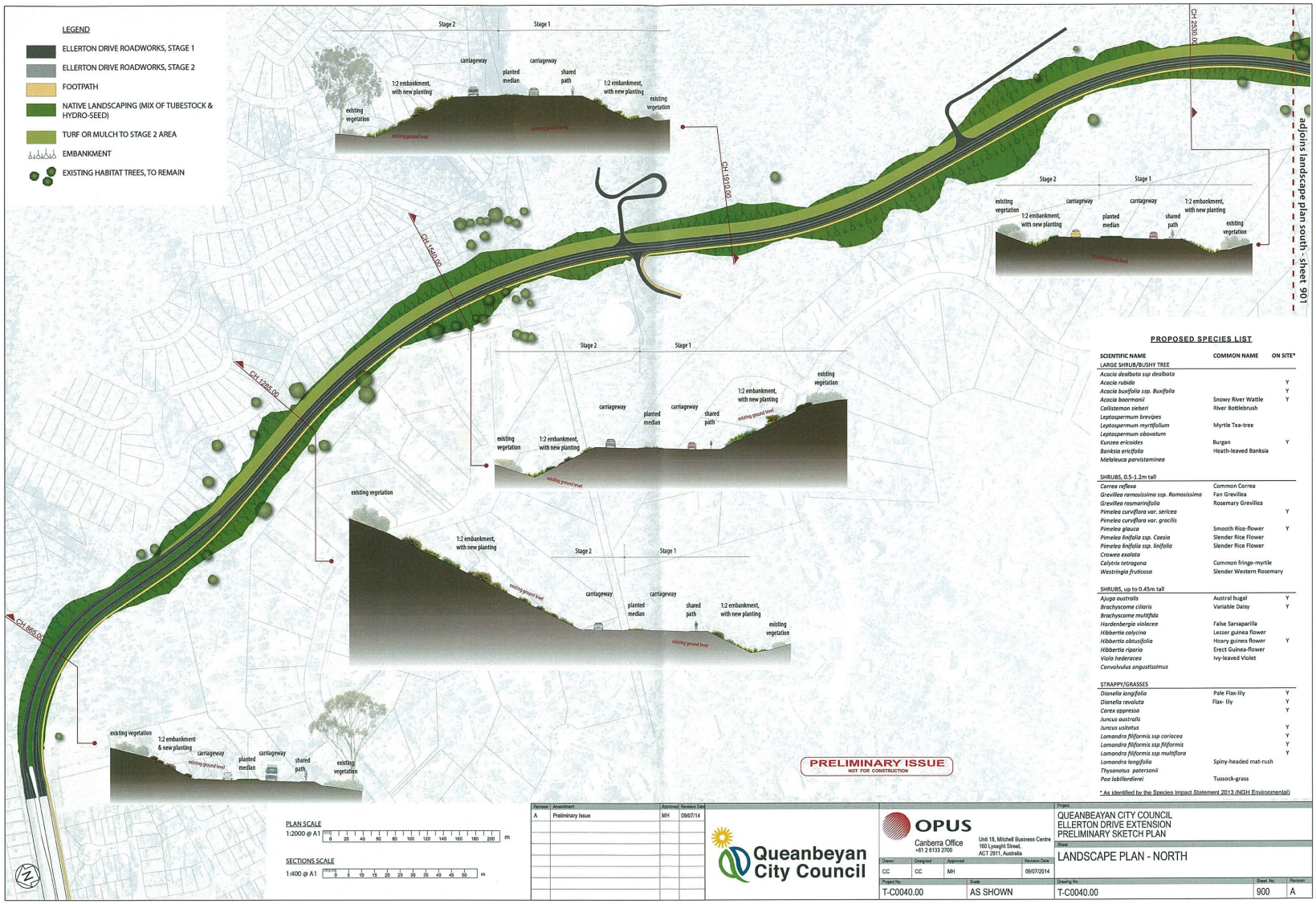
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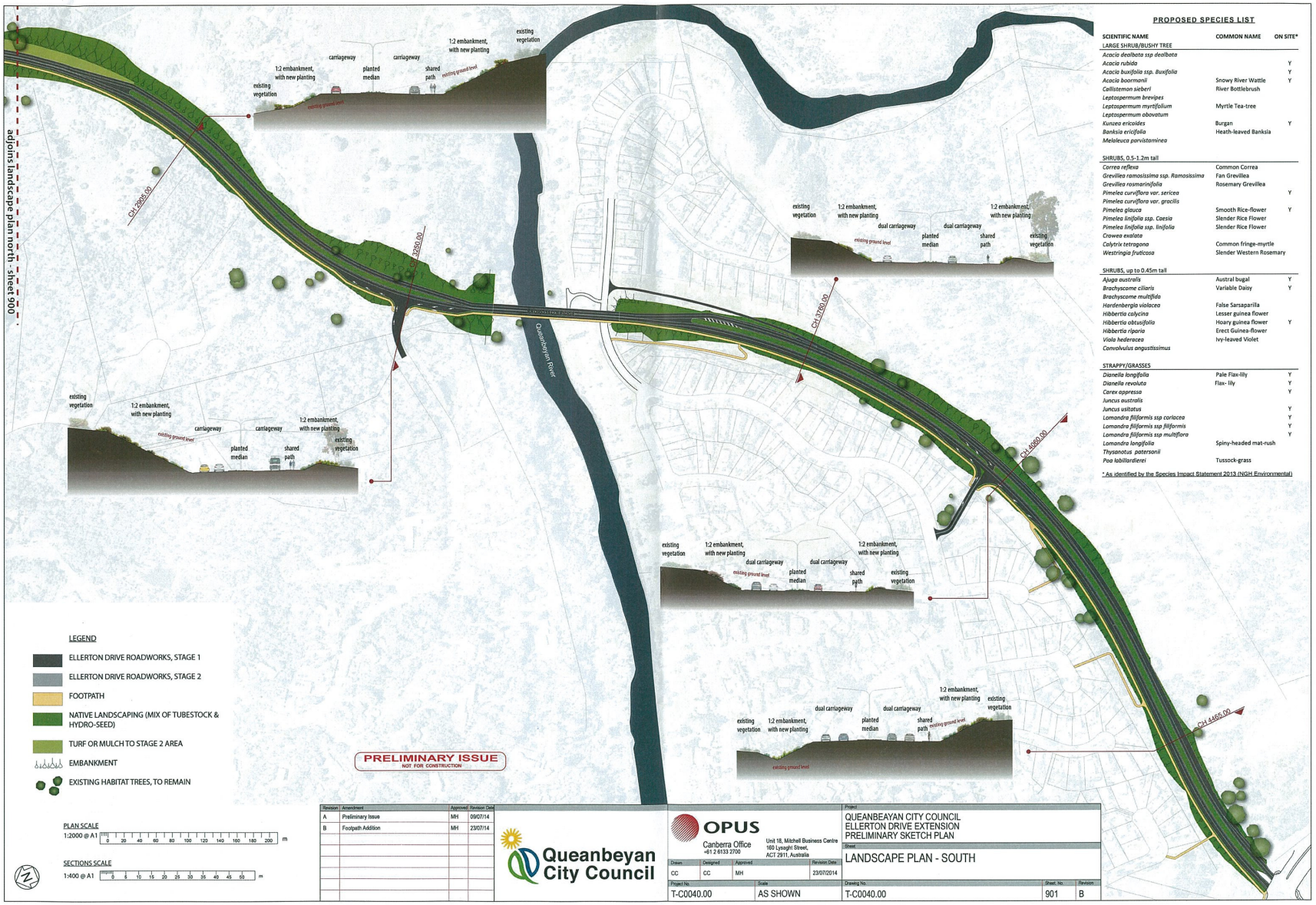
ELLERTON DRIVE ROADWORKS, STAGE 1
ELLERTON DRIVE ROADWORKS, STAGE 2
FOOTPATH
NATIVE LANDSCAPING (MIX OF TUBESTOCK & HYDRO-SEED)
TURF OR MULCH TO STAGE 2 AREA
EMBANKMENT
EXISTING HABITAT TREES, TO REMAIN
CH 2530.00
adjoins landscape plan south - sheet 901
CH 1515.00
CH 1540.00
CH 1295.00
CH 865.00
Stage 2
Stage 1
carriageway
planted median
shared path
1:2 embankment, with new planting
existing vegetation
existing ground level
1:2 embankment & new planting
PRELIMINARY ISSUE
NOT FOR CONSTRUCTION
PLAN SCALE
1:2000 @ A1
SECTIONS SCALE
1:400 @ A1
PROPOSED SPECIES LIST
SCIENTIFIC NAME
COMMON NAME
ON SITE*
LARGE SHRUB/BUSHY TREE
Acacia dealbata ssp dealbata
Acacia rubida
Y
Acacia buxifolia ssp. Buxifolia
Y
Acacia boormanii
Snowy River Wattle
Y
Callistemon sieberi
River Bottlebrush
Leptospermum brevipes
Leptospermum myrtifolium
Myrtle Tea-tree
Leptospermum obovatum
Kunzea ericoides
Burgan
Y
Banksia ericifolia
Heath-leaved Banksia
Melaleuca parvistaminea
SHRUBS, 0.5-1.2m tall
Correa reflexa
Common Correa
Grevillea ramosissima ssp. Ramosissima
Fan Grevillea
Grevillea rosmarinifolia
Rosemary Grevillea
Pimelea curviflora var. sericea
Y
Pimelea curviflora var. gracilis
Pimelea glauca
Smooth Rice-flower
Y
Pimelea linifolia ssp. Caesia
Slender Rice Flower
Pimelea linifolia ssp. linifolia
Slender Rice Flower
Crowea exalata
Calytrix tetragona
Common fringe-myrtle
Westringia fruticosa
Slender Western Rosemary
SHRUBS, up to 0.45m tall
Ajuga australis
Austral bugal
Y
Brachyscome ciliaris
Variable Daisy
Y
Brachyscome multifida
Hardenbergia violacea
False Sarsaparilla
Hibbertia calycina
Lesser guinea flower
Hibbertia obtusifolia
Hoary guinea flower
Y
Hibbertia riparia
Erect Guinea-flower
Viola hederacea
Ivy-leaved Violet
Convolvulus angustissimus
STRAPPY/GRASSES
Dianella longifolia
Pale Flax-lily
Y
Dianella revoluta
Flax- lily
Y
Carex appressa
Y
Juncus australis
Juncus usitatus
Y
Lomandra filiformis ssp coriacea
Y
Lomandra filiformis ssp filiformis
Y
Lomandra filiformis ssp multiflora
Y
Lomandra longifolia
Spiny-headed mat-rush
Thysanotus patersonii
Poa labillardierei
Tussock-grass
* As identified by the Species Impact Statement 2013 (NGH Environmental)
Revision
Amendment
Approved
Revision Date
A
Preliminary Issue
MH
09/07/14
Queanbeyan City Council
OPUS
Canberra Office
+61 2 6133 2700
Unit 18, Mitchell Business Centre
160 Lyneghl Street,
ACT 2911, Australia
Drawn
Designed
Approved
Revision Date
CC
CC
MH
09/07/2014
Project No.
Scale
T-C0040.00
AS SHOWN
Project
QUEANBEAYAN CITY COUNCIL
ELLERTON DRIVE EXTENSION
PRELIMINARY SKETCH PLAN
Sheet
LANDSCAPE PLAN - NORTH
Drawing No.
Sheet No.
Revision
T-C0040.00
900
A


adjoins landscape plan north - sheet 900
CH 2905.00
CH 3250.00
CH 3760.00
CH 4060.00
CH 4465.00
Queanbeyan River
existing vegetation
1:2 embankment, with new planting
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planted median
shared path
existing ground level
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Kunzea ericoides
Burgan
Y
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Grevillea rosmarinifolia
Rosemary Grevillea
Pimelea curviflora var. sericea
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Smooth Rice-flower
Y
Pimelea linifolia ssp. Caesia
Slender Rice Flower
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Spiny-headed mat-rush
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Tussock-grass
* As identified by the Species Impact Statement 2013 (NGH Environmental)
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PRELIMINARY SKETCH PLAN
Sheet
LANDSCAPE PLAN - SOUTH
Project No.
T-C0040.00
Scale
AS SHOWN
Drawing No.
T-C0040.00
Sheet. No.
901
Revision
B

Appendix P – Noise Report

global environmental solutions

Ellerton Drive Extension

Noise Impact Assessment

Operation and Construction

Report Number 670.10568-R1

9 December 2014

Opus International Consultants
PO Box 42,
Dickson ACT 2602

Version: Revision 1

Ellerton Drive Extension

Noise Impact Assessment

Operation and Construction

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DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
670.10568-R1	Revision 1	9 December 2014	Zhang Lai	David Lindsey	Jamie Hladky
670.10568-R1	Revision 0	15 October 2014	Zhang Lai	David Lindsey	Jamie Hladky

The Queanbeyan City Council (QCC) proposes to construct a 4.6 km long extension to the Ellerton Drive. The existing Ellerton Drive connects to Yass Road and Bungendore Street at a roundabout and terminates approximately 850 m southeast of this roundabout. The proposal is to extent Ellerton Drive from its current terminus to the existing Old Cooma Road and Edwin Land Parkway intersection, forming the fourth leg of this intersection. This will be a two lane single carriageway roadway and was identified to be required by 2017.

SLR Consulting (Australia) Pty Ltd (SLR) has been engaged by Opus International Consultants (Opus) to conduct a noise impact assessment for the proposed extension. This is required as part of the design and documentation processes undertaken by Opus. The objective of SLR's engagement was to assess the potential noise impacts of the operation of the proposed extension.

All of the identified potentially impacted sensitive receivers were grouped into 8 Noise Catchment Areas. In March – April 2014, SLR conducted ambient noise monitoring at 11 locations to determine the existing ambient noise environment. In addition, concurrent traffic count was also conducted at the existing Edwin Land Parkway and Old Cooma Road intersection to allow validation of the noise model.

OPERATIONAL NOISE CRITERIA

Upon completion of the proposed Ellerton Drive extension, the entire Ellerton Drive is considered to be a sub-arterial road. The RNP assessment criteria applicable for this project was determined to be:

Road Category	**Type of Project/Land Use**	**Assessment Criteria (dBA)**	
		Daytime (7 am – 10 pm)	**Night-time (10 pm – 7 am)**
Freeway/ arterial/ sub-arterial roads	1. existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	$L_{Aeq(15hour)}$ 55 (external)	$L_{Aeq(9hour)}$ 50 (external)

In addition to the noise criteria above, the RNP describes a "Relative Increase Criteria" of 12 dB above existing traffic noise. This criterion is primarily intended to protect existing quiet areas from excessive changes in amenity. Most of the existing residences along the proposed extension are currently not affected by significant traffic noise. Therefore, the "Relative Increase Criteria" are also considered in this assessment.

VALIDATION OF NOISE MODEL

Validation of the noise model was performed based on noise monitoring conducted at the Edwin Land Parkway road reserve and 12 Alfred Place, Karabar. The variations between the model-predicted noise levels and the measured noise levels were within ±2 dB. In accordance to guidelines provided by NSW Environmental Noise Management Manual, these variances are considered to be acceptable. Therefore, it was determined that the noise model provides results which enable a reliable assessment of the project.

OPERATIONAL NOISE ASSESSMENT FINDINGS

The modelled traffic speed was 60 km/hr from the existing section of Ellerton Drive to about Ch1200 and 80 km/hr from Ch1200 onwards to the Old Cooma Road intersection. The road pavement adopted in the noise model was dense graded asphalt (DGA)

Executive Summary

The following summarises the findings of the noise prediction and assessment conducted for the design year (2027, 10 years after project opening):

- NCA1
    - 26 out of 26 receivers exceed the relevant RNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 9 dB
    - Level of exceedance of the Relative Increase Criteria was up to 8 dB
    - Possible feasible and reasonable mitigation:
        - Upgraded property boundary fence to a height of 3 to 3.6 m
        - Building treatment for 2nd storey receivers (approximately 7 properties)
- NCA2
    - 15 out of 20 receivers exceed the relevant RNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 8 dB
    - Level of exceedance of the Relative Increase Criteria was up to 6 dB
    - Possible feasible and reasonable mitigation:
        - Upgraded property boundary fence to a height of 2.4 m
- NCA3
    - 8 out of 11 receivers exceed the relevant RNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 6 dB
    - Level of exceedance of the Relative Increase Criteria was up to 11 dB
    - Possible feasible and reasonable mitigation:
        - Building treatment for receivers exceeding relevant criteria (approximately 8 properties)
- NCA4
    - 4 out of 11 receivers exceed the relevant RNP criteria
    - No exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$
    - Level of exceedance of the Relative Increase Criteria was up to 5 dB
    - Possible feasible and reasonable mitigation:
        - Building treatment for receivers exceeding relevant criteria (approximately 4 properties)
- NCA5
    - 4 out of 10 receivers exceed the relevant RNP criteria
    - No exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$
    - Level of exceedance of the Relative Increase Criteria was up to 7 dB
    - Possible feasible and reasonable mitigation:
        - Building treatment for receivers exceeding relevant criteria (approximately 4 properties)

Executive Summary

- NCA6
    - 1 out of 1 receiver exceeds the relevant RNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 7 dB
    - Level of exceedance of the Relative Increase Criteria was up to 12 dB
    - Possible feasible and reasonable mitigation:
        - Building treatment for receivers exceeding relevant criteria (1 property)
- NCA7
    - 15 out of 15 receivers exceed the relevant RNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 10 dB
    - Level of exceedance of the Relative Increase Criteria was up to 13 dB
    - Possible feasible and reasonable mitigation:
        - Upgraded property boundary fence to a height of 3.6 to 4.2 m
        - Building treatment for 2nd storey receivers, isolated receivers and receivers where fence is not feasible due to driveway access requirements (approximately 7 properties)
- NCA8
    - 39 out of 39 receivers exceed the relevant RNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 10 dB
    - Level of exceedance of the Relative Increase Criteria was up to 14 dB
    - Possible feasible and reasonable mitigation:
        - Upgraded property boundary fence to a height of 2.1 to 3.6 m for receivers at Webber Place, Fitzgibbon Place, Caroline Place, Alfred Place.
        - Road side noise barrier of 1.5 to 3 m for receivers at Barracks Flat Drive
        - Building treatment for 2nd storey receivers, isolated receivers and receivers where fence is not feasible due to driveway access requirements (approximately 11 properties)

Further information in relation to the recommended noise barrier is presented in **Appendix P**.

Based on the results presented in **Appendix O**, properties that may require further consideration of property treatment are highlighted Green.

CONSTRUCTION NOISE

Based on the typical construction stages assumed in the assessment, it was found that the predicted noise levels exceed the noise affected noise management levels determined based on the measured Rating Background Level within the project area. The worst level of exceedance was predicted to be 32 dB. It was recommended that a standard suite of mitigation measures be implemented in order to mitigate and reduce the potential noise impact associated with the construction of the project.

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1 INTRODUCTION

1.1 Project Background

The Queanbeyan City Council (QCC) proposes to construct a 4.6 km long extension to the Ellerton Drive. The existing Ellerton Drive connects to Yass Road and Bungendore Street at a roundabout and terminates approximately 850 m southeast of this roundabout. The proposal is to extent Ellerton Drive from its current terminus to the existing Old Cooma Road and Edwin Land Parkway intersection, forming the fourth leg of this intersection. This will be a two lane single carriageway roadway and was identified to be required by 2017.

A previous traffic study commissioned by the QCC determined that the Queanbeyan road network requires to be upgraded to accommodate the rising population. The extension of Ellerton Drive was identified to be one major piece of work as part of the entire potential improvements that are required. The proposed project is shown in **Figure 1**.

1.2 Report Objectives

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Opus International Consultants (Opus) to assess the operational and construction noise impacts of the proposed extension. This is required as part of the design and documentation processes undertaken by Opus. .

1.3 Relevant Guidelines

The noise and vibration guidelines for construction and operations are based on the publications managed by the Environment Protection Authority [1] (EPA). The guidelines applicable to this assessment include:

- Operational Noise – *Road Noise Policy* (RNP), DECCW 2011
- Construction Noise – *Interim Construction Noise Guideline* (ICNG), DECC 2009
- Construction Vibration (Human Comfort) – *Assessing Vibration - a technical guideline,* DEC 2006
- British Standard BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2*.

The following additional guidelines and standards are also referenced in this study:

- Noise measurement procedure (operational) – *AS* 2702:1984 *Acoustic Methods of Measurement of Road Traffic Noise*
- Noise measurement procedure (construction) – AS 1055:1997 *Acoustics – Description and Measurement of Environmental Noise*
- Acoustic instrumentation – AS IEC 61672.1-2004 *Electroacoustics - Sound Level Meters*
- RMS assessment requirements – *Preparing an Operational Noise and Vibration Assessment*, RMS July 2011
- RMS noise management response – *Environmental Noise Management Manual (ENMM),* RTA 2001

1.4 Terminology

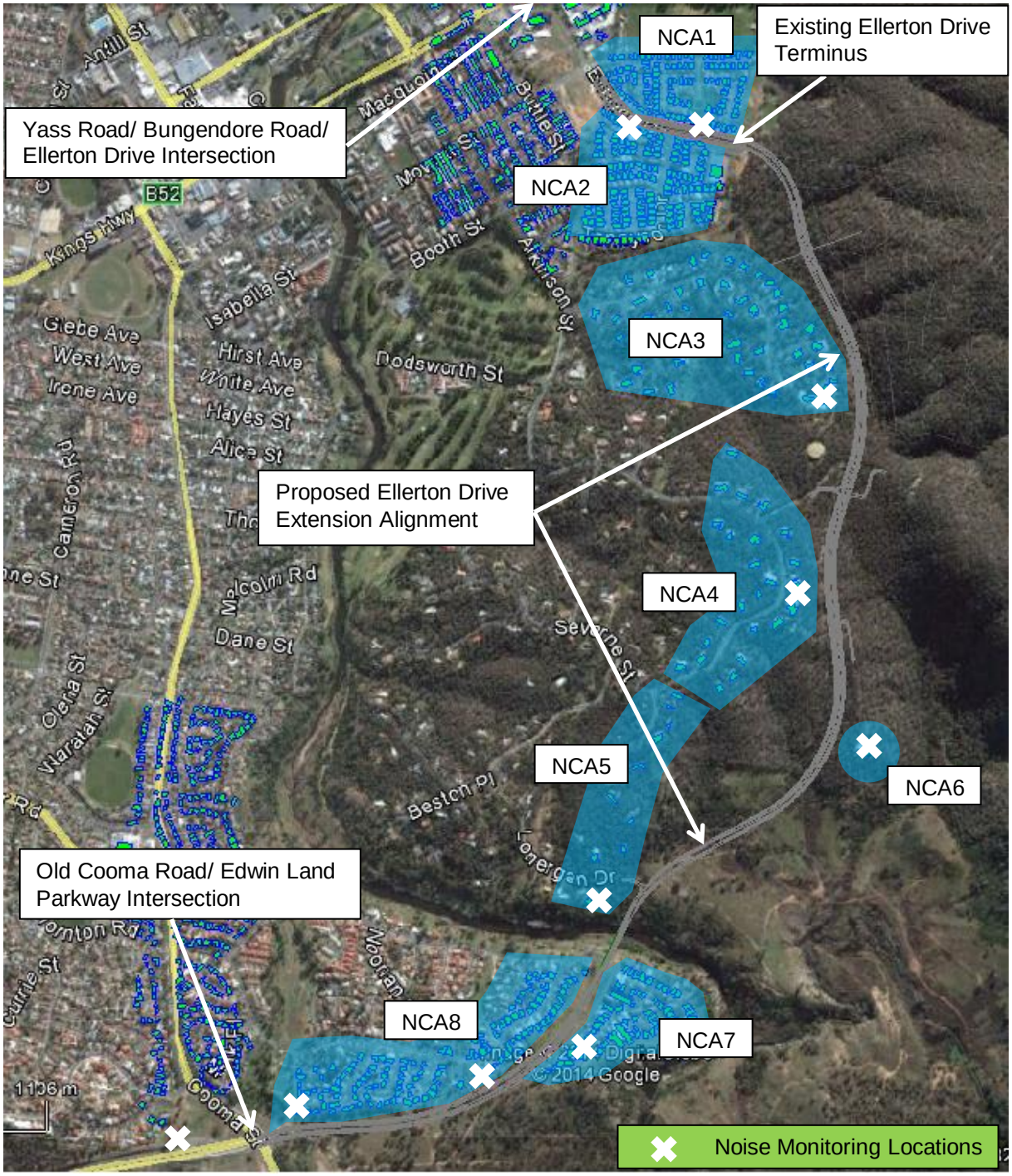
Specific acoustic terminology is used within this assessment. An explanation of common acoustic terms is included as **Appendix A**.

[1] Noise and Vibration guidelines are available at the following web address: http://www.environment.nsw.gov.au/noise

2 PROJECT AREA

Figure 1 indicates the locations of the proposed extension and potentially affected sensitive receivers along the route of the proposed alignment, grouped in separate Noise Catchment Areas (NCA).

Figure 1 Proposed Extension Alignment and Potentially Affected Sensitive Receivers



3 EXISTING AMBIENT NOISE ENVIRONMENT

In order to characterise the noise environment across the project area (in relation to both construction and operation) and to establish existing ambient noise levels upon which to base the noise emission targets, environmental noise monitoring was performed at selected representative locations within the project area. As indicated in **Figure 1**, a total of 8 NCA's have been determined to assist with the noise assessment. At least one noise monitoring location was established within each NCA to assist with understanding the existing ambient environment.

3.1 Monitoring Methodology

3.1.1 Unattended Noise Monitoring

Unattended noise monitoring was conducted using ARL type 316 noise monitors. The instrument signal calibration was conducted before and after each measurement survey, with the variation in calibrated levels not exceeding ±0.5 dBA.

All unattended monitoring equipment was programmed to record continuously statistical noise level indices in 15 minute intervals including the L_{Amax}, L_{A1}, L_{A10}, L_{A50}, L_{A90}, L_{A99}, L_{Amin} and L_{Aeq}.

In addition, operator attended monitoring was also conducted at each selected locations. This will assist in understanding of the source and spectral information.

3.1.2 Attended Noise Monitoring

Operator-attended ambient noise survey was conducted at all noise monitoring locations in order to support the identification and occurrence of ambient noise sources.

Attended ambient noise measurements were performed using a calibrated Rion NA-28 Sound Level Meter (S/N: 01060054). The instrument calibration was checked before and after the measurements, with the variation in calibrated levels not exceeding the acceptable variation of ±0.5 dBA (AS 1055).

The acoustic instrumentation (SLM and calibrator) employed throughout the monitoring programme was designed to comply with the requirements of AS IEC 61672.1-2004 "*Electroacoustics - Sound Level Meters"* and carry current NATA or manufacturer calibration certificates.

3.1.3 Traffic Counting

In accordance with RMS document *Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report*, traffic counting was undertaken concurrently with the noise monitoring near the Old Cooma Road and Edwin Land Parkway intersection. Traffic counting was conducted on all three existing approaches of this intersection.

In addition to these concurrent traffic counting data, past traffic data at the Bungendore Road, Yass Road and existing Ellerton Drive intersection was also provided by the Council to assist with the noise study.

3.2 Monitoring Results

3.2.1 Unattended Noise Monitoring

A summary of the ambient noise logging results during ICNG and RNP defined time periods (where applicable) is contained in **Table 1**. A full graphical representation of the noise level recorded is provided in **Appendix B** to **Appendix L**.

Periods affected by adverse weather have been excluded from the results according to the procedure outlined in the *NSW Industrial Noise Policy* (INP).

Table 1 Ambient Noise Logging Results

Noise Monitoring Location	Ambient Noise Logging Results				
NCA1	**– ICNG Defined Time Periods**				
55 Thomas Royal Garden	**Monitoring Period**	**Noise Level (dBA re 20 μPa)**			
		RBL	**LAeq**	**L_{10}**	**L_1**
7 – 17 March 2014	**Daytime**	31	46	41	51
	Evening	28	46	40	48
S/N: 16-207-049	**Night-time**	23	40	30	38
NCA2.1	**– ICNG Defined Time Periods**				
50 Stone Haven Circuit	**Monitoring Period**	**Noise Level (dBA re 20 μPa)**			
		RBL	**LAeq**	**L_{10}**	**L_1**
7 – 17 March 2014	**Daytime**	36	50	49	59
	Evening	33	58	47	58
S/N: 16-207-043	**Night-time**	24	42	34	45
NCA2.2	**– ICNG Defined Time Periods**				
16 Geebung Place	**Monitoring Period**	**Noise Level (dBA re 20 μPa)**			
		RBL	**LAeq**	**L_{10}**	**L_1**
7 – 17 March 2014	**Daytime**	29	48	42	52
	Evening	32	44	40	46
S/N: 16-203-528	**Night-time**	26	38	67	43
NCA3	**– ICNG Defined Time Periods**				
40 Taylor Place	**Monitoring Period**	**Noise Level (dBA re 20 μPa)**			
		RBL	**LAeq**	**L_{10}**	**L_1**
7 – 17 March 2014	**Daytime**	30	57	39	49
	Evening	28	52	40	48
S/N: 16-203-530	**Night-time**	23	38	31	37
NCA4	**– ICNG Defined Time Periods**				
46 Severne Street	**Monitoring Period**	**Noise Level (dBA re 20 μPa)**			
		RBL	**LAeq**	**L_{10}**	**L_1**
7 – 17 March 2014	**Daytime**	27	46	39	49
	Evening	28	53	42	50
S/N: 16-306-044	**Night-time**	25	41	39	46
NCA5	**– ICNG Defined Time Periods**				
35 Lonergan Drive	**Monitoring Period**	**Noise Level (dBA re 20 μPa)**			
		RBL	**LAeq**	**L_{10}**	**L_1**
6 – 17 March 2014	**Daytime**	30	51	44	51
	Evening	32	57	43	48
S/N: 16-306-041	**Night-time**	29	46	39	45
NCA6	**– ICNG Defined Time Periods**				
40a Serverne Street	**Monitoring Period**	**Noise Level (dBA re 20 μPa)**			
		RBL	**LAeq**	**L_{10}**	**L_1**
	Daytime	30	45	40	47

Noise Monitoring Location	Ambient Noise Logging Results				
7 – 17 March 2014	**Evening**	29	47	49	53
S/N: 16-203-526	**Night-time**	26	44	45	52
NCA7 26 Doeberl Place	**– ICNG Defined Time Periods**				
	Monitoring Period	**Noise Level (dBA re 20 μPa)**			
		RBL	**LAeq**	**L_{10}**	**L_1**
7 – 17 March 2014	**Daytime**	30	51	41	48
S/N: 16-004-033	**Evening**	29	45	40	47
	Night-time	25	44	30	37
NCA8.1 78 Barracks Flat Drive	**– ICNG Defined Time Periods**				
	Monitoring Period	**Noise Level (dBA re 20 μPa)**			
		RBL	**LAeq**	**L_{10}**	**L_1**
7 – 17 April 2014	**Daytime**	30	47	43	53
	Evening	29	52	41	49
S/N: 16-306-044	**Night-time**	24	49	33	39
	– ICNG Defined Time Periods				
	Monitoring Period	**Noise Level (dBA re 20 μPa)**			
		RBL	**LAeq**	**L_{10}**	**L_1**
NCA8.2 12 Alfred Place	**Daytime**	40	57	53	61
	Evening	34	54	49	55
	Night-time	26	53	42	50
7 – 17 April 2014	**– RNP Defined Time Periods**				
S/N: 16-203-526	**Monitoring Period**	**Noise Level $L_{Aeq(Period)}$ (dBA)**			
	Daytime (7am-10pm)	56			
	Night-time (10pm-7am)	53			
Edwin Land Parkway Road Reserve near 19 Nimbus Place	**– RNP Defined Time Periods**				
	Monitoring Period	**Noise Level $L_{Aeq(Period)}$ (dBA)**			
	Daytime (7am-10pm)	59			
7 – 17 April 2014	**Night-time (10pm-7am)**	51			
S/N: 16-207-049					

Note 1: ICNG Governing Periods – Day: 7.00 am to 6.00 pm Monday to Saturday, 8.00 am to 6.00 pm Sunday; Evening: 6.00 pm to 10.00 pm; Night: 10.00 pm to 7.00 am Monday to Saturday, 10.00 pm to 8.00 am Sunday.

Note 2: RNP Governing Periods – Day: 7.00 am to 10.00 pm; Night: 10.00 pm to 7.00 am.

3.2.2 Attended Noise Monitoring

A summary of the 15 minute operator-attended ambient noise survey undertaken at the noise logging site, is shown in **Table 2**.

Table 2 Operator-Attended Ambient Noise Survey at Noise Logging Location

Noise Survey Location	Measurement Details	Measured Noise Level (dBA)			Description of Ambient Noise Sources – Typical Maximum Noise Levels LAmax
		LA90	LAeq	LAmax	
NCA1 55 Thomas Royal Garden	17/03/14 04:09 pm Light winds 1-2 m/s Cloud cover 2/8	41	44	60	Distant traffic noise: 41-42 Distant truck: up to 45 Wind in trees: 41-45 Dog bark: up to 51 Noisy exhaust from bike: up to 60 Existing background noise level dominated by distant traffic (likely to be from Bungendore Street / Kings Highway)
NCA2.1 50 Stone Haven Circuit	17/03/14 03:37 pm Light winds 1-2 m/s Cloud cover 2/8	43	50	65	Distant traffic noise: 45-49 Truck along Ellerton Drive: up to 65 Existing background noise level dominated by distant traffic (likely to be from Bungendore Street / Kings Highway)
NCA2.2 16 Geebung Place	17/03/14 03:13 pm Light winds 1-2 m/s Cloud cover 2/8	40	50	68	Distant road traffic and heavy vehicles: faintly audible Distant construction noise (excavator or the like): up to 45 Car door slam: 45-47 Constant insect noise Interference from resident: up to 66
NCA3 40 Taylor Place	07/03/14 08:42 am Wind calm Cloud cover 0/8	35	41	65	Distant traffic noise: 36-39 Household noise: up to 39 Aircraft: up to 52 Dog: 39-41 Birds: up to 43 Resident door slam: up to 65
NCA4 46 Severne Street	17/03/14 05:19 pm Light winds 1-2 m/s Cloud cover 2/8	34	42	65	Distant traffic: 33-35 Birds: 46-65 Hammering noise from odd number neighbour: up to 41
NCA5 35 Lonergan Drive	06/03/14 08:20 am Light winds 1-2 m/s Cloud cover 3/8	30	44	64	Light aircraft: up to 39 Local traffic: 32-36 Car traffic within Karbar: 39-45 Bus travelling uphill along residential street in Karabar: 48-52 Distant car radio noise: up to 31 Birds (cockatoo): up to 64
NCA6 40a Serverne Street	17/03/14 04:49 pm Mild winds 2-3 m/s Cloud cover 2/8	39	44	58	Distant traffic noise: 35-38 Hammering noise from neighbour: 39-41 Birds: 46-58
NCA7 26 Doeberl Place	17/03/14 06:31 pm Wind calm Cloud cover 1/8	36	40	56	Distant traffic from Old Cooma Road:36-39 Dog barking: 53-56

Noise Survey Location	Measurement Details	Measured Noise Level (dBA)			Description of Ambient Noise Sources – Typical Maximum Noise Levels LAmax
		LA90	LAeq	LAmax	
NCA8.2 12 Alfred Place	17/04/14 08:10 am Wind calm Cloud cover 1/8	42	55	79	Traffic on Old Cooma Road:44-47 Truck on ELP: 45-52 Exhaust from truck: 54-58 Birds: 65 Dog barking next door:75-79

3.2.3 Traffic Counting

Traffic data recorded during the survey period of NCA8.2 and Edwin Land Parkway road reserve and past traffic count data are shown in **Table 3**.

Table 3 Traffic Count Data

Traffic Counting Location		15 Hour[1]		9 Hour[2]	
		Light[3]	Heavy[4]	Light[3]	Heavy[4]
Concurrent Traffic Count (existing Edwin Land Parkway and Old Cooma Road Intersection)					
Edwin Land Parkway	Eastbound	2115	104	204	12
	Westbound	2112	120	210	11
Old Cooma Road (north of ELP)	Northbound	3206	240	297	24
	Southbound	3243	230	269	27
Old Cooma Road (south of ELP)	Northbound	1821	270	185	30
	Southbound	1883	264	203	29
Past Traffic Count Nov-Dec 2013 (Bungendore Road, Yass Road and existing Ellerton Drive intersection)					
Yass Road	Northbound	5403	548	818	73
	Southbound	5765	489	408	40
Bungendore Road (west of Yass Road)	Eastbound	10308	668	1049	69
	Westbound	10088	642	831	92
Bungendore Road (east of Yass Road)	Eastbound	5432	353	399	56
	Westbound	5069	249	527	41

Note 1: Time period for 15 Hour average daily traffic volume data is 7.00 am to 10.00 pm.
Note 2: Time period for 9 Hour average daily traffic volume data is 10.00 pm to 7.00 am.
Note 3: Vehicle types included in Light classification are Class 1 and 2 vehicles.
Note 4: Vehicle types included in Heavy classification are Class 3 to 12 vehicles.

4 NOISE AND VIBRATION GOALS

4.1 Operational Noise – NSW Road Noise Policy

4.1.1 Guideline Overview

For traffic operating on public roads, the NSW Government's *Road Noise Policy* (RNP) is appropriate for assessing potential road traffic noise impacts.

The NSW Government issued the RNP on 1 July 2011. The document identifies strategies that address the issue of road traffic noise from:

- Existing roads.
- New road projects.
- Road redevelopment projects.
- New traffic-generating developments.

The RNP noise criteria aim to protect amenity inside and immediately around permanent residences, schools, hospitals and other sensitive land uses, rather than at all points in a given locality, which would not be practical or possible. Although it is not mandatory to achieve the noise assessment criteria in the RNP, project proponents need to provide justification if it is not considered feasible or reasonable to achieve them.

The guideline recognises that there are generally more opportunities to minimise noise impacts from new roads and road corridors, especially those in greenfield locations, through judicious road design and land use planning. The scope to reduce noise impacts from existing roads and corridors is more limited.

The RNP criteria are applicable both at the time of project opening and also in a design year, typically taken to be ten years after project completion.

4.1.2 Noise Assessment Criteria – Residential Land Uses

Upon completion of the proposed Ellerton Drive extension, the entire Ellerton Drive is considered to be a sub-arterial road. **Table 4** summarises the RNP assessment criteria for residences to be applied for this project. These criteria are presented for assessment against facade noise levels as measured at the most affected point in front of a building.

Table 4 RNP Criteria – Residential Land Uses

Road Category	Type of Project/Land Use	Assessment Criteria (dBA)	
		Daytime (7 am – 10 pm)	**Night-time (10 pm – 7 am)**
Freeway/ arterial/ sub-arterial roads	1. existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	$L_{Aeq(15hour)}$ 55 (external)	$L_{Aeq(9hour)}$ 50 (external)

In addition to the noise criteria in **Table 4**, the RNP describes a "Relative Increase Criteria" of 12 dB above existing traffic noise. This criterion is primarily intended to protect existing quiet areas from excessive changes in amenity. Most of the existing residences along the proposed extension are currently not affected by significant traffic noise. Therefore, the "Relative Increase Criteria" are also considered in this assessment.

It must be noted that not all properties that exceed the base criteria automatically qualify for consideration of noise mitigation. All properties that exceed the base criteria will be examined to see if acoustic benefits can be gained from changes in the proposed road alignment, or other similar measures that could provide acoustic benefit.

The ENMM fully details the procedures for which properties qualify for noise mitigation. This is a multi-step process and initially involves the identification of those properties where there is;

- Exceedance of the base objective; and
- The proposal results in a predicted change in the noise environment of 2dBA or more, when comparing the future scenario including the proposal and the 'future existing' scenario excluding the proposal;

Table 5 presents a matrix of conditions, indicating which properties are further considered for noise mitigation.

Table 5 Operational Noise Level Matrix

Overall Noise Level	**Change in Noise level**		
	Change <0 dBA (ie decrease in noise)	**0 < change ≤ 2 dBA (ie marginal increase)**	**Increase > 2 dBA (ie noticeable increase)**
< Base Criteria	No further consideration of noise mitigation		
Less than 2 dBA above Base Criteria	No further consideration of noise mitigation		Further consideration is given to the provision of noise mitigation
Between 2dBA to 5dBA above the base criteria	No further consideration of noise mitigation		
More than 5dBA above the base criteria (termed Acute noise level)	Further consideration is given to the provision of noise mitigation		

Where properties qualify for further consideration of noise mitigation, the options available are further assessed in terms of their:

- Reasonableness – which includes considerations of cost (ie the relationship between cost and noise reduction provided), equity, visual impacts, the change in noise levels etc); and
- Feasibility - ie engineering considerations, including whether it can be readily built, consideration of; stormwater access, safety issues, maintenance requirements, etc.

4.1.3 Sleep Disturbance

Guidance for the assessment of sleep disturbance given in the RNP is reproduced as follows:

> *"Triggers for, and effects of sleep disturbance from, exposure to intermittent noise such as noise from road traffic are still being studied. There appears to be insufficient evidence to set new indicators for potential sleep disturbance due to road traffic noise. The NSW Roads and Traffic Authority's Practice Note 3 (NSW Roads and Traffic Authority 2008) outlines a protocol for assessing and reporting on maximum noise levels and the potential for sleep disturbance."*

NSW Roads and Traffic Authority's *Environmental Noise Management Manual* (ENMM) – Practice Note III protocol for assessing the potential for sleep disturbance is determined by performing L_{AFmax} – $L_{Aeq(1hr)}$ calculation on individual vehicle passby noise measurements. The number of night-time passby events where the L_{AFmax} – $L_{Aeq(1hr)}$ difference is greater than 15 dB is to be determined.

With regard to reaction to potential sleep disturbance events, the RNP gives the following guidance:

> *From the research on sleep disturbance to date it can be concluded that:*
>
> - *maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep*
> - *one or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly.*

It is generally accepted that internal noise levels in a dwelling, with the windows open are 10 dB lower than external noise levels. Based on a worst case minimum attenuation, with windows open, of 10 dB, the first conclusion above suggests that short term external noises of 60 dBA to 65 dBA are unlikely to cause awakening reactions.

The second conclusion suggests that one or two noise events per night with maximum external noise levels of 75 dBA to 80 dBA are not likely to affect health and wellbeing significantly.

4.2 Construction Noise Goals

4.2.1 Construction Noise Metrics

The noise metrics used to describe construction noise emissions in the modelling and assessments are:

$L_{A1(1minute)}$ The "typical maximum noise level" for an event, used in the assessment of potential sleep disturbance during night-time periods. Alternatively, the assessment may be conducted using the L_{Amax} or maximum noise level.

$L_{Aeq(15minute)}$ The "energy average noise level" evaluated over a 15-minute period. This parameter is used to assess the potential construction noise impacts.

L_{A90} The "background noise level" in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15\ minute)}$ construction noise management levels are based on the L_{A90} background noise levels.

The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (ie A-weighted).

4.2.2 Noise Management Levels

Residential Receivers

The applicable construction noise goals (Noise Management Levels - NML) for this project are described in the *Interim Construction Noise Guideline* (ICNG - DECC 2009).

For construction work during standard hours, a Noise Management Level ($L_{Aeq(15minute)}$) of RBL + 10 dB applies for residential receivers. Construction work outside of the recommended standard hours should not be undertaken without strong justification. Where construction work outside standard hours is required, a Noise Management Level ($L_{Aeq(15minute)}$) of RBL + 5 dB applies for residential receivers.

These NMLs aim to represent the level above which there may be some community reaction to construction noise. Where the predicted levels exceed the noise management level, all feasible and reasonable work practices should be applied to minimise the potential noise impacts. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Where $L_{Aeq(15minute)}$ construction noise levels are predicted to exceed 75 dBA, the relevant authority (consent, determining or regulatory) may require respite periods to be observed. This may include 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 works near schools, or mid-morning or mid-afternoon for works near residences).
- If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

The ICNG states that where construction works are planned to extend over more than two consecutive nights, the impact assessment should cover the maximum noise level from the proposed works. In addition to the NMLs, where construction would be required during the night-time period the potential for sleep disturbance to residential receivers should therefore be assessed.

The EPA's current approach to assessing potential sleep disturbance (*Application Notes to Industrial Noise Policy)* is to apply an initial screening criterion of background plus 15 dB and to undertake further analysis if the screening criterion cannot be achieved. The sleep disturbance screening criterion applies outside bedroom windows during the night-time period.

Where the screening criterion cannot be met, the additional analysis should consider the number of potential sleep disturbance events during the night, the level of exceedance and the noise from other events.

4.3 Construction Vibration Goals

The effects of vibration in buildings can be divided into three main categories – those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced.

4.3.1 Human Comfort Vibration

The EPA's *Assessing Vibration: a technical guideline* provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV) rather than a continuous vibration level. The VDV is dependent upon the level and duration of the short-term vibration event, as well as the number of events occurring during the daytime or night-time period.

The VDVs recommended in the document for vibration of an intermittent nature (ie construction works where more than three distinct vibration events occur) are presented in **Table 6**.

Table 6 Acceptable Vibration Dose Values for Intermittent Vibration (m/s$^{1.75}$) (*Assessing Vibration: a technical guideline)*

Location	Daytime[1]		Night-time[1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas[2]	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

1 Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.
2 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas.
Source: BS 6472–1992

4.3.2 Effects on Building Contents

People can perceive floor vibration at levels well below those likely to cause damage to building contents or affect the operation of typical equipment. For most receivers, the controlling vibration criterion will be the human comfort criterion, and it is therefore not normally required to set separate criteria in relation to the effect of construction vibration on most building contents.

Where appropriate, objectives for the satisfactory operation of critical instruments or manufacturing processes should be sourced from manufacturer's data and/or other published objectives

4.3.3 Structural Damage Vibration

Structural damage vibration limits are based on Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives* and British Standard BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2*. These standards provide frequency-dependent vibration limits related to cosmetic damage, noting that cosmetic damage is very minor in nature, is readily repairable and does not affect the structural integrity of the building. The recommended vibration limits from BS7385 for transient vibration for minimal risk of cosmetic damage to residential and industrial buildings is shown in **Table 7**.

Table 7 Transient Vibration Guide Values for Minimal Risk of Cosmetic Damage (BS7385)

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	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

4.3.4 Ground-Borne (Regenerated) Noise

Ground-borne (or regenerated) construction noise can be present on construction projects where vibration from activities such as rockbreaking, road heading, rotary cutting and rock drilling/sawing can be transmitted through the ground and into the habitable areas of nearby buildings. Ground-borne noise occurs when this vibration in the ground and/or building elements is regenerated as audible noise within areas of occupancy inside the building.

The NSW EPA's ICNG defines internal ground-borne noise goals for residential receivers of 40 dBA $L_{Aeq(15minute)}$ during the evening (6:00 pm to 10:00 pm) and 35 dBA $L_{Aeq(15minute)}$ during the night-time (10:00 pm to 7:00 am). The goals are only applicable when ground-borne noise levels are higher than airborne noise levels.

5 OPERATIONAL NOISE ASSESSMENT

5.1 Assessment Methodology

The 'build' and 'no build' operational scenarios have been assessed within one year of project opening and for the design year (10 years after opening). The noise modelling has been conducted using the SoundPLAN V7.1 suite of acoustics software implementing the Calculation of Road Traffic Noise (CORTN) prediction model for all calculations. The relevant traffic forecast data used is presented in **Table 8**.

Table 8 Traffic Forecast Data

Traffic Counting Location		15 Hour[1]		9 Hour[2]	
		Light[3]	Heavy[4]	Light[3]	Heavy[4]
Within One Year of Project Opening					
Ellerton Drive Extension	Northbound	1576	175	143	16
	Southbound	1865	207	186	21
Edwin Land Parkway	Eastbound	4228	207	435	25
	Westbound	2705	154	281	14
Old Cooma Road (north of ELP)	Northbound	7771	582	728	564
	Southbound	6013	426	564	57
Old Cooma Road (south of ELP)	Northbound	6120	907	552	88
	Southbound	5865	822	558	79
Yass Road	Northbound	7081	601	596	58
	Southbound	5539	561	483	43
Bungendore Road (west of Yass Road)	Eastbound	9200	596	864	57
	Westbound	9162	583	829	92
Bungendore Road (east of Yass Road)	Eastbound	6733	437	565	79
	Westbound	7617	374	649	51
Design Year (10 Years after Project Opening)					
Ellerton Drive Extension	Northbound	2017	106	132	7
	Southbound	3059	161	263	14
Edwin Land Parkway	Eastbound	5929	290	577	33
	Westbound	5006	284	500	26
Old Cooma Road (north of ELP)	Northbound	9040	677	905	74
	Southbound	7144	506	702	70
Old Cooma Road (south of ELP)	Northbound	10233	1517	957	153
	Southbound	10195	1430	975	139
Yass Road	Northbound	8457	717	710	69
	Southbound	7255	735	646	58
Bungendore Road (west of Yass Road)	Eastbound	9316	603	888	59
	Westbound	8054	513	721	80
Bungendore Road (east of Yass Road)	Eastbound	8220	533	694	97
	Westbound	8520	419	726	57

Note 1: Time period for 15 Hour average daily traffic volume data is 7.00 am to 10.00 pm.
Note 2: Time period for 9 Hour average daily traffic volume data is 10.00 pm to 7.00 am.
Note 3: Vehicle types included in Light classification are Class 1 and 2 vehicles.
Note 4: Vehicle types included in Heavy classification are Class 3 to 12 vehicles.

Road traffic noise levels were predicted using RMS and EPA recommended procedures, as detailed in the CORTN methodology. The input data for each section of the road for these calculations includes the total traffic count, the percentage of heavy vehicles within the total traffic flow and vehicle speed.

5.2 Noise Model Validation

The predicted operational noise levels for the existing scenario have been compared to the noise levels measured during the ambient noise survey, discussed in **Section 3**, for the purpose of model validation. This is shown in **Table 9**.

Table 9 Model Validation – Comparison of Predicted Noise Levels to Measured Noise Levels

Noise Logging Location	Noise Logging Address	Measured Existing Noise Levels (dBA)		Predicted Existing Noise Levels (dBA)		Comparison of Noise Levels – Predicted Minus Measured (dBA)	
		Daytime LAeq(15hour)	Night-time LAeq(9hour)	Daytime LAeq(15hour)	Night-time LAeq(9hour)	Daytime LAeq(15hour)	Night-time LAeq(9hour)
NCA8.2	12 Alfred Place	53	48	53	46	0	-2
ELP	Edwin Land Parkway Road Reserve	59	51	57	50	-2	-1

The NSW Environmental Noise Management Manual (ENMM) notes that "*it should be recognised that noise prediction modelling has some accuracy limitations and will commonly produce acceptable errors of around 2 dBA*". This approach to validation has been found to be acceptable on a number of past projects in NSW.

On the basis of the comparison of the noise model predictions with the baseline measurement results, it is concluded that the noise model provides results which enable a reliable assessment of the project.

5.3 Predicted Operational Noise Levels

The predicted operational noise levels for the within 1 year of opening 'no build' and 'build' scenarios, as well as the change in noise levels and the level above the RNP criteria are shown in **Table 10**.

The predicted operational noise levels for the design year (10 years after project opening) 'no build' and 'build' scenarios, as well as the relative increase in noise level and the level above the RNP criteria for the representative receivers in each Noise Catchment Area are shown in **Table 11**.

The modelled traffic speed was 60 km/hr from the existing section of Ellerton Drive to about Ch1200 and 80 km/hr from Ch1200 onwards to the Old Cooma Road intersection. The road pavement adopted in the noise model was dense graded asphalt (DGA)

Table 10 Within 1 Year of Opening – Predicted Operational Noise Levels

Representative Receiver Address	Predicted Noise Levels (dBA)				Relative Increase (dBA)		Year of Opening 'Build' Scenario Level Above RNP Criteria (dBA) i.e. LAeq(15hour) 55 LAeq(9hour) 50		Year of Opening 'Build' Scenario Level Exceed 12 dB 'Relative Increase Criteria'?		Year of Opening 'Build' Scenario Noise Level Considered Acute?[1]	
	Year of Opening – 'No Build' Scenario		Year of Opening – 'Build' Scenario									
	Daytime LAeq(15hour)	Night-time LAeq(9hour)	Daytime LAeq(15hour)	Night-time LAeq(9hour)	Daytime LAeq(15hour)	Night-time LAeq(9hour)	Daytime LAeq(15hour)	Night-time LAeq(9hour)	Daytime LAeq(15hour)	Night-time LAeq(9hour)	Daytime LAeq(15hour)	Night-time LAeq(9hour)
NCA1 53 Thomas Royal Garden	43	36	64	57	20.9	20.7	8.9	6.7	YES	YES	No	No
NCA2 2 Tennyson Drive	43	36	60	52	16.4	15.8	4.7	2.2	YES	YES	No	No
NCA3 40 Taylor Place	37	30	58	51	21.3	20.9	3.4	1	YES	YES	No	No
NCA4 40 Severne Street	37	30	51	44	14.3	14.0	-	-	YES	YES	No	No
NCA5 26 Lonergan Drive	35	28	53	46	18.3	18.1	-	-	YES	YES	No	No
NCA6 40A Severne Street	38	31	57	49	18.7	18.4	1.5	-	YES	YES	No	No
NCA7 32 Doeberl Place	40	33	62	55	22.5	22.3	7.1	4.8	YES	YES	No	No
NCA8 108 Barracks Flat Drive	33	26	56	49	23.4	23.3	1.4	-	YES	YES	No	No
NCA8 20 Caroline Place	55	48	62	54	6.8	6.7	6.8	4.4	-	-	No	No

Note 1: Acute noise is defined as day $L_{Aeq(15hour)}$ 65dBA and night-time as $L_{Aeq(9hour)}$ 60dBA.

The results of the noise prediction for all receivers for the year of opening scenario are presented in **Appendix M**.

Table 11 Design Year – Predicted Operational Noise Levels

Representative Receiver Address	Predicted Noise Levels (dBA)				Relative Increase (dBA)		Design Year 'Build' Scenario Level Above RNP Criteria (dBA) i.e. $L_{Aeq(15hour)}$ 55 $L_{Aeq(9hour)}$ 50		Design Year 'Build' Scenario Level Exceed 12 dB 'Relative Increase Criteria'?		Design Year 'Build' Scenario Noise Level Considered Acute?[1]	
	Design Year – 'No Build' Scenario		Design Year – 'Build' Scenario									
	Daytime $L_{Aeq(15hour)}$	Night-time $L_{Aeq(9hour)}$	Daytime $L_{Aeq(15hour)}$	Night-time $L_{Aeq(9hour)}$	Daytime $L_{Aeq(15hour)}$	Night-time $L_{Aeq(9hour)}$	Daytime $L_{Aeq(15hour)}$	Night-time $L_{Aeq(9hour)}$	Daytime $L_{Aeq(15hour)}$	Night-time $L_{Aeq(9hour)}$	Daytime $L_{Aeq(15hour)}$	Night-time $L_{Aeq(9hour)}$
NCA1 53 Thomas Royal Garden	43	36	60	52	17.2	16.0	5.3	2.1	YES	YES	No	No
NCA2 2 Tennyson Drive	44	37	60	52	15.8	14.6	4.7	1.5	YES	YES	No	No
NCA3 40 Taylor Place	41	34	58	50	16.8	15.6	2.9	-	YES	YES	No	No
NCA4 40 Severne Street	39	32	52	44	13.4	12.1	-	-	YES	YES	No	No
NCA5 26 Lonergan Drive	36	29	57	49	21.0	19.7	1.9	-	YES	YES	No	No
NCA6 40A Severne Street	39	32	57	49	18.5	17.2	2	-	YES	YES	No	No
NCA7 32 Doeberl Place	42	35	64	55	21.7	20.3	8.5	5.2	YES	YES	No	No
NCA8 108 Barracks Flat Drive	58	50	62	54	4.4	3.8	6.9	4.1	YES	YES	No	No
NCA8 20 Caroline Place	43	36	60	52	17.2	16.0	5.3	2.1	-	-	No	No

Note 1: Acute noise is defined as day $L_{Aeq(15hour)}$ 65dBA and night-time as $L_{Aeq(9hour)}$ 60dBA.

The results of the noise prediction for all receivers for the design year scenario are presented in **Appendix N**.

The predicted noise levels in **Table 11** show that the relative increase in noise levels between the design year 'build' and 'no build' scenarios range from 3.8 to 21.7 dB for both the daytime and night-time periods. The relative increase in noise levels at 8 out of the total 9 selected representative properties were predicted to be in excess of 12 dB, which exceeds that "Relative Increase Criteria" as discussed in **Section 4.1.2**.

Predicted noise levels for the design year 'build' scenario exceed the RNP $L_{Aeq(15hour)}$ daytime criteria by up to 8.5 dB and the $L_{Aeq(9hour)}$ night-time criteria by up to 5.2 dB.

Where exceedances of the RNP criteria are identified, feasible and reasonable noise mitigation measures should be assessed.

5.4 Assessment of Reasonable and Feasible Mitigation Measures

5.4.1 Procedure Overview

Where exceedances of the noise criteria are identified, the RNP describes noise mitigation measures to be considered in order of priority:

1. Road design and traffic management
2. Quieter pavement surfaces
3. In-corridor noise barriers/mounds
4. At-property treatments or localised barriers/mounds

The priority of mitigation measures recognises that noise control at the source is preferable over noise path control and noise mitigation at the receiver.

The RNP notes that it is not mandatory to achieve the noise assessment criteria, and that noise mitigation measures should be both feasible and reasonable. Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the abatement measure. To make such a judgement, consideration may be given to noise impacts, noise mitigation benefits, the cost effectiveness of noise mitigation and community views.

5.4.2 Reasonable and Feasible Definition

Where the noise goals in the design year 'build' scenario are found to be exceeded as a result of a project, the RNP and the ENMM require the project to adopt "reasonable and feasible" mitigation measures to meet the targets.

Practice Note IV of the ENMM defines what "reasonable and feasible" factors may be considered when investigating noise mitigation measures.

"**Reasonableness**" relates to the application of wider judgements. The factors to be considered are:

- The noise reduction provided and the number of people protected
- The cost of mitigation, including the total cost and cost variations with different benefits provided
- Community views and wishes
- Visual impacts
- Existing and future noise levels, including changes in noise levels
- The benefits arising from the proposed road or road development

"**Feasibility**" relates to engineering considerations (what can be practically built) and may include:

- The inherent limitations of different techniques to reduce noise emissions from road traffic noise sources
- Safety issues, such as restrictions on road vision
- Road corridor site constraints such as space limitations
- Floodway and stormwater flow obstruction
- Access requirements
- Maintenance requirements

5.4.3 NCA1

The findings from the noise assessment of NCA1 are presented in **Table 12**.

Table 12 NCA1 – Noise Assessment Findings

Item		Description
Number of potentially affected residential properties	Total	26
	More than 1 storey	7 out of 26
	Exceed RNP Criteria[1]	26 out of 26
Range of predicted noise levels	LAeq(15hour)	54.3 – 63.4 dBA
	LAeq(9hour)	46.1 – 55.2 dBA
	Relative Increase (both LAeq(15hour) and LAeq(9hour))	3.3 – 19.9 dB

Note 1: including LAeq(15hour), LAeq(9hour) and Relative Increase Criteria

The modelled scenarios for NCA1 include sections of approximately 1.5 m high existing fences along the residential property boundaries. Based on observations made on site at 55 Thomas Royal Garden, the height of the existing fence was low relative to the elevations of the dwellings and the road and found to be insufficient in blocking direct line of sight from the dwelling to the road.

An aerial photograph of NCA1 is presented in **Figure 2**. Considering that the affected dwellings are closely situated to each other with a combined frontage of approximately 440 m, it is likely to be both reasonable and feasible that mitigation in the form upgrading the property boundary fence be provided.

It is therefore recommended that all existing fences (common with the project) be removed and replaced with an appropriate noise barrier. At a height of 3 to 3.6 m (dependent on location, see **Appendix P**), predictions show that the day and night time traffic noise levels would meet the relevant RNP criteria (including the Relative Increase Criteria) for all ground level receivers.

Double-Storey Properties

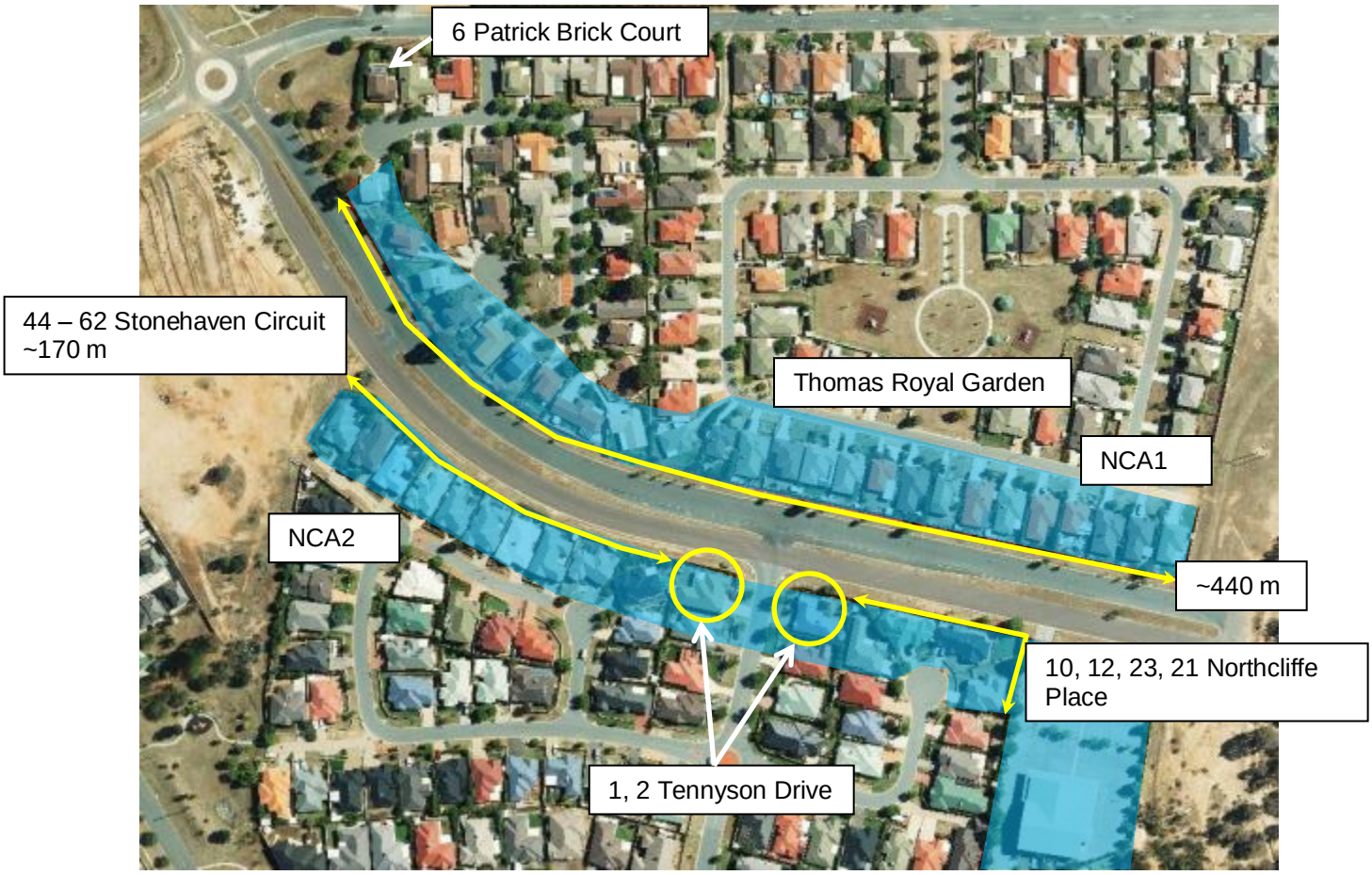
Seven out of the 26 properties were identified to consist of more than one storey. In our view, it is not likely to be feasible and reasonable to increase the height of the noise barrier in the attempt of achieving compliance for the 2nd storey receivers. If deemed reasonable and feasible in further assessment, SLR recommends that specific building treatments be provided for the 2nd storey of the relevant properties. This option is further discussed in **Section 5.4.9**.

Further information in relation to the recommended noise barrier is presented in **Appendix P**.

6 Patrick Brick Court

The location of this receiver is presented in **Figure 2**. The predicted noise levels at this property exceed the criteria by up to 2 dB. A noise barrier recommended above can be extended along the nature reserve at a height of 3 m and this is expected to achieve compliance to the criteria at this location. However, this may not be feasible considering extending this barrier only benefits one property. This property is a double storey property and the second storey is likely to be considered for building treatment as discussed above. On this basis, it is likely that the provision of building treatment for both levels of the property is likely to be a more feasible option compared to extending the length of the barrier.

Figure 2 Aerial Photograph – NCA1 and Part of NCA2



5.4.4 NCA2

The findings from the noise assessment of NCA2 are presented in **Table 13**.

Table 13 NCA2 – Noise Assessment Findings

Item		Description
Number of potentially affected residential properties	Total	20
	More than 1 storey	None
	Exceed RNP Criteria[1]	15 out of 20
Range of predicted noise levels	LAeq(15hour)	47.1 – 62.2 dBA
	LAeq(9hour)	39.1 – 54.1 dBA
	Relative Increase (both LAeq(15hour) and LAeq(9hour))	2.8 – 17.7 dB

Note 1: including LAeq(15hour), LAeq(9hour) and Relative Increase Criteria

An aerial photograph of part of NCA2 is presented in **Figure 2**.

44 – 62 Stonehaven Circuit

The modelled scenarios for these properties include sections of approximately 1.8 m high existing fences along the residential property boundaries. Out of these 10 properties, the day and night time criteria were exceeded at nine and three locations respectively. The average levels of exceedances were predicted to be 3 dB and 1 dB respectively. The relative increase criteria were predicted to be met at all locations.

It is therefore recommended that all existing fences (common with the project) be removed and replaced with an appropriate noise barrier. At a height of the 2.4 m, predictions show that the day and night time traffic noise levels would meet the relevant RNP criteria (including the Relative Increase Criteria) for all ground level receivers.

Further information in relation to the recommended noise barrier is presented in **Appendix P**.

Northcliffe Place

At these properties, the predicted noise levels were up to 7.4 dB in exceedance of the RNP criteria at 2 properties. If fence replacement is deemed feasible and reasonable in other properties in NCA1 and NCA2, it is likely that replacing the fence at Northcliffe Place residences is likely to be a suitable mitigation option. It was determined that the relevant criteria were predicted to be met with a 2.4 m high fence.

1, 2 Tennyson Drive

Due to driveway access requirements, it is likely that provision of noise barrier is not considered to be feasible along the side boundaries of these properties. Provision of barrier along the boundary of 2 Tennyson Drive was predicted to provide partial acoustic benefit. On this basis, if deemed reasonable and feasible in further assessment, it is likely that specific building treatment is a more feasible and reasonable mitigation option for these properties. This option is further discussed in **Section 5.4.9**.

5.4.5 NCA3

The findings from the noise assessment of NCA3 are presented in **Table 14**.

Table 14 NCA3 – Noise Assessment Findings

Item		Description
Number of potentially affected residential properties	Total	11
	More than 1 storey	None
	Exceed RNP Criteria[1]	8 out of 11
Range of predicted noise levels	$L_{Aeq(15hour)}$	49.4 – 57.9 dBA
	$L_{Aeq(9hour)}$	41.5 – 49.6 dBA
	Relative Increase (both $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$)	5.2 – 19.3 dB

Note 1: including $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and Relative Increase Criteria

During the noise mitigation assessment, a road side barrier of approximately 650 m in length and 3 m in height was modelled outside of the northbound carriageway from approximately chainage 1000 to chainage 1700. Based on the modelled results, it was predicted that the modelled noise barrier decreases the number of properties that exceed the RNP criteria from 8 to 4. This implies that the implementation of road side barrier for these residences is not likely to be feasible as there is an obvious limitation on the effectiveness of the noise barrier.

In addition, the dwellings within NCA3 are generally situated on larger blocks and do not have any boundary fences apart from wire fence. Therefore, the use of localised barrier i.e. property boundary fence is not likely to be acceptable to the community as it is likely to have detrimental effect on the existing 'semi-rural' characteristics of the properties.

The sole reasonable and feasible mitigation strategy is therefore likely to be the use of building treatment for all 8 properties that exceed the RNP criteria. This option is further discussed in **Section 5.4.9**.

Further information in relation to the recommended noise barrier is presented in **Appendix P**.

Figure 3 Aerial Photograph – NCA3

5.4.6 NCA4, NCA5 and NCA6

The findings from the noise assessment of NCA4, NCA5 and NCA6 are presented in **Table 15**. An aerial photograph of these noise catchment areas is presented in **Figure 4**.

Table 15 NCA4, NCA5 and NCA6 – Noise Assessment Findings

Item		Description		
		NCA4	**NCA5**	**NCA6**
Number of potentially affected residential properties	Total	13	10	1
	More than 1 storey	None	None	None
	Exceed RNP Criteria[1]	4 out of 11	4 out of 10	1 out of 1
Range of predicted noise levels	$L_{Aeq(15hour)}$	43.1 – 52.2 dBA	45.5 – 56.9 dBA	57.5 dBA
	$L_{Aeq(9hour)}$	35.5 – 44.0 dBA	37.5 – 48.6 dBA	49.2 dBA
	Relative Increase (both $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$)	2.0 – 14.3 dB	5.4 – 21 dB	17.7 – 19

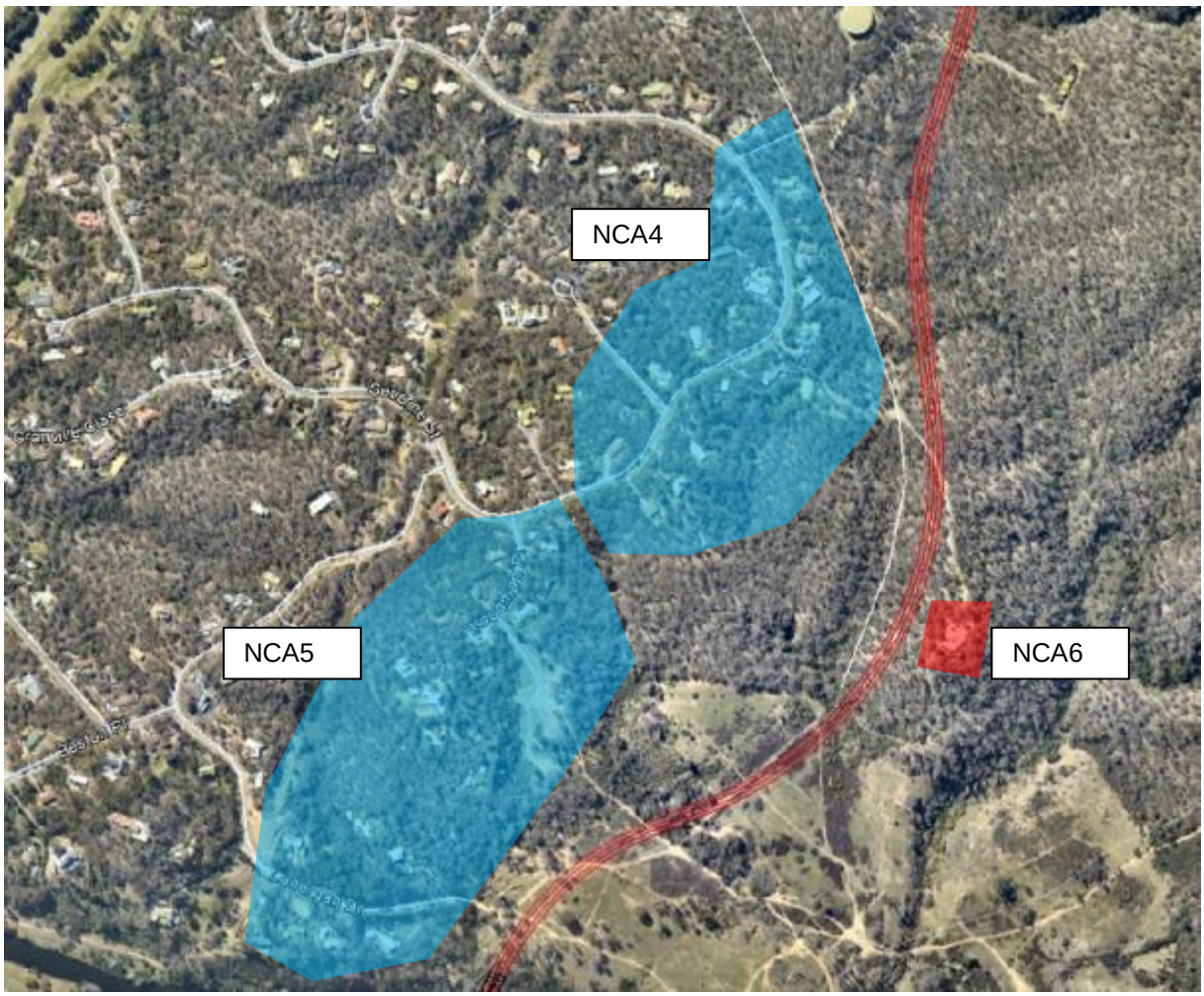
Note 1: including $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and Relative Increase Criteria

Similar to NCA3 as discussed in **Section 0**, NCA4, NCA5 and NCA6 are of semi-rural characteristics with dwellings being positioned on relatively large block of lands. Therefore, localised barrier in the form of boundary fence is not likely to be acceptable. In addition, as the number of dwellings predicted to exceed the RNP criteria in each NCA is relatively small (up to 4 only in each catchment area), the implementation of road side noise barrier is not likely to be feasible.

Therefore, in our view, building treatment is likely to be the only appropriate form of noise mitigation to be considered. This option is further discussed in **Section 5.4.9**.

Further information in relation to the recommended noise barrier is presented in **Appendix P**.

Figure 4 Aerial Photograph – NCA4, NCA5 and NCA6



5.4.7 NCA7

The findings from the noise assessment of NCA7 are presented in **Table 16**.

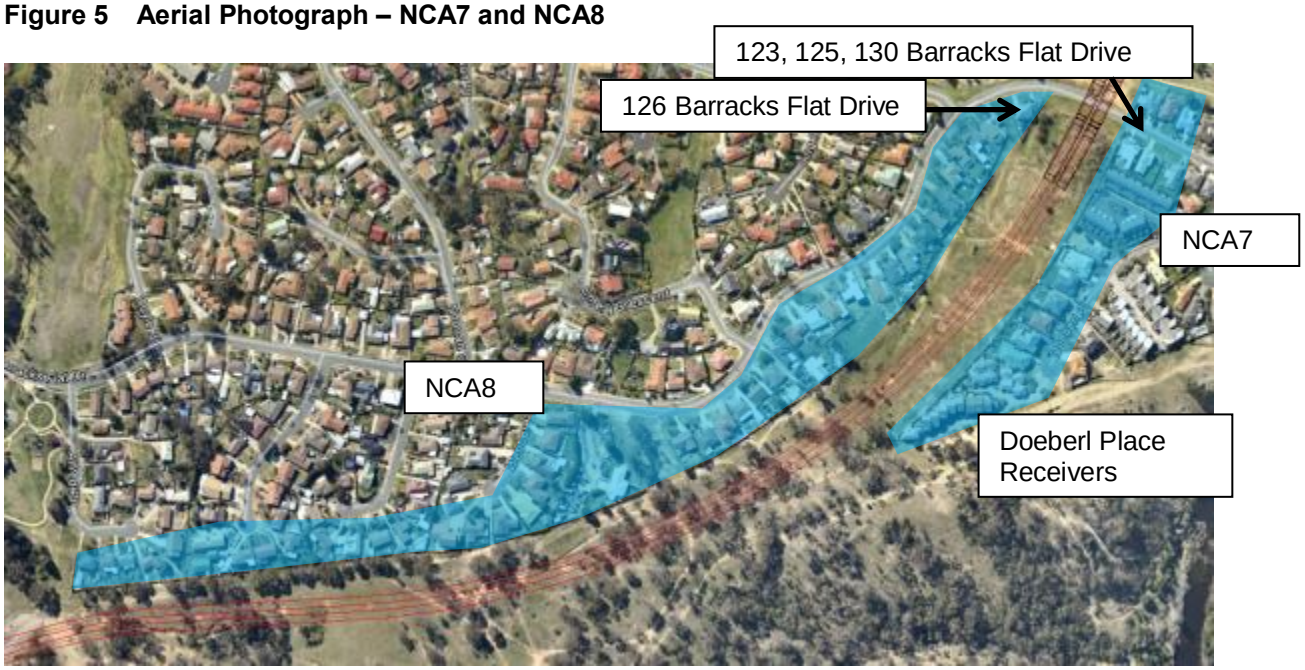
Table 16 NCA7 – Noise Assessment Findings

Item		Description
Number of potentially affected residential properties	Total	15
	More than 1 storey	7
	Exceed RNP Criteria[1]	15 out of 15
Range of predicted noise levels	LAeq(15hour)	54.3 – 62.7 dBA
	LAeq(9hour)	46.1 – 54.6 dBA
	Relative Increase (both LAeq(15hour) and LAeq(9hour))	12.2 – 23.6 dB

Note 1: including LAeq(15hour), LAeq(9hour) and Relative Increase Criteria

An aerial photograph of NCA7 and NCA8 is presented in **Figure 4**.

Figure 5 Aerial Photograph – NCA7 and NCA8



123, 125, 130 Barrack Flats Drive

These properties are located at a setback of approximately 35 m from the proposed alignment and bridge structure over Queanbeyan River. These properties are also located at much lower elevation compared to the elevation of the proposed roadway (approximately 7 to 12 m lower).

A 1.3 m safety barrier with approximately 0.6 m of solid concrete base is currently documented along the edge of the proposed bridge. Due to the relative position between the proposed alignment and these properties as discussed above, the 0.6 m high solid barrier along the edge of the bridge act as an effective noise barrier by providing shielding for the tyre contact noise component, which is the dominant road traffic noise source.

Doeberl Place

The modelled scenarios for NCA7 include sections of approximately 1.8 m high existing fences along the residential property boundaries. However, this existing fence is not sufficient to act as an effective noise barrier. Considering that the affected dwellings are closely situated to each other with a combined frontage of approximately 360 m, it is likely to be reasonable and feasible that mitigation in the form of upgrading the property boundary fence be provided. One other advantage of this option is that the recommended noise barrier along the property boundary also provides shielding for the traffic/vehicle acceleration noise associated with the on-ramp from Barracks Flat Drive onto the southbound traffic of the main alignment.

It is therefore recommended that all existing fence be removed and replaced with appropriate noise barrier. At a height of the 3.6 to 4.2 m, it was predicted that the day and night time traffic noise levels would meet the relevant RNP criteria (excluding the Relative Increase Criteria) for all ground level receivers. With this implemented, the Relative Increase Criteria of 12 dB is still exceeded at most properties. However, significant improvements have been achieved with the level of exceedances of the Relative Increase Criteria for the ground level receivers generally reduced to within 3 dB.

Further information in relation to the recommended noise barrier is presented in **Appendix P**.

Double-Storey Properties

Seven out of 15 properties were identified to consist of more than one storey. In our view, it is not likely to be feasible and reasonable to increase the height of the noise barrier in the attempt of achieving compliance for the 2nd storey receivers. If deemed reasonable and feasible in further assessment, SLR recommends that specific building treatments be provided for the 2nd storey of the relevant properties. This option is further discussed in **Section 5.4.9**.

5.4.8 NCA8

The findings from the noise assessment of NCA8 are presented in **Table 17**.

Table 17 NCA8 – Noise Assessment Findings

Item		Description
Number of potentially affected residential properties	Total	39
	More than 1 storey	16
	Exceed RNP Criteria[1]	39 out of 39
Range of predicted noise levels	LAeq(15hour)	48.6 – 62.8 dBA
	LAeq(9hour)	40.5 – 55.0 dBA
	Relative Increase (both LAeq(15hour) and LAeq(9hour))	1.6 – 23.6 dB

Note 1: including LAeq(15hour), LAeq(9hour) and Relative Increase Criteria

Barracks Flat Drive Receivers

The modelled scenarios for these properties include sections of approximately up to 1.5 m high existing fences along the residential property boundaries. However, these existing fences are found to be not sufficient to act as an effective noise barrier. Considering that the affected dwellings are closely situated to each other with a combined frontage of approximately 500 m, it was determined that mitigation in the form roadside barrier is likely to be the more feasible and reasonable option in achieving the noise reduction required. With a roadside barrier of 1.5 to 3 m, it was predicted that the day and night time traffic noise levels would meet the relevant RNP criteria (excluding the Relative Increase Criteria) for most ground level receivers. With this implemented, the Relative Increase Criteria of 12 dB is still exceeded at a number of properties. With this implemented, the Relative Increase Criteria of 12 dB is still exceeded at most properties. However, significant improvements have been achieved with the level of exceedances of the Relative Increase Criteria for the ground level receivers generally reduced to within 2 dB.

Further information in relation to the recommended noise barrier is presented in **Appendix P**.

Webber Place, Fitzgibbon Place, Caroline Place, Alfred Place

The modelled scenarios for these properties include sections of up to 1.8 m high existing fences along the residential property boundaries. Considering that the affected dwellings are closely situated to each other with a combined frontage of approximately 520 m, it was determined that mitigation in the form upgraded property boundary fence is likely to be the more feasible and reasonable option in achieving the noise reduction required.

It is therefore recommended that all existing fence be removed and replaced with appropriate noise barrier. At a height of 2.1 to 3.6 m, it was predicted that the day and night time traffic noise levels due to the proposed Ellerton Drive Extension would meet the relevant RNP criteria (excluding the Relative Increase Criteria) for most ground level receivers. With this implemented, the Relative Increase Criteria of 12 dB is still exceeded at most properties. However, significant improvements have been achieved with the level of exceedances of the Relative Increase Criteria for the ground level receivers generally reduced to within 3 dB.

A number of properties at Alfred Place were found to exceed the criteria after the implementation of upgraded property boundary noise barrier. This was however due to contribution from existing traffic noise from Old Cooma Road and was therefore considered to be acceptable.

Further information in relation to the recommended noise barrier is presented in **Appendix P**.

Elevated/Isolated Receivers and Double Storey Properties

A number of receivers have been identified to be at a much higher elevation or being much closer to the alignment than most of the adjacent assessed receivers. These receivers include:

- 12 Webber Place
- 17 Caroline Place
- 90 Barracks Flat Drive
- 18 Alfred Place
- 16 Alfred Place
- 14 Alfred Place

It was initially found that achieving compliance with the noise criteria requires that a noise barrier be more than 5 m high for these receivers. Compared to the noise barrier height requirements determined for the neighbouring receivers, noise barrier at such heights is not likely to be considered feasible and reasonable. Similarly, noise barrier is not likely to be a feasible mitigation option for double storey properties. It is therefore determined that building treatment is likely to be the more appropriate form of noise mitigation to be considered for these properties. This option is further discussed in **Section 5.4.9**. It was determined that a total of approximately 11 properties should be considered for building treatment.

5.4.9 Residual Architectural Property Treatments

Treatments to buildings usually involve higher performance windows, doors and seals to keep noise out. Building treatments effectively require occupants to keep their windows and doors closed and hence alternative ventilation is usually required to maintain adequate air flow. An obvious disadvantage is that building treatments would not have any effect on the noise levels outside the dwelling in their front or back yards.

The acoustic treatment of individual dwellings is generally not favoured and is generally the final resolution for reasons including:

- It may not be effective for lightweight buildings.
- It provides no protection to outdoor areas.
- Mechanical ventilation and/or air-conditioning is required, resulting in higher energy consumption.

Based on past experience, the following procedure is recommended to determine what extent of specific treatment is required:

- Inspect the relevant properties and determine the status of the dwelling, noting including and not limited to the type of construction, type of interior spaces most impacted by road noise, window sizes, glazing type etc.
- Conduct sound insulation testing to determine the existing noise reduction that can be provided by the existing construction.
- Determine whether any changes/modification/upgrade of the façade element is required based on existing sound insulation properties and type of spaces affected. Typically, if applicable, the weakest elements on the façade are the windows'/sliding doors' frames and glazing.
- Consult with relevant property owner/occupants in relation to specific personal preferences.
- Determine the most appropriate/preferred method of provided alternative means of natural ventilation. Examples of suitable products/method include Acoustica Aeropac Ventilator or similar, an in-ceiling ducted system to draw fresh air from the quiet side of the house to the rooms in concern.

Based on past experience, where the external noise level are 10 dB or less above the applicable RNP criteria, the acceptable internal noise levels may be achieved with windows closed on exposed facades using existing construction. In general, a light framed building with single glazed (closed) windows with sealed wall vents will provide an external to internal noise reduction of 20 dB. Therefore, in many cases, the extent of building treatment required is the provision of mechanical ventilation (subject to individual consultation with the dwelling owners) to ensure sufficient airflow inside the dwelling, so as to meet the requirements of the Building Code of Australia.

5.4.10 Summary

A summary of possible reasonable and feasible mitigation options is presented in **Table 18**. Further assessment and consideration should be conducted by the Project Team to determine the final mitigation treatments to be implemented.

Table 18 Possible Mitigation Strategies – NCA1 to NCA8

NCA	Possible Reasonable and Feasible Mitigation
1	Upgraded property boundary fence to a height of 3 to 3.6 m
	Building treatment for 2nd storey receivers (approximately 7 properties)
2	Upgraded property boundary fence to a height of 2.4 m
3	Building treatment for receivers exceeding relevant criteria (approximately 8 properties)
4	Building treatment for receivers exceeding relevant criteria (approximately 4 properties)
5	Building treatment for receivers exceeding relevant criteria (approximately 4 properties)
6	Building treatment for receivers exceeding relevant criteria (1 property)
7	Upgraded property boundary fence to a height of 3.6 to 4.2 m
	Building treatment for 2nd storey receivers, isolated receivers and receivers where fence is not feasible due to driveway access requirements (approximately 7 properties)
8	Upgraded property boundary fence to a height of 2.1 to 3.6 m for receivers at Webber Place, Fitzgibbon Place, Caroline Place, Alfred Place
	Road side noise barrier of 1.5 to 3 m for receivers at Barracks Flat Drive
	Building treatment for 2nd storey receivers, isolated receivers and receivers where fence is not feasible due to driveway access requirements (approximately 17 properties)

The following information are appended to this report for reference purposes:

- **Appendix O** - noise prediction for receivers with possible upgraded boundary fence for the design year scenario
- **Appendix P** - locations where upgraded boundary fence are recommended
- **Appendix Q** – $L_{Aeq(15hour)}$ noise contours with the implementation of upgraded boundary fence
- **Appendix R** – $L_{Aeq(9hour)}$ noise contours with the implementation of upgraded boundary fence

Based on the results presented in **Appendix O**, properties that may require further consideration of property treatment are highlighted Green.

6 CONSTRUCTION NOISE ASSESSMENT

6.1 Construction Works

6.1.1 Construction Scenarios

Based on our experience, the likely construction stages for the project and associated equipment are shown in **Table 19**. The table also contains Sound Power Level data for individual items of plant together with the combined Sound Power Level for each scenario.

Table 19 Construction Works

Stage	Scenario	Equipment[1]	No of Items	Max. L_{Aeq} Sound Power Level (dBA)		L_{Amax} Sound Power Level (dBA)	
				Individual Item	Activity	Individual Item	Activity
1	Clearing and Grubbing, Tree Removal[3]	Excavator (20 tonne)	1	99	109	105	116
		Truck (10 tonne)	1	98		103	
		Chainsaw	1	108		116	
2	Bored piling and precast placement	Bored piling rig	1	108	106	112	112
		Mobile Crane (25 tonne)	2	99		105	
		Truck	2	98		103	
3	Construction of New Kerbs, Drainage Pits and Pipes	Excavator (20 tonne)	1	99	119	105	124
		Truck (10 tonne)	1	98		103	
		Jackhammer*[2]	1	108		113	
		Excavator (Breaker)*[2]	1	121		124	
		Concrete Truck / Agitator	1	106		112	
		Concrete Pump	1	106		109	
		Vibratory Roller (~10 - 12 tonne)*	1	109		114	
4	Compaction of Road Pavement and Laying of Asphalt Paving	Scraper	1	118	123	123	125
		Dozer	1	110		114	
		Compactor	1	110		116	
		Vibratory Roller	1	109		114	
		Excavator	1	99		105	
		Grader	1	107		115	
		Water truck	1	107		114	
		Excavator mounted drill	1	121		124	
		Asphalt paving machine	1	120		125	
5	Noise Wall Construction[3]	Excavator (20 tonne)	1	99	110	105	112
		Truck (10 tonne)	1	98		103	
		Concrete Truck / Agitator	1	106		112	

Stage	Scenario	Equipment[1]	No of Items	Max. L_{Aeq} Sound Power Level (dBA)		L_{Amax} Sound Power Level (dBA)	
				Individual Item	Activity	Individual Item	Activity
		Concrete Pump	1	106		109	
		Mobile Crane (25 tonne)	1	99		105	

Note 1: * denotes "annoying" item of equipment, as defined in the ICNG, and as such includes a +5 dBA penalty to predictions.

Note 2: Overall SWL assumes a maximum 7.5 minutes on-time in any 15-minute period.

Note 3: These construction scenarios are included as a provision in the event that noise wall construction works or tree clearing around the works areas are required.

The *Interim Construction Noise Guideline* (ICNG) lists a number of construction activities which have been proven to be "annoying" and which require to have a 5 dB penalty applied to them. Annoying characteristics may include tones, impulses, low frequency noise and intermittent noise. The ICNG identifies the following proposed activities as being particularly annoying and as such, a 5 dB correction has been incorporated into the noise modelling process for them.

- use of power saws, such as used for cutting timber, rail lines, masonry, road pavement or steel work
- grinding metal, concrete or masonry
- rock drilling
- line drilling
- vibratory rolling
- bitumen milling or profiling
- jackhammering, rock hammering or rock breaking
- impact piling

6.2 Construction Noise Management Levels

As discussed in **Section 4.2**, the *NSW "Interim Construction Noise Guideline"* (ICNG) sets out the requirements for assessing the potential noise impacts at sensitive receivers. The process involves the following two steps:

1) Determine project specific Noise Management Levels (NMLs) for noise affected receivers.
2) Where the construction noise levels are predicted to exceed the NMLs, all feasible and reasonable work practices would be investigated to minimise noise emissions.

On the basis of the background noise logging results presented in **Table 1**, a summary of the NMLs during the daytime, evening and night-time periods is provided in **Table 20**.

Table 20 Construction Noise Management Levels

Receiver Group	Noise Management Levels - NMLs (dBA)		
	Daytime Period[1]	Evening Period[2]	Night-time Period[3]
NCA1	41	35	35
NCA2	46	38	35
NCA3 to NCA8	40	35	35

Note 1: Standard daytime construction hours: 7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm on Saturdays and no work on Sundays or Public Holidays.

Note 2: Out-of-hours evening hours: 6.00 pm to 10.00 pm.

Note 3: Out-of-hours night-time hours: 10.00 pm to 7.00 am Sunday to Friday, 10.00 pm Saturday to 8.00 am Sunday.

6.3 Assessment of Construction Works

For assessment purposes, it is assumed that construction works will be conducted during normal daytime working hours only. The standard daytime periods are 7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm Saturday.

Based on the scenarios and the sound power levels outlined in **Table 19**, construction noise levels have been predicted at the nearest receivers. The resultant daytime, evening and night-time $L_{Aeq(15minute)}$ noise level predictions, where appropriate, in addition to the number of properties with NML exceedances, are presented in **Table 21** for the various activities and compared with the relevant Noise Management Levels.

In practice, noise levels will depend on the number of plant items and equipment operating at any one time and their precise location relative to the receiver of interest. Noise levels will vary due to the movement of plant and equipment about the worksites and the concurrent operation of plant. In some cases, reductions in noise levels will occur when plant are located in cuttings or behind embankments, buildings or other items of equipment.

The predictions in **Table 21** are representative of the worst-case scenario with all equipment listed in **Table 19** operating simultaneously.

Table 21 Construction Noise Predictions

Receiver	Noise Level – $L_{Aeq(15minute)}$ (dBA)						
	Worst-case Predicted					NML	Exceedance
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5		
NCA1	52	<30	62	66	53	41	Up to 21 dB
NCA2	52	<30	62	66	53	46	Up to 20 dB
NCA3	54	<30	64	68	55	40	Up to 24 dB
NCA4	52	<30	62	66	53	40	Up to 26 dB
NCA5	57	53	67	71	58	40	Up to 31 dB
NCA6	50	<30	60	64	51	40	Up to 24 dB
NCA7	58	62	68	72	59	40	Up to 32 dB
NCA8	48	60	58	62	49	40	Up to 22 dB

6.4 Findings

A worst-case exceedance of the daytime (standard construction hours) $L_{Aeq(15minute)}$ noise goal of up to 32 dB is predicted at the most affected sensitive receiver locations within the project area. While this level of exceedance is common for these types of construction activities at similar separation distances, mitigation measures should be undertaken to minimise the impact on the surrounding sensitive receivers.

All predicted noise levels at the identified representative noise-sensitive receivers during the proposed construction scenarios do not exceed 75 dBA $L_{Aeq(15minute)}$ and therefore are not considered to be Highly Noise Affected.

6.5 Mitigation Measures

6.5.1 Recommended Noise Mitigation

The expected noise management level exceedances are likely to be concerning for surrounding residents and particular effort should be directed towards the implementation of all reasonable noise mitigation and management strategies.

The standard suite of mitigation measures includes management measures such as community consultation, site inductions (with guidance on how to minimise noise and vibration) and the preparation of site specific construction noise and vibration management plans. The strategy also includes several recommendations for reducing the source noise levels of construction equipment via good planning and equipment selection.

Examples of mitigation measures which may be considered appropriate for these works are:

- Use of localised acoustic hoarding around significantly noisy items of plant (eg rock breaker), where practicable. This would be expected to provide between 5 dB and 10 dB of additional noise attenuation provided the line-of-sight between all receivers and the construction equipment is broken. The barrier is most affective when it is located either close to the noise source or the receiver.
- Scheduling of the higher Noise Management Level exceedance activities/locations to be undertaken predominantly during less noise-sensitive periods, where available and possible. The community should be consulted to assist in identifying less noise sensitive periods.
- Briefing of the work team in order to create awareness of the locality of sensitive receivers and the importance of minimising noise emissions.
- Ensuring any spoil is placed and not dropped into awaiting trucks.
- Establishing load points as far as practicable from sensitive receivers.
- Use of less noise-intensive equipment, where reasonable and feasible.
- Non-tonal reversing alarms fitted to all construction vehicles.
- Scheduling of respite periods and possible provision of temporary re-location where continuously noisy night-time activities are required.

In order to minimise the potential noise and vibration impacts upon nearby sensitive receivers, construction works should be undertaken during the EPA's standard daytime construction periods (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays) where possible.

Out of Hours Works should be minimised as far as is practicable.

6.5.2 Requirements of the Construction Noise and Vibration Management Plan

Prior to construction, when more specific information is available in relation to the proposed construction works, a site specific Construction Noise and Vibration Management Plan (CNVMP) would be prepared. This would address each major stage of the construction works and identify the appropriate mitigation and management measures, consistent with the requirements of the *Interim Construction Noise Guideline*.

The objectives of the CNVMP are as follows:

- Assist in ensuring that the noise emissions during the construction works comply with the noise management levels and goals nominated in **Section 4.2**.
- Determine noise and vibration monitoring, reporting and response procedures.
- Describe specific mitigation treatments, management methods and procedures to be implemented to control noise and vibration during construction.
- Describe construction timetabling to minimise noise impacts including time and duration restrictions, respite periods and frequency.
- Describe procedures for notifying residents of construction activities likely to affect their amenity through noise and vibration.
- Define contingency plans to be implemented in the event of non-compliances and/or noise complaints.

In addition to the noise mitigation measures outlined in **Section 6.5.1**, as a minimum, for the proposed daytime works, it is recommended that the project undertake community consultation (letterbox drops) and representative noise monitoring during the early works.

The purpose of letter box drops is to provide specific notification of the duration and timing of the construction activities so that residents are informed about the proposed works ahead of time.

The purpose of the monitoring is to validate the construction noise predictions and confirm that the noise levels from individual equipment are not excessive.

For out of hours works (OOHW), additional noise management is recommended including individual briefings and phone calls to consult with the affected residents. Typically, any OOHW would be subject to a separate approval on a case-by-case basis.

7 CONCLUSION

The Queanbeyan City Council (QCC) proposes to construct a 4.6 km long extension to the Ellerton Drive. The existing Ellerton Drive connects to Yass Road and Bungendore Street at a roundabout and terminates approximately 850 m southeast of this roundabout. The proposal is to extent Ellerton Drive from its current terminus to the existing Old Cooma Road and Edwin Land Parkway intersection, forming the fourth leg of this intersection. This will be two lane single carriageway roadway and was identified to be required by 2017.

SLR Consulting (Australia) Pty Ltd (SLR) has been engaged by Opus International Consultants (Opus) to conduct a noise impact assessment for the proposed extension. This is required as part of the design and documentation processes undertaken by Opus. The objective of SLR's engagement was to assess the potential noise impacts of the operation of the proposed extension.

All of the identified potentially impacted sensitive receivers were grouped into 8 Noise Catchment Areas. In March – April 2014, SLR conducted ambient noise monitoring at 11 locations to determine the existing ambient noise environment. In addition, concurrent traffic count was also conducted at the existing Edwin Land Parkway and Old Cooma Road intersection to allow validation of the noise model.

7.1 Operational noise criteria

Upon completion of the proposed Ellerton Drive extension, the entire Ellerton Drive is considered to be a sub-arterial road. The RNP assessment criteria applicable for this project is determine to be:

Road Category	**Type of Project/Land Use**	**Assessment Criteria (dBA)**	
		Daytime (7 am – 10 pm)	**Night-time (10 pm – 7 am)**
Freeway/ arterial/ sub-arterial roads	1. existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	$L_{Aeq(15hour)}$ 55 (external)	$L_{Aeq(9hour)}$ 50 (external)

In addition to the noise criteria above, the RNP describes a "Relative Increase Criteria" of 12 dB above existing traffic noise. This criterion is primarily intended to protect existing quiet areas from excessive changes in amenity. Most of the existing residences along the proposed extension are currently not affected by significant traffic noise. Therefore, the "Relative Increase Criteria" are also considered in this assessment.

7.2 Validation of Noise model

Validation of the noise model was performed based on noise monitoring conducted at the Edwin Land Parkway road reserve and 12 Alfred Place, Karabar. The variations between the model-predicted noise levels and the measured noise levels were within ±2 dB. In accordance to guidelines provided by NSW Environmental Noise Management Manual, these variances are considered to be acceptable. Therefore, it was determined that the noise model provides results which enable a reliable assessment of the project.

7.3 Operational Noise Assessment Findings

The modelled traffic speed was 60 km/hr from the existing section of Ellerton Drive to about Ch1200 and 80 km/hr from Ch1200 onwards to the Old Cooma Road intersection. The road pavement adopted in the noise model was dense graded asphalt (DGA).

The following summarises the findings of the noise prediction and assessment conducted for the design year (2027, 10 years after project opening). It should however be noted that further assessment and investigation is required to determine whether the suggest mitigations are reasonable and feasible (e.g. taking into account preferences within the community etc.)

- NCA1
    - 26 out of 26 receivers exceed the relevantRNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 9 dB
    - Level of exceedance of the Relative Increase Criteria was up to 8 dB
    - Possible feasible and reasonable mitigation:
        - Upgraded property boundary fence to a height of 3 to 3.6 m
        - Building treatment for 2nd storey receivers (approximately 7 properties)
- NCA2
    - 15 out of 20 receivers exceed the relevantRNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 8 dB
    - Level of exceedance of the Relative Increase Criteria was up to 6 dB
    - Possible feasible and reasonable mitigation:
        - Upgraded property boundary fence to a height of 2.4 m
- NCA3
    - 8 out of 11 receivers exceed the relevant RNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 6 dB
    - Level of exceedance of the Relative Increase Criteria was up to 11 dB
    - Possible feasible and reasonable mitigation:
        - Building treatment for receivers exceeding relevant criteria (approximately 8 properties)
- NCA4
    - 4 out of 11 receivers exceed the relevant RNP criteria
    - No exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$
    - Level of exceedance of the Relative Increase Criteria was up to 5 dB
    - Possible feasible and reasonable mitigation:
        - Building treatment for receivers exceeding relevant criteria (approximately 4 properties)
- NCA5
    - 4 out of 10 receivers exceed the relevant RNP criteria
    - No exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$
    - Level of exceedance of the Relative Increase Criteria was up to 7 dB
    - Possible feasible and reasonable mitigation:
        - Building treatment for receivers exceeding relevant criteria (approximately 4 properties)

- NCA6
    - 1 out of 1 receiver exceeds that relevant RNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 7 dB
    - Level of exceedance of the Relative Increase Criteria was up to 12 dB
    - Possible feasible and reasonable mitigation:
        - Building treatment for receivers exceeding relevant criteria (1 property)
- NCA7
    - 15 out of 15 receivers exceed the relevant RNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 10 dB
    - Level of exceedance of the Relative Increase Criteria was up to 13 dB
    - Possible feasible and reasonable mitigation:
        - Upgraded property boundary fence to a height of 3.6 to 4.2 m
        - Building treatment for 2nd storey receivers, isolated receivers and receivers where fence is not feasible due to driveway access requirements (approximately 7 properties)
- NCA8
    - 39 out of 39 receivers exceed the relevant RNP criteria
    - Level of exceedance of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ was up to 10 dB
    - Level of exceedance of the Relative Increase Criteria was up to 14 dB
    - Possible feasible and reasonable mitigation:
        - Upgraded property boundary fence to a height of 2.1 to 3.6 m for receivers at Webber Place, Fitzgibbon Place, Caroline Place, Alfred Place.
        - Road side noise barrier of 1.5 to 3 m for receivers at Barracks Flat Drive
        - Building treatment for 2nd storey receivers, isolated receivers and receivers where fence is not feasible due to driveway access requirements (approximately 21 properties)

7.4 Construction Noise

Based on the typical construction stages assumed in the assessment, it was found that the predicted noise levels exceed the noise affected noise management levels determined based on the measured Rating Background Level within the project area. The worst level of exceedance was predicted to be 32 dB. It was recommended that a standard suite of mitigation measures be implemented in order to mitigate and reduce the potential noise impact associated with the construction of the project.

1 Sound Level or Noise Level

The terms "sound" and "noise" are almost interchangeable, except that in common usage "noise" is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2 "A" Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an "A-weighting" filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The figure below lists examples of typical noise levels

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as "linear", and the units are expressed as dB(lin) or dB.

3 Sound Power Level

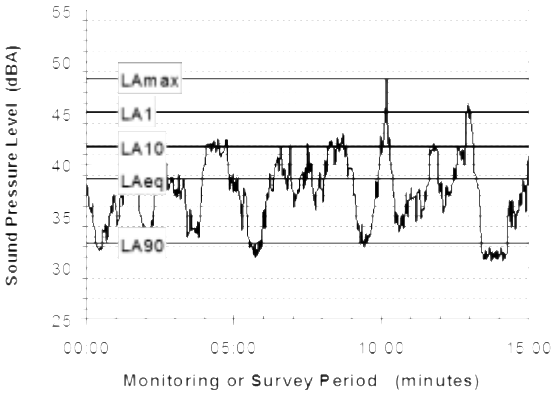
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

L_{Amax} The maximum noise level during the 15 minute interval

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the "repeatable minimum" L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or "average" levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than "broad band" noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

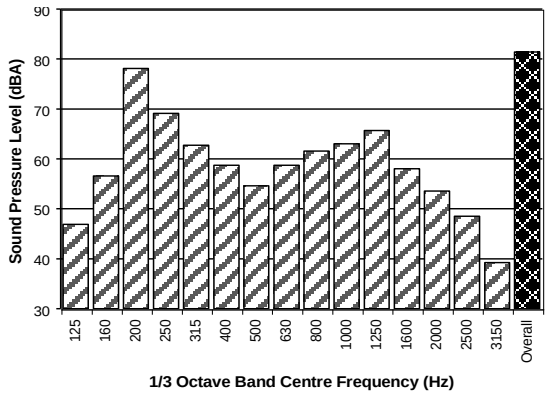
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of "peak" velocity or "rms" velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as "peak particle velocity", or PPV. The latter incorporates "root mean squared" averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated.

A vibration level V, expressed in mm/s can be converted to decibels by the formula $20 \log (V/V_0)$, where V_0 is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

9 Human Perception of Vibration

People are able to "feel" vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

10 Over-Pressure

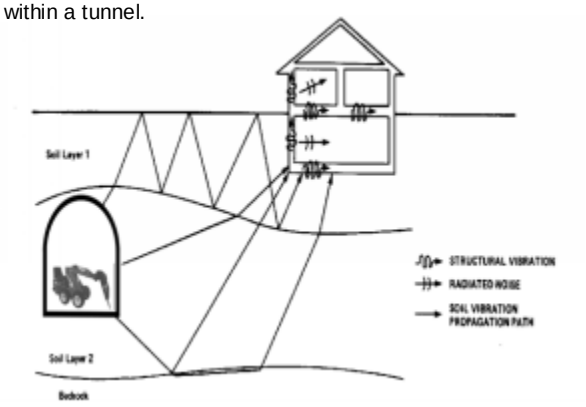
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

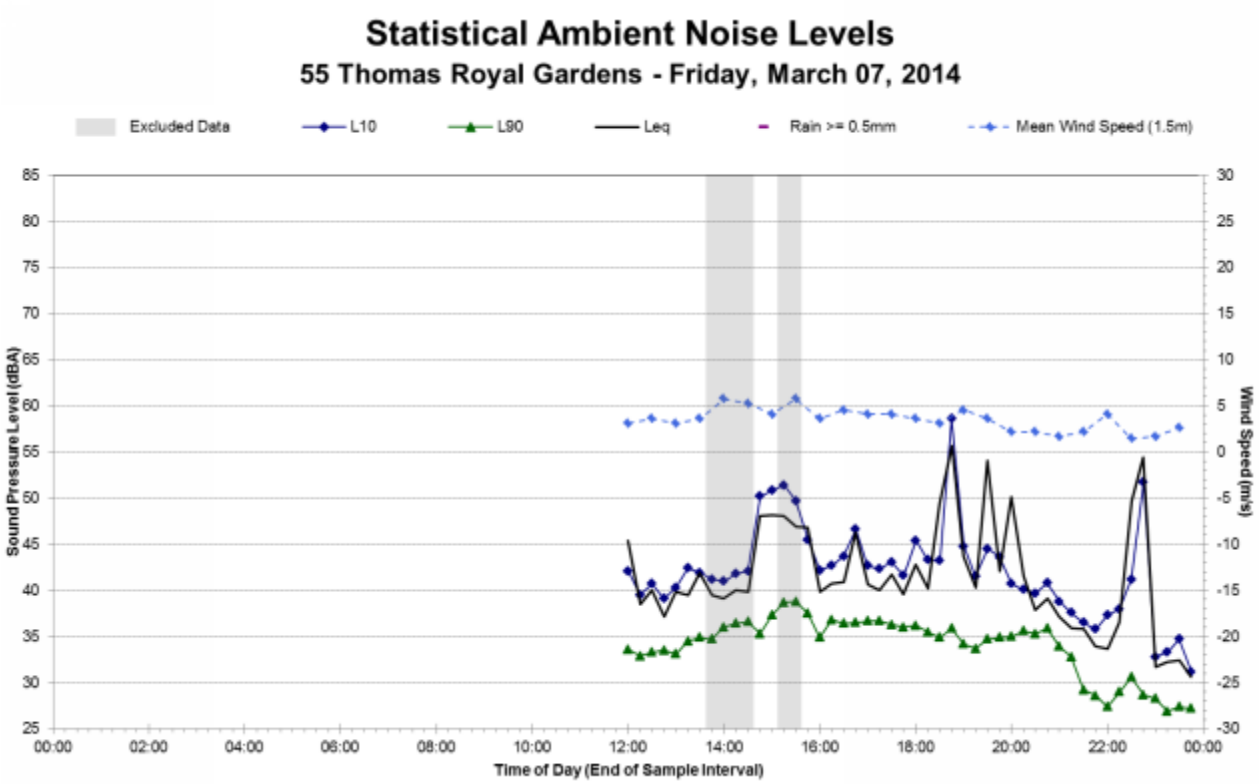
Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed "structure-borne noise", "ground-borne noise" or "regenerated noise". This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

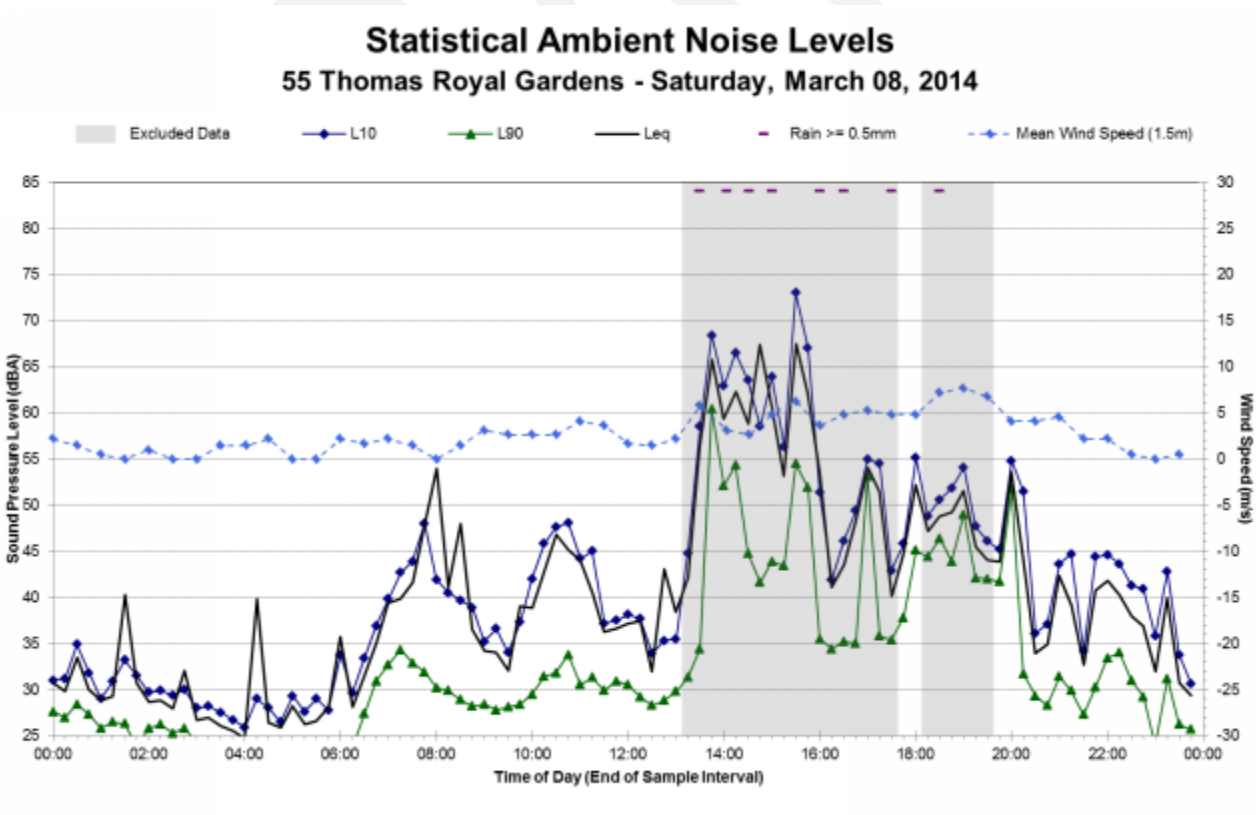
Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

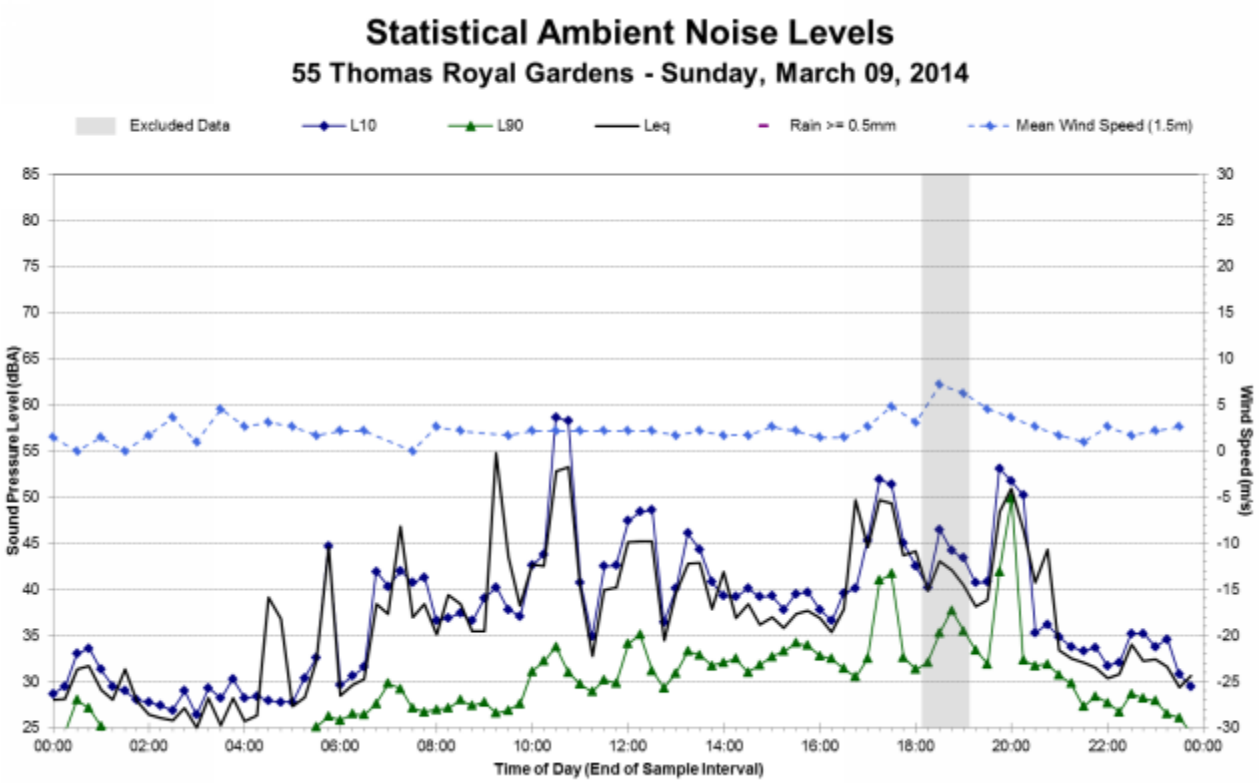
The following figure presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.

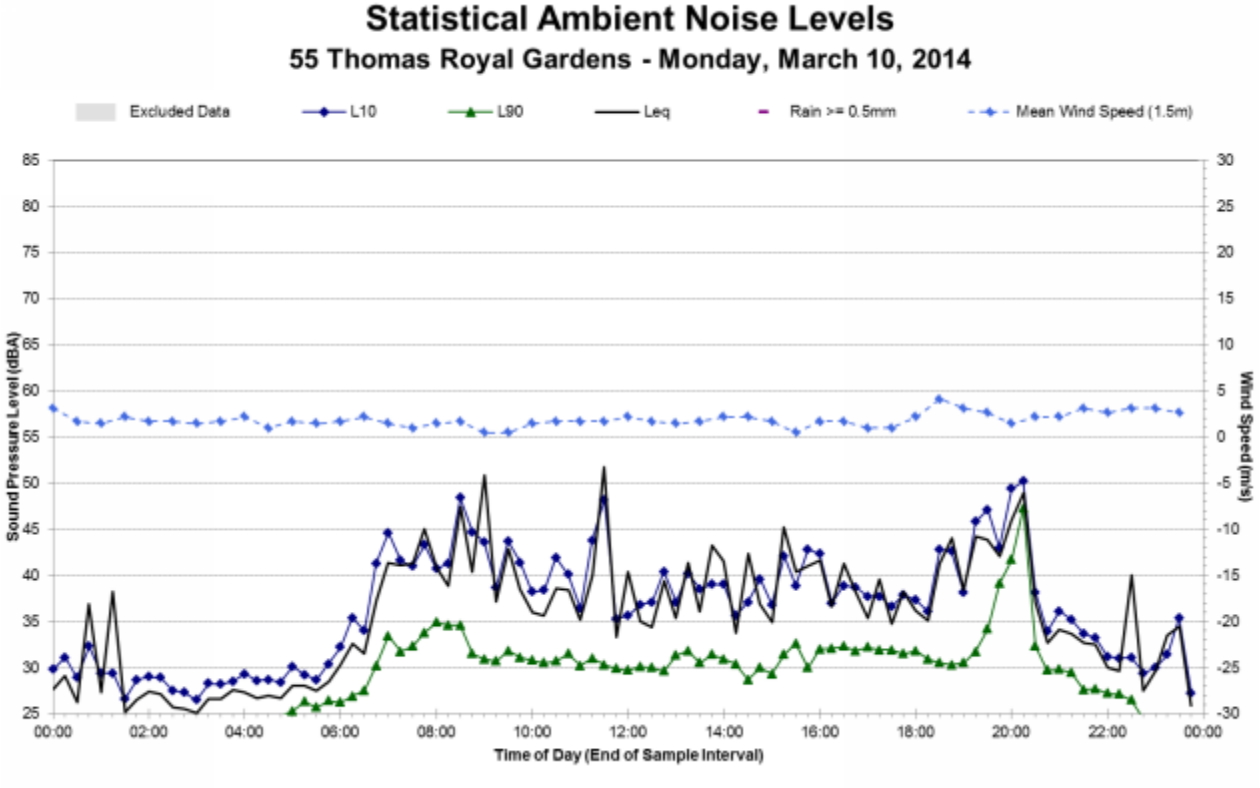


The term "regenerated noise" is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise.


Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Friday, March 07, 2014
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Saturday, March 08, 2014
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Sunday, March 09, 2014
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Monday, March 10, 2014
Excluded Data
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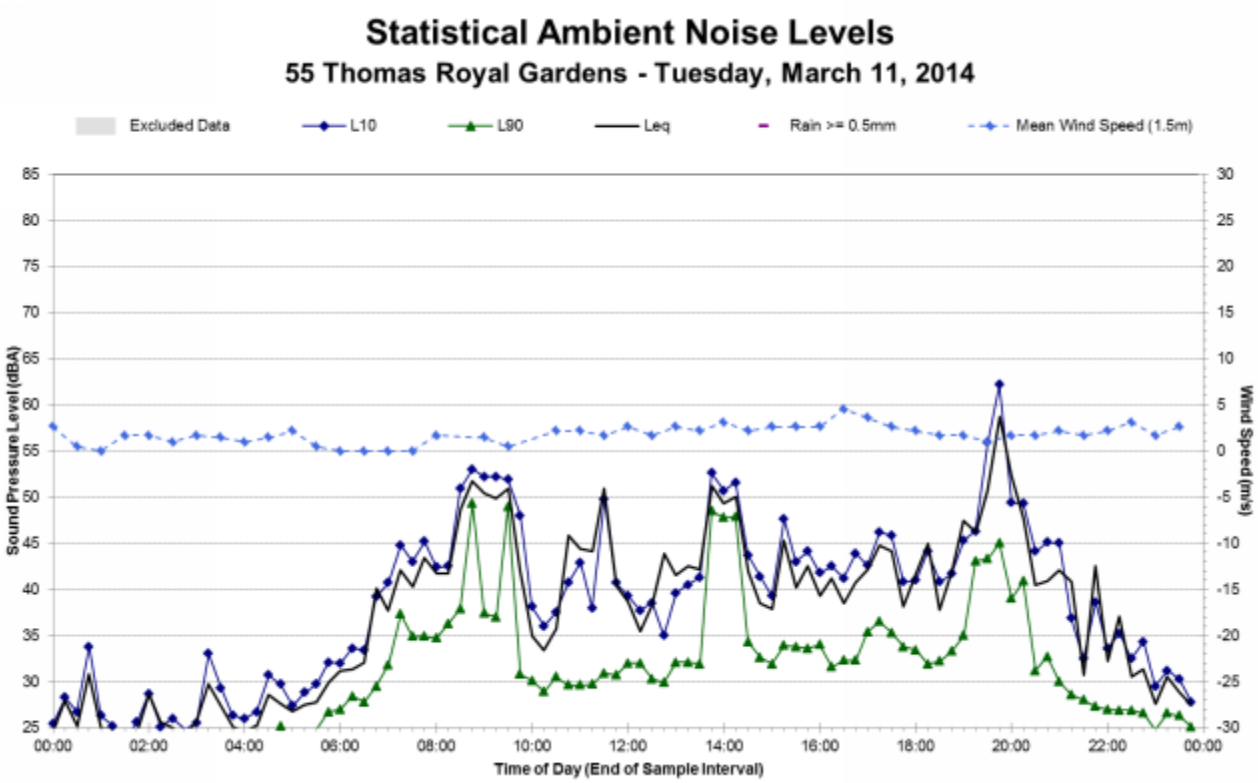
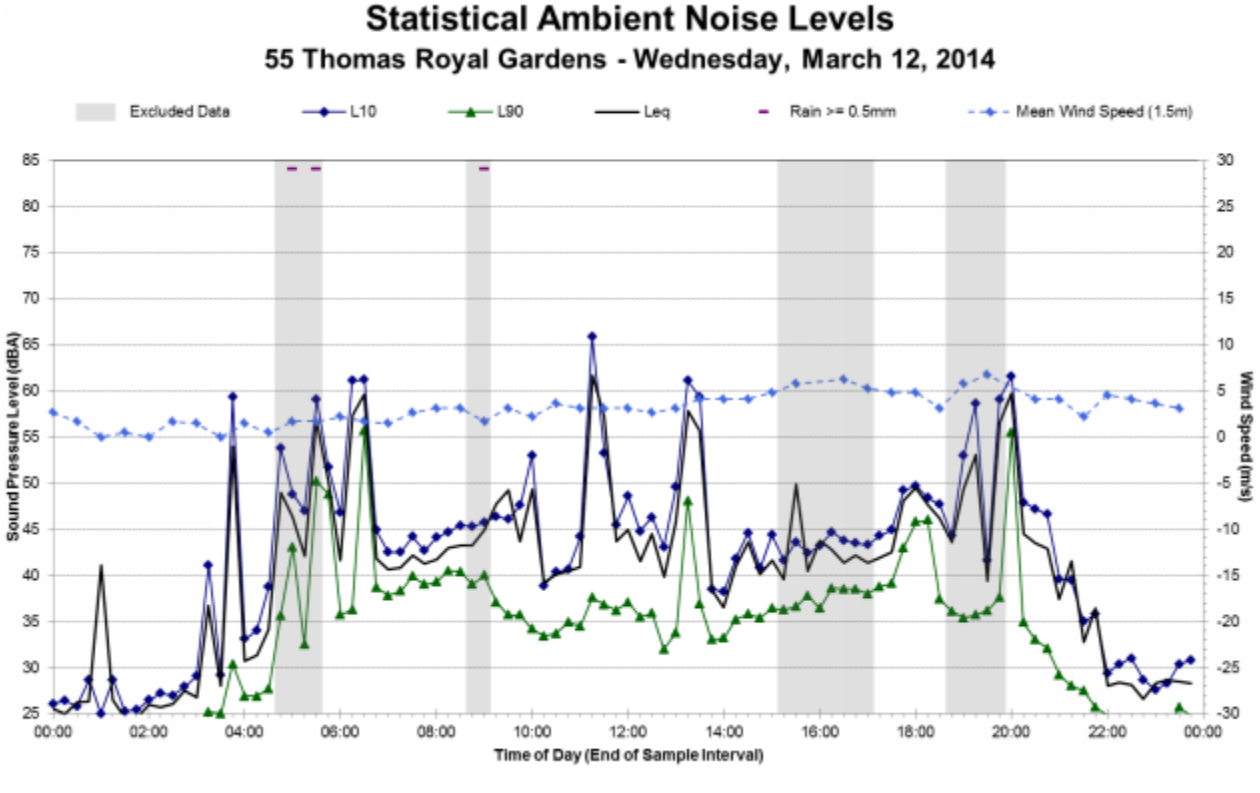
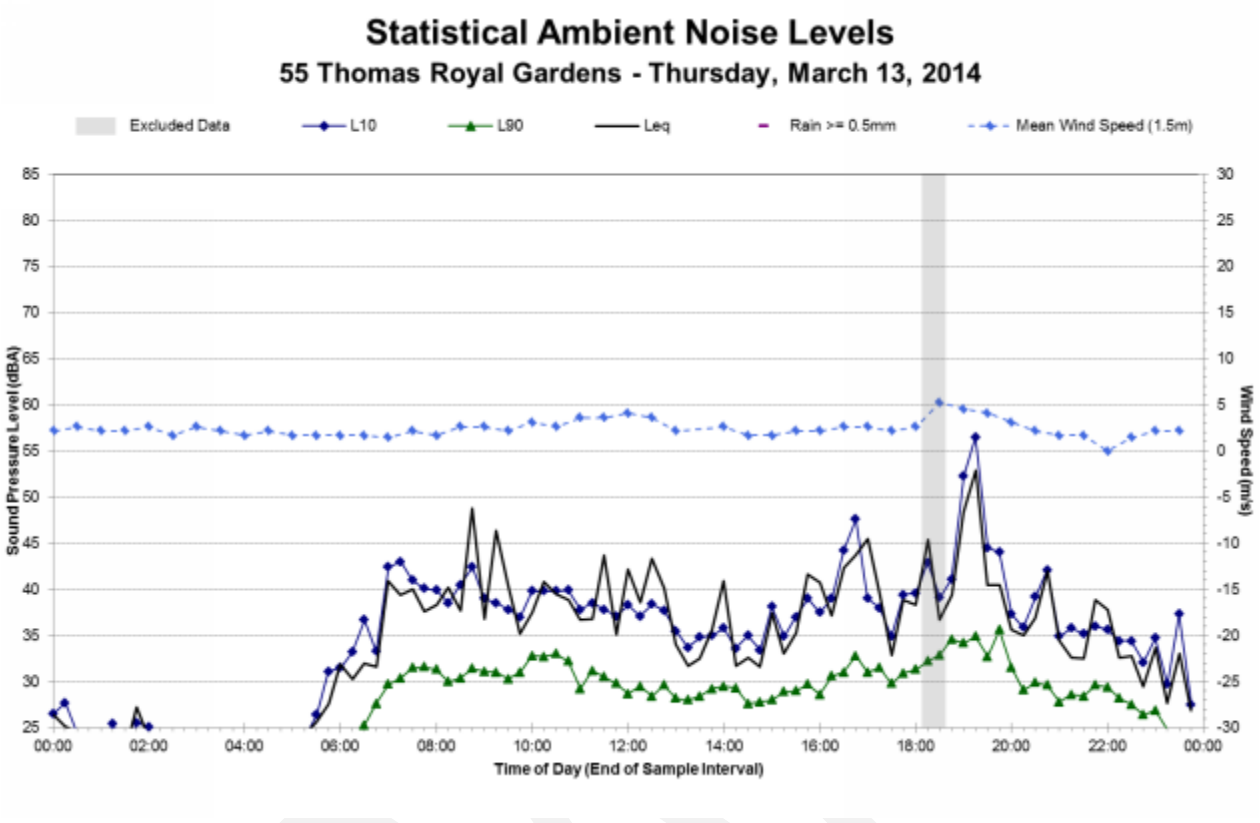
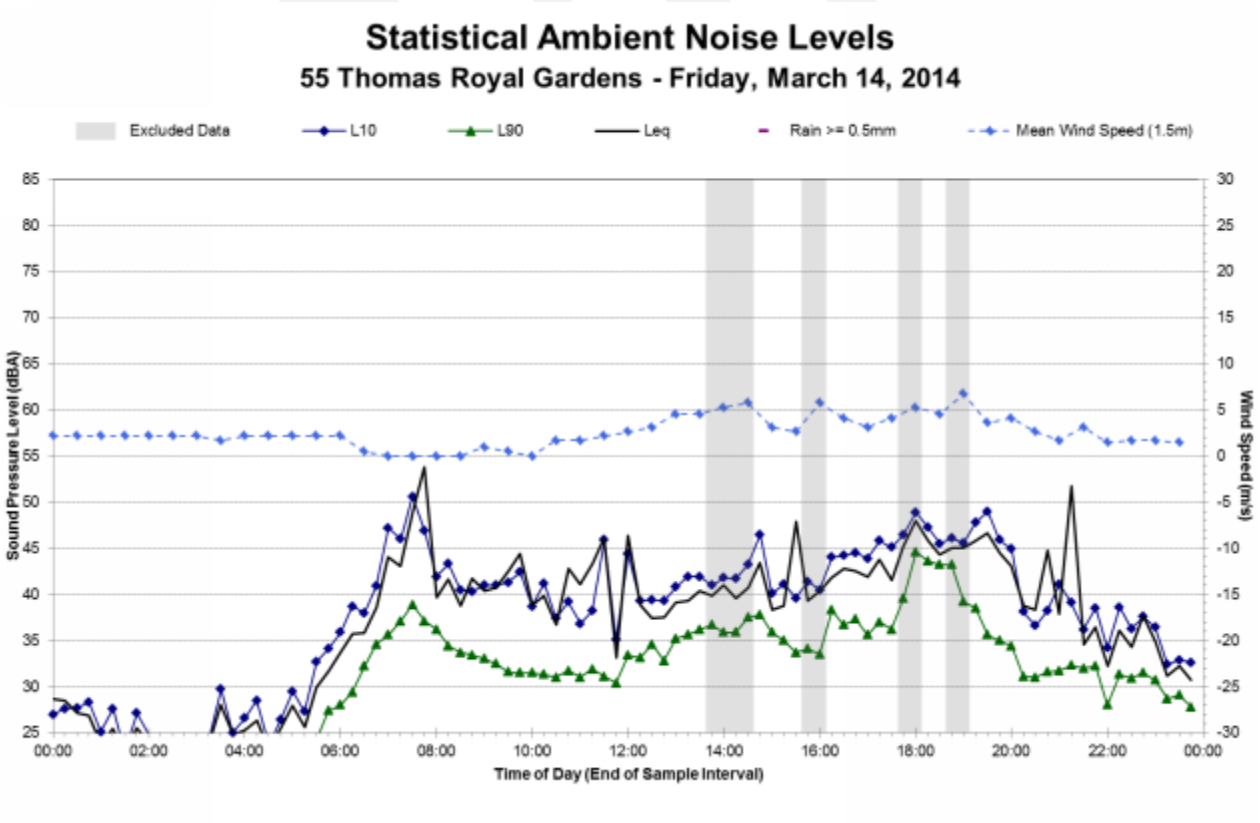
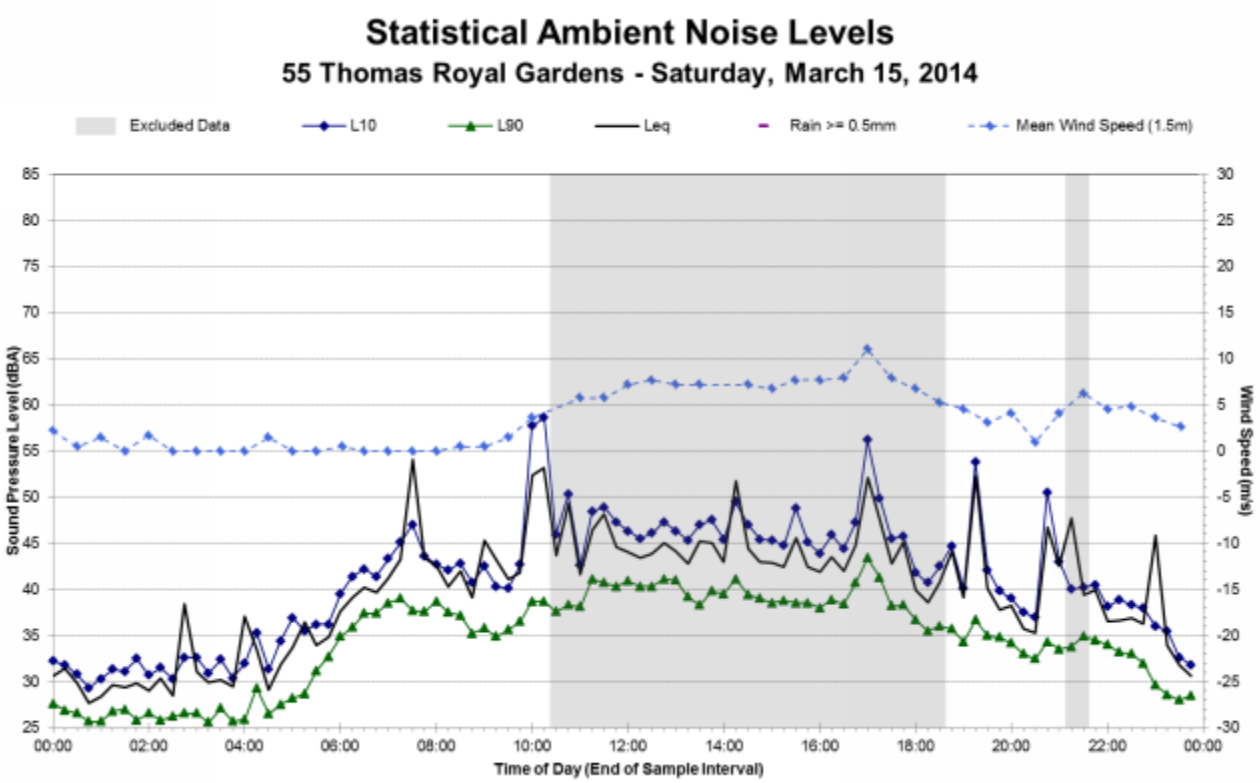
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

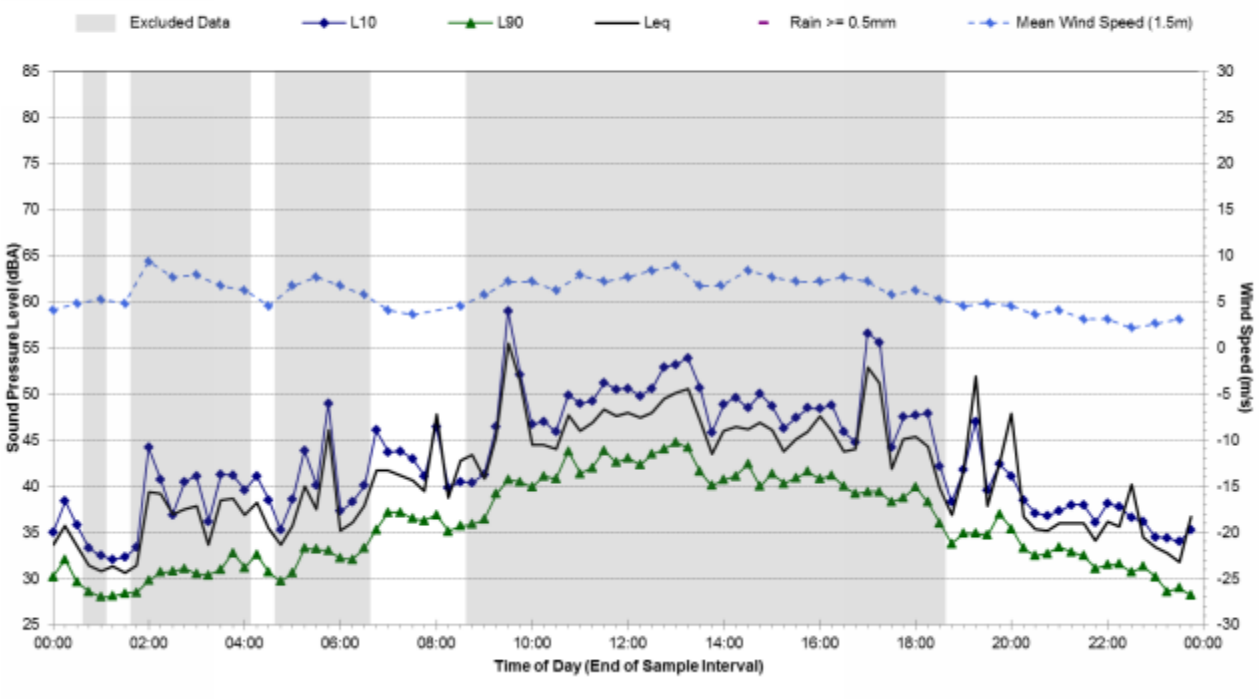

Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Tuesday, March 11, 2014
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

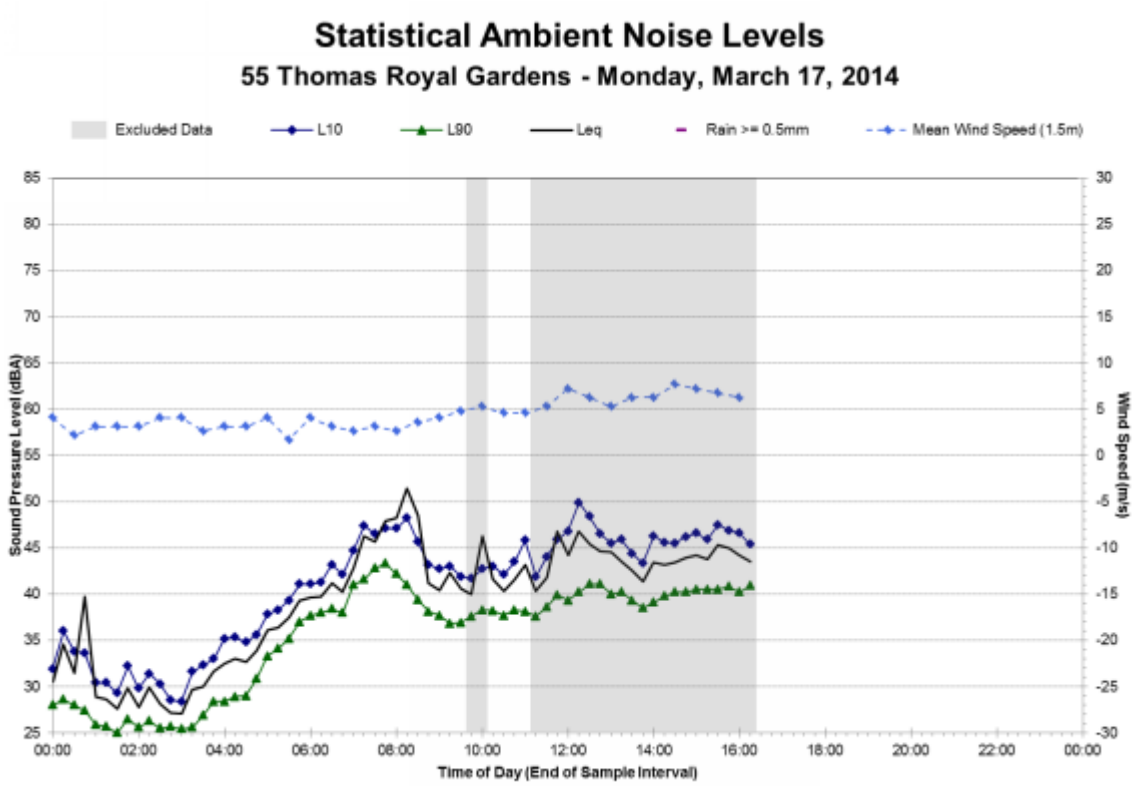

Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Wednesday, March 12, 2014
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Thursday, March 13, 2014
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Friday, March 14, 2014
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Saturday, March 15, 2014
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Sunday, March 16, 2014
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
55 Thomas Royal Gardens - Monday, March 17, 2014
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)