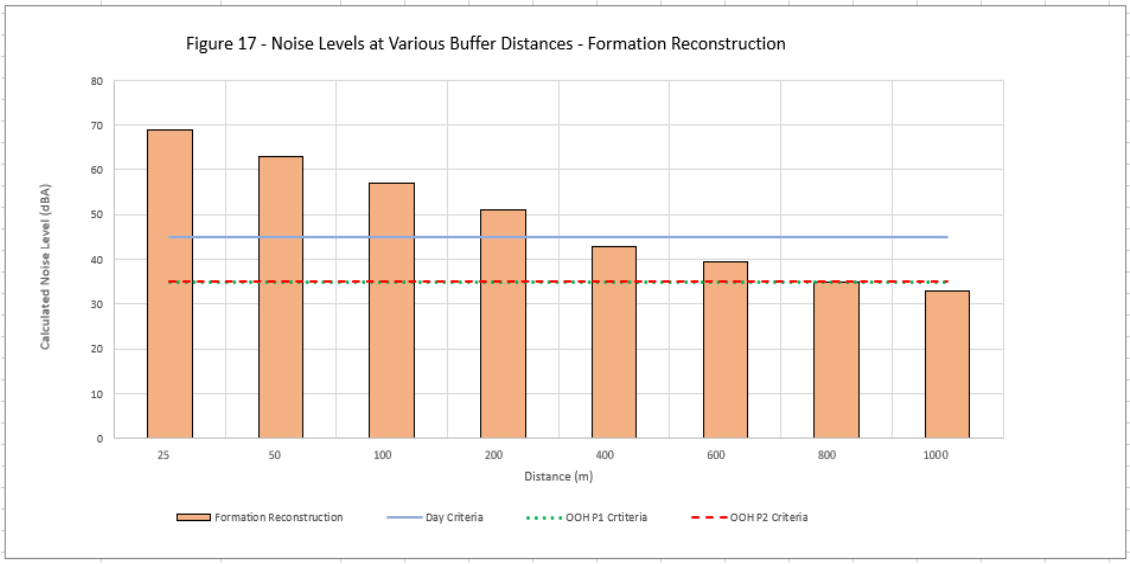


Figure 18 - Noise Levels at Various Buffer Distances - Concrete Re-sleepering

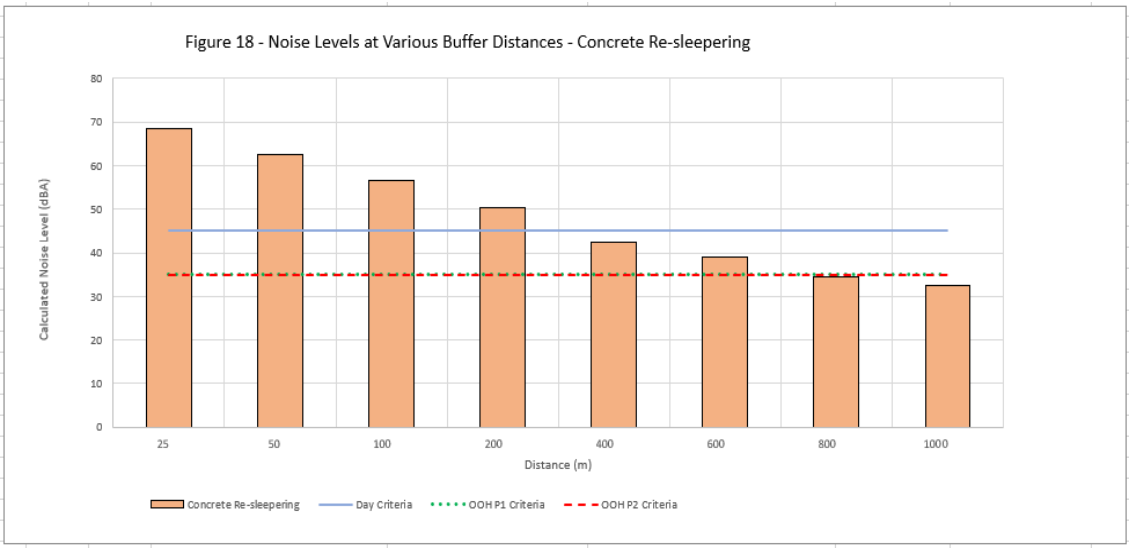


Figure 19 - Noise Levels at Various Buffer Distances - Re-railing

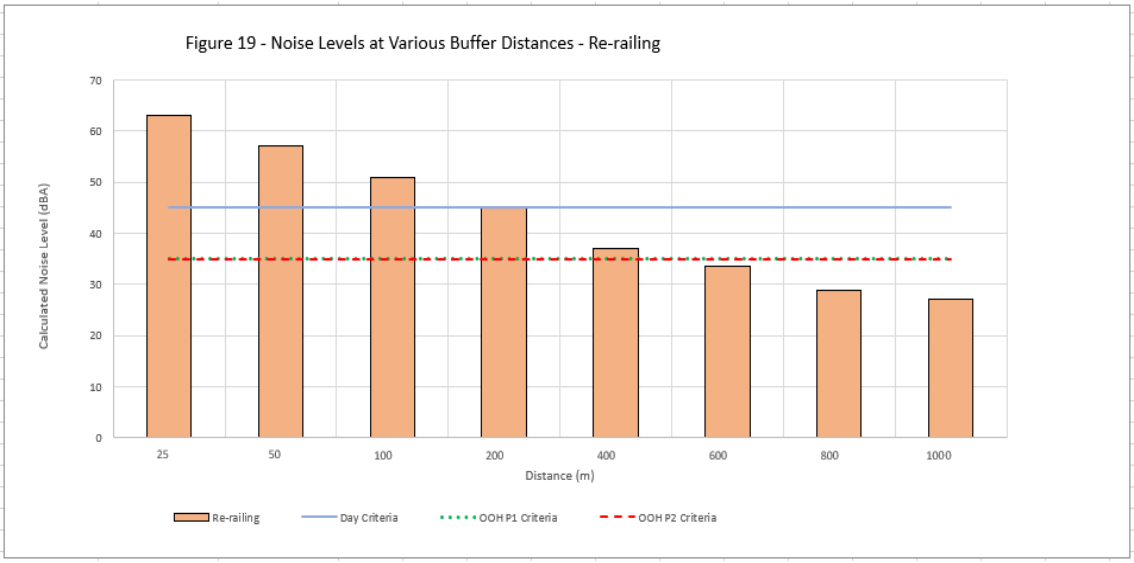
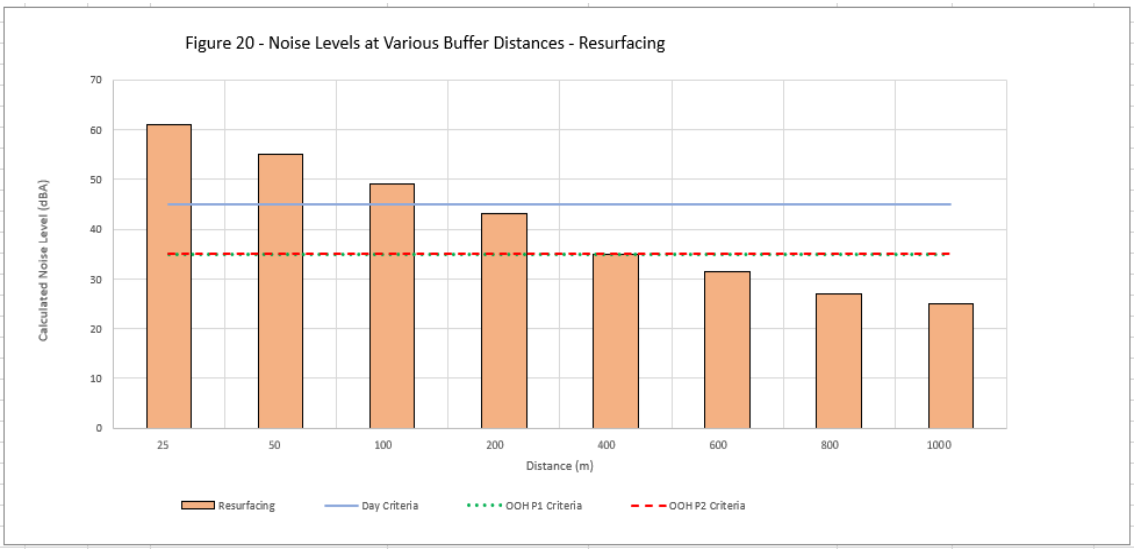


Figure 20 - Noise Levels at Various Buffer Distances - Resurfacing



The results of the analysis demonstrate that predicted $LA_{eq(15min)}$ noise emissions are anticipated to exceed the day period (standard hours) criterion for residential receivers within NCA 3 to approximately 350m from the Project Area with a maximum exceedance of the NML of up to 20dB $LA_{eq(15min)}$. It is predicted that up to 60 residential receivers may experience noise levels above the day period NML during formation reconstruction and concrete re-sleepering.

During the evening and night periods residential receivers to approximately 800m are predicted to experience construction noise levels above the relevant NMLs, with up to 180 residential receivers anticipated to experience construction noise levels above the evening and night period NMLs. The highest exceedance of the NMLs is predicted to be on the order of 30dB $LA_{eq(15min)}$ during the evening and night periods.

A summary of the highest predicted construction noise levels at the nearest residential receivers, affected distances, number of potentially affected receivers is provided in **Table 19**.

Table 19 Summary of Construction Affected Distances and Number of Affected Receivers – NCA 3

Construction Scenario	Highest Predicted Noise Level[1] dBA	Day Period		Evening Period		Night Period	
		Affected Distances (m)	Affected receivers	Affected Distances (m)	Affected receivers	Affected Distances (m)	Affected receivers
Site Establishment	57	175	<20	400	~65	400	~65
Formation Reconstruction	65	350	<60	800	~180	800	~180
Concrete Re-sleepering	65	350	<60	800	~180	800	~180
Re-railing	62	200	<20	500	~90	500	~90
Resurfacing	59	190	<20	415	~70	415	~70

Note 1: Denotes the predicted noise level at the nearest residential receiver.

6.3.4 Construction Noise Buffer Distances – Non-Residential Receivers

Construction buffer distances for non-residential receivers are provided in **Table 20**.

Table 20 Summary of Construction Buffer Distances – Non-Residential Receivers

Receiver Type	Criteria, dB LAeq(15min)	Buffer Distances (m)				
		Site Establishment	Formation Reconstruction	Concrete Re-sleepering	Re-railing	Resurfacing
Schools / Hospitals / Worship	55[1]	90	225	210	110	90
	65[2]	30	70	65	65	30
	70[3]	15	40	35	20	15
Passive Recreation	60	40	125	120	65	40
Active Recreation	65	30	70	65	35	30
Commercial Receivers	70	15	40	35	20	15
Industrial Premises	75	9	25	20	11	9

Note 1: External noise level assumes a 10dB transmission loss for a light framed building with single glazing (windows open) as per the ENMM (RTA, 2001).
Note 2: External noise level assumes a 20dB transmission loss for a light framed building with single glazing (windows closed) as per the ENMM (RTA, 2001).
Note 3: External noise level assumes a 25dB transmission loss for a masonry building with single glazing (windows closed) as per the ENMM (RTA, 2001).

Results of the noise level prediction identifies that for schools, hospital wards and places of worship with light framed construction, construction noise levels are predicted to exceed the relevant internal criterion for distances up to 225m from the Project Area with windows open during formation reconstruction. A review of aerial imagery indicates that two schools, identified as Narrabri High School and Narrabri West Public School are located within 225m of the Project Area, and would experience noise levels of up to 6dB $L_{Aeq(15min)}$ above the internal criteria. Where windows remain closed, the internal criterion would be met within all school classrooms.

For commercial receivers and industrial receivers, premises within 40m and 25m respectively are predicted to experience construction noise levels above the relevant criteria. A review of aerial imagery identified up to 10 commercial or industrial premises located immediately adjacent to the rail corridor, which may experience noise levels above the relevant NMLs.

It is noted that there are no places of worship, hospital wards or places of active or passive recreation located within the affected areas.

6.3.5 Sleep Disturbance Assessment Results

Table 21 presents the offset calculations for maximum noise levels of transient events during construction for receivers with a clear line of sight and receivers with no line of sight (ie shielded by buildings or intervening topography) to the project activities.

Table 21 Maximum Noise Level Results

Offset Distance to receiver (m)	Calculated L_{Amax}, dB		Sleep Disturbance Criteria dB L_{Amax}	
	Line of Sight	No Line of Sight	NCA 1	NCA 2 / 3
25	**75**	**70**	46	45
50	**69**	**64**	46	45
100	**63**	**58**	46	45
250	**55**	**50**	46	45
500	**49**	**44**	46	45
750	**45**	**40**	46	45
1000	**43**	**38**	46	45
1250	**41**	**36**	46	45

Note: Offset distances where exceedance of the sleep disturbance criterion is predicted are shown in bold.

The results of the assessment indicate that receivers up to 750m from the Project Area, assuming direct line of sight, may experience L_{Amax} noise levels above the sleep disturbance criteria. For receivers with a partial line of sight, noise levels are predicted to exceed the sleep disturbance criteria to approximately 475m from the Project Area. Therefore, LAmax events should be carefully managed and minimised, limiting the occurrence of banging and crashing events during night periods.

6.4 Vibration Assessment Results

Table 3 of the Construction Noise Strategy (CNS) (Transport for NSW, 2016) sets out safe working distances to achieve the human response vibration dose criteria for residential receivers ($0.2m/s^{1.75}$). The safe working distances for the most vibration intensive activities identified in the CNS is 100m for human comfort and 25m for cosmetic damage from the use of heavy vibratory rollers. For heritage buildings in poor structural condition, the safe working distance is 50m for heavy vibratory equipment. It is noted that where the heritage building is of sound structural integrity, the safe working distance of 25m for cosmetic damage applies.

A review of aerial imagery identified that there are up to 170 buildings within 100m of the Project Area. The inhabitants of these buildings may experience vibration levels that are noticeable during vibration intensive construction activities. It is also noted that there are few buildings within 25m of the proposal site, including residential dwellings at 2 Logan Street and 7 Wade Street, Narrabri, NSW.

It is understood that there is one heritage building (Narrabri Station) located within the potential affected area for vibration. Following selection of final plant and equipment, where vibration intensive work is planned to occur close to Narrabri Station, minimum offset distances should be reviewed. Where works will occur within the minimum safe working distances and there is a risk of exceeding the cosmetic damage objective, a different construction method with lower source vibration levels should be considered, or, vibration monitoring should be undertaken at the commencement and through the works.

6.5 Operational Noise Assessment

The Project would generally involve the replacement of existing wooden sleepers with Heavy Duty concrete sleepers, the addition of new ballast, and upgrade of rail to 53kg/m rail or 60kg/m rail. A discussion of the potential influence of the Project on operational noise levels is provided below.

It is understood that the rail alignment will remain consistent with the existing alignment, however, to accommodate the new ballast below the new concrete sleepers, the track will be lifted by up to 200mm. It is considered that a track lift of up to 200mm would have a negligible impact on operational noise levels.

Based on the Dutch railway noise calculation method (RMR-2012), the change from wooden sleepers to concrete sleepers is expected to result in a decrease in rail noise emissions of up to 2dB $LA_{eq(period)}$. Furthermore, a study by Weiss et al (2018), presented at the Euronoise 2018 conference, observed a decrease in noise emissions of up to 3.1dB $LA_{eq(period)}$ from wooden and concrete sleepers. Similarly, the higher density material of the concrete sleepers is predicted to contribute to lower LA_{max} noise levels.

It is understood that the line speed through Narrabri would not materially change as a result of the Project, with the speed through Narrabri governed by infrastructure and safety constraints. In terms of operations, the Narrabri 'future state' (i.e. in years 2025 and 2030) will be consistent or marginally lower than the Narrabri 'current state' (i.e. normal operating conditions), which involves two passenger service movements per day, three mandatory train paths (six movements) per day and ad hoc freight services as scheduled. It is noted that the current and future state operations are below the current enhanced train frequencies of up to six train paths per day due to current record grain and cotton harvests. Therefore, as line speeds and rail movements between current state and future state are not anticipated to increase, there would be a negligible impact on operational noise. As the volume of train paths returns from enhanced current capacity state to current state, rail noise levels are anticipated to reduce.

In summary, with no material changes to operational conditions anticipated and improved acoustic performance of concrete sleepers relative to wooden sleepers, it is considered that operational rail noise levels will decrease by upwards of 2dB $LA_{eq(period)}$ due to the improvements facilitated by the Project. It is therefore concluded that the RING 2dB $LA_{eq(period)}$ and 3dB LA_{max} relative increase criteria would be achieved.

7 Recommendations

7.1 Noise Management Objectives

The primary objective of noise emission management is to limit noise impacts from construction works on the surrounding community. The ARTC may adopt the following strategies to achieve this objective:

- ensure that construction activities meet construction noise goals within the allowable hours of operation as far as practicable;
- where noise levels are above relevant goals, implement reasonable and feasible best practice noise controls to minimise noise emissions and/or exposure duration at affected receivers; and
- where the use of best practice noise controls do not adequately address exceedance of noise goals, adopt alternative measures to minimise impacts on the community.

7.2 Construction Noise Recommendations

As per Condition O 9. 4 of EPL 3142, noise impacts from railway construction works must be managed in accordance with the recommendations of the INCG. The ICNG sets out numerous practical recommendations to assist in mitigating construction noise emissions. Recommendations provided in the INCG include operational strategies, source noise control strategies, noise barrier controls, and community consultation.

It is estimated that adopting strategies contained in this standard would achieve the following noise attenuation, and would therefore satisfy the relevant criteria:

- Up to 10dBA where space requirements place limitations on the attenuation options available; and
- Up to 20dBA in situations where noise source noise mitigation measures (silencers, mufflers, etc) can be combined with noise barriers and other management techniques.

Where exceedances of the noise criteria are anticipated, a combination of mitigation, management and consultation with the local communities will be considered. The following mitigation measures are recommended in Table 22 for consideration.

Table 22 Management of Nosie and Vibration Impacts	
Mitigation Type	Recommended Mitigation Measure
Universal Work Practices	Toolbox and induction of personnel prior to shift to inform relevant receptors and mitigation measures.
	Minimise the use of UHF radios and avoid shouting on site.
	Minimise the need for vehicle reversing by arranging for on-way site traffic routes.
	Where possible, avoid metal on metal impact noise.
Plant and Equipment	Employing quieter techniques for all high noise activities and choosing quieter plant based on optimal power and size to most efficiently perform the required task.
	Operating plant and equipment in a conservative manner (no over-revving).
	Plant and equipment should be inspected and maintained to minimise noise and vibration level increases.
On Site Noise Mitigation	All plant should be shut down when not in use. Plant to be parked/started at farthest point from relevant assessment locations.
	All plant are to utilise the broadband reverse alarm in lieu of the traditional 'tonal' type reverse alarm.
	Where possible, positioning of site shed/containers in locations that would screen potential neighbouring receptors.
Work Scheduling	Where practicable, ensure those noisy plant/machinery are not working simultaneously in close proximity to sensitive receivers.
	Scheduling noisy activities to coincide with high levels of ambient noise so that noise is partially masked and is not as intrusive.
	Planning deliveries and access to the site to occur efficiently and within areas located away from sensitive receivers.
Consultation and Notification	Undertake letter box drops to notify receivers of potential works.
	Notify receivers within the potential affected offset distances in advance of works.
Vibration Monitoring	Where works will occur within the minimum safe working distances and there is a risk of exceeding the cosmetic damage objective, vibration monitoring should be undertaken at the commencement and through the works.

In addition to the management measures listed above, EPL 3142 states that where noise sensitive receivers are required to be notified under Condition O9.4e, the notification must be made not less than 5 days before those works and activities are to be undertaken, unless agreement has been reached with the local community.

a) The notification must:

   i) By letterbox drop or other targeted and equivalent method; and

   ii) Published on the project website where one exists.

b) The notification must:

   i) Clearly outline the reason that the work is required to be undertaken outside the hours specified in Condition O9.1;

   ii) Include a diagram that clearly identifies the location of the proposed works in relation to nearby cross streets and local landmarks;

   iii) Include details of relevant time restrictions that apply t the proposed works;

   iv) Clearly outline in plain English the location, nature, scope and duration of the proposed works;

   v) Detail the expected noise impact of the works on noise sensitive receivers;

   vi) Detail mitigation measures to be implemented to minimise noise and/or vibration impacts;

   vii) Clearly state how complaints may be made and additional information obtained; and

   viii) Include the number of telephone complaints line required by the licence, an afterhours contact number specific to the works and activities, and the project website address where applicable.

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8 Conclusion

Muller Acoustic Consulting Pty Ltd (MAC) has completed a Noise Assessment (NA) consisting of construction works for standard construction hours and out of hours work periods, and operational noise changes associated with the proposed Narrabri to Turrawan Line Upgrade Project, Narrabri, NSW.

The results of the assessment demonstrate that construction noise levels have the potential to be above the relevant standard and out of hours NMLs for residential receivers within each of the noise catchment areas. Within NCA 1, up to 610 receivers within 750m of the Project Area are predicted to experience noise levels above the NMLs, with the closest receiver anticipated to experience noise levels of up to 72dB $LA_{eq(15min)}$. Similarly, for NCA 2 and NCA 3, receivers within 800m of the Project Area are predicted to experience noise levels above the night period NML with up to 710 and 180 residential receivers respectively located within the affected area. Accordingly, the NA provides prescriptive reasonable and feasible recommendations that can be implemented to reduce impact to the community. Notwithstanding, noise levels are predicted to satisfy the highly noise affected criteria of 75dBA, $LA_{eq(15min)}$, at all assessment locations.

Additionally, two schools and up to ten commercial or industrial receivers are predicted to experience noise levels above the relevant non-residential receiver NMLs. It is noted that the prediction for noise impacts within school classrooms assumed windows partially open for adequate ventilation. Where windows remain closed, noise levels would remain below the internal criteria for all school classrooms.

Maximum noise emissions from transient construction events are predicted to exceed the relevant NPI criteria at rural receivers with direct line of sight to the Project Area up to 750m from the construction works while suburban residential receivers with obscured line of sight to approximately 475m from the Project Area are anticipated to experience noise levels above the relevant sleep disturbance criteria. Therefore, LA_{max} events, such as the occurrence of banging and crashing, will be carefully managed and minimised throughout the project.

An assessment of safe working distances to achieve vibration limits demonstrates that during vibration intensive activities, receivers up to 100m from the Project Area may experience vibration levels above the human comfort limit, while buildings within 25m (non-sensitive) and 50m (heritage buildings) may experience vibration levels above the cosmetic damage vibration limits. It is recommended that following final selection of plant and equipment, safe working distances are reviewed. Where vibration levels are likely to exceed the relevant limits, alternate practices should be considered or monitoring at the beginning and throughout the construction period should be undertaken.

The direct change to noise levels as a result the track improvements works are anticipated to result in a reduction in rail noise emissions of upwards of 2dB $L_{Aeq(period)}$. Similarly, the replacement of wooden sleepers with higher density concrete sleepers is likely to result in a decrease in L_{Amax} noise levels also. A review of operational conditions indicates that noise emissions from indirect changes including line speeds and freight volumes are likely to be negligible or lower than under enhanced current capacity state. Hence, the change in operational rail noise levels is predicted to meet the RING relative increase criteria.

In summary, it is recommended that during construction, noise control and management measures provided in this report are adopted to minimise impacts to receiver catchments, specifically during noise intensive works.

Appendix A – Glossary of Terms

A number of technical terms have been used in this report and are explained in **Table A1**.

Table A1 Glossary of Acoustical Terms

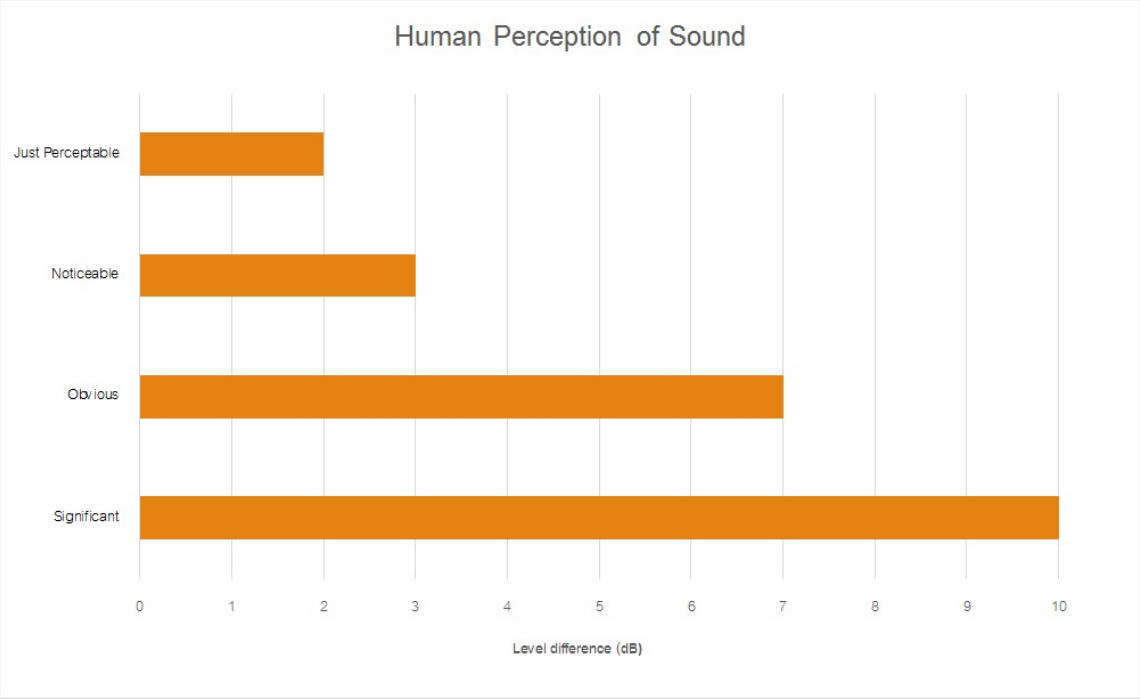
Term	Description
1/3 Octave	Single octave bands divided into three parts
Octave	A division of the frequency range into bands, the upper frequency limit of each band being twice the lower frequency limit.
ABL	Assessment Background Level (ABL) is defined in the NPI as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L90 statistical noise levels.
Ambient Noise	The total noise associated with a given environment. Typically, a composite of sounds from all sources located both near and far where no particular sound is dominant.
A Weighting	A standard weighting of the audible frequencies designed to reflect the response of the human ear to sound.
Background Noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is usually represented by the LA90 descriptor
dBA	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
dB(Z), dB(L)	Decibels Z-weighted or decibels Linear (unweighted).
Extraneous Noise	Sound resulting from activities that are not typical of the area.
Hertz (Hz)	The measure of frequency of sound wave oscillations per second - 1 oscillation per second equals 1 hertz.
LA10	A sound level which is exceeded 10% of the time.
LA90	Commonly referred to as the background noise, this is the level exceeded 90% of the time.
LAeq	Represents the average noise energy or equivalent sound pressure level over a given period.
LAmax	The maximum sound pressure level received at the microphone during a measuring interval.
Masking	The phenomenon of one sound interfering with the perception of another sound. For example, the interference of traffic noise with use of a public telephone on a busy street.
RBL	The Rating Background Level (RBL) as defined in the NPI, is an overall single figure representing the background level for each assessment period over the whole monitoring period. The RBL, as defined is the median of ABL values over the whole monitoring period.
Sound power level (Lw or SWL)	This is a measure of the total power radiated by a source in the form of sound and is given by 10.log10 (W/Wo). Where W is the sound power in watts to the reference level of 10^{-12} watts.
Sound pressure level (Lp or SPL)	the level of sound pressure; as measured at a distance by a standard sound level meter. This differs from Lw in that it is the sound level at a receiver position as opposed to the sound 'intensity' of the source.

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

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

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

Figure A1 – Human Perception of Sound



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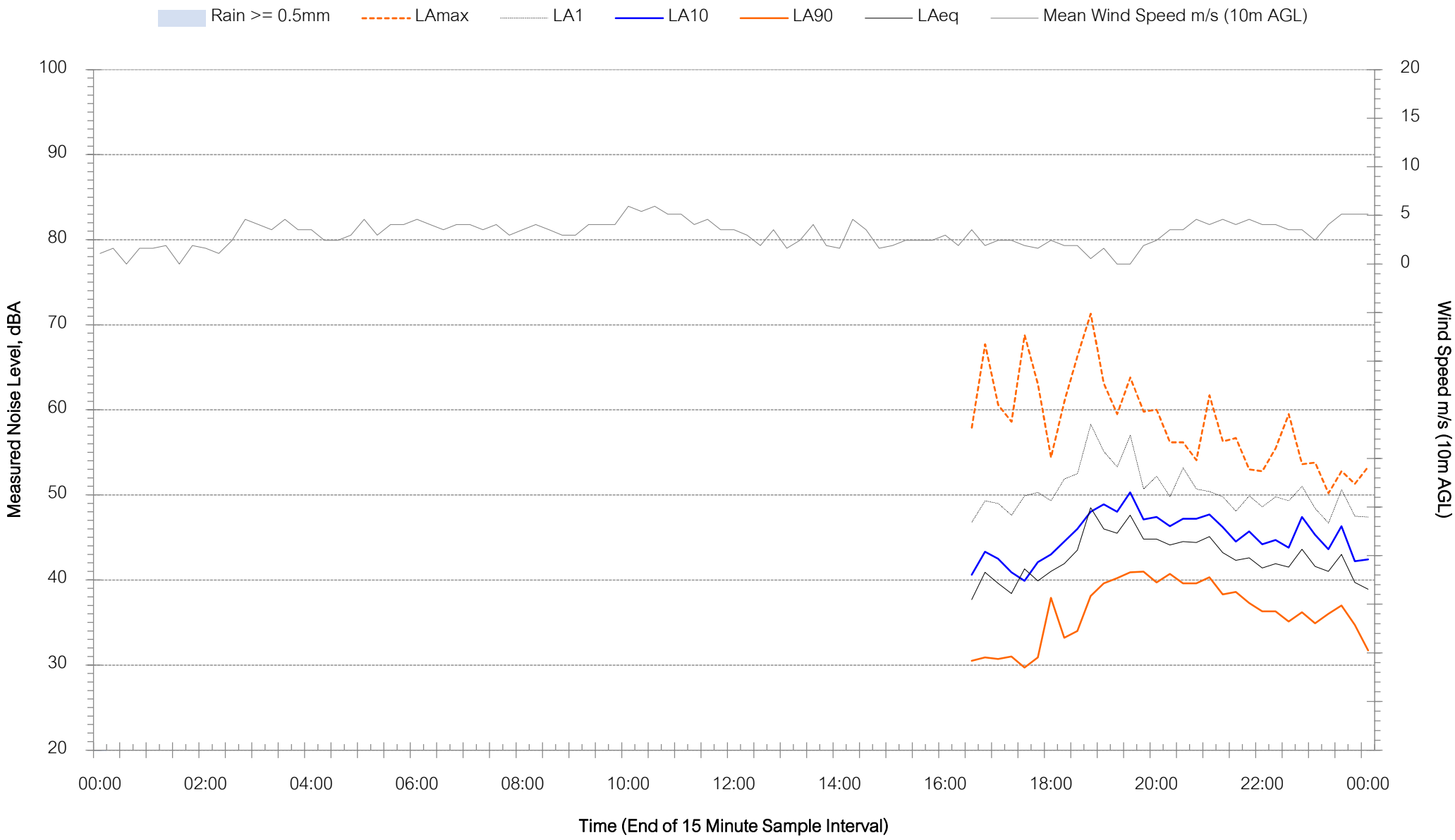
Appendix B – Noise Monitoring Charts

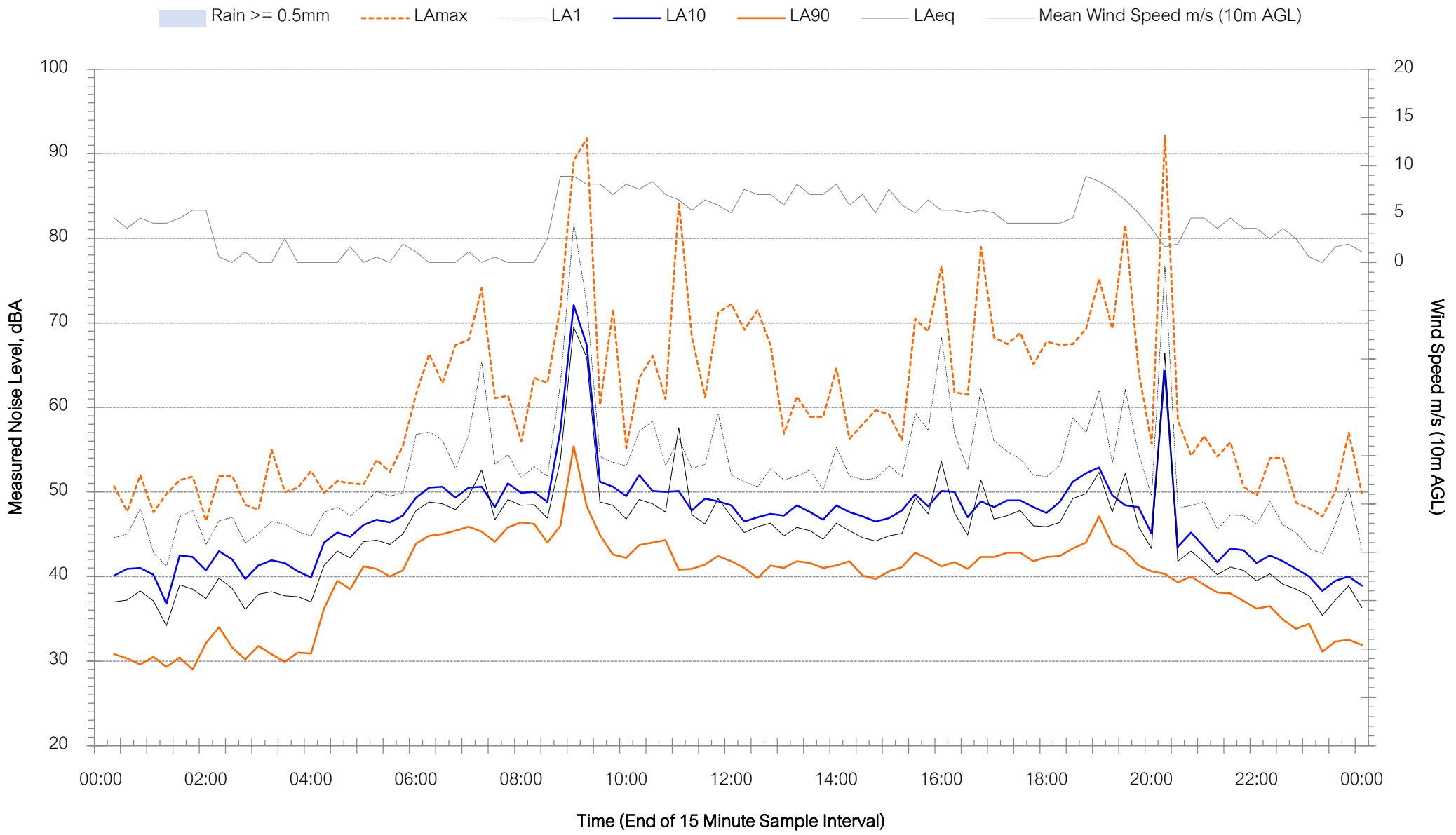
Background Noise Levels

Hillam Avenue, Narrabri - Wednesday 6 October 2021



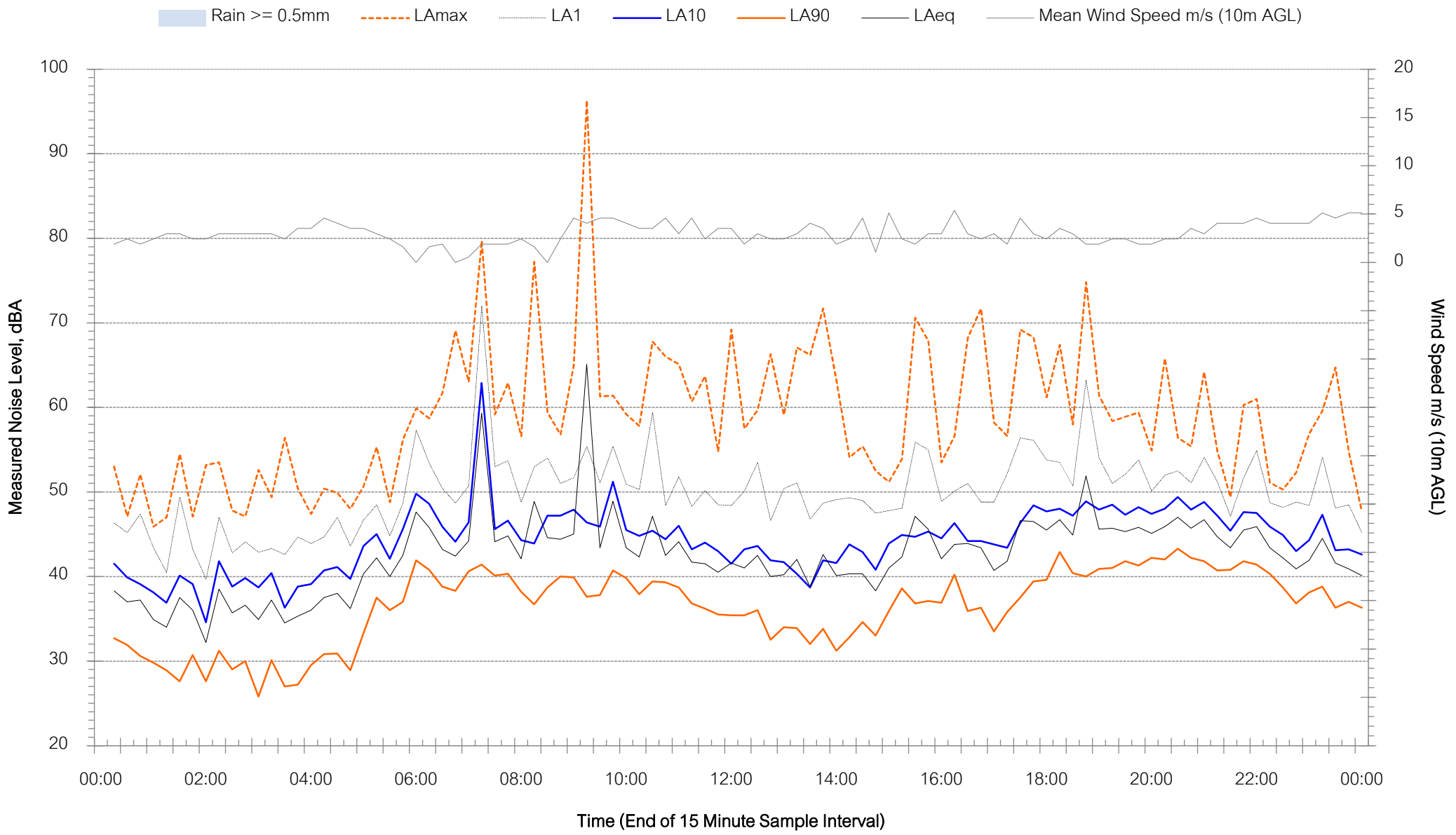
Background Noise Levels

Hillam Avenue, Narrabri - Thursday 7 October 2021



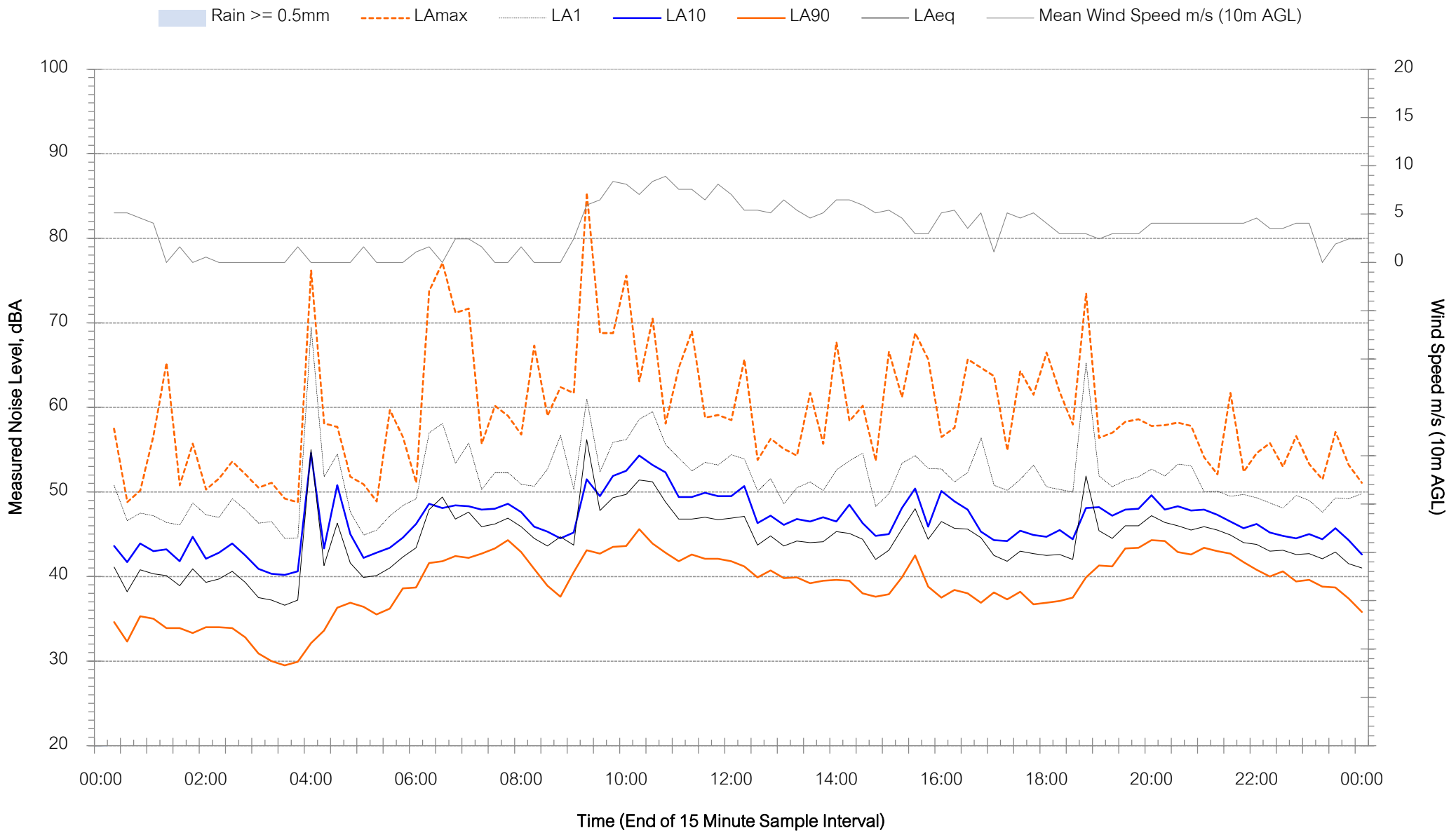
Background Noise Levels

Hillam Avenue, Narrabri - Friday 8 October 2021



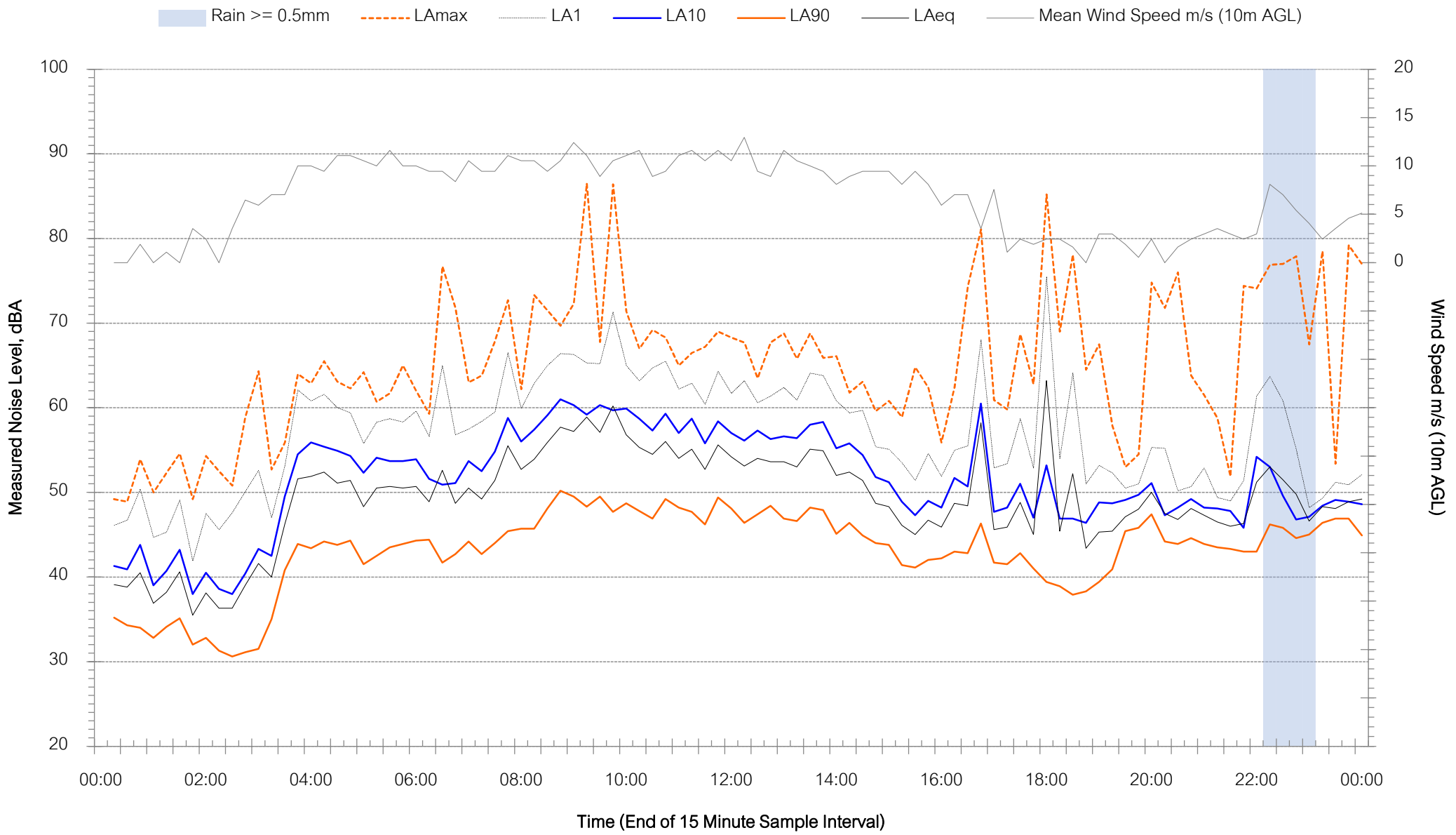
Background Noise Levels

Hillam Avenue, Narrabri - Saturday 9 October 2021



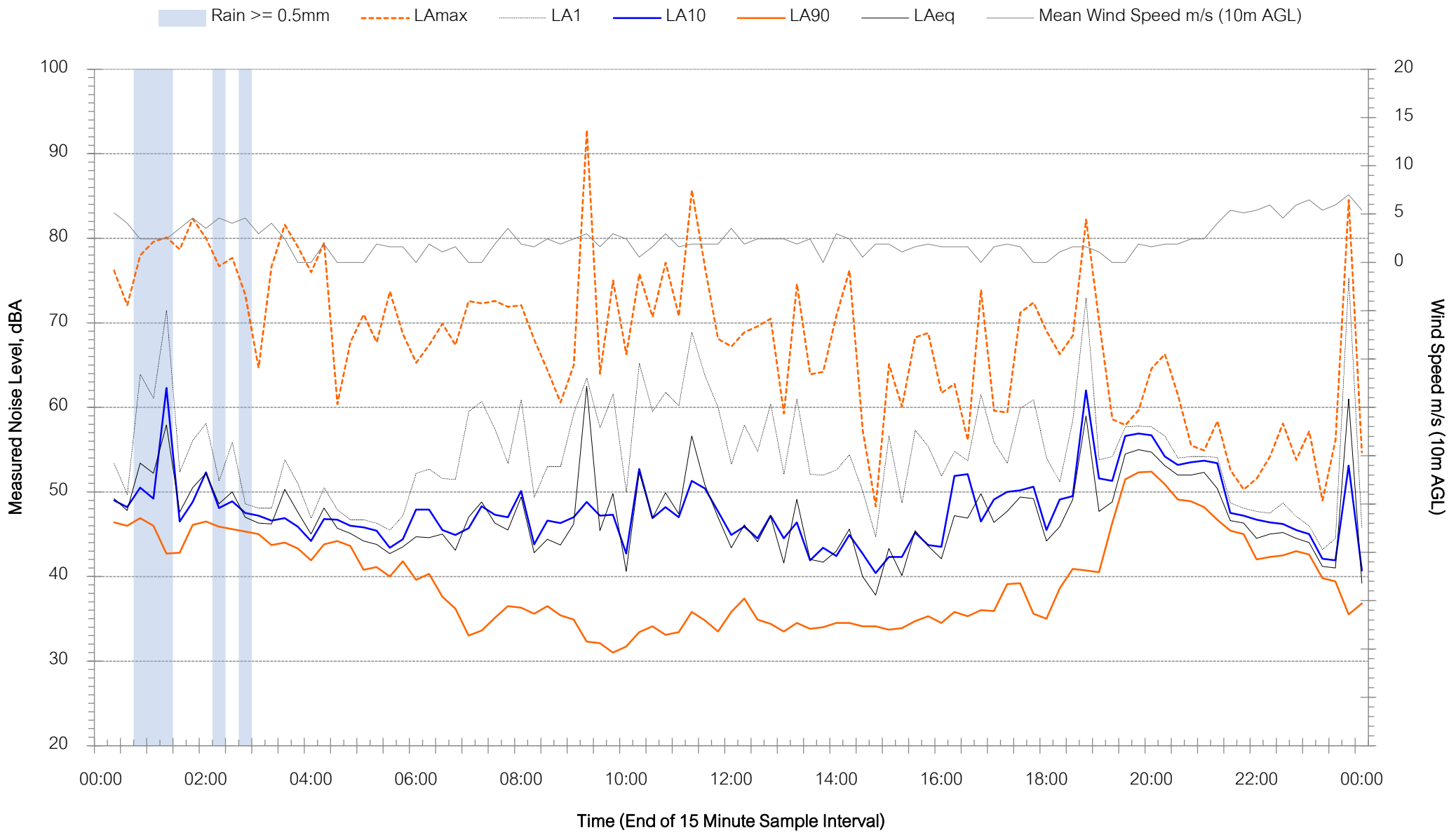
Background Noise Levels

Hillam Avenue, Narrabri - Sunday 10 October 2021



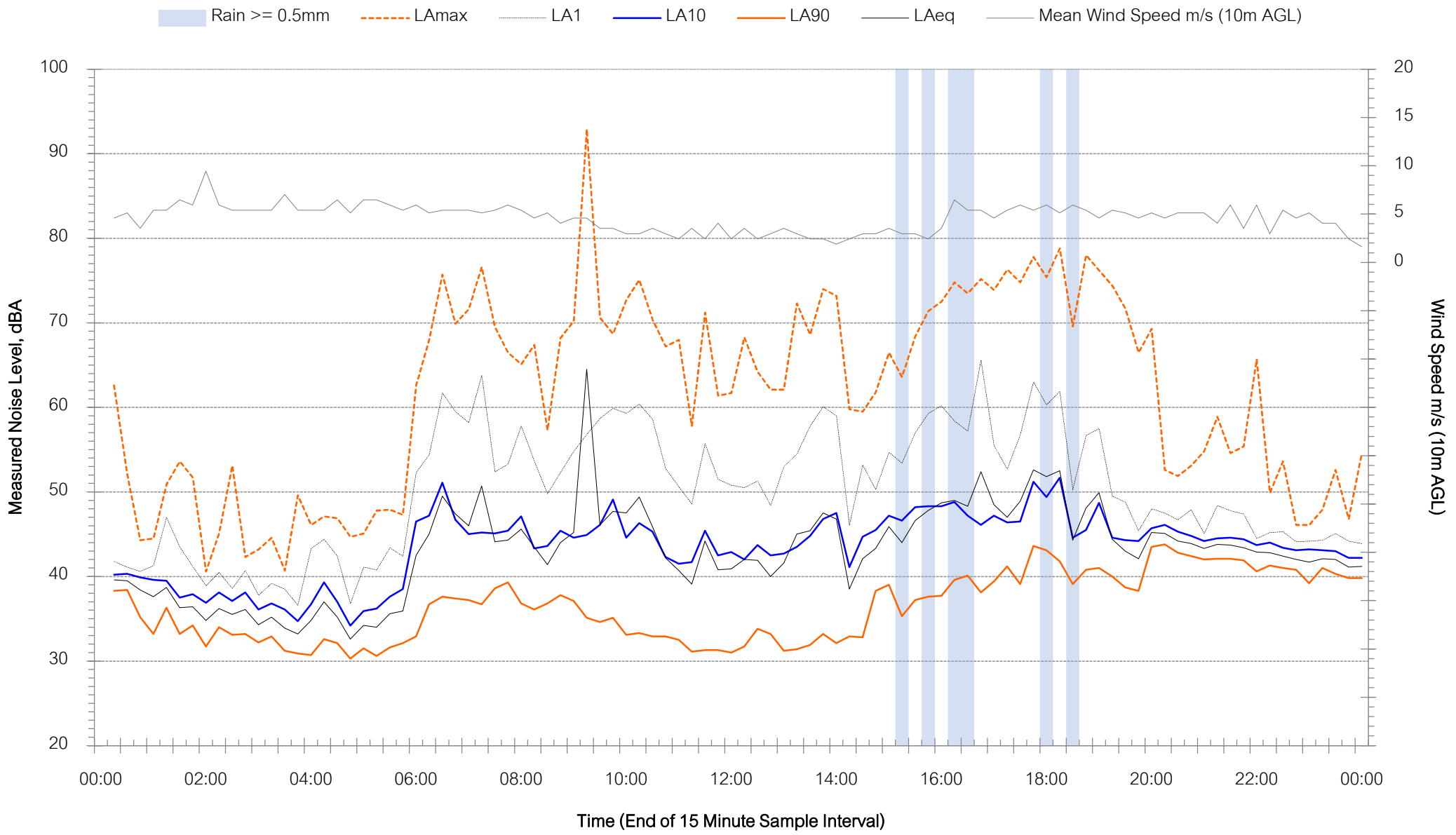
Background Noise Levels

Hillam Avenue, Narrabri - Monday 11 October 2021



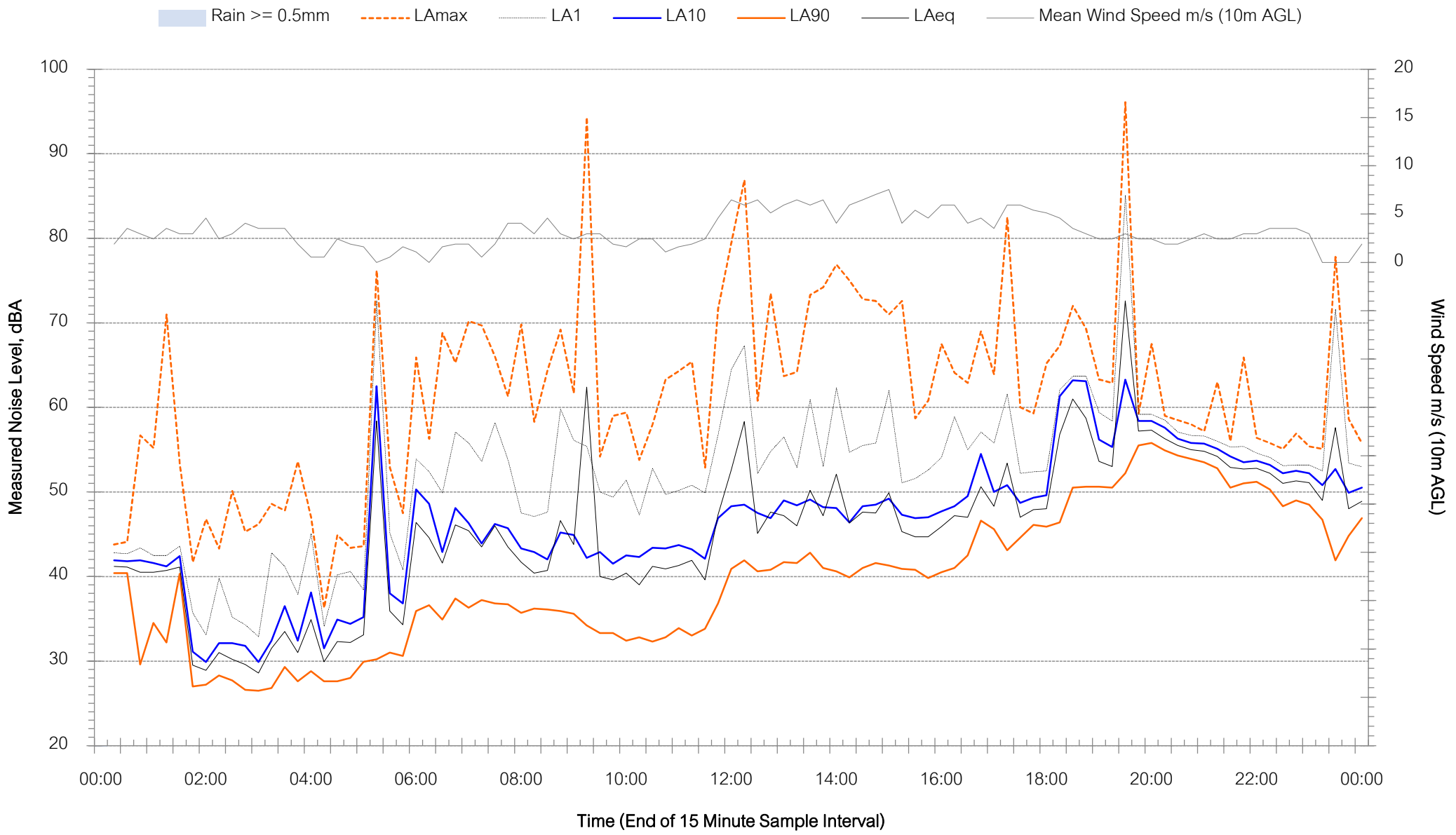
Background Noise Levels

Hillam Avenue, Narrabri - Tuesday 12 October 2021



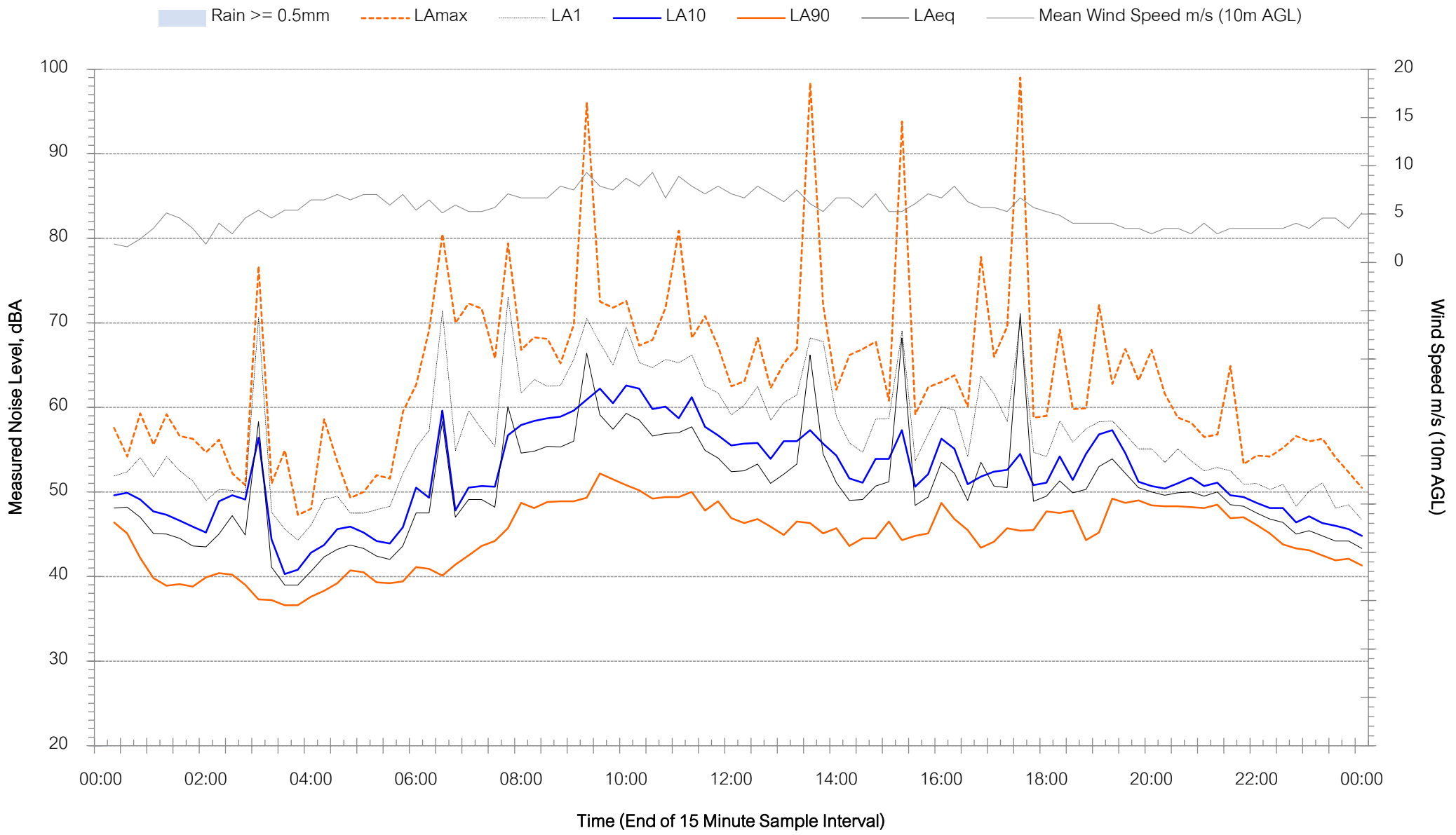
Background Noise Levels

Hillam Avenue, Narrabri - Wednesday 13 October 2021



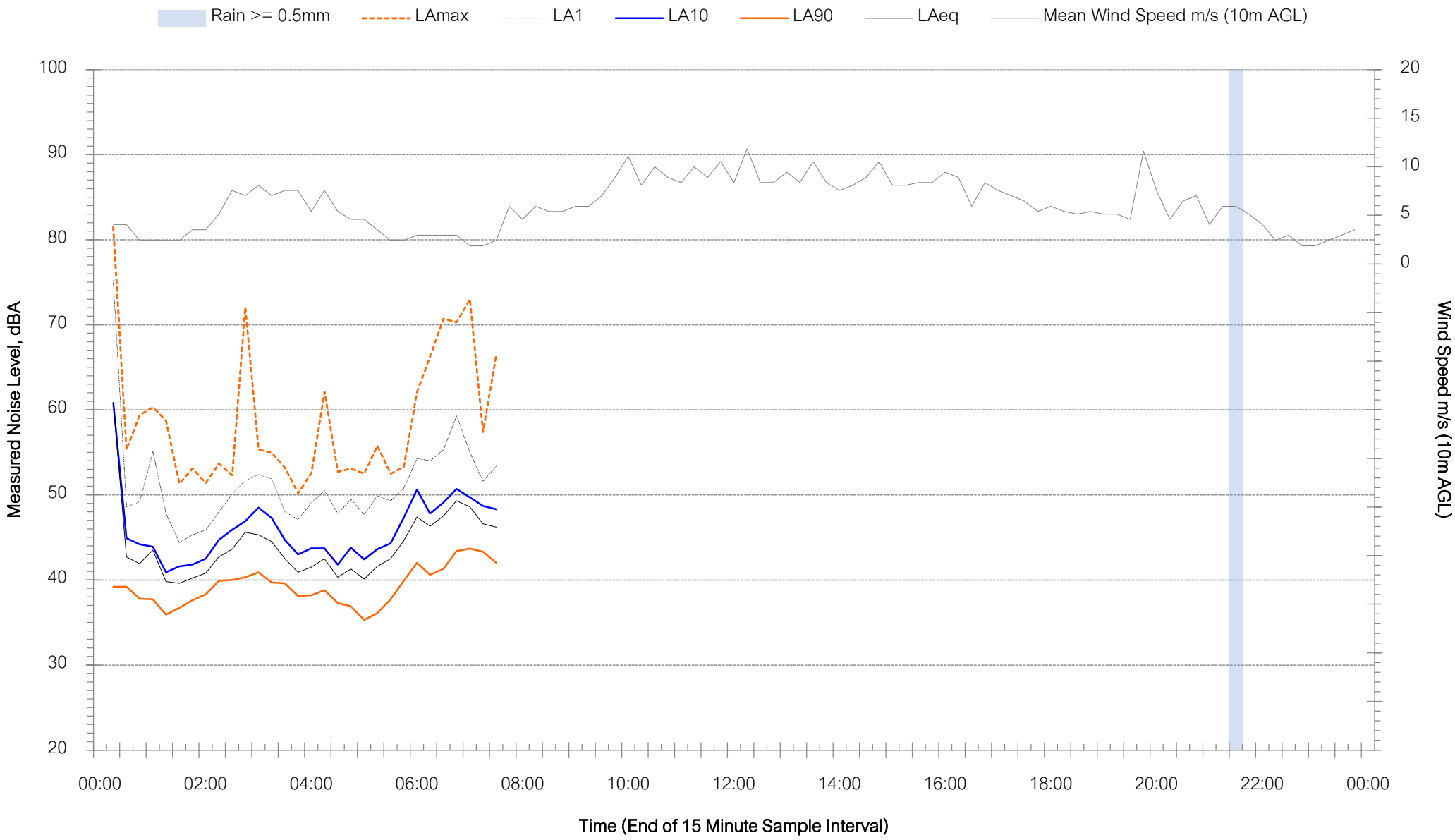
Background Noise Levels

Hillam Avenue, Narrabri - Thursday 14 October 2021



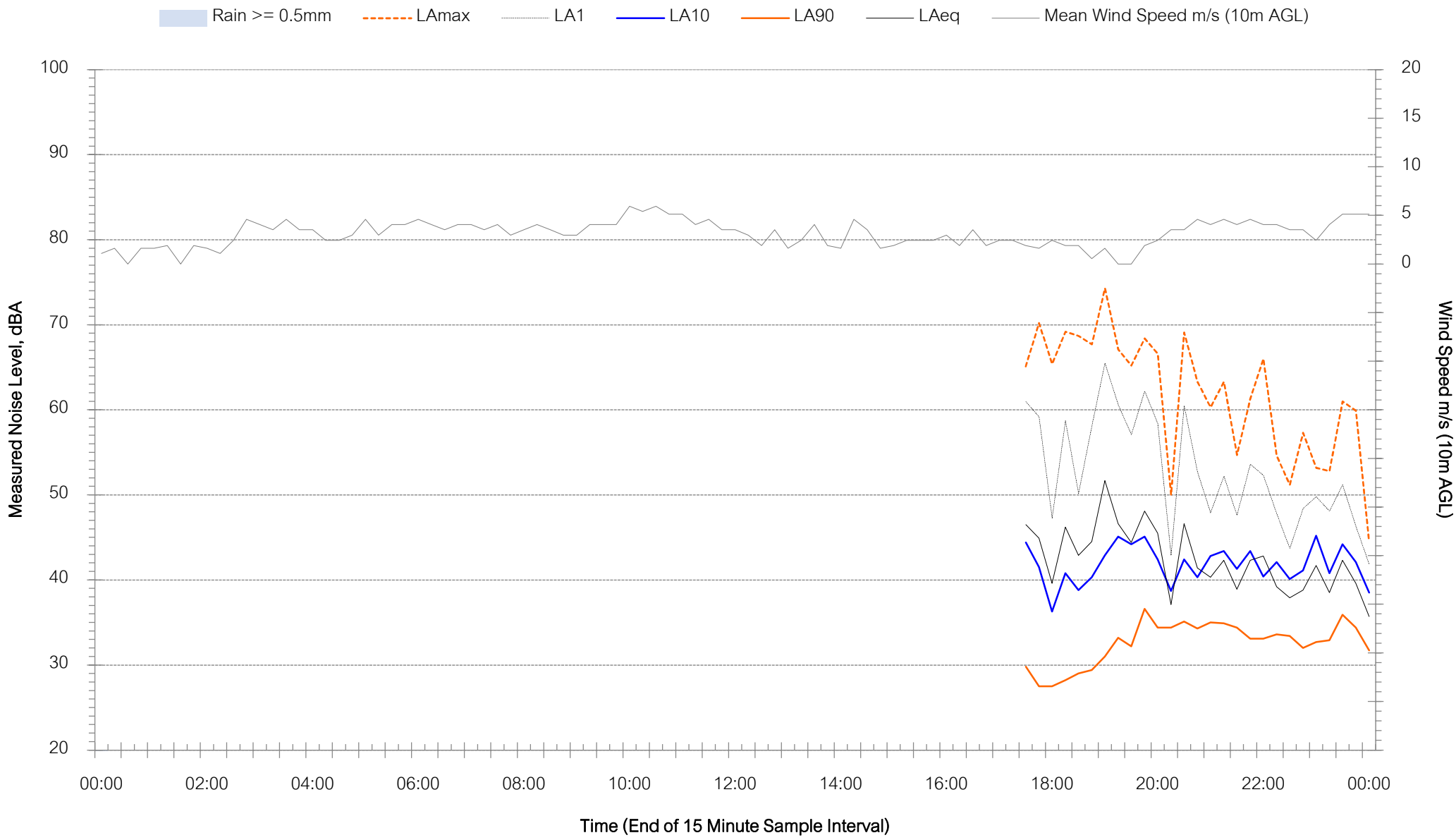
Background Noise Levels

Hillam Avenue, Narrabri - Friday 15 October 2021



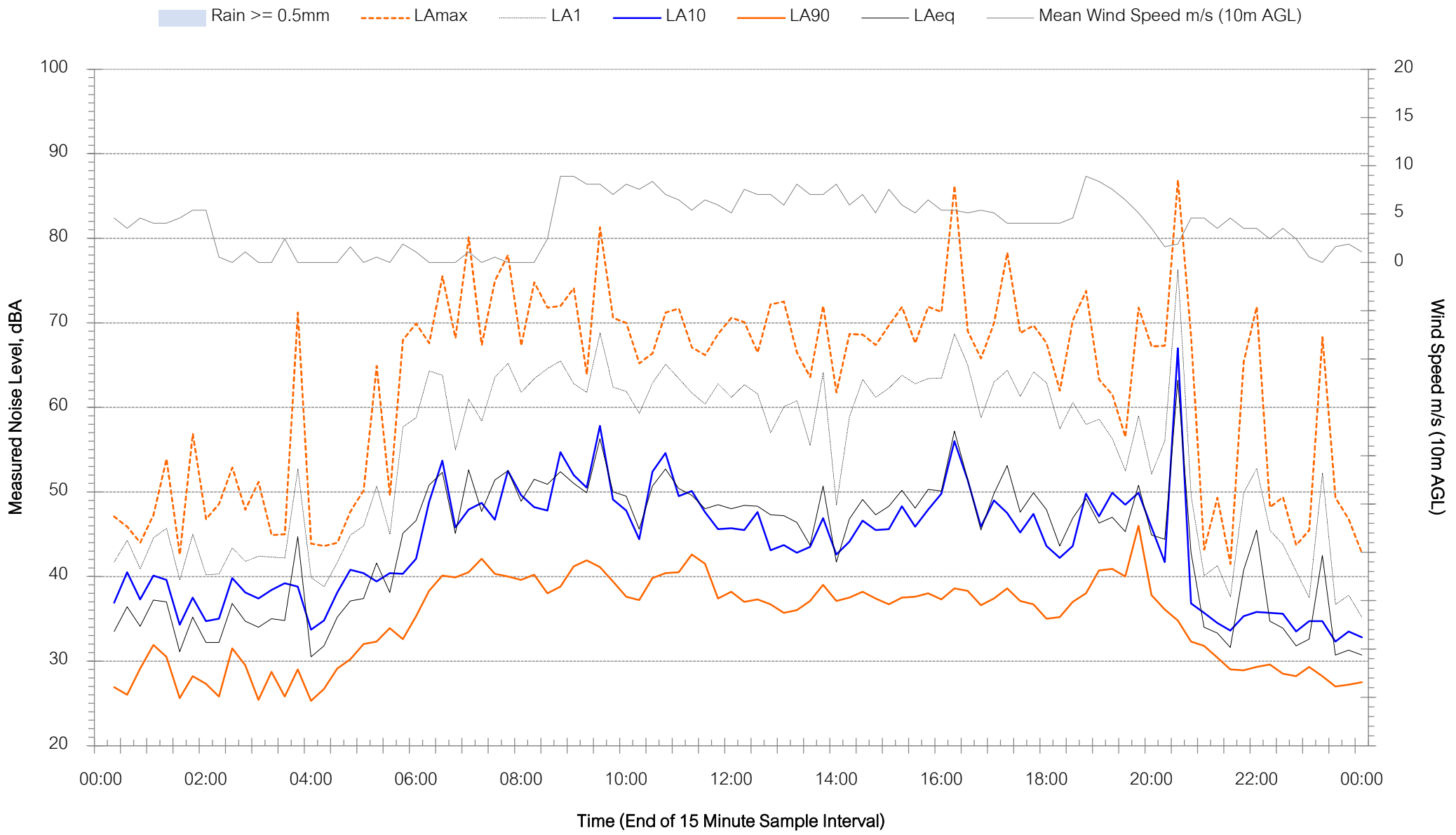
Background Noise Levels

Logan Street, Narrabri - Wednesday 6 October 2021



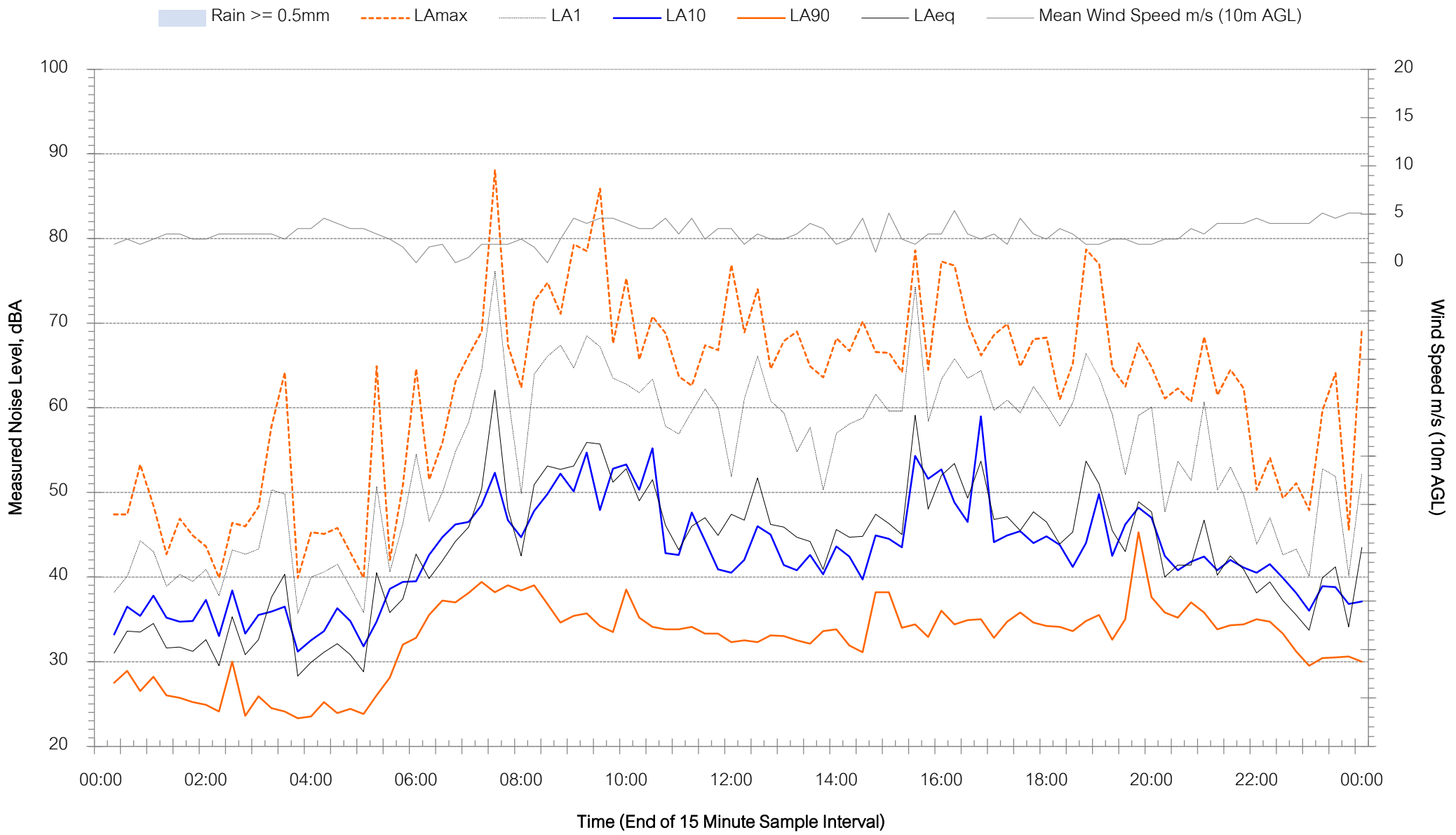
Background Noise Levels

Logan Street, Narrabri - Thursday 7 October 2021



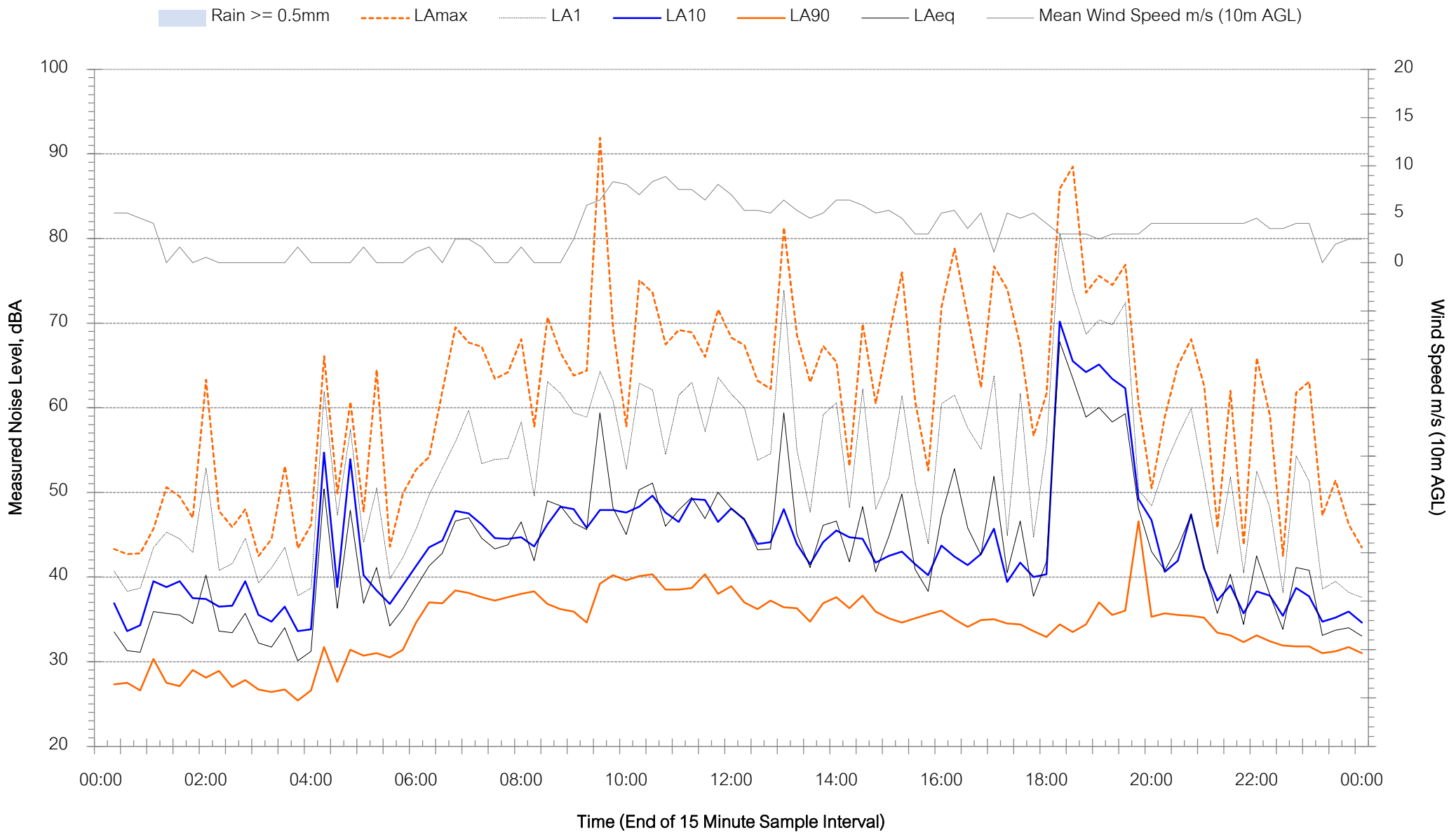
Background Noise Levels

Logan Street, Narrabri - Friday 8 October 2021



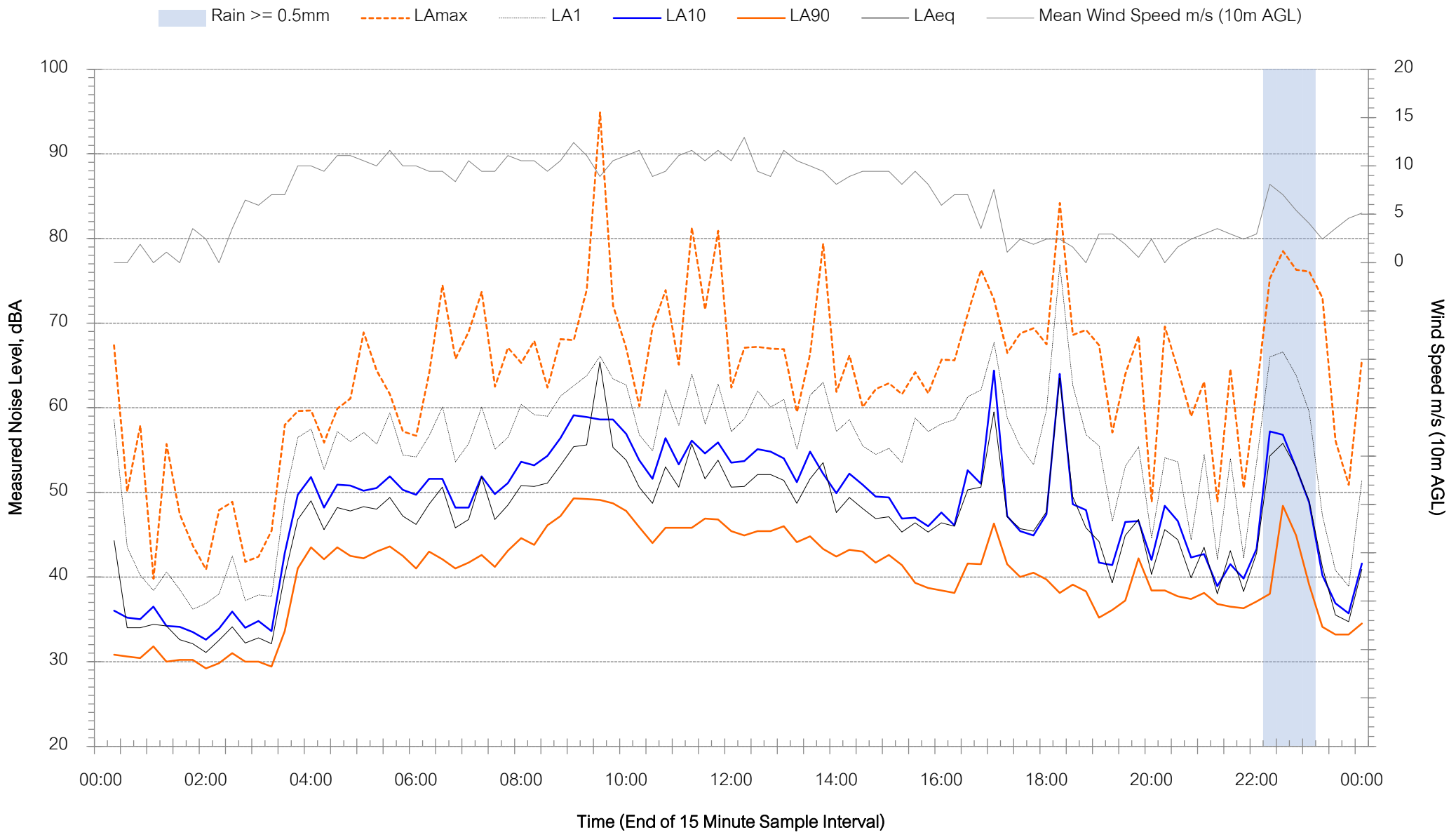
Background Noise Levels

Logan Street, Narrabri - Saturday 9 October 2021



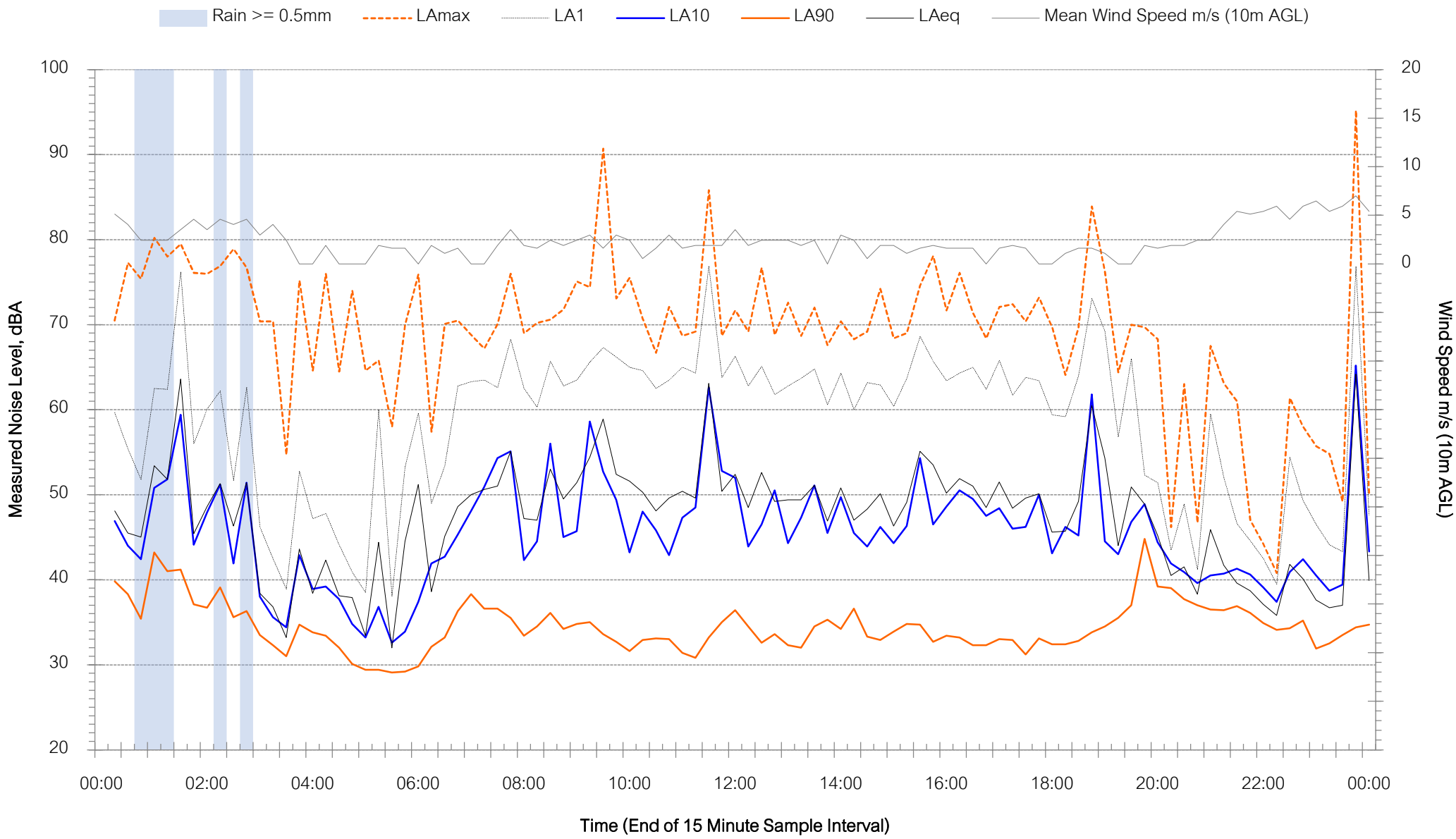
Background Noise Levels

Logan Street, Narrabri - Sunday 10 October 2021



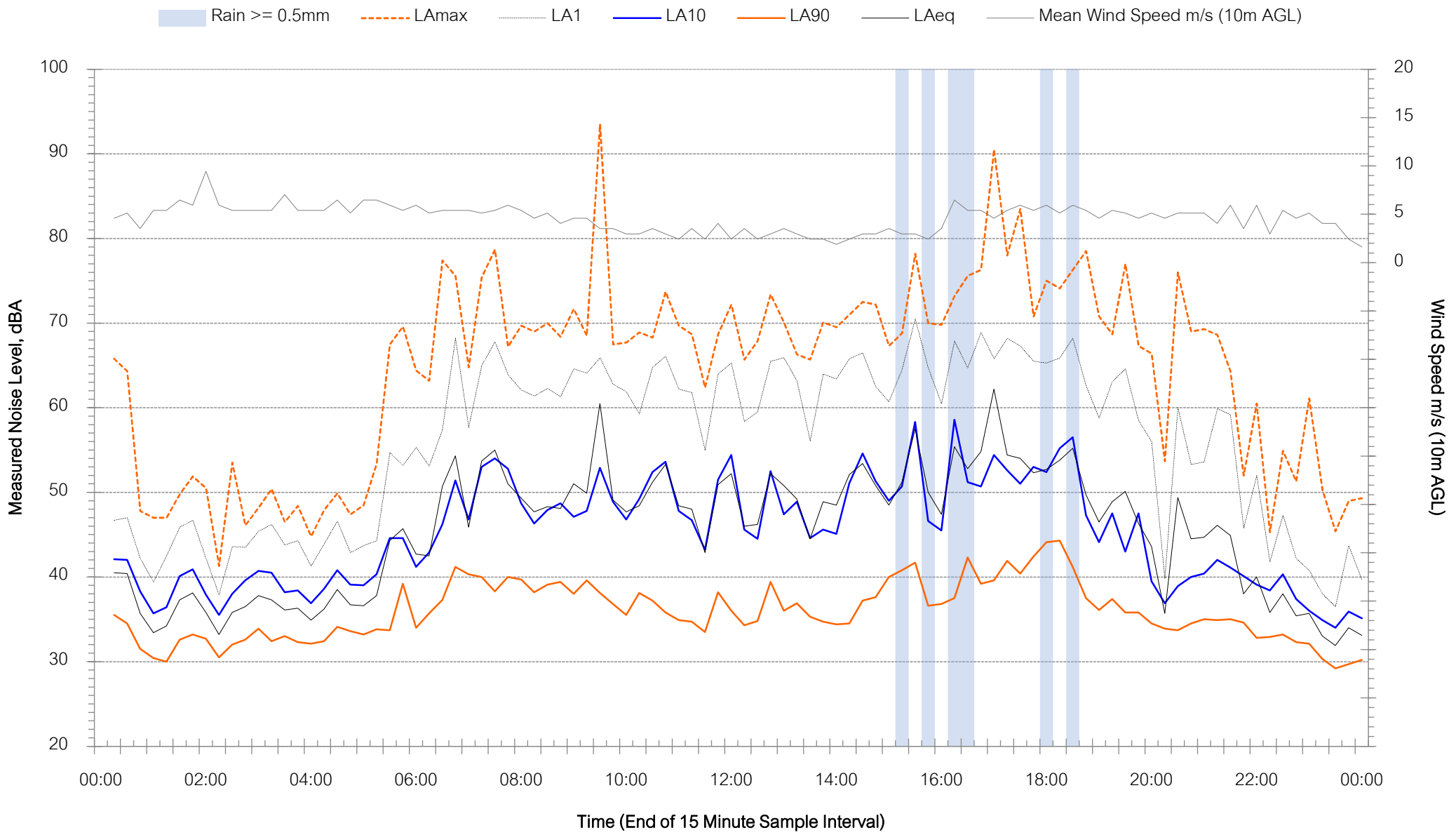
Background Noise Levels

Logan Street, Narrabri - Monday 11 October 2021



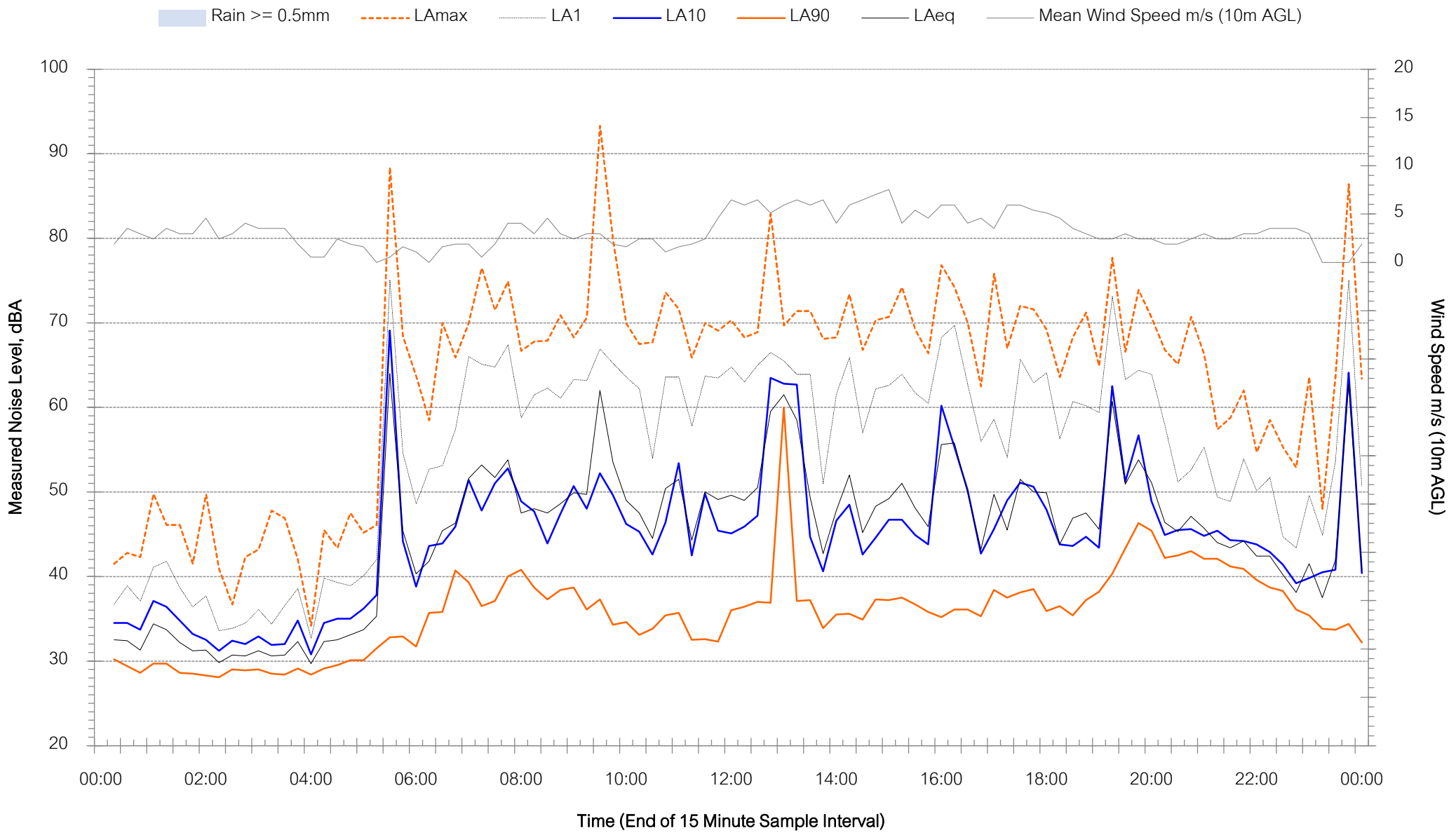
Background Noise Levels

Logan Street, Narrabri - Tuesday 12 October 2021



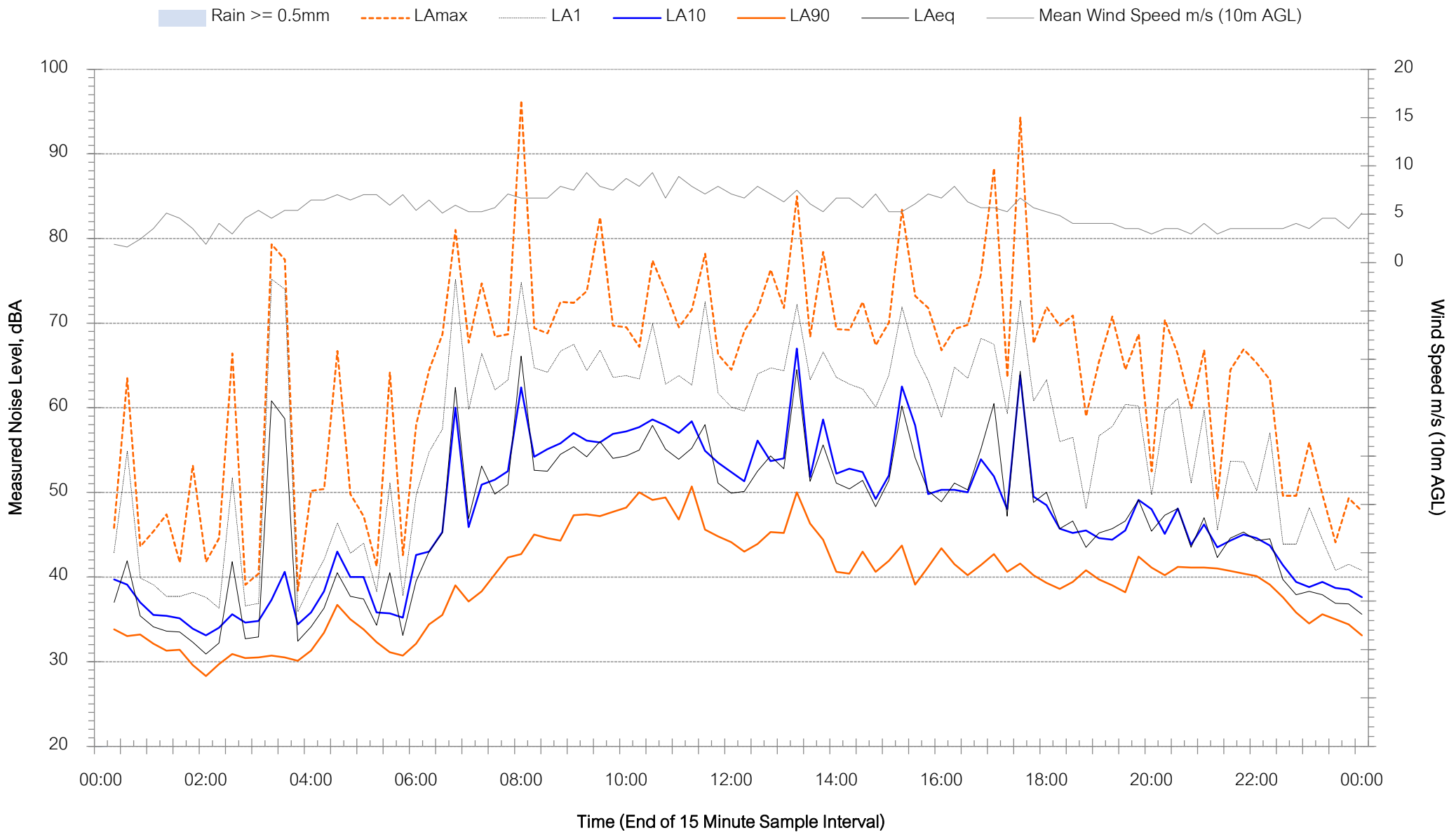
Background Noise Levels

Logan Street, Narrabri - Wednesday 13 October 2021



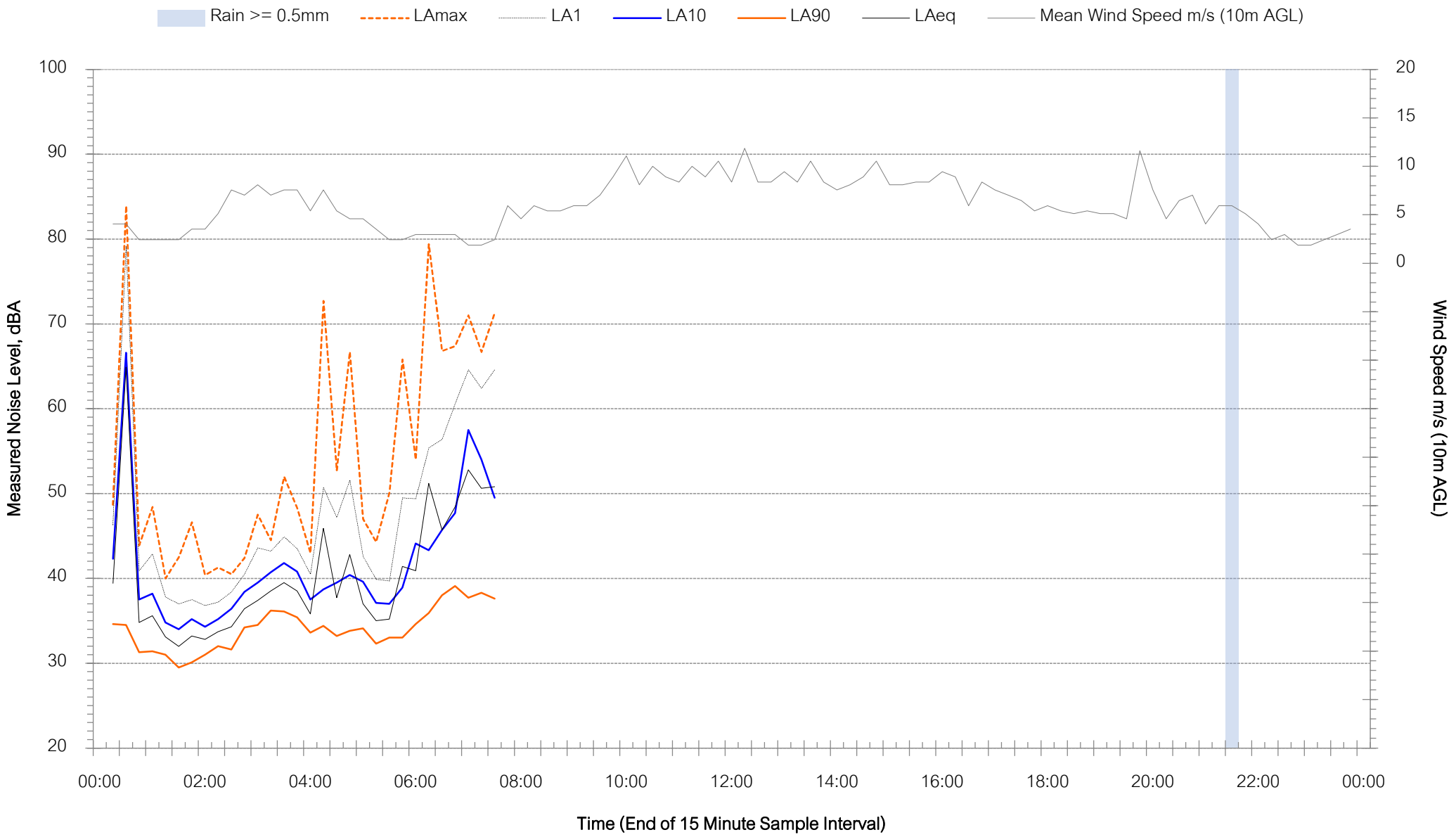
Background Noise Levels

Logan Street, Narrabri - Thursday 14 October 2021



Background Noise Levels

Logan Street, Narrabri - Friday 15 October 2021



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Appendix C – Affected Distances Mapping – Formation Reconstruction / Concrete Re-sleepering

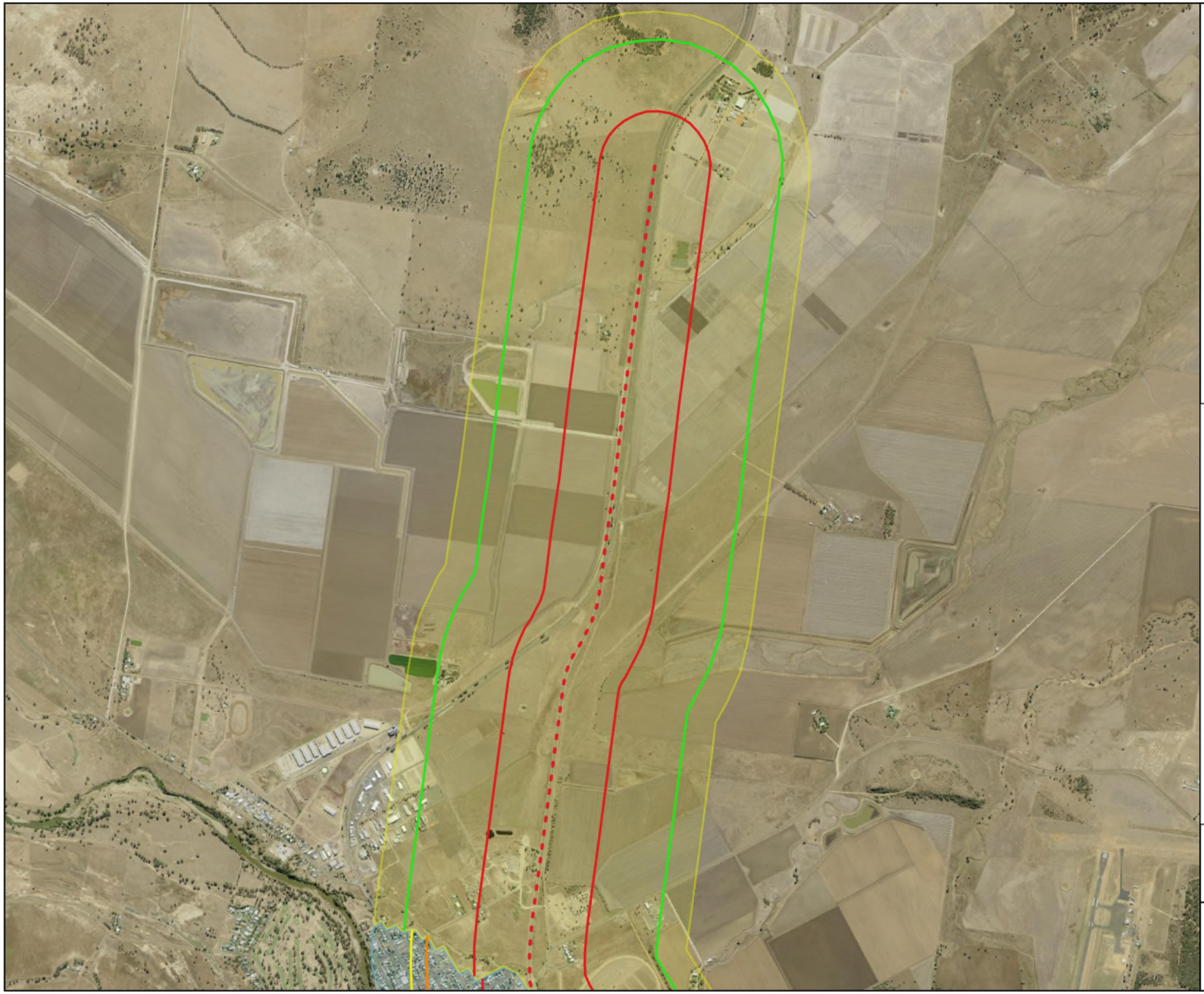

FIGURE C1

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

Narrabri Coal to Turrawan

Turrwan to Narrabri North

NCA 1

NCA 2

NCA 3

Affected Areas (Residential)

Day

Evening

Night

Evening/Night (NCA 3)

0 300 600 900 1200 m

N

MAC

FIGURE C2

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 100 200 300 400 m

N

MAC

FIGURE C3

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 100 200 300 400 m

N

MAC

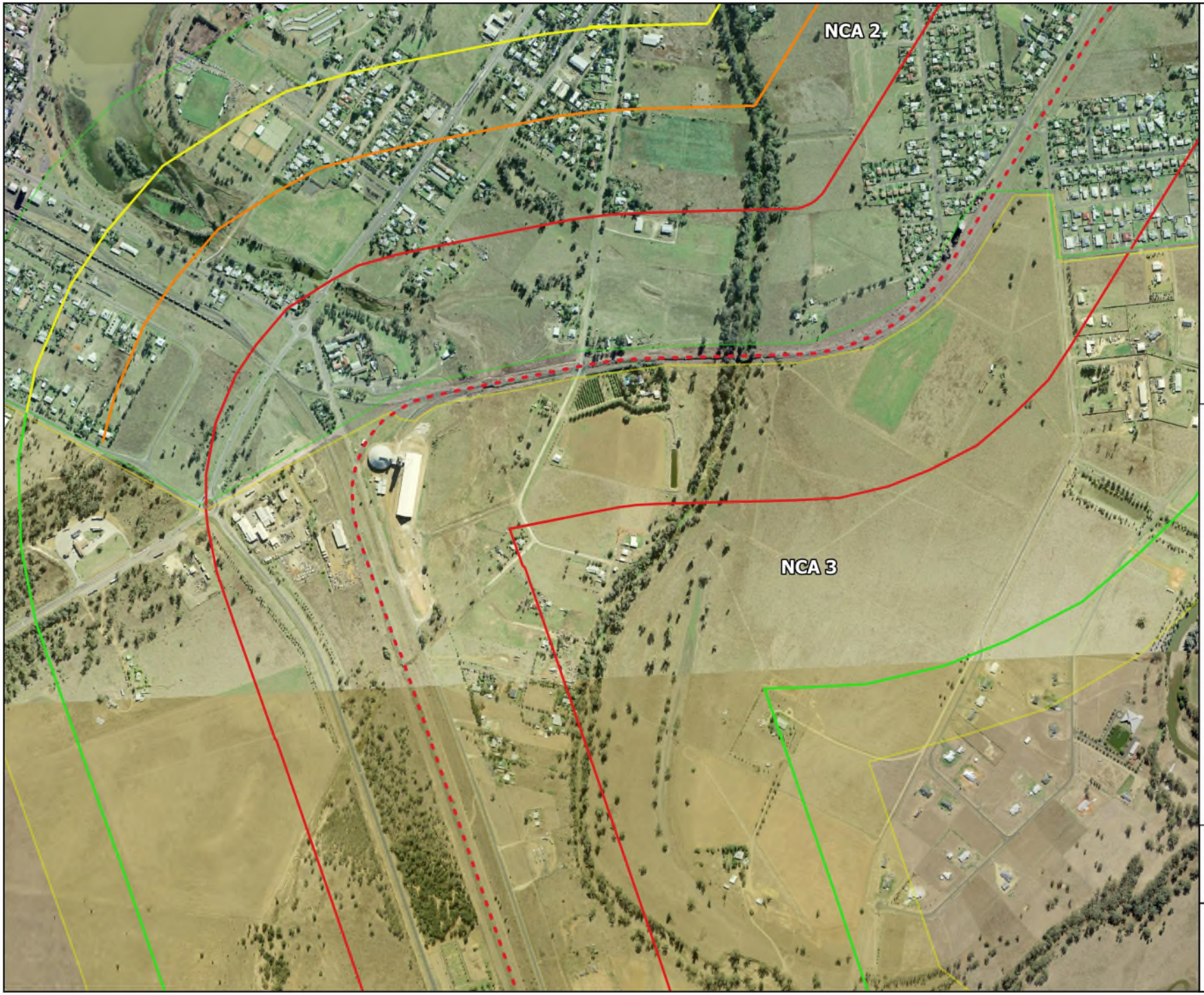

FIGURE C4

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 100 200 300 400 m

N

MAC

FIGURE C5

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 150 300 450 600 m

N

MAC

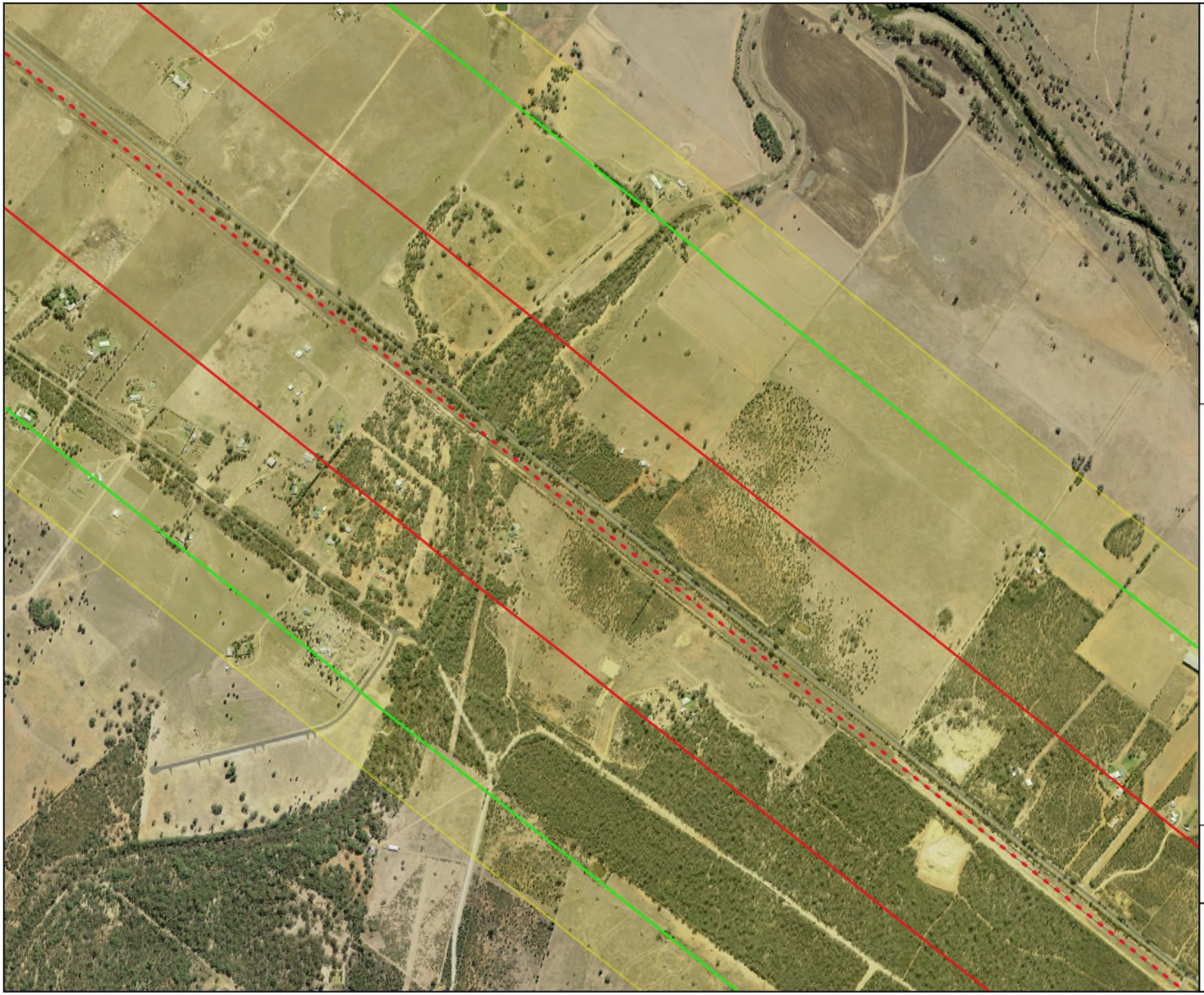

FIGURE C6

Affected Distances

Formation Reconstruction / Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 150 300 450 600 m

N

MAC
Muller Acoustic Consulting

FIGURE C7

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 150 300 450 600 m

N

MAC
Muller Acoustic Consulting

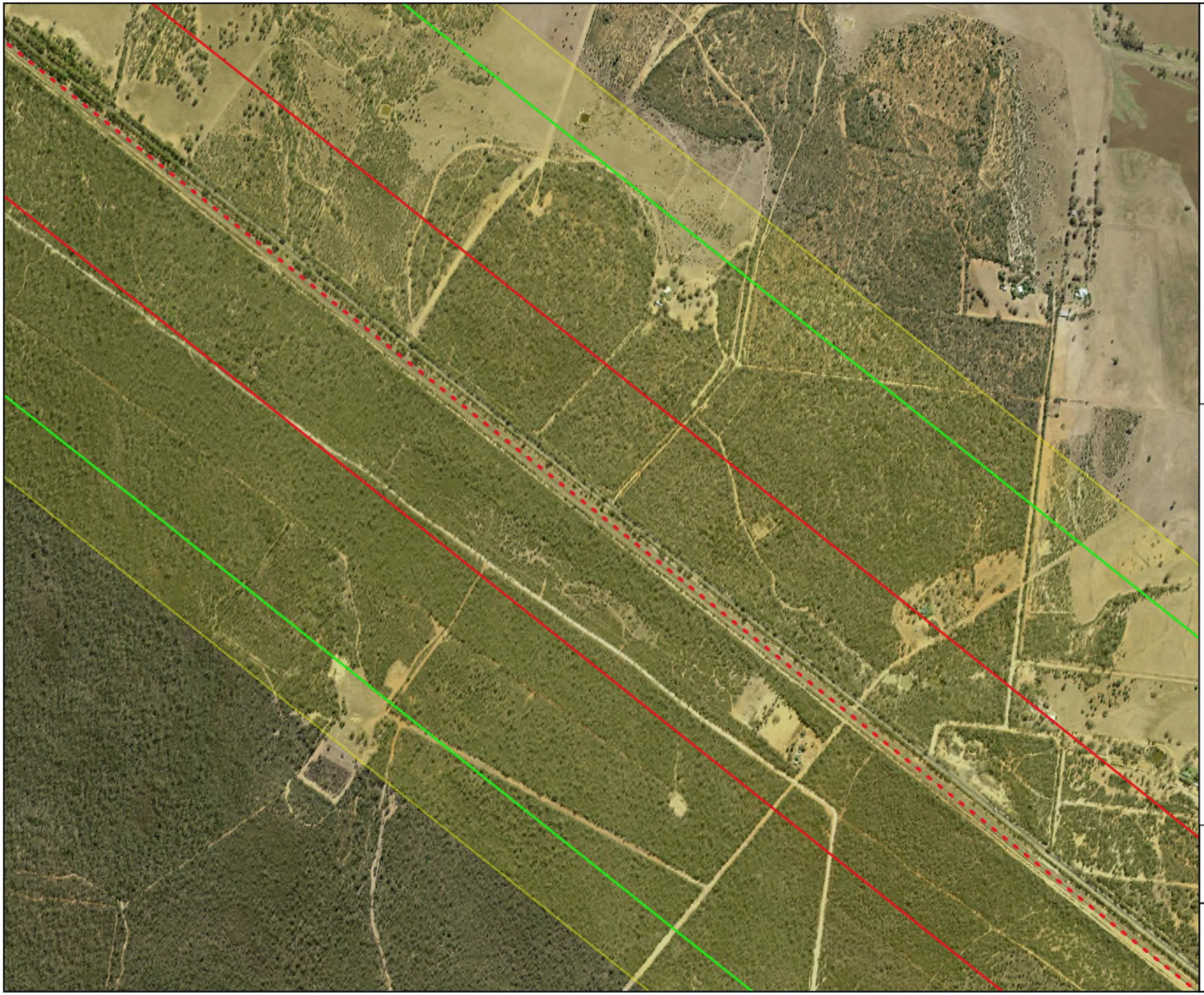

FIGURE C8

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 150 300 450 600 m

N

MAC
Muller Acoustic Consulting

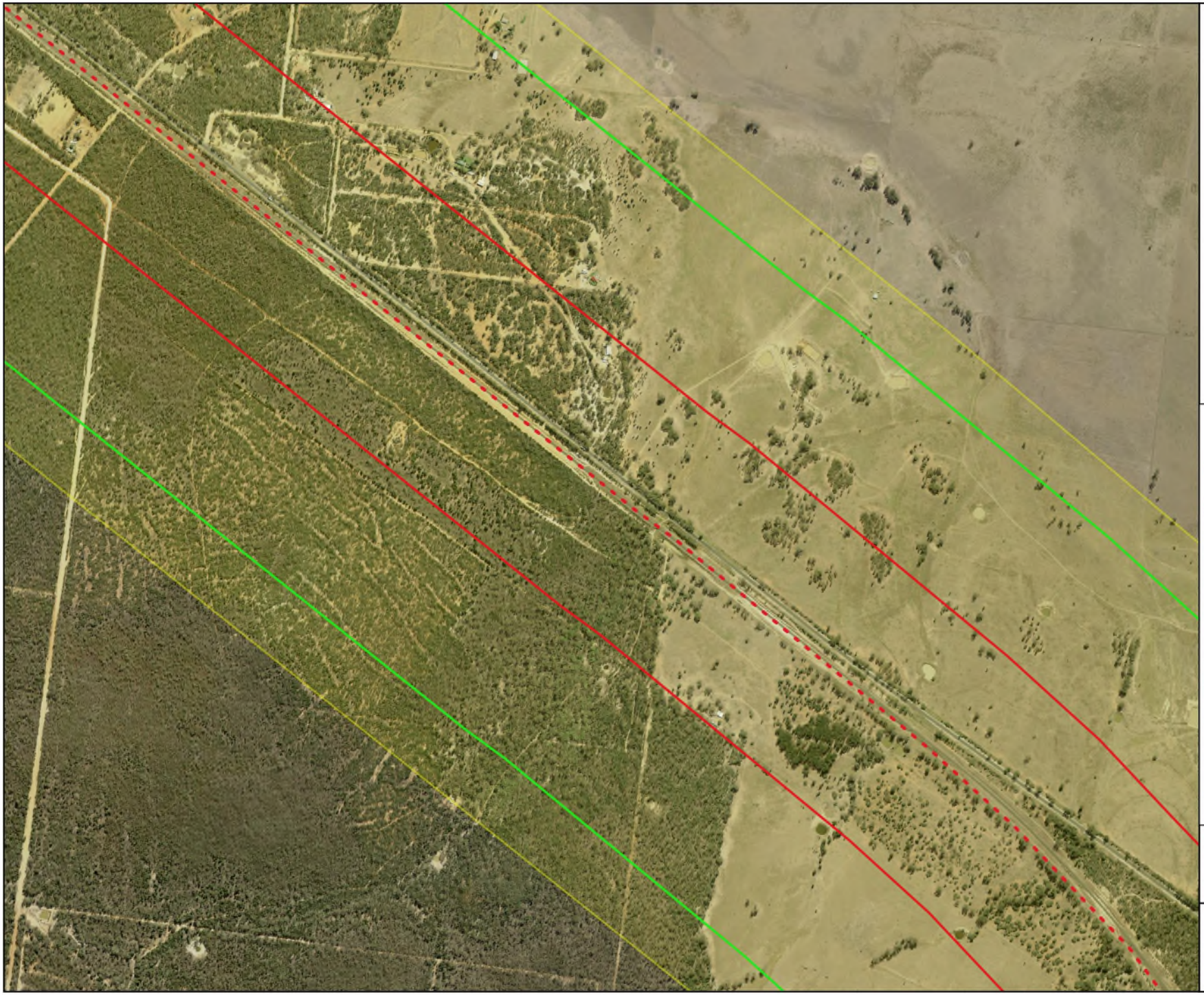

FIGURE C9

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 150 300 450 600 m

N

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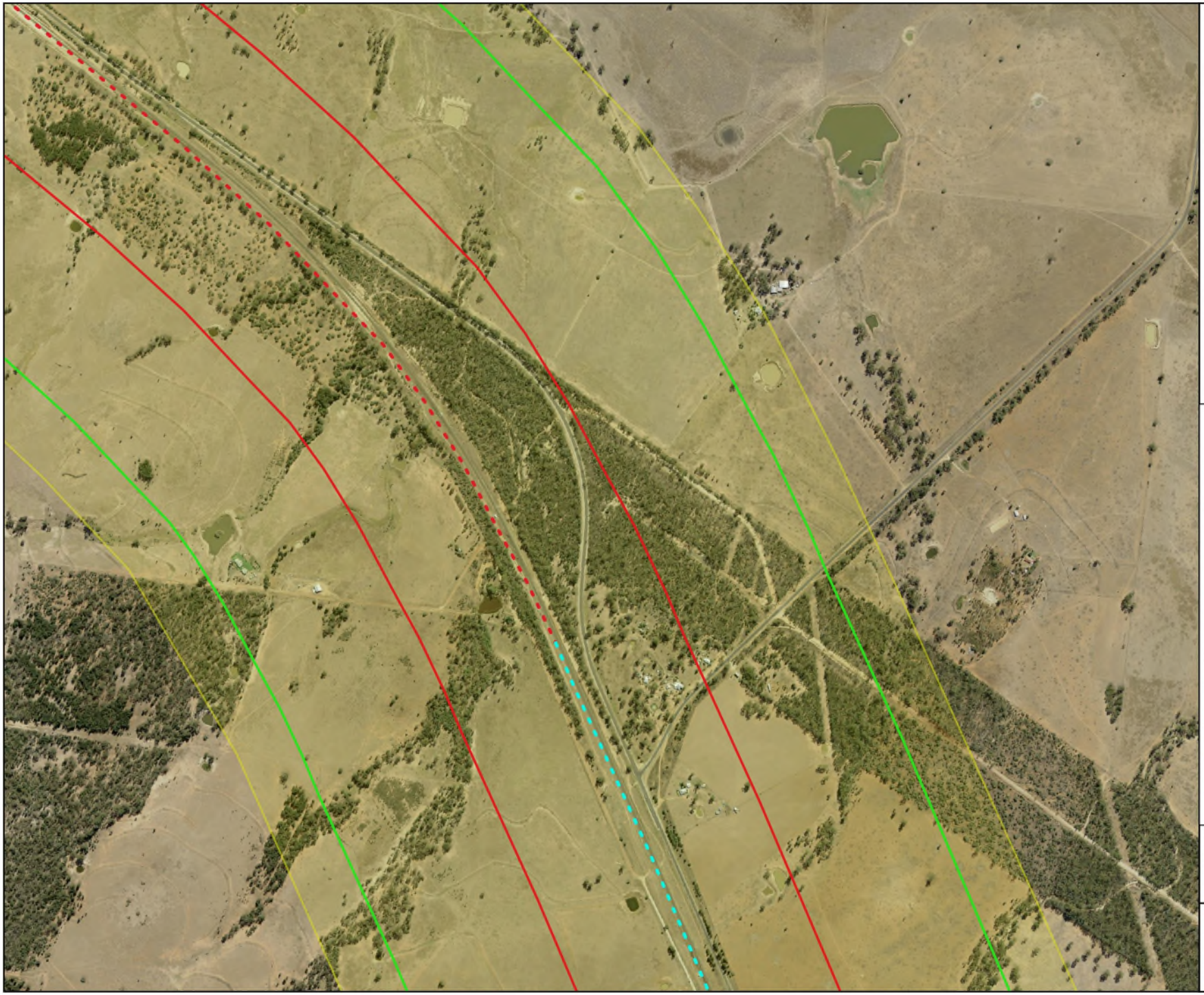

FIGURE C10

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 150 300 450 600 m

N

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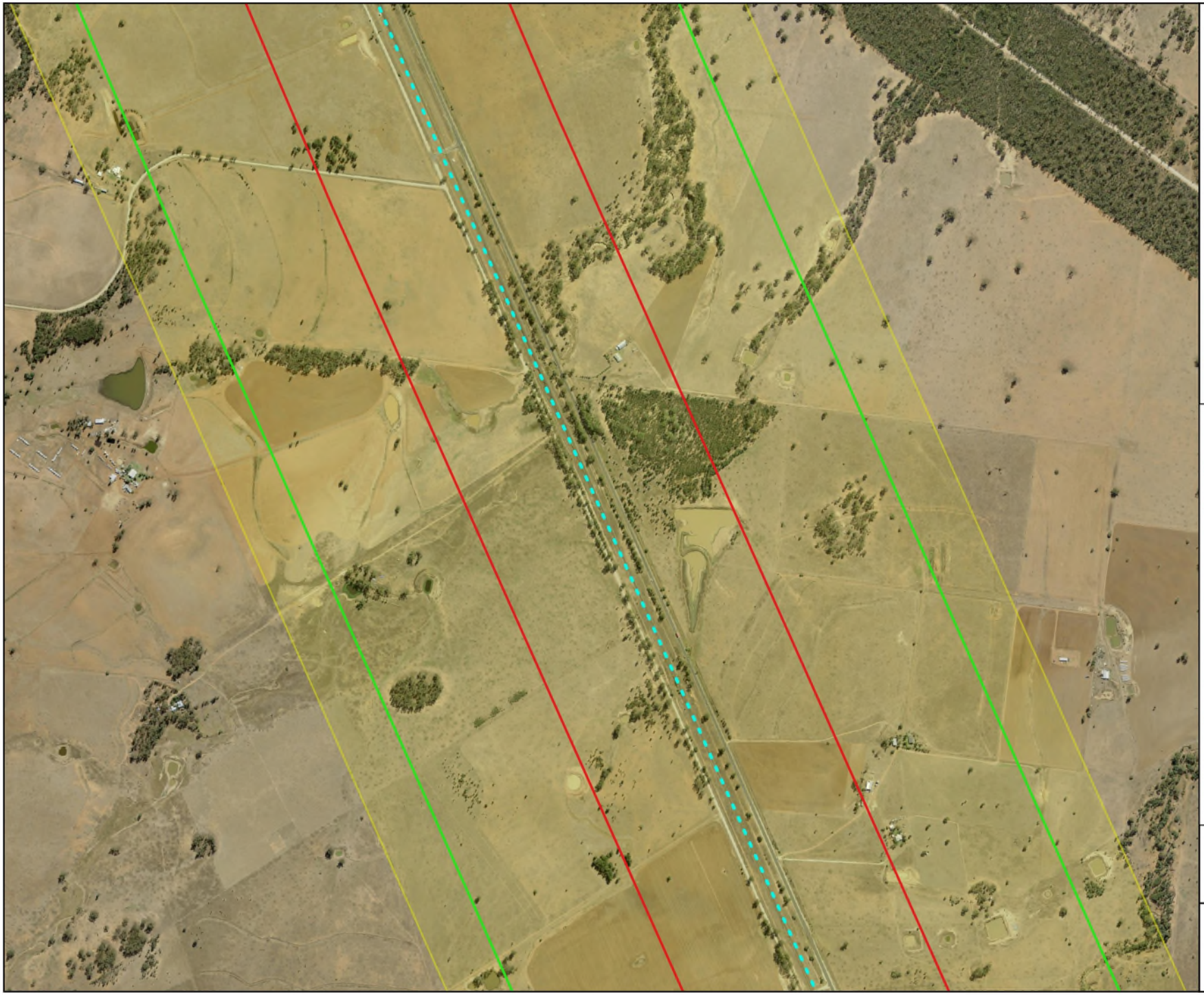

FIGURE C11

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 150 300 450 600 m

N

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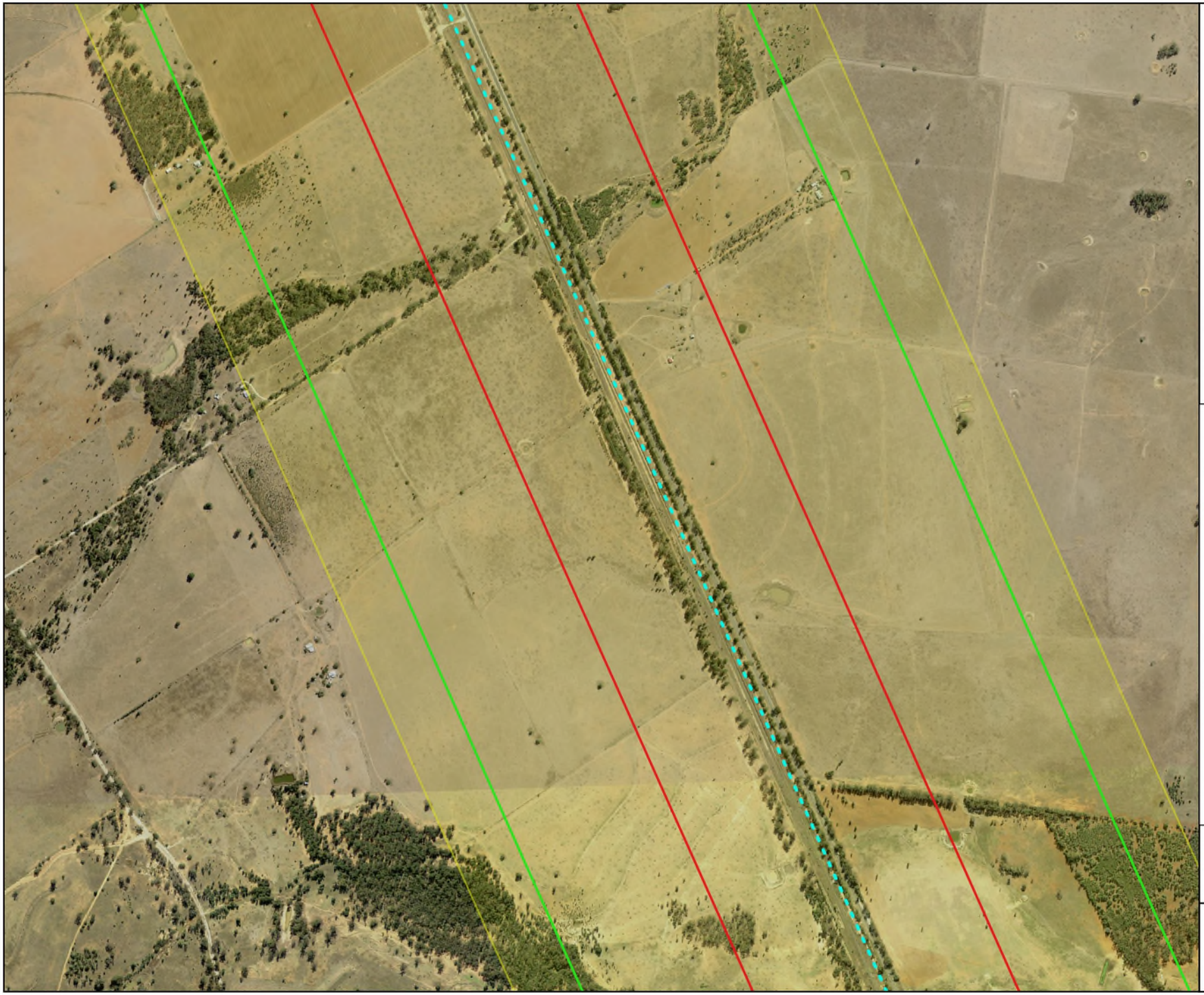

FIGURE C12

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

- Narrabri Coal to Turrawan
- Turrwan to Narrabri North
- NCA 1
- NCA 2
- NCA 3

Affected Areas (Residential)

- Day
- Evening
- Night
- Evening/Night (NCA 3)

0 150 300 450 600 m

N

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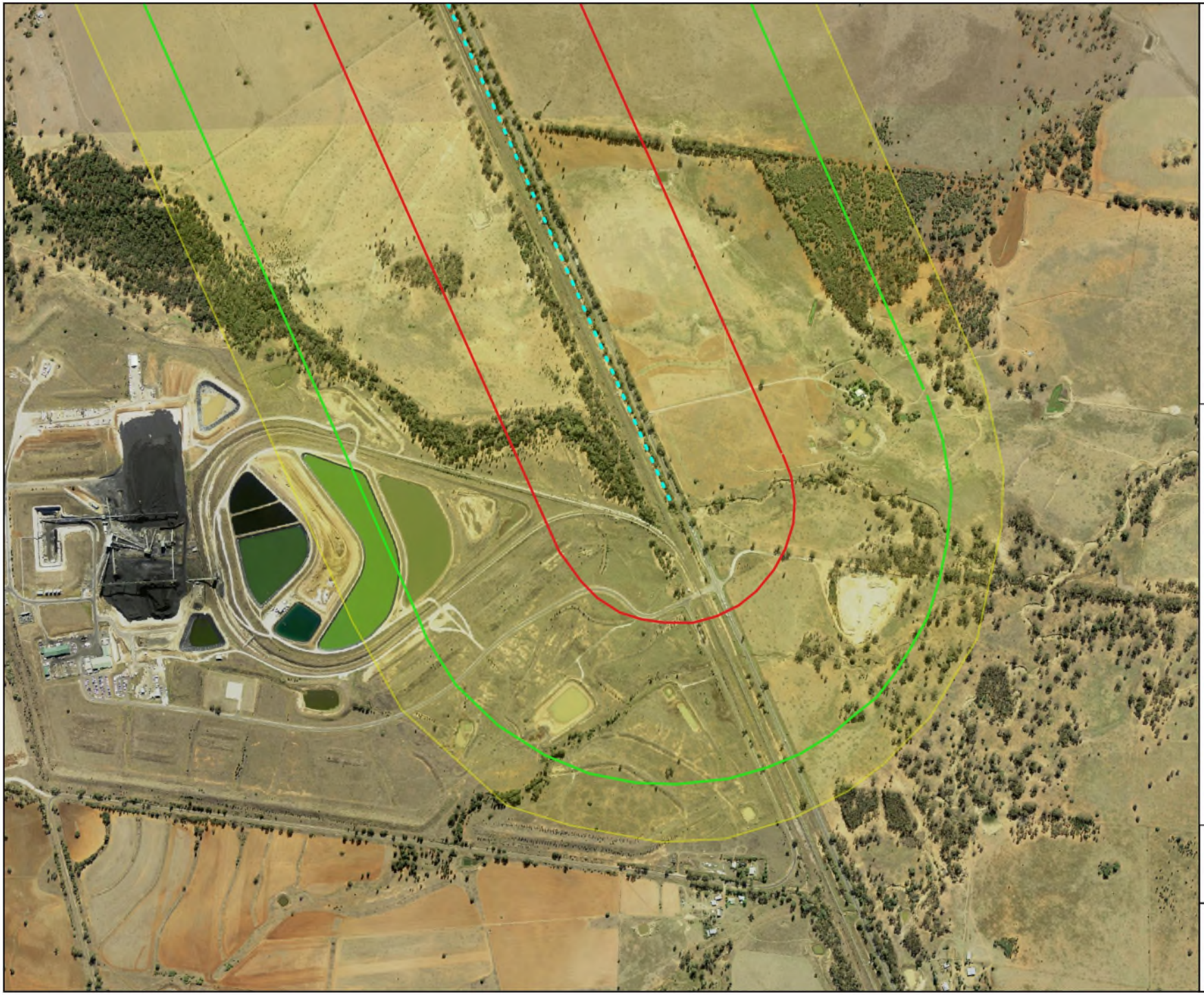

FIGURE C13

Affected Distances

Formation Reconstruction /

Concrete Re-sleepering

MAC211422-01

N2TLU Project

KEY

Narrabri Coal to Turrawan

Turrwan to Narrabri North

NCA 1

NCA 2

NCA 3

Affected Areas (Residential)

Day

Evening

Night

Evening/Night (NCA 3)

0 150 300 450 600 m

N

MAC

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