Operational, Construction Noise and Vibration Impact Assessment

MR349 Maitland Bay Drive and Picnic Parade
Intersection Upgrade
Ettalong Beach, NSW.

Prepared for: Beca Pty Ltd
September 2019
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MAC
Muller Acoustic Consulting

Document Information

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Intersection Upgrade Ettalong Beach, NSW.

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A number of technical terms have been used in this report and are explained in the following table.

Table A-1: Glossary of Terms

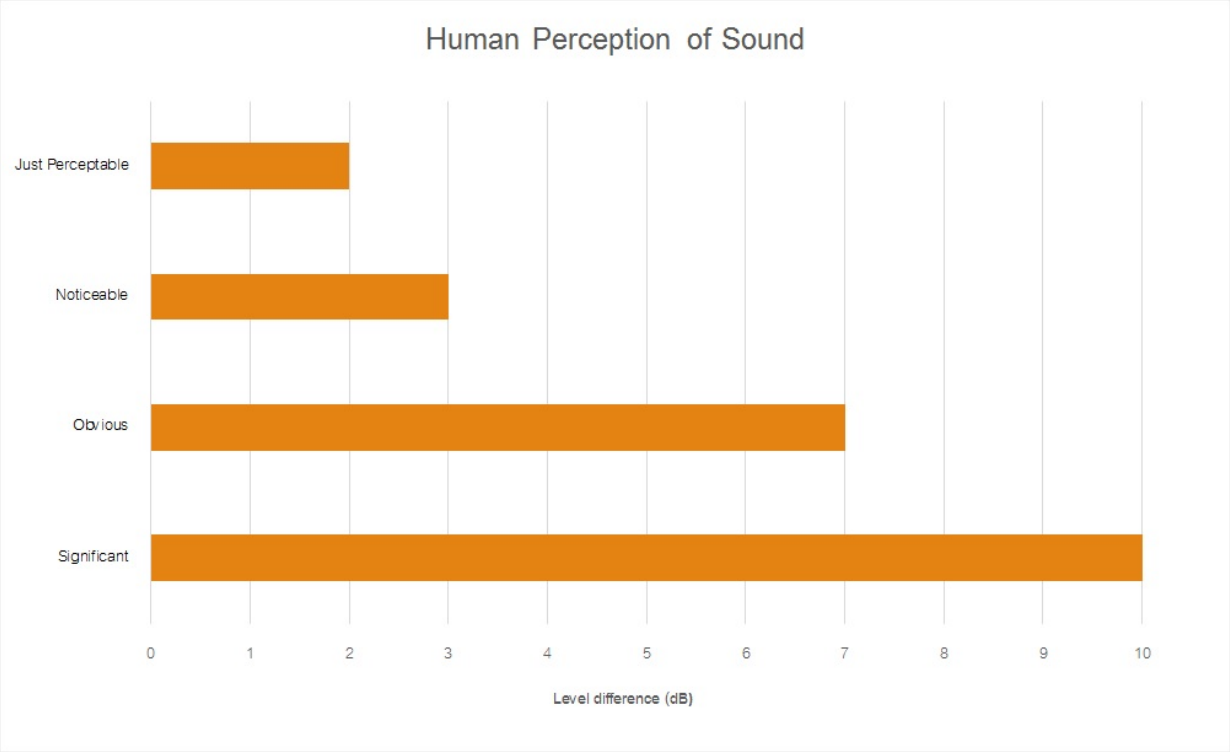
Term	Description
1/3 Octave	Single octave bands divided into three parts
Octave	A division of the frequency range into bands, the upper frequency limit of each band being twice the lower frequency limit.
ABL	Assessment Background Level (ABL) is defined in the INP as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L90 statistical noise levels.
Ambient Noise	The noise associated with a given environment. Typically a composite of sounds from many sources positioned both near and far where no particular sound is dominant.
A Weighting	A standard weighting of the audible frequencies designed to reflect the response of the human ear to noise.
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 Linear or decibels Z-weighted.
Hertz (Hz)	The measure of frequency of sound wave oscillations per second - 1 oscillation per second equals 1 hertz.
LA10	A noise level which is exceeded 10 % of the time. It is about the equivalent to the average of maximum noise levels.
LA90	Commonly referred to as the background noise, this is the level exceeded 90 % of the time.
LAeq	The summation of noise over a selected period of time. It is the energy average noise from a source, and is the equivalent continuous sound pressure level over a given period.
LAmax	The maximum root mean squared (rms) sound pressure level received at the microphone during a measuring interval.
RBL	The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the ABL's.
Sound power level (LW)	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental location of the source and is independent of the surrounding environment. Or a measure of the energy emitted from a source as sound and is given by : = 10.log10 (W/Wo) Where : W is the sound power in watts and Wo is the sound reference power at 10-12 watts.
Peak Particle Velocity	Peak Particle Velocity is the maximum instantaneous velocity of a particle at a point at any given time interval

Term	Description
OOHP1	Out of Hours Construction Period 1: Monday to Friday – 6pm to 10pm, Saturdays – 1pm to 6pm, Sundays 8am to 6pm.
OOHP2	Out of Hours Construction Period 2: Monday to Friday – 10pm to 7am, Saturdays/Sundays – 6pm to 7am (8am on Sunday mornings

Table A-2: Common Noise Sources and Their Typical Sound Pressure Levels (SPL), dBA

Source	Typical Sound Levels
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 A-1 – Human Perception of Sound



1 Introduction

Muller Acoustic Consulting Pty Ltd (MAC) has been commissioned by Beca Pty Ltd (Beca) on behalf of Roads and Maritime Services (Roads and Maritime) to complete an Operational, Construction Noise and Vibration Assessment for the proposed upgrade at the intersection of Maitland Bay Drive and Picnic Parade, Ettalong Beach, NSW.

This assessment is based on the finalised 100% concept design stage.

Construction is expected to commence in the second half of 2020 and would take around twelve months to complete, hence a quantitative assessment has been completed. Works are proposed to be predominantly carried out during standard construction hours (i.e. between 7am and 6pm) to minimise impact on the surrounding noise sensitive receivers and to improve worker safety, however several activities, which are presented in Section 2.1, will be conducted during out of hours periods to reduce the impact on traffic using the road.

This report presents the results, findings and recommendations of the Operational, Construction Noise and Vibration Assessment for the proposal and has been prepared to accompany the Review of Environmental Factors (REF) being prepared by Beca. The assessment has been carried out in general accordance with the following documents:

- Protection of the Environment Operations Act 1997 (POEO Act)
- Environment Protection Authority (EPA) 2017, NSW Noise Policy for Industry (NPI)
- Roads and Maritime Services (Roads and Maritime) 2015, Construction Noise and Vibration Guideline (CNVG)
- Department of Environment and Climate Change (DECC) 2009, Interim Construction Noise Guideline (ICNG)
- Australian Standard AS 2436-2010 (R2016) Guide to Noise Control on Construction, Maintenance and Demolition Sites
- Roads and Maritime Services (Roads and Maritime) 2015, Noise Criteria Guideline (NCG)
- Roads and Maritime Services (Roads and Maritime) 2015, Noise Mitigation Guideline (NMG)
- AS IEC 61672.1-2019 Electroacoustics - Sound level meters - Specifications
- Standards Australia - AS 1055.1-2018 Acoustics - Description and measurement of environmental noise
- Department of Environment and Conservation (DEC) 2006, Assessing Vibration: A Technical Guideline
- German Standard DIN4150-3 Structural Vibration: Effects of vibration on structures.
- British Standard 7385:2:1993 Evaluation and measurement for vibration in buildings, Part 2 Guide to damage levels from groundborne vibration.

- Roads and Maritime Services QA Specification PS211 Project Review of Environmental Factors for Maitland Bay Drive Picnic Parade Intersection Upgrade
- Roads and Maritime Services QA Specification PS311 Environmental Compliance for Maitland Bay Drive Picnic Parade Intersection Upgrade

1.1 Objectives of this Assessment

The key objectives of this assessment are to quantify potential operational noise, construction noise and vibration emissions from the proposal.

Areas addressed in this assessment report include:

- Provide a technical document that can support the overall REF for the proposal
- Identification of sensitive receivers
- Quantifying potential operational noise, construction noise and vibration impacts from the proposal based on the proposal brief information
- Review reasonable and feasible control measures to mitigate noise and vibration emissions with the aim of meeting noise management levels and relevant vibration criteria

The structure and format of this report has been prepared in accordance with Roads and Maritime documents Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report (Roads and Maritime, 2016), and the Editorial Style Guide (Roads and Maritime, 2019).

2 Proposal Description

2.1 General

Roads and Maritime propose the upgrade of the intersection of Maitland Bay Drive and Picnic Parade, Ettalong Beach with the replacement of the current seagull intersection with a single lane roundabout with a single approach and departure lane to be maintained. (See **Appendix A** for concept plans.)

The key features included in the proposal design are:

- Widening of the southern side Maitland Bay Drive to the west of Picnic Parade
- Provide a single lane roundabout to improve safety and road usage
- Relocation and adjustment of utilities as needed by the upgrade work
- Provide improved pedestrian and cycleway within the proposal area

The proposal also includes the modification to the existing road surface and the partial acquisition of Ettalong Oval on the southern side of Maitland Bay Drive.

The primary objectives of the proposal are:

- Reduce queuing time and projected delays on Picnic Parade during peak periods
- Improve access to the Ettalong business and leisure precinct
- Improve safety for all road users at the intersection including vehicle passengers, pedestrians and cyclists

Construction is expected to commence in July 2020 and would take around nine months to complete, hence as construction is in excess of three weeks, as per INCG guidance a quantitative assessment has been completed. The majority of work will be carried out during standard construction hours (i.e. between 7am and 6pm) to minimise impact on the surrounding noise sensitive receivers and to improve worker safety. The location of the proposal is shown in Figure 3-1 and an overview of the proposal is provided in Figure 3-2. The key noise generating activities along with their proposed construction hours are listed below:

- Site Establishment
- Vegetation Clearing
- Utility Relocation
- Milling of Road Surface
- Kerb work and Construction of Roundabout/Installation of Safety Barriers
- New Asphalt Layers Construction
- Line marking and installation of Road Furniture

A potential temporary construction compound site has been identified for the proposal. The potential compound is situated in the northern end of Ettalong Oval, as illustrated in Figure 3-1. The compound would facilitate secure parking and storage of plant and equipment associated with the proposal and leased for a period of about 12 months pending landholder agreement. Parking for vehicles during the proposed construction work would be available in the temporary compound site car park or on the road verge.

3 Existing Ambient Noise Environment

The community's reaction to noise from construction may be influenced by the time of day that work is carried out. Residents are potentially more affected by work that occurs during out of hours (OOH) periods (ie evening or night periods). Therefore, it is important to understand the existing noise environment surrounding the proposal to manage and minimise potential noise impact on the environment and local community.

The proposed site is in the suburban area of Ettalong Beach, NSW and with residential receivers located to the south and south east of the proposal with several active and passive recreational areas also located to the south side of the proposal. Figure 3-1 provides a locality plan identifying the key work areas of the proposal in relation to surrounding receivers. The worst case receivers which are directly next to the proposal work are also identified in Figure 3-1.

3.1 Unattended Noise Monitoring

To establish the existing background noise environment of the proposal area, unattended noise logging was conducted at one location, 2A Picnic Parade, Ettalong Beach, NSW, which is the closest residential receiver to the proposal. The monitoring location (L1) is representative of the surrounding noise sensitive receptors to the proposal. The location was selected taking into account ambient noise sources which may influence the readings, the proximity of assessment locations to the proposal and security issues. The selected monitoring location is shown in Figure 3-1.

The noise survey was conducted in general accordance with the procedures described in Australian Standard AS 1055:2018, "Acoustics - Description and Measurement of Environmental Noise". Measurements were carried out using one Svantek Type 1, Svan 977 noise monitor from Friday 10 May 2019 to Tuesday 21 May 2019. This period meets the minimum one-week period for baseline noise monitoring as per Fact Sheet A of the NPI and coincided with traffic counts for the proposal. Observations on-site identified the surrounding locality typical of a suburban environment, with traffic noise the dominant audible noise source. Calibration of all instrumentation was checked before and after measurements. Drift in calibration did not exceed ±0.5 dBA. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates. Data affected by adverse meteorological conditions have been excluded from the results in accordance with methods provided in the NPI. The results of long-term unattended noise monitoring are provided in Table 3-1 The noise monitoring charts for the background logging assessment are provided in Appendix B.

Table 3-1: Background Noise Monitoring Summary

Location	Measured background noise level, RBL, dBA			Measured LAeq, dBA		
	Day 7am to 6pm	Evening 6pm to 10pm	Night 10pm to 7am	Day 7am to 6pm	Evening 6pm to 10pm	Night 10pm to 7am
L1	57	44	34	68	63	60

Note 1: Excludes periods of wind or rain affected data, meteorological data obtained from the Bureau of Meteorology Gosford AWS (33.4°S 151.36°E 7m AMSL).

The monitored noise levels at L1 are representative of the ambient noise environment of any property along an arterial or major road. The noise levels are controlled throughout the day and evening period due to passing road traffic. The noise levels are lower during the night period with levels representative of occasional traffic and general suburban hum. This is in keeping with the variation in traffic flows from traffic counts.

FIGURE 3-1

LOCALITY PLAN

REF: MAC190795

0 100m

KEY

- R1 — RESIDENTIAL RECEIVER
- AR1 — ACTIVE RECREATION RECEIVER
- PR1 — PASSIVE RECREATION RECEIVER
- SITE LOCATION
- SITE COMPOUND
- L1 — MONITORING LOCATION

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FIGURE 3-2

PROPOSAL OVERVIEW

REF: MAC190795

0 50m

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4 Assessment of Traffic Noise Impact

4.1 Operational Road Noise Criteria

In accordance with Section 5.5 of the Noise Criteria Guideline (NCG) (Roads and Maritime, 2015), the proposal is classified as minor work. Section 5.5 of the NCG is reproduced below:

'Some work may be primarily to improve safety. This may include minor straightening of curves, installing traffic control devices, intersection widening and turning bay extensions or making minor road adjustments. These works are not considered redeveloped or new as they are not intended to increase the traffic carrying capacity of the overall road or accommodate a significant increase in heavy vehicle traffic.'

Section 6.6 of the NCG outlines that the existing road criteria applies where the minor work increase noise levels by more than 2.0 dBA relative to the existing noise levels at the worst affected receiver. Table 4-1 presents the existing road criteria from the NCG

Table 4-1: Existing Road Noise Criteria

Road Category	Type of project/ land use	Assessment criteria – dB(A)	
		Day (7am-10pm)	Night (10pm-7am)
Freeway/arterial/sub arterial roads	Existing residences affected by noise from redevelopment of existing freeway/arteria/sub-arterial roads	$L_{Aeq\ (15\ hour)}$ 60 (external)	$L_{Aeq\ (9\ hour)}$ 55 (external)
Locals Roads	Existing residences affected by noise from new local road corridors	$L_{Aeq\ (1\ hour)}$ 55 (external)	$L_{Aeq\ (1\ hour)}$ 50 (external)

There will be no change in traffic volumes using Maitland Bay Drive and Picnic Parade due to the proposal, as the proposal's primary aim is to reduce queue time for road users at the intersection and not to address an increase in traffic on the junction. This is outlined in the Traffic and Transport Assessment being prepared for the upgrade (Cardno, June 2019) which outlines a maximum increase in traffic along Maitland bay Drive by 2039 of 1.34% which is considered negligible.

However the distance to receivers is reducing at the nearest residential receiver, 2A Picnic Parade, as a result of the proposal. Therefore, in accordance with section 6.6 of the NCG, the proposed work is classified as minor works. Notwithstanding future noise levels may increase existing levels at the nearest receiver by more than 2 dBA, hence, operational traffic noise has been reviewed as per the NCG.

4.2 Operational Road Noise Assessment

4.2.1 Existing Traffic Flows

Traffic data for the existing traffic travelling along Maitland Bay Drive and Picnic Parade has been quantified using traffic counters and adopted to calibrate the noise model for the proposal. The traffic data was collected between Friday 10 May 2019 and Friday 17 May 2019. Table 4-2 presents the results of the traffic counts for both directions of flow of traffic.

Table 4-2: Existing Traffic Flows

Road	Day (07:00 to 22:00)			Night (22:00 to 07:00)		
	Average Daily Traffic Flow Volume	%Heavy Vehicles	Speed Limit	Average Daily Traffic Flow Volume	%Heavy Vehicles	Speed Limit
Maitland Bay Drive Westbound West of Picnic Parade	8203	3.5	70	1067	5.5	70
Maitland Bay Drive Eastbound West of Picnic Parade	880	4.1	70	499	6.2	70
Maitland Bay Drive Westbound East of Picnic Parade	8824	4.6	70	1049	7.1	70
Maitland Bay Drive Eastbound East of Picnic Parade	9335	4.8	70	522	8.6	70
Picnic Parade Northbound	2943	5.1	60	192	7.8	60
Picnic Parade Southbound	3012	5.9	60	154	11.7	60

4.2.2 Noise Modelling Parameters

The operational road traffic assessment has been completed utilising the Calculation of Road Traffic Noise (CoRTN) which was developed by the United Kingdom Department of Environment. This modelling method is widely accepted in Australia and the preferred method for assessing operational road traffic emissions by the NSW Environmental Protection Agency (EPA) and the Roads and Maritime.

Brüel and Kjær Predictor Type 7810 (Version 11.10) noise modelling software was used to assess operational traffic noise impacts from the proposal. The model incorporated three-dimensional ground contours, and buildings along Maitland Bay Drive and Picnic Parade and the surrounding locality. Table 4-3 presents the parameters used in the modelling process

Table 4-3: Road Traffic Noise Parameters

Paramater	Adopted Value
Road Surface	Standard dense graded asphalt
Source Height	0.5m cars
	0.5m truck tyres
	3.6m truck exhausts
Receiver height	1.5m above ground level
Receiver location	1m from the building façade
Receiver façade reflection	+2.5 dBA
Ground Absorption Coefficient	0.6
L10 to Leq Correction	-3 dBA
ARRB Correction	-1.7 dBA
Modelled Road Speed	Maitland Bay Drive - 80km/hr
	Picnic Parade - 60km/hr

4.3 Operational Traffic Noise Results

4.3.1 Model Validation

The noise model was validated using the results of the unattended noise logger (L1) installed at 2A Picnic Parade, next to the proposal site. Table 4-4 summaries the results of the validation modelling, outlining the modelled traffic noise levels for existing conditions compared to the measured traffic noise levels at location L1.

Table 4-4: Road Traffic Model Noise Validation

Location	LAeq,15hr Daytime Noise Level			LAeq,9hr Night-time Noise Level		
	Measured Level	Predicted Level	Variance	Measured Level	Predicted Level	Variance
L1 2A Picnic Parade	66.9	67.1	0.2	59.6	59.4	-0.2

4.3.2 Comparison of Existing and Future Traffic Noise Levels

In accordance with the Roads and Maritime Procedure for Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report (Roads and Maritime, 2016), an assessment of road traffic noise has been carried out for the existing and future road. It is reiterated that the proposal is not expected to increase traffic volumes or change the traffic mix.

Noise levels for existing and future traffic were quantified by direct calculation to three key receivers along the proposal site. These are noted to be the potentially most affected because of road traffic noise from the proposal. Remaining receivers have been reviewed and are anticipated to not receive a change in road traffic noise levels from the proposal. able 4-5 presents the results of the road traffic noise assessment for each scenario.

Table 4-5: Road Traffic Noise Results

Receivers[1]	Day Predicted level, LAeq(15hr), dBA			Night Predicted level, LAeq(9hr), dBA		
	Existing	Future (with build)	Change, dB	Existing	Future (with build)	Change, dB
AR1 Broken Bay Scout Hall	63.3	65.2	1.9	Not in Use		
R6 Ingenia Lifestyle Ettalong Beach	66.4	67.6	1.2	58.9	60.2	1.3
R17 2A Picnic Parade	65.6	66.5	0.9	57.9	59.2	1.3
RNP Target Noise Criteria						
LAeq(15hr) 60			LAeq(9hr) 55			

Note 1: Levels calculated to the most exposed façade, excludes dwelling structure and includes +2.5dB façade correction.

4.3.3 Discussion of Road Traffic Noise Level Results

A comparison of the existing and future (ie post proposal) traffic noise levels identify that Maitland Bay Drive is the significant contributor to received noise levels in the locality surrounding the proposal and in particular the proposed change in noise levels are anticipated to increase by less than 2 dB at all receivers.

The NSW EPA Road Noise Policy does not provide any sleep disturbance criteria for assessing the maximum noise events associated with vehicle passbys. The ENMM outlines that a maximum noise assessment is to be used “as a tool to help prioritise and rank mitigation measures” however also states that they ‘should not be applied as a decisive criterion in itself”, Notwithstanding the above the ENMM also states that maximum internal noise levels below 50-55dBA are unlikely to cause awakenings reactions.

For the proposal, the near point of vehicle passby on Picnic Parade at the nearest receiver (R17) is not changing with passby speeds also expected to remain unchanged. A maximum passby sound power of 104dBA for heavy vehicles will results in a received noise level at the façade of R17 of 74dBA. Taking into account a 20dBA loss for glazing, the predicted maximum internal noise level from traffic is 54dBA, which meets the maximum allowable internal level outlined in the ENMM. It is reiterated that these levels are consistant with the maximum levels currently being received at the dwelling.

4.4 Construction Generated Road Noise

The precise number of site construction personnel on this proposal was not available when this assessment was being completed. It is noted that further refinement to the final construction methodology is pending, with the exact number of site personnel to be finalised prior to construction. Notwithstanding, a construction road noise level assessment has been completed assuming a worst case of 40 construction personnel on average per shift, which is a typical of such sized proposal, using the designated car park at the site compound in the north west corner of the proposal site (see Figure 3-1). It is noted that this is representative of the peak onsite personnel during the labour intensive activities and will only be during short durations during the 12 month proposal program The worst-case hypothetical day time assessment of road noise emissions using Calculation of Road Traffic Noise (CORTN) for construction generated road traffic will be about 35 dBA, LAeq(15hr) and will not exceed the relevant daytime and night-time road noise criteria and not increase existing levels by more than 2 dB. Therefore, road traffic noise impacts from site construction personnel are anticipated to be negligible when compared against existing traffic volumes experienced across the intersection for the standard construction hours period. A comparison of the predicted construction traffic noise emissions and the existing traffic flows along Maitland Bay Drive is presented in Table 4-6.

Table 4-6:Construction Traffic Noise Results

Receiver	Day Period, LAeq(15hr)				Night Period, LAeq(9hr)			
	Noise from Existing Road Traffic	Construction Generated Traffic Noise	Cumulative Traffic Noise Level including Construction Traffic Noise	Increase in Traffic Noise Level	Noise from Existing Road Traffic	Construction Generated Traffic Noise	Cumulative Traffic Noise Level including Construction Traffic Noise	Increase in Traffic Noise Level
R6 Ingenia Lifestyle Ettalong Beach	66.4	35.0	66.4	0.0	58.9	35.0	58.9	0.0
R17 2A Picnic Parade	65.6	35.0	65.6	0.0	57.9	35.0	57.9	0.0

5 Construction Noise Criteria

5.1 Interim Construction Noise Guideline

The assessment and management of noise from construction work is completed with reference to the ICNG. The ICNG is specifically aimed at managing noise from construction work regulated by the EPA, and is used to help in setting statutory conditions in licences or other regulatory instruments. The types of construction regulated by the EPA under the POEO Act (1997), include construction, maintenance and renewal activities carried out by a public authority, such as road upgrades as described in Schedule 1 of the POEO Act.

The ICNG sets out procedures to identify and address the impact 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 proposals with typical durations of more than three weeks
- Qualitative, which is suited to short term infrastructure maintenance (for proposals with a typical duration of less than three weeks).

The method for a quantitative assessment needs a more complex approach, involving noise emission predictions from construction activities to the nearest relevant receivers. The qualitative assessment method is a more simplified approach that relies more on noise management strategies. This study has adopted a quantitative assessment approach. Steps of the quantitative approach are summarised in Figure 5-1.

The quantitative approach includes identification of potentially affected receivers, description of activities involved in the proposal, derivation of the construction noise management levels, quantification of potential noise impact at receivers and, provides management and mitigation recommendations.

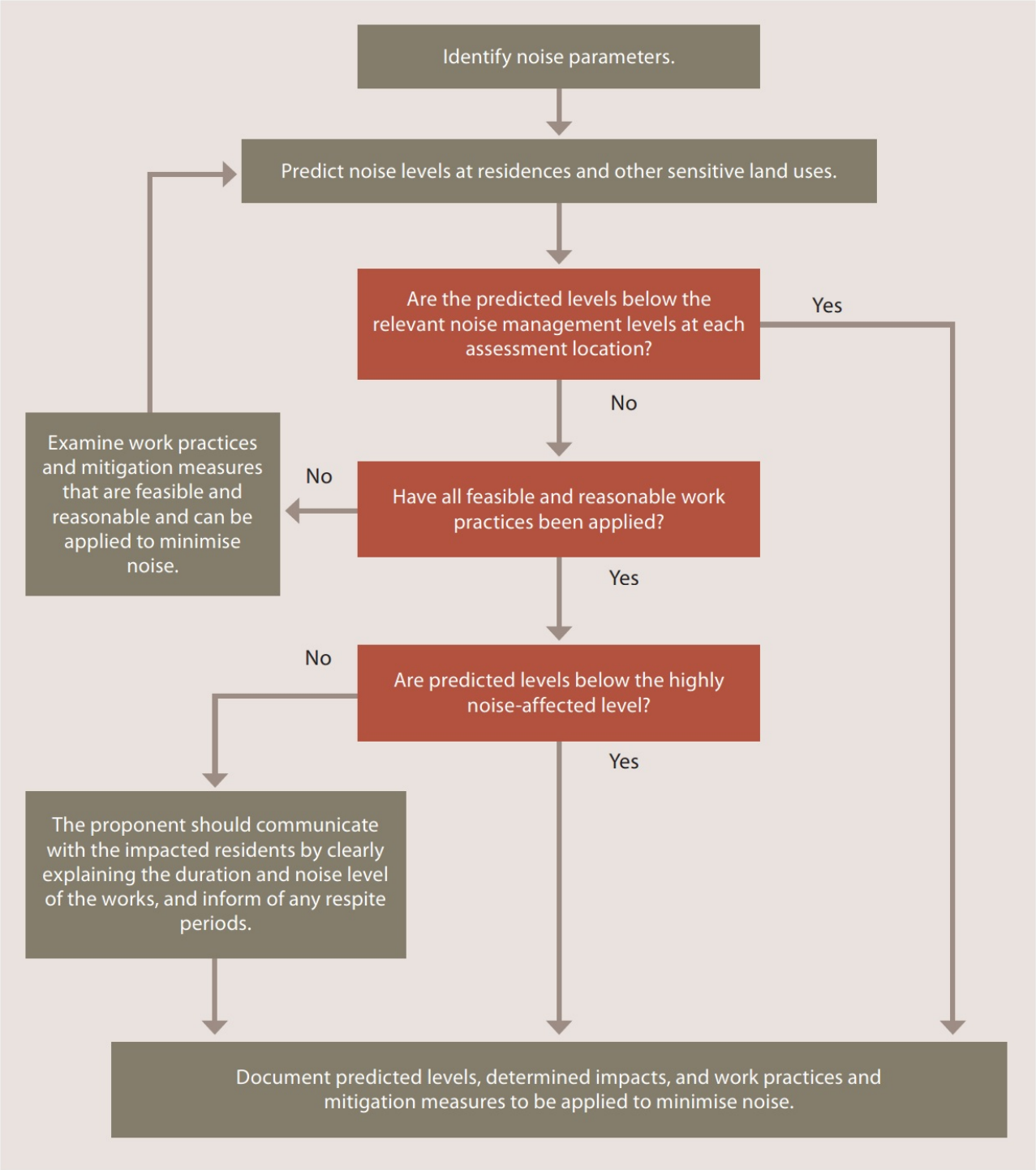

Figure 5-1: Quantitative Assessment Processes for Assessing and Managing Construction Noise.

Table 5-1: Recommended Standard Hours for Construction

Period	Preferred Construction Hours
Day (Standard construction hours)	Monday to Friday - 7am to 6pm Saturdays - 8am to 1pm Sundays or Public Holidays - No construction

The recommended hours do not apply in the event of direction from police, or other relevant authorities, for safety reasons or where needed in an emergency to avoid the loss of lives, property and/or to prevent environmental harm. Work conducted outside of standard hours are considered out of hours work (OOH). OOH periods are divided into two categories representing evening and night periods and cover the hours listed below:

Period 1 (evening/low risk period): Monday to Friday – 6pm to 10pm, Saturdays – 1pm to 6pm, Sundays 8am to 6pm.

Period 2 (night/medium to high risk period): Monday to Friday – 10pm to 7am, Saturdays/Sundays – 6pm to 7am (8am on Sunday mornings).

These periods are higher risk than standard construction hours due to the typically lower RBL and corresponding NML during these periods and potential for sleep disturbance at residential receivers.

5.2 Construction Noise Management Levels

The ICNG provides guidance on the assessment and management of construction noise. Section 4 of the ICNG details the quantitative assessment method involving predicting noise levels and comparing them with the noise management level (NML), which are important indicators of the level of construction noise impact. Table 5-2 provides the ICNG recommended LAeq(15min) noise management levels and how they are to be applied.

Table 5-2: ICNG Residential 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 + 10 dB.	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 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 need 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. 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 + 5 dB.	A strong justification would typically be needed 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 5 dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

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.

NMLs have been developed for nearby residential receivers for standard hours construction work. Table 5-3 provides a summary of the proposal construction NMLs.

Table 5-3: Noise Management Level Summary

Location	Assessment Period	RBL, dBA	NML LAeq(15min) dBA	Highly noise affected NML LAeq(15min) dBA
All Residential Receivers	Day (Standard Hours)	57	67 Standard hours (RBL+10dBA)	75 Standard Hours
	Evening (OOHW Period 1)	44	49 Outside Recommended hours (RBL+5dBA)	75 Outside Recommended Hours
	Night (OOHW Period 2)	34	39 Outside Recommended hours (RBL+5dBA)	75 Outside Recommended Hours
Active Recreation Areas	When in Use	N/A[1]	65	75
Passive Recreation Areas	When in Use	N/A[1]	60	75

The Highly Affected Noise management level is a hypothetical level which is adopted to ensure the avoidance of a strong community reaction. Should this level be exceeded the construction method is to be reviewed to reduce the impact on surrounding noise sensitive receivers.

Note 1: Areas other than residential receivers<NML are prescribed in the ICNG and not derived from the monitored RBL

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6 Noise Assessment Method

6.1 Modelling Method

A computer model was developed to determine the acoustic impact of standard construction emissions to nearby receivers. The modelling incorporated existing topographical data for the subject site. DGMR (iNoise, Version 2019) noise modelling software was used to assess the potential noise impact associated with the proposal. The model calculation method used to predict noise levels was in accordance with ISO 9613-1 'Acoustics - Attenuation of sound during propagation outdoors. Part 1: Calculation of the absorption of sound by the atmosphere' and ISO 9613-2 'Acoustics - Attenuation of sound during propagation outdoors. Part 2: General method of calculation'.

6.2 Construction Staging

The proposal is to be undertaken in six discreet construction stages. A brief description of each construction stage is reproduced below from the Construction Strategy Report (BECA, 2019).

- Stage 1 will involve construction of both permanent and temporary pavements in the southwest corner and southeast corner. The water main and sewer main will be relocated at this stage. The traffic flow will run along the existing Maitland Bay Drive and Picnic Parade intersection within a reduced cross section.
- Stage 2 construction will involve upgrading the existing Picnic Parade so that the south side of Maitland Bay Drive will have new and temporary pavement in place. Traffic flow will run along the existing Maitland Bay Drive. Picnic Parade will veer to the west where the new/temporary pavement was constructed in Stage 1.
- Stage 3a construction will be upgrading the northern most lane of the existing Maitland Bay Drive to the proposed level as traffic flow can continue along the southern side of Maitland Bay Drive on existing pavement as well as where pavement was built up in the previous two stages.
- Stage 3b construction will be upgrading the southernmost lane of the existing Maitland Bay Drive to the proposed level. The two traffic lanes will be split either side of the construction with the east bound lane on the new pavement constructed previously and the southern lane running along the very edge of existing pavement and previously constructed pavement.
- Stage 4 construction will be finishing the southern side of Maitland Bay Drive to finish of all pavement works in the project. Traffic flow will run along the northern most side of Maitland Bay Drive and Picnic Parade can run up the same alignment as used in stage 3a and 3b.
- Stage 5 construction involves finishing the roundabout, islands in Picnic Parade and east of the roundabout, local accesses, carparks, kerbs and footpaths in the southeast corner. During this stage, the temporary pavement in this location should be converted into footpath/carpark or removed. Traffic flow will maintain on the north side of Maitland Bay Drive as well as veering off to the west of Picnic Parade as done in Stage 2.
- Stage 6 construction will involve completing the islands surrounding the roundabout as well as finishing the kerbs, footpath and carpark to the southwest of the intersection. During this stage the temporary pavement in this location should be converted into footpath/carpark or removed. Traffic flow will be as intended by the design with reduced lane widths to allow clearance to the construction.

  Several construction operations are proposed as part of each of the construction stages. Accordingly, seven modelled activities have been assessed to represent the operations to be undertaken each construction stage. These activities are outlined below in Section 6.3

6.3 Modelled Activities

As the final proposal design is yet to be completed, representative construction activities considered to potentially have the greatest noise impact on nearby receivers were developed for the proposal. The construction schedule is broken up into seven construction stages.

6.3.1 Activity 1 – Establishment of Site Compound

The site compound will be established at the northern end of Ettalong Oval, next to the Broken Bay Scout Hall. The Scout Hall is typically used between 7pm and 9pm twice a week. Where possible, compound installation should be planned outside these times. The compound is anticipated to be installed at the commencement of the proposal prior to other work starting. During site establishment, there will be multiple activities being completed, some of which are noise intensive, such as excavations and material deliveries and others that will be acoustically insignificant, ie tasks that will need the use of hand power tools.

6.3.2 Activity 2 – Vegetation Removal

Vegetation removal will primarily occur in Kitchener Park car park adjacent to Maitland Bay Drive and the north eastern boundary of Ettalong Oval with the potential for further vegetation removal once the relocation of utilities starts. It is noted that no trees are to be removed within Kitchener Park. Vegetation removal will occur during standard construction hours. Vegetation removal activities are not anticipated to occur at sustained levels at any one receiver for prolonged periods.

6.3.3 Activity 3 – Utility Relocation

This activity includes the moving of underground and above ground utilities including adjusting power and water supply as per the Utility Strategy Report prepared for the proposal. Work will include the relocation of a 450mm water main, 250 rising sewer main and two light poles. The majority of the utility relocation are on the southern side of the proposal site next to the intersection of Picnic Parade. The time needed to move utilities is now unknown and will only be confirmed during the detailed design phase and the condition of each utility is confirmed.

6.3.4 Activity 4 – Milling of Existing Road Surface

The existing road surface will be milled along the entire proposal area. Fill and Cut will be carried out in several areas to level the road alignment before the laying of the final road surface, however the amount of fill and cut required is currently estimated to be minor,

6.3.5 Activity 5 – Kerbing and Roundabout Construction /Installation of Safety Barriers

Construct new road kerbing along the widened lanes of the proposal including foot paths, median strips and slip-lanes as well as the construction of the roundabout structure.

6.3.6 Activity 6 – Construction of New Asphalt Layers

Construct new road surface along the entire alignment including widened lanes of the proposal, median strips and turning bays. This activity is anticipated to only occur a minimum of two consecutive periods in close proximity to receivers.

6.3.7 Activity 7 – Line Marking and Installation of Road Furniture

Line marking is proposed to occur during standard construction hours, as line marking is a relatively rapid process, receivers are anticipated to experience maximum predicted noise levels for short periods during this activity.

6.3.8 Additional Activities

Several additional activities have been identified for the proposal at completion of this draft report. These activities include the installation of W-beam barriers and the resurfacing and linemarking in Kitchener Park car park.

The overall fleet sound power of the installation of the W-beam barriers, is in keeping with the kerbing works and construction of the roundabout with the overall fleet sound powers only differing by one dB. Accordingly, the results of the kerbing and roundabout construction or representative of the installation of the w-beam barrier work.

The resurfacing and linemarking of the Kitchener Park car park, has not been assessed due to the time constraint between the finalisation of this activity and submission of the draft REF. These activities will be reviewed and quantified once 100% design for the proposal are available. Notwithstanding, this report provides indicative noise emissions and management initiatives for the proposal.

6.4 Sound Power Levels

Proposed equipment to be used on the proposal are listed in Table 6-1 along with each item's sound power level. It is noted that sound power levels for plant assessed in this report were sourced from the MAC database. For each activity, all sources were assessed as operating simultaneously. It is noted that additional non-standard plant may be used during construction activities for the proposal. Items such as welders, dewatering pumps and shoring boxes may be utilised during utility relocation. These plant can be interchanged for other plant listed in the construction fleet and are considered to be acoustically insignificant compared to larger plant such as excavators and hammers

Table 6-1: Acoustically Significant Sources - Sound Power Levels

Item	Sound Power Levels, LAeq(15min) dBA	Activity						
		1	2	3	4	5	6	7
35T Excavator	110	x1	x1	x1	x1			
Rollers (20-30t)	109				x1		x1	
Bitumen sprayer / paving machine	116						x1	
Profiler	116						x1	
Concrete Agitator	111					x1		
Chainsaw	106		x1					
Mulcher	116		x1					
Rock or Jack hammer	122				x1			
Vibrating Plate	100			x1				
Line Marking Machine	108							x1
Concrete Quick Cut Saw	118				x1			
Hand power tools	96	x1		x1	x1			
Truck and Dog	108	x1		x1	x1	x1	x1	
Traffic control	102	x1	x1	x1	x1	x1	x1	x1
Grader	113				x1			
Lighting plant/generator	104	x1	x1		x1	x1	x1	x1
10 Site Personnel	92	x1	x1	x2	x2	x2	x2	x1
3 Light Vehicles	93	x1	x1		x1	x1	x1	x1
Bogie Tipper	98	x1	x1				x1	
Scissor Lift	98			x1				
Trencher	108			x1				
Extrusion Machine	98					x1		
Total		113	119	115	124	114	120	110

Noise sources have been adjusted to account for their operational duration during a 15 minute period.

Total Fleet Sound Powers are the calculated Logarithmic total of all individual fleet item sound powers for that particular activity.

7 Construction Noise Predictions

Predictions have quantified levels from each nominated construction activity for the proposal. The LAeq(15min) noise contours for each activity are presented in Figure 7-1 to Figure 7-7 and are representative of received noise levels for all assessment periods.

It is reiterated that the noise contours reflect the maximum predicted exposure levels to receivers as construction activities pass in close proximity.

The levels presented (based on the 80% design detail) are for construction activities that occur during standard construction hours as outlined in Section 5.1 of this report. Tabulated results for the nearest receivers to the proposal are presented in Appendix D.

Figure 7-1: Activity 1 Establishment of Site Compound

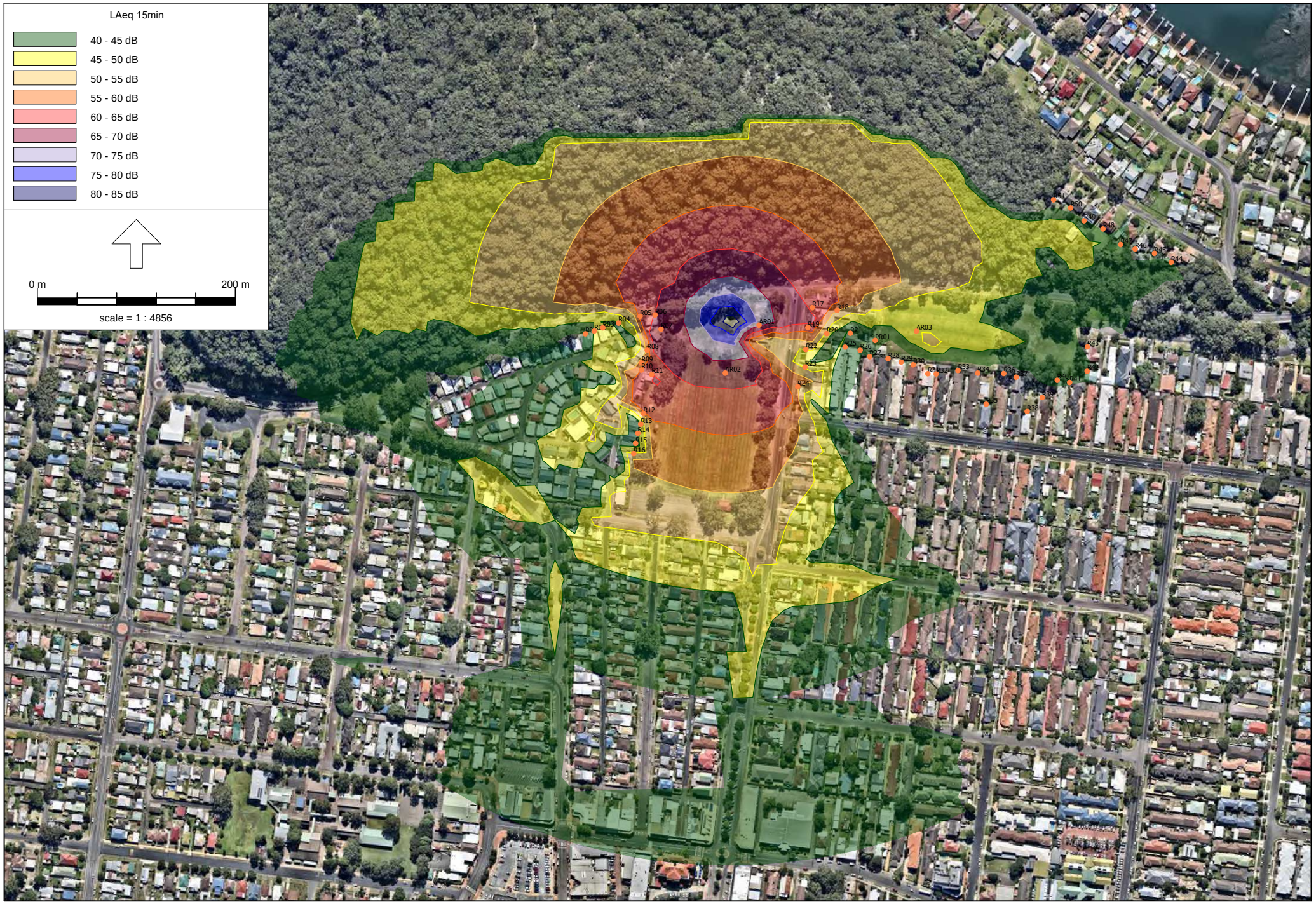

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Figure 7-2: Activity 2 Vegetation Removal

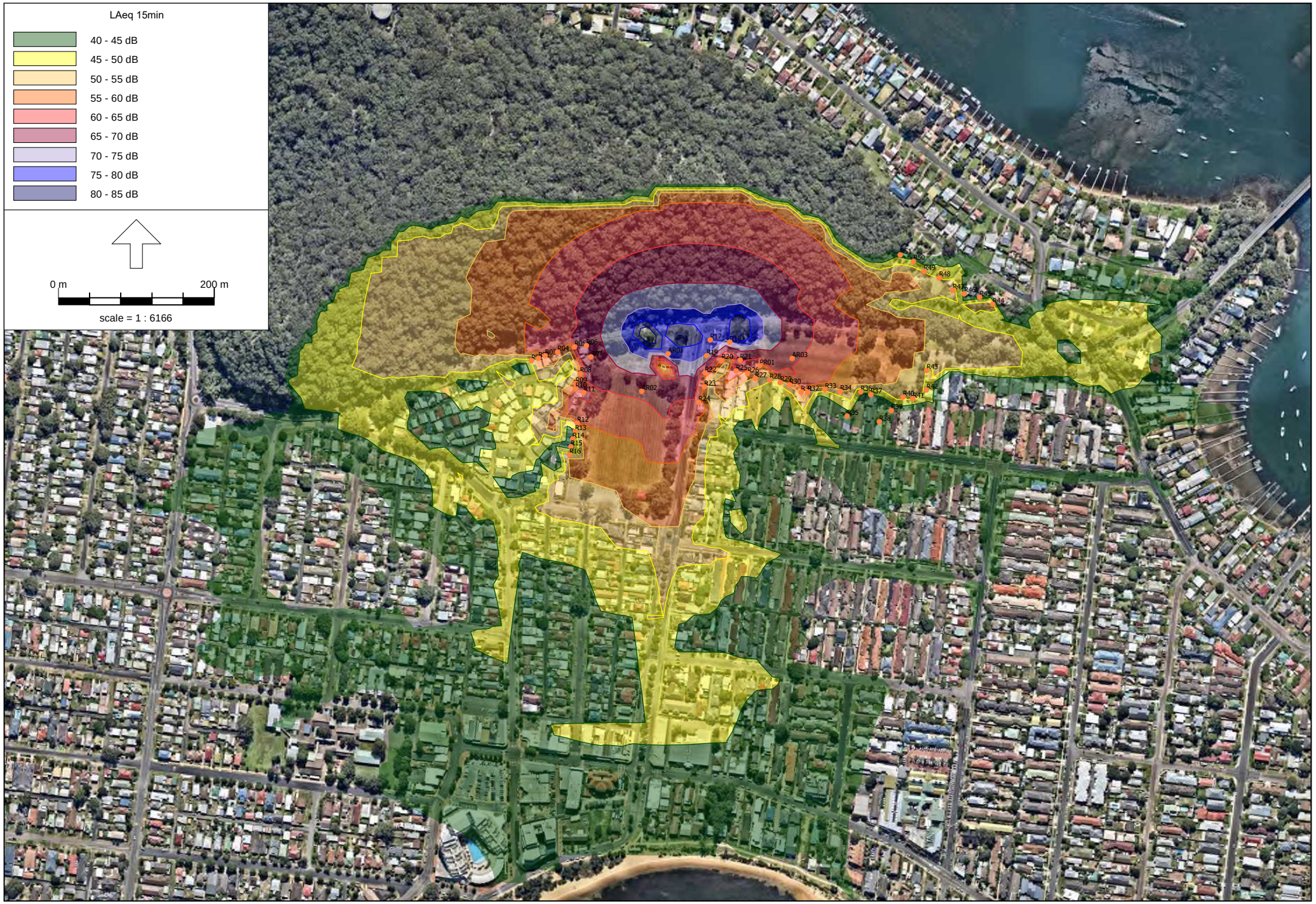

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Figure 7-3: Activity 3 Utility Relocation

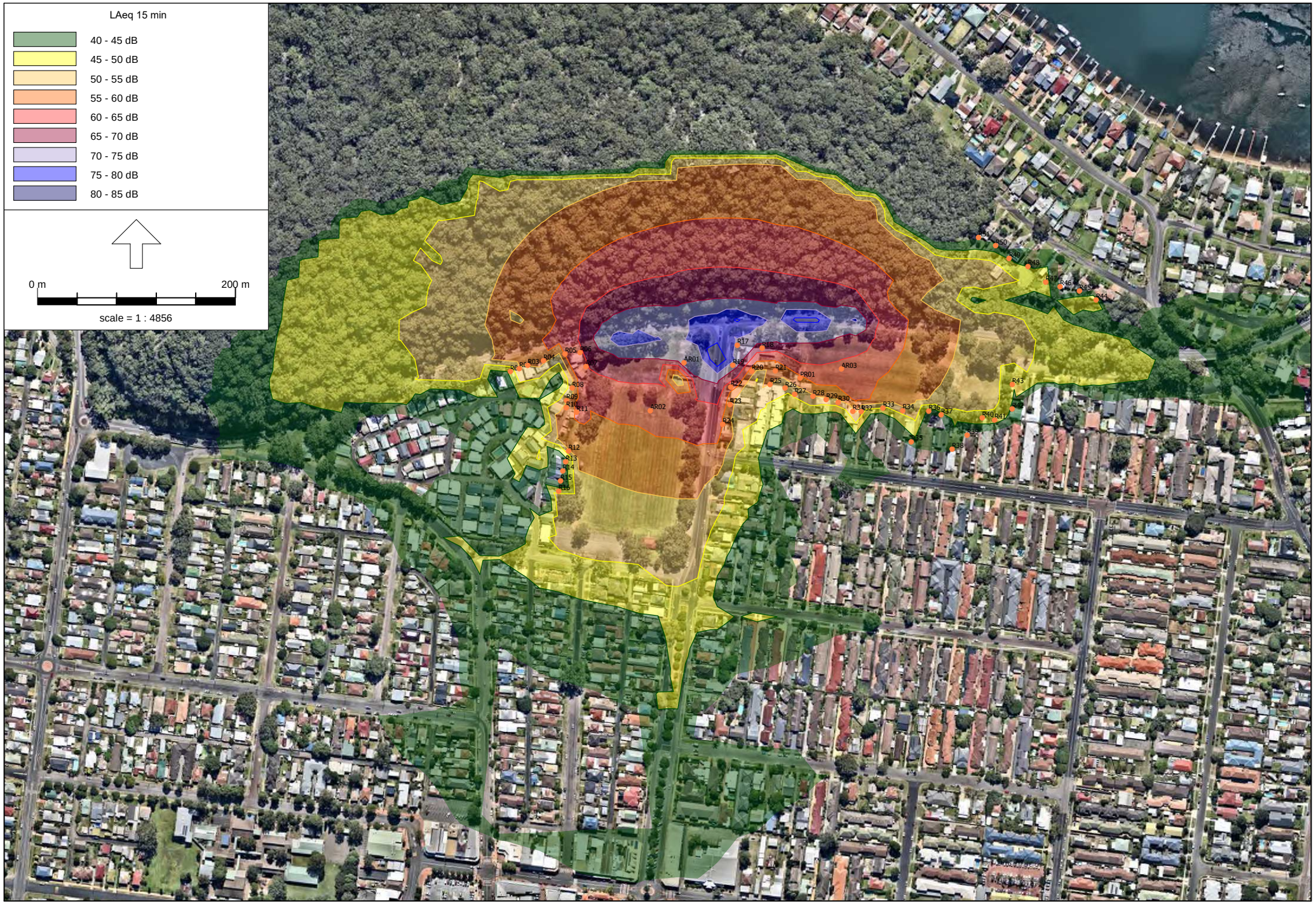

Figure 7-4: Activity 4 Milling of Exisiting Road Surface

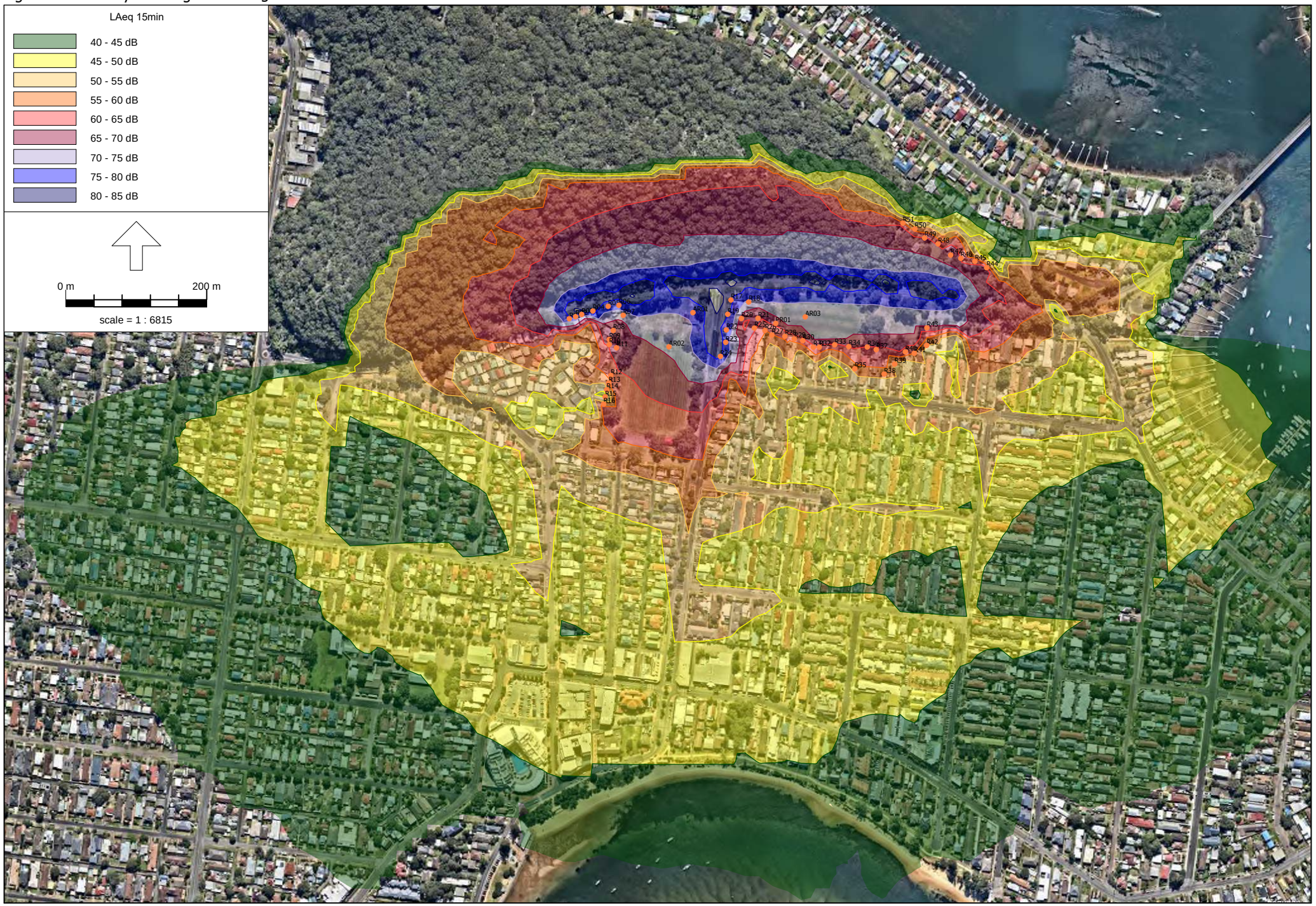

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Figure 7-5: Activity 5 Kerbing and Roundabout Construction/ Installation of Safety Barriers

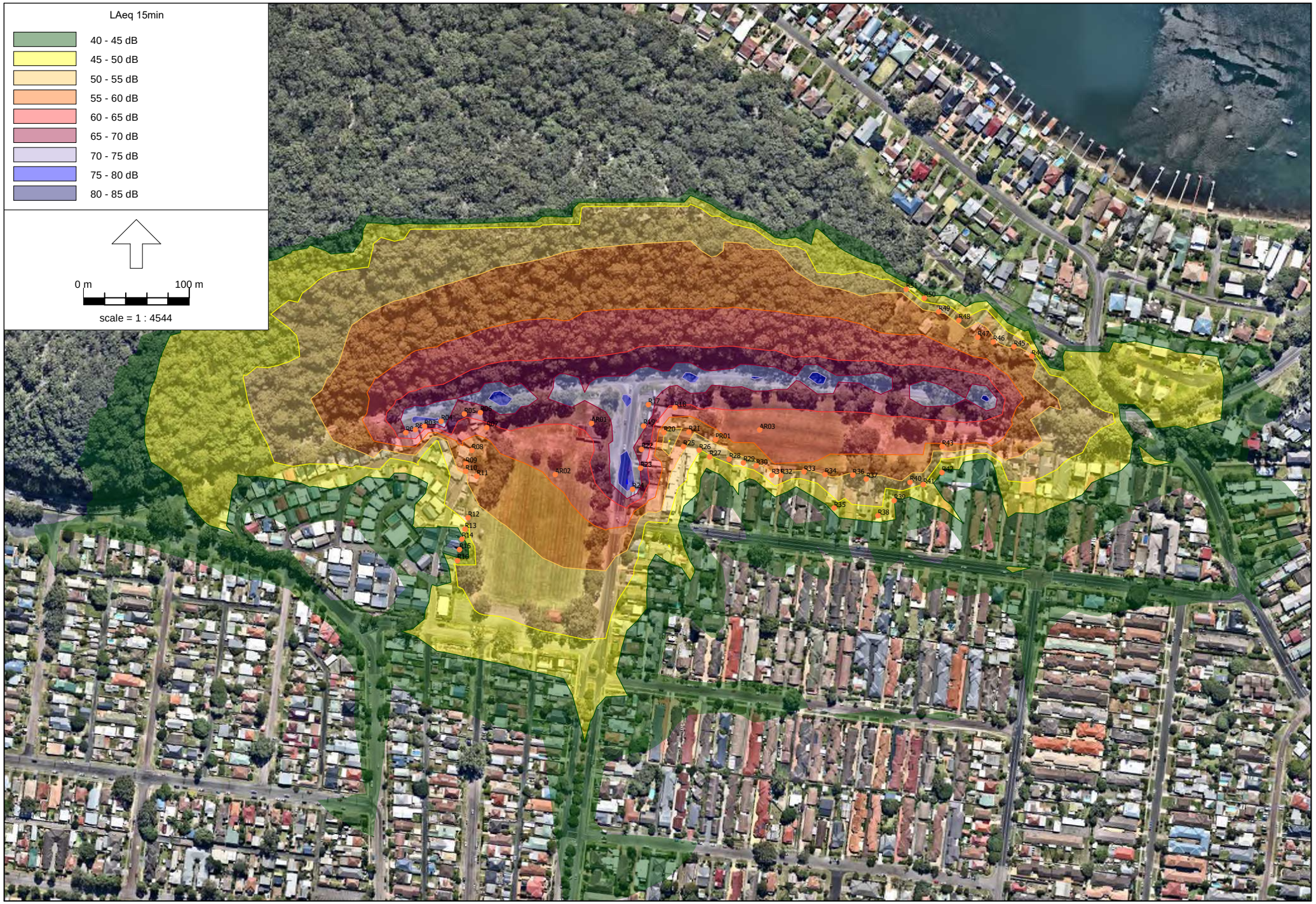

Figure 7-6: Activity 6 Construction of New Asphalt Layers

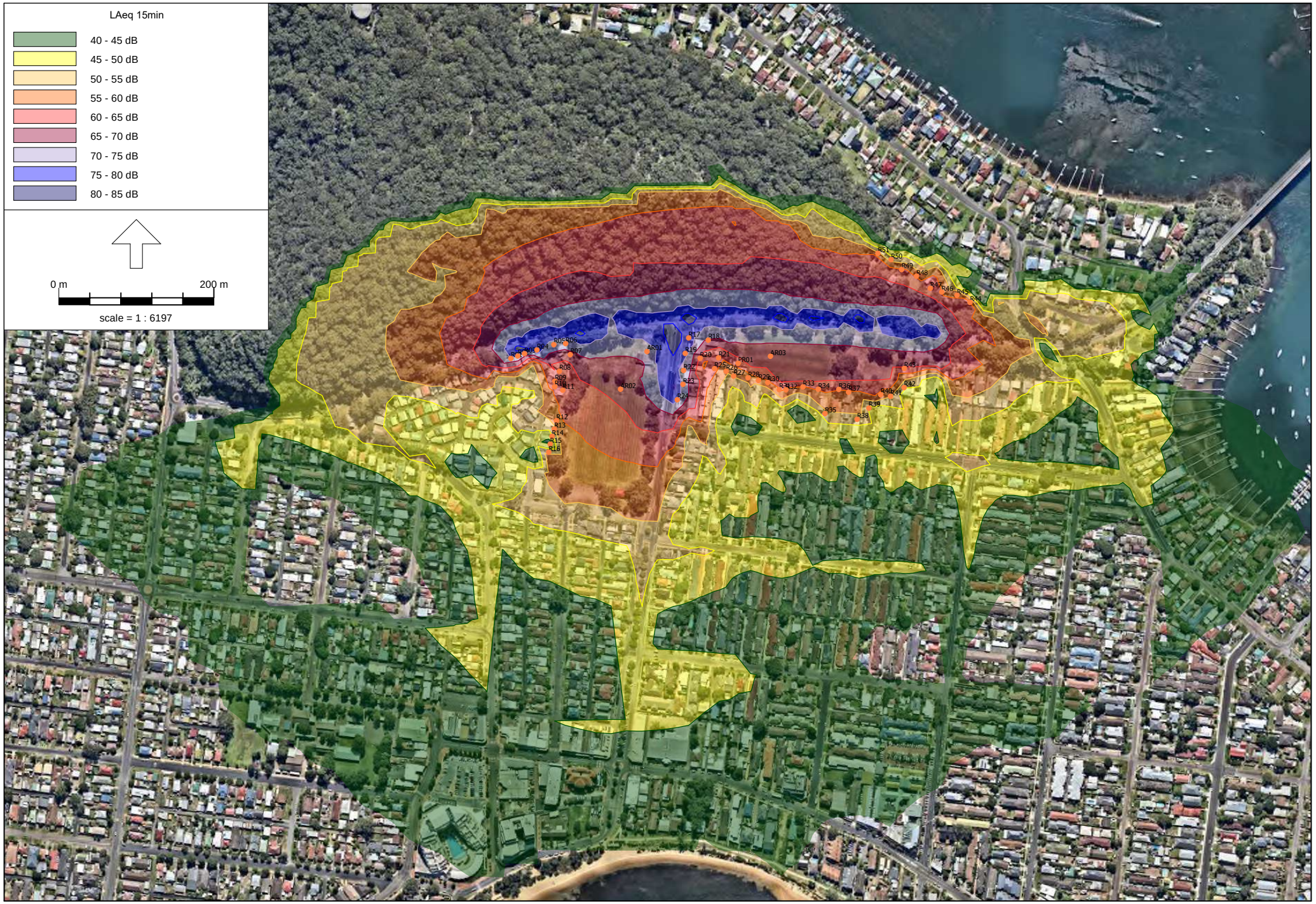

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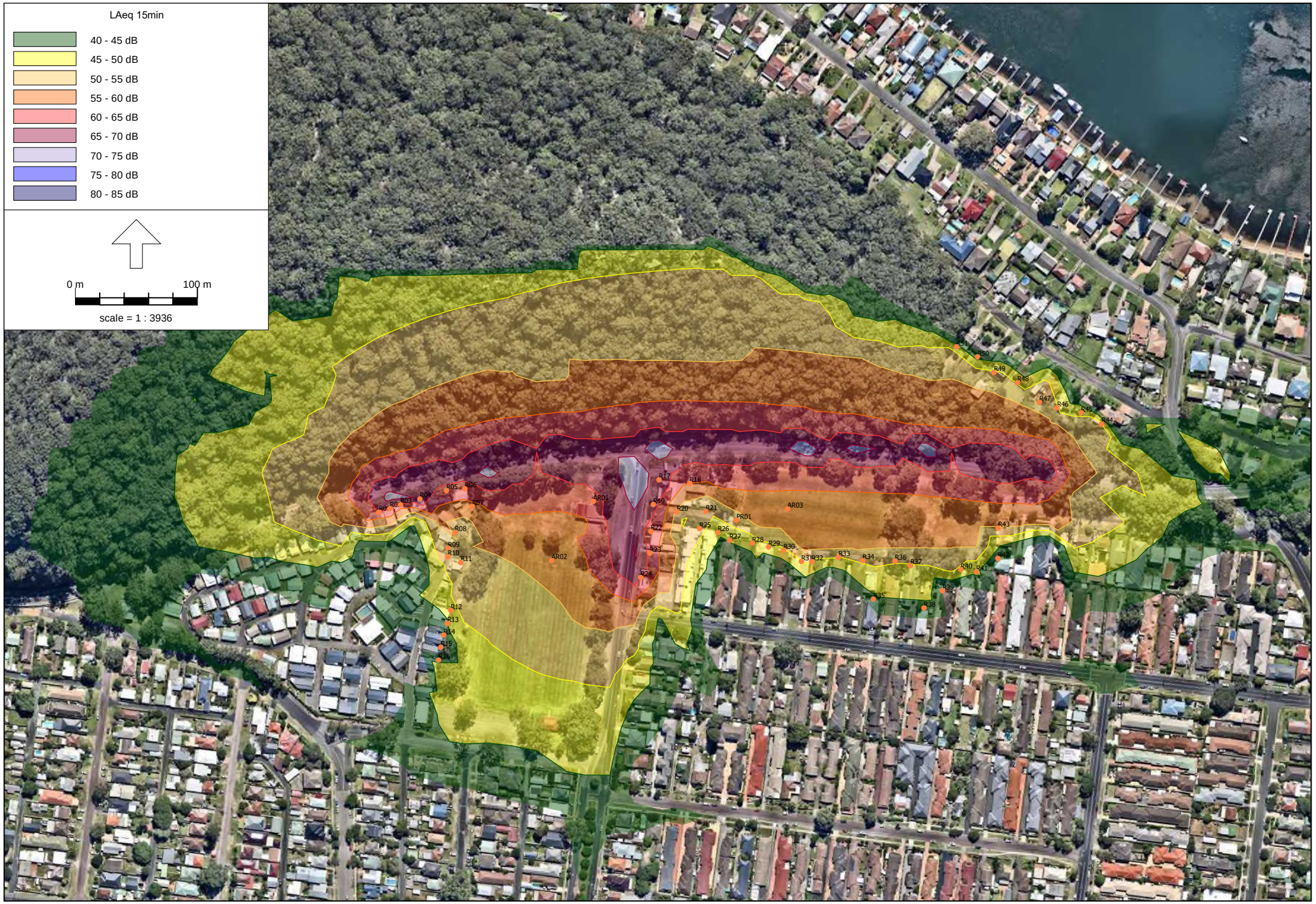
Figure 7-7: Activity 7 Linemarking



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7.1 Discussion of Results

The results of the noise assessment demonstrate that noise levels during the proposed standard and OOH construction periods may exceed relevant NMLs on occasion at receivers surrounding the proposal.

It is noted that the predicted noise levels from the upgrade work are in keeping with the amplitude of emissions during peak traffic flows.

The discussion of results for each activity are below and provide guidance as to the type of noise management and controls that may be relevant to each activity.

7.1.1 Activity 1 – Establishment of Site Compound

Noise modelling results for Activity 1, Establishment of the Site Compound, shows that receivers AR1, and AR2 are the only receivers to exceed the daytime NML, These receivers are not occupied at all times and establishment of compound should be planned with respect to their use. All other receivers complied with the daytime NML. A total of 37 receivers exceed the worst case OOHP2 NML, however it should be noted that the establishment of site compounds in typically undertaken during standard hours for safety reasons.

7.1.2 Activity 2 – Vegetation Removal

For Activity 2, Vegetation Removal, two receivers, AR1 and R17, were above the highly noise affected management level with a total of nine receivers (R6, R7, R8, R17, R18, R19, R21, R22 and R23) predicted to be above the daytime noise management level of 67dBA for residential receivers with AR1, AR2,AR3 and PR1 also predicted to be above their respective daytime noise management levels. A total of 54 receivers exceed the OOHP2 NML for vegetation removal, however vegetation removal is expected to be carried out during very short periods at any one location, reducing the impact upon surrounding receivers.

7.1.3 Activity 3 – Utility Relocation

For Activity 3, Utility Relocation, three receivers AR1, PR1, R17 and R19 are predicted to be above their respective daytime noise management levels with two receivers (R34 and R51) exceeding the OOHP2 NML as the works pass the near point of each receiver. The majority of the utility relocation is mainly surrounding the intersection of Maitland Bay Drive and Picnic Parade, where the majority of utilities are located.

7.1.4 Activity 4 – Milling of Existing Road Surface

The results of modelling for Activity 4 shows that seven receivers R1, R2, R3, R4, R5,R6, R17 ,R19, R22, R23, R24 are predicted to be above the highly noise affected management level as work progresses pass the near point of the receivers. Additionally, a total of seventeen receivers (R1, R2, R3, R4, R5, R6, R7, R17, R18, R19, R22, R23, R24, AR1, AR2, AR3 and PR1) are above their respective daytime noise management levels and all receivers are above the OOHP2 NML. Milling works represents a substantial portion of the overall construction work and is the loudest activities to be completed as part of the proposal.

7.1.5 Activity 5 – Kerbing and Roundabout Construction

For Activity 5 kerbing and construction of the roundabout /installation of safety barriers, one receiver R2, is above the highly noise affected noise management level of 75dBA with a further eleven (R1, R2, R3, R4, R5, R6, R17, R19, R22, R23 and R24 are predicted to be above the daytime noise management level, of 67 dBA for residential receivers. Furthermore, all receivers are predicted to be above the OOHP2 NML as the works progress past the near point to each receiver for this activity. Mitigation measures outlined in Section 7.2 are expected to reduce the noise impact on surrounding receivers by up to 10 dB.

7.1.6 Activity 6 – Construction of New Asphalt Layers

For Activity 6, construction of the new asphalt layers, seven receivers, R1, R2, R3, R4, R5, R17 and R19 all are predicted to be above the highly noise affected noise management level and a total 17 receivers (R1, R2, R3, R4, R5, R6, R7, R17, R18, R19, R22, R23, R24, AR1, AR2, AR3 and PR1) are predicted to be above of their daytime noise management level. Additionally, all receivers are predicted to be above the OOHP2 NML for this construction activity. Mitigation measures presented in Section 7.2 of this report will reduce the impact of this activity on surrounding noise sensitive receivers.

7.1.7 Activity 7 – Line Marking and Installation of Road Furniture

During Activity 7, Line marking, only one receiver, R2, is predicted to be above the daytime noise management level of 67 dBA as work passes the near point of the receiver. During OOHP2 all receivers with the exception of R27, are predicted to be above the applicable NML for this period. Due to the rapid process of Line Marking, noise levels will not be sustained at any one location for a prolonged period.

7.2 Feasible and Reasonable Mitigation Measures - Noise

Noise modelling identifies that relevant NMLs for the proposal could be exceeded when each construction activity occurs in the vicinity of receivers. The ICNG outlines noise management and mitigation initiatives to minimise the impact and improve the acoustic amenity of receivers potentially affected by road construction proposals. The guideline suggests there are no prescribed noise controls for construction work, instead:

“All feasible and reasonable work practices should be put in place to minimise noise impacts. This approach gives construction site managers and construction workers the greatest flexibility to manage noise.”

Seven key strategies in reducing construction noise emissions are outlined in Section 6 of the ICNG that should be applied on a case-by-case basis and include the following:

Strategy 1: Universal Work Practices

Strategy 2: Consultation and Notification

Strategy 3: Plant and Equipment

Strategy 4: Onsite

Strategy 5: Work Scheduling

Strategy 6: Transmission Path

Strategy 7: At residence (measures) or other sensitive Land Uses (last resort)

In addition, Australian Standard AS 2436-2010 (R2016) “Guide to Noise Control on Construction, Maintenance and Demolition Sites” sets out numerous practical recommendations to help in mitigating construction noise emissions.

Recommendations provided in the ICNG and AS2436 include combinations of operational strategies, source noise control strategies, noise barrier controls, and community consultation.

It is estimated that adopting strategies contained in this standard may result in the following noise attenuation:

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

7.2.1 Universal Work Practices

Universal work practices that can be applied to the proposal (and all subsequent activities) include:

- conduct toolbox talks pre-shift to communicate awareness about the importance of noise emission management
- ensure site managers periodically check noise emissions at receivers next to noisy activities so that potential problems can be rectified
- UHF radios will be used for communication with no yelling allowed
- no slamming of doors is allowed
- plant will be parked in accessible and where possible shielded locations before being used for work
- minimise the use of reverse alarms
- site access will be gained via entry points most remote to receivers
- minimise clustering of plant items
- management are to communicate to staff and contractors the importance of minimising noise emissions to the community when arriving and leaving site
- a noise monitoring program is to be put in place to quantify noise emissions from construction activities and guide practical reasonable and feasible noise control measures Table 7-1 outlines the levels above the NMLs which trigger noise monitoring.

7.2.2 Consultation and Notification

Community Consultation will be as per the standard RMS Project Planning Principals for Community Consultation and will be managed by the RMS project manager for the entirety of the proposal duration.

7.2.3 Plant and Equipment and On Site

General

- as far as practical, locate lighting plant away from sensitive receivers
- for vegetation removal, where possible mulching should be conducted during standard construction hours
- no reversing of vehicles (reverse alarms) during out of hours work (ie the vehicles will do a complete U turn if needed to change direction or have spotters)
- use of air brakes is not permitted
- all plant will be driven in a conservative manner (no over-revving)

- machinery will not be permitted to ‘warm-up’ before the nominated working hours or next to receivers
- where possible, machinery will be used/orientated to direct noise away from the closest sensitive receivers
- undertake regular maintenance of machinery to minimise noise emissions. Maintenance will be confined to standard daytime construction hours and where possible, away from noise sensitive receivers presented in Figure 3-1.
- the quietest suitable machinery reasonably available will be selected for each work activity
- all machinery will have efficient low noise muffler design and be well-maintained
- the offset distance between noisy items of plant/machinery and nearby sensitive receivers will be maximised
- queuing of vehicles is not to occur next to any residential receiver
- where queuing is needed, for example due to safety reasons, a site entry position will be selected that is well removed from receivers. Where this is not feasible, engines are to be switched off to reduce their overall noise impact on receivers
- where practicable, ensure the coincidence of noisy plant/machinery working simultaneously in close proximity to sensitive receivers is avoided
- inform truck drivers of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (for example, minimising the use of engine brakes, and no extended periods of engine idling)

7.2.4 Work Scheduling

- schedule noisy activities around times of high background noise (local road traffic or when other local noise sources are active) where possible to provide masking or to reduce the amount that the construction noise intrudes above the background
- care should be taken to minimise noise from any refueling and ensure plant is as far as practical from receivers when refueling
- optimise the number of vehicle trips to and from the site – movements can be organised to amalgamate loads rather than using a number of vehicles with smaller loads
- designate access routes to the site, through consultation with potentially noise-affected residences and other sensitive land uses, and make drivers aware of nominated vehicle routes
- provide designated on-site truck waiting areas away from residences and other sensitive land uses. Truck waiting areas may need bunding or walls to minimise noise
- provision of the dedicated staff/contractor car parking area away from residences is considered a practical and effective noise control measure to minimise impacts of staff entering and leaving the proposal

- schedule delivery of materials to occur during the day to avoid noise emission associated with deliveries

7.2.5 Transmission Path

- where possible eliminate or reduce the line-of-sight from noise emission sources to residences or other sensitive land uses using temporary barriers or mobile screens
- temporary noise barriers can be constructed from hoardings or pvc curtains attached to temporary fences. Stockpiles and shipping containers are also effective barriers
- consider mobile screens for work that is static or plant that will be stationary for the duration of the work (ie drainage work, or around compressors and generators)
- erect temporary noise barriers at shift start up to ensure that noise during the entire shift is minimised

7.2.6 At residence (measures) or other sensitive Land Uses (last resort)

- examine and put in place, where feasible and reasonable, the option of relocating noise-affected occupants for short periods of time, such as when high noise levels from construction occur at night and there are no feasible and reasonable ways of reducing noise levels. For example, the proponent could offer alternative accommodation or other respite measures (such as movie tickets) where mitigation is sought and there are no feasible and reasonable work methods available.

7.3 Additional Mitigation Measures

Standard noise mitigation and management measures in accordance with the ICNG would be put in place for the proposal where practicable.

The CNVG (Roads and Maritime, 2016) outlines a range of additional mitigation measures which are recommended in order to manage the potential impact. The additional CNVG measures reproduced in Table 7-1 will be considered by Roads and Maritime after incorporation of feasible and reasonable mitigation measures for the proposal outlined in Section 5.5. Appendix D provides a detailed definition of each additional mitigation measure listed below.

Table 7-1 Triggers for Additional Mitigation Measures - Airborne Noise

Perception	Predicted airborne noise level at receiver		Additional mitigation measures Type[1]	Mitigation Levels[2]
	dB(A) above RBL	dB(A) above NML		
All Hours				
75dBA or greater			LB, V, PC, RO	HA
Standard Hours: Mon - Fri (7am – 6pm), Sat (8am – 1pm), Sun/Pub Holidays (Nil)				
Noticeable	5 to 10	0	-	NML
Clearly Audible	10 to 20	< 10	-	NML
Moderately intrusive	20 to 30	10 to 20	LB, V	NML+10
Highly intrusive	> 30	> 20	LB, V	NML+20
OOH Period 1: Mon – Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Pub Hol (8am – 6pm)				
Noticeable	5 to 10	< 5	-	NML
Clearly Audible	10 to 20	5 to 15	LB, R1, NR	NML+5
Moderately intrusive	20 to 30	15 to 25	V, LB, R1, NR	NML+15
Highly intrusive	> 30	> 25	V, IB, LB, R1, NR, PC, SN	NML+25
OOH Period 2: Mon – Fri (10pm – 7am), Sat (10pm – 8am), Sun/Pub Holidays (6pm – 7am)				
Noticeable	5 to 10	< 5	LB	NML
Clearly Audible	10 to 20	5 to 15	V, LB, R2, NR	NML+5
Moderately intrusive	20 to 30	15 to 25	V, IB, LB, PC, SN, R2, NR	NML+15
Highly intrusive	> 30	> 25	AA, V, IB, LB, PC, SN, R2, NR	NML+25

Note 1: AA = Alternative accommodation, R1 = Respite Period 1, V = Validation of predicted noise levels (not needed for proposals less than 3 weeks), PC = Phone calls, IB = Individual briefings (not needed for proposals less than 3 weeks), SN = Specific notifications, LB = Letter box drops, R2 = Respite Period 2, NR = Negotiated Respite.
Note 2: Perception = relates to level above RBL, NML = Noise Management Level (see Appendix D) HA = Highly Affected (> 75 dB(A) - applies to residences only)

Figure 7-8 to Figure 7-14 presents the noise management zones for each work activity during worst case Out of Hours Period 2 construction hours following the application of reasonable and feasible mitigation measures (as per Section 7.2), which would reduce pre-mitigation construction noise emissions by about 10 dB. It is again noted that these are indicative noise predictions only, and are likely to vary during upgrade work as plant location and operation varies. The noise management zones for each work activity during standard construction hours are presented in Appendix E of this report.

Figure 7-8: Activity 1 Establishment of Site Compound - OOHP2 Trigger for Additional Mitigation Measures

Figure 7-9: Activity 2 Vegetation Removal - OOHP2 Trigger for Additional Mitigation Measures

Figure 7-10: Activity 3 Utility Relocation - OOHP2 Trigger for Additional Migitation Measures

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Figure 7-11: Activity 4 Milling of Exisiting Road Surface - OOHP2 Trigger for Additional Mitigation Measures

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Figure 7-12: Activity 5 Kerbing and Roundabout Construction/Installation of Safety Barriers - OOHP2 Trigger for Additional Mitigation Measures

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Figure 7-13: Activity 6 Construction of New Asphalt Layers - OOHP2 Trigger for Additional Mitigation Measures

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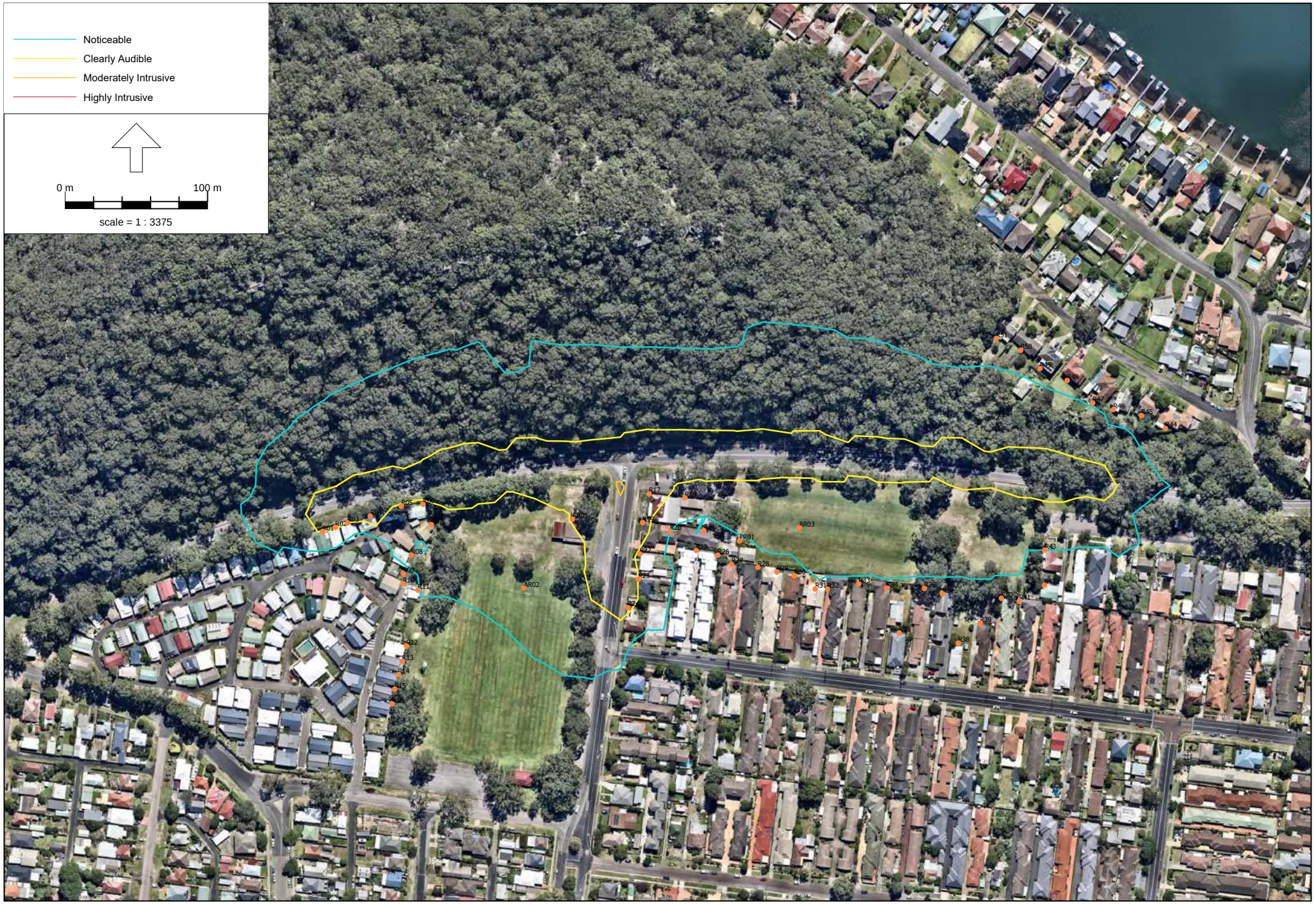
Figure 7-14: Activity 7 Linemarking - OOHP2 Trigger for Additional Mitigation Measures



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7.4 Construction Environmental Management Plan

Roads and Maritime Service QA Specification PS311 Environmental Design and Compliance document requires that a Construction Environmental Management Plan be prepared as part of the 80% design brief. This management plan will provide specific noise controls pertaining to this proposal to assist in the management of noise emissions from the work.

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8 Assessment of Construction Vibration Impacts

8.1 Vibration Criteria

British Standard BS 7385:Part 2-1993 “Evaluation and measurement for vibration in buildings Part 2”, gives guidance on the levels of vibration which building structures could be damaged. BS7385 also takes into consideration the frequency of the vibration which is critical when assessing the likelihood of building damage.

Guide values are set for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to result in a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and heavy commercial/industrial buildings are presented in Table 8-1, with a visual representation presented in Figure 8-1. Where sources of continuous vibration may give rise to dynamic magnification due to resonance, the values provided in Table 8-1 should be reduced by 50%, this is especially the case with respect to Peak Particle Velocity (PPV) at lower frequencies. It is noted that no heritage listed buildings have been identified in the area surrounding the proposal footprint and accordingly heritage buildings have not been included in this assessment.

Table 8-1 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 to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and Heavy Commercial Buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz

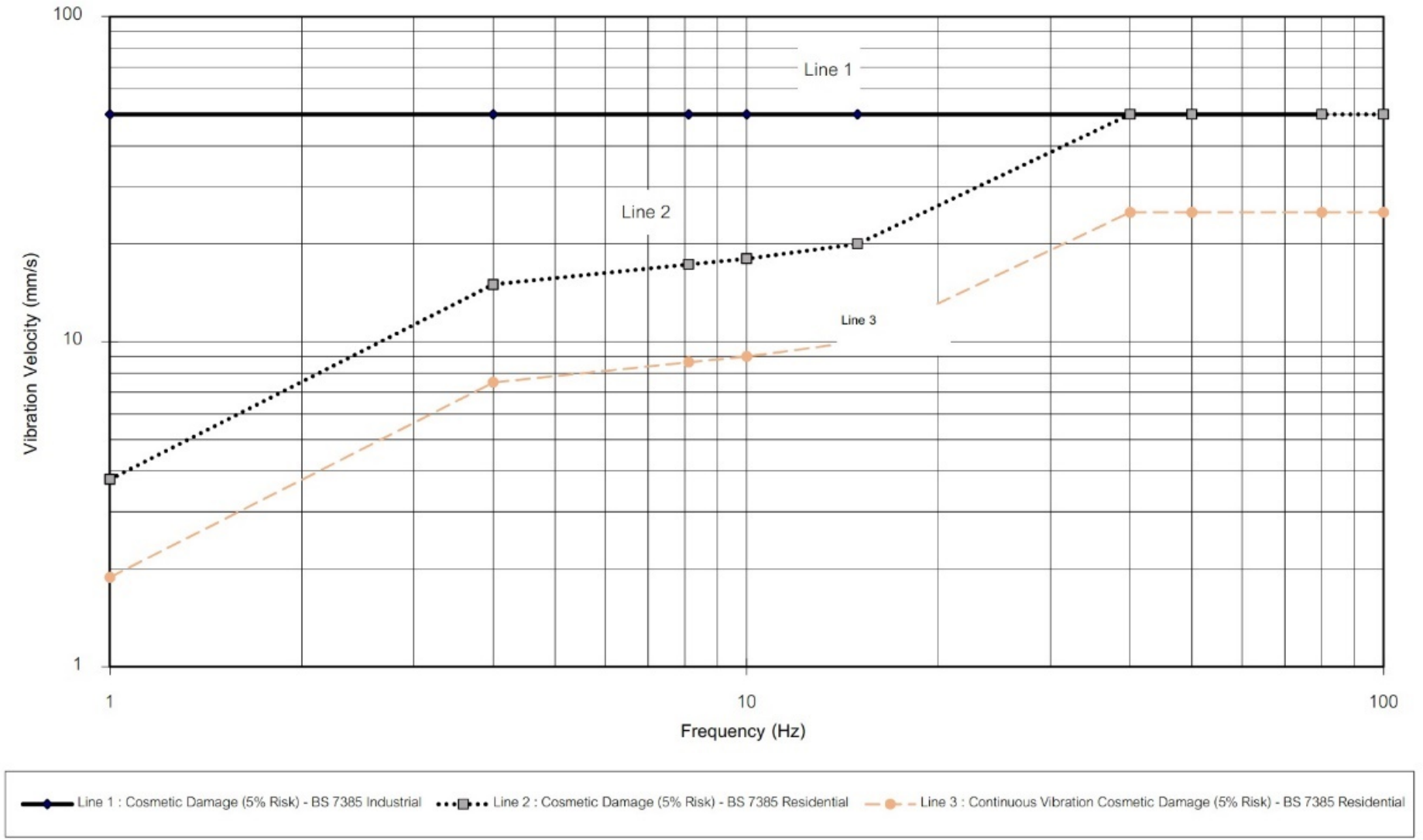

Figure 8-1-Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

8.1.1 Human Comfort – Assessing Vibration a Technical Guideline

Humans are far more sensitive to vibration than is commonly realised 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 DECC and is based on guidelines contained in BS 6472 – 1992, Evaluation of human exposure to vibration in buildings (1-80 Hz) 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 8-2.

Table 8-2 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. 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 three or fewer these would be assessed against impulsive vibration criteria.

Continuous Vibration

Appendix C of the guideline outlines acceptable criteria for human exposure to continuous vibration (1-80Hz), the criteria are dependent on both the time of activity (usually daytime or night-time) and the occupied place being assessed. Table 8-3 reproduces the preferred and maximum criteria relating to measured peak velocity.

Table 8-3 Criteria for Exposure to Continuous Vibration

Place	Time	Peak Velocity (mm/s)	
		Preferred	Maximum
Critical working areas (e.g. hospital operating theatres, precision laboratories)	Day or Night	0.14	0.28
Residences	Day	0.28	0.56
	Night	0.20	0.40
Offices	Day or Night	0.56	1.1
Workshops	Day or Night	1.1	2.2

Note: rms velocity (mm/s) and vibration velocity value (dB re 10^{-9} mm/s) values given for most critical frequency >8Hz assuming sinusoidal motion.

Impulsive vibration

Appendix C of the guideline outlines acceptable criteria for human exposure to impulsive vibration (1-80Hz), these criteria are dependent on both the time of activity (usually daytime or night-time) and the occupied place being assessed. Impulsive vibration (as defined in Section 2.1 of the guideline) is generally associated with 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. Table 8-4 reproduces the preferred and maximum criteria relating to measured peak velocity.

Table 8-4 Criteria for exposure to impulsive vibration

Place	Time	Assessment Criteria	
		Peak Velocity (mm/s)	
		Preferred	Maximum
Critical working areas (e.g. hospital operating theatres, precision laboratories)	Day or Night	0.14	0.28
Residences	Day	8.6	17.0
	Night	2.8	5.6
Offices	Day or Night	18.0	36.0
Workshops	Day or Night	18.0	36.0

Notes: 1. rms velocity (mm/s) and vibration velocity value (dB re 10 -9 mm/s)
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 needs the measurement of the overall weighted rms (root mean square) acceleration levels over the frequency range 1 Hz to 80 Hz. 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 Vibration Dose Values (VDV) for Intermittent Vibration is reproduced in Table 8-5.

Table 8-5 Acceptable Vibration Dose Values (VDV) 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

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.

8.2 Vibration Assessment

The major potential sources of construction vibration includes vibrating rollers. Equipment and plant have the potential to operate at a minimum offset distance of 10 m from the nearest residential receivers (R17, 2A Picnic Parade), when work occurs along the proposal site.

Generally, rolling would take place before road resurfacing, or when relocation of services has occurred. Peak levels of vibration from rolling typically occurs as the roller stops to change direction and a resonance is created as the roller (and vibrator) is stationary. Vibrating rollers typically generate vibration emissions between 10 to 50 Hz. Therefore, the relevant vibration criteria for rolling is between 5 mm/s and 15 mm/s for standard type building structures.

Table 8-6 provides the recommended minimum working distances for the use of various vibration intensive sources to nearby receivers.

Table 8-6 Minimum Working Distances or Vibratory Plant (m)

Plant item	Rating / Description	Minimum working distance	
		Cosmetic damage (BS 7385)	Human response (OH&E Vibration guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 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)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m

Note: Source, CNVG (Roads and Maritime, 2015)

8.3 Feasible and Reasonable Mitigation Measures - Vibration

To minimise vibration impact during rolling activities, it is recommended that large vibratory rollers be substituted with smaller units or replaced with alternative compaction techniques (ie wacker packers), where feasible.

It is recommended that when using a 13 tonne roller, the minimum offset distance to receptors is at least 15 metres or greater to satisfy the minimum offset criteria specified in the CNVG to satisfy BS7385.

Where substitution of equipment is not feasible or practical, vibration monitoring should be considered throughout the proposal to quantify and manage vibration emissions. The monitoring instrumentation can be setup with specific vibration limits that, when triggered, text or email the site manager that there has been elevated emissions. This allows the site manger to pro-actively manage or implement changes to construction activities where necessary.

8.4 Additional Mitigation Measures – Vibration

Where the minimum offset distance to a receiver is exceeded and the predicted vibration levels at a receiver have the potential to exceed the maximum allowable vibration levels , additional mitigation measures outlined in Table C.3 of the CVNG should be implemented. The additional mitigation measures outlined in Table C.3 of the CVNG are reproduced in Table 8-7.

Table 8-7 Vibration Additional Mitigation Measures

Predicted ground-borne vibration level at receiver	**Additional Mitigation Measure**	
Perception	**Type [1]**	**Apply to[2]**
Standard Hours: Mon- Fri (7am – 6pm), Sat (8am-1pm), Sun/Pub Hol (NIL)		
Predicted Vibration Exceeds Maximum Levels	V, N, RP	All
OOHW Period 1: Mon- Fri (6pm-10pm), Sat (7am - 8am & 1pm - 10pm), Sun/Pub Hol (8am-6pm)		
Predicted Vibration Exceeds Maximum Levels	V, IB, N, RO, PC, RP, SN	All
OOHW Period 2: Mon- Fri (10pm - 7am), Sat (10pm – 8am), Sun/Pub Hol (6pm – 7am)		
Predicted Vibration Exceeds Maximum Levels	AA, V, IB, PC, RP, SN	All

Note 1: AA= Alternate Accommodation, V – Validation of Predicted Noise Levels, IB – individual briefings, N = Notification Drops, RO = Project Specific Respite Offers, PC= Phone Calls, SN = Specific Notifications

Note 2: All affected receivers

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9 Conclusion

Muller Acoustic Consulting Pty Ltd (MAC) has completed an Operational, Construction Noise and Vibration Assessment for the proposed Maitland Bay Drive and Picnic Parade Intersection Upgrade, Ettalong Beach, NSW.

A comparison of the existing and future (ie post proposal) traffic noise levels identify that the proposal and in particular the proposed change in noise level to existing noise levels will not increase by more than 2 dB at all receivers.

For construction noise, several activities have been identified to generate noise levels above noise management levels for the proposal, with the highly affected LAeq(15min) noise management level of 75 dBA exceeded at several receivers.

Key noise reasonable and feasible reduction strategies provided in this report would see noise emissions significantly reduced with most residences falling within the “Noticeable” noise band.

Impact associated with vibration emissions are not anticipated for the proposal if use of vibrating sources (ie rollers) are properly managed.

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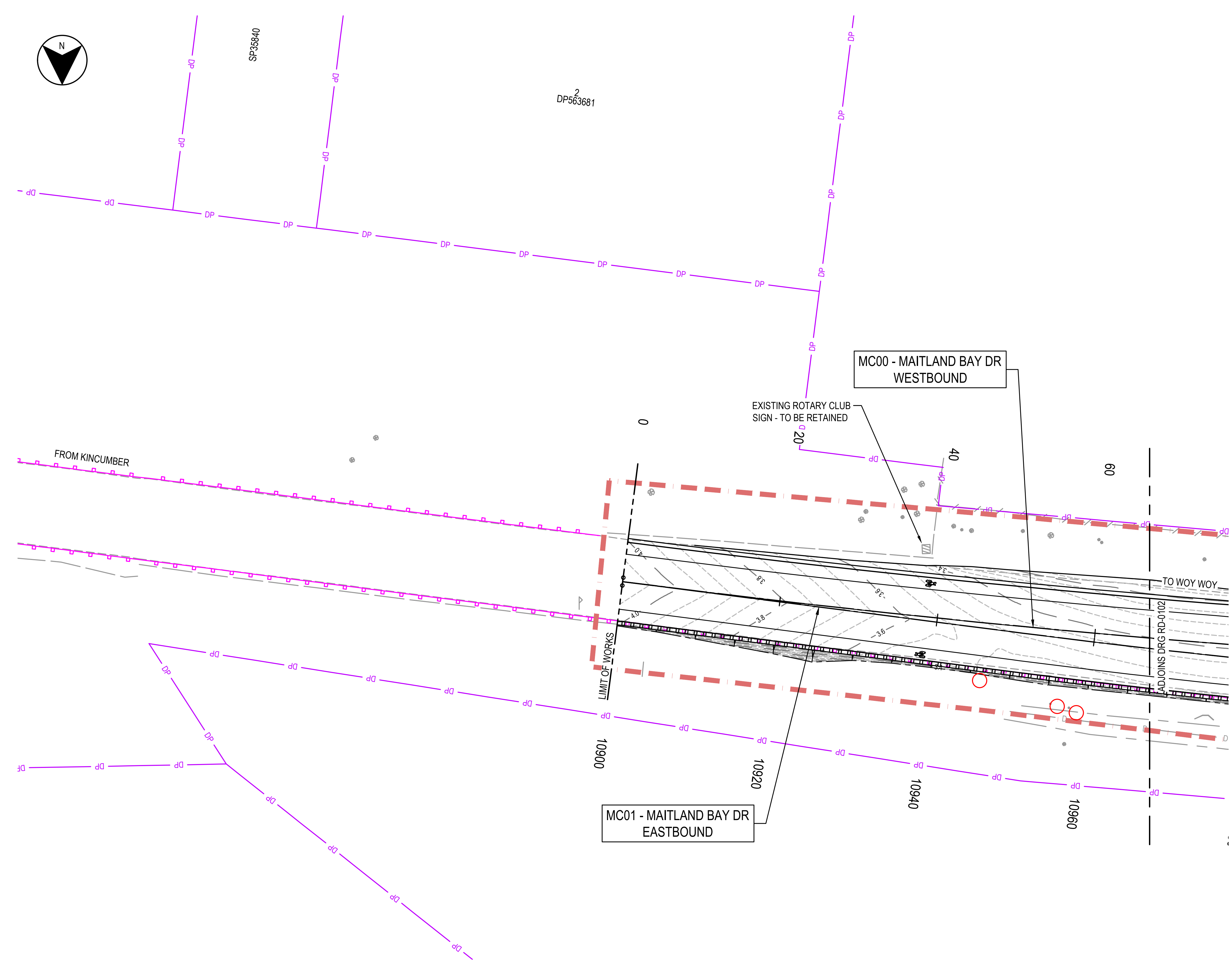
Appendix A – Concept Plans



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- PROPOSAL BOUNDARY
- PROPOSED SAFETY GUARD RAIL
- EXISTING SAFETY GUARD RAIL
- SURVEY INFORMATION
- DESIGN LAYOUT
- PROPOSED MAJOR CONTOURS (0.2m INTERVALS)
- PROPOSED MINOR CONTOURS (0.05m INTERVALS)
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- PROPOSED HANDRAIL
- EXISTING SIGN SUPPORT
- PROPOSED STREET LIGHTING
- EXISTING STREET LIGHT / POWER POLE
- EXISTING OVERHEAD WIRES
- INDICATIVE LOCATION OF THREATENED SPECIES MAGENTA LILLY PILLY/ SYZYGIUM PANICULATUM

LEGEND

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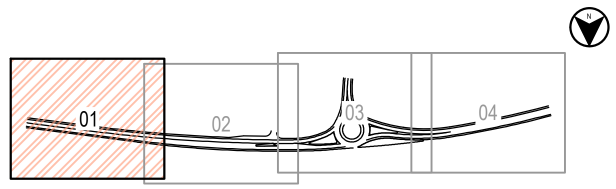

KEY PLAN

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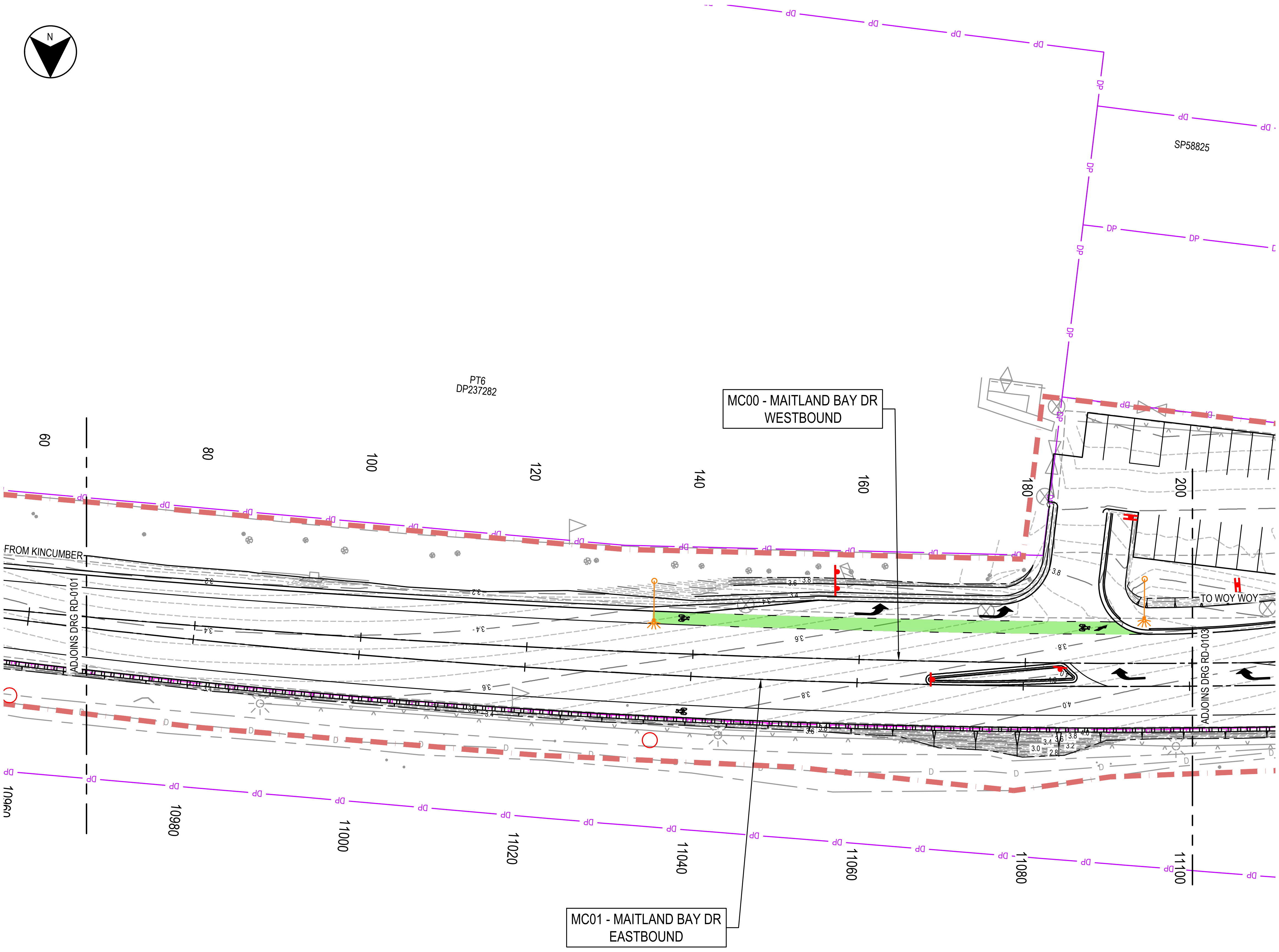

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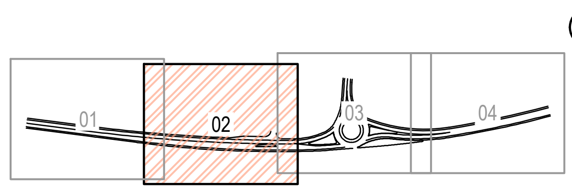

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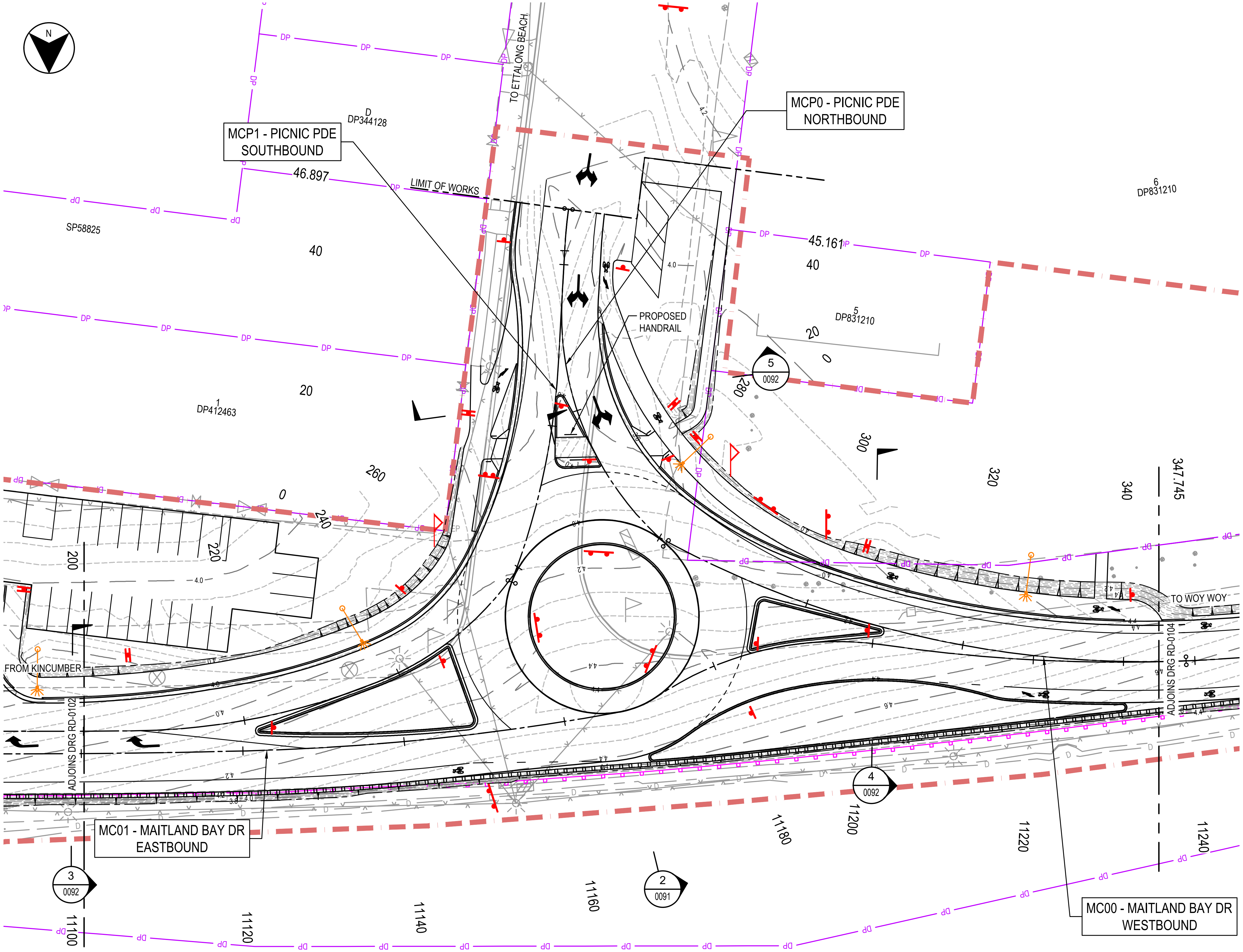

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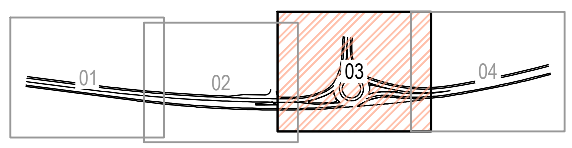

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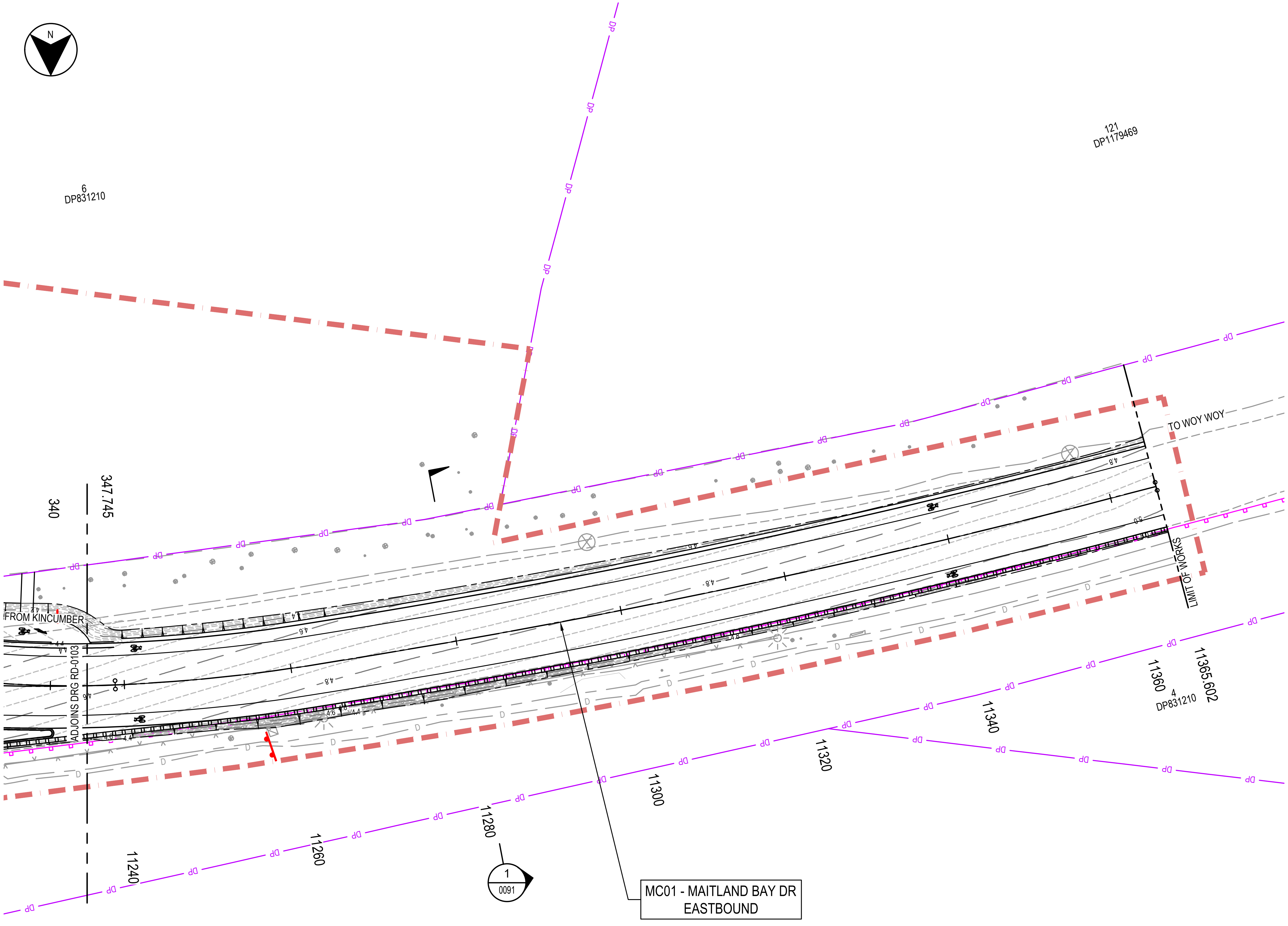

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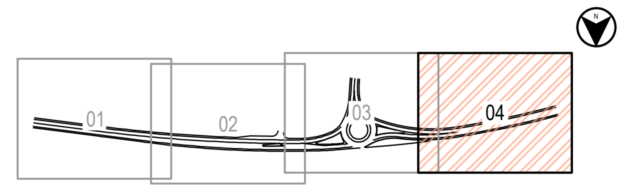

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PROJECT MNGR	C.MORLEY	23.08.19

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Appendix B – Noise Logging Charts

Background Noise Levels

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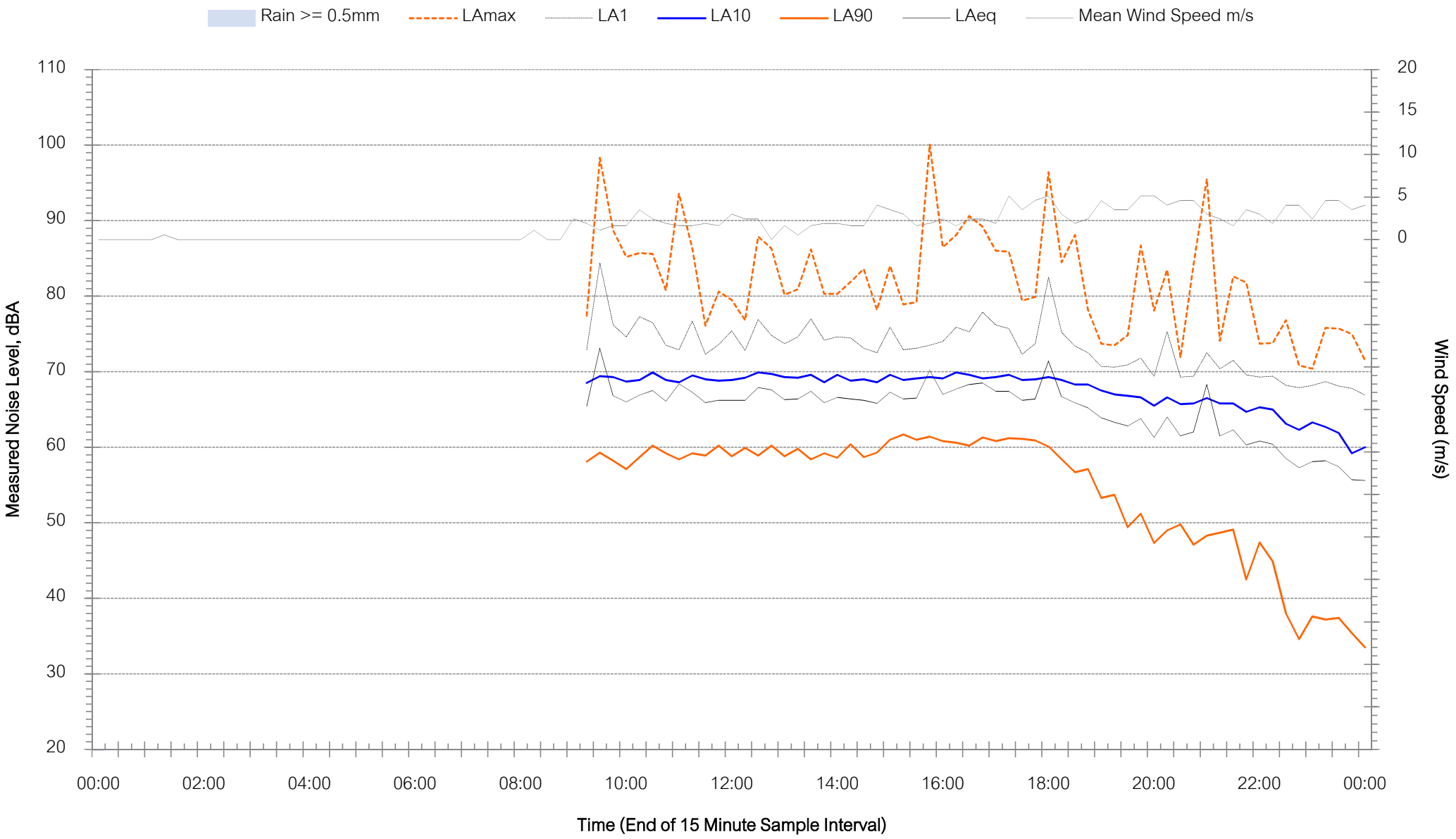
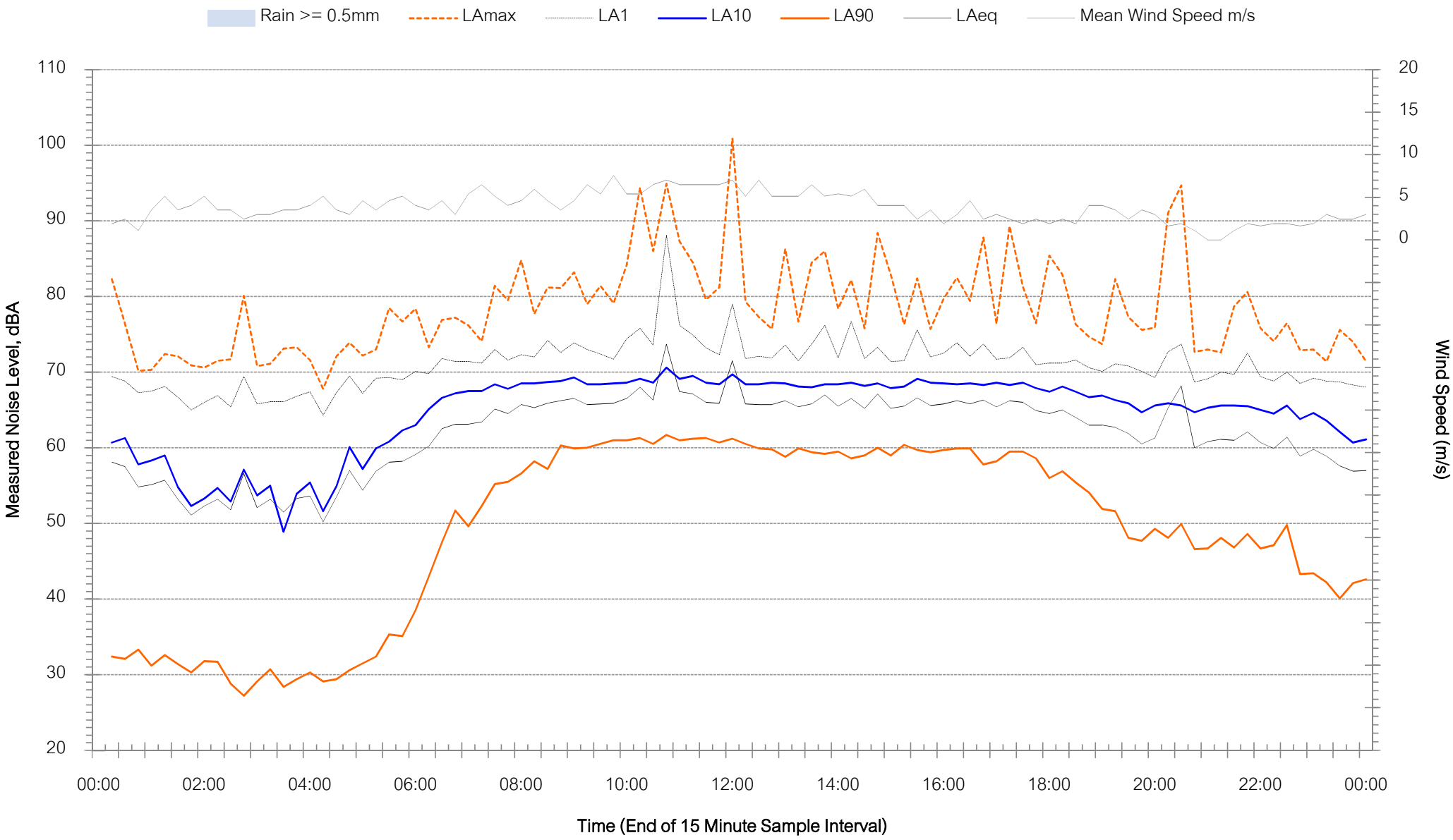


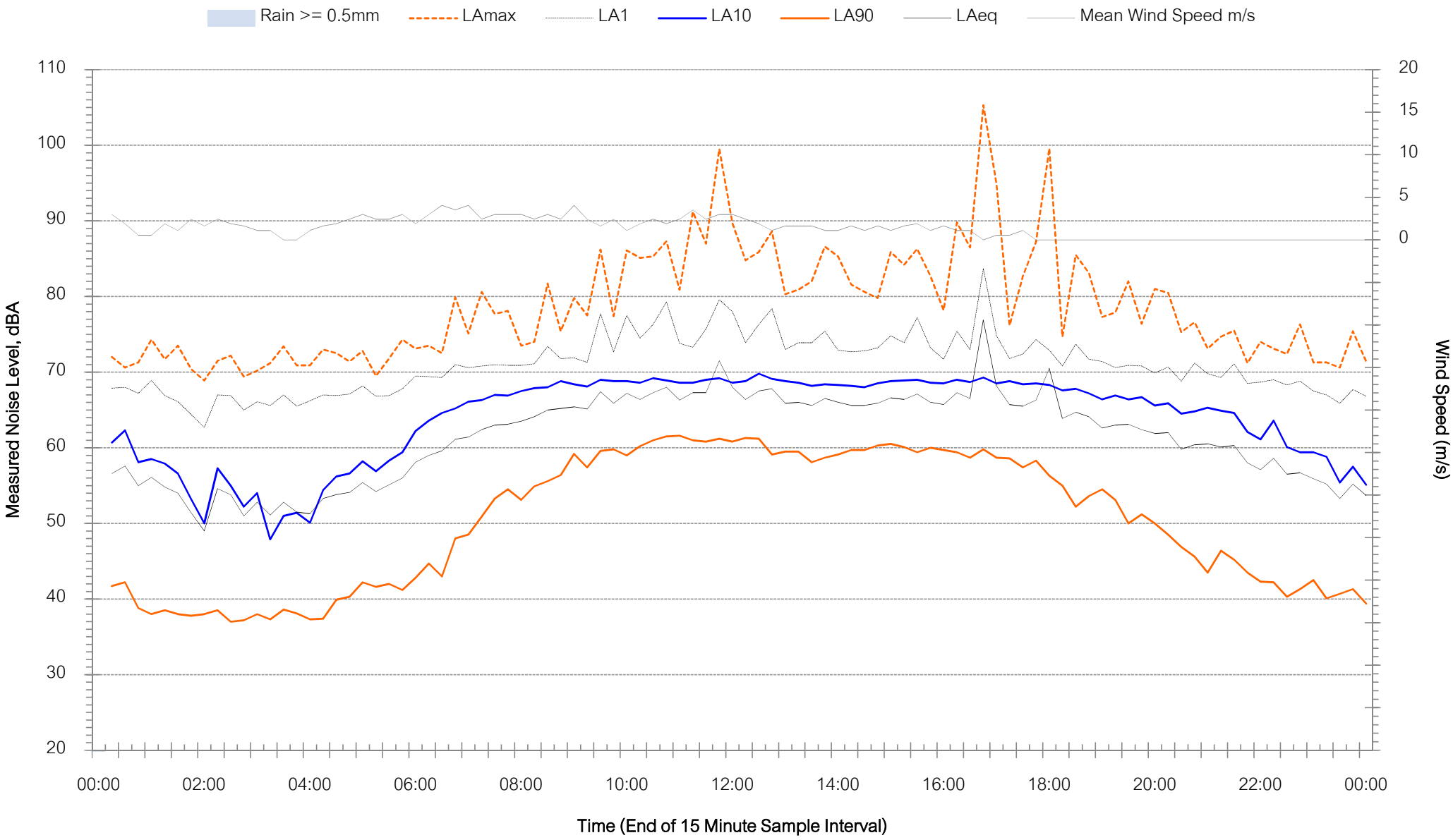
Background Noise Levels

Maitland Bay Drive - Saturday 11 May 2019



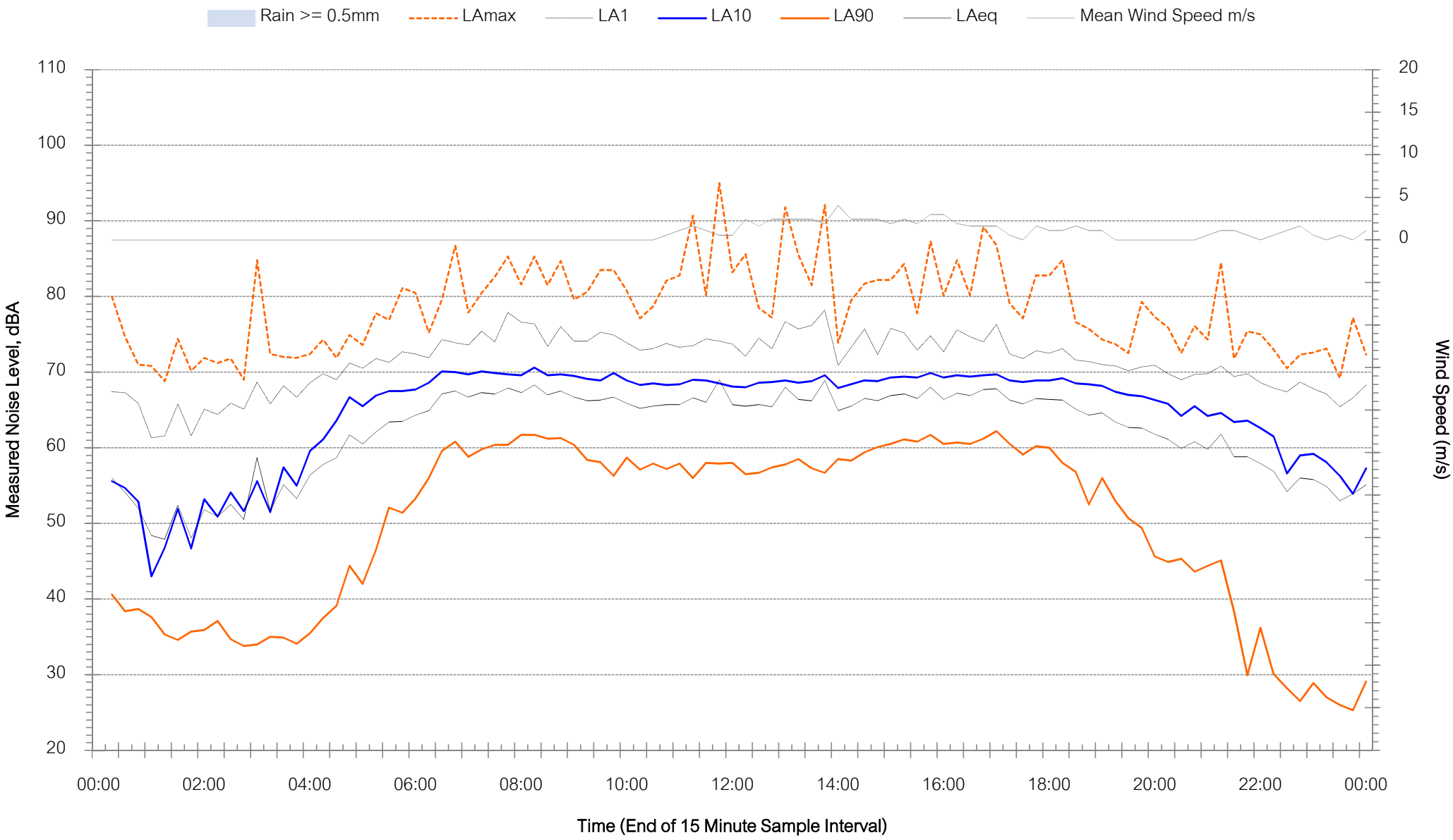
Background Noise Levels

Maitland Bay Drive - Sunday 12 May 2019



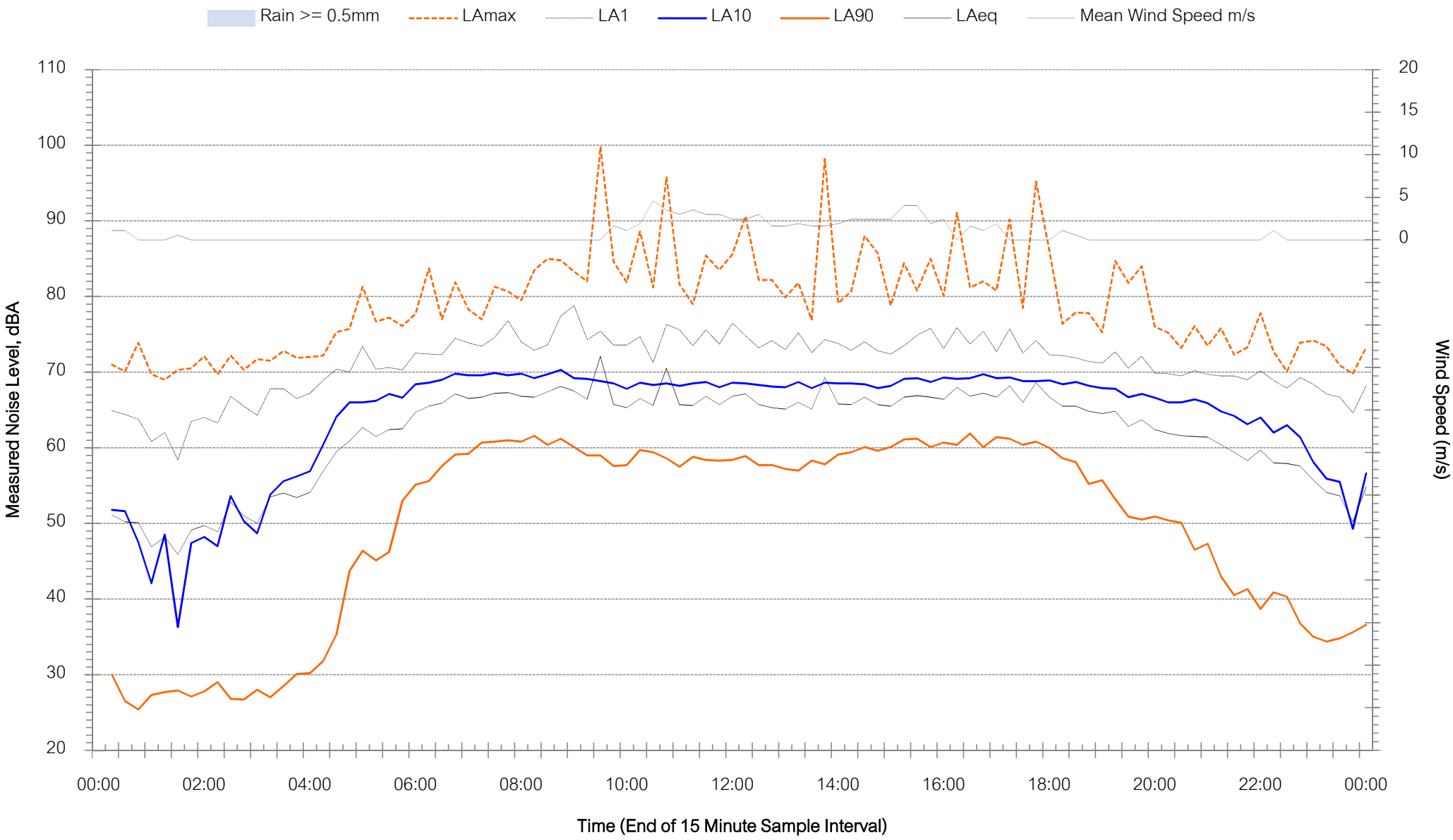
Background Noise Levels

Maitland Bay Drive - Monday 13 May 2019



Background Noise Levels

Maitland Bay Drive - Tuesday 14 May 2019



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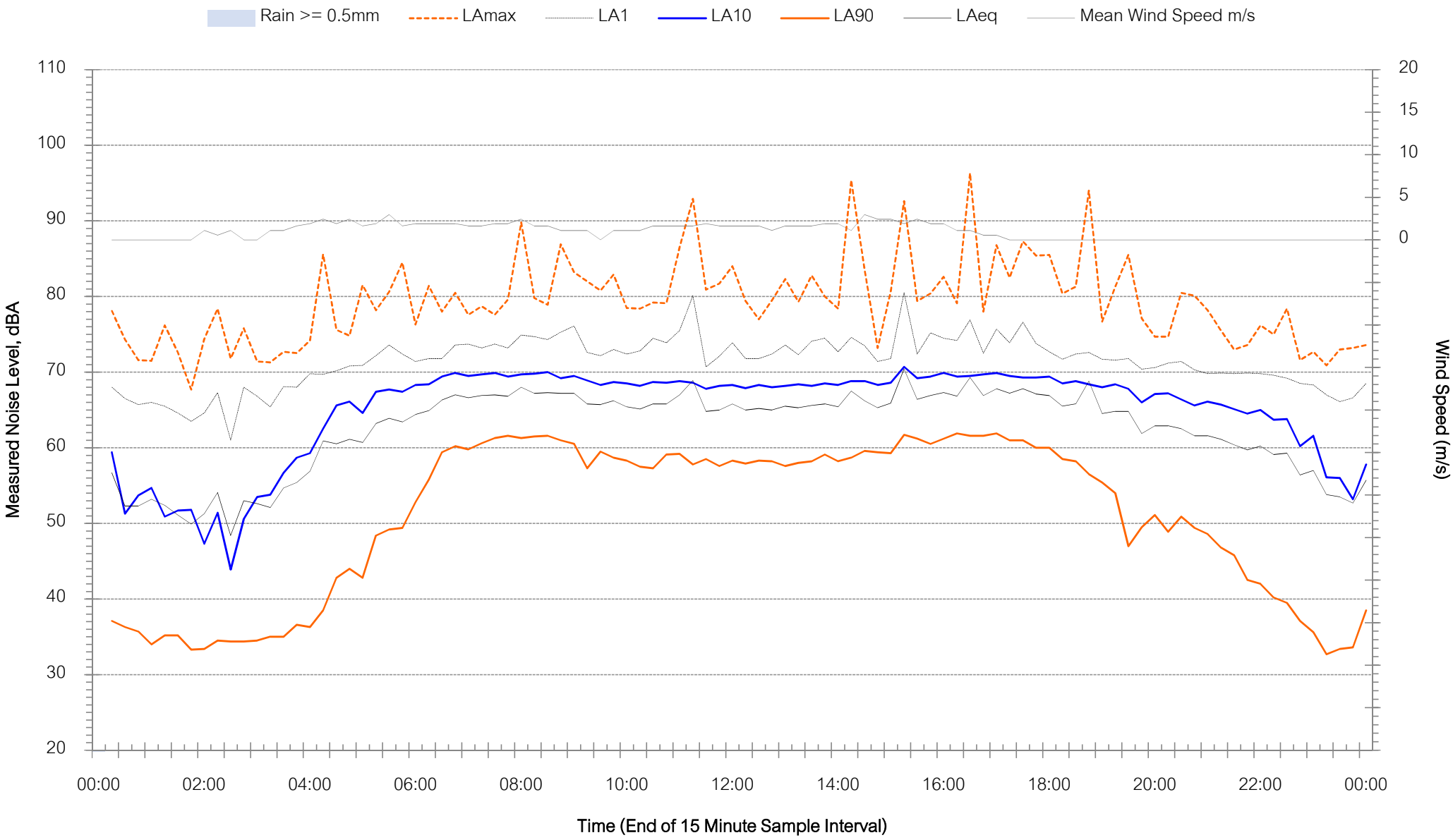

Background Noise Levels

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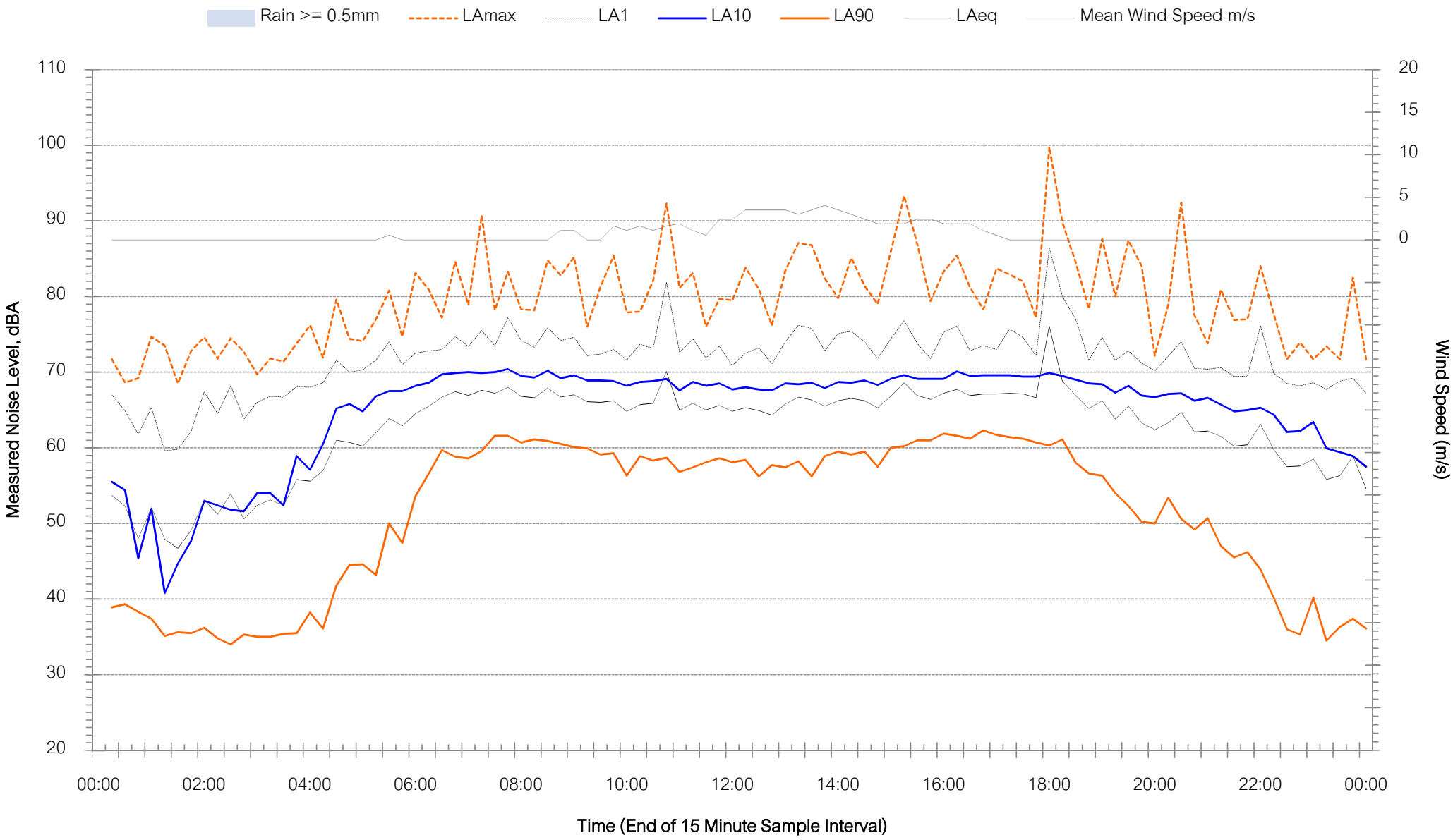

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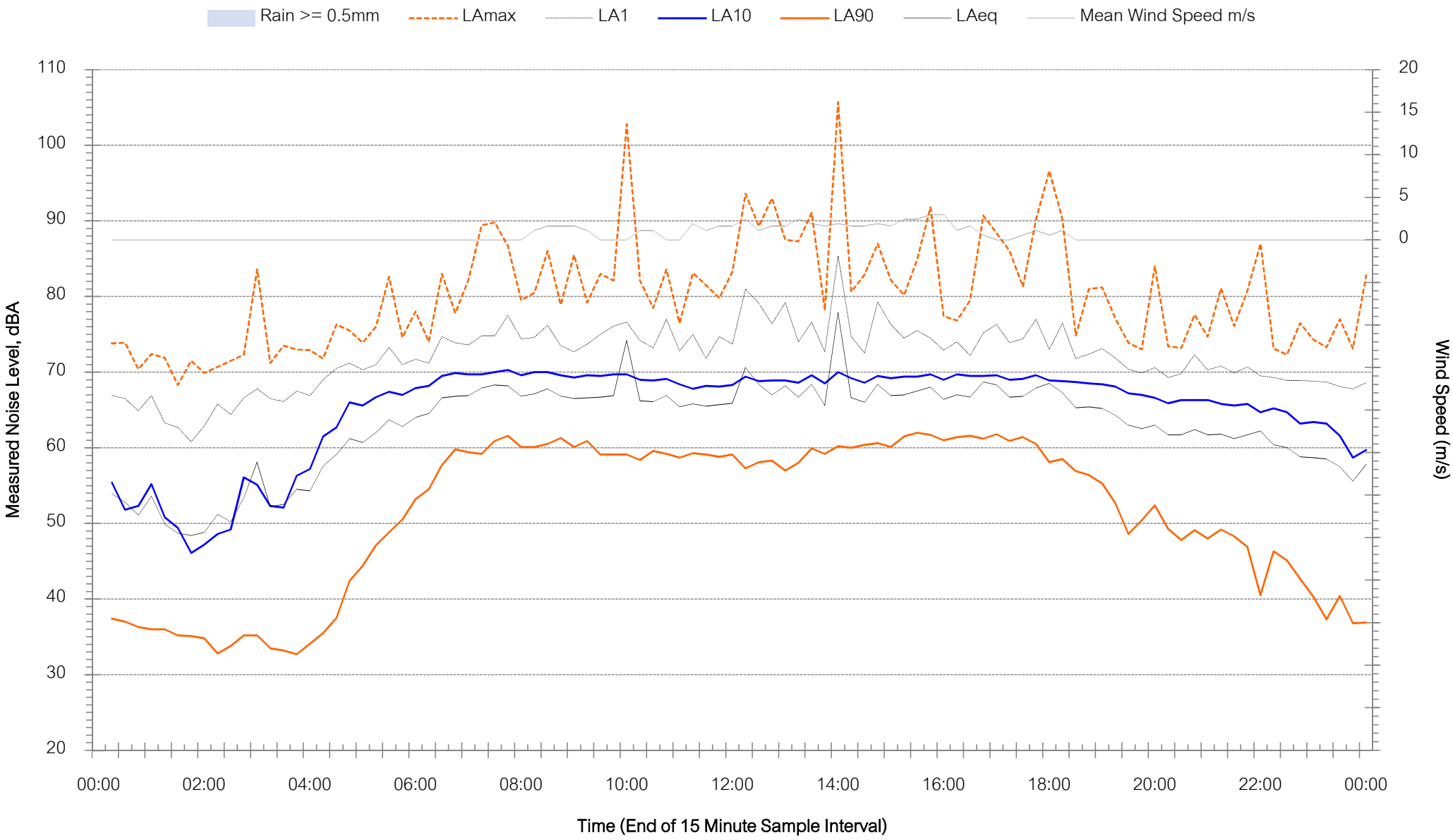
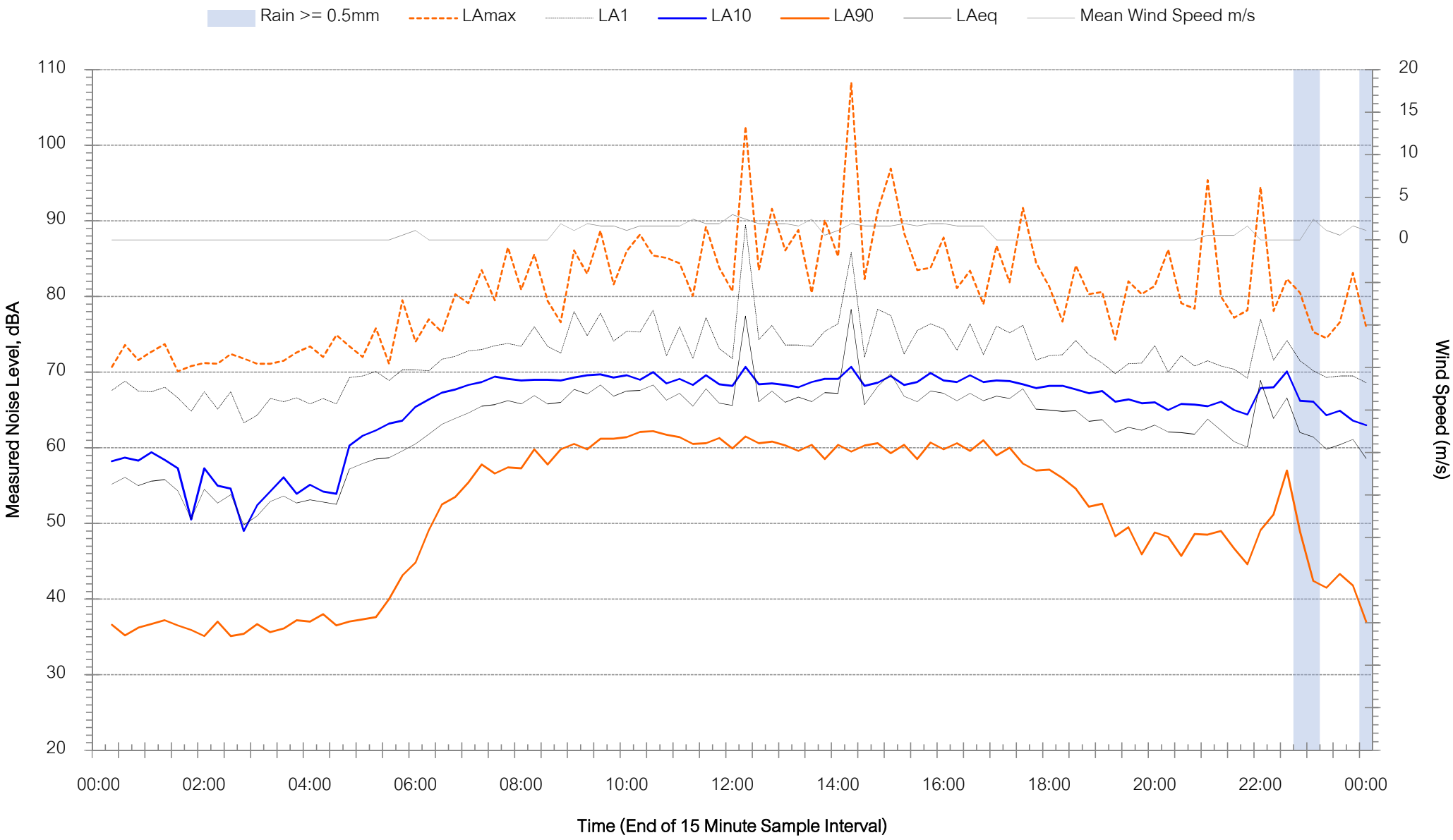


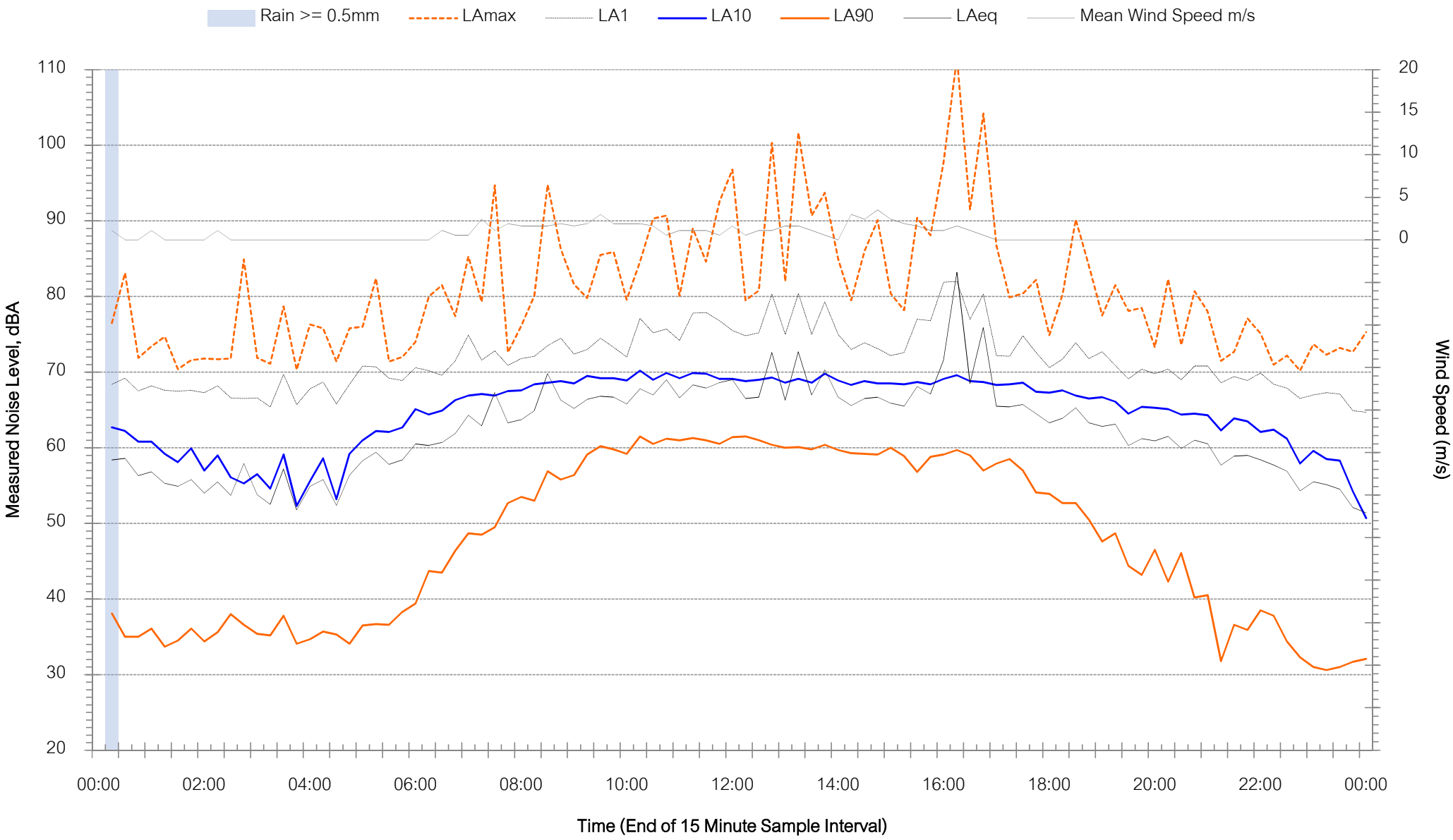
Background Noise Levels

Maitland Bay Drive - Saturday 18 May 2019



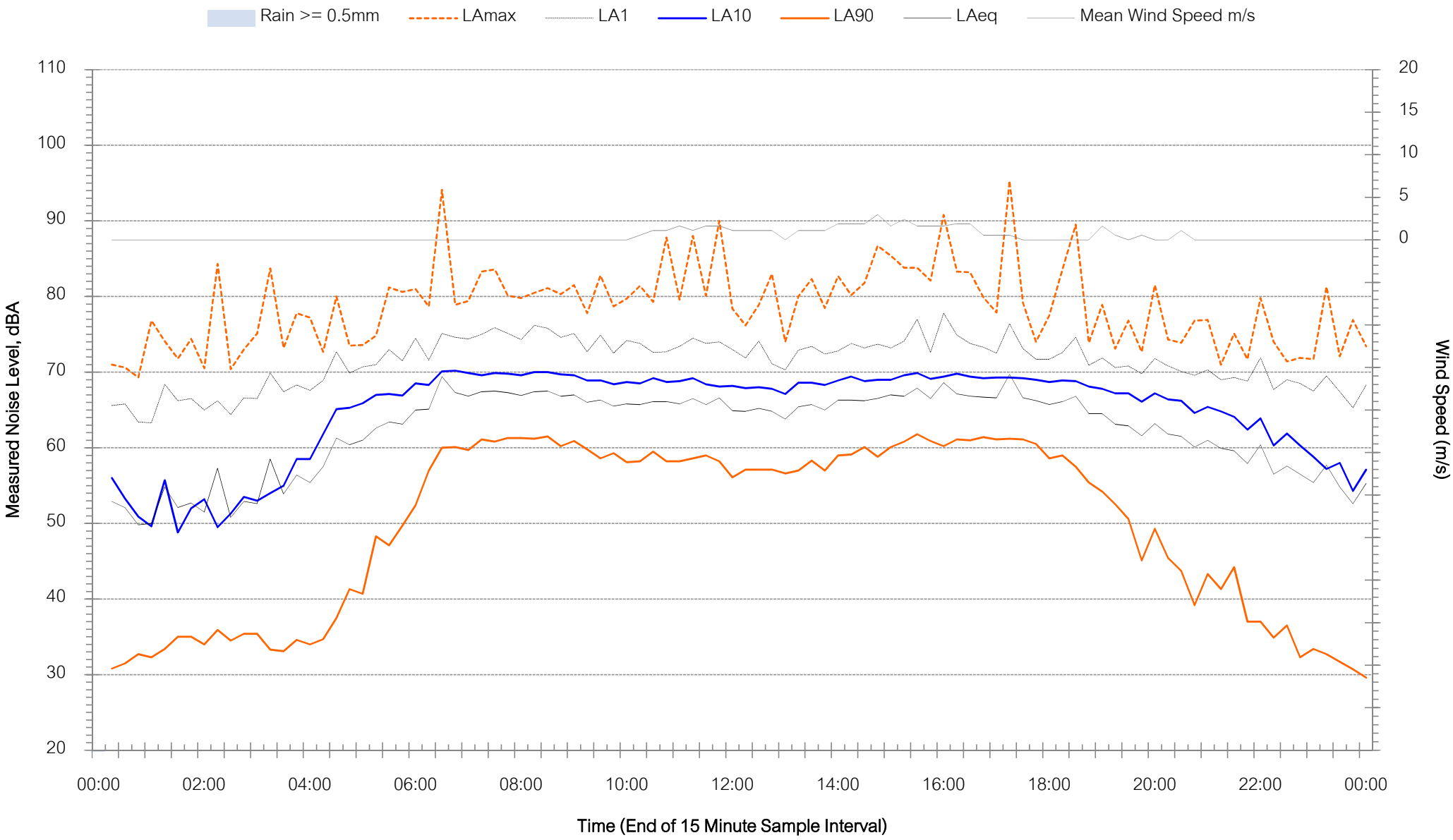
Background Noise Levels

Maitland Bay Drive - Sunday 19 May 2019



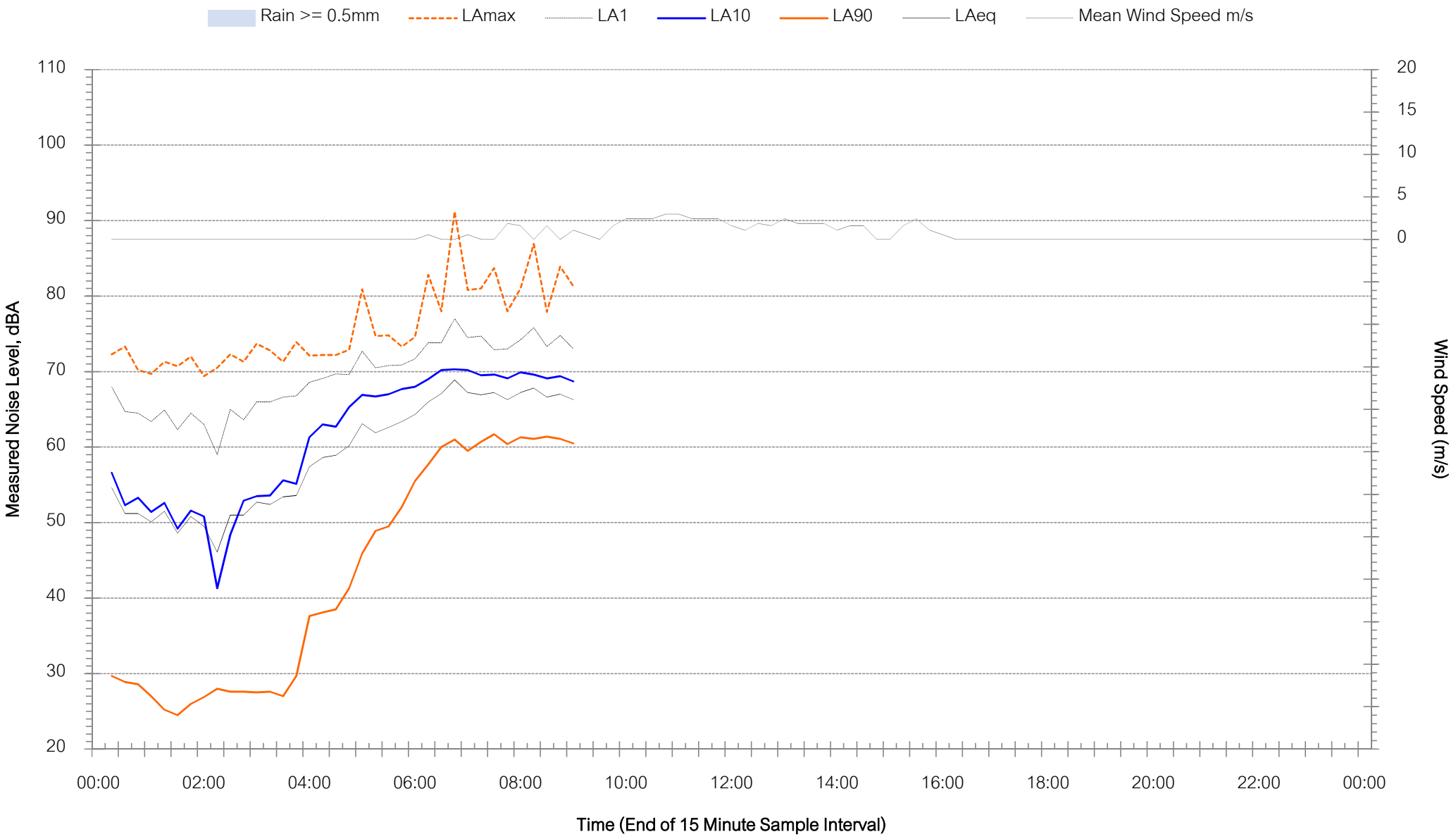
Background Noise Levels

Maitland Bay Drive - Monday 20 May 2019



Background Noise Levels

Maitland Bay Drive - Tuesday 21 May 2019



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Appendix C – Additional Mitigation Measures

Additional mitigation measures as outlined in Section 11.2.2 of the CNVG (Roads and Maritime, 2015) are summarised below. Many of these measures need communication with the community.

Specific notifications (SN)

Specific notifications are letterbox dropped or hand distributed to identified stakeholders no later than seven days ahead of construction activities that are likely to exceed the noise objectives. The exact conditions under which specific notifications would proceed are defined in the relevant Additional Mitigation Measures (Tables C1 to C3). This form of communication is used to support periodic notifications, or to advertise unscheduled work.

Phone calls (PC)

Phone calls detailing relevant information would be made to identified/affected stakeholders within seven days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs etc.

Individual briefings (IB)

Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the proposal.

Respite Offer (RO)

Respite Offers should be made where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed 3 hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers.

Respite Period 1 (R1)

Out of hours construction noise in out of hours period 1 shall be limited to no more than three consecutive evenings per week except where there is a Negotiated Respite. For night work these periods of work should be separated by not less than one week and no more than 6 evenings per month

Respite Period 2 (R2)

Night time construction noise in out of hours period 2 shall be limited to two consecutive nights except for where there is a Negotiated Respite. For night work these periods of work should be separated by not less than one week and 6 nights per month.

Negotiated Respite (NR)

Respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration proposals. In this instance and where it can be strongly justified it may be beneficial to increase the number of evenings or nights worked through Negotiated Respite so that the proposal can be completed more quickly.

Alternate accommodation for short or long periods may be considered and negotiated with affected receivers. This measure is determined on a proposal-by-proposal basis, and may not be applicable to all Roads and Maritime proposals and affected receivers.

The receivers that should be liaised with to gain community support for Negotiated Respite include those where out of hours work exceed the NML.

Where there are few receivers above the NML each of these receivers should be visited to discuss the proposal to gain support for Negotiated Respite.

In instances where there are many receivers above the NML it may not be practical discuss the proposal with every receiver. Instead the community should be proactively engaged so they have an incentive to participate in discussion supporting Negotiated Respite. Support may be demonstrated from surveys, online feedback, contact phone numbers and community events.

Alternative accommodation (AA)

Alternative accommodation options should be provided to residents living in close proximity to construction work that are likely to incur noise levels significantly above the applicable level (Tables C1-C3). The specifics of the offer will be determined on a proposal-by-proposal basis.

Verification

Please see Appendix F of the CNVG for more details about verification of Noise and Vibration levels after complaints and as part of routine checks of noise levels.

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Appendix D – Tabulated Noise Results

Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

Unmitigated Single Point Results Standard Construction Hours							
Receiver	Activity/Scenario						
	1	2	3	4	5	6	7
R1	37	44	48	80	71	76	66
R2	39	44	49	82	76	77	68
R3	40	47	50	80	71	75	66
R4	42	48	48	81	74	77	67
R5	55	65	62	81	71	76	67
R6	65	68	65	79	70	74	65
R7	66	67	64	73	62	68	58
R8	66	67	62	68	58	64	54
R9	64	65	61	67	57	63	53
R10	66	65	61	67	56	63	53
R11	65	65	60	68	57	64	54
R12	60	59	56	64	54	60	50
R13	59	59	55	63	53	59	49
R14	58	58	55	62	53	58	48
R15	59	59	55	62	52	58	48
R16	58	59	54	62	52	58	48
R17	64	75	74	80	71	76	66
R18	45	74	66	73	63	69	59
R19	64	74	73	80	72	76	66
R20	47	60	57	62	52	58	48
R21	52	67	60	65	55	60	51
R22	50	70	68	79	69	74	65
R23	49	67	65	79	69	74	64
R24	59	65	62	78	70	74	64
R25	48	51	46	63	45	59	49
R26	45	61	52	64	54	59	50
R27	33	49	42	51	40	46	36
R28	36	46	52	62	51	57	48
R29	38	45	53	63	53	58	49
R30	41	59	54	63	53	59	49
R31	36	59	55	63	53	59	49
R32	34	57	50	58	48	53	44
R33	37	57	52	63	53	59	49
R34	36	38	38	62	52	58	48
R35	33	46	44	59	48	54	44
R36	41	52	49	62	52	57	48
R37	31	51	48	62	52	58	48
R38	31	44	40	58	48	54	44
R39	31	44	43	60	50	55	46
R40	43	51	49	62	52	57	48
R41	23	35	43	61	50	56	46
R42	39	50	47	63	53	59	49
R43	35	51	46	69	59	65	55
R44	42	51	47	65	55	60	50
R45	43	52	48	66	56	62	52
R46	44	53	49	68	57	63	54
R47	44	53	49	68	58	64	54
R48	40	49	44	67	56	62	53
R49	41	50	45	66	55	61	52
R50	38	45	40	65	55	60	50
R51	34	44	37	62	53	57	47
AR1	74	76	70	77	66	72	63
AR2	67	66	62	72	61	67	57
AR3	48	66	63	72	62	68	58
PR1	34	61	63	71	61	67	57

Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

Application of Feasible and Reasonable Mitigation Measures Single Point Results Standard Construction Hours							
Receiver	Activity/Scenario						
	1	2	3	4	5	6	7
R1	27	34	38	70	61	66	56
R2	29	34	39	72	66	67	58
R3	30	37	40	70	61	65	56
R4	32	38	38	71	64	67	57
R5	45	55	52	71	61	66	57
R6	55	58	55	69	60	64	55
R7	56	57	54	63	52	58	48
R8	56	57	52	58	48	54	44
R9	54	55	51	57	47	53	43
R10	56	55	51	57	46	53	43
R11	55	55	50	58	47	54	44
R12	50	49	46	54	44	50	40
R13	49	49	45	53	43	49	39
R14	48	48	45	52	43	48	38
R15	49	49	45	52	42	48	38
R16	48	49	44	52	42	48	38
R17	54	65	64	70	61	66	56
R18	35	64	56	63	53	59	49
R19	54	64	63	70	62	66	56
R20	37	50	47	52	42	48	38
R21	42	57	50	55	45	50	41
R22	40	60	58	69	59	64	55
R23	39	57	55	69	59	64	54
R24	49	55	52	68	60	64	54
R25	38	41	36	53	35	49	39
R26	35	51	42	54	44	49	40
R27	23	39	32	41	30	36	26
R28	26	36	42	52	41	47	38
R29	28	35	43	53	43	48	39
R30	31	49	44	53	43	49	39
R31	26	49	45	53	43	49	39
R32	24	47	40	48	38	43	34
R33	27	47	42	53	43	49	39
R34	26	28	28	52	42	48	38
R35	23	36	34	49	38	44	34
R36	31	42	39	52	42	47	38
R37	21	41	38	52	42	48	38
R38	21	34	30	48	38	44	34
R39	21	34	33	50	40	45	36
R40	33	41	39	52	42	47	38
R41	13	25	33	51	40	46	36
R42	29	40	37	53	43	49	39
R43	25	41	36	59	49	55	45
R44	32	41	37	55	45	50	40
R45	33	42	38	56	46	52	42
R46	34	43	39	58	47	53	44
R47	34	43	39	58	48	54	44
R48	30	39	34	57	46	52	43
R49	31	40	35	56	45	51	42
R50	28	35	30	55	45	50	40
R51	24	34	27	52	43	47	37
AR1	64	66	60	67	56	62	53
AR2	57	56	52	62	51	57	47
AR3	38	56	53	62	52	58	48
PR1	24	51	53	61	51	57	47

Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

Unmitigated Single Point Results Out of Hours Period 2							
Receiver	Activity/Scenario						
	1	2	3	4	5	6	7
R1	37	44	48	80	71	76	66
R2	39	44	49	82	76	77	68
R3	40	47	50	80	71	75	66
R4	42	48	48	81	74	77	67
R5	55	65	62	81	71	76	67
R6	65	68	65	79	70	74	65
R7	66	67	64	73	62	68	58
R8	66	67	62	68	58	64	54
R9	64	65	61	67	57	63	53
R10	66	65	61	67	56	63	53
R11	65	65	60	68	57	64	54
R12	60	59	56	64	54	60	50
R13	59	59	55	63	53	59	49
R14	58	58	55	62	53	58	48
R15	59	59	55	62	52	58	48
R16	58	59	54	62	52	58	48
R17	64	75	74	80	71	76	66
R18	45	74	66	73	63	69	59
R19	64	74	73	80	72	76	66
R20	47	60	57	62	52	58	48
R21	52	67	60	65	55	60	51
R22	50	70	68	79	69	74	65
R23	49	67	65	79	69	74	64
R24	59	65	62	78	70	74	64
R25	48	51	46	63	45	59	49
R26	45	61	52	64	54	59	50
R27	33	49	42	51	40	46	36
R28	36	46	52	62	51	57	48
R29	38	45	53	63	53	58	49
R30	41	59	54	63	53	59	49
R31	36	59	55	63	53	59	49
R32	34	57	50	58	48	53	44
R33	37	57	52	63	53	59	49
R34	36	38	38	62	52	58	48
R35	33	46	44	59	48	54	44
R36	41	52	49	62	52	57	48
R37	31	51	48	62	52	58	48
R38	31	44	40	58	48	54	44
R39	31	44	43	60	50	55	46
R40	43	51	49	62	52	57	48
R41	23	35	43	61	50	56	46
R42	39	50	47	63	53	59	49
R43	35	51	46	69	59	65	55
R44	42	51	47	65	55	60	50
R45	43	52	48	66	56	62	52
R46	44	53	49	68	57	63	54
R47	44	53	49	68	58	64	54
R48	40	49	44	67	56	62	53
R49	41	50	45	66	55	61	52
R50	38	45	40	65	55	60	50
R51	34	44	37	62	53	57	47
AR1	74	76	70	77	66	72	63
AR2	67	66	62	72	61	67	57
AR3	48	66	63	72	62	68	58
PR1	34	61	63	71	61	67	57

Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

Application of Feasible and Reasonable Mitigation Measures Single Point Results Out of Hours Period 2							
Receiver	Activity/Scenario						
	1	2	3	4	5	6	7
R1	27	34	38	70	61	66	56
R2	29	34	39	72	66	67	58
R3	30	37	40	70	61	65	56
R4	32	38	38	71	64	67	57
R5	45	55	52	71	61	66	57
R6	55	58	55	69	60	64	55
R7	56	57	54	63	52	58	48
R8	56	57	52	58	48	54	44
R9	54	55	51	57	47	53	43
R10	56	55	51	57	46	53	43
R11	55	55	50	58	47	54	44
R12	50	49	46	54	44	50	40
R13	49	49	45	53	43	49	39
R14	48	48	45	52	43	48	38
R15	49	49	45	52	42	48	38
R16	48	49	44	52	42	48	38
R17	54	65	64	70	61	66	56
R18	35	64	56	63	53	59	49
R19	54	64	63	70	62	66	56
R20	37	50	47	52	42	48	38
R21	42	57	50	55	45	50	41
R22	40	60	58	69	59	64	55
R23	39	57	55	69	59	64	54
R24	49	55	52	68	60	64	54
R25	38	41	36	53	35	49	39
R26	35	51	42	54	44	49	40
R27	23	39	32	41	30	36	26
R28	26	36	42	52	41	47	38
R29	28	35	43	53	43	48	39
R30	31	49	44	53	43	49	39
R31	26	49	45	53	43	49	39
R32	24	47	40	48	38	43	34
R33	27	47	42	53	43	49	39
R34	26	28	28	52	42	48	38
R35	23	36	34	49	38	44	34
R36	31	42	39	52	42	47	38
R37	21	41	38	52	42	48	38
R38	21	34	30	48	38	44	34
R39	21	34	33	50	40	45	36
R40	33	41	39	52	42	47	38
R41	13	25	33	51	40	46	36
R42	29	40	37	53	43	49	39
R43	25	41	36	59	49	55	45
R44	32	41	37	55	45	50	40
R45	33	42	38	56	46	52	42
R46	34	43	39	58	47	53	44
R47	34	43	39	58	48	54	44
R48	30	39	34	57	46	52	43
R49	31	40	35	56	45	51	42
R50	28	35	30	55	45	50	40
R51	24	34	27	52	43	47	37
AR1	64	66	60	67	56	62	53
AR2	57	56	52	62	51	57	47
AR3	38	56	53	62	52	58	48
PR1	24	51	53	61	51	57	47

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Appendix E – Standard Construction Hours Mitigated Noise Management Contours

Figure E-1: Activity 1 Establishment of Site Compound - Standard Hours Trigger for Additional Mitigation Measures

Figure E-2: Activity 2 Vegetation Removal - Standard Hours Trigger for Additional Mitiagtion Measures

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Figure E-3: Activity 3 Utility Relocation - Standard Hours Trigger for Additional Mitigation Measures

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Figure E-4: Activity 4 Milling of Exisiting Road Surface - Standard Hours Trigger for Additional Mitigation Measures

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Figure E-5: Activity 5 Kerbing and Roundabout Construction/Installation of Safety Barriers - Standard Hours Trigger for Additional Mitigation Measures

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Figure E-6: Activity 6 Construction of New Asphalt Layers - Standard Hours Trigger for Additional Mitigation Measures

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Figure E-7: Activity 7 Linemarking - Standard Hours Trigger for Additional Mitigation Measures

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