Appendix G: Morley-Ellenbrook Line: Preliminary Design Noise and Vibration Assessment - Part 2 (SLR 2019)

MORLEY-ELLENBROOK LINE

Preliminary Design
Noise and Vibration Assessment - Part 2

Prepared for:

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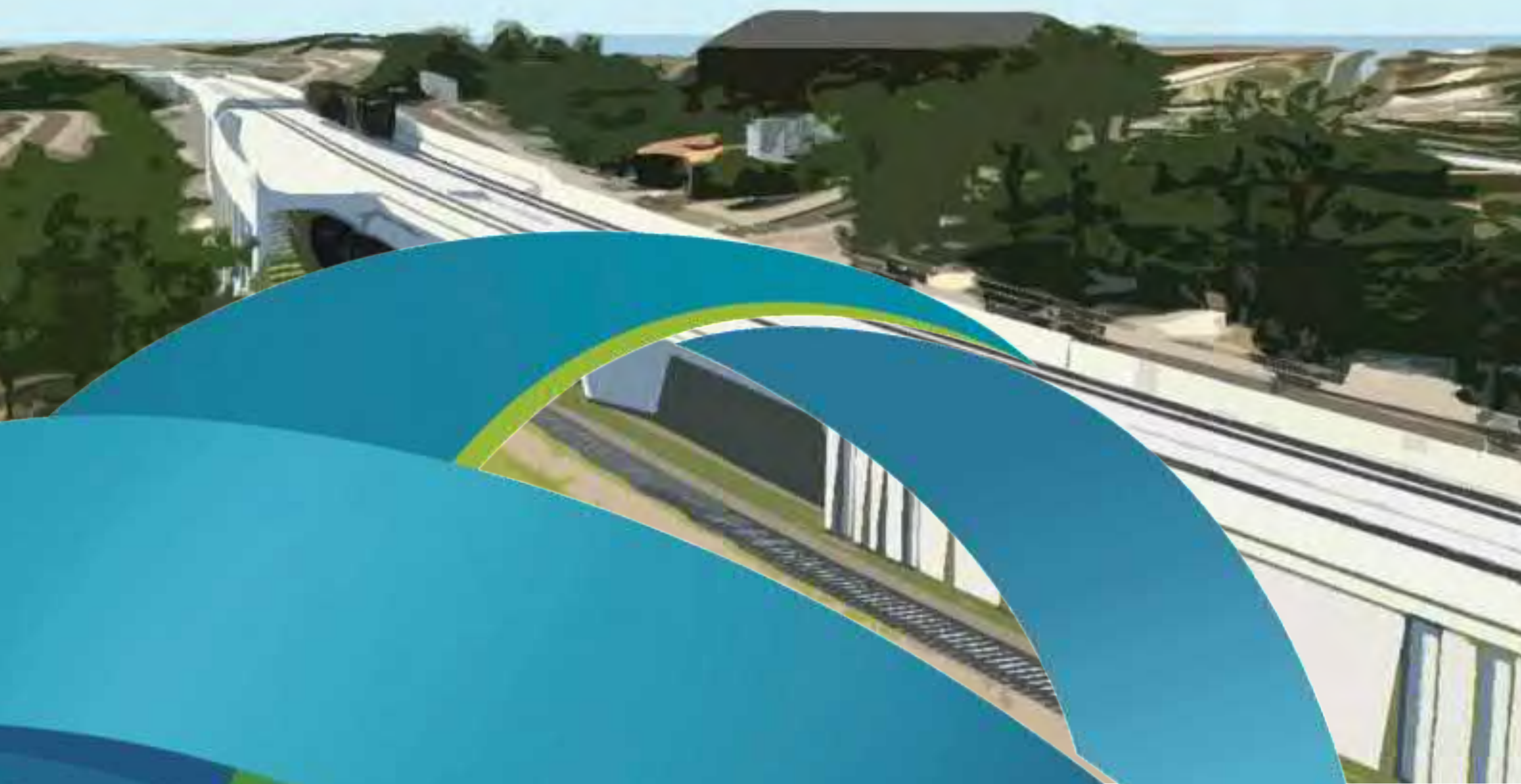

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Public Transport Authority (PTA) (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

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675.11323.00100-R02-v2.0	26 August 2019	Luke Zoontjens	Binghui Li	Luke Zoontjens
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EXECUTIVE SUMMARY

The proposed introduction of the Morley to Ellenbrook Line (MEL) will lead to a shift in operational noise and vibration emissions in its vicinity.

This document presents a desktop assessment of existing and future railway noise and vibration levels and provides in principle recommendations for improvement where they may be required.

This report details noise and vibration results for the section of MEL alignment which extends from the existing eastern edge of Tonkin Highway to the proposed Ellenbrook Station (Part 2).

Key findings - noise

Design noise targets have been developed from *State Planning Policy 5.4: Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (SPP5.4), industry guidelines and relevant past projects.

In regards to forecast airborne noise levels from MEL rail operations in Part 2,

- As a result of the project, 200 residences are modelled to be above levels which require *consideration* of mitigation, depending on the metric used (period average or maximum passby).
- Without mitigation, 16 residences are above the Airborne Noise Design Level (**Section 3.1**), there mitigation must be *provided*.

An extent of noise walls referred to as 'Revision A' is detailed in **Table 9** in **Section 5.1.4**. Implementation of these noise mitigation treatments is expected to achieve noise objectives at all residences assessed, with the exception of 2 residences which are modelled to receive noise levels within 2 dB. Further refinements to the mitigation are expected as detail in the design develops.

There is risk that trains entering passing loops or crossovers may navigate relatively sharp curvature which under certain conditions can generate additional curving noise (wheel squeal or flanging noise). Such noise if presented would be a key source of annoyance but would not exceed current statutory environmental objectives at nearby dwellings. Care must be taken to maximise the curvature of track where practicable and consider the use of superelevation to assist with steering. If there are issues during service, typical local controls in practice are usually limited to wayside friction modifier systems and close fitting noise walls.

Specific controls or noise management plans may be required in relation to the Ellenbrook railcar stowage area depending on how its design progresses. Untreated, there is some potential for residential complaint on the basis of early-morning use of yard horns, driver communications and additional curving noise under turnouts.

Key findings – vibration

To assess risks of annoyance from ground borne vibration (GBV), investigation trigger levels were adopted from interstate guidelines and historical projects. For residential development, a floor vibration trigger level of $L_{v,RMS}$ 106 dB was used. Ground borne noise (GBN) which is 'rumbly' noise produced by vibration of internal building surfaces can also be a source of annoyance, and a L_{Amax} 35 dB night time investigation trigger level was used consistent with similar past projects.

In regards to forecast vibration levels from MEL rail operations,

- 270 properties closest to the alignment were assessed. Of these properties,

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    - 33 residential properties are forecast to have GBV levels up to 9 dB above the relevant investigation trigger level prior to any specific mitigation; and
    - 53 residential properties are forecast to have GBN levels up to 13 dB above the relevant investigation trigger level prior to any specific mitigation;

- Improvements may be achieved through the use of suitable under ballast matting (UBM) and/or under sleeper pads (USPs) with suitable trackform. Generally such controls if correctly specified and installed can achieve at least a 10 dB reduction in vibration levels, so compliance with recommended vibration investigation trigger levels is considered reasonably practicable.

Additional extents of mitigation are suggested near currently vacant lots that could be developed as residential or other vibration sensitive usages, to 'future-proof' against development infill close to the railway.

Recommendations

1. In lieu of detailed design, budget for:

    - Review / optimisation of mitigation and control measures during detailed design in accordance with this report;
    - Either low height (close fitting) or boundary noise walls on both passenger main lines. One option of wall extents and heights is indicated as follows (**Table 9**);

Table Recommended noise wall extent (in lieu of source controls)

References	Nearest main line, position	Approximate chainages, km	Heights and lengths, m	Approximate total area, m^2	Rationale, forecast outcome
MEL UP2	MEL UP near Lord Street, Paley Way to Castlereagh Way	21.98 – 20.50	1.8 m high by 1,490 m long	2,670	Reduces L_{Amax} levels at approximately 90 residences to east to L_{Amax} 80 dB or less
MEL DN4	MEL DN near Vaucluse Crescent on approach to Ellenbrook Station	25.46 – 25.68	2.4 to 3.0 high by 220 m long	675	Comply with Design Levels at approximately 12 residences Reduces L_{Amax} levels at approximately 40 residences plus Ellenbrook Christian College to L_{Amax} 85 dB or less
MEL UP3	MEL UP near Messina Grove, Ponte Vecchio Boulevard after Ellenbrook Station	25.65 – 24.62	2.4 to 4.0 m high by 1,020 m long	3,102	

Note 1 At locations where concrete upstands are already anticipated as part of structural / safety considerations, i.e. no additional structure

    - Vibration mitigation extent as provided in the table below (**Table 11**);

Table Recommended vibration mitigation extent (in lieu of other source controls, subject to review)

Rail development section – Part 1	Reference (Note[1])	Approximate chainages, km	Total length, km
New development section	UBM6	17.00 – 17.40	0.40
	UBM7	17.90 – 18.30	0.40
	UBM8	19.80 – 22.85	3.05
	UBM9	24.24 – 25.70	1.46

Note 1 Refers to both UP and DN lines. Under sleeper pads (USPs) may also suffice subject to detailed review.

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- Detailed review of vibration controls based on local geotechnical information and existing site survey(s), which also considers increased extents beyond **Table 11** to future proof against long term development infill.

2. Ensure the rail engineering of the passing loops minimises the risk of curving noise through design, such as avoiding short radii curves and situations where there may be regular wheel flange contact with the rails.
3. Develop a project noise and vibration management plan to advise relevant local government authorities (i.e. City of Swan) of the agreed approach for railway sections within their jurisdiction.
4. Consider passenger cabin in-car noise during travel within tunnel sections at speed: this may not be a significant design factor if relatively short in duration.
5. Share outcomes with planning, local government authorities to assist in future land use planning near the project area.
6. Undertake consultation with community stakeholders where there may be a history of complaints or specific concerns over noise and/or vibration impact.

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1 Introduction

The Morley-Ellenbrook Line (MEL) project involves the operation of passenger rail services between Bayswater and Ellenbrook with four new stations (currently named Morley East, Malaga, Whiteman Park and Ellenbrook) as indicated in **Figure 1** below. The new railway line will serve Perth's north-east suburbs to support existing communities with improved transport connections and create new communities through integrated station precincts.

In accordance with the State Planning Policy SPP5.4, these proposed rail sections are generally assessed as new major rail infrastructure development, except for the section within the existing transport corridor adjacent to Bayswater Station which is considered to be major redevelopment of an existing railway.

This document presents a desktop assessment of existing and future railway noise and vibration levels for the proposed Morley-Ellenbrook Line and provides in principle recommendations for mitigation where required.

1.1 Scope

SLR was engaged by the Public Transport Authority (PTA) to undertake the following scope of works:

- Identify sensitive noise and vibration receptors in close proximity to the new railway alignments, and relevant operational assessment objectives.
- Undertake modelling predictions of operational noise and vibration levels to be received at the identified sensitive receptors, and assess these levels for compliance with relevant assessment objectives. The assessment is to account for sources of previous measurements, as well as prediction uncertainties determined in accordance with relevant industry guidelines.
- Where predicted noise and vibration levels exceed the assessment objectives, recommend mitigation measures where practicable and reasonable where predicted noise and vibrations levels exceed the assessment objectives to achieve relevant compliance.

Key elements to be considered within this assessment are comprised of the following:

- **Airborne noise**. The major sources for airborne noise emissions from the proposed new rail line include passenger rail operations and some sources near or within proposed train stations, including vehicle movements (within bus loops, kiss and ride areas and carparks), mechanical plants, public address systems and crowd noise etc. Noise from the proposed passenger rail operations is considered as the prime element for the airborne noise assessment, as the proposed rail operations are expected to dominate noise emissions within the rail reserve along the entire alignment.
- **Ground-borne vibration (GBV).** Due to close proximity to existing residential properties from some sections of the proposed new rail alignments, there could be potential for excessive floor vibrations within adjacent residences.
- **Regenerated/ground-borne noise (GBN).** Regenerated noise or ground-borne noise (GBN) and low frequency noise are now widely recognised noise problems, and are commonly perceived as vibration due to its low frequency characteristics. Although these elements are not clearly specified within the current state policy framework in Western Australia, there are well developed applicable objectives that have been used in some other states in Australia and internationally.

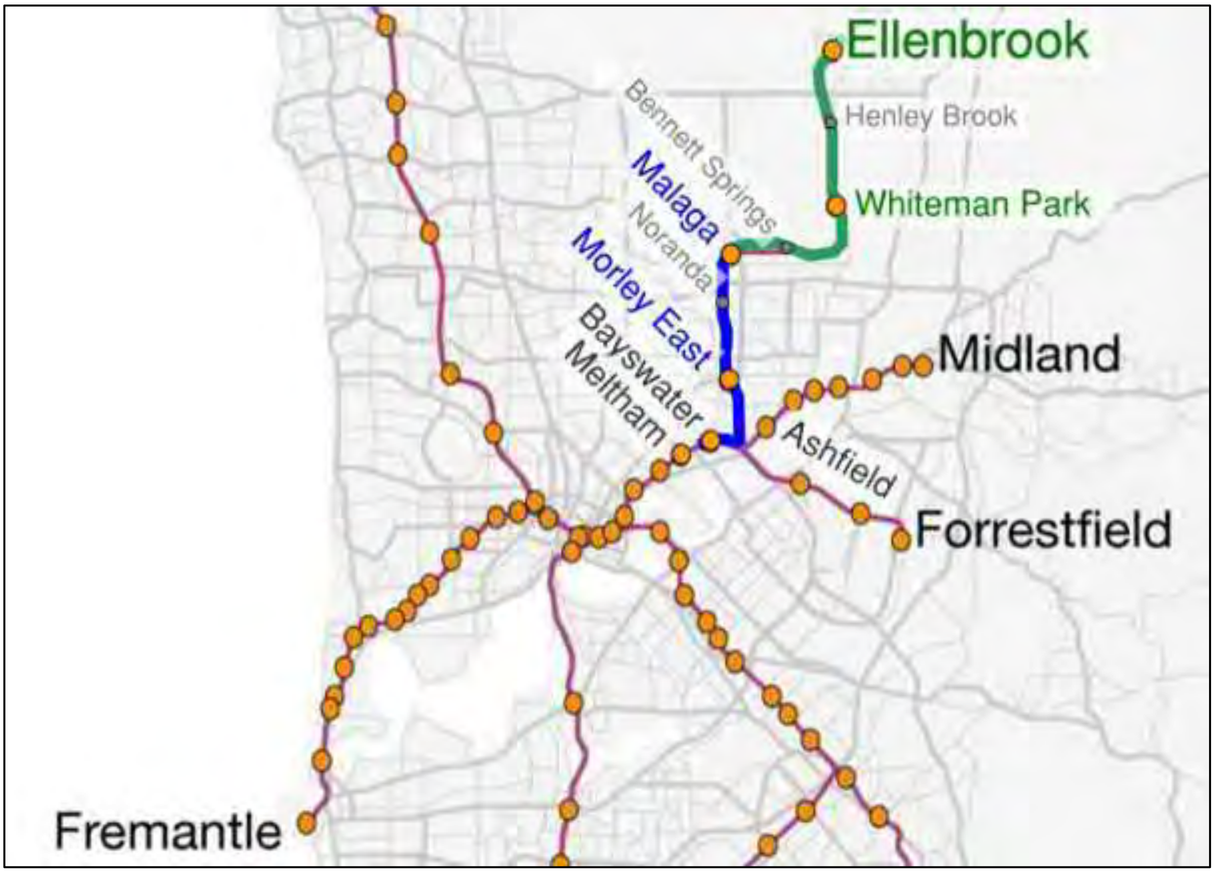
1.2 Locality

The project is divided into the following three sections for the assessment study:

- Part 1: Rail operations between Bayswater Station and Malaga Station;
- Part 2: Rail operations between Malaga Station and Ellenbrook Stowage yards;
- Whole Project: Bus loops, road vehicles and stations associated with Parts 1 and 2 above.

An overview of the site extent is indicated in **Figure 1**.

Figure 1 Annotated map of proposed Perth metro rail network (Source: MEL-MNO-ELUP-RS-RPT-0001.E.IFU). 'Part 1' is coloured blue, 'Part 2' green. This figure also indicates proposed Noranda, Bennett Springs and Henley Brook stations.



This assessment study report only considers noise and vibration impacts associated with Part 2 (coloured green in **Figure 1**).

2 Review of relevant legislation and guidelines

The following table provides the proposed noise and vibration assessment framework for this project.

Table 1 Morley-Ellenbrook Line Noise and Vibration Assessment Framework

Aspect / Source	Statutory / Government Policy	Australian / International Standards	Industry best practice / SLR recommendation
Operational environmental noise			
Airborne noise from trains, rail operations	SPP5.4[1]	-	SPP5.4 NSWRING[2]
Road vehicle movements (bus loops, kiss and ride areas			-
Station mechanical ventilation plant Crowd noise Public address systems Outdoor Driver communications within stowage / turnback facilities	EPNR1997[3]	AS2107:2016[4]	EPNR1997
Car parking		EU Parking Area Noise 2007[5]	
Operational vibration effects			
Ground-borne vibration (GBV) from rail operations	-	AS/ISO 2631.2:2014[6] BS 6472:2008 ISO 14837[7]	AS 2670.2:1990[8] NSWRING NSW DEC Guidelines[9] ASHRAE 2011[10]
Ground-borne noise (GBN) ('regenerated noise') noise from rail operations	-	-	NSWRING

Selected aspects to this table are further discussed in the following subsections.

The adopted noise and vibration objectives (for the purpose of recommending mitigation measures within this assessment framework) are listed in **Section 3**.

[1] Western Australia State Planning Policy 5.4, Road and Rail Transport Noise and Freight Considerations in Land Use Planning, GOVERNMENT GAZETTE, WA, 22 September 2009 ("SPP5.4", "The Policy").
[2] New South Wales Rail Infrastructure Noise Guideline, NSW EPA, May 2013.
[3] Western Australia Environmental Protection (Noise) Regulations 1997 ("EPNR1997", "The Regulations") as amended.
[4] Australian/New Zealand Standard 2107:2016 'Recommended design levels and reverberation times for building interiors'.
[5] Bayer, Landesamt für Umwelt 2007, *Parking Area Noise - Recommendations for the Calculation of Sound Emissions of Parking Areas, Motorcar Centers and Bus Stations as well as of Multi-Storey Car Parks and Underground Car Parks*, Bayerisches Landesamt für Umwelt, Parkplatzlämstudie 6, Aufl., August 2007.
[6] AS ISO 2631.2:2014 Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Vibration in buildings (1 Hz to 80 Hz).
[7] International Standard ISO 14837-1 2005 "*Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General guidance*".
[8] Australian Standard AS 2670.2 1990 "*Evaluation of Human Exposure to Whole Body Vibration - Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)".*
[9] Department of Environment and Conservation NSW, "Assessing Vibration: a technical guideline" (2006) http://www.environment.nsw.gov.au/resources/noise/vibrationguide0643.pdf
[10] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 2011, HVAC Applications – SI Edition, Chapter 47.

2.1 Applicable airborne noise legislation and guidelines

The objectives applicable to noise emissions from road, rail and freight related transport noise are based on the following noise parameters:

- period average levels ($L_{Aeq,day}$ and $L_{Aeq,night}$) as outlined in SPP5.4, and
- maximum event levels (L_{Amax}) as discussed in the NSWRING.

Table 2 provides a comparison of the outdoor noise objectives stated within SPP5.4, Table 1 of the NSWRING and past major PTA projects[11]. These noise objectives are relevant to the emission of railway or road traffic noise as received at a sensitive land use such as residential dwellings, schools and child care centres. The objectives are applicable at 1 metre from the most exposed habitable façade of the building receiving the noise, at ground floor level only.

Table 2 Comparison of outdoor noise objectives in SPP5.4 and NSWRING

Type of development	Policy / Reference	Day period average	Night period average	Maximum passby level
"Major new rail infrastructure proposal"	SPP5.4	Noise Target $L_{Aeq,day}$ 55 dB Noise Limit $L_{Aeq,day}$ 60 dB (6am – 10pm)	Noise Target $L_{Aeq,night}$ 50 dB Noise Limit $L_{Aeq,night}$ 55 dB (10pm – 6am)	-
	Historical PTA projects	-	-	Noise Target $L_{Aeq,night}$ 75 dB Noise Limit $L_{Aeq,night}$ 80 dB
"New rail line development"	NSWRING	Predicted rail noise levels exceed: $L_{Aeq,(15h)}$ 60 dB (7am to 10pm)	$L_{Aeq,(9h)}$ 55 dB (10pm – 7am)	L_{AFmax} 80 dB (95% events)
"Major redevelopment of an existing railway"	SPP5.4	Practicable noise management and mitigation measures should be considered [..] having regard to— • the existing transport noise levels; • the likely changes in noise emissions resulting from the proposal; and • the nature and scale of the works and the potential for noise amelioration.		
"Redevelopment of an existing rail line"	NSWRING	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dB or more, or existing L_{Amax} rail noise levels by 3 dB or more and Predicted rail noise levels exceed: $L_{Aeq,(15h)}$ 65 dB (7am to 10pm)	$L_{Aeq,(9h)}$ 60 dB (10pm – 7am)	L_{AFmax} 85 dB (95% events)

Discussion of period average (L_{Aeq}) and maximum passby event level (L_{Amax}) objectives are provided in the following subsections.

All other environmental noise sources are proposed to be assessed in accordance with the Regulations (EPNR1997). These noise sources include stationary plant, road vehicle movements not on public roads, crowd noise and public address systems.

[11] E.g. Minister for the Environment. (2003). Metropolitan Region Scheme Amendment No 992/33 Clarkson-Butler (Assessment No. 1139) Statement Number 000629. Perth: Government of Western Australia.

2.1.1 Discussion of period average level objectives

It should be noted that the SPP5.4 Noise Targets and Limits in above are not specifically applicable to the major redevelopment of existing transport infrastructure. As noted from **Figure 1**, a new rail section will operate within the existing transport corridor adjacent to Bayswater Station. This section of the project is considered to be a major redevelopment of an existing railway, as opposed to a new rail infrastructure project.

From **Table 2** it can be seen that here is reasonable alignment between the NSWRING and SPP5.4 such that achieving the SPP5.4 Noise Limits would also likely achieve the NSWRING trigger levels in regards to period average noise levels.

The 5dB difference between the outdoor SPP5.4 Noise Target and Noise Limit in **Table 2** above represents an acceptable margin for compliance. The policy states that "*In most situations in which either the noise-sensitive land use or the major road or railway already exists, it should be practicable to achieve outdoor noise levels within this acceptable margin*". Section 5.3.2 of SPP5.4 states that

> *In the application of the noise criteria to new major road and rail infrastructure projects, the objective of this policy is that the new infrastructure be designed and constructed so that the noise emissions are at a level that—*
>
> - *provides an acceptable level of acoustic amenity for existing noise-sensitive land uses and for the planning of new noise-sensitive developments;*
> - *is consistent with other planning policies and community expectations; and*
> - *is practicably achievable.*
>
> *[..]*
>
> *Transport infrastructure providers are also required to consider design measures to meet the noise target of $L_{Aeq(Day)}$ 55dB and $L_{Aeq(Night)}$ 50dB, and to implement these measures where reasonable and practicable.*
>
> *If a new rail or major road infrastructure project is to be constructed in the vicinity of a future noise-sensitive land use, mitigation measures should be implemented in accordance with this part of the policy. For this purpose, a proposed noise-sensitive land use is any noise sensitive development that is subject to an approved detailed area plan, subdivision approval or development approval, such that the transport infrastructure provider is able to adequately design noise mitigation measures to protect that development. In these instances, the infrastructure provider and developer are both responsible for ensuring that the objectives of this policy are achieved, and a mutually beneficial noise management plan, including individual responsibilities, should be negotiated between the parties.*

Therefore objectives for this project are adopted from SPP5.4 Noise Targets and Noise Limits, which are consistent with the NSWRING noise trigger levels.

2.1.2 Discussion of maximum event noise level objectives

Maximum event noise level objectives are not defined within SPP5.4 but have historically been applied on major railway projects in Western Australia since the early 2000s. From **Table 2** it can be seen that similar to previous PTA projects the NSWRING recommends a maximum event passby noise level of L_{Amax} 80 dB for new rail line development. However, it is considered more stringent than historical PTA projects through the use of the 'Fast' or shorter time constant (i.e. L_{AFmax}) for the noise parameter – the one-second 'Slow' weighting as historically used in WA is less sensitive to noise of very short duration.

Therefore it is here proposed to use a maximum 'Trigger Level' of L_{Amax} 75 dB and 'Design Level' of L_{Amax} 80 dB based on the maximum level parameter with the Slow (S) time weighting (i.e. L_{ASmax}). For simplicity and consistency it is proposed to apply this throughout the study area despite some sections being within an existing rail transport corridor.

2.2 Applicable ground-borne noise and vibration legislation and guidelines

2.2.1 Ground borne noise (GBN)

From a review of relevant guidelines and relevant project experiences, GBN objectives are more critical to compliance than GBV and will drive the design of mitigation within the rail corridor. The NSWRING recommends the following GBN trigger levels for further investigation:

Table 3 NSWRING GBN trigger levels

Sensitive land use	Time of day	Internal noise trigger levels, dB Development increases existing rail noise levels by 3 dB or more *and* resulting rail noise levels exceed:
Residential	Day (7 am–10 pm)	L_{ASmax} 40
	Night (10 pm–7 am)	L_{ASmax} 35
Schools, educational institutions, places of worship	When in use	L_{ASmax} 40 to 45

Under the NSWRING, "Residential" typically means "any residential premises located in a zone as defined in a planning instrument that permits new residential land use as a primary use". For this project, that includes any existing residence that is reasonably expected to be occupied during railway operations, or any residence that has Development Approval at the time of the procurement contract, including future residential buildings, hotels and overnight accommodation along or adjacent to the proposed route. This means that:

- Existing buildings apparently used as residences and not to be demolished as part of the project are assessed as residential; and
- Any residential dwellings that are not constructed (or likely to be approved for construction) prior to contractor award are not considered as residential in this assessment.

For schools, educational institutions and places of worship, the lower value of the range is most applicable where low internal noise levels are expected, such as in areas assigned to studying, listening or praying. More stringent objectives may be selected in some cases, particularly where the area is remote and ambient levels are well below L_{Aeq} 30 dB, however this should be balanced with the number of events in each period. The NSWRING states that:

> *It appears reasonable to conclude that ground-borne noise at or below 30 dB L_{Amax} will not result in adverse reactions, even where the source of noise is new and occurs in areas with low ambient noise levels. Levels of 35–40 dB L_{Amax} are more typically applied and likely to be sufficient for most urban residential situations, even where there are large numbers of pass-by events.*

A ground borne noise trigger level of L_{ASmax} 35 dB is here adopted, on the basis of the above and the number of expected train movements in the area during the night period.

2.2.2 Ground borne vibration (GBV)

Table 4 presents objectives for assessing human exposure to continuous vibration from the 2006 NSW DEC guidelines (listed in and referenced by the NSWRING), which are consistent with BS 6472 and the now-withdrawn AS 2670.2:1990. These levels are generally assessed at the floor midspan of a building space with a sensitive usage.

Table 4 Criteria for exposure to continuous vibration (2006 NSW DEC Guidelines)

Place / usage	Time period	Preferred (Note 1)	Maximum (Note 1)
Critical working areas (e.g. hospital operating theatres, precision laboratories)	Day or night	0.10 mm/s (100 dB)	0.20 mm/s (106 dB)
Residences	Day	0.20 mm/s (106 dB)	0.40 mm/s (112 dB)
	Night	0.14 mm/s (103 dB)	0.28 mm/s (109 dB)
Offices	Day or night	0.40 mm/s (112 dB)	0.80 mm/s (118 dB)
Workshops	Day or night	0.80 mm/s (118 dB)	1.6 mm/s (124 dB)

Note 1 These values are assessed as one second root-mean-square (RMS) vertical values at the internal floor midspan of a vibration sensitive space. dB values are referenced to 1 nm/s.

From the table above it can be seen that within this guideline the preferred night time *floor* vibration goal is $L_{v,RMS,1s}$ 103 dB, with a maximum of $L_{v,RMS,1s}$ 109 dB. Historically, a target equivalent to the day period is used given the expected low number of train movements in the area during the night period, and that typical sensitivities are reduced by beds and other soft furniture which does not seem to be addressed by the NSWRING.

On the basis of being consistent with previous rail projects within the Perth metropolitan area, a vibration trigger level of $L_{v,RMS,1s}$ 106 dB is here adopted for residential premises regardless of time period. All other usages are assessed against the 'Preferred' criterion.

3 Design objectives summary

The following subsections detail objectives that are intended to apply to those sensitive land uses along or adjacent to the proposed route that are to be assessed in this study.

3.1 Airborne noise objectives

The table below outlines objective levels in regards to airborne noise during operation. From this point on, only the Rail Operations – Airborne Noise Trigger Level (Trigger Level) and Rail Operations – Airborne Noise Design Level (Design Level) as defined in this table are used to assess railway noise emissions.

Table 5 Project rail operations noise objective levels

#	Parameter	Objective[12]	Value(s) (Note[1])	Basis
N1	Rail Operations – Noise Generally	Noise levels from rail operations will be managed as low as is reasonably practicable.	demonstrated	SPP5.4
N2	Rail Operations – Airborne Noise Trigger Level	Noise mitigation must be considered where the noise level is above the prescribed Rail Operations – Airborne Noise Trigger Level.	$L_{Aeq,day}$ 55 dB $L_{Aeq,night}$ 50 dB L_{Amax} 75 dB	SPP5.4 Noise Target Historical PTA projects
N3	Rail Operations – Airborne Noise Design Level	Noise mitigation must be provided where the combined noise level resulting from the proposal and existing rail operations is • above the $L_{Aeq,day}$ or $L_{Aeq,night}$ Rail Operations – Airborne Noise Trigger Level by more than 5 dB, and • above the $L_{Aeq,day}$ or $L_{Aeq,night}$ noise level that would result from operation of existing rail infrastructure prior to the proposal.	demonstrated	SPP5.4 Noise Limit

Note 1 'Demonstrated' means the objective is achieved to the satisfaction of the approval authority.

Note that these objectives do not mandate the provision of noise mitigation on the basis of maximum noise levels (L_{Amax}) alone. In other words:

- if railway noise levels are above $L_{Aeq,day}$ 55 dB, $L_{Aeq,night}$ 50 dB or L_{Amax} 75 dB (i.e. the Noise Trigger Level), noise mitigation must be considered; and
- If railway noise levels exceed existing railway noise levels in terms of ($L_{Aeq,day}$ or $L_{Aeq,night}$) and also exceed either $L_{Aeq,day}$ 60 dB, $L_{Aeq,night}$ 55 dB (i.e. the Noise Design Level), then mitigation must be provided.

These objectives are assessed outdoors, 1 metre from the main building on a lot associated with a noise sensitive usage. Consistent with SPP5.4, they are assessed at ground level locations however in this report results are provided for all floor levels where identified from surveys.

3.2 Groundborne vibration objectives

Table 6 presents objectives in regards to ground borne vibration (GBV) and noise (GBN) during operation.

Where vibration levels are predicted to be above these objectives, the project will consider the use of reasonable and practicable controls to achieve compliance.

[12] Airborne noise objectives are referenced to 20 microPascals (dB re 20µPa) and here apply at an external distance of 1 metre from a suitably representative building facade with a noise sensitive use located on noise sensitive premises and 1.5m above ground. L_{Amax} values are applicable to the 95th percentile train passby event.

Table 6 Project rail operations GBV and GBN objectives

#	Parameter	Objective[13]	Value (Note[1])	Basis
V1	Rail Operations – Generally	Vibration levels from rail operations will be managed as low as is reasonably practicable.	demonstrated	Industry best practice
V2	Rail Operations Building Vibration Trigger Level	Mitigation of vibration via ground or structural pathways must be considered where the vector sum Rail Operations Building Vibration Trigger Level is exceeded as applicable to the 95th percentile train passby event measured at a reasonably representative location of the building occupancy, with appropriate use of frequency weightings from ISO 2631.1:1997[14] as amended or AS ISO 2631.2:2014[15].		AS2670.2:1990 ISO2631 ASHRAE[16] guidelines NSWRING
		Medical clinical treatment, surgery or recovery areas, or facilities operating precision equipment	Curve 1 ($L_{v,RMS,1s}$ ~100dB)	
		Residential and hotel accommodation	Curve 2 ($L_{v,RMS,1s}$ ~106dB)	
		Commercial premises, Public buildings, Churches and community centres and the like	Curve 4 ($L_{v,RMS,1s}$ ~112dB)	
		Light and general industrial buildings	Curve 8 ($L_{v,RMS,1s}$ ~118dB)	
V3	Rail Operations Regenerated Noise/GBN Trigger Level	Mitigation of vibration via ground or structural pathways must be considered where the Rail Operations Regenerated Noise Trigger Level is exceeded as applicable to the 95th percentile train passby event and measured at centre of reasonably representative interior space(s) of each building usage.		Historical PTA projects NSWRING
		Residential and hotel accommodation, 10pm to 6am	L_{ASmax} 35dB	
		Residential and hotel accommodation, 6am to 10pm	L_{ASmax} 40dB	
		Commercial buildings, Public buildings, Churches and community centres and the like	L_{ASmax} 45dB	
		Retail and point of sale areas	L_{ASmax} 50dB	
		Occupiable light and general industrial buildings	L_{ASmax} 50dB	

Note 1 'Demonstrated' means the objective is achieved to the satisfaction of the approval authority.

[13] Vibration objectives are referenced to 1nm/s (dB re 1nm/s), use the subscript 'v' and are assessed on the basis of 1 second root mean square (RMS) values.
[14] ISO 2631-1:1997 Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 1: General requirements.
[15] AS ISO 2631.2:2014 Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Vibration in buildings (1 Hz to 80 Hz).
[16] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc (ASHRAE), 2011 ASHRAE Handbook - Heating, Ventilating, and Air-Conditioning APPLICATIONS - SI Edition, Atlanta GA http://www.ashrae.org.

4 Design assumptions

This section outlines some key input assumptions, modelling and assessment methodologies associated with noise and vibration impact assessment studies for the project.

Technical details are provided in **Appendix B.3**.

4.1 Operational scenarios

This assessment refers to three scenarios:

- The '**Existing**' (also referred to as the 'No Build') scenario which represents the configuration, arrangement and traffic volumes that would exist at the time the proposed upgrade would have commenced operations
- The '**Build**' scenario represents 20 years after completion of the upgrade; and
- The '**Build+M**' (Build including mitigation) scenario which has the same geometry and features as the 'Build' scenario, but with any controls considered requisite for compliance with the design objectives.

The assessment considers the following scenarios and traffic volumes developed on the basis of the operational assumptions report[17]. The year 2041 represents the 'ultimate' scenario consistent with a 20 year design horizon as recommended in SPP5.4.

It should be noted that Part 2 of the project is a new rail line section, and therefore the assessment study for this section covered by this report only considers the '**Build**' scenario and the '**Build+M**' scenario.

Table 7 Operational scenarios and rolling stock types

Scenarios, Year	Services	Day / Night Volumes (Note [1])	Comments, Rationale
'Build', 2041 'Build+M', 2041	Bayswater – Ellenbrook (Series B)	74 / 16	For MEL, 3 car trains replaced with 6 car trains in 2041. All services have 10 minute headways except for 15 minute headways in the evening

Note 1 Normal Monday to Friday services, one way. Day period refers to 6 am to 10 pm period; Night refers to 10pm to 6 am period.

Series C trains are considered to have similar noise emission profiles and lengths as Series B trains, so no specific scenarios for Series C trains are included.

By inspection of this table, $L_{Aeq,night}$ values are expected to be the controlling factor for the potential noise mitigation design since the difference between $L_{Aeq,day}$ and $L_{Aeq,night}$ due to traffic alone will be less than 5 dB. L_{Amax} values are considered unaffected by the time of day.

[17] METRONET Morley-Ellenbrook Line MEL Project scenario operational assumptions – Option 7A Final report, 06 March 2019, reference 'MEL-MNO-ELUP-RS-RPT-0001.E.IFU'

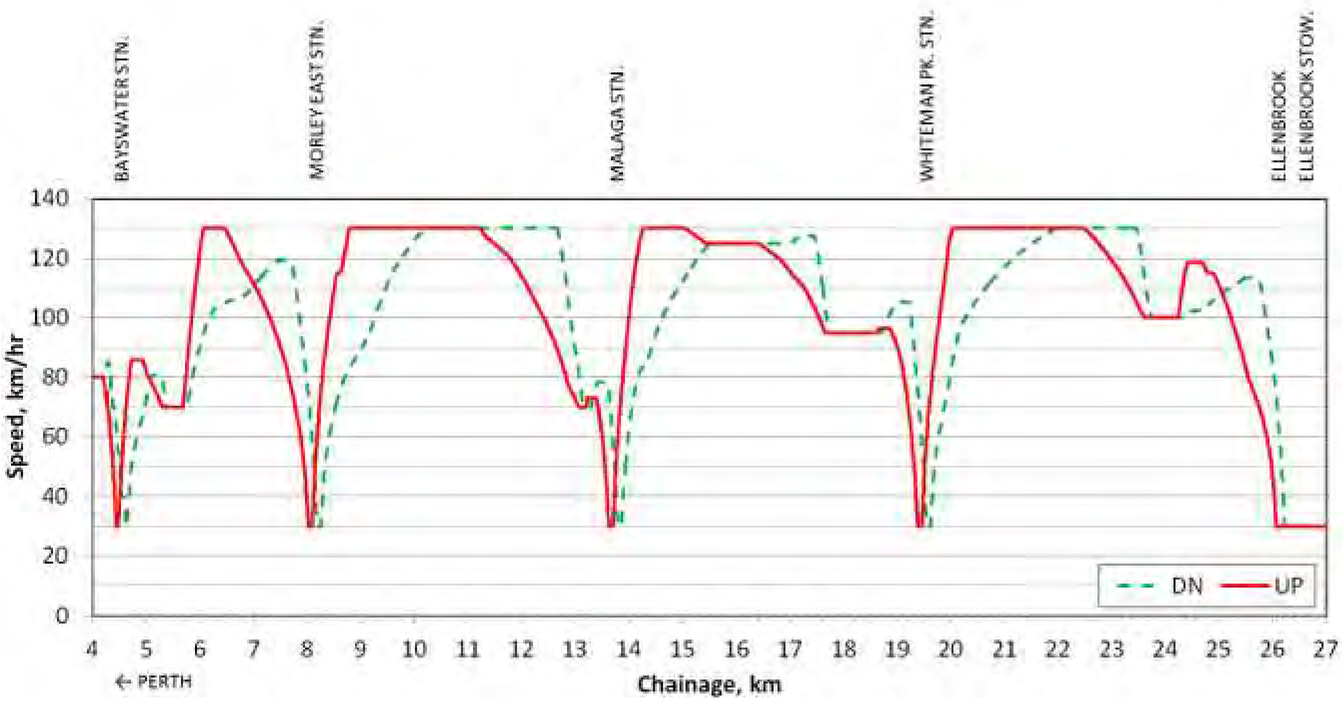
4.2 Speed profiles

Train speed and scheduling has a critical influence on noise and vibration emissions. The modelled speed profiles for both up and down lines as indicated in **Table 8** and **Figure 2** represent a stopping pattern. Note that the first and last trains (referred to as positioning runs) are considered to constitute less than 5% of all traffic. This means that the objectives adopted (which are based on the 5th highest percentile event or averaged over significant time periods) are not sensitive to those events.

Table 8 Modelled speed profiles

Line	Constraints
Bayswater – Ellenbrook	As per **Figure 2**. Minimum of 30 km/hr within stations and stowage areas.

Figure 2 MEL modelled speed profile '20190417'



These speed profiles were provided by the PTA and are considered reasonably representative but subject to change during detailed design stages.

Future stations on this line (e.g. Henley Brook and Bennett Springs indicated in **Figure 1**) are not modelled in this study. However, introducing a station is expected to reduce noise and vibration impacts via reduced speeds. Therefore if other future proposed stations were added, it is unlikely there would be an increase in noise and vibration emissions (provided traffic volumes and signal speeds are maintained).

5 Assessment of airborne noise from rail operations

5.1 Basis

5.1.1 Airborne noise modelling methodology

Given the early stages of planning, this study uses previously established railway noise emission levels to forecast both existing and future noise emission levels. A 3D noise model was constructed to account for varying topographic conditions, shielding and reflecting effects from building structures, planned rail movements and noise emission input data for individual train movements. The development and validation of this model is described further in **Appendix B.1**.

For the 'Existing' scenario, noise barrier and fence heights and locations were sourced as follows:

- Residential fencing separating properties were generally not modelled unless determined to be critical to receiver results at the most exposed properties. This is because the condition and effective height of all such boundary walls is generally unknown.
- Generally, locations of walls facing the railway reserve were sourced from Landgate and reviewed with necessary corrections being made to reflect their realistic existing conditions. The modelling was then carried out on the basis that these fences and barriers are acoustically solid, i.e. they perform as effective noise barriers, being of suitable construction to sufficiently reduce noise transmission.

The 'Build' scenario uses the noise mitigation in the 'Existing' scenario with the following modifications:

- Noise walls modelled in the 'Existing' scenario are removed for the Build scenario where they appear to conflict with the as-designed MEL alignment and structures.

The noise wall extent described was then developed on the following principles:

- Height and extent to achieve the objectives in **Section 3.1**, noting that these will be refined during detailed design with regard to other factors such as visual impact, safety of egress from track, security and vehicle access.
- Heights are limited to 4.0 metres with minimum 0.3 m vertical and 10 metre horizontal stages.
- Walls are located in plan either on the expected rail reserve boundary, on principle shared path (PSP) fence lines, or at least 3.5 metres from the nearest rail centreline (subject to final approval).

  Generally, for flat ground, closer fitting walls do not need to be as tall as those on the boundary. Only in some locations such as where the rail line is in a cutting are walls on the boundary (at the top of the cutting) likely to be more cost effective.

Note that in accordance with SPP5.4 and its guidelines, the design of noise mitigation considers only the railways – not the cumulative noise level from freeway road traffic. This is in part because the proponent of the railway does not have appropriate design control over freeway assets.

The Nordic Rail Traffic Noise Prediction (Kilde 130) algorithm has been utilised within noise modelling platform SoundPLAN 8.1 for the prediction of received noise levels at adjacent noise sensitive receivers. This algorithm has been refined since its introduction in 1984 and is commonly utilised for rail noise assessments within Western Australia. It calculates emission noise level based on the scheduled train operational parameters including speed, length and number of train movements, and it can predict equivalent noise levels (L_{Aeq}) and maximum noise levels (L_{Amax}) as required.

This 3D noise model environment accounts for varying topographic conditions, shielding and reflecting effects from building structures, planned rail movements and noise emission input data for individual train movement that has been validated via in-situ measurements.

Further details regarding the airborne noise modelling methodologies, including reference source levels and environmental model inputs, as well as uncertainty of modelling predictions, are provided in detail in **Appendices B.1** and **B.3**.

5.1.2 Modelled 'existing' rail web dampers

No rail web dampers were modelled for Part 2.

5.1.3 Modelled 'existing' noise walls

Existing freeway noise walls were modelled based on the drawing packages received to date[18].

5.1.4 Modelled extent of new noise walls

Table 9 indicates the extent of mitigation modelled in the Build+M scenario further to that considered to exist at the time of construction.

Table 9 Extent of noise wall mitigation modelled as compliant – Wall extent 'Revision A', Part 2

References	Nearest main line, position	Approximate chainages, km	Heights and lengths, m	Approximate total area, m^2	Rationale, forecast outcome
MEL UP2	MEL UP near Lord Street, Paley Way to Castlereagh Way	21.98 – 20.50	1.8 m high by 1,490 m long	2,670	Reduces L_{Amax} levels at approximately 90 residences to east to L_{Amax} 80 dB or less
MEL DN4	MEL DN near Vaucluse Crescent on approach to Ellenbrook Station	25.46 – 25.68	2.4 to 3.0 high by 220 m long	675	Comply with Design Levels at approximately 12 residences Reduces L_{Amax} levels at approximately 40 residences plus Ellenbrook Christian College to L_{Amax} 85 dB or less
MEL UP3	MEL UP near Messina Grove, Ponte Vecchio Boulevard after Ellenbrook Station	25.65 – 24.62	2.4 to 4.0 m high by 1,020 m long	3,102	

5.2 Results

Table 10 presents an overall summary of results and these are discussed in the following subsections. Further detail is also provided in the following appendices:

- **Appendix C.1** which presents tabulated results of the noise predictions.

[18] Teambinder references MEL-MNO-MRWA-CI-REF-0005 and MEL-MNO.MRWA-CI-REF-0047 via MEL-MNO-MET-EXT-E-00189 dated 2 May 2019.

- **Appendix D** presents individual $L_{Aeq,day}$ and L_{Amax} figures for the 'Existing', and 'Build + M' scenario results.
- **Appendix E** presents noise contour maps of selected scenarios:
  - Build railway Day period noise levels prior to mitigation.
  - Build railway Night period noise levels prior to mitigation.
  - Build railway Maximum passby noise levels prior to mitigation.

Table 10 Airborne noise forecast results summary

Aspect[1]	Parameter[2]	Build, 2041 (no mitigation)	Build+M, 2041 (including mitigation)
Extent	Residences assessed	450	450
Period average ($L_{Aeq,day}$, $L_{Aeq,night}$) Rail Operations – Airborne Noise **Trigger Level** Period average levels	Minimum number of exceedances[3]	150 (33%)	126 (28%)
	Highest exceedance, dB	8	7
Maximum passby (L_{Amax}) Rail Operations – Airborne Noise **Trigger Level** Maximum passby levels	Minimum number of exceedances[3]	200 (44%)	183 (41%)
	Highest exceedance, dB	14	11
Period average ($L_{Aeq,day}$, $L_{Aeq,night}$) Rail Operations – Airborne Noise **Design Level** Period average level	Minimum number of exceedances[3]	16 (3.6%)	2 (0.4%)
	Highest exceedance, dB	3	2

Note 1 Definitions are provided in **Section 3.1**.
Note 2 Residential premises only.
Note 3 The term 'minimum' is used as there may be multiple dwellings at the same address or similar noise levels at properties further away from (e.g. not adjacent to) the rail reserve which are not represented in this table.

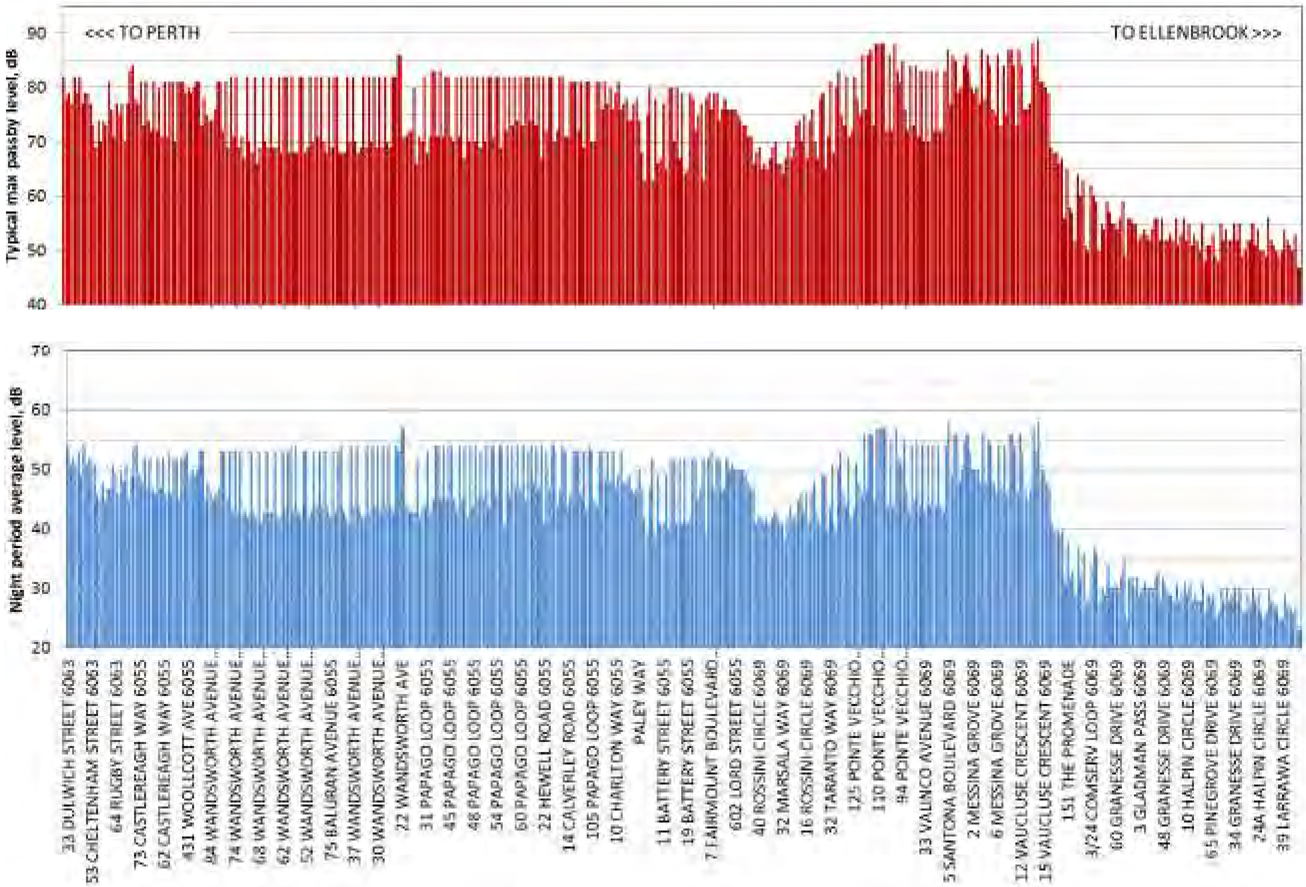
5.2.1 Build scenario

From **Table 10** it can be seen that for the Build scenario (as a result of the project),

- 200 are modelled to be above the Airborne Noise Trigger Level ('N2' in **Table 5** in **Section 3.1**) which triggers the consideration of noise controls: this means that for this area, mitigation must be considered but not necessarily provided if say doing so is unreasonable or impracticable, and
- 16 residences are modelled to be above the Airborne Noise Design Level ('N3' in **Table 5** in **Section 3.1**) which means mitigation must be provided.

Figure 3 presents the modelled distribution in day period ($L_{Aeq,day}$) and maximum (L_{Amax}) levels. This figure indicates that noise levels are forecast to be highest in the Ponte Vecchio Boulevard and Vaucluse Crescent / Messina Grove areas of Ellenbrook.

Figure 3 Distribution in residential $L_{Aeq,day}$ and L_{Amax} per address (ordered by chainage), Build scenario.



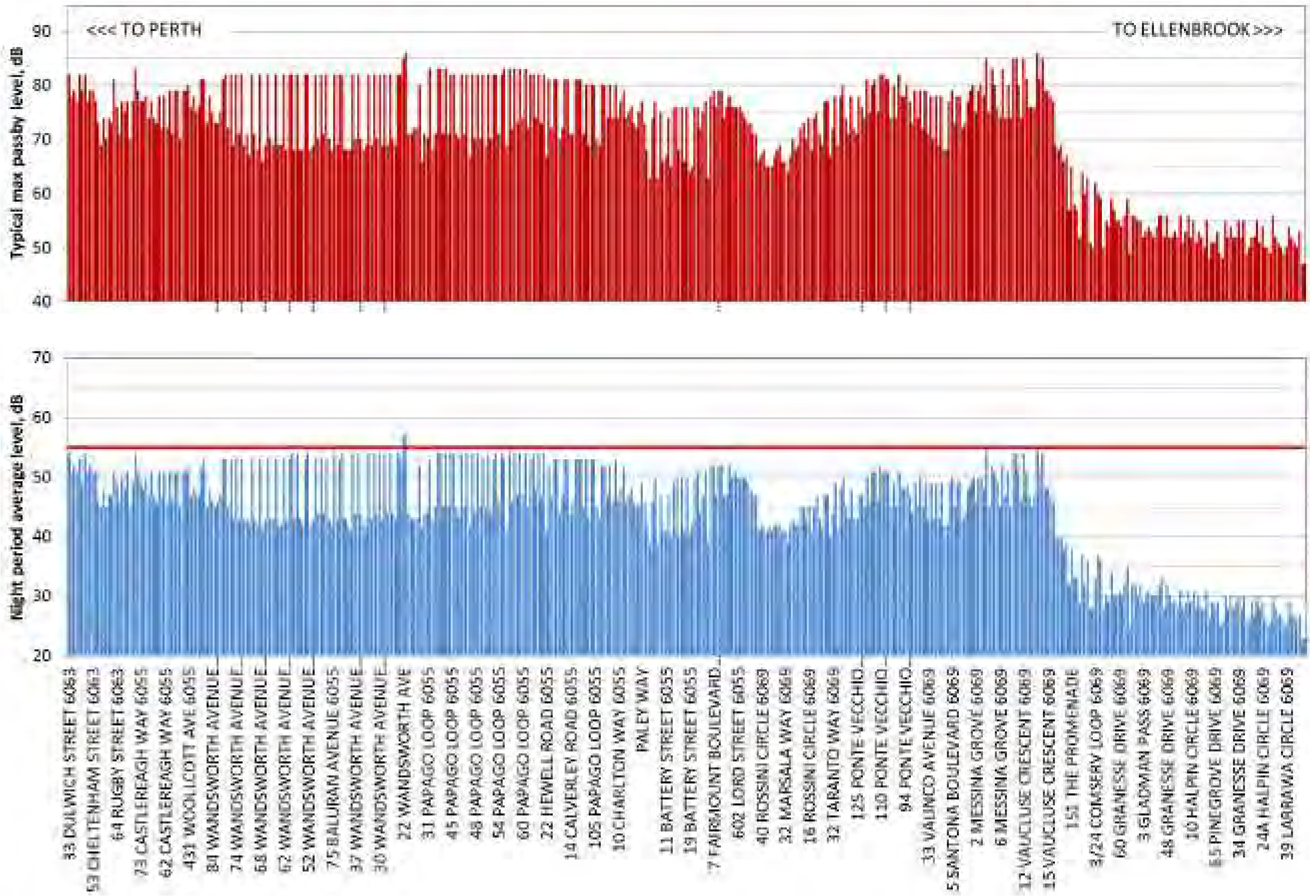
5.2.2 Build+M scenario

Table 10 indicates that with mitigation as described in **Section 5.1.4**, two residences (0.4% of all those assessed) are modelled to be above the design level, with the most affected modelled as 2 dB above the design level in **Section 3.1**.

Figure 4 presents the modelled distribution in day period ($L_{Aeq,day}$) and maximum (L_{Amax}) levels.

In **Figure 4** it can be seen that night period noise levels with mitigation are forecast to be above the design level at a development near 22 Wandsworth Avenue. These results were estimated for elevated upper levels where proposed noise walls are relatively ineffective – the use of source controls such as rail web dampers would be more effective here and should be considered as part of detailed design.

Figure 4 Distribution in residential $L_{Aeq,day}$ and L_{Amax} per address (ordered by chainage), Build+M scenario. Airborne Noise Design Level is indicated by red horizontal line.



5.3 Recommended airborne noise controls

Given the site context, airborne noise controls are considered at this design stage to be limited to the following:

- **Noise walls**: To achieve effective noise reductions, noise barriers may be located either within the rail reserve, on defined property boundaries, or in place of existing walls (as a potential upgrade). Generally, wall(s) located closer to the noise source (or receiver) are more effective.

  Table 10 shows that the wall extent 'Revision A' (nominated in **Section 5.1.4**) is effective at reducing noise for all residential receivers to within 1 dB of the objectives listed in **Section 3.1**: the number of residences forecast to be above the Airborne Noise Design Level is reduced from 16 to 2. Further noise reduction can be achieved with the use of sound absorptive linings, rail web dampers or closer fitting noise walls.

- **Sound absorptive panels:** Within the Ellenbrook area there are several locations where noise received at sensitive premises is due to reflected noise paths from within dive structures and not just via the most direct pathways. Here the solution would be to use sound absorptive panels to control these reflections within the dive structure.

- **Rail web dampers**: Field trials commissioned by the PTA in 2017 indicate a noise reduction potential of between 4 and 5 dB using rail web dampers[19].

[19] SLR Consulting 2017, *Rail web damper trials – noise and vibration assessment*, SLR Report 675.11094. Ballasted track with RP65221 pads.

Experience with previous projects involving 2 parallel railway lines indicates that the likely costs of rail web dampers are likely to be less than noise walls on one or both railway reserve boundaries, once all construction and operational factors are managed such as structural wind loading, fence removal, construction site mobilization, vandalism, lighting, accessibility around crossings and visual impacts.

The installation of rail dampers carries risks of increased maintenance costs in removing dampers for major trackwork activities (such as rail replacement). However, installation also carries benefits in terms of reduced rates of rail roughness and corrugation growth, which in turn is expected to lead to fewer major trackwork events and therefore reduced maintenance costs.

From the results presented, either control (or a combination thereof) would suffice in terms of meeting the objectives listed in **Section 3.1**, with optimization of extents subject to detailed design.

The detailed design of these treatments will need to suitably interface with controls associated with other projects under construction.

6 Assessment of GBN and GBV from rail operations

6.1 Basis

6.1.1 Methodology

The GBV and GBN modelling for this project was conducted using an SLR-developed modelling process which is essentially an ISO 14837 Environmental Assessment Model as detailed in **Appendix B.2.** The relevant algorithms incorporated into this model are well documented in authoritative references and are widely used within the acoustical consulting profession, both in Australia and internationally.

The assessment was undertaken using the following assumptions:

- The effects of noise walls or retaining structures, as well as ground condition changes associated with road construction development are conservatively not considered in the model.
- Study area considers all representative receivers within 100 metres from the centreline of each railway, in 5 metre segments, based on historical field data demonstrating compliance typically within 50 metres.
- Reasonable similarity in ground propagation effects between the locations used for baseline measurements and those near receiver positions.
- The analysis is based on vibration measured in the vertical direction only with adjustments for transverse / longitudinal vibration components (which are considered to be of minimal consequence at extended distances as captured in the design uncertainty).
- Buildings within 15 metres of any railway centreline will be demolished or not assessable.
- Building amplification effects as per **Appendix B.2.3**. In practice building response effects will vary (this variance is captured in the modelled design uncertainty).
- The mitigation option in the form of resilient ballast matting is assumed to achieve overall 10 dB reduction in the vibration source emissions from rail operations.

6.1.2 Modelled extent of mitigation

The following table describes minimum recommended extent of vibration mitigation in the form of resilient ballast matting, in order to achieve relevant GBN and GBV compliance. Larger extents should be considered as a way to 'future-proof' against development infill near the railway.

Table 11 Vibration mitigation (i.e. resilient under ballast matting) extent, Part 2

Rail development section – Part 1	Reference (Note[1])	Approximate chainages, km	Total length, km
New development section	UBM6	17.00 – 17.40	0.40
	UBM7	17.90 – 18.30	0.40
	UBM8	19.80 – 22.85	3.05
	UBM9	24.24 – 25.70	1.46

Note 1 Refers to both UP and DN lines

The following subsections present the basis of the above assessment recommendation results.

6.2 Results

GBN and GBV result summaries are presented in **Table 12**, based on the assessment of 270 premises against the 'V3' design criteria listed in **Table 6** (**Section 3.2**).

Table 12 Forecast GBV and GBN modelled results – 'Build', 'Build+M' scenarios

Usage	Aspect	Objective (Section 3.2)	'Build' scenario (prior to mitigation)	'Build+M' scenario (with mitigation)	Expected outcome, comments
Residential	Groundborne vibration (GBV)	$L_{v,RMS,1s}$ 106 dB	33 up to 9 dB above objective	All within objective	OK
	Groundborne noise (GBN)	L_{Amax} 35 dB	53 up to 13 dB above objective	11 up to 3 dB above objective	Performance limited by existing rail infrastructure outside scope of MEL. Review as detail develops
Non-residential (Commercial/ Industrial)	Groundborne vibration (GBV)	$L_{v,RMS,1s}$ 112 to 118 dB	All within objective	All within objective	
	Groundborne noise (GBN)	L_{Amax} 45 to 50 dB	All within objective	All within objective	

Refer to **Appendix C.2** for individual results.

From these tables it can be seen that as a result of the proposal:

- Without mitigation, 53 residences are predicted to exceed relevant investigation trigger levels by up to 13 dB, and they are distributed near the following chainage sections:
  - 17.10 km – 17.40 km (Dulwich Street),
  - 17.98 km – 18.2 km (Rugby Street),
  - ~20 km to 22.85 km (Brabham area), and
  - 24.8 km – 25.10 km (Ponte Vecchio Boulevard, Valinco Avenue).
- With mitigation measures in place ('Build+M' scenario),
  - the number of properties above GBN investigation trigger levels reduces from 53 to 11 and the maximum difference reduces from 13 to 3 dB.
  - All residences are modelled to have GBV levels below relevant investigation trigger levels.

Note that these estimates include emissions from other activities or transport infrastructure outside the scope of MEL which limit the project's ability to achieve any specific limits.

Appendix D.2 presents figures indicating modelled GBN and GBV levels versus chainage for selected assessment scenarios under both untreated ('Build') and treated ('Build+M') cases.

Appendix E presents GBN and GBV colour maps of selected scenarios.

6.3 Recommended GBN and GBV controls

Although the model does allow for some variance in source emission levels and ground conditions, specific ground and rail conditions can vary significantly over the alignment beyond that modelled. Also, the performance assumption of a 10 dB reduction from the proposed resilient ballast matting is considered preliminary at this reference design stage and dependent on correct specification and implementation.

Therefore, detailed studies of all major influencing factors, including range of geotechnical and rail conditions along the alignment, as well as the performance specifications of mitigation measure options, are recommended during detailed design stages.

It is important to note that once the rail alignment and trackform is fixed, options to reduce vibration emissions are limited to rail support stiffness, 'above rail' assets (rolling stock) and operational measures. Therefore, the objectives as outlined in **Section 3.2** are used to consider mitigation options and potentially further study to understand and manage the risk of potential environmental impact.

Specifically, should these objectives be exceeded, the next steps in relation to mitigation consideration during detailed design stage will be to:

- Determine the location(s) and level(s) of any exceedances;
- Rank reasonable and practicable noise and vibration mitigation measures in order of overall effectiveness. Key opportunities to reduce vibration emissions from the railway (and therefore both GBV and GBN impacts) are considered to be:
    - Resilient under ballast matting (UBM), which locates between the ballast and below ground support. This system requires careful specification of performance in order to perform optimally.
    - Under-sleeper pads (USPs), which are cast into the base of each sleeper and installed with the sleeper as one unit. This treatment requires careful specification as in some circumstances it can lead to increased generation of low-frequency noise from the sleepers.
    - High attenuation rail support pads/trackforms, which depending on specification can lead to increased rolling noise emissions and affect compliance with airborne noise objectives.
- Identify achievable vibration levels for the project taking into account reasonable mitigation measures.
- Consult with the design team to discuss where and why the trigger levels cannot reasonably be achieved, and options for improvement.

7 Summary

7.1 Key findings

A desktop assessment of existing and future railway noise and vibration levels for Part 2 (Malaga Station to Ellenbrook) of the Morley-Ellenbrook Line has been undertaken. The findings of this assessment are:

- In regards to airborne noise levels,
    - As a result of the project, 200 residences are modelled to be above levels which require *consideration* of mitigation, depending on the metric used (period average or maximum passby).
    - Without mitigation, 16 residences are above the Airborne Noise Design Level (**Section 3.1**), there mitigation must be *provided*.
    - With 'Revision A' mitigation as proposed in **Section 5.1.4**, two residences (0.4% of all those assessed) are forecast to be above the design level by up to 2 dB. Given the accuracy of the model and conservative assumptions made, it is not proposed to review the mitigation extents until the detail in the design further progresses.
- In regards to the ground borne noise (GBN) and ground borne vibration (GBV) objectives in **Section 3.2** and the 270 properties assessed,
    - 33 residential properties are forecast to have GBV levels up to 9 dB above the relevant investigation trigger level prior to any specific mitigation;
    - 53 residential properties are forecast to have GBN levels up to 13 dB above the relevant investigation trigger level prior to any specific mitigation;
    - A 10 dB reduction in GBN and GBV levels may be achieved through the use of suitable under ballast matting (UBM) as per **Section 6.1.2** at the majority of properties if correctly specified and installed.
    - Additional extents of mitigation are suggested near currently vacant lots that could be developed as residential or other vibration sensitive usages, to 'future-proof' against development infill close to the railway.
- There is risk that trains entering passing loops or crossovers may navigate relatively sharp curvature which under certain conditions can generate additional curving noise (wheel squeal or flanging noise). Such noise if presented would be a key source of annoyance but would not exceed current statutory environmental objectives at nearby dwellings. Care must be taken to maximise the curvature of track where practicable and consider the use of superelevation to assist with steering. Typical local controls in practice if there are issues during service involve wayside friction modifier systems and close fitting noise walls.

7.2 Recommendations

1. In lieu of detailed design, budget for:
    - Review / optimisation of mitigation and control measures during detailed design in accordance with this report;
    - Either low height (and close fitting) or boundary noise walls on both passenger main lines as indicated in **Table 9**;
    - Minimum vibration mitigation extent as provided in **Table 11**; and

- Detailed review of vibration controls based on local geotechnical information and existing site survey(s), which also considers increased extents beyond **Table 11** to future proof against long term development infill.

2. Ensure the rail engineering of the passing loops minimises the risk of curving noise through design, such as avoiding short radii curves and situations where there may be regular wheel flange contact with the rails.
3. Share outcomes with planning, local government authorities to assist in future land use planning near the project area.
4. Develop a project noise and vibration management plan to advise relevant local government authorities (i.e. City of Swan) of the agreed approach for railway sections within their jurisdiction.
5. Consider passenger cabin in-car noise during travel within dive tunnel sections at speed: this may not be a significant design factor if relatively short in duration.
6. Undertake consultation with community stakeholders where there may be a history of complaints or specific concerns over noise and/or vibration impact.

APPENDIX A

A Glossary of terms

The following subsections discuss the applicability of various transport policies and standards in regards to noise and vibration, and several local projects of relevance.

A.1 Terms used

The following table lists key nomenclature used in this report

Table A.13 Terms used

Parameter	Comment
a, a_w	(Vibration) acceleration, the subscript 'w' refers to weighting / frequency correction used. Units are m/s^2.
dB	Decibel, a unit of sound or vibration which is described as a ratio of the result to a fixed reference value. All sound pressure levels (LpA, LA, LAeq etc.) quoted in this report are referenced to 20 micro Pascals (dB re 20µPa).
	Vibration velocity levels (L_v) quoted in this report are referenced to 1 nanometre per second (dB re 10-9 m/s), noting that some US criteria use dB re 10^{-6} in/s.
Guidelines	Implementation Guidelines for State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning
L_{Amax}	The maximum A-weighted noise level associated with a sampling period.
$L_{Amax,95\%}$	The "typical maximum noise level" for a train pass-by event. For operational rail noise, LAmax refers to the maximum noise level not exceeded for 95% of rail pass-by events measured using the 'slow' (sometimes denoted by subscript 'S') response setting on a sound level meter.
L_{A1}	The A-weighted noise level exceeded for 1% of a given measurement period. This parameter is often used to represent the typical maximum noise level in a given period.
L_{A10}	The A-weighted noise level exceeded for 10% of a given measurement period and is utilised normally to characterise average maximum noise levels.
L_{Aeq}	The A-weighted average noise level. It is defined as the steady noise level that contains the same amount of acoustical energy as a given time-varying noise over the same measurement period.
L_{A90}	The A-weighted noise level exceeded for 90% of a given measurement period and is representative of the average minimum background noise level (in the absence of the source under consideration), or simply the "background" level.
L_v	Unweighted vibration velocity level, see dB.
$L_{v,RMS,1s}$	Maximum unweighted RMS vibration velocity level over a 1 second period.
L_w, L_{wA}	'Sound power' (L_w) refers to the total rate of sound generation of a given item of plant. This quantity is independent of the distance from the plant item (analogous to the wattage power of a light-bulb) and allows direct comparison of the relative acoustic 'size' of different plant items. From this data, the sound pressure level (or noise level) at any offset distance from the plant can be calculated (analogous to the light intensity from a light-bulb – the greater the distance, the less intense).
Policy	State Planning Policy 5.4 – Road and Rail Transport Noise and Freight Considerations in Land Use Planning
RMS	Root Mean Square, a parameter used to estimate the average energy level of a continuous signal.

The following table describes key terms used in this report.

A.2 Noise

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 following table presents examples of typical noise levels.

Table A.14 Guide to sound pressure level ranges for selected environments (dB re 20µPa)

Subjective Evaluation	L_{Aeq}	Comments / Examples
Intolerable. Onset of pain. Exceeds daily exposure limit in under a second.	140	Military jet engine at 30 metres
	130	2kW disaster warning siren at 1 metre
Very loud. Risk of exceeding daily noise exposure limit in under a minute.	120	Jet aircraft take-off at runway edge
	110	Rock concert; freight train main horn at 25 metres
Loud. Onset of risk to exceeding daily recommended noise exposure limit.	100	225mm angle grinder at 1 metre, car horn at 3 metres
	90	Heavy industrial factory interior
Noisy	80	Shouting at 1 metre, kerb side of busy street
	70	Freeway at 20 metres
Moderate	60	Normal conversation at 1 metre, department stores
	50	General office areas
Quiet	40	Office air conditioning background level
Very quiet	30	Bedroom in quiet suburban area
Almost silent	20	Whisper, rural bedroom at night
	10	Human breathing at 3 metres
	0	Threshold of typical hearing

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 symbol ‘A’ represents A-weighted sound pressure level (SPL): the weighting is designed to better represent the hearing ability of the average listener at each frequency.

The ability to discern a change in noise level varies between individual listeners, however it is reasonable to suggest that a change of up to 3 dB in the level of a sound is difficult for most people to detect, and a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB change corresponds to an approximate doubling or halving in loudness and is readily noticeable.

L_{Aeq} values represent an energy average of sound over time and are basic indicators of loudness. However there other ways to statistically represent sound and common noise level descriptors that may be used are illustrated in the following figure and are described below.

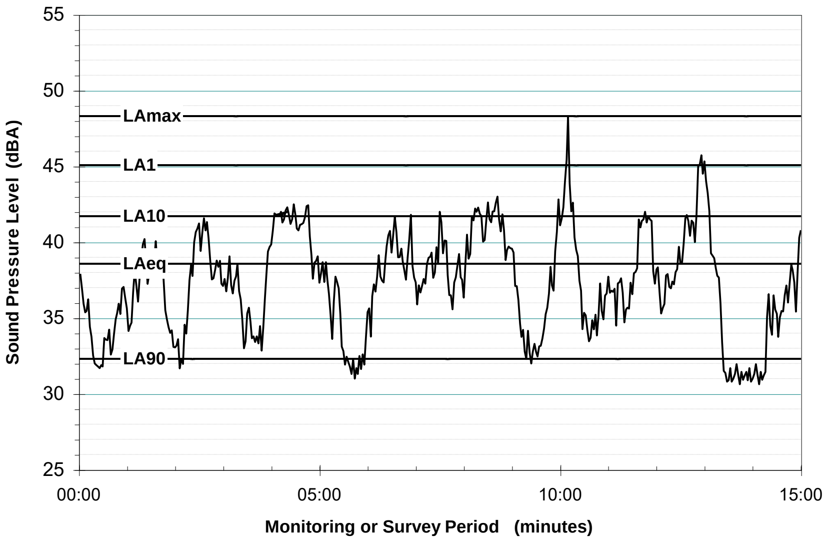


Figure A.5 Example of typical noise indices (1 second logging)

For example, the L_{Amax} parameter is used to describe the highest noise level over a relatively short period (typically 1 second), and the L_{A90} (90th percentile A-weighted result) indicates ambient or background noise levels.

A.3 Ground-borne ('regenerated') noise and vibration

Vibration is the term used to describe the oscillating or transient motions in physical bodies. This motion can be described in terms of vibration displacement, vibration velocity or vibration acceleration. Most ground borne vibration (GBV) assessments are of human response / comfort first, as the risk of cosmetic and structural damage to buildings occurs at vibration levels that are orders of magnitude higher.

Vibration and sound are intimately related. Vibrating objects can generate (radiate) sound and, conversely, sound waves (particularly at lower frequencies) can also cause objects to vibrate. Noise that propagates through a structure as vibration and is radiated by vibrating wall, ceiling and floor surfaces is termed "ground-borne noise" (GBN), "regenerated noise", or sometimes "structure-borne noise".

The primary noise metrics used to describe railway induced GBN emissions in the modelling and assessments are:

- L_{vSmax}: The "typical maximum vibration level" for a train passby event, being the highest 1 second maximum root-mean square (RMS) value in dB re 1 nm/s. For operational rail GBV, this similarly refers to the 5th highest percentile of L_{vSmax} results.
- L_{Asmax}: The "typical maximum noise level" for a train passby event, in dB re 20 µPa. For operational rail GBN, L_{ASmax} refers to the maximum noise level not exceeded for 95% of rail passby events measured using the sound level meter 'slow' (1 second) response setting. Statistically this is the 5th highest percentile of L_{ASmax} results. The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (i.e. A-weighted).

  On the basis of guidance in International Standard ISO 14837-1 2005 Mechanical vibration - Ground-borne noise and vibration arising from rail systems – Part 1: General guidance, ground-borne noise levels are evaluated over the 20 Hz to 315 Hz frequency range.

The following figure gives examples of typical vibration levels associated with surface and underground railway projects together with the approximate sensitivities of buildings, people and precision equipment. The vibration levels are expressed in terms of the vibration velocity (in mm/s and in decibels).

Table A.15 Guide to one-second maximum RMS floor vibration level ranges for selected environments

Typical response	mm/s	dB re 1nm/s	Comments / typical events
Visible response in building items, structural damage risk	16	144	High impact events such as blasting or dynamic compaction in close proximity to structures.
	10	140	
	8.0	138	
Cosmetic damage to some buildings possible over extended periods	5.0	134	
	3.0	130	Impact pile driving, 15 metres. Freight trains at 80 km/h, ~10 metres.
Noticeable. Minor cosmetic damage is feasible to buildings that are in fragile condition / an existing state of disrepair	2.0	126	
	1.0	120	Rock breaking at 15 metres. Vibratory roller at 10 metres.
	0.8	118	Typical target for workshops.
	0.4	112	Freight trains at 80 km/h, ~40 metres. **Regenerated noise highly likely** in typical residential buildings.
Barely noticeable	0.3	110	
	0.2	106	Typical residential daytime target for continuous vibration.
Threshold of human perception to vibration	0.15	104	Passenger trains at 80 km/h, ~30 metres.
Not felt	0.10	100	Operating rooms, surgeries.
Impacts to microscopic and precision equipment	0.050	94	Recommended criterion for bench microscopes < 400x magnification
	0.030	90	
	0.025	88	Micro-surgery devices, eye surgery.
	0.012	82	Electron microscopes <30,000x magnification.
	0.010	80	
	0.006	76	Electron microscopes >30,000x magnification.
	0.003	70	Photolithography to 0.25 microns.

Vibration measurements may be carried out in a single axis or as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse. Velocity is commonly described in terms of millimetres per second (mm/s).

APPENDIX B

B Basis of assessment

B.1 Noise

B.1.1 Background

As it is not practicable to measure noise at all locations, a validated noise model is used to predict noise levels throughout the area. Two different computation algorithms are here referred to as:

- **'Kilde'**: The Nordic Rail Traffic Noise Prediction Method (Kilde 130) has been used for rail noise assessments. This method has been refined since its introduction in 1984 and is commonly utilised for rail noise assessments within Western Australia. It calculates emission noise level based on the scheduled train operational parameters including speed, length and number of train movements, and it can predict both equivalent (L_{Aeq}) and the maximum noise levels (L_{Amax}) as required.

  The benefits of retaining Kilde 130 over more recent numerical code versions (such as Nord2000 Rail) are consistency with existing model and field data, and relatively short propagation distances over which such weather corrected models are not necessarily more accurate.

- **'N2k'**: The Nord2000 Rail prediction method is an update to the Kilde formulation based on advancements in the late 1990s. The main benefit comes from the fact that the N2k methodology calculates in terms of one-third octave bands, rather than a single number to represent all frequencies. This is critical in regards to the design of noise walls, because their effectiveness is strongly frequency dependent – the difference in noise reduction at higher frequencies is vastly different compared to low frequencies. These differences again vary with each road type, traffic mix and speed.

  Another key difference is that Nord 2000 methodology can also account for environmental factors such as ground roughness (absorption) and weather conditions much more accurately.

For this project and given limitations in as-built environmental data, the Kilde model was utilised for screening assessment purposes.

B.1.2 Source factors

Source noise levels

For both existing and build modelling scenarios, the reference noise emissions adopted for Type A and Type B passenger trains on ballasted track are presented in the following table.

Table B.16 Reference railway noise emissions, ballasted track, 15 m distance

Rolling stock	Reference Conditions		Reference Noise Emissions		Source
	Length, m	Speed, km/h	L_{50} L_{AE}, dB	L_5 L_{Amax}, dB	
Series A trains (4 cars)	86	80	89	89	Historical measurements Refer Appendix A for adjustments due to local track factors
Series B trains (6 cars)	146	80	89	88	
		30 (stowage areas)	78	75	

The reference noise emission values are based on historical noise measurements of train passbys undertaken by SLR Consulting at a number of locations in the Perth metropolitan area. These measurements have been analysed to establish the above reference noise emissions for typical rolling noise under the ballasted trackform.

There are many factors influencing rolling noise levels in practice irrespective of the rolling stock, including:

- **Rail roughness and track condition.** Local noise emissions are particularly sensitive to rail roughness conditions and driver behaviour (e.g. abrupt acceleration/deceleration while exiting/approaching rail curve sections / stations). Track roughness conditions are here assumed to be similar to that during historical measurements.
- **Speed.** The Kilde130 formulation is used to estimate the variation in noise emissions with speed according to the profiles indicated in **Section 4.2**.
- **Trackform and supports**. Trackform and support structure has been modelled throughout as either ballasted or slab track. Where direct fix slab track is introduced over ballasted track, noise levels increase as a result of generally softer rail supports (which tends to increase noise emitted by the rails) and less sound absorption (ballast provides sound absorptive benefits).
- **Local features** such as turnouts can introduce discontinuities or sudden changes which increase noise emissions. Adjustments for turnouts will be applied as per **Appendix A**.
- **Local curving noise gain**. There is potential for flange/wheel squeal noise in areas of short radius turns and turnouts assuming similar wheel and track conditions to existing infrastructure. Such noise if presented could be a key source of annoyance (e.g. exceeding set L_{Amax} trigger levels).

Track condition

Table B.17 describes the track conditions as modelled. In lieu of site specific information these are considered representative of existing and future track within the study area. Noise levels from any slab track sections are likely to be higher than typical ballasted track, due to softer rail supports and no ballast to provide sound absorption.

It has been assumed that the rail tracks are in good condition and the running surface of the rail head is free of audible defects, and tracks being constructed with welded rail joints which does not cause any increase in train passby noise level.

Table B.17 Track conditions

Parameter	Ballasted track	Slab track direct fix
Location(s)	All	None (subject to design development
Track structure	Ballasted on grade track, typ. 200-250 mm depth. Concrete monobloc sleepers, 700 mm centres.	Direct slab fix, 700 mm centres
Rail fastener system	AS50kg on Pandrol RP65221 installed thickness 8mm, natural rubber	AS50kg on Delkor ‘ALT.1’ (c_{dyn} ~20 MN/m)
Rail surface condition	ISO3095. The assessment relies on the track to be continuously welded and ground smooth to the same specification as existing (or better), and maintained to be free of defects.	

Turnouts

Turnouts/switch points have been modelled as swing nose type with a 6 dB increase in noise emissions over a 10 m distance.

Turnouts are modelled at the locations indicated in **Table B.18**.

Table B.18 Track turnout locations and modelled type

Scenarios	General location	Reference	Track and chainage(s), km	Type
Build, Build+M	Northeast of Ellenbrook Station (partially covered by road bridge)	UP main passing loop entry	MEL UP 26.44	Swing nose frog (SNX)
		UP main passing loop exit	MEL UP 26.50	Swing nose frog (SNX)
		DN main passing loop entry	MEL DN 26.44	Swing nose frog (SNX)
		DN main passing loop exit	MEL DN 26.50	Swing nose frog (SNX)

Risk of Wheel Squeal / Flanging Noise

No correction has been applied for curved track (i.e. less than 600 m radius but more than 300 m radius). It is noted that trains entering passing loops may navigate relatively sharp curvature which under certain conditions can generate additional curving noise (wheel squeal or flanging noise). Such noise if presented would be a key source of annoyance but would not exceed the **Section 3.1** objectives at nearby dwellings. Care must be taken to maximise the curvature of track where practicable and consider the use of superelevation to assist with steering. Typical local controls in practice if there are issues during service involve wayside friction modifier systems and close fitting noise walls.

Risk of Additional Structural Noise

The proposed viaduct structures in **Table B.20** are understood to use concrete spans with slab track form above. Generally, radiated noise from the viaduct structure in this instance is considered to be less significant in terms of overall objectives, and no specific adjustments are proposed. This should be reviewed further if there are attached lightweight panels or joints which could re-radiate noise.

B.1.3 Propagation factors

Outside the rail reserve, the environmental factors relevant to noise propagation of moving sources were modelled as follows:

- Topography dataset of existing conditions for the assessment area was sourced from Landgate, and the 3D rail alignment was provided by the PTA.
- Given the relatively short propagation distances, weather conditions for each time period were considered neutral as 20°C, with no wind or temperature gradient effects.
- Conservatively, for the entire project area 50% of the ground between source and receiver is assumed to be hard reflective, with the exception of significant road and sealed concrete surfaces which are modelled as 90% hard reflective.

B.1.4 Receiver adjustments

Receivers (noise affected premises considered in this assessment) were modelled as follows:

- The noise receivers were identified using aerial imagery surveys dated October 2018 as provided by Landgate and free online map resources.
- Point receivers were placed at one metre from the most exposed habitable façade of the nearest residential buildings and 1.5 m above ground level (and higher for multi-storey developments). The effects of nearby building reflections were directly calculated instead of the default façade correction (+2.5dB).
- The forecasts are made in terms of L_{Amax}, $L_{Aeq,Day}$ and $L_{Aeq,Night}$ for comparison with set objectives.

B.1.5 Uncertainty of prediction

Uncertainty (U_{95}) is the measure of dispersion or variance that may be expected with a claimed performance value. The subscript '95' means a 95% confidence interval. It represents the estimated range in which the true value lies for 95 out of 100 repeated events which is considered to be an internationally established level of risk appetite. The accuracy of the noise prediction methodology is subject to variation as follows:

Inclusions

- On site measurement system during initial noise testing. The uncertainty of measurement is here estimated for the calibration acceleration signal used in accordance with the referenced standard.
- Effect of variation in train speed against that estimated.
- Variation in rail roughness within each track section assessed from that measured.
- Variation in condition of train rolling stock (wheels, suspension etc.).
- Potential error in speed corrections as applied to field results.
- Variation in the additional noise associated with turnouts or track features, based on FTA estimates.
- Time domain effects in calculating L_{AE} results, as speeds along the alignment will vary.
- Variation in train-car length with respect to variability L_{AE} values.
- Ground absorption rate and interaction effects. Variation due to differences in ground surface type and level from that modelled.
- Effects associated with barriers as interpreted within model.
- Variation of position within receiver location.
- Resolution of measurement results reported to overall dB values.
- On site measurement system during final testing, estimated as per previous item (initial testing since the methods are considered equivalent.

The expected level of system measurement uncertainty as estimated according to the ISO Guide to Measurement Uncertainty is outlined in the following table.

Table B.19 Estimated measurement uncertainty by system

Parameter	System	U_{95} (Note [1])	Student's t-factor
L_{Aeq}, L_{Amax}	Kilde130	4 dB	2.00

Note 1 The U_{95} is the expanded uncertainty of measurement for a 95% confidence interval. It represents the estimated range in which the true value lies for 95 out of 100 repeated events.

All sound pressure levels quoted in this report are referenced to 20 micro Pascals (dB re 20µPa).

A U_{95} of 4 dB indicates that the true value is expected to be within 4 dB of the estimates provided for 95% of all observations.

Excluded / Other Sources of Error

The following items have been considered in the study but are not included in the above estimate of uncertainty because their influences were not able to be reasonably estimated:

- Local track features or discontinuities in the rail which could create short term changes in noise level, such as turn outs, short radius turns or insulated rail joints.
- Effectiveness of specific acoustic treatments, such as sound absorptive panels or rail dampers.
- Variation in rolling stock or rail infrastructure condition over time – e.g. from reduced maintenance undertaken.
- Departure in speed from the profile used in the model.

B.2 Vibration

B.2.1 Background

The prediction of ground-borne noise and vibration from rail systems is a complex and developing technical field. Whilst much research has been undertaken into various aspects associated with GBN and vibration from underground rail systems, there is currently no universally accepted modelling approach, and several different modelling approaches are currently in use (including empirical methods, finite element methods, boundary element methods and combinations of these).

International Standard ISO 14837-1 2005 "*Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General guidance*" provides useful guidance in relation to the extent of assessment that is typically required for new rail systems including:

- **Scoping Model** at the very earliest stages
- **Environmental Assessment Model** during planning process and preliminary design
- **Detailed Design Model** to finalise extent and form of mitigation for construction

Whilst a number of possible calculation methods are available, each method needs to take into account the key parameters identified in the ISO standard. For this assessment, an Environmental Assessment Model has been adopted noting that local site measurements have not yet been undertaken, although historical data has been used from similar trackform and ground conditions.

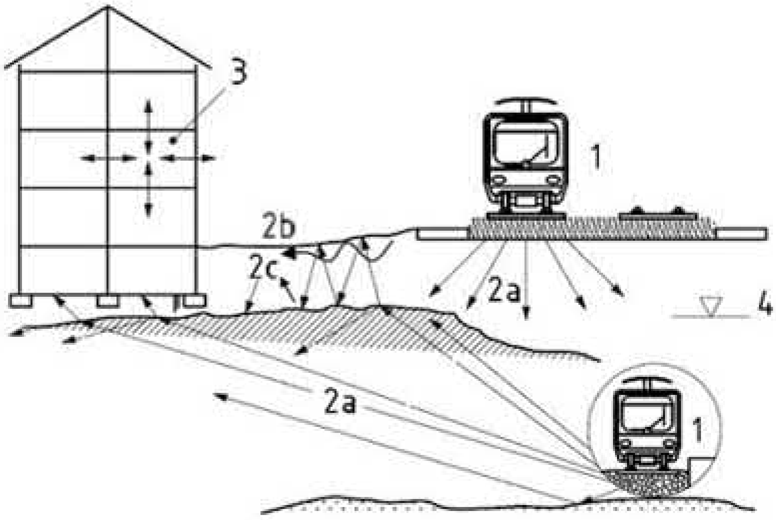
In accordance with the ISO standard, the GBN and vibration modelling considers all of the parameters that are critical in determining the absolute levels of GBN and vibration and the benefits (or otherwise) of different design and mitigation options.

The modelling for this project was conducted using an SLR-developed modelling process for the core calculations. The algorithms incorporated into the in-house model are well documented in authoritative references and are widely used within the acoustical consulting profession, both in Australia and internationally.

An overview of the modelling approach is illustrated in the below figure and takes into account source vibration levels, the vibration propagation between the tunnel and nearby building foundations, and the propagation of vibration within the building elements.

A summary of the key modelling assumptions are provided in the following sections:

- **Source** - route alignment, rolling stock design, rail type, trackform design, tunnel design, construction tolerances, operations and maintenance
- **Propagation Path** - ground type and vibration propagation wave types
- **Receiver** - Building construction



Key

1 source

2 propagation:
- 2 a body waves (compression, shear)
- 2 b surface waves (e.g. Rayleigh, Love)
- 2 c interface waves (e.g. Stoneley)

3 receiver (vibration, re-radiated noise)

4 water table

NOTE The components of the system comprising source, propagation and receiver are interdependent.

Figure B.6 Example of Rail Vibration Source, Propagation and Receiver System (ISO 14837)

For this project, the potential GBN and vibration impacts would be limited to receivers located within an approximate 100 m wide corridor above the centreline of the proposed rail alignments. At each chainage, forecast levels at properties beyond this distance are expected to result in compliance.

In the modelling process, the various vibration contributions from different wave types are not sufficiently defined to allow them to be calculated separately. In comparison, the detailed modelling process via numerical techniques such as finite element analysis and boundary element analysis would require the ground and buildings to be modelled in great detail to represent the propagation path over the required frequency range.

Due to the above, as well as given the extensive land area along the proposed alignment, detailed modelling approach at this stage of the assessment is not feasible. As such, the modelling was carried out using a combination of theoretical and empirical relationships to determine the attenuation and/or amplification of the ground-borne vibration levels.

B.2.2 Source factors

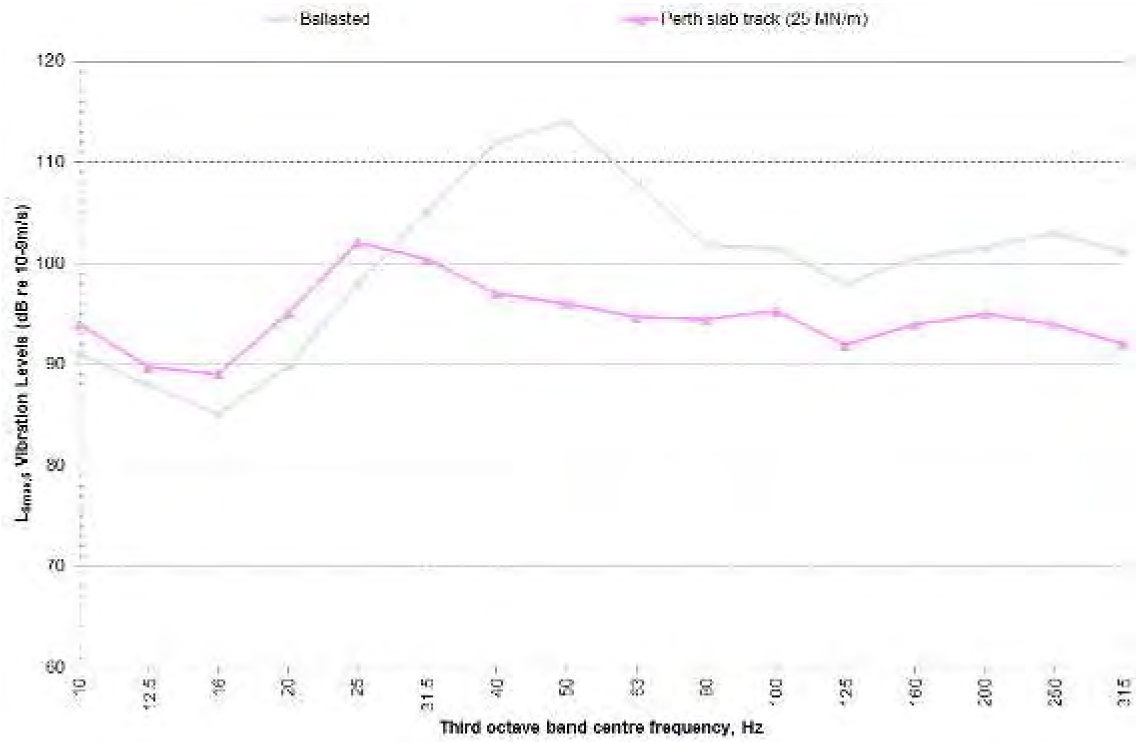
Rail Condition

The track condition is a key factor that influences source vibration levels. Measurements of rail roughness on the Perth network to indicate the track conditions were not undertaken to coincide with any of those historical (pre-EIS) vibration measurements, predominantly due to lack of local capability at the time to undertake these types of measurements.

Trackform

The figure below presents modelled source vibration levels at a set distance and speed.

Figure B.7 Source reference vibration levels modelled at 4 m from railway centreline, 80 km/hr



There are other factors influencing vibration levels in practice irrespective of the rolling stock, including:

- **Rail roughness and track condition.** Track roughness conditions are here assumed to be similar to that during historical measurements.
- **Speed.** Vibration levels are adjusted from the reference case using a '20 log (v/v_{ref})' relationship.
- **Trackform and supports**. A consistent trackform and support structure has been modelled throughout – where softer rail support pads or say track slab sections are introduced, corrections will be applied to estimate the relative change in source level emissions.
- **Local features** such as turnouts can introduce discontinuities or sudden changes which increase vibration emissions. The above source levels do not include adjustments for track that is jointed or presents gaps. The assessment relies on the temporary track to be continuously welded and ground smooth to the same specification as existing or better.

Adjustments for these items have been applied as per **Appendix B.3 below**.

Track Features

An adjustment of +6 dB was applied for track sections within 5 m of turnouts. This is in line with the US FTA "*Transit Noise and Vibration Impact Assessment*" which indicate that vibration levels are typically 6 dB higher for track sections adjacent to swingnose (SNX) turnouts for continuing trains, and is in consistency with SLR's experience on similar projects.

Speed Effects

For the movement of trains, the vibration levels typically increase by 6 dB for doubling of train speed. This relationship has been adopted for this assessment based on being reasonably representative of SLR's experience on other projects where there are relatively small differences in speed.

Speed adjustments from the reference vibration level have been made using the following formula on a 1/3 octave frequency basis:

$$L_{v,adjusted} = L_{v,reference} + 20\log_{10}\left(\frac{v}{v_{reference}}\right)$$

where

- $L_{v,reference}$ is the reference source spectra for 80 km/hr in dB
- *v* is the modelled speed according to the speed profile (refer **Section 4.2**) in km/hr

It is possible that trains could be timetabled to cross in separate directions adjacent to the same receiver location on a regular basis. The maximum increase in GBN and vibration levels could theoretically be up to 3 dB in the worst case situation. However, in most cases, the increase in GBN levels would only be 1 or 2 dB, due to one track having a higher contribution than the other: and this scenario (at less than 5% event occurrence at any receiver) is filtered through the use of an objective which represents 95% of events.

The maintenance of the track and rolling stock can have a significant influence on GBN and vibration levels. The source vibration levels in **Figure B**.7 are based on measurements for track and rollingstock in Perth, with the train tracks and wheel in good operational condition (i.e. no wheel-flats, corrugation etc.).

B.2.3 Propagation factors

In lieu of detailed geotechnical information, the ground is treated as isotropic and homogenous in structure, with constant distance loss rates across the study area.

Ground losses

The propagation of vibration through the ground is a complex phenomenon. Even for a simple source, the received vibration at any point includes the combined effects of several different wave types, plus reflections and other effects caused by changes in ground conditions along the propagation path.

Attenuation with distance occurs due to the geometric spreading of the wave front and due to other losses within the ground material, known as "damping". The attenuation due to geometric spreading occurs equally for all frequencies, whereas the damping component is frequency dependent, with greater loss per metre occurring at high frequencies than at low frequencies.

For geometric spreading, trains were represented by point sources spaced at 5 m intervals, with the distance attenuation from each point calculated according to:

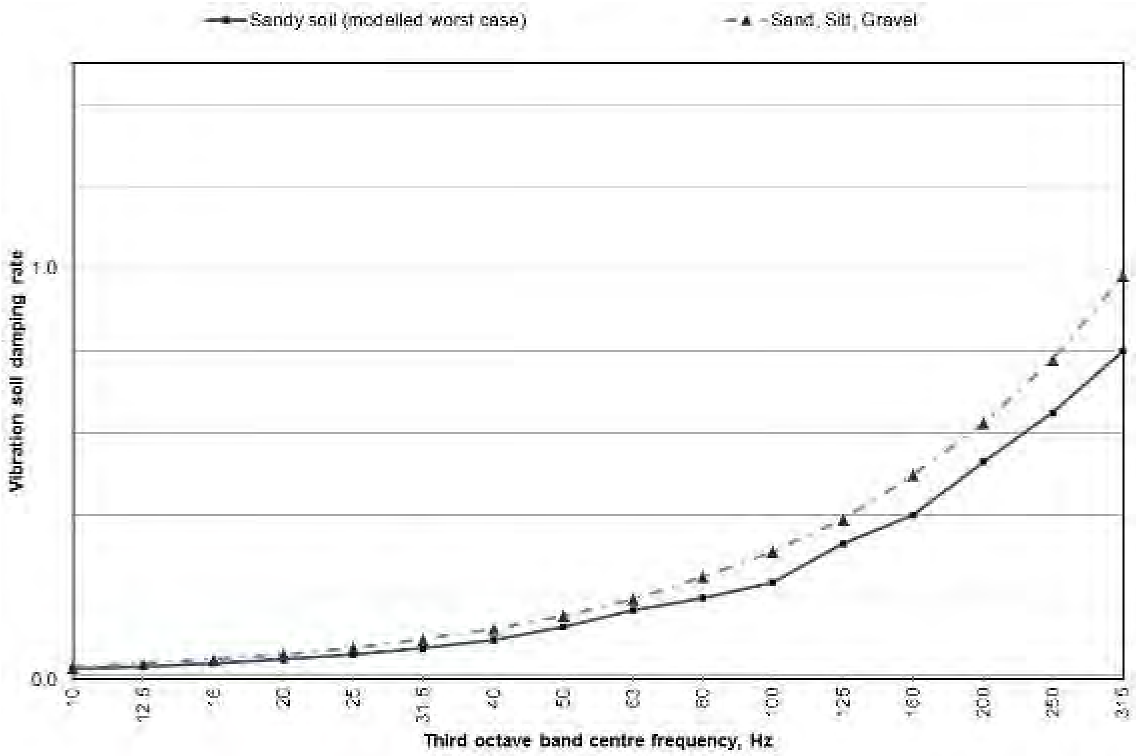
$$V(spreading) = 10\log_{10}\left(\frac{4}{\mathrm{r}}\right)$$

where *V(spreading)* is the change in vibration level (in dB re 1 nm/s), distance r is the slant distance between the point source and the receiver location and 4 m is the reference distance of the source vibration spectrum.

Changes in trackform or train speed, curves and other local characteristics can result in variations in vibration emissions within the zone of influence of a given building. Hence, it is desirable for modelling to represent the train over its full length.

Damping losses are also estimated according to the rates shown in **Figure B.8** based on Nelson (1987)[20].

Figure B.8 Modelled ground damping loss rate, dB per metre



Receivers

Vibration incident on building structures will undergo a coupling loss, usually resulting in lower levels of vibration in the building's footings than in the surrounding ground.

Losses also occur with the transfer of vibration from floor-to-floor within buildings. The model incorporates the losses listed in Nelson (1987) and extrapolated to include frequency bands below 16 Hz.

The GBN and vibration levels attenuate by approximately 2 dB per floor for the first 4 floors and by approximately 1 dB per floor thereafter. The majority of receivers are typically either 1 to 2 storey established residences with some commercial properties near the station.

Low-frequency vibration can be amplified within buildings by resonances in floors and walls. The amplification spectra presented has been adopted based on estimates by Nelson (1987).

The indoor GBN level is calculated from the floor vibration levels using a theoretical adjustment of -27 dB in line with historical guidelines; however, an adjustment of -32 dB is likely to be more appropriate in the experience of the author and subject to further study of local conditions.

[20] P. Nelson, Chapter 16 Low Frequency Noise and Vibration from Trains (Remington, Kurzweil and Towers), in Transportation Noise Reference Book, Butterworths, 1987

B.2.4 Receiver adjustments

Adjustments for vibration entering and propagating within buildings are made according to **Table B.20.**

- **Coupling loss between structure and groundsoil** – this is the change in level as vibration enters a structure.
- **Floor to floor adjustment (per floor above ground)** – this is designed to estimate the reduction in vibration level as it transfers into upper floors.
- **Amplification adjustment** – this factor represents the estimated worst case change (increase) in noise and vibration levels due to building resonance effects. In practice, levels will significantly vary depending on location within the receiving space, e.g. whether the measurement position is near a structural wall or is at the mid-span of a floor.

Table B.20 Vibration receiver adjustments, dB

Aspect	Scenario	Third octave band centre frequency, Hz																		
		5	6.3	8	10	12	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315
Coupling loss between structure and groundsoil	Large Masonry on Piles	-6	-6	-6	-6	-7	-7	-7	-8	-9	-10	-11	-12	-13	-13	-14	-14	-15	-15	-15
	Large Masonry on Spread Footings	-11	-11	-11	-11	-12	-13	-14	-14	-15	-15	-15	-15	-14	-14	-14	-14	-13	-12	-11
	2-4 Storey Masonry on Spread Footings	-5	-6	-6	-7	-9	-11	-11	-12	-13	-13	-13	-13	-13	-12	-12	-11	-10	-9	-8
	1-2 Storey Commercial	-4	-5	-5	-6	-7	-8	-8	-9	-9	-9	-9	-9	-9	-8	-8	-8	-7	-6	-5
	Single Residential	-3	-3	-4	-4	-5	-5	-6	-6	-6	-6	-6	-6	-6	-5	-5	-5	-5	-5	-5
Floor to floor adjustment (per floor above ground)	1st floor	-1	-1	-1	-1	-1.5	-1.5	-1.5	-2	-2	-2	-3	-3	-3	-2	-2	-2	-3	-3	-3
	2nd and above	-1	-1	-1	-1	-1.5	-1.5	-1.5	-2	-2	-2	-2	-2	-2	-3	-3	-3	-3	-3	-3
Amplification adjustment	Floor / wall vibration	+10	+10	+10	+10	+10	+10	+10	+11	+11	+11	+10	+9	+9	-	-	-	-	-	-
	Amplification, ground borne noise	-	-	-	-	-	-	+6	+7	+7	+8	+8	+7	+7	+5	+4	+3	+2	+1	+1

B.2.5 Uncertainty of Prediction

Inclusions

The accuracy of the prediction methodologies as outlined for ground-borne vibration ($L_{v,RMS,1s}$, 8 to 80 Hz) and noise (L_{Amax}, 20 to 315 Hz) is subject to variation in results obtained as follows:

Source Levels

- On site measurement system during initial vibration testing. The uncertainty of measurement is here estimated for the calibration acceleration signal used in accordance with the referenced standard.
- Effect of variation in actual train speed against that estimated during baseline measurements. This is taken to be 5%.
- Variation in rail roughness within each track section assessed, assumed to be controlled to within 2 dB of or less than that determined within Subiaco Tunnel in September 2015.
- Variation in condition of train rolling stock (wheels, suspension etc.). This has been estimated from (speed corrected) results for each Series at the same site (Subiaco for Series A, Anketell Tunnel for Series B), allowing for the other factors listed here.
- Potential error in speed corrections as applied to field results.
- Variation in the additional vibration associated with turnouts or track features, based on FTA estimates.
- Time domain effects in calculating one second averaged results, as speeds along the alignment will vary. For example, at speeds above 29 m/s, some one second averaged results will contain vibration from three wheelsets (say one whole car plus half of the next) instead of one or two.
- Variation in unsprung vehicle mass due to wear or condition.

Transmission Path

- Variation in track fastener performance from that claimed. A 2 dB variance has been allowed for tolerances in production and installation, temperature and non-linear effects.
- Variation in wall structural response at the base of the tunnel wall. Effect of variation in the impedance of the tunnel structure along the alignment from that measured previously.
- Ground attenuation rate. Variation due to changes in media damping, water table and stratification / diffraction effects, estimated from FTA guidelines.
- Model effects associated with 3D discretisation of alignment into 5 m lengths and individual train lengths, for a separation distance of 25 m.
- Error in calculation of effective slant distance from estimates of foundation depth, tunnel structure and scaling effects.

Building Floor Response

- Variation in coupling loss and amplification factors due to building foundation design and variation in floor and wall stiffnesses. Estimated from field measurements of residential buildings and adjacent ground soil in Perth and Nelson[21] guidelines.

[21] P. Nelson, Chapter 16 Low Frequency Noise and Vibration from Trains (Remington, Kurzweil and Towers), in Transportation Noise Reference Book, Butterworths, 1987

Room Response

- Variation of position within the receiving room. This has been estimated on the basis of the difference between the highest and lowest measured level at the same moment within a bedroom of typical dimensions and furnishings, for all measurements more than 1.5 m from a reflecting surface.
- Variation in internal reverberation time. Although regenerated noise within a small space is expected to be controlled by direct field contributions, consideration has been given to the range of influence between different furnishings and surfaces.
- Conversion of room surface vibration into airborne noise based on correlation between Nelson and US FTA[22] guidelines.
- Resolution of measurement results reported to overall dB values.
- On site measurement system during final testing, estimated as per previous item (initial testing since the methods are considered equivalent.

The combined uncertainty is provided in the following table according to the ISO Guide to Uncertainty of Measurement (GUM).

Table B.21 Estimated measurement uncertainty by system

Parameter	System	U_{90} (Note 1)	Student's t-factor
L_{vSmax}	SLR numerical code	5 dB	2.00

Note 1 The U_{95} is the expanded uncertainty of measurement for a 95% confidence interval. It represents the estimated range in which the true value lies for 95 out of 100 repeated events.

All sound pressure levels quoted in this report are referenced to 20 micro Pascals (dB re 20µPa).

A U_{90} of 5 dB indicates that the true value is expected to be no more than 5 dB above the estimate provided for 95% of all observations.

Excluded / Other Sources of Error

The following items are not included in the above estimate of uncertainty:

- Local track features or discontinuities in the rail which could create short term changes in noise level, such as turn outs, short radius turns or open joints.
- Effectiveness of specific acoustic treatments, such as sound absorptive panels or rail dampers.
- Variation in rolling stock or rail infrastructure condition over time – e.g. from reduced maintenance undertaken.
- Departure in speed from the profile used in the model.

[22] Transit Noise and Vibration Impact Assessment, United States Federal Transit Association, 2006

B.3 Design assumptions summary

Table B.22 below outlines general design assumptions for the project.

Table B.22 Design assumptions

Aspect	Parameter	Approach	Rationale, Validation
Generally	Study area extents, Part 1	Bayswater Station to Malaga Station	-
	Study area extents, Part 2	Malaga Station to Ellenbrook Stowage yards	-
	Study area extents, Part 3	Bus loops, road vehicles and stations associated with Sections A and B	-
	Track alignment	As provided to date	Have 3D of the DN, but not UP. Have assumed height of UP rail = DN rail at same chainage.
	Locations of turnouts and track features	No turnouts or local track features within tunnels which could modify source levels	-
	Design margin	0.5 dB	Ignores margin of uncertainty
Operations	Number of train movements and mix, Bayswater to Ellenbrook	Table 7	MEL-MNO-ELUP-RS-RPT-0001.E.IFU
	Traffic volumes	Table 7	-
	Rolling stock	Table 7	-
	Speed profile	Section 4.2	Note: not signal or max speed
Construction	Track type	Tunnels: Delkor ALT.1 or performance equivalent direct slab fix Ballasted track on bridges/viaducts: ballasted, AS60kg on concrete monobloc sleepers @ 700 mm centres, 250-500 mm ballast, RP65221 pads	Similar to existing Perth trackform
	Height of track above local ground level, ballasted track	600 mm from top of rail to ground capping layer (underside of ballast layer)	-
	Height of track above local ground level, slab track and bridges/viaducts	300 mm from top of rail to slab surface	-
	Tunnel cross section	Box cut and cover with dimensions 6.1 m (height) by 9.2 m (width)	Subiaco Tunnel example
	Tunnel linings	Minimum 300 mm steel fibre reinforced 40 MPa concrete	-
	Tunnel coupling loss to groundsoil	0 dB	Conservative
	Bridge and Viaduct construction generally	Steel fibre reinforced 40 MPa concrete, free of any loose panels that may generate additional noise under vibration	-

Aspect	Parameter	Approach	Rationale, Validation
	Bridges and Viaducts, dimensions of noise screening elements on each side	Outboard: Minimum 0.8 metres above top of rail, 2.4 metres from rail centreline Inboard (between lines): no screening elements	A reinforced concrete upstand for derailment containment, this dimension also refers to any additional solid screening on top.
	Bridges and Viaducts, finishes of slab and wall surfaces	Brushed concrete, 95% sound reflective	-
Vehicle dynamics	General details, length, axle loads etc.	As provided to date	-
	Wheel condition	Disc braked (UCI) No influence of wheel flats / defects	Unknown what is actual
Track dynamics	Rail type, main lines	AS50kg	-
	Rail type, turnouts	AS60kg	-
	Vertical dynamic stiffness of slab track, Delkor ALT.1	25 MN/m	-
	Vertical dynamic stiffness of ballast track, RP65221 rail pad	100 MN/m	-
	Rail condition	ISO 3095 continuously welded Welded or insulated rail joints are assumed to not increase local noise / vibration emissions.	In lieu of field data comparing to relevant benchmarks such as ISO 3095. The running surface of the rail head is free of significant defects.
	Variation in stiffness over time	Modelled levels are upper limit actual.	Stiffness values can increase with ageing over time, reducing isolation performance.
Source noise emissions	Reference passby rail noise emissions	Table B.19	-
Source vibration emissions	Base vibration overall level, ballasted track on grade, RP65221 rail pad, 5th percentile (L_5)	Figure B.7	SLR field measurements Federal Transit Administration 2006, Transit Noise and Vibration Impact Assessment, ("FTA Guidelines") Report FTA-VA-90-1003-06.
	Base vibration spectra, track slab in tunnel, represent tunnel invert position, Delkor ALT.1, 5th percentile (L_5)	Figure B.7 (Based on ballasted track on grade less 5 dB)	
	Base vibration spectra, slab track in tunnel, for softer rail pads	Adjusted based on single degree of freedom (SDOF) model, using differences in trackform stiffness and sleeper spacings as relevant.	Note some trackforms with secondary resilient elements require a multi-degree of freedom (MDOF) model
Environmental factors, generally	Ground contours	As provided	-
	Dive structures within rail corridor	Commence where ground terrain is less than 0.6 m below rail centreline, terminate to box tunnel where ground provided is more than 5.5 metres above rail centreline	Estimated in line of design terrain

Aspect	Parameter	Approach	Rationale, Validation
	Ground contour lines / elevation data outside the rail corridor	As provided	Ground terrain outside the rail corridor will not change substantially.
	Spatial conflicted buildings	Removed within 20 metres of railway centrelines	-
Environmental factors, airborne noise	Numerical code	Kilde130	Outdated but conservative and validated against local field measurements.
	Air propagation / diffraction losses for stationary sources	-	-
	Adjustment to source levels for direct fix slab track over ballasted track	+4 dB	FTA guidelines
	Airborne noise correction for swing frog / nose crossing (SNX), per	+6 dB over 15 m	SLR field data
	Airborne noise correction for fixed frog crossing (FFX), per	+10 dB over 15 m	FTA guidelines
	Airborne noise correction for curved track less than 500 m radius but more than 300 m radius	+3 dB	Does not include local curving noise effects such as wheel squeal or flanging
	Airborne noise correction for curved track less than 300 m radius	+4 dB	
Environmental factors, vibration	Vibration correction for curved track less than 500 m radius but more than 300 m radius	+3 dB	-
	Vibration correction for curved track less than 300 m radius	+4 dB	-
	Vibration Correction for swing frog / nose crossing (SNX), per	+6 dB over 15 m	-
	Vibration Correction for fixed frog crossing (FFX), per	+10 dB over 15 m	-
	Ground soil types and layering	Isotropic, homogeneous	Considered homogenous layering
	Propagation model	'1.5D' using 3D distance between nearest building foundation and 5 metre rail segments	Industry standard approach
	Ground vibration propagation losses	Excess attenuation based on 3D distance and Figure B.8	Isotropic, homogenous media. No effects of stratification / layering / water table etc. (requires advanced '2.5D' or higher model)
	Adjustments for coupling losses into buildings	Table B.20	FTA industry guidelines
	Vibration losses between floors	Table B.20	
	Floor amplification values	Table B.20	

APPENDIX C

C Results tables

C.1 Noise

The following table lists forecasted individual property results in terms of airborne noise (ABN) for the Build+M scenario prior to mitigation. $L_{Aeq,night}$ values are omitted for brevity, as $L_{Aeq,day}$ results are forecast to control the level of compliance due to relative traffic volumes in each period. Refer to **Appendix D** for results with mitigation included.

Table C.23 Individual ABN results by location, prior to mitigation

Address	Chainage, km	Distance, m	Floor (Note[1])	Usage	$L_{Aeq,night}$, dB					L_{Amax}, dB					Likely result
33 DULWICH STREET 6063	17.12	95	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
33 DULWICH STREET 6063	17.13	122	GF	Res.	51	51	0	55	-4	78	78	0	80	-2	OK
33 DULWICH STREET 6063	17.26	134	GF	Res.	52	52	0	55	-3	79	79	0	80	-1	OK
32 DULWICH STREET 6063	17.36	140	GF	Res.	51	51	0	55	-4	77	77	0	80	-3	OK
58 DULWICH STREET 6063	17.36	92	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
58 DULWICH STREET 6063	17.37	115	GF	Res.	49	49	0	55	-6	79	79	0	80	-1	OK
58 DULWICH STREET 6063	17.40	90	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
32 DULWICH STREET 6063	17.47	149	GF	Res.	51	51	0	55	-4	77	77	0	80	-3	OK
35 CHELTENHAM STREET 6063	17.50	112	GF	Res.	52	52	0	55	-3	79	79	0	80	-1	OK
53 CHELTENHAM STREET 6063	17.67	104	GF	Res.	51	51	0	55	-4	79	79	0	80	-1	OK
60 CHELTENHAM STREET 6063	17.79	92	GF	Res.	51	51	0	55	-4	77	77	0	80	-3	OK
62 CHELTENHAM STREET 6063	17.88	116	GF	Res.	46	46	0	55	-9	73	73	0	80	-7	OK
53 RUGBY STREET 6063	17.98	98	GF	Res.	45	45	0	55	-10	69	69	0	80	-11	OK
53 RUGBY STREET 6063	18.00	49	GF	Res.	48	48	0	55	-7	74	74	0	80	-6	OK
67 RUGBY STREET 6063	18.02	81	GF	Res.	45	45	0	55	-10	70	70	0	80	-10	OK
67 RUGBY STREET 6063	18.05	59	GF	Res.	47	47	0	55	-8	74	74	0	80	-6	OK
67 RUGBY STREET 6063	18.08	83	GF	Res.	47	47	0	55	-8	73	73	0	80	-7	OK
64 RUGBY STREET 6063	18.12	26	GF	Res.	51	51	0	55	-4	81	81	0	80	1	OK
64 RUGBY STREET 6063	18.14	52	GF	Res.	49	49	0	55	-6	76	76	0	80	-4	OK
75 RUGBY STREET 6063	18.16	111	GF	Res.	46	46	0	55	-9	71	71	0	80	-9	OK
75 RUGBY STREET 6063	18.18	86	GF	Res.	50	50	0	55	-5	77	77	0	80	-3	OK
29 REPTON STREET 6055	18.30	145	GF	Res.	48	48	0	55	-7	75	75	0	80	-5	OK
49 REPTON STREET 6055	18.45	114	GF	Res.	51	51	0	55	-4	77	77	0	80	-3	OK
178 LORD STREET 6055	18.48	277	GF	Res.	45	45	0	55	-10	70	70	0	80	-10	OK
99C LORD ST WHITEMAN PARK	19.75	130	GF	RC	49	49	0	-	-	77	77	0	-	-	OK
99 LORD ST WHITEMAN PARK	19.91	79	GF	Res.	54	54	0	55	-1	83	83	0	80	3	OK
70 CASTLEREAGH WAY 6055	20.54	71	GF	Res.	54	51	-3	55	-4	84	79	-5	80	-1	OK
73 CASTLEREAGH WAY 6055	20.54	113	GF	Res.	49	49	0	55	-6	78	77	-1	80	-3	OK
71 CASTLEREAGH WAY 6055	20.55	115	GF	Res.	48	48	0	55	-7	77	77	0	80	-3	OK
68 CASTLEREAGH WAY 6055	20.55	76	GF	Res.	52	50	-2	55	-5	81	78	-3	80	-2	OK
69 CASTLEREAGH WAY 6055	20.56	114	GF	Res.	47	47	0	55	-8	73	74	1	80	-6	OK
66 CASTLEREAGH WAY 6055	20.56	71	GF	Res.	52	51	-1	55	-4	81	77	-4	80	-3	OK
67 CASTLEREAGH WAY 6055	20.56	113	GF	Res.	47	47	0	55	-8	74	74	0	80	-6	OK
65 CASTLEREAGH WAY 6055	20.57	115	GF	Res.	46	46	0	55	-9	72	73	1	80	-7	OK
64 CASTLEREAGH WAY 6055	20.58	72	GF	Res.	52	51	-1	55	-4	81	78	-3	80	-2	OK
63 CASTLEREAGH WAY 6055	20.58	112	GF	Res.	47	47	0	55	-8	72	72	0	80	-8	OK
62 CASTLEREAGH WAY 6055	20.59	72	GF	Res.	52	51	-1	55	-4	80	78	-2	80	-2	OK
61 CASTLEREAGH WAY 6055	20.59	114	GF	Res.	46	46	0	55	-9	71	72	1	80	-8	OK
60 CASTLEREAGH WAY 6055	20.60	73	GF	Res.	53	51	-2	55	-4	81	79	-2	80	-1	OK
47 CASTLEREAGH WAY 6055	20.61	113	GF	Res.	46	46	0	55	-9	71	71	0	80	-9	OK
58 CASTLEREAGH WAY 6055	20.62	74	GF	Res.	52	51	-1	55	-4	81	79	-2	80	-1	OK
56 CASTLEREAGH WAY 6055	20.63	75	GF	Res.	52	51	-1	55	-4	81	79	-2	80	-1	OK
50 CASTLEREAGH WAY 6055	20.64	113	GF	Res.	45	45	0	55	-10	70	70	0	80	-10	OK
54 CASTLEREAGH WAY 6055	20.64	76	GF	Res.	52	51	-1	55	-4	81	79	-2	80	-1	OK
52 CASTLEREAGH WAY 6055	20.66	76	GF	Res.	52	51	-1	55	-4	81	79	-2	80	-1	OK
431 WOOLLCOTT AVE 6055	20.68	77	GF	Res.	53	52	-1	55	-3	81	80	-1	80	0	OK
427 WOOLLCOTT AVE 6055	20.69	113	GF	Res.	49	47	-2	55	-8	79	76	-3	80	-4	OK

Address	Ch ain	Dis tan	Flo	Us age	$L_{Aeq,night}$, dB					L_{Amax}, dB					Lik ely
429 WOOLLCOTT AVE BRABHAM 6055	20.69	98	GF	Res.	50	48	-2	55	-7	80	78	-2	80	-2	OK
428 WOOLLCOTT AVE 6055	20.73	113	GF	Res.	49	47	-2	55	-8	79	75	-4	80	-5	OK
430 WOOLLCOTT AVE 6055	20.73	100	GF	Res.	50	47	-3	55	-8	80	76	-4	80	-4	OK
432 WOOLLCOTT AVE 6055	20.74	76	GF	Res.	53	52	-1	55	-3	81	81	0	80	1	OK
82B WANDSWORTH AVENUE 6055	20.78	76	GF	Res.	53	53	0	55	-2	81	81	0	80	1	OK
86 WANDSWORTH AVENUE 6055	20.79	135	GF	Res.	45	45	0	55	-10	73	73	0	80	-7	OK
82C WANDSWORTH AVENUE 6055	20.79	98	GF	Res.	48	48	0	55	-7	78	78	0	80	-2	OK
84 WANDSWORTH AVENUE 6055	20.79	124	GF	Res.	46	46	0	55	-9	75	75	0	80	-5	OK
85 WANDSWORTH AVENUE 6055	20.80	145	GF	Res.	45	45	0	55	-10	74	73	-1	80	-7	OK
83 WANDSWORTH AVENUE 6055	20.81	135	GF	Res.	46	46	0	55	-9	74	73	-1	80	-7	OK
81 WANDSWORTH AVENUE 6055	20.81	124	GF	Res.	47	47	0	55	-8	76	75	-1	80	-5	OK
80 WANDSWORTH AVENUE 6055	20.81	78	GF	Res.	53	53	0	55	-2	81	81	0	80	1	OK
78 WANDSWORTH AVENUE 6055	20.83	78	GF	Res.	53	53	0	55	-2	81	82	1	80	2	OK
77 WANDSWORTH AVENUE 6055	20.83	120	GF	Res.	45	45	0	55	-10	72	72	0	80	-8	OK
76 WANDSWORTH AVENUE 6055	20.84	78	GF	Res.	53	53	0	55	-2	81	82	1	80	2	OK
15 MAJELLA STREET 6055	20.84	149	GF	Res.	43	43	0	55	-12	69	69	0	80	-11	OK
74 WANDSWORTH AVENUE 6055	20.85	78	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
73 WANDSWORTH AVENUE 6055	20.86	119	GF	Res.	43	43	0	55	-12	71	71	0	80	-9	OK
72 WANDSWORTH AVENUE 6055	20.87	79	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
21 MAJELLA STREET 6055	20.87	153	GF	Res.	43	43	0	55	-12	69	69	0	80	-11	OK
71 WANDSWORTH AVENUE 6055	20.87	119	GF	Res.	43	43	0	55	-12	71	71	0	80	-9	OK
23 MAJELLA STREET 6055	20.88	149	GF	Res.	42	42	0	55	-13	67	67	0	80	-13	OK
70 WANDSWORTH AVENUE 6055	20.88	78	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
69 WANDSWORTH AVENUE 6055	20.88	118	GF	Res.	43	43	0	55	-12	70	71	1	80	-9	OK
25 MAJELLA STREET 6055	20.89	148	GF	Res.	42	42	0	55	-13	68	68	0	80	-12	OK
68 WANDSWORTH AVENUE 6055	20.89	76	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
27 MAJELLA STREET 6055	20.89	149	GF	Res.	41	41	0	55	-14	66	66	0	80	-14	OK
35 SCHENLEY ROAD 6055	20.90	117	GF	Res.	43	43	0	55	-12	69	69	0	80	-11	OK
66 WANDSWORTH AVENUE 6055	20.90	80	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
33 SCHENLEY ROAD 6055	20.91	135	GF	Res.	43	43	0	55	-12	70	70	0	80	-10	OK
29 MAJELLA STREET 6055	20.91	160	GF	Res.	43	43	0	55	-12	69	69	0	80	-11	OK
64 WANDSWORTH AVENUE 6055	20.92	79	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
32 SCHENLEY ROAD 6055	20.93	144	GF	Res.	42	42	0	55	-13	69	69	0	80	-11	OK
34 SCHENLEY ROAD 6055	20.93	133	GF	Res.	42	42	0	55	-13	69	69	0	80	-11	OK
62 WANDSWORTH AVENUE 6055	20.93	78	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
36 SCHENLEY ROAD 6055	20.94	117	GF	Res.	43	43	0	55	-12	68	68	0	80	-12	OK
60 WANDSWORTH AVENUE 6055	20.95	79	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
58 WANDSWORTH AVENUE 6055	20.96	78	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
57 WANDSWORTH AVENUE 6055	20.96	118	GF	Res.	43	43	0	55	-12	68	68	0	80	-12	OK
56 WANDSWORTH AVENUE 6055	20.98	78	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
55 WANDSWORTH AVENUE 6055	20.98	121	GF	Res.	43	43	0	55	-12	68	68	0	80	-12	OK
31 GARIGAL STREET 6055	20.99	141	GF	Res.	42	42	0	55	-13	68	68	0	80	-12	OK
54 WANDSWORTH AVENUE 6055	20.99	77	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
52 WANDSWORTH AVENUE 6055	21.00	77	GF	Res.	53	54	1	55	-1	82	82	0	80	2	OK
30 GARIGAL STREET 6055	21.01	142	GF	Res.	42	42	0	55	-13	68	68	0	80	-12	OK
51 WANDSWORTH AVENUE 6055	21.01	119	GF	Res.	43	43	0	55	-12	69	69	0	80	-11	OK
50 WANDSWORTH AVENUE 6055	21.02	77	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
49 WANDSWORTH AVENUE 6055	21.02	119	GF	Res.	44	44	0	55	-11	70	70	0	80	-10	OK
48 WANDSWORTH AVENUE 6055	21.03	76	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
47 WANDSWORTH AVENUE 6055	21.03	119	GF	Res.	44	44	0	55	-11	71	71	0	80	-9	OK
46 WANDSWORTH AVENUE 6055	21.05	82	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
45 WANDSWORTH AVENUE 6055	21.05	120	GF	Res.	44	43	-1	55	-12	70	70	0	80	-10	OK
75 BALURAN AVENUE 6055	21.05	144	GF	Res.	42	42	0	55	-13	68	68	0	80	-12	OK
44 WANDSWORTH AVENUE 6055	21.06	79	GF	Res.	53	54	1	55	-1	82	82	0	80	2	OK
41 WANDSWORTH AVENUE 6055	21.07	118	GF	Res.	43	43	0	55	-12	69	69	0	80	-11	OK
42 WANDSWORTH AVENUE 6055	21.08	76	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
40 WANDSWORTH AVENUE 6055	21.09	78	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
39 WANDSWORTH AVENUE 6055	21.09	117	GF	Res.	43	43	0	55	-12	68	68	0	80	-12	OK
74 BALURAN AVENUE 6055	21.09	142	GF	Res.	42	42	0	55	-13	68	68	0	80	-12	OK
72 BALURAN AVENUE 6055	21.10	156	GF	Res.	41	41	0	55	-14	68	68	0	80	-12	OK
38 WANDSWORTH AVENUE 6055	21.10	76	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
37 WANDSWORTH AVENUE 6055	21.11	119	GF	Res.	44	44	0	55	-11	70	70	0	80	-10	OK
36 WANDSWORTH AVENUE 6055	21.12	78	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
35 WANDSWORTH AVENUE 6055	21.12	118	GF	Res.	44	44	0	55	-11	70	70	0	80	-10	OK

Address	Chain	Distan	Flo	Usage	$L_{Aeq,night}$, dB					L_{Amax}, dB					Likely
13 POTOMAC STREET 6055	21.12	140	GF	Res.	42	42	0	55	-13	68	68	0	80	-12	OK
11 POTOMAC STREET 6055	21.13	154	GF	Res.	42	42	0	55	-13	69	69	0	80	-11	OK
34 WANDSWORTH AVENUE 6055	21.13	77	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
16 POTOMAC STREET 6055	21.14	143	GF	Res.	43	43	0	55	-12	69	69	0	80	-11	OK
32 WANDSWORTH AVENUE 6055	21.14	77	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
23 WANDSWORTH AVENUE 6055	21.15	118	GF	Res.	44	44	0	55	-11	70	70	0	80	-10	OK
30 WANDSWORTH AVENUE 6055	21.16	76	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
21 WANDSWORTH AVENUE 6055	21.16	117	GF	Res.	43	43	0	55	-12	69	69	0	80	-11	OK
28 WANDSWORTH AVENUE 6055	21.17	76	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
19 WANDSWORTH AVENUE 6055	21.17	117	GF	Res.	44	44	0	55	-11	69	69	0	80	-11	OK
26 WANDSWORTH AVENUE 6055	21.18	76	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
17 WANDSWORTH AVENUE 6055	21.19	119	GF	Res.	44	44	0	55	-11	70	70	0	80	-10	OK
15 WANDSWORTH AVENUE 6055	21.19	147	GF	Res.	43	43	0	55	-12	69	69	0	80	-11	OK
24 WANDSWORTH AVENUE 6055	21.19	76	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
22 WANDSWORTH AVE (Note[1])	21.22	74	F 2	Res.	53	53	0	55	-2	82	82	0	80	2	OK
22 WANDSWORTH AVE (Note[1])	21.22	74	F 1	Res.	57	57	0	55	**2**	86	85	-1	80	5	**+2 dB**
22 WANDSWORTH AVE	21.22	74	GF	Res.	57	57	0	55	**2**	86	86	0	80	6	**+2 dB**
20 WANDSWORTH AVENUE 6055	21.22	110	GF	Res.	44	44	0	55	-11	71	71	0	80	-9	OK
14 WANDSWORTH AVENUE 6055	21.24	156	GF	Res.	43	43	0	55	-12	71	71	0	80	-9	OK
16 WANDSWORTH AVENUE 6055	21.24	141	GF	Res.	43	43	0	55	-12	72	72	0	80	-8	OK
18 WANDSWORTH AVENUE 6055	21.24	130	GF	Res.	43	43	0	55	-12	72	72	0	80	-8	OK
35 PAPAGO LOOP	21.25	73	GF	Res.	52	52	0	55	-3	80	80	0	80	0	OK
33 PAPAGO LOOP 6055	21.25	126	GF	Res.	42	42	0	55	-13	66	66	0	80	-14	OK
29 PAPAGO LOOP 6055	21.27	155	GF	Res.	44	44	0	55	-11	71	71	0	80	-9	OK
31 PAPAGO LOOP 6055	21.27	141	GF	Res.	44	44	0	55	-11	70	70	0	80	-10	OK
37 PAPAGO LOOP 6055	21.28	86	GF	Res.	53	53	0	55	-2	82	83	1	80	3	OK
36 PAPAGO LOOP 6055	21.29	147	GF	Res.	43	43	0	55	-12	68	68	0	80	-12	OK
38 PAPAGO LOOP 6055	21.29	126	GF	Res.	45	45	0	55	-10	71	71	0	80	-9	OK
39 PAPAGO LOOP 6055	21.29	81	GF	Res.	54	54	0	55	-1	83	83	0	80	3	OK
41 PAPAGO LOOP 6055	21.30	81	GF	Res.	54	54	0	55	-1	83	83	0	80	3	OK
40 PAPAGO LOOP 6055	21.31	125	GF	Res.	45	45	0	55	-10	71	71	0	80	-9	OK
43 PAPAGO LOOP 6055	21.31	80	GF	Res.	54	54	0	55	-1	83	83	0	80	3	OK
42 PAPAGO LOOP 6055	21.31	126	GF	Res.	45	45	0	55	-10	71	71	0	80	-9	OK
45 PAPAGO LOOP 6055	21.32	80	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
47 PAPAGO LOOP 6055	21.33	79	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
44 PAPAGO LOOP 6055	21.33	126	GF	Res.	45	45	0	55	-10	71	71	0	80	-9	OK
47 SYON WAY 6055	21.33	147	GF	Res.	43	43	0	55	-12	70	70	0	80	-10	OK
49 PAPAGO LOOP 6055	21.34	77	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
46 PAPAGO LOOP 6055	21.36	126	GF	Res.	45	45	0	55	-10	71	71	0	80	-9	OK
51 PAPAGO LOOP 6055	21.36	81	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
46 SYON WAY 6055	21.36	152	GF	Res.	42	42	0	55	-13	67	67	0	80	-13	OK
53 PAPAGO LOOP 6055	21.37	81	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
48 PAPAGO LOOP 6055	21.38	125	GF	Res.	44	44	0	55	-11	70	70	0	80	-10	OK
55 PAPAGO LOOP 6055	21.38	79	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
50 PAPAGO LOOP 6055	21.39	124	GF	Res.	45	45	0	55	-10	70	70	0	80	-10	OK
57 PAPAGO LOOP 6055	21.39	76	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK
52 PAPAGO LOOP 6055	21.40	127	GF	Res.	45	45	0	55	-10	69	69	0	80	-11	OK
59 PAPAGO LOOP 6055	21.40	79	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
2 SYON WAY 6055	21.41	155	GF	Res.	44	44	0	55	-11	70	70	0	80	-10	OK
61 PAPAGO LOOP 6055	21.41	76	GF	Res.	54	53	-1	55	-2	82	82	0	80	2	OK
63 PAPAGO LOOP 6055	21.43	80	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
54 PAPAGO LOOP 6055	21.43	125	GF	Res.	46	46	0	55	-9	71	71	0	80	-9	OK
65 PAPAGO LOOP 6055	21.43	79	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
67 PAPAGO LOOP 6055	21.44	82	GF	Res.	54	53	-1	55	-2	82	83	1	80	3	OK
3 SYON WAY 6055	21.44	144	GF	Res.	41	41	0	55	-14	69	69	0	80	-11	OK
69 PAPAGO LOOP 6055	21.45	81	GF	Res.	54	54	0	55	-1	82	83	1	80	3	OK
56 PAPAGO LOOP 6055	21.45	126	GF	Res.	46	46	0	55	-9	72	72	0	80	-8	OK
71 PAPAGO LOOP 6055	21.46	83	GF	Res.	54	54	0	55	-1	82	83	1	80	3	OK
58 PAPAGO LOOP 6055	21.47	126	GF	Res.	47	47	0	55	-8	73	73	0	80	-7	OK
73 PAPAGO LOOP 6055	21.47	82	GF	Res.	54	54	0	55	-1	82	83	1	80	3	OK
60 PAPAGO LOOP 6055	21.48	126	GF	Res.	47	47	0	55	-8	74	74	0	80	-6	OK
75 PAPAGO LOOP 6055	21.48	80	GF	Res.	54	54	0	55	-1	82	83	1	80	3	OK
23 HEWELL ROAD 6055	21.49	149	GF	Res.	45	45	0	55	-10	73	72	-1	80	-8	OK
77 PAPAGO LOOP 6055	21.49	84	GF	Res.	53	53	0	55	-2	82	82	0	80	2	OK

Address	Ch ain	Dis tan	Flo	Us age	$L_{Aeq,night}$, dB					L_{Amax}, dB					Lik ely
79 PAPAGO LOOP 6055	21.50	81	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
62 PAPAGO LOOP 6055	21.51	126	GF	Res.	48	48	0	55	-7	74	74	0	80	-6	OK
81 PAPAGO LOOP 6055	21.51	81	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
64 PAPAGO LOOP 6055	21.53	128	GF	Res.	47	47	0	55	-8	73	73	0	80	-7	OK
83 PAPAGO LOOP 6055	21.53	80	GF	Res.	54	54	0	55	-1	82	82	0	80	2	OK
22 HEWELL ROAD 6055	21.53	153	GF	Res.	41	41	0	55	-14	67	67	0	80	-13	OK
85 PAPAGO LOOP 6055	21.54	84	GF	Res.	53	52	-1	55	-3	82	81	-1	80	1	OK
66 PAPAGO LOOP 6055	21.54	125	GF	Res.	47	47	0	55	-8	72	72	0	80	-8	OK
87 PAPAGO LOOP 6055	21.54	79	GF	Res.	54	53	-1	55	-2	82	81	-1	80	1	OK
89 PAPAGO LOOP 6055	21.55	81	GF	Res.	54	53	-1	55	-2	82	81	-1	80	1	OK
15 CALVERLEY ROAD 6055	21.56	154	GF	Res.	44	44	0	55	-11	70	70	0	80	-10	OK
68 PAPAGO LOOP 6055	21.56	124	GF	Res.	47	47	0	55	-8	72	72	0	80	-8	OK
91 PAPAGO LOOP 6055	21.56	82	GF	Res.	54	53	-1	55	-2	82	81	-1	80	1	OK
93 PAPAGO LOOP 6055	21.57	84	GF	Res.	53	53	0	55	-2	82	81	-1	80	1	OK
14 CALVERLEY ROAD 6055	21.58	145	GF	Res.	44	44	0	55	-11	71	71	0	80	-9	OK
16 CALVERLEY ROAD 6055	21.59	126	GF	Res.	46	46	0	55	-9	71	71	0	80	-9	OK
95 PAPAGO LOOP 6055	21.59	83	GF	Res.	53	53	0	55	-2	81	81	0	80	1	OK
97 PAPAGO LOOP 6055	21.60	82	GF	Res.	53	53	0	55	-2	81	81	0	80	1	OK
99 PAPAGO LOOP 6055	21.61	84	GF	Res.	53	53	0	55	-2	81	81	0	80	1	OK
13 PIEDMONT WAY 6055	21.62	126	GF	Res.	46	45	-1	55	-10	72	71	-1	80	-9	OK
101 PAPAGO LOOP 6055	21.63	83	GF	Res.	53	53	0	55	-2	81	80	-1	80	0	OK
11 PIEDMONT WAY 6055	21.63	154	GF	Res.	43	43	0	55	-12	69	69	0	80	-11	OK
103 PAPAGO LOOP 6055	21.64	84	GF	Res.	54	53	-1	55	-2	81	80	-1	80	0	OK
105 PAPAGO LOOP 6055	21.66	82	GF	Res.	53	53	0	55	-2	81	80	-1	80	0	OK
18 PIEDMONT WAY 6055	21.66	128	GF	Res.	45	45	0	55	-10	70	70	0	80	-10	OK
18 PIEDMONT WAY 6055	21.67	144	GF	Res.	44	43	-1	55	-12	70	69	-1	80	-11	OK
107 PAPAGO LOOP 6055	21.68	83	GF	Res.	53	52	-1	55	-3	81	80	-1	80	0	OK
109 PAPAGO LOOP 6055	21.69	82	GF	Res.	53	52	-1	55	-3	81	80	-1	80	0	OK
15 CHARLTON WAY 6055	21.70	129	GF	Res.	48	47	-1	55	-8	76	74	-2	80	-6	OK
111 PAPAGO LOOP 6055	21.70	80	GF	Res.	53	52	-1	55	-3	81	80	-1	80	0	OK
13 CHARLTON WAY 6055	21.71	144	GF	Res.	48	46	-2	55	-9	77	74	-3	80	-6	OK
14 CHARLTON WAY 6055	21.76	83	GF	Res.	53	53	0	55	-2	80	80	0	80	0	OK
10 CHARLTON WAY 6055	21.76	115	GF	Res.	47	46	-1	55	-9	76	74	-2	80	-6	OK
12 CHARLTON WAY 6055	21.77	102	GF	Res.	49	48	-1	55	-7	79	77	-2	80	-3	OK
9 PALEY WAY 6055	21.79	93	GF	Res.	53	52	-1	55	-3	81	79	-2	80	-1	OK
3 PALEY WAY 6055	21.80	135	GF	Res.	48	46	-2	55	-9	76	74	-2	80	-6	OK
5 PALEY WAY 6055	21.80	123	GF	Res.	48	47	-1	55	-8	77	75	-2	80	-5	OK
7 PALEY WAY 6055	21.80	112	GF	Res.	49	48	-1	55	-7	78	76	-2	80	-4	OK
31 FAIRMOUNT BOULEVARD 6055	21.83	172	GF	Res.	47	46	-1	55	-9	74	73	-1	80	-7	OK
2 PALEY WAY	21.83	133	GF	Res.	46	45	-1	55	-10	74	72	-2	80	-8	OK
4 PALEY WAY	21.83	116	GF	Res.	47	45	-2	55	-10	77	75	-2	80	-5	OK
PALEY WAY	21.83	101	GF	Res.	50	49	-1	55	-6	78	77	-1	80	-3	OK
29 FAIRMOUNT BOULEVARD 6055	21.84	165	GF	Res.	47	46	-1	55	-9	74	73	-1	80	-7	OK
3 BATTERY STREET 6055	21.84	203	GF	Res.	42	42	0	55	-13	68	68	0	80	-12	OK
5 BATTERY STREET 6055	21.85	189	GF	Res.	39	39	0	55	-16	63	63	0	80	-17	OK
27 FAIRMOUNT BOULEVARD 6055	21.86	160	GF	Res.	47	46	-1	55	-9	75	74	-1	80	-6	OK
8 PALEY WAY	21.86	104	GF	Res.	52	50	-2	55	-5	80	77	-3	80	-3	OK
7 BATTERY STREET 6055	21.87	181	GF	Res.	39	39	0	55	-16	63	63	0	80	-17	OK
25 FAIRMOUNT BOULEVARD 6055	21.88	146	GF	Res.	49	47	-2	55	-8	78	75	-3	80	-5	OK
9 BATTERY STREET 6055	21.88	178	GF	Res.	41	41	0	55	-14	66	66	0	80	-14	OK
11 BATTERY STREET 6055	21.90	174	GF	Res.	41	41	0	55	-14	67	67	0	80	-13	OK
23 FAIRMOUNT BOULEVARD 6055	21.90	132	GF	Res.	49	47	-2	55	-8	77	74	-3	80	-6	OK
13 BATTERY STREET 6055	21.91	158	GF	Res.	40	40	0	55	-15	65	65	0	80	-15	OK
21 FAIRMOUNT BOULEVARD 6055	21.92	127	GF	Res.	52	49	-3	55	-6	80	76	-4	80	-4	OK
19 FAIRMOUNT BOULEVARD 6055	21.93	125	GF	Res.	52	50	-2	55	-5	80	76	-4	80	-4	OK
15 BATTERY STREET 6055	21.94	156	GF	Res.	41	40	-1	55	-15	70	68	-2	80	-12	OK
17 FAIRMOUNT BOULEVARD 6055	21.95	128	GF	Res.	52	50	-2	55	-5	80	76	-4	80	-4	OK
17 BATTERY STREET 6055	21.95	162	GF	Res.	41	41	0	55	-14	67	66	-1	80	-14	OK
15 FAIRMOUNT BOULEVARD 6055	21.97	130	GF	Res.	52	50	-2	55	-5	79	76	-3	80	-4	OK
19 BATTERY STREET 6055	21.97	160	GF	Res.	41	41	0	55	-14	64	64	0	80	-16	OK
21 BATTERY STREET 6055	21.98	165	GF	Res.	42	42	0	55	-13	65	65	0	80	-15	OK
13 FAIRMOUNT BOULEVARD 6055	21.99	131	GF	Res.	52	50	-2	55	-5	79	76	-3	80	-4	OK
2 TAPPEN WAY 6055	22.00	130	GF	Res.	52	51	-1	55	-4	78	76	-2	80	-4	OK
6 TAPPEN WAY 6055	22.01	167	GF	Res.	45	44	-1	55	-11	72	72	0	80	-8	OK

Address	Chain	Distan	Flo	Usage	$L_{Aeq,night}$, dB					L_{Amax}, dB					Likely
4 TAPPEN WAY 6055	22.01	152	GF	Res.	47	47	0	55	-8	75	75	0	80	-5	OK
11 FAIRMOUNT BOULEVARD 6055	22.03	135	GF	Res.	52	51	-1	55	-4	77	77	0	80	-3	OK
3 TAPPEN WAY 6055	22.05	162	GF	Res.	39	39	0	55	-16	63	63	0	80	-17	OK
9 FAIRMOUNT BOULEVARD 6055	22.05	136	GF	Res.	52	52	0	55	-3	78	78	0	80	-2	OK
7 FAIRMOUNT BOULEVARD 6055	22.06	136	GF	Res.	53	52	-1	55	-3	79	79	0	80	-1	OK
4 BILDERSEE AVENUE 6055	22.08	167	GF	Res.	47	47	0	55	-8	76	76	0	80	-4	OK
5 FAIRMOUNT BOULEVARD 6055	22.08	139	GF	Res.	52	52	0	55	-3	79	79	0	80	-1	OK
1 BILDERSEE AVENUE 6055	22.11	145	GF	Res.	52	52	0	55	-3	79	79	0	80	-1	OK
3 BILDERSEE AVENUE 6055	22.12	166	GF	Res.	47	47	0	55	-8	74	74	0	80	-6	OK
339 PARK STREET 6055	22.17	176	GF	Res.	47	47	0	55	-8	76	76	0	80	-4	OK
341 PARK STREET 6055	22.19	152	GF	Res.	52	52	0	55	-3	78	78	0	80	-2	OK
10 STARFLOWER PLACE 6055	22.39	210	GF	Res.	50	50	0	55	-5	76	76	0	80	-4	OK
24 STARFLOWER PLACE 6055	22.47	213	GF	Res.	51	51	0	55	-4	76	76	0	80	-4	OK
602 LORD STREET 6055	22.59	216	GF	Res.	50	50	0	55	-5	76	76	0	80	-4	OK
608 LORD STREET 6055	22.66	214	GF	Res.	50	50	0	55	-5	76	76	0	80	-4	OK
616 LORD STREET 6055	22.74	232	GF	Res.	50	50	0	55	-5	75	75	0	80	-5	OK
628 LORD STREET 6055	22.81	250	GF	Res.	50	50	0	55	-5	74	74	0	80	-6	OK
644 LORD STREET 6055	22.88	298	GF	Res.	49	49	0	55	-6	73	73	0	80	-7	OK
646 LORD STREET 6055	22.98	289	GF	Res.	48	48	0	55	-7	73	73	0	80	-7	OK
658 LORD STREET 6055	23.07	384	GF	Res.	47	47	0	55	-8	71	71	0	80	-9	OK
668 LORD STREET 6055	23.18	374	GF	Res.	47	47	0	55	-8	71	71	0	80	-9	OK
742B LORD STREET 6055	24.10	518	GF	Res.	41	41	0	55	-14	66	66	0	80	-14	OK
40 ROSSINI CIRCLE 6069	24.34	109	GF	Res.	42	42	0	55	-13	68	67	-1	80	-13	OK
38 ROSSINI CIRCLE 6069	24.36	109	GF	Res.	42	42	0	55	-13	69	68	-1	80	-12	OK
19 ROSSINI CIRCLE 6069	24.36	153	GF	Res.	41	41	0	55	-14	65	65	0	80	-15	OK
36 ROSSINI CIRCLE 6069	24.38	107	GF	Res.	42	42	0	55	-13	66	65	-1	80	-15	OK
33 MARSALA WAY 6069	24.39	149	GF	Res.	41	41	0	55	-14	65	65	0	80	-15	OK
34 ROSSINI CIRCLE 6069	24.39	101	GF	Res.	42	42	0	55	-13	67	67	0	80	-13	OK
32 ROSSINI CIRCLE 6069	24.41	96	GF	Res.	43	42	-1	55	-13	69	68	-1	80	-12	OK
30 ROSSINI CIRCLE 6069	24.42	96	GF	Res.	43	42	-1	55	-13	70	69	-1	80	-11	OK
28 ROSSINI CIRCLE 6069	24.44	93	GF	Res.	41	41	0	55	-14	66	66	0	80	-14	OK
32 MARSALA WAY 6069	24.45	136	GF	Res.	41	41	0	55	-14	66	66	0	80	-14	OK
30 MARSALA WAY 6069	24.45	156	GF	Res.	38	39	1	55	-16	64	64	0	80	-16	OK
26 ROSSINI CIRCLE 6069	24.45	90	GF	Res.	42	42	0	55	-13	67	67	0	80	-13	OK
24 ROSSINI CIRCLE 6069	24.46	81	GF	Res.	44	43	-1	55	-12	70	70	0	80	-10	OK
35 BELLINI AVENUE 6069	24.48	134	GF	Res.	42	42	0	55	-13	67	68	1	80	-12	OK
22 ROSSINI CIRCLE 6069	24.48	86	GF	Res.	42	42	0	55	-13	69	69	0	80	-11	OK
20 ROSSINI CIRCLE 6069	24.50	76	GF	Res.	45	45	0	55	-10	73	72	-1	80	-8	OK
18 ROSSINI CIRCLE 6069	24.51	72	GF	Res.	46	45	-1	55	-10	74	73	-1	80	-7	OK
38 BELLINI AVENUE 6069	24.52	123	GF	Res.	43	43	0	55	-12	70	70	0	80	-10	OK
16 ROSSINI CIRCLE 6069	24.53	76	GF	Res.	46	45	-1	55	-10	75	74	-1	80	-6	OK
36 BELLINI AVENUE 6069	24.53	148	GF	Res.	41	41	0	55	-14	67	68	1	80	-12	OK
14 ROSSINI CIRCLE 6069	24.54	71	GF	Res.	46	45	-1	55	-10	74	74	0	80	-6	OK
12 ROSSINI CIRCLE 6069	24.55	65	GF	Res.	48	47	-1	55	-8	76	75	-1	80	-5	OK
29 TARANTO WAY 6069	24.56	113	GF	Res.	43	43	0	55	-12	70	71	1	80	-9	OK
27 TARANTO WAY 6069	24.57	139	GF	Res.	41	41	0	55	-14	67	69	2	80	-11	OK
10 ROSSINI CIRCLE 6069	24.58	62	GF	Res.	49	47	-2	55	-8	78	77	-1	80	-3	OK
8 ROSSINI CIRCLE 6069	24.59	62	GF	Res.	49	47	-2	55	-8	79	77	-2	80	-3	OK
28 TARANTO WAY 6069	24.61	143	GF	Res.	40	40	0	55	-15	65	67	2	80	-13	OK
32 TARANTO WAY 6069	24.61	101	GF	Res.	44	44	0	55	-11	71	72	1	80	-8	OK
6 ROSSINI CIRCLE 6069	24.61	54	GF	Res.	51	49	-2	55	-6	81	78	-3	80	-2	OK
30 TARANTO WAY 6069	24.61	131	GF	Res.	40	41	1	55	-14	68	69	1	80	-11	OK
4 ROSSINI CIRCLE 6069	24.63	56	GF	Res.	50	48	-2	55	-7	80	78	-2	80	-2	OK
2 ROSSINI CIRCLE 6069	24.65	45	GF	Res.	53	50	-3	55	-5	83	80	-3	80	0	OK
130 PONTE VECCHIO BOULEVARD 6069	24.65	92	GF	Res.	46	45	-1	55	-10	75	74	-1	80	-6	OK
132 PONTE VECCHIO BOULEVARD 6069	24.65	122	GF	Res.	44	43	-1	55	-12	73	71	-2	80	-9	OK
121 PONTE VECCHIO BOULEVARD 6069	24.70	54	GF	Res.	52	48	-4	55	-7	82	78	-4	80	-2	OK
123 PONTE VECCHIO BOULEVARD 6069	24.70	80	GF	Res.	42	43	1	55	-12	71	72	1	80	-8	OK
125 PONTE VECCHIO BOULEVARD 6069	24.71	95	GF	Res.	43	43	0	55	-12	72	71	-1	80	-9	OK
117 PONTE VECCHIO BOULEVARD 6069	24.74	45	GF	Res.	51	47	-4	55	-8	82	78	-4	80	-2	OK
115 PONTE VECCHIO BOULEVARD 6069	24.75	65	GF	Res.	48	47	-1	55	-8	78	76	-2	80	-4	OK
2 SANTORINI TURN 6069	24.76	75	GF	Res.	46	45	-1	55	-10	75	74	-1	80	-6	OK
116 PONTE VECCHIO BOULEVARD 6069	24.77	20	GF	Res.	56	50	-6	55	-5	86	81	-5	80	1	OK
1 SANTORINI TURN 6069	24.79	72	GF	Res.	47	46	-1	55	-9	76	75	-1	80	-5	OK

Address	Chain	Distan	Flo	Usage	$L_{Aeq,night}$, dB					L_{Amax}, dB					Likely
114 PONTE VECCHIO BOULEVARD 6069	24.79	22	GF	Res.	56	51	-5	55	-4	86	80	-6	80	0	OK
112 PONTE VECCHIO BOULEVARD 6069	24.81	19	GF	Res.	56	51	-5	55	-4	87	81	-6	80	1	OK
2 VERONA WAY 6069	24.82	68	GF	Res.	45	46	1	55	-9	73	75	2	80	-5	OK
110 PONTE VECCHIO BOULEVARD 6069	24.82	16	GF	Res.	57	52	-5	55	-3	88	82	-6	80	2	OK
108 PONTE VECCHIO BOULEVARD 6069	24.84	16	GF	Res.	57	51	-6	55	-4	88	82	-6	80	2	OK
106 PONTE VECCHIO BOULEVARD 6069	24.86	17	GF	Res.	57	51	-6	55	-4	88	81	-7	80	1	OK
104 PONTE VECCHIO BOULEVARD 6069	24.87	17	GF	Res.	57	51	-6	55	-4	88	81	-7	80	1	OK
1 VERONA WAY 6069	24.87	68	GF	Res.	44	45	1	55	-10	72	74	2	80	-6	OK
102 PONTE VECCHIO BOULEVARD 6069	24.89	21	GF	Res.	55	49	-6	55	-6	86	80	-6	80	0	OK
91 PONTE VECCHIO BOULEVARD 6069	24.90	70	GF	Res.	44	45	1	55	-10	72	74	2	80	-6	OK
100 PONTE VECCHIO BOULEVARD 6069	24.90	15	GF	Res.	57	51	-6	55	-4	88	82	-6	80	2	OK
98 PONTE VECCHIO BOULEVARD 6069	24.93	22	GF	Res.	52	48	-4	55	-7	83	78	-5	80	-2	OK
94 PONTE VECCHIO BOULEVARD 6069	24.95	29	GF	Res.	51	48	-3	55	-7	81	78	-3	80	-2	OK
50 VALINCO AVENUE 6069	24.96	20	GF	Res.	55	49	-6	55	-6	85	80	-5	80	0	OK
92 PONTE VECCHIO BOULEVARD 6069	24.96	44	GF	Res.	47	47	0	55	-8	76	77	1	80	-3	OK
90 PONTE VECCHIO BOULEVARD 6069	24.98	74	GF	Res.	43	44	1	55	-11	72	73	1	80	-7	OK
48 VALINCO AVENUE 6069	24.99	25	GF	Res.	54	49	-5	55	-6	84	79	-5	80	-1	OK
37 VALINCO AVENUE 6069	25.00	67	GF	Res.	45	45	0	55	-10	73	74	1	80	-6	OK
46 VALINCO AVENUE 6069	25.01	23	GF	Res.	55	50	-5	55	-5	84	79	-5	80	-1	OK
35 VALINCO AVENUE 6069	25.03	72	GF	Res.	44	45	1	55	-10	71	72	1	80	-8	OK
44 VALINCO AVENUE 6069	25.03	27	GF	Res.	54	49	-5	55	-6	83	79	-4	80	-1	OK
33 VALINCO AVENUE 6069	25.04	95	GF	Res.	43	43	0	55	-12	70	71	1	80	-9	OK
42 VALINCO AVENUE 6069	25.05	29	GF	Res.	54	49	-5	55	-6	83	78	-5	80	-2	OK
31 VALINCO AVENUE 6069	25.06	109	GF	Res.	44	43	-1	55	-12	70	70	0	80	-10	OK
40 VALINCO AVENUE 6069	25.07	31	GF	Res.	54	49	-5	55	-6	83	78	-5	80	-2	OK
29 VALINCO AVENUE 6069	25.08	123	GF	Res.	44	43	-1	55	-12	72	69	-3	80	-11	OK
38 VALINCO AVENUE 6069	25.08	32	GF	Res.	54	49	-5	55	-6	83	78	-5	80	-2	OK
27 VALINCO AVENUE 6069	25.09	136	GF	Res.	44	42	-2	55	-13	72	68	-4	80	-12	OK
25 VALINCO AVENUE 6069	25.10	147	GF	Res.	43	42	-1	55	-13	72	68	-4	80	-12	OK
36 VALINCO AVENUE 6069	25.11	34	GF	Res.	54	49	-5	55	-6	83	77	-6	80	-3	OK
5 SANTONA BOULEVARD 6069	25.16	30	GF	IA	58	50	-8	55	-5	87	79	-8	80	-1	OK
5 SANTONA BOULEVARD 6069	25.18	77	GF	IA	49	45	-4	55	-10	77	73	-4	80	-7	OK
5 SANTONA BOULEVARD 6069	25.19	37	GF	IA	56	49	-7	55	-6	86	78	-8	80	-2	OK
5 SANTONA BOULEVARD 6069	25.25	42	GF	IA	56	49	-7	55	-6	85	78	-7	80	-2	OK
5 SANTONA BOULEVARD 6069	25.27	80	GF	IA	48	43	-5	55	-12	79	72	-7	80	-8	OK
5 SANTONA BOULEVARD 6069	25.28	86	GF	IA	50	44	-6	55	-11	80	73	-7	80	-7	OK
5 SANTONA BOULEVARD 6069	25.35	51	GF	IA	55	48	-7	55	-7	84	77	-7	80	-3	OK
5 SANTONA BOULEVARD 6069	25.38	40	GF	IA	56	49	-7	55	-6	86	79	-7	80	-1	OK
1 MESSINA GROVE 6069	25.48	43	GF	Res.	53	50	-3	55	-5	83	80	-3	80	0	OK
2 MESSINA GROVE 6069	25.48	84	GF	Res.	50	46	-4	55	-9	80	75	-5	80	-5	OK
24 SAN LORENZO BOULEVARD 6069	25.49	87	GF	Res.	50	50	0	55	-5	79	79	0	80	-1	OK
22 SAN LORENZO BOULEVARD 6069	25.50	69	GF	Res.	50	50	0	55	-5	80	80	0	80	0	OK
26 SAN LORENZO BOULEVARD 6069	25.50	115	GF	Res.	48	48	0	55	-7	77	78	1	80	-2	OK
2 VAUCLUSE CRESCENT 6069	25.50	19	GF	Res.	56	55	-1	55	0	87	85	-2	80	5	OK
4 MESSINA GROVE 6069	25.51	90	GF	Res.	48	45	-3	55	-10	78	75	-3	80	-5	OK
4 VAUCLUSE CRESCENT 6069	25.51	24	GF	Res.	55	52	-3	55	-3	86	83	-3	80	3	OK
3 MESSINA GROVE 6069	25.52	49	GF	Res.	54	51	-3	55	-4	84	80	-4	80	0	OK
3 VAUCLUSE CRESCENT 6069	25.53	65	GF	Res.	48	49	1	55	-6	76	76	0	80	-4	OK
6 MESSINA GROVE 6069	25.53	94	GF	Res.	46	45	-1	55	-10	75	74	-1	80	-6	OK
6 VAUCLUSE CRESCENT 6069	25.53	26	GF	Res.	54	52	-2	55	-3	86	83	-3	80	3	OK
5 VAUCLUSE CRESCENT 6069	25.54	65	GF	Res.	47	47	0	55	-8	73	74	1	80	-6	OK
5 MESSINA GROVE 6069	25.54	50	GF	Res.	54	51	-3	55	-4	84	80	-4	80	0	OK
8 MESSINA GROVE 6069	25.54	96	GF	Res.	46	45	-1	55	-10	75	74	-1	80	-6	OK
8 VAUCLUSE CRESCENT 6069	25.54	21	GF	Res.	56	54	-2	55	-1	87	85	-2	80	5	OK
10 VAUCLUSE CRESCENT 6069	25.56	23	GF	Res.	56	54	-2	55	-1	87	85	-2	80	5	OK
7 MESSINA GROVE 6069	25.56	52	GF	Res.	54	51	-3	55	-4	84	80	-4	80	0	OK
7 VAUCLUSE CRESCENT 6069	25.57	68	GF	Res.	46	46	0	55	-9	73	74	1	80	-6	OK
12 VAUCLUSE CRESCENT 6069	25.58	25	GF	Res.	56	54	-2	55	-1	87	85	-2	80	5	OK
9 MESSINA GROVE 6069	25.58	49	GF	Res.	53	51	-2	55	-4	84	81	-3	80	1	OK
2 TOULON LANE 6069	25.58	104	GF	Res.	47	47	0	55	-8	76	76	0	80	-4	OK
4 TOULON LANE 6069	25.59	123	GF	Res.	45	45	0	55	-10	76	76	0	80	-4	OK
9 VAUCLUSE CRESCENT 6069	25.59	67	GF	Res.	47	47	0	55	-8	77	76	-1	80	-4	OK
14 VAUCLUSE CRESCENT 6069	25.59	24	GF	Res.	57	55	-2	55	0	88	86	-2	80	6	OK
11 MESSINA GROVE 6069	25.60	56	GF	Res.	53	51	-2	55	-4	84	81	-3	80	1	OK

Address	Ch ain	Dis tan	Flo	Us age	$L_{Aeq,night}$, dB					L_{Amax}, dB					Lik ely
16 VAUCLUSE CRESCENT 6069	25.61	27	GF	Res.	58	54	-4	55	-1	89	85	-4	80	5	OK
11 VAUCLUSE CRESCENT 6069	25.62	80	GF	Res.	50	48	-2	55	-7	81	79	-2	80	-1	OK
15 VAUCLUSE CRESCENT 6069	25.63	89	GF	Res.	50	48	-2	55	-7	81	79	-2	80	-1	OK
17 VAUCLUSE CRESCENT 6069	25.65	110	GF	Res.	48	47	-1	55	-8	80	78	-2	80	-2	OK
19 VAUCLUSE CRESCENT 6069	25.65	125	GF	Res.	47	46	-1	55	-9	79	77	-2	80	-3	OK
PLAZA TURN 6069	25.98	197	GF	RC	41	40	-1	-	-	69	69	0	-	-	OK
48 ELLEN STIRLING BLVD ELLENBROOK (Note[1])	26.25	76	F 1	RC	40	40	0	-	-	68	68	0	-	-	OK
48 ELLEN STIRLING BLVD ELLENBROOK	26.25	76	GF	RC	40	40	0	-	-	68	69	1	-	-	OK
17 COMMERCIAL ROAD ELLENBROOK (Note[1])	26.30	41	F 1	RC	39	38	-1	-	-	66	66	0	-	-	OK
17 COMMERCIAL ROAD ELLENBROOK	26.30	41	GF	RC	40	39	-1	-	-	67	67	0	-	-	OK
2 CIVIC TERRACE 6069	26.31	132	GF	Res.	31	32	1	55	-23	56	57	1	80	-23	OK
151 THE PROMENADE	26.36	32	GF	RC	38	38	0	-	-	65	65	0	-	-	OK
5 LOCKE LANE 6069	26.46	143	GF	Res.	32	33	1	55	-22	58	58	0	80	-22	OK
3 LOCKE LANE 6069	26.47	90	GF	Res.	33	33	0	55	-22	57	57	0	80	-23	OK
1/11 COMSERV LOOP 6069	26.50	115	GF	Res.	29	29	0	55	-26	52	52	0	80	-28	OK
1/15 COMSERV LOOP 6069	26.52	82	GF	Res.	37	37	0	55	-18	64	64	0	80	-16	OK
16 COMSERV LOOP 6069	26.57	143	GF	Res.	32	32	0	55	-23	60	60	0	80	-20	OK
19 COMSERV LOOP 6069	26.58	51	GF	Res.	36	36	0	55	-19	63	63	0	80	-17	OK
19 COMSERV LOOP 6069	26.58	78	GF	Res.	28	28	0	55	-27	51	51	0	80	-29	OK
20 COMSERV LOOP 6069	26.59	122	GF	Res.	28	28	0	55	-27	50	50	0	80	-30	OK
3/24 COMSERV LOOP 6069	26.61	119	GF	Res.	34	33	-1	55	-22	62	62	0	80	-18	OK
23 COMSERV LOOP 6069	26.61	20	GF	Res.	37	37	0	55	-18	60	60	0	80	-20	OK
27 COMSERV LOOP 6069	26.63	21	GF	RC	36	36	0	-	-	59	59	0	-	-	OK
87 GRANESSE DRIVE 6069	26.63	119	GF	Res.	28	28	0	55	-27	50	50	0	80	-30	OK
89 GRANESSE DRIVE 6069	26.63	142	GF	Res.	30	30	0	55	-25	55	55	0	80	-25	OK
28 COMSERV LOOP 6069	26.64	108	GF	Res.	29	29	0	55	-26	54	54	0	80	-26	OK
31 COMSERV LOOP 6069	26.67	22	GF	Res.	34	34	0	55	-21	59	59	0	80	-21	OK
30 COMSERV LOOP 6069	26.68	90	GF	Res.	30	30	0	55	-25	57	57	0	80	-23	OK
62 GRANESSE DRIVE 6069	26.68	88	GF	Res.	30	30	0	55	-25	55	55	0	80	-25	OK
60 GRANESSE DRIVE 6069	26.68	70	GF	Res.	31	31	0	55	-24	55	55	0	80	-25	OK
64 GRANESSE DRIVE 6069	26.69	106	GF	Res.	30	30	0	55	-25	54	54	0	80	-26	OK
58 GRANESSE DRIVE 6069	26.69	38	GF	Res.	32	32	0	55	-23	56	56	0	80	-24	OK
33 COMSERV LOOP 6069	26.69	23	GF	Res.	35	35	0	55	-20	59	59	0	80	-21	OK
36 COMSERV LOOP 6069	26.69	120	GF	Res.	25	25	0	55	-30	49	49	0	80	-31	OK
56 GRANESSE DRIVE 6069	26.71	36	GF	Res.	32	32	0	55	-23	56	56	0	80	-24	OK
54 GRANESSE DRIVE 6069	26.72	38	GF	Res.	32	32	0	55	-23	56	56	0	80	-24	OK
51 THE BROADWAY 6069	26.72	48	GF	Res.	30	30	0	55	-25	55	55	0	80	-25	OK
52 GRANESSE DRIVE 6069	26.74	38	GF	Res.	32	32	0	55	-23	55	55	0	80	-25	OK
3 GLADMAN PASS 6069	26.74	74	GF	Res.	29	29	0	55	-26	52	52	0	80	-28	OK
5 GLADMAN PASS 6069	26.74	90	GF	Res.	30	30	0	55	-25	53	53	0	80	-27	OK
51 THE BROADWAY 6069	26.75	50	GF	Res.	31	31	0	55	-24	54	54	0	80	-26	OK
4 GLADMAN PASS 6069	26.76	56	GF	Res.	30	30	0	55	-25	53	53	0	80	-27	OK
6 GLADMAN PASS 6069	26.76	75	GF	Res.	30	30	0	55	-25	52	52	0	80	-28	OK
8 GLADMAN PASS 6069	26.77	88	GF	Res.	30	30	0	55	-25	54	54	0	80	-26	OK
2 GLADMAN PASS 6069	26.77	34	GF	Res.	32	32	0	55	-23	56	56	0	80	-24	OK
51 THE BROADWAY 6069	26.80	29	GF	RC	33	33	0	-	-	56	56	0	-	-	OK
43 ROCKLEA CRESCENT 6069	26.80	145	GF	Res.	28	28	0	55	-27	52	52	0	80	-28	OK
48 GRANESSE DRIVE 6069	26.80	37	GF	Res.	32	32	0	55	-23	56	56	0	80	-24	OK
4 HALPIN CIRCLE 6069	26.80	73	GF	Res.	30	30	0	55	-25	52	52	0	80	-28	OK
45 ROCKLEA CRESCENT 6069	26.81	132	GF	Res.	29	29	0	55	-26	52	52	0	80	-28	OK
6 HALPIN CIRCLE 6069	26.82	74	GF	Res.	29	29	0	55	-26	53	53	0	80	-27	OK
47 ROCKLEA CRESCENT 6069	26.82	119	GF	Res.	28	28	0	55	-27	52	52	0	80	-28	OK
46 GRANESSE DRIVE 6069	26.82	37	GF	Res.	31	31	0	55	-24	56	56	0	80	-24	OK
49 ROCKLEA CRESCENT 6069	26.83	108	GF	Res.	28	28	0	55	-27	51	51	0	80	-29	OK
8 HALPIN CIRCLE 6069	26.84	71	GF	Res.	29	29	0	55	-26	53	53	0	80	-27	OK
44 GRANESSE DRIVE 6069	26.85	34	GF	Res.	31	31	0	55	-24	56	56	0	80	-24	OK
10 HALPIN CIRCLE 6069	26.86	78	GF	Res.	29	29	0	55	-26	52	52	0	80	-28	OK
42 GRANESSE DRIVE 6069	26.86	36	GF	Res.	31	31	0	55	-24	55	55	0	80	-25	OK
53 ROCKLEA CRESCENT 6069	26.86	91	GF	Res.	28	28	0	55	-27	51	51	0	80	-29	OK
12 HALPIN CIRCLE 6069	26.87	69	GF	Res.	29	30	1	55	-25	53	53	0	80	-27	OK
55 ROCKLEA CRESCENT 6069	26.88	103	GF	Res.	28	28	0	55	-27	52	52	0	80	-28	OK
57 ROCKLEA CRESCENT 6069	26.88	117	GF	Res.	28	28	0	55	-27	50	50	0	80	-30	OK

Address	Ch ain	Dis tan	Flo	Us age	$L_{Aeq,night}$, dB					L_{Amax}, dB					Lik ely
40 GRANESSE DRIVE 6069	26.88	37	GF	Res.	31	31	0	55	-24	55	55	0	80	-25	OK
59 ROCKLEA CRESCENT 6069	26.89	129	GF	Res.	26	26	0	55	-29	48	48	0	80	-32	OK
14 HALPIN CIRCLE 6069	26.89	76	GF	Res.	29	29	0	55	-26	51	51	0	80	-29	OK
65 PINEGROVE DRIVE 6069	26.90	78	GF	Res.	28	28	0	55	-27	51	51	0	80	-29	OK
16 HALPIN CIRCLE 6069	26.91	61	GF	Res.	29	29	0	55	-26	53	53	0	80	-27	OK
63 PINEGROVE DRIVE 6069	26.91	98	GF	Res.	25	25	0	55	-30	49	49	0	80	-31	OK
61 PINEGROVE DRIVE 6069	26.92	119	GF	Res.	26	26	0	55	-29	48	48	0	80	-32	OK
38 GRANESSE DRIVE 6069	26.92	36	GF	Res.	30	30	0	55	-25	55	55	0	80	-25	OK
18 HALPIN CIRCLE 6069	26.93	65	GF	Res.	28	28	0	55	-27	52	52	0	80	-28	OK
36 GRANESSE DRIVE 6069	26.94	37	GF	Res.	30	30	0	55	-25	54	54	0	80	-26	OK
20 HALPIN CIRCLE 6069	26.94	75	GF	Res.	28	28	0	55	-27	52	52	0	80	-28	OK
104 PINEGROVE DRIVE 6069	26.95	64	GF	Res.	29	29	0	55	-26	52	52	0	80	-28	OK
34 GRANESSE DRIVE 6069	26.95	37	GF	Res.	30	30	0	55	-25	55	55	0	80	-25	OK
22 HALPIN CIRCLE 6069	26.96	76	GF	Res.	28	28	0	55	-27	52	52	0	80	-28	OK
34 GRANESSE DRIVE 6069	26.96	38	GF	Res.	30	30	0	55	-25	55	55	0	80	-25	OK
98 PINEGROVE DRIVE 6069	26.96	112	GF	Res.	26	26	0	55	-29	49	49	0	80	-31	OK
102 PINEGROVE DRIVE 6069	26.96	92	GF	Res.	26	26	0	55	-29	50	50	0	80	-30	OK
24A HALPIN CIRCLE 6069	26.97	69	GF	Res.	29	29	0	55	-26	52	52	0	80	-28	OK
58 LARRAWA CIRCLE 6069	26.98	63	GF	Res.	27	27	0	55	-28	52	52	0	80	-28	OK
32 GRANESSE DRIVE 6069	26.98	37	GF	Res.	30	30	0	55	-25	55	55	0	80	-25	OK
24A HALPIN CIRCLE 6069	26.99	80	GF	Res.	28	28	0	55	-27	51	51	0	80	-29	OK
24A HALPIN CIRCLE 6069	26.99	57	GF	Res.	29	29	0	55	-26	54	54	0	80	-26	OK
60 LARRAWA CIRCLE 6069	27.00	82	GF	Res.	26	26	0	55	-29	50	50	0	80	-30	OK
62 LARRAWA CIRCLE 6069	27.00	93	GF	Res.	25	25	0	55	-30	50	50	0	80	-30	OK
64 LARRAWA CIRCLE 6069	27.00	105	GF	Res.	26	26	0	55	-29	49	49	0	80	-31	OK
30 GRANESSE DRIVE 6069	27.01	31	GF	Res.	30	30	0	55	-25	56	56	0	80	-24	OK
28 GRANESSE DRIVE 6069	27.02	58	GF	Res.	28	28	0	55	-27	52	52	0	80	-28	OK
26 GRANESSE DRIVE 6069	27.02	78	GF	Res.	27	27	0	55	-28	51	51	0	80	-29	OK
35 LARRAWA CIRCLE 6069	27.03	77	GF	Res.	27	27	0	55	-28	50	50	0	80	-30	OK
35 LARRAWA CIRCLE 6069	27.04	98	GF	Res.	25	25	0	55	-30	49	49	0	80	-31	OK
39 LARRAWA CIRCLE 6069	27.04	113	GF	Res.	25	25	0	55	-30	50	50	0	80	-30	OK
1 DUCANE WAY 6069	27.05	38	GF	Res.	29	29	0	55	-26	54	54	0	80	-26	OK
27 GRANESSE DRIVE 6069	27.05	66	GF	Res.	27	27	0	55	-28	52	52	0	80	-28	OK
83 LARRAWA CIRCLE 6069	27.05	80	GF	Res.	27	27	0	55	-28	51	51	0	80	-29	OK
25 GRANESSE DRIVE 6069	27.06	84	GF	Res.	26	26	0	55	-29	50	50	0	80	-30	OK
3 DUCANE WAY 6069	27.07	38	GF	Res.	27	27	0	55	-28	53	53	0	80	-27	OK
81 LARRAWA CIRCLE 6069	27.07	95	GF	Res.	23	23	0	55	-32	47	47	0	80	-33	OK
79 LARRAWA CIRCLE 6069	27.07	108	GF	Res.	23	23	0	55	-32	47	47	0	80	-33	OK

Note 1 “GF” Ground floor; “F 1” first floor. SPP5.4 criteria apply to ground level locations only.

C.2 Vibration

The following table lists forecasted individual property results in terms of ground-borne vibration (GBV) and ground-borne noise (GBN).

Table C.24 Individual GBV and GBN results by location (ordered by increasing chainage)

Address	Usage	Existing DN chainage, km	Distance, m	GBV (dB re 1nm/s)					GBN (dB re 20 µpa)					Likely Result
				Target	Build	Margin	Build+M	Margin	Target	Build	Margin	Build+M	Margin	
CRANLEIGH STREET 6063	Res.	17.11	39	106	110	4	100	-6	35	42	7	32	-3	OK
33 DULWICH STREET 6063	Res.	17.13	101	106	101	-5	91	-15	35	33	-2	23	-12	OK
51 DULWICH STREET 6063	Res.	17.29	41	106	109	3	100	-6	35	42	7	32	-3	OK
58 DULWICH STREET 6063	Res.	17.37	93	106	102	-4	100	-6	35	34	-1	32	-3	OK
58 DULWICH STREET 6063	Res.	17.39	91	106	102	-4	101	-5	35	34	-1	33	-2	OK
60 CHELTENHAM STREET 6063	Comm.	17.74	41	112	107	-5	107	-5	45	40	-5	40	-5	OK
60 CHELTENHAM STREET 6063	Comm.	17.75	66	112	103	-9	103	-9	45	35	-10	35	-10	OK
60 CHELTENHAM STREET 6063	Comm.	17.79	92	112	99	-13	99	-13	45	31	-14	31	-14	OK
60 CHELTENHAM STREET 6063	Comm.	17.86	31	112	109	-3	109	-3	45	42	-3	42	-3	OK
53 RUGBY STREET 6063	Res.	17.99	102	106	98	-8	90	-16	35	30	-5	22	-13	OK
53 RUGBY STREET 6063	Res.	18.01	32	106	109	3	99	-7	35	42	7	32	-3	OK
53 RUGBY STREET 6063	Res.	18.02	50	106	105	-1	95	-11	35	37	2	27	-8	OK
53 RUGBY STREET 6063	Res.	18.02	46	106	106	0	96	-10	35	38	3	28	-7	OK
67 RUGBY STREET 6063	Res.	18.03	79	106	101	-5	91	-15	35	33	-2	23	-12	OK
67 RUGBY STREET 6063	Res.	18.04	62	106	103	-3	93	-13	35	35	0	25	-10	OK
67 RUGBY STREET 6063	Res.	18.06	58	106	104	-2	94	-12	35	36	1	26	-9	OK
67 RUGBY STREET 6063	Res.	18.07	79	106	101	-5	91	-15	35	33	-2	23	-12	OK
64 RUGBY STREET 6063	Res.	18.14	24	106	111	5	101	-5	35	44	9	34	-1	OK
64 RUGBY STREET 6063	Res.	18.14	55	106	104	-2	94	-12	35	36	1	26	-9	OK
75 RUGBY STREET 6063	Res.	18.18	84	106	100	-6	91	-15	35	32	-3	23	-12	OK
LORD STREET 6068	Res.	19.90	79	106	98	-8	102	-4	35	31	-4	34	-1	OK
80 WANDSWORTH AVENUE 6055	Res.	20.82	84	106	102	-4	96	-10	35	34	-1	28	-7	OK
78 WANDSWORTH AVENUE 6055	Res.	20.83	84	106	102	-4	95	-11	35	34	-1	27	-8	OK
76 WANDSWORTH AVENUE 6055	Res.	20.84	84	106	102	-4	95	-11	35	34	-1	27	-8	OK
74 WANDSWORTH AVENUE 6055	Res.	20.85	84	106	102	-4	94	-12	35	34	-1	26	-9	OK
72 WANDSWORTH AVENUE 6055	Res.	20.88	85	106	102	-4	93	-13	35	34	-1	26	-9	OK
68 WANDSWORTH AVENUE 6055	Res.	20.89	82	106	102	-4	94	-12	35	34	-1	26	-9	OK
70 WANDSWORTH AVENUE 6055	Res.	20.89	84	106	102	-4	94	-12	35	34	-1	26	-9	OK
66 WANDSWORTH AVENUE 6055	Res.	20.90	86	106	102	-4	93	-13	35	34	-1	25	-10	OK
64 WANDSWORTH AVENUE 6055	Res.	20.92	85	106	102	-4	94	-12	35	34	-1	26	-9	OK
62 WANDSWORTH AVENUE 6055	Res.	20.93	84	106	102	-4	94	-12	35	34	-1	26	-9	OK
60 WANDSWORTH AVENUE 6055	Res.	20.95	85	106	102	-4	93	-13	35	34	-1	26	-9	OK
58 WANDSWORTH AVENUE 6055	Res.	20.96	84	106	102	-4	94	-12	35	34	-1	26	-9	OK
56 WANDSWORTH AVENUE 6055	Res.	20.97	84	106	102	-4	94	-12	35	34	-1	26	-9	OK
54 WANDSWORTH AVENUE 6055	Res.	21.00	83	106	102	-4	94	-12	35	34	-1	26	-9	OK
52 WANDSWORTH AVENUE 6055	Res.	21.00	83	106	102	-4	94	-12	35	34	-1	26	-9	OK
50 WANDSWORTH AVENUE 6055	Res.	21.03	83	106	102	-4	94	-12	35	34	-1	26	-9	OK
48 WANDSWORTH AVENUE 6055	Res.	21.03	82	106	102	-4	94	-12	35	34	-1	26	-9	OK
46 WANDSWORTH AVENUE 6055	Res.	21.05	88	106	102	-4	93	-13	35	34	-1	25	-10	OK
44 WANDSWORTH AVENUE 6055	Res.	21.06	85	106	102	-4	93	-13	35	34	-1	25	-10	OK
42 WANDSWORTH AVENUE 6055	Res.	21.08	82	106	102	-4	94	-12	35	34	-1	26	-9	OK
40 WANDSWORTH AVENUE 6055	Res.	21.08	84	106	102	-4	94	-12	35	34	-1	26	-9	OK
38 WANDSWORTH AVENUE 6055	Res.	21.10	83	106	102	-4	94	-12	35	34	-1	26	-9	OK
34 WANDSWORTH AVENUE 6055	Res.	21.13	83	106	102	-4	94	-12	35	34	-1	26	-9	OK
36 WANDSWORTH AVENUE 6055	Res.	21.13	84	106	102	-4	94	-12	35	34	-1	26	-9	OK
32 WANDSWORTH AVENUE 6055	Res.	21.15	83	106	102	-4	94	-12	35	34	-1	26	-9	OK
30 WANDSWORTH AVENUE 6055	Res.	21.16	82	106	102	-4	94	-12	35	34	-1	26	-9	OK
28 WANDSWORTH AVENUE 6055	Res.	21.17	82	106	103	-3	94	-12	35	35	0	26	-9	OK

Address	Usage	Existing DN chainage, km	Distance, m	GBV (dB re 1nm/s)					GBN (dB re 20 µpa)					Likely Result
				Target	Build	Margin	Build+M	Margin	Target	Build	Margin	Build+M	Margin	
26 WANDSWORTH AVENUE 6055	Res.	21.19	82	106	103	-3	94	-12	35	35	0	26	-9	OK
24 WANDSWORTH AVENUE 6055	Res.	21.19	82	106	103	-3	94	-12	35	35	0	26	-9	OK
37 PAPAGO LOOP 6055	Res.	21.29	92	106	101	-5	93	-13	35	33	-2	25	-10	OK
39 PAPAGO LOOP 6055	Res.	21.30	87	106	102	-4	93	-13	35	34	-1	25	-10	OK
41 PAPAGO LOOP 6055	Res.	21.31	87	106	102	-4	93	-13	35	34	-1	25	-10	OK
43 PAPAGO LOOP 6055	Res.	21.32	86	106	102	-4	93	-13	35	34	-1	25	-10	OK
45 PAPAGO LOOP 6055	Res.	21.33	86	106	102	-4	93	-13	35	34	-1	25	-10	OK
47 PAPAGO LOOP 6055	Res.	21.34	85	106	102	-4	94	-12	35	34	-1	26	-9	OK
49 PAPAGO LOOP 6055	Res.	21.34	83	106	103	-3	94	-12	35	35	0	26	-9	OK
51 PAPAGO LOOP 6055	Res.	21.36	87	106	102	-4	93	-13	35	34	-1	25	-10	OK
53 PAPAGO LOOP 6055	Res.	21.37	87	106	102	-4	93	-13	35	34	-1	25	-10	OK
55 PAPAGO LOOP 6055	Res.	21.38	85	106	102	-4	93	-13	35	34	-1	25	-10	OK
57 PAPAGO LOOP 6055	Res.	21.40	82	106	103	-3	94	-12	35	35	0	26	-9	OK
59 PAPAGO LOOP 6055	Res.	21.41	86	106	102	-4	93	-13	35	34	-1	25	-10	OK
61 PAPAGO LOOP 6055	Res.	21.42	83	106	103	-3	94	-12	35	35	0	26	-9	OK
63 PAPAGO LOOP 6055	Res.	21.43	86	106	102	-4	93	-13	35	34	-1	25	-10	OK
65 PAPAGO LOOP 6055	Res.	21.44	85	106	102	-4	93	-13	35	34	-1	26	-9	OK
67 PAPAGO LOOP 6055	Res.	21.45	89	106	102	-4	93	-13	35	34	-1	25	-10	OK
69 PAPAGO LOOP 6055	Res.	21.46	88	106	102	-4	93	-13	35	34	-1	25	-10	OK
73 PAPAGO LOOP 6055	Res.	21.47	88	106	102	-4	93	-13	35	34	-1	25	-10	OK
71 PAPAGO LOOP 6055	Res.	21.47	89	106	102	-4	93	-13	35	34	-1	25	-10	OK
75 PAPAGO LOOP 6055	Res.	21.48	86	106	102	-4	93	-13	35	34	-1	25	-10	OK
77 PAPAGO LOOP 6055	Res.	21.49	90	106	102	-4	93	-13	35	34	-1	25	-10	OK
79 PAPAGO LOOP 6055	Res.	21.50	87	106	102	-4	93	-13	35	34	-1	25	-10	OK
81 PAPAGO LOOP 6055	Res.	21.51	88	106	102	-4	93	-13	35	34	-1	25	-10	OK
83 PAPAGO LOOP 6055	Res.	21.53	86	106	102	-4	93	-13	35	34	-1	25	-10	OK
85 PAPAGO LOOP 6055	Res.	21.54	90	106	102	-4	93	-13	35	34	-1	25	-10	OK
87 PAPAGO LOOP 6055	Res.	21.55	86	106	102	-4	93	-13	35	34	-1	25	-10	OK
89 PAPAGO LOOP 6055	Res.	21.55	87	106	102	-4	93	-13	35	34	-1	25	-10	OK
91 PAPAGO LOOP 6055	Res.	21.56	88	106	102	-4	93	-13	35	34	-1	25	-10	OK
93 PAPAGO LOOP 6055	Res.	21.58	91	106	102	-4	93	-13	35	34	-1	25	-10	OK
95 PAPAGO LOOP 6055	Res.	21.59	89	106	102	-4	93	-13	35	34	-1	25	-10	OK
97 PAPAGO LOOP 6055	Res.	21.60	88	106	102	-4	93	-13	35	34	-1	25	-10	OK
99 PAPAGO LOOP 6055	Res.	21.61	90	106	102	-4	93	-13	35	34	-1	25	-10	OK
103 PAPAGO LOOP 6055	Res.	21.64	90	106	102	-4	93	-13	35	34	-1	25	-10	OK
101 PAPAGO LOOP 6055	Res.	21.64	89	106	102	-4	93	-13	35	34	-1	25	-10	OK
105 PAPAGO LOOP 6055	Res.	21.66	88	106	102	-4	93	-13	35	34	-1	25	-10	OK
107 PAPAGO LOOP 6055	Res.	21.68	89	106	102	-4	93	-13	35	34	-1	25	-10	OK
109 PAPAGO LOOP 6055	Res.	21.69	88	106	102	-4	93	-13	35	34	-1	25	-10	OK
111 PAPAGO LOOP 6055	Res.	21.70	86	106	103	-3	93	-13	35	35	0	25	-10	OK
12 CHARLTON WAY 6055	Res.	21.75	103	106	101	-5	91	-15	35	33	-2	23	-12	OK
14 CHARLTON WAY 6055	Res.	21.75	89	106	102	-4	93	-13	35	34	-1	25	-10	OK
9 PALEY WAY 6055	Res.	21.79	98	106	101	-5	92	-14	35	33	-2	24	-11	OK
32 ROSSINI CIRCLE 6069	Res.	24.41	102	106	99	-7	96	-10	35	31	-4	28	-7	OK
30 ROSSINI CIRCLE 6069	Res.	24.44	100	106	99	-7	95	-11	35	31	-4	27	-8	OK
28 ROSSINI CIRCLE 6069	Res.	24.45	99	106	99	-7	94	-12	35	31	-4	26	-9	OK
26 ROSSINI CIRCLE 6069	Res.	24.47	95	106	100	-6	93	-13	35	32	-3	25	-10	OK
24 ROSSINI CIRCLE 6069	Res.	24.47	87	106	101	-5	93	-13	35	33	-2	25	-10	OK
22 ROSSINI CIRCLE 6069	Res.	24.49	91	106	100	-6	91	-15	35	32	-3	23	-12	OK
20 ROSSINI CIRCLE 6069	Res.	24.51	80	106	101	-5	91	-15	35	33	-2	23	-12	OK
18 ROSSINI CIRCLE 6069	Res.	24.52	77	106	102	-4	92	-14	35	34	-1	24	-11	OK
16 ROSSINI CIRCLE 6069	Res.	24.54	81	106	101	-5	91	-15	35	33	-2	23	-12	OK
14 ROSSINI CIRCLE 6069	Res.	24.55	76	106	102	-4	92	-14	35	34	-1	24	-11	OK
12 ROSSINI CIRCLE 6069	Res.	24.56	71	106	103	-3	93	-13	35	35	0	25	-10	OK
10 ROSSINI CIRCLE 6069	Res.	24.58	68	106	103	-3	93	-13	35	35	0	25	-10	OK
8 ROSSINI CIRCLE 6069	Res.	24.61	66	106	103	-3	93	-13	35	35	0	25	-10	OK

Address	Usage	Existing DN chainage, km	Distance, m	GBV (dB re 1nm/s)					GBN (dB re 20 µpa)					Likely Result
				Target	Build	Margin	Build+M	Margin	Target	Build	Margin	Build+M	Margin	
6 ROSSINI CIRCLE 6069	Res.	24.62	59	106	104	-2	94	-12	35	37	2	27	-8	OK
4 ROSSINI CIRCLE 6069	Res.	24.64	61	106	104	-2	94	-12	35	36	1	26	-9	OK
130 PONTE VECCHIO BOULEVARD 6069	Res.	24.64	98	106	99	-7	89	-17	35	31	-4	21	-14	OK
2 ROSSINI CIRCLE 6069	Res.	24.66	49	106	106	0	96	-10	35	38	3	28	-7	OK
121 PONTE VECCHIO BOULEVARD 6069	Res.	24.69	60	106	104	-2	94	-12	35	36	1	26	-9	OK
123 PONTE VECCHIO BOULEVARD 6069	Res.	24.69	77	106	102	-4	92	-14	35	34	-1	24	-11	OK
125 PONTE VECCHIO BOULEVARD 6069	Res.	24.70	92	106	100	-6	90	-16	35	32	-3	22	-13	OK
117 PONTE VECCHIO BOULEVARD 6069	Res.	24.74	49	106	106	0	96	-10	35	38	3	28	-7	OK
115 PONTE VECCHIO BOULEVARD 6069	Res.	24.75	65	106	103	-3	93	-13	35	36	1	26	-9	OK
2 SANTORINI TURN 6069	Res.	24.76	78	106	102	-4	92	-14	35	34	-1	24	-11	OK
4 SANTORINI TURN 6069	Res.	24.77	88	106	101	-5	91	-15	35	33	-2	23	-12	OK
116 PONTE VECCHIO BOULEVARD 6069	Res.	24.77	25	106	112	6	102	-4	35	45	10	35	0	OK
6 SANTORINI TURN 6069	Res.	24.77	102	106	99	-7	89	-17	35	31	-4	21	-14	OK
1 SANTORINI TURN 6069	Res.	24.80	75	106	102	-4	92	-14	35	34	-1	24	-11	OK
114 PONTE VECCHIO BOULEVARD 6069	Res.	24.80	28	106	111	5	101	-5	35	44	9	34	-1	OK
3 SANTORINI TURN 6069	Res.	24.81	90	106	100	-6	90	-16	35	32	-3	22	-13	OK
112 PONTE VECCHIO BOULEVARD 6069	Res.	24.82	25	106	112	6	102	-4	35	44	9	34	-1	OK
5 SANTORINI TURN 6069	Res.	24.82	105	106	99	-7	89	-17	35	31	-4	21	-14	OK
110 PONTE VECCHIO BOULEVARD 6069	Res.	24.82	22	106	113	7	103	-3	35	46	11	36	1	+1 dB
2 VERONA WAY 6069	Res.	24.83	70	106	103	-3	93	-13	35	35	0	25	-10	OK
108 PONTE VECCHIO BOULEVARD 6069	Res.	24.84	22	106	113	7	103	-3	35	46	11	36	1	+1 dB
4 VERONA WAY 6069	Res.	24.85	85	106	101	-5	91	-15	35	33	-2	23	-12	OK
6 VERONA WAY 6069	Res.	24.85	97	106	100	-6	90	-16	35	32	-3	22	-13	OK
106 PONTE VECCHIO BOULEVARD 6069	Res.	24.86	23	106	113	7	103	-3	35	45	10	35	0	+0 dB
104 PONTE VECCHIO BOULEVARD 6069	Res.	24.87	23	106	113	7	103	-3	35	46	11	36	1	+1 dB
1 VERONA WAY 6069	Res.	24.88	69	106	103	-3	93	-13	35	35	0	25	-10	OK
102 PONTE VECCHIO BOULEVARD 6069	Res.	24.88	26	106	112	6	102	-4	35	44	9	34	-1	OK
3 VERONA WAY 6069	Res.	24.89	84	106	101	-5	91	-15	35	33	-2	23	-12	OK
100 PONTE VECCHIO BOULEVARD 6069	Res.	24.90	21	106	113	7	103	-3	35	46	11	36	1	+1 dB
5 VERONA WAY 6069	Res.	24.90	101	106	99	-7	89	-17	35	31	-4	21	-14	OK
98 PONTE VECCHIO BOULEVARD 6069	Res.	24.92	20	106	114	8	104	-2	35	47	12	37	2	+2 dB
91 PONTE VECCHIO BOULEVARD 6069	Res.	24.92	71	106	103	-3	93	-13	35	35	0	25	-10	OK
89 PONTE VECCHIO BOULEVARD 6069	Res.	24.93	87	106	101	-5	91	-15	35	33	-2	23	-12	OK
94 PONTE VECCHIO BOULEVARD 6069	Res.	24.96	34	106	109	3	99	-7	35	42	7	32	-3	OK
50 VALINCO AVENUE 6069	Res.	24.97	23	106	113	7	103	-3	35	46	11	36	1	+1 dB
92 PONTE VECCHIO BOULEVARD 6069	Res.	24.97	48	106	107	1	97	-9	35	39	4	29	-6	OK
90 PONTE VECCHIO BOULEVARD 6069	Res.	24.98	78	106	102	-4	92	-14	35	34	-1	24	-11	OK
88 PONTE VECCHIO BOULEVARD 6069	Res.	25.00	95	106	100	-6	90	-16	35	32	-3	22	-13	OK
48 VALINCO AVENUE 6069	Res.	25.00	31	106	110	4	100	-6	35	43	8	33	-2	OK
37 VALINCO AVENUE 6069	Res.	25.01	72	106	103	-3	93	-13	35	35	0	25	-10	OK
46 VALINCO AVENUE 6069	Res.	25.02	29	106	111	5	101	-5	35	44	9	34	-1	OK
33 VALINCO AVENUE 6069	Res.	25.04	95	106	100	-6	90	-16	35	32	-3	22	-13	OK
44 VALINCO AVENUE 6069	Res.	25.04	33	106	110	4	100	-6	35	43	8	33	-2	OK
42 VALINCO AVENUE 6069	Res.	25.06	35	106	109	3	99	-7	35	42	7	32	-3	OK
40 VALINCO AVENUE 6069	Res.	25.08	37	106	109	3	99	-7	35	41	6	31	-4	OK
38 VALINCO AVENUE 6069	Res.	25.09	38	106	109	3	99	-7	35	41	6	31	-4	OK
36 VALINCO AVENUE 6069	Res.	25.12	39	106	108	2	99	-7	35	41	6	31	-4	OK
35 VALINCO AVENUE 6069	Res.	25.03	77	106	102	-4	92	-14	35	34	-1	24	-11	OK
5 SANTONA BOULEVARD 6069	Comm.	25.18	35	112	109	-3	102	-10	45	41	-4	34	-11	OK
5 SANTONA BOULEVARD 6069	Comm.	25.20	80	112	101	-11	98	-14	45	33	-12	30	-15	OK
5 SANTONA BOULEVARD 6069	Comm.	25.20	42	112	107	-5	104	-8	45	39	-6	37	-8	OK
5 SANTONA BOULEVARD 6069	Comm.	25.26	46	112	107	-5	107	-5	45	40	-5	40	-5	OK
5 SANTONA BOULEVARD 6069	Comm.	25.27	80	112	102	-10	102	-10	45	34	-11	34	-11	OK
5 SANTONA BOULEVARD 6069	Comm.	25.30	89	112	101	-11	101	-11	45	33	-12	33	-12	OK
5 SANTONA BOULEVARD 6069	Comm.	25.37	53	112	106	-6	106	-6	45	38	-7	38	-7	OK
5 SANTONA BOULEVARD 6069	Comm.	25.39	43	112	108	-4	106	-6	45	40	-5	39	-6	OK

Address	Usage	Existing DN chainage, km	Distance, m	GBV (dB re 1nm/s)					GBN (dB re 20 µpa)					Likely Result
				Target	Build	Margin	Build+M	Margin	Target	Build	Margin	Build+M	Margin	
2 MESSINA GROVE 6069	Res.	25.49	89	106	101	-5	93	-13	35	33	-2	25	-10	OK
1 MESSINA GROVE 6069	Res.	25.50	46	106	107	1	97	-9	35	40	5	30	-5	OK
26 SAN LORENZO BOULEVARD 6069	Res.	25.50	99	106	100	-6	91	-15	35	32	-3	23	-12	OK
2 VAUCLUSE CRESCENT 6069	Res.	25.50	20	106	114	8	104	-2	35	47	12	37	2	**+2 dB**
4 MESSINA GROVE 6069	Res.	25.51	94	106	101	-5	91	-15	35	33	-2	23	-12	OK
22 SAN LORENZO BOULEVARD 6069	Res.	25.52	64	106	104	-2	94	-12	35	37	2	27	-8	OK
24 SAN LORENZO BOULEVARD 6069	Res.	25.52	83	106	102	-4	92	-14	35	34	-1	24	-11	OK
4 VAUCLUSE CRESCENT 6069	Res.	25.52	19	106	115	9	105	-1	35	48	13	38	3	**+3 dB**
3 MESSINA GROVE 6069	Res.	25.52	54	106	106	0	96	-10	35	38	3	28	-7	OK
3 VAUCLUSE CRESCENT 6069	Res.	25.53	66	106	104	-2	94	-12	35	36	1	26	-9	OK
6 MESSINA GROVE 6069	Res.	25.53	100	106	100	-6	90	-16	35	32	-3	22	-13	OK
5 VAUCLUSE CRESCENT 6069	Res.	25.54	65	106	104	-2	94	-12	35	36	1	26	-9	OK
5 MESSINA GROVE 6069	Res.	25.54	55	106	106	0	96	-10	35	38	3	28	-7	OK
6 VAUCLUSE CRESCENT 6069	Res.	25.54	27	106	112	6	102	-4	35	45	10	35	0	OK
14 VILLEFORT AVENUE 6069	Res.	25.54	95	106	100	-6	90	-16	35	32	-3	22	-13	OK
8 MESSINA GROVE 6069	Res.	25.54	101	106	100	-6	90	-16	35	32	-3	22	-13	OK
8 VAUCLUSE CRESCENT 6069	Res.	25.54	22	106	113	7	103	-3	35	46	11	36	1	**+1 dB**
7 VAUCLUSE CRESCENT 6069	Res.	25.56	69	106	104	-2	94	-12	35	36	1	26	-9	OK
7 MESSINA GROVE 6069	Res.	25.56	57	106	106	0	96	-10	35	38	3	28	-7	OK
10 VAUCLUSE CRESCENT 6069	Res.	25.56	21	106	114	8	104	-2	35	47	12	37	2	**+2 dB**
12 VAUCLUSE CRESCENT 6069	Res.	25.57	25	106	113	7	103	-3	35	45	10	35	0	OK
9 MESSINA GROVE 6069	Res.	25.58	54	106	106	0	97	-9	35	38	3	29	-6	OK
9 VAUCLUSE CRESCENT 6069	Res.	25.58	68	106	104	-2	95	-11	35	36	1	27	-8	OK
15 VILLEFORT AVENUE 6069	Res.	25.59	94	106	101	-5	94	-12	35	33	-2	26	-9	OK
11 MESSINA GROVE 6069	Res.	25.60	60	106	105	-1	97	-9	35	37	2	29	-6	OK
16 VAUCLUSE CRESCENT 6069	Res.	25.60	28	106	112	6	102	-4	35	44	9	35	0	OK
14 VAUCLUSE CRESCENT 6069	Res.	25.60	25	106	113	7	103	-3	35	45	10	36	1	**+1 dB**
11 VAUCLUSE CRESCENT 6069	Res.	25.61	74	106	103	-3	97	-9	35	35	0	29	-6	OK
15 VAUCLUSE CRESCENT 6069	Res.	25.63	87	106	101	-5	97	-9	35	33	-2	29	-6	OK
4 TRANSIT WAY 6069	Comm.	25.75	43	112	107	-5	107	-5	45	39	-6	39	-6	OK
38 ELLEN STIRLING PARADE 6069	Comm.	26.26	109	112	89	-23	89	-23	45	21	-24	21	-24	OK
151 THE PROMENADE 6069	Comm.	26.37	32	112	103	-9	103	-9	45	36	-9	36	-9	OK
3 LOCKE LANE 6069	Comm.	26.49	90	112	92	-20	92	-20	45	24	-21	24	-21	OK
1/15 COMSERV LOOP 6069	Comm.	26.52	86	112	92	-20	92	-20	45	24	-21	24	-21	OK
19 COMSERV LOOP 6069	Comm.	26.57	58	112	95	-17	95	-17	45	27	-18	27	-18	OK
19 COMSERV LOOP 6069	Comm.	26.59	78	112	92	-20	92	-20	45	24	-21	24	-21	OK
23 COMSERV LOOP 6069	Comm.	26.61	26	112	102	-10	102	-10	45	34	-11	34	-11	OK
27 COMSERV LOOP 6069	Comm.	26.63	24	112	102	-10	102	-10	45	35	-10	35	-10	OK
28 COMSERV LOOP 6069	Comm.	26.66	104	112	89	-23	89	-23	45	21	-24	21	-24	OK
31 COMSERV LOOP 6069	Comm.	26.66	28	112	101	-11	101	-11	45	34	-11	34	-11	OK
30 COMSERV LOOP 6069	Comm.	26.68	95	112	90	-22	90	-22	45	22	-23	22	-23	OK
33 COMSERV LOOP 6069	Comm.	26.68	29	112	101	-11	101	-11	45	34	-11	34	-11	OK
60 GRANESSE DRIVE 6069	Res.	26.69	66	106	95	-11	95	-11	35	27	-8	27	-8	OK
58 GRANESSE DRIVE 6069	Res.	26.70	39	106	100	-6	100	-6	35	32	-3	32	-3	OK
62 GRANESSE DRIVE 6069	Res.	26.71	83	106	93	-13	93	-13	35	25	-10	25	-10	OK
56 GRANESSE DRIVE 6069	Res.	26.71	37	106	100	-6	100	-6	35	32	-3	32	-3	OK
54 GRANESSE DRIVE 6069	Res.	26.73	39	106	100	-6	100	-6	35	32	-3	32	-3	OK
51 THE BROADWAY 6069	Comm.	26.73	51	112	96	-16	96	-16	45	29	-16	29	-16	OK
3 GLADMAN PASS 6069	Res.	26.73	65	106	95	-11	95	-11	35	27	-8	27	-8	OK
5 GLADMAN PASS 6069	Res.	26.74	84	106	93	-13	93	-13	35	25	-10	25	-10	OK
52 GRANESSE DRIVE 6069	Res.	26.75	39	106	100	-6	100	-6	35	32	-3	32	-3	OK
51 THE BROADWAY 6069	Comm.	26.75	56	112	96	-16	96	-16	45	28	-17	28	-17	OK
4 GLADMAN PASS 6069	Res.	26.77	53	106	97	-9	97	-9	35	29	-6	29	-6	OK
6 GLADMAN PASS 6069	Res.	26.77	67	106	95	-11	95	-11	35	27	-8	27	-8	OK
2 GLADMAN PASS 6069	Res.	26.77	35	106	100	-6	100	-6	35	33	-2	33	-2	OK
8 GLADMAN PASS 6069	Res.	26.78	83	106	93	-13	93	-13	35	25	-10	25	-10	OK

Address	Usage	Existing DN chainage, km	Distance, m	GBV (dB re 1nm/s)					GBN (dB re 20 µpa)					Likely Result
				Target	Build	Margin	Build+M	Margin	Target	Build	Margin	Build+M	Margin	
48 GRANESSE DRIVE 6069	Res.	26.81	38	106	100	-6	100	-6	35	32	-3	32	-3	OK
4 HALPIN CIRCLE 6069	Res.	26.81	74	106	94	-12	94	-12	35	26	-9	26	-9	OK
6 HALPIN CIRCLE 6069	Res.	26.83	75	106	94	-12	94	-12	35	26	-9	26	-9	OK
46 GRANESSE DRIVE 6069	Res.	26.83	38	106	100	-6	100	-6	35	32	-3	32	-3	OK
51 THE BROADWAY 6069	Comm.	26.85	28	112	101	-11	101	-11	45	33	-12	33	-12	OK
8 HALPIN CIRCLE 6069	Res.	26.85	72	106	94	-12	94	-12	35	26	-9	26	-9	OK
44 GRANESSE DRIVE 6069	Res.	26.85	35	106	100	-6	100	-6	35	33	-2	33	-2	OK
10 HALPIN CIRCLE 6069	Res.	26.86	79	106	93	-13	93	-13	35	25	-10	25	-10	OK
42 GRANESSE DRIVE 6069	Res.	26.87	36	106	100	-6	100	-6	35	32	-3	32	-3	OK
53 ROCKLEA CRESCENT 6069	Res.	26.87	95	106	91	-15	91	-15	35	23	-12	23	-12	OK
12 HALPIN CIRCLE 6069	Res.	26.88	70	106	94	-12	94	-12	35	27	-8	27	-8	OK
14 HALPIN CIRCLE 6069	Res.	26.89	65	106	95	-11	95	-11	35	27	-8	27	-8	OK
40 GRANESSE DRIVE 6069	Res.	26.89	38	106	100	-6	100	-6	35	32	-3	32	-3	OK
65 PINEGROVE DRIVE 6069	Res.	26.91	84	106	93	-13	93	-13	35	25	-10	25	-10	OK
16 HALPIN CIRCLE 6069	Res.	26.91	62	106	96	-10	96	-10	35	28	-7	28	-7	OK
63 PINEGROVE DRIVE 6069	Res.	26.91	101	106	91	-15	91	-15	35	23	-12	23	-12	OK
38 GRANESSE DRIVE 6069	Res.	26.93	37	106	100	-6	100	-6	35	32	-3	32	-3	OK
20 HALPIN CIRCLE 6069	Res.	26.94	75	106	94	-12	94	-12	35	26	-9	26	-9	OK
18 HALPIN CIRCLE 6069	Res.	26.94	66	106	95	-11	95	-11	35	27	-8	27	-8	OK
36 GRANESSE DRIVE 6069	Res.	26.95	37	106	100	-6	100	-6	35	32	-3	32	-3	OK
34 GRANESSE DRIVE 6069	Res.	26.95	37	106	100	-6	100	-6	35	32	-3	32	-3	OK
22 HALPIN CIRCLE 6069	Res.	26.95	77	106	93	-13	93	-13	35	26	-9	26	-9	OK
104 PINEGROVE DRIVE 6069	Res.	26.96	69	106	94	-12	94	-12	35	27	-8	27	-8	OK
102 PINEGROVE DRIVE 6069	Res.	26.97	90	106	92	-14	92	-14	35	24	-11	24	-11	OK
24A HALPIN CIRCLE 6069	Res.	26.98	70	106	94	-12	94	-12	35	27	-8	27	-8	OK
58 LARRAWA CIRCLE 6069	Res.	26.98	68	106	95	-11	95	-11	35	27	-8	27	-8	OK
24A HALPIN CIRCLE 6069	Res.	26.99	58	106	96	-10	96	-10	35	28	-7	28	-7	OK
32 GRANESSE DRIVE 6069	Res.	26.99	37	106	100	-6	100	-6	35	32	-3	32	-3	OK
24A HALPIN CIRCLE 6069	Res.	27.00	79	106	93	-13	93	-13	35	25	-10	25	-10	OK
26 HALPIN CIRCLE 6069	Res.	27.00	94	106	91	-15	91	-15	35	23	-12	23	-12	OK
60 LARRAWA CIRCLE 6069	Res.	27.00	79	106	93	-13	93	-13	35	25	-10	25	-10	OK
30 GRANESSE DRIVE 6069	Res.	27.00	32	106	101	-5	101	-5	35	33	-2	33	-2	OK
62 LARRAWA CIRCLE 6069	Res.	27.00	92	106	92	-14	92	-14	35	24	-11	24	-11	OK
28 GRANESSE DRIVE 6069	Res.	27.02	50	106	97	-9	97	-9	35	30	-5	30	-5	OK
24 GRANESSE DRIVE 6069	Res.	27.03	87	106	92	-14	92	-14	35	24	-11	24	-11	OK
26 GRANESSE DRIVE 6069	Res.	27.03	70	106	94	-12	94	-12	35	26	-9	26	-9	OK
35 LARRAWA CIRCLE 6069	Res.	27.04	81	106	93	-13	93	-13	35	25	-10	25	-10	OK
37 LARRAWA CIRCLE 6069	Res.	27.04	96	106	91	-15	91	-15	35	23	-12	23	-12	OK
27 GRANESSE DRIVE 6069	Res.	27.06	66	106	94	-12	94	-12	35	26	-9	26	-9	OK
25 GRANESSE DRIVE 6069	Res.	27.06	83	106	92	-14	92	-14	35	24	-11	24	-11	OK
3 DUCANE WAY 6069	Res.	27.06	38	106	99	-7	99	-7	35	31	-4	31	-4	OK
83 LARRAWA CIRCLE 6069	Res.	27.07	83	106	92	-14	92	-14	35	24	-11	24	-11	OK
81 LARRAWA CIRCLE 6069	Res.	27.07	98	106	90	-16	90	-16	35	22	-13	22	-13	OK
28 DELMAGE CIRCLE 6069	Res.	27.08	67	106	93	-13	93	-13	35	25	-10	25	-10	OK
31 DELMAGE CIRCLE 6069	Res.	27.08	91	106	88	-18	88	-18	35	20	-15	20	-15	OK
26 DELMAGE CIRCLE 6069	Res.	27.08	85	106	90	-16	90	-16	35	22	-13	22	-13	OK
29 DELMAGE CIRCLE 6069	Res.	27.08	71	106	91	-15	91	-15	35	23	-12	23	-12	OK
124 LARRAWA CIRCLE 6069	Res.	27.08	102	106	88	-18	88	-18	35	20	-15	20	-15	OK
27 DELMAGE CIRCLE 6069	Res.	27.08	58	106	93	-13	93	-13	35	25	-10	25	-10	OK
5 DUCANE WAY 6069	Res.	27.08	43	106	96	-10	96	-10	35	29	-6	29	-6	OK
126 LARRAWA CIRCLE 6069	Res.	27.08	88	106	90	-16	90	-16	35	22	-13	22	-13	OK
29 LARRAWA CIRCLE 6069	Res.	27.08	100	106	88	-18	88	-18	35	20	-15	20	-15	OK
25 DELMAGE CIRCLE 6069	Res.	27.08	86	106	90	-16	90	-16	35	21	-14	21	-14	OK
1 DUCANE WAY 6069	Res.	27.05	39	106	99	-7	99	-7	35	31	-4	31	-4	OK

APPENDIX D

D Result figures

D.1 Noise

Figure D.9 Single point receiver results, 'Build' scenario, Day period: Forecast $L_{Aeq,day}$ results prior to mitigation. Sheet 1 of 6.

Figure D.10 Single point receiver results, 'Build' scenario, Day period: Forecast $L_{Aeq,day}$ results prior to mitigation. Sheet 2 of 6.

Figure D.11 Single point receiver results, 'Build' scenario, Day period: Forecast $L_{Aeq,day}$ results prior to mitigation. Sheet 3 of 6.

Figure D.12 Single point receiver results, 'Build' scenario, Day period: Forecast $L_{Aeq,day}$ results prior to mitigation. Sheet 4 of 6.

Figure D.13 Single point receiver results, 'Build' scenario, Day period: Forecast $L_{Aeq,day}$ results prior to mitigation. Sheet 5 of 6.

Figure D.14 Single point receiver results, 'Build' scenario, Day period: Forecast $L_{Aeq,day}$ results prior to mitigation. Sheet 6 of 6.

Figure D.15 Single point receiver results, 'Build+M' (Build with mitigation) scenario, Day period: Forecast $L_{Aeq,day}$ results with mitigation. Sheet 1 of 6.

Figure D.16 Single point receiver results, 'Build+M' (Build with mitigation) scenario, Day period: Forecast $L_{Aeq,day}$ results with mitigation. Sheet 2 of 6.

Figure D.17 Single point receiver results, 'Build+M'' (Build with mitigation) scenario, Day period: Forecast $L_{Aeq,day}$ results with mitigation. Sheet 3 of 6.

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Figure D.18 Single point receiver results, 'Build+M' (Build with mitigation) scenario, Day period: Forecast $L_{Aeq,day}$ results with mitigation. Sheet 4 of 6.

Figure D.19 Single point receiver results, 'Build+M' (Build with mitigation) scenario, Day period: Forecast $L_{Aeq,day}$ results with mitigation. Sheet 5 of 6.

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Figure D.20 Single point receiver results, 'Build+M' (Build with mitigation) scenario, Day period: Forecast $L_{Aeq,day}$ results with mitigation. Sheet 6 of 6.

Figure D.21 Single point receiver results, 'Build+M' (Build with mitigation) scenario, Maximum Level: Forecast L_{Amax} results with mitigation. Sheet 1 of 6.

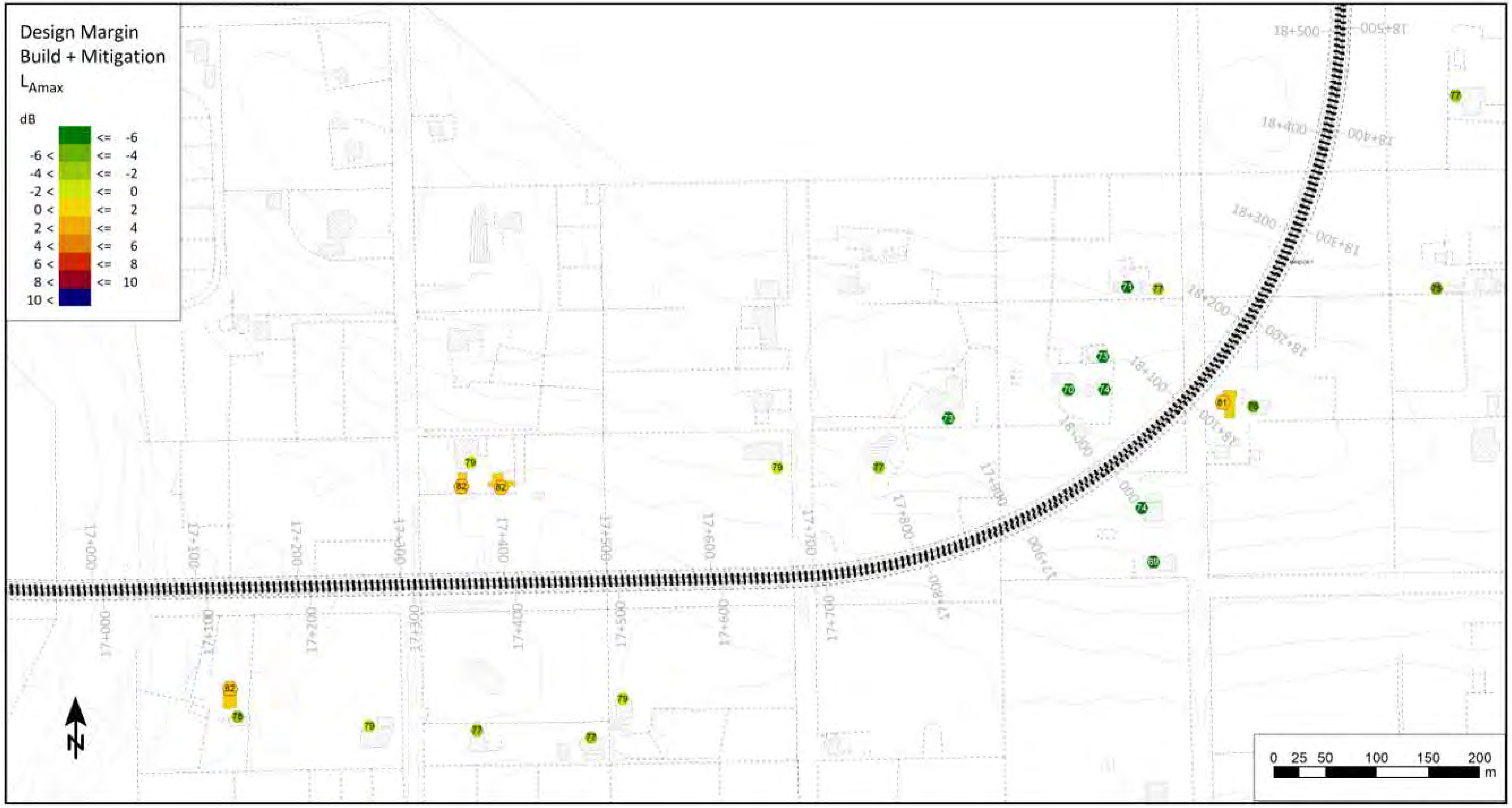


Figure D.22 Single point receiver results, 'Build+M' (Build with mitigation) scenario, Maximum Level: Forecast L_{Amax} results with mitigation. Sheet 2 of 6.

Figure D.23 Single point receiver results, 'Build+M'' (Build with mitigation) scenario, Maximum Level: Forecast L_{Amax} results with mitigation. Sheet 3 of 6.

Figure D.24 Single point receiver results, 'Build+M' (Build with mitigation) scenario, Maximum Level: Forecast L_{Amax} results with mitigation. Sheet 4 of 6.

Figure D.25 Single point receiver results, 'Build+M' (Build with mitigation) scenario, Maximum Level: Forecast L_{Amax} results with mitigation. Sheet 5 of 6.

Figure D.26 Single point receiver results, 'Build+M' (Build with mitigation) scenario, Maximum Level: Forecast L_{Amax} results with mitigation. Sheet 6 of 6.

D.2 Vibration

Figure D.27 Single point receiver results, GBN Residential - 17.00-21.85 km.

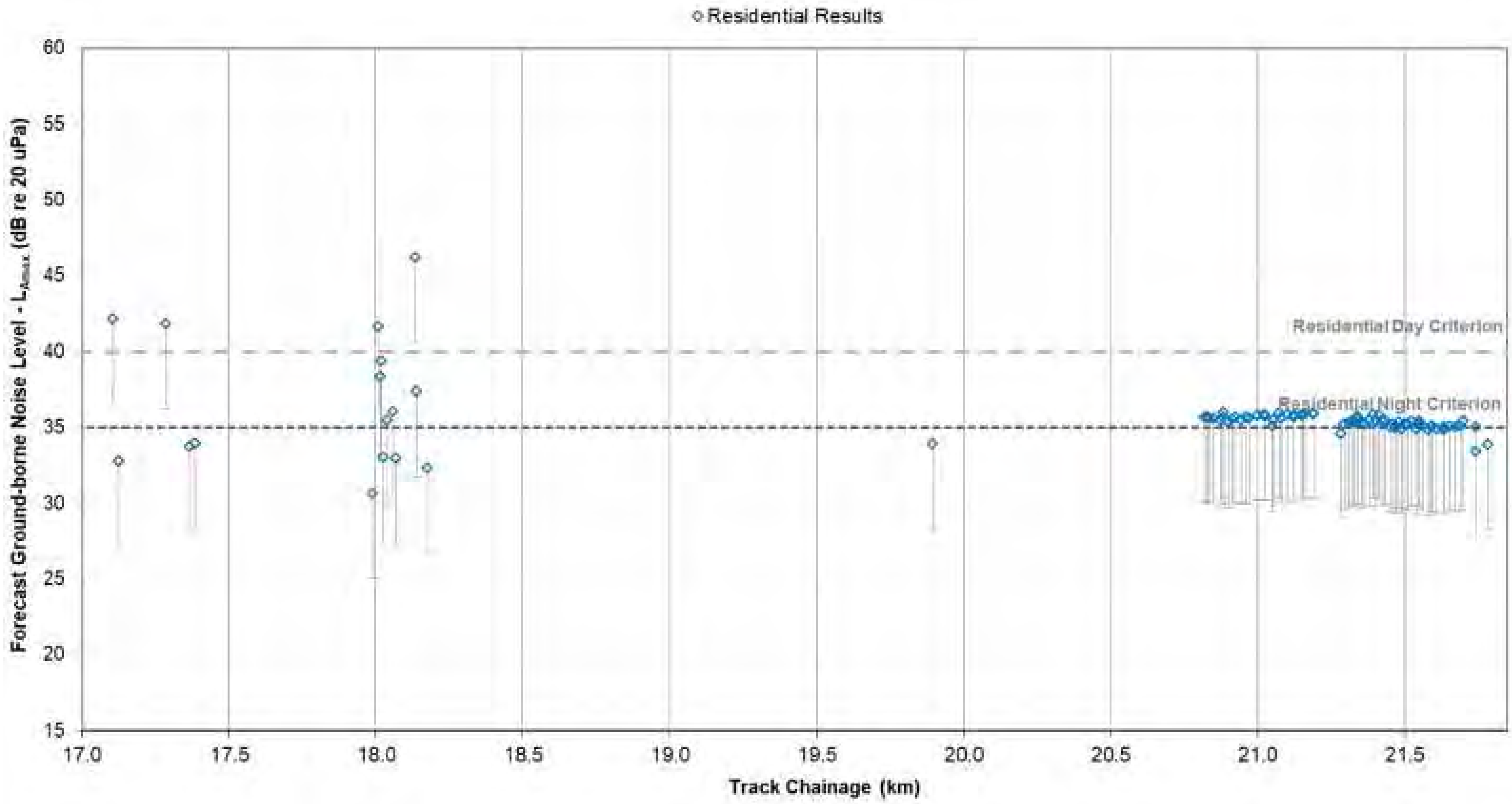


Figure D.28 Single point receiver results, GBN Residential - 24.20-27.20 km.

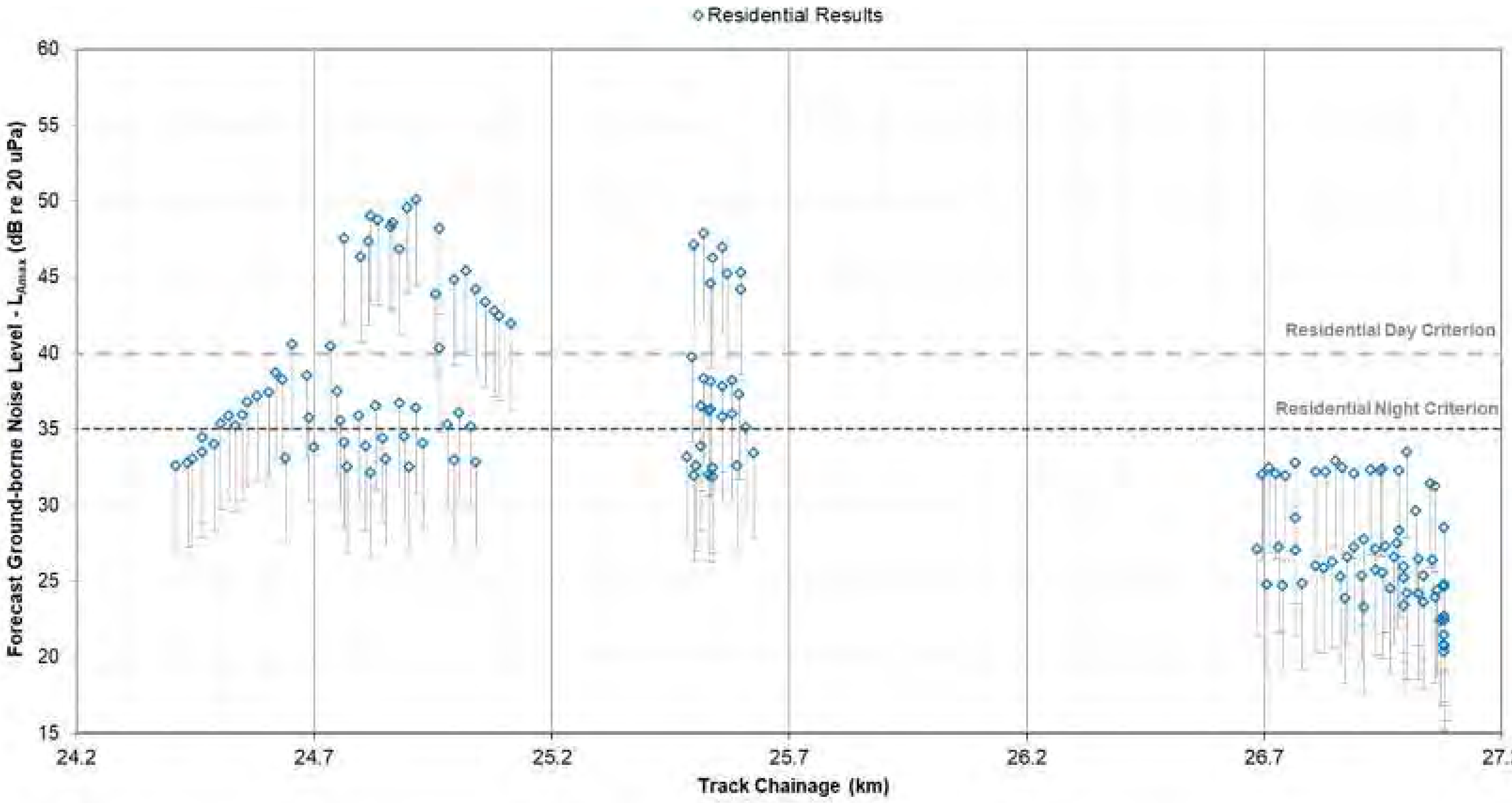


Figure D.29 Single point receiver results, GBN Commercial –17.00-21.85 km.

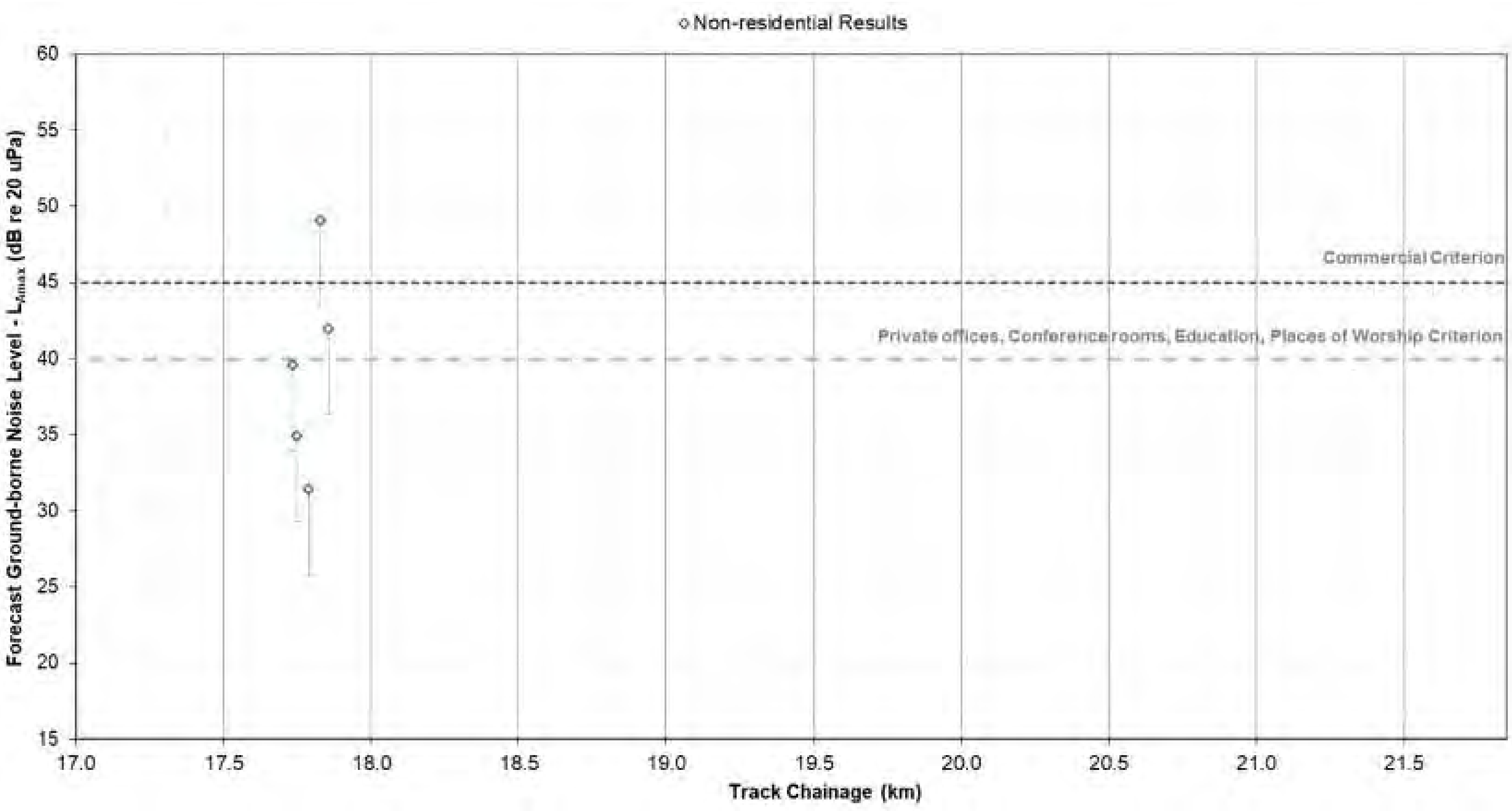


Figure D.30 Single point receiver results, GBN Commercial –24.20-27.20 km.

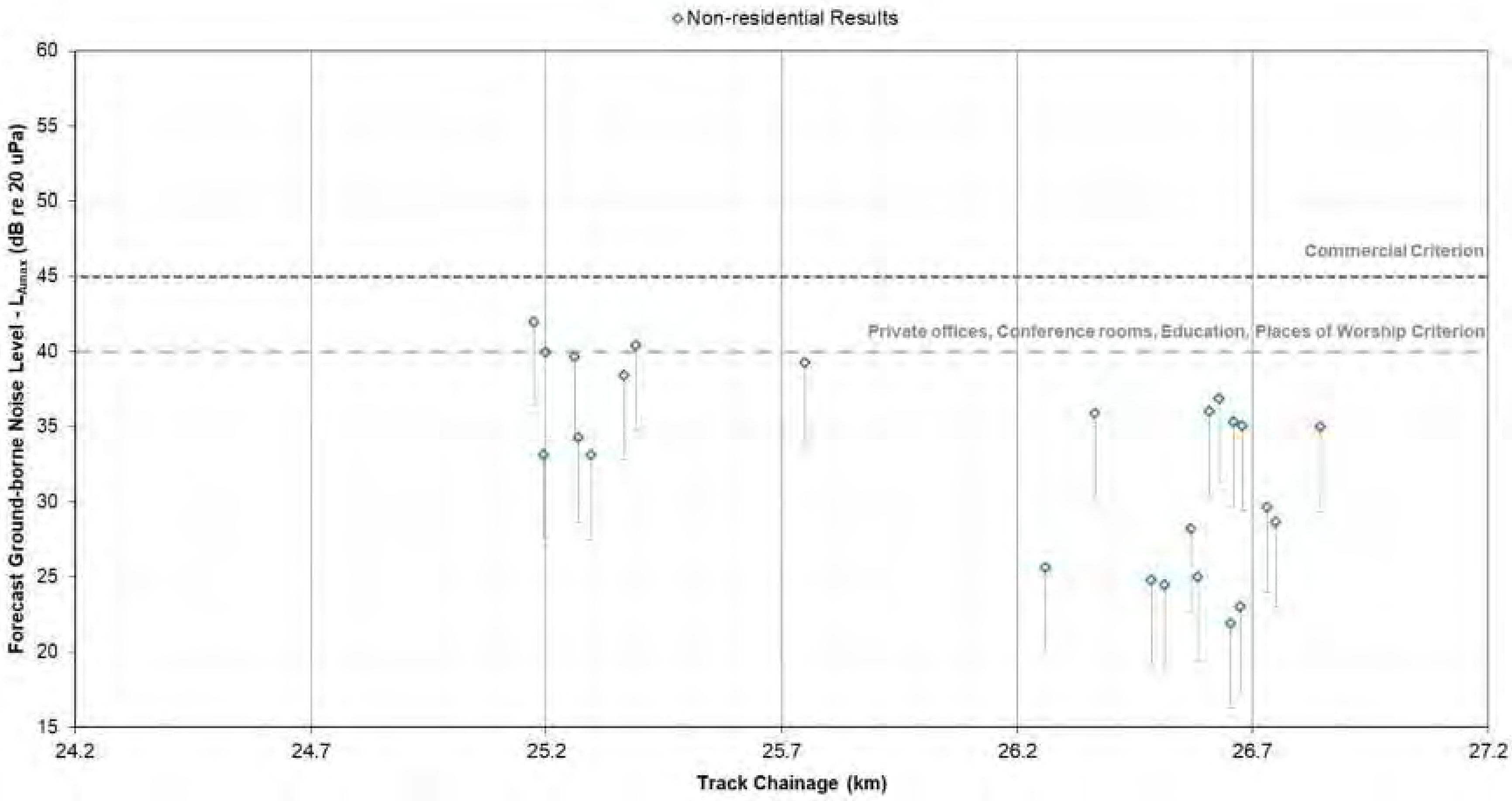


Figure D.31 Single point receiver results, GBV Residential – 17.00-21.85 km.

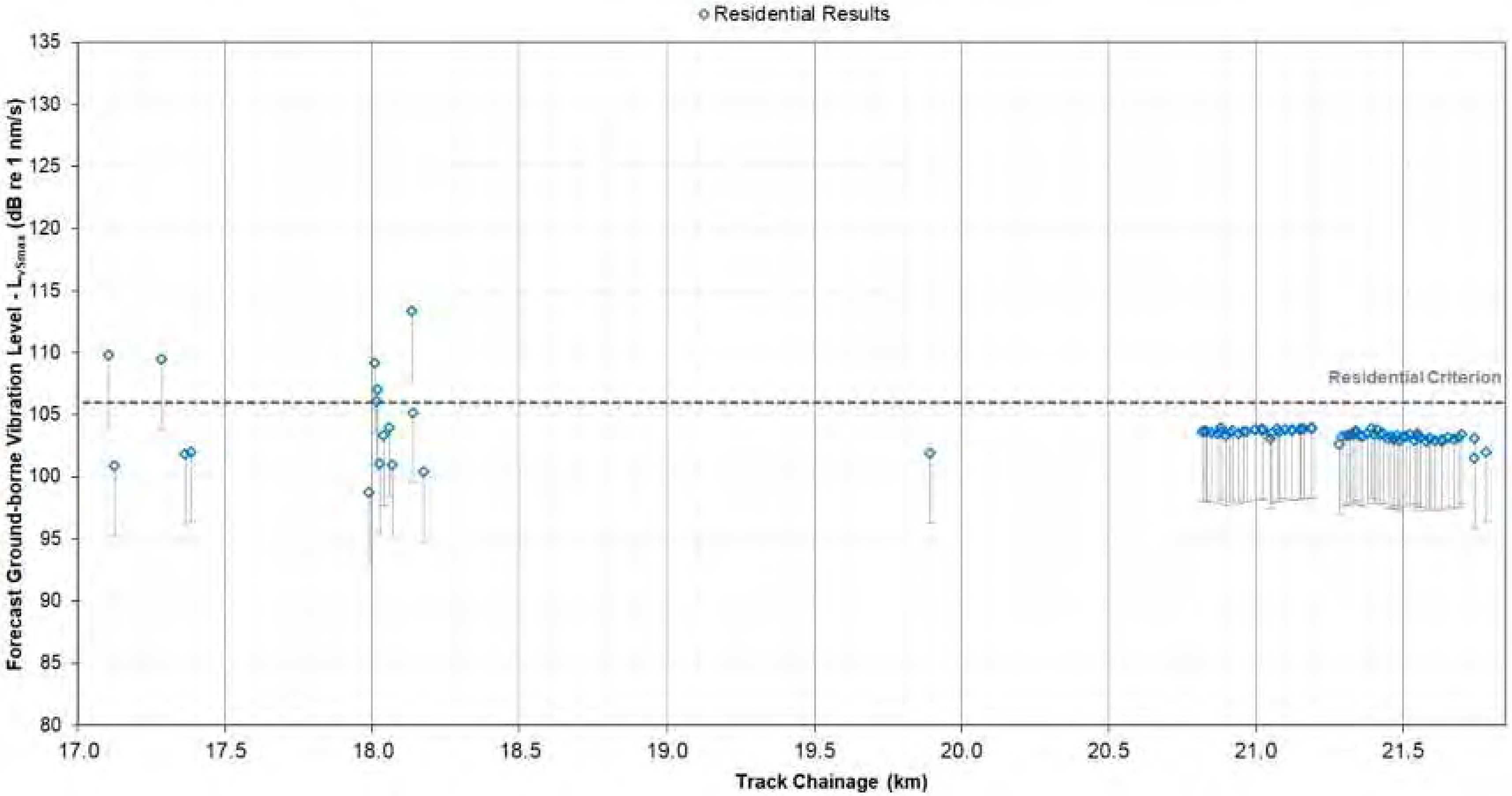


Figure D.32 Single point receiver results, GBV Residential 24.20-27.20 km.

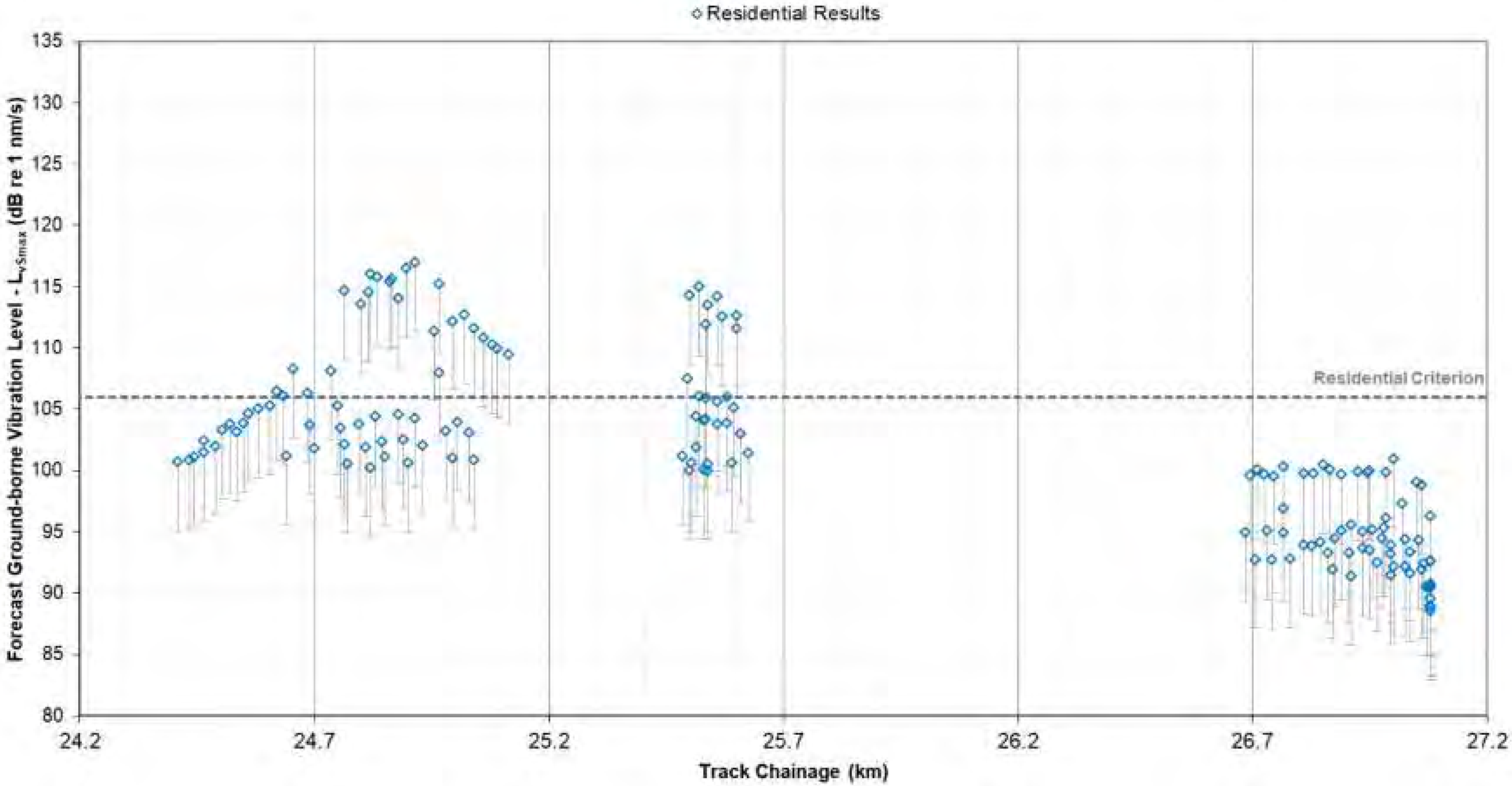


Figure D.33 Single point receiver results, GBV Commercial – 17.00-21.85 km.

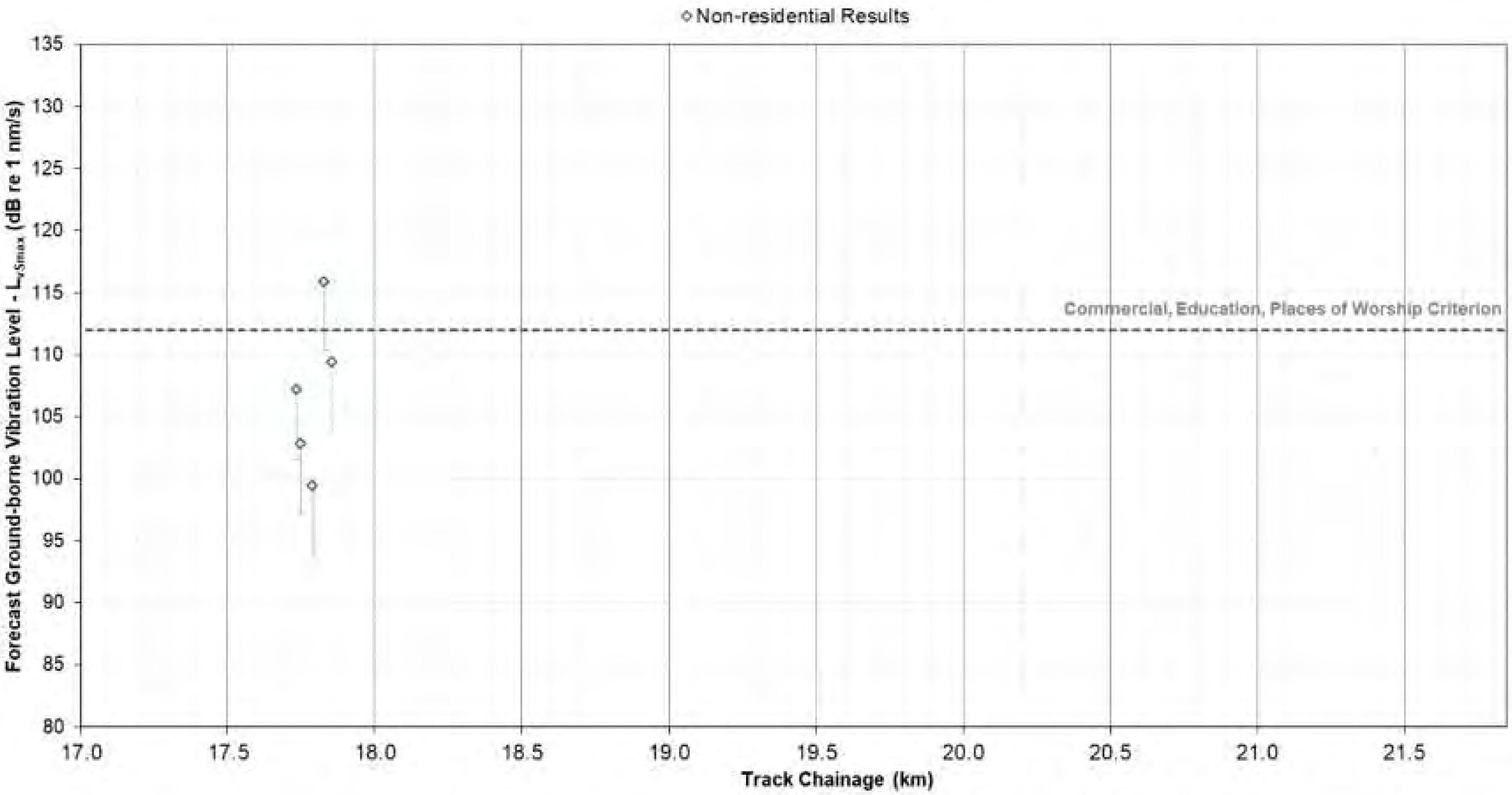


Figure D.34 Single point receiver results, GBV Commercial – 24.20-27.20 km.

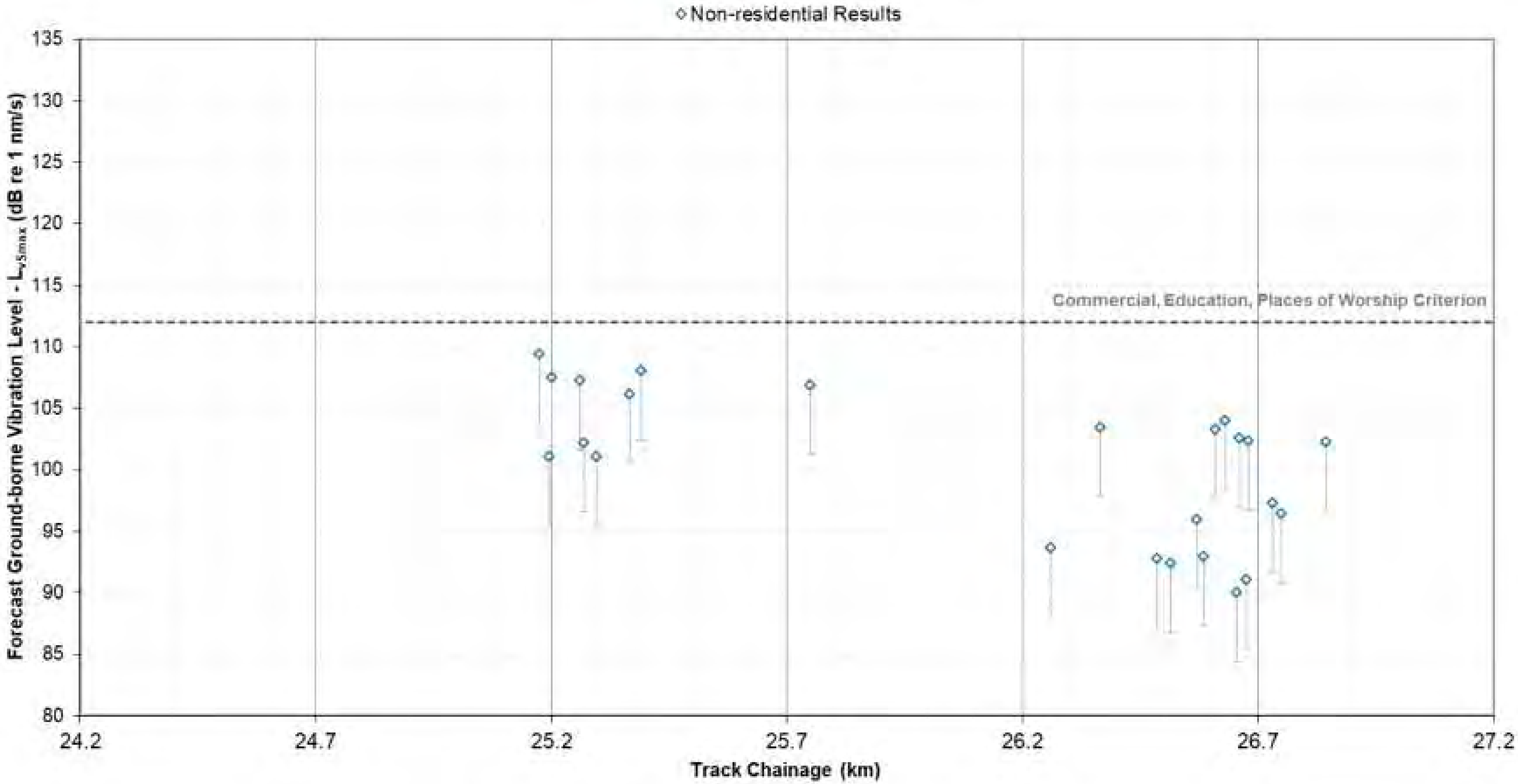


Figure D.35 Single point receiver results, GBN Residential –17.00-21.85 km km with under ballast matting.

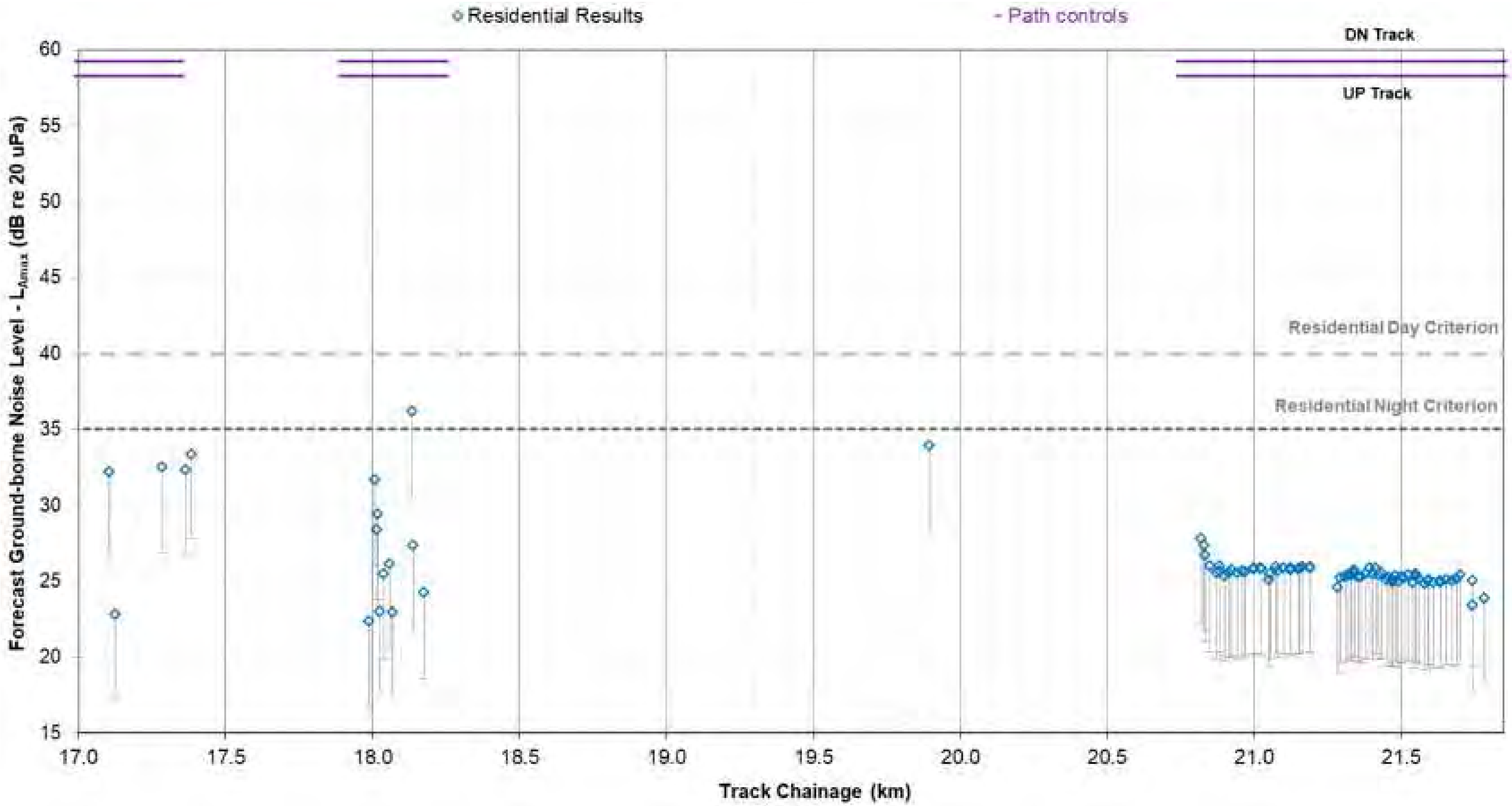


Figure D.36 Single point receiver results, GBN Residential –24.20-27.20 km km with under ballast matting.

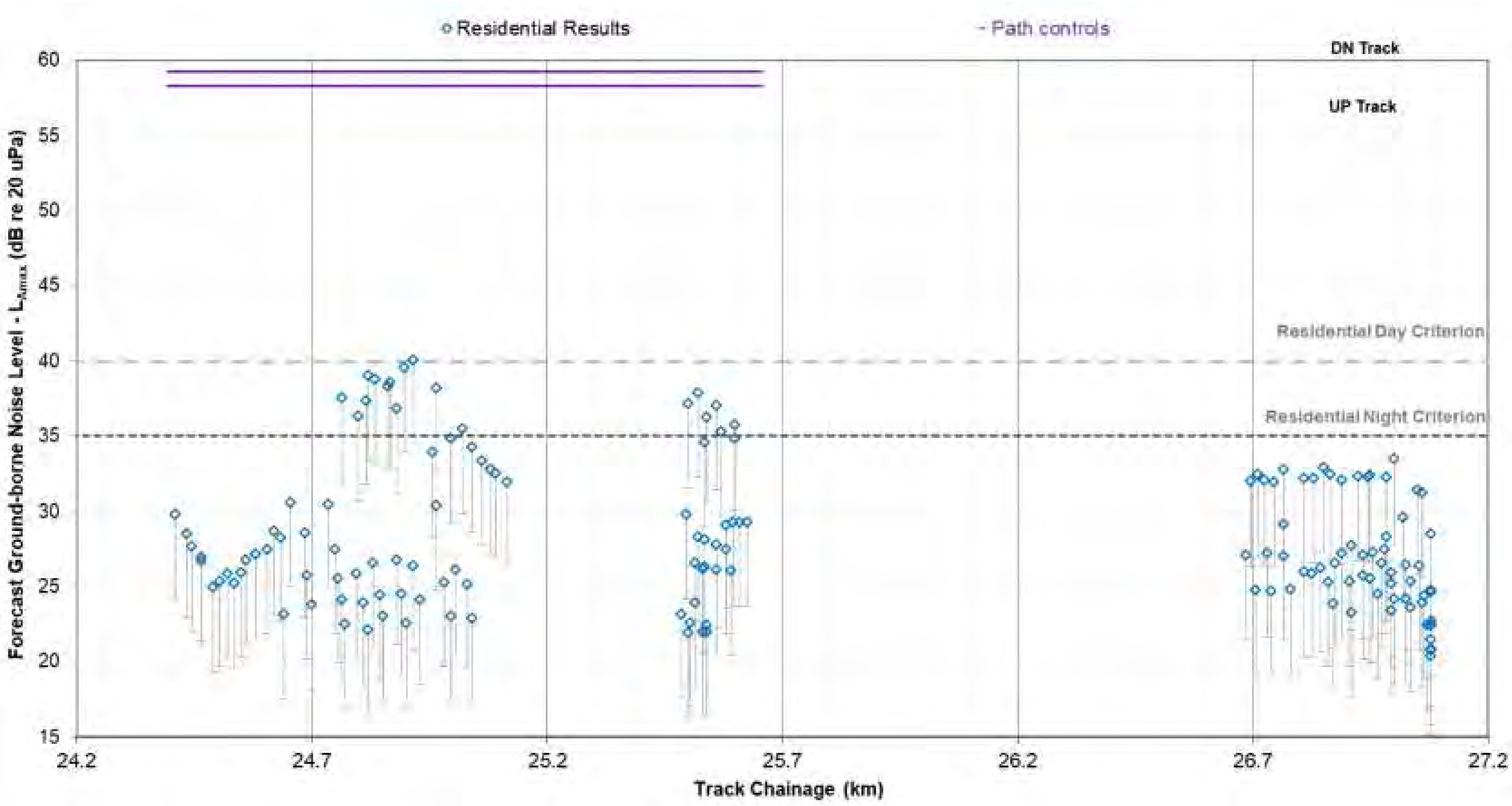


Figure D.37 Single point receiver results, GBN Commercial – 17.00-1.85 km km with under ballast matting.

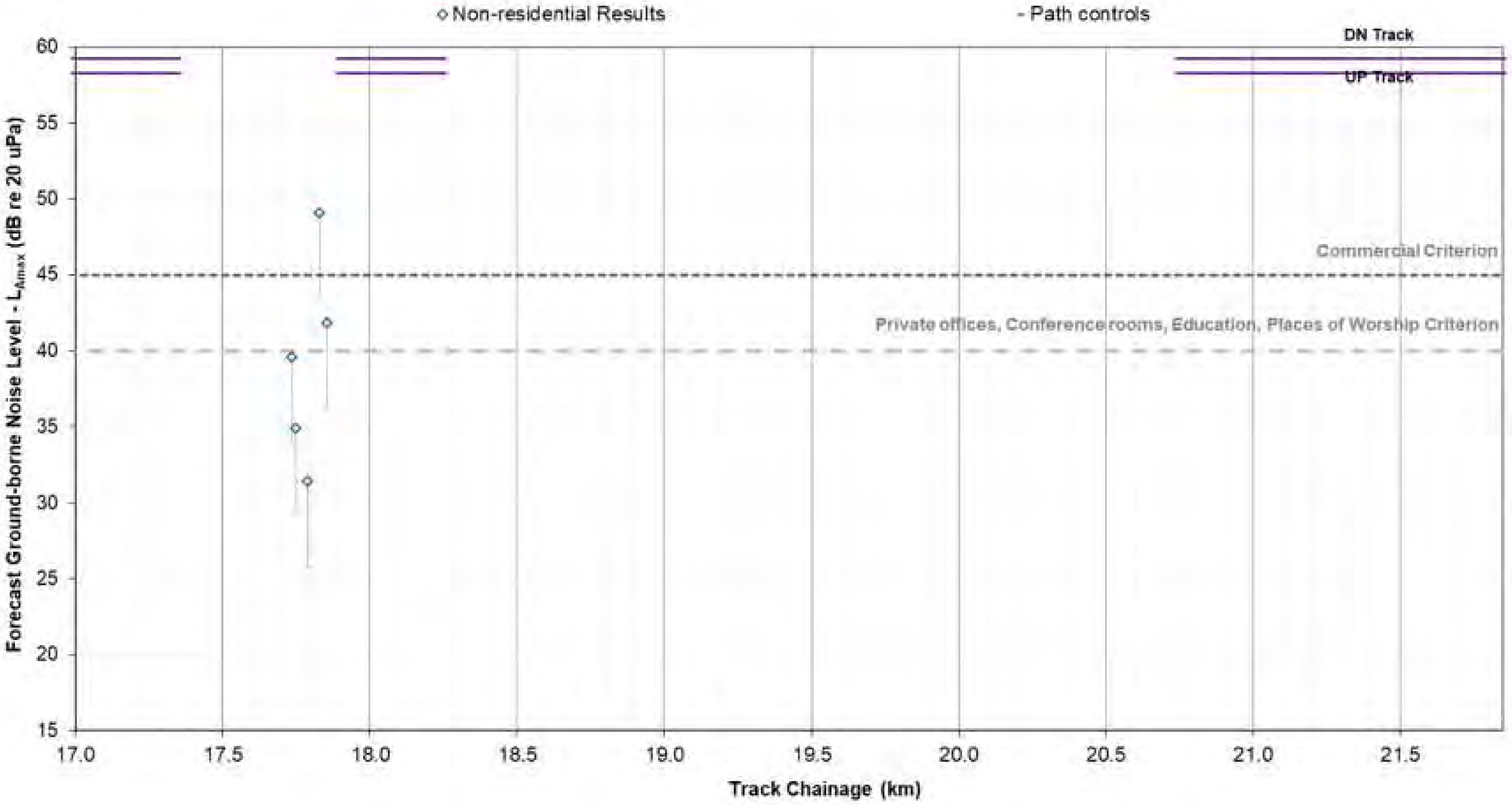


Figure D.38 Single point receiver results, GBN Commercial –24.20-27.20 km with under ballast matting.

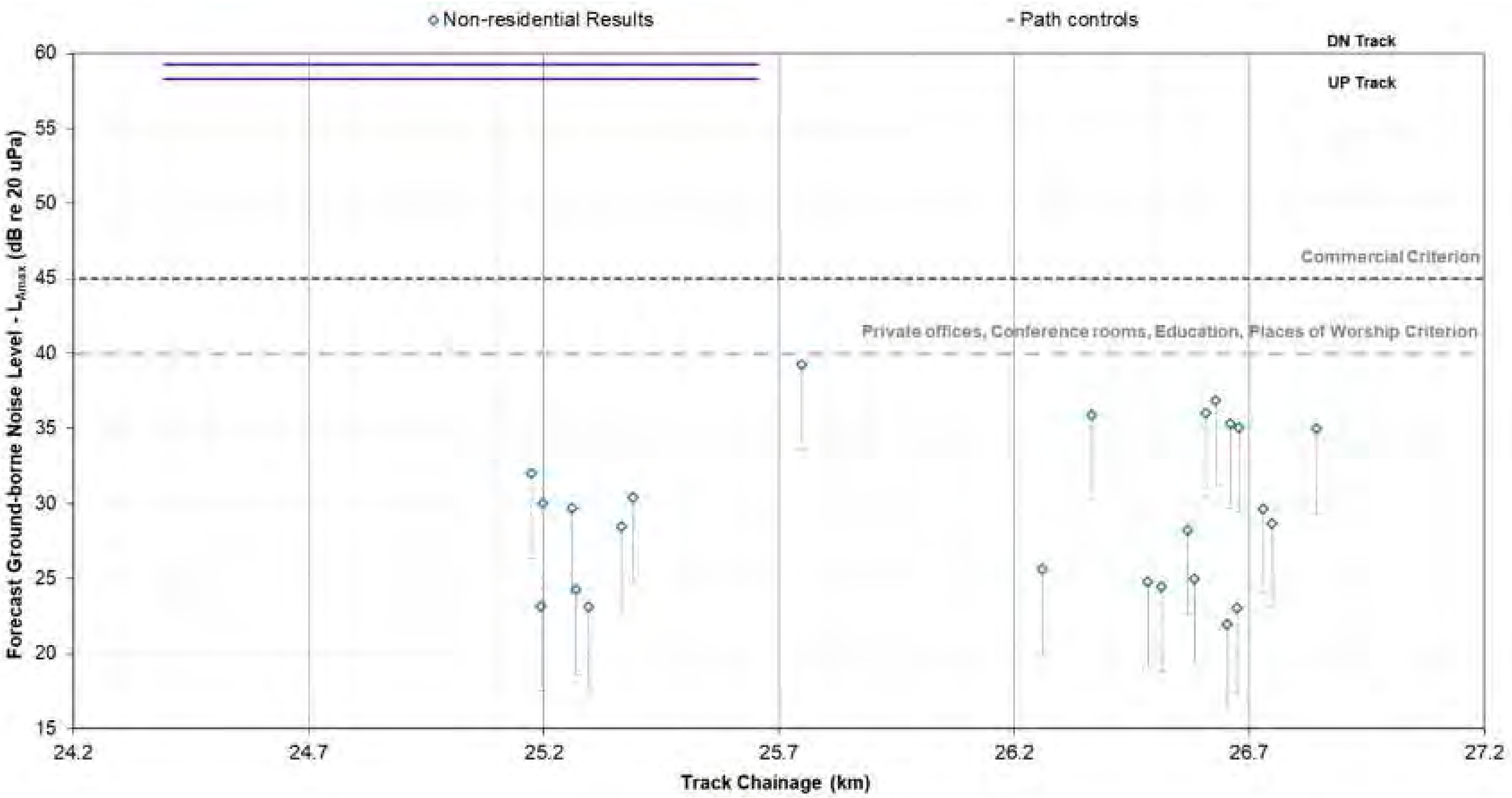


Figure D.39 Single point receiver results, GBV Residential –17.00-21.85 km km with under ballast matting.

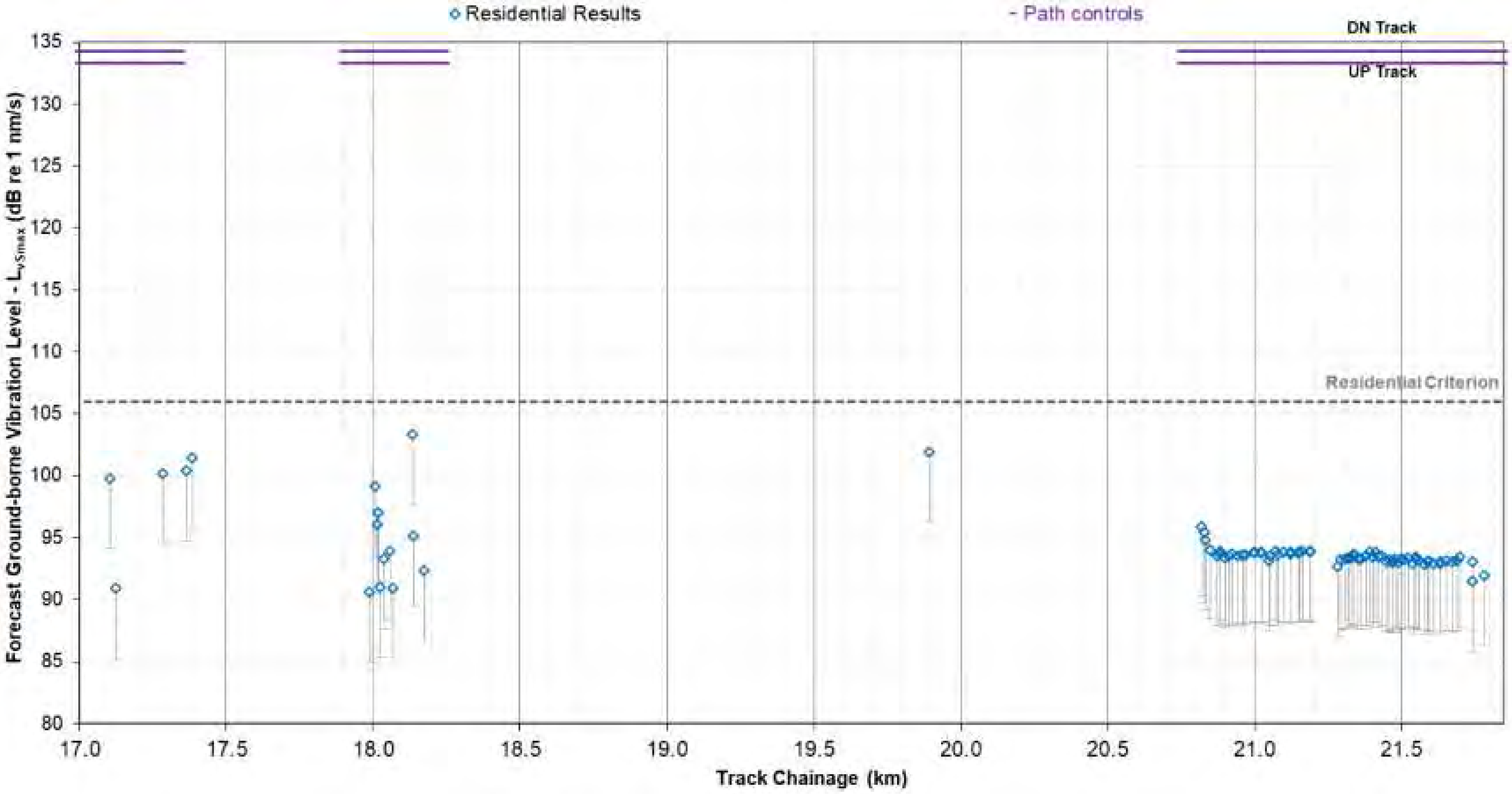


Figure D.40 Single point receiver results, GBV Residential –24.20-27.20 km km with under ballast matting.

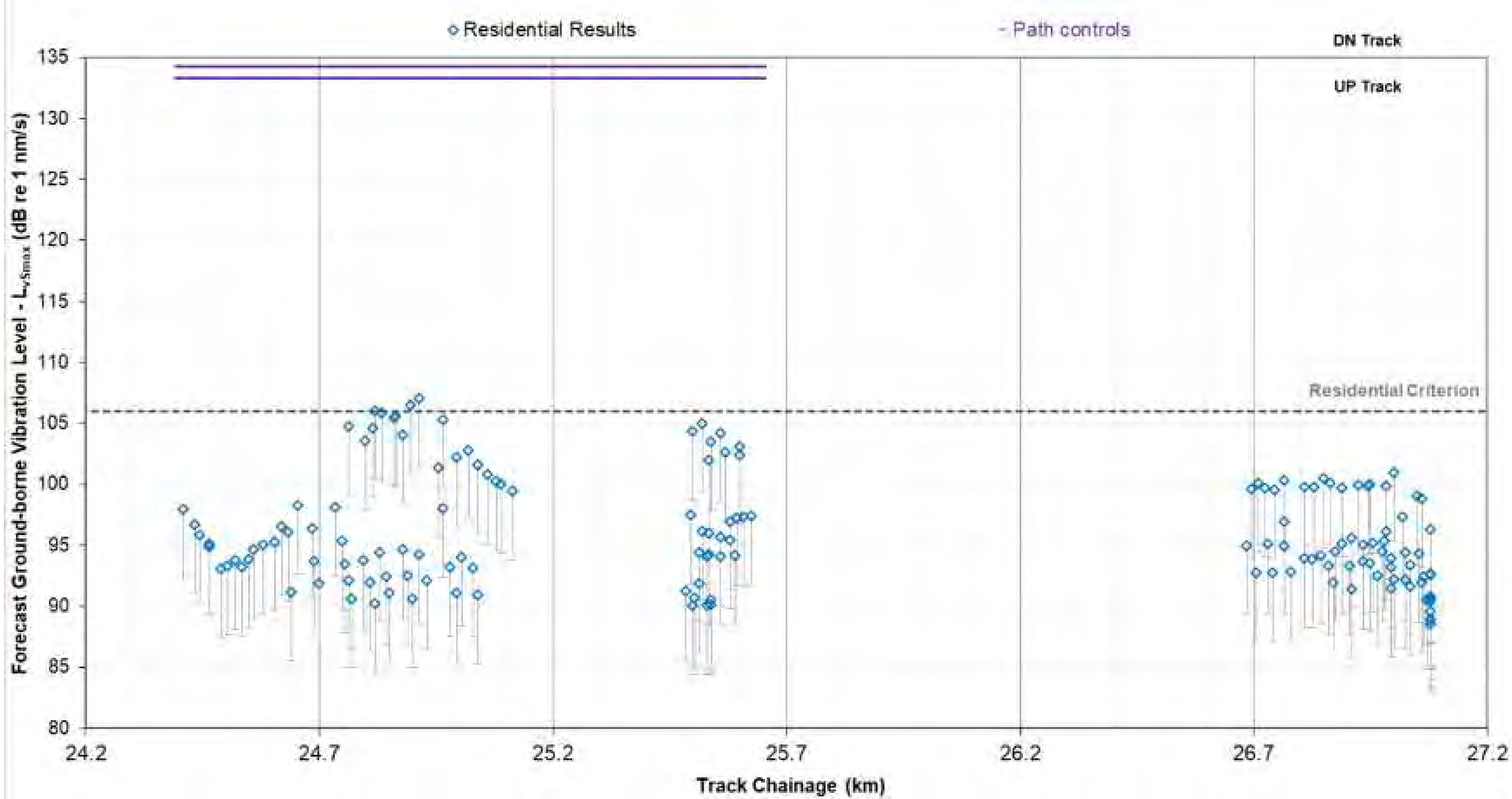


Figure D.41 Single point receiver results, GBV Commercial – 17.00-21.85 km with under ballast matting.

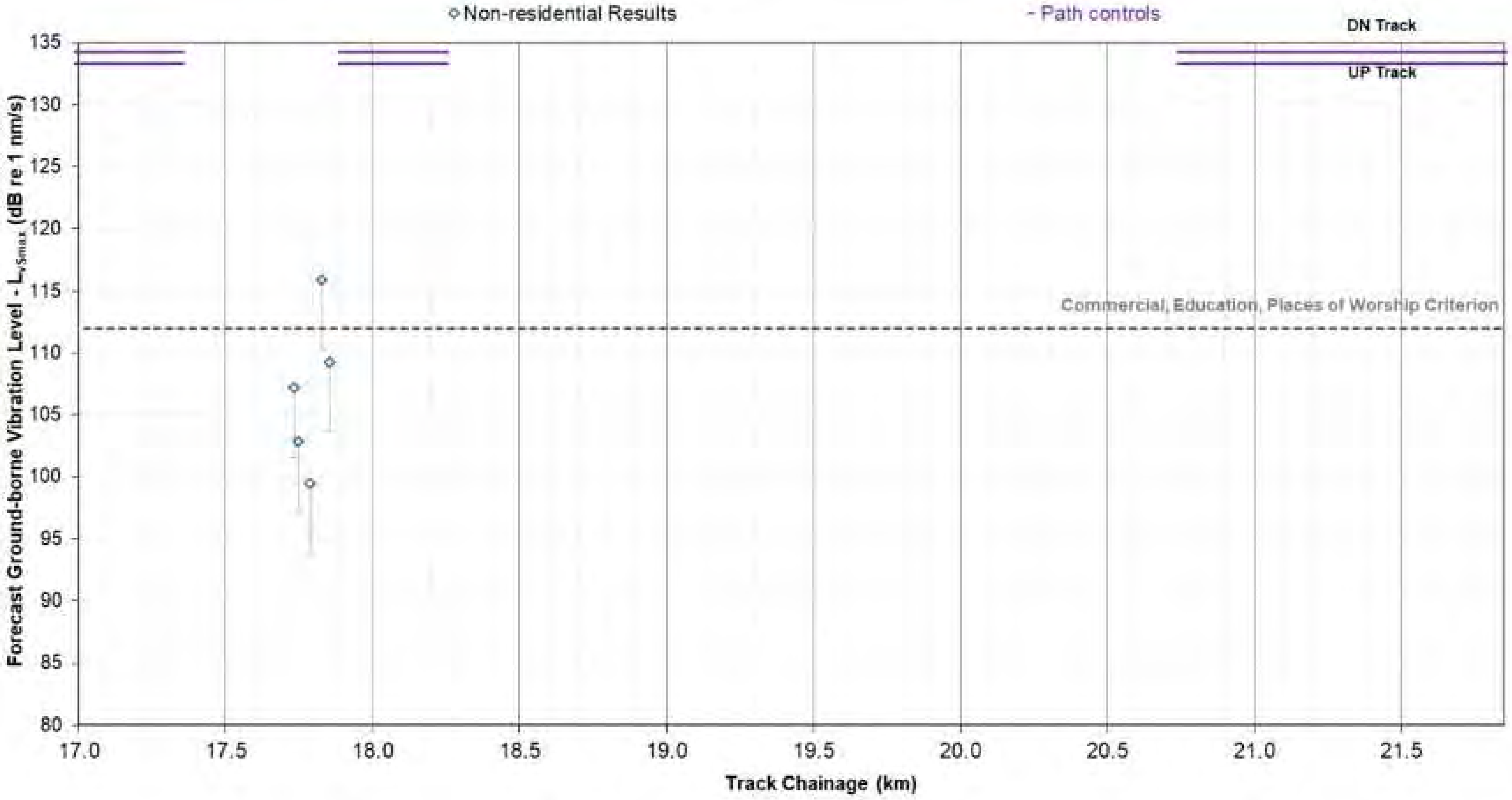
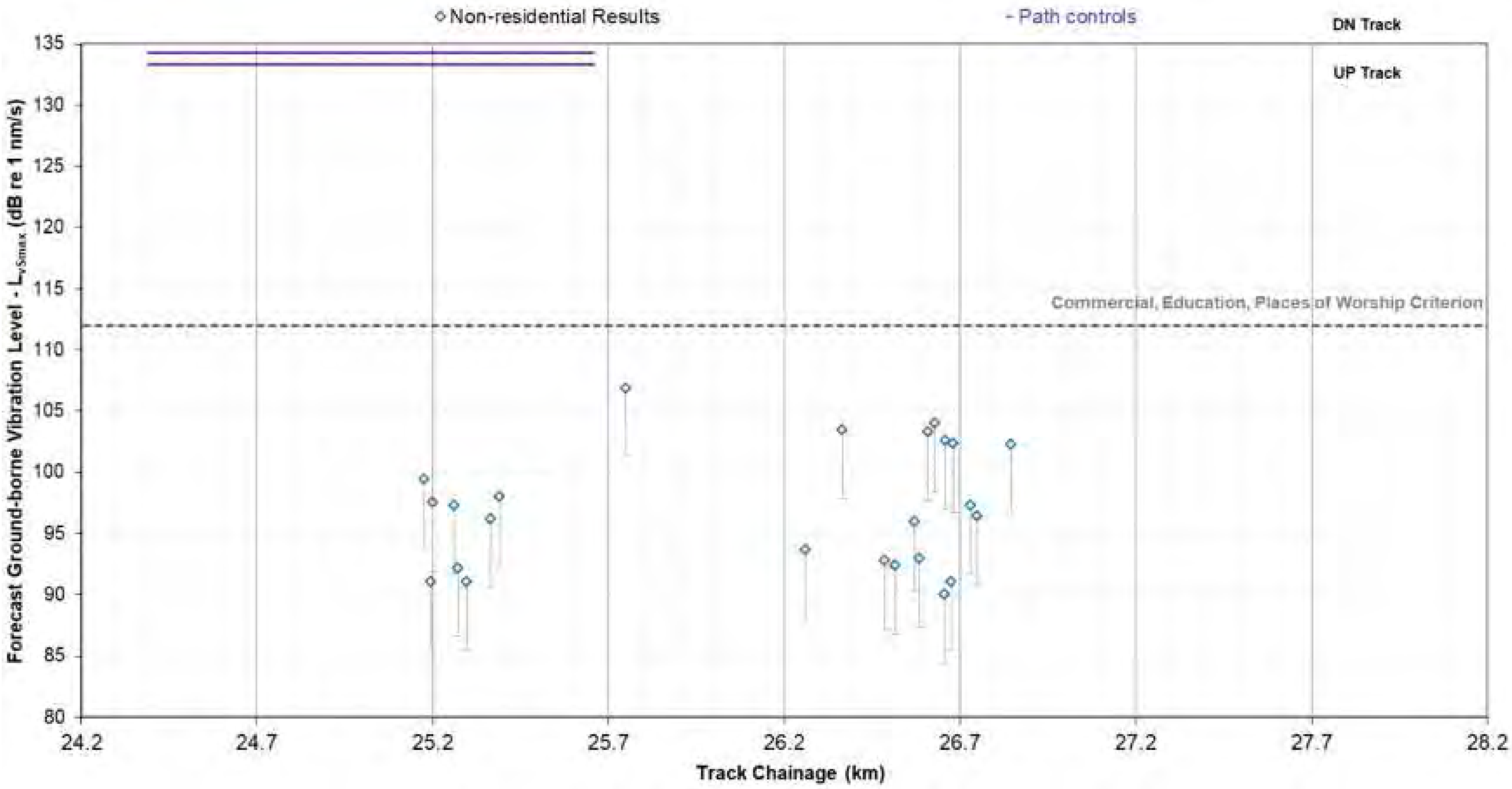
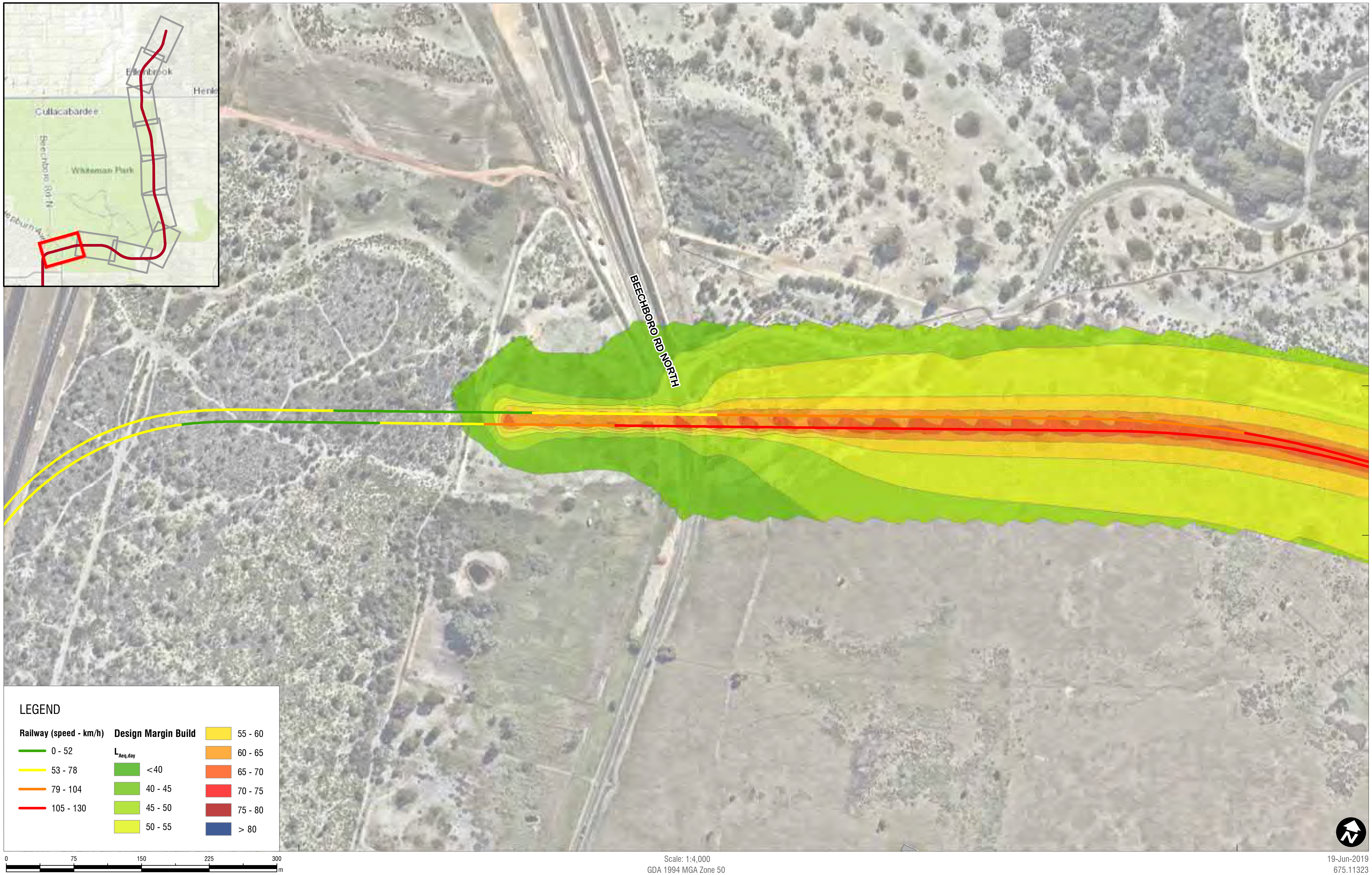


Figure D.42 Single point receiver results, GBV Commercial – 24.20-27.20 km with under ballast matting.



APPENDIX E

E Drawings



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Note: To be read in conjunction with SLR report 675.11323.00200

MEL Operations Section B– Airborne Noise – Build – Day period – Prior to mitigation

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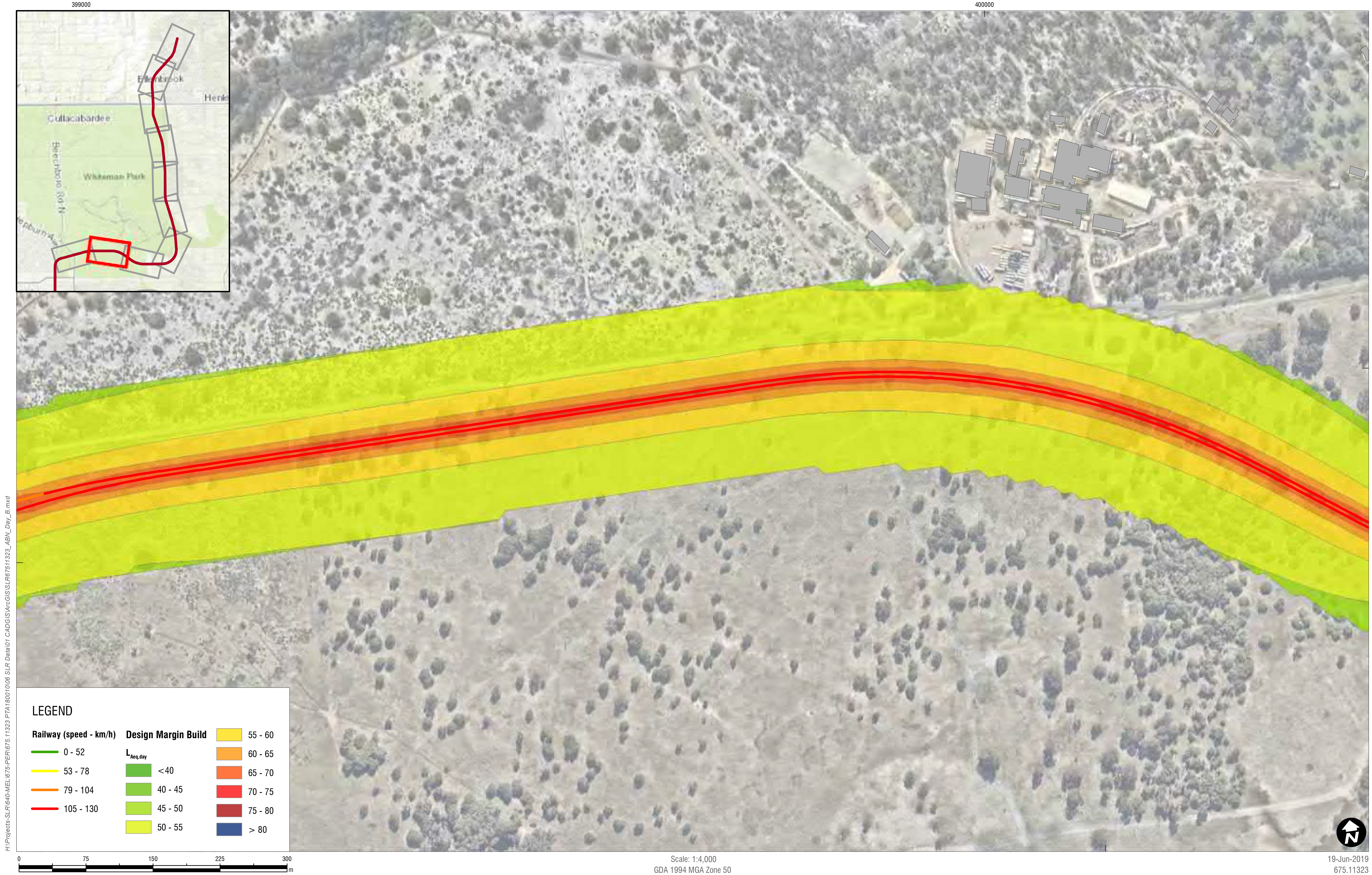

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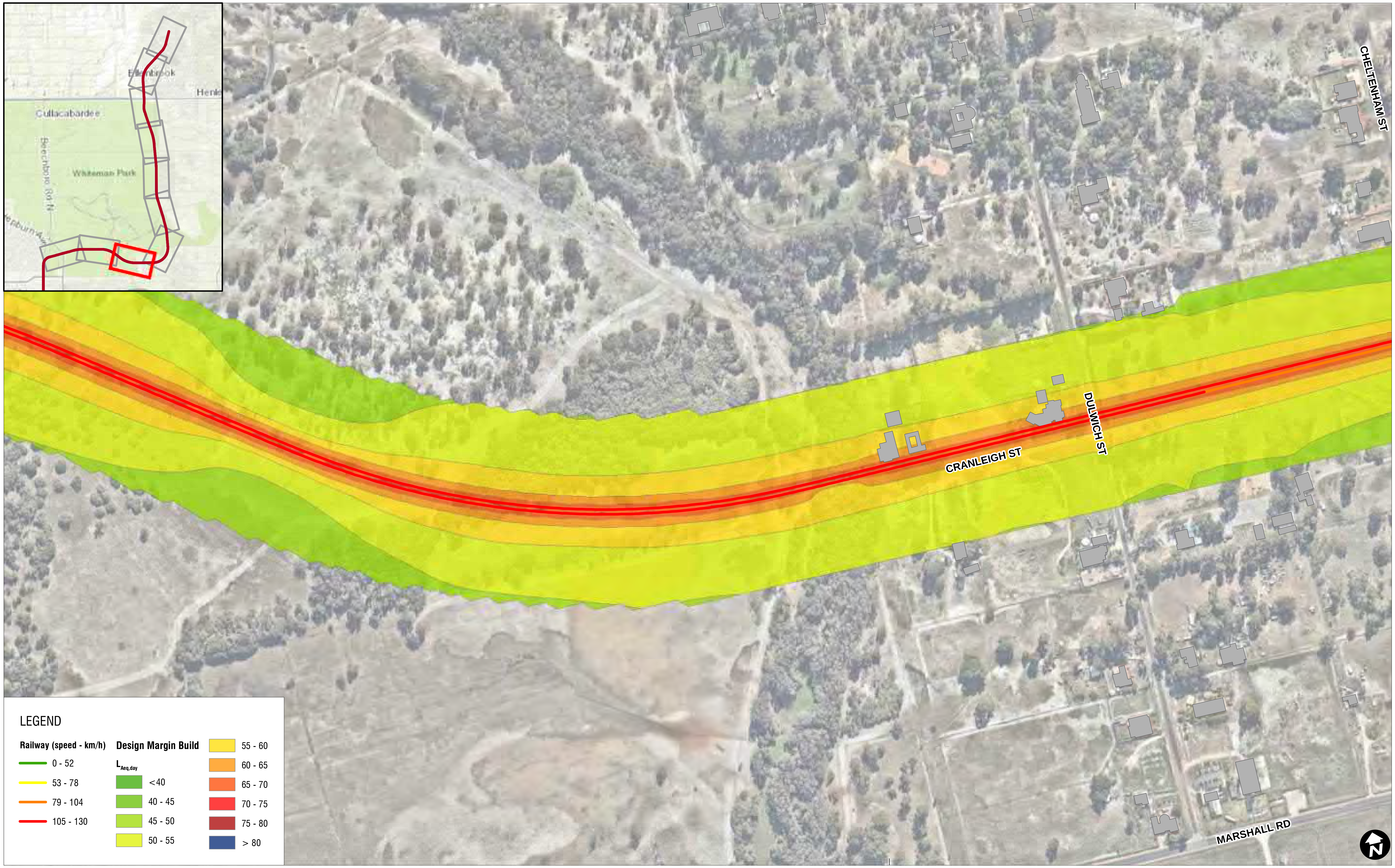
MEL Operations Section B– Airborne Noise – Build – Day period – Prior to mitigation

SLR67511323_ABN_Day_B - 2



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MEL Operations Section B– Airborne Noise – Build – Day period – Prior to mitigation

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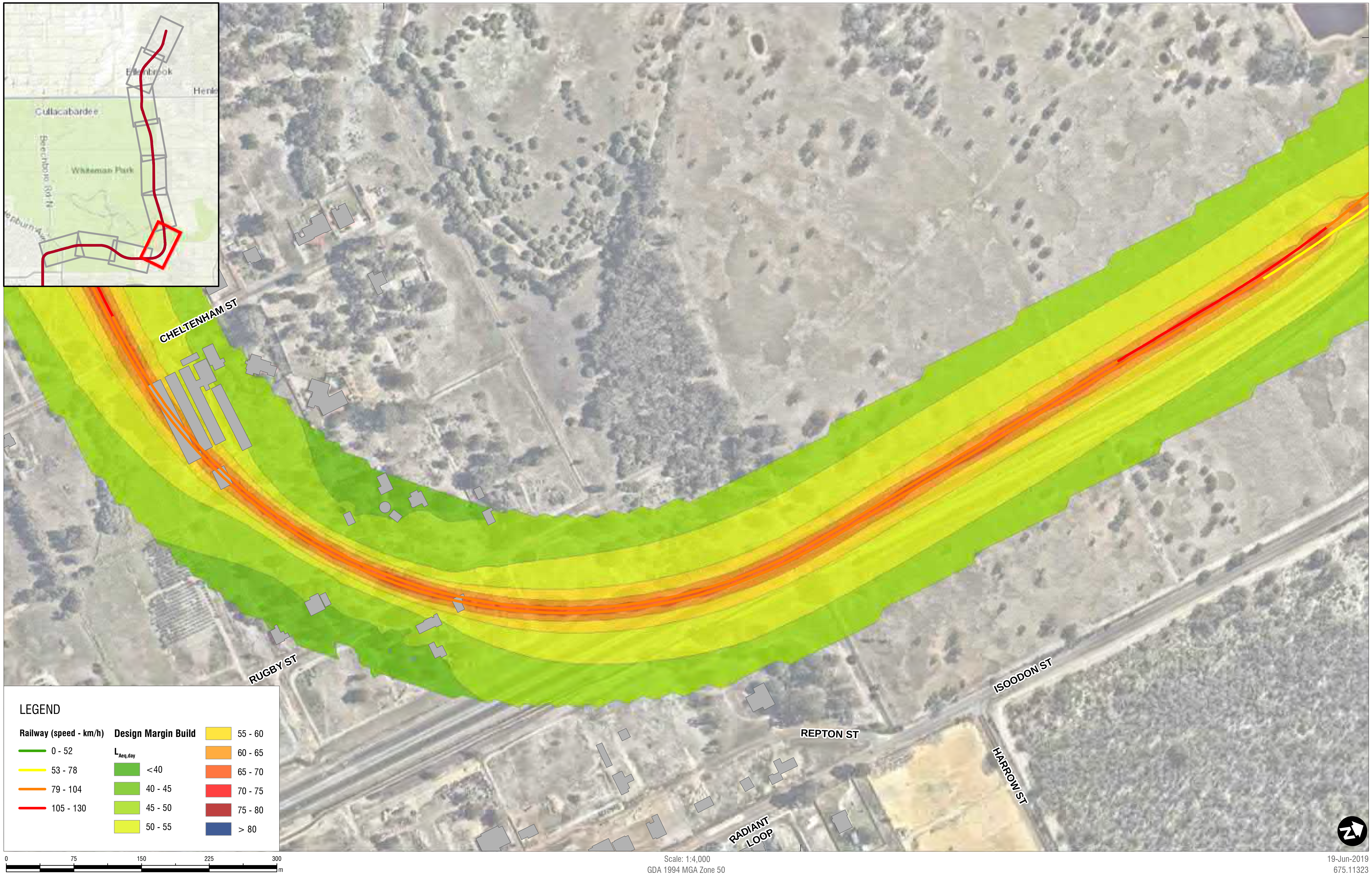

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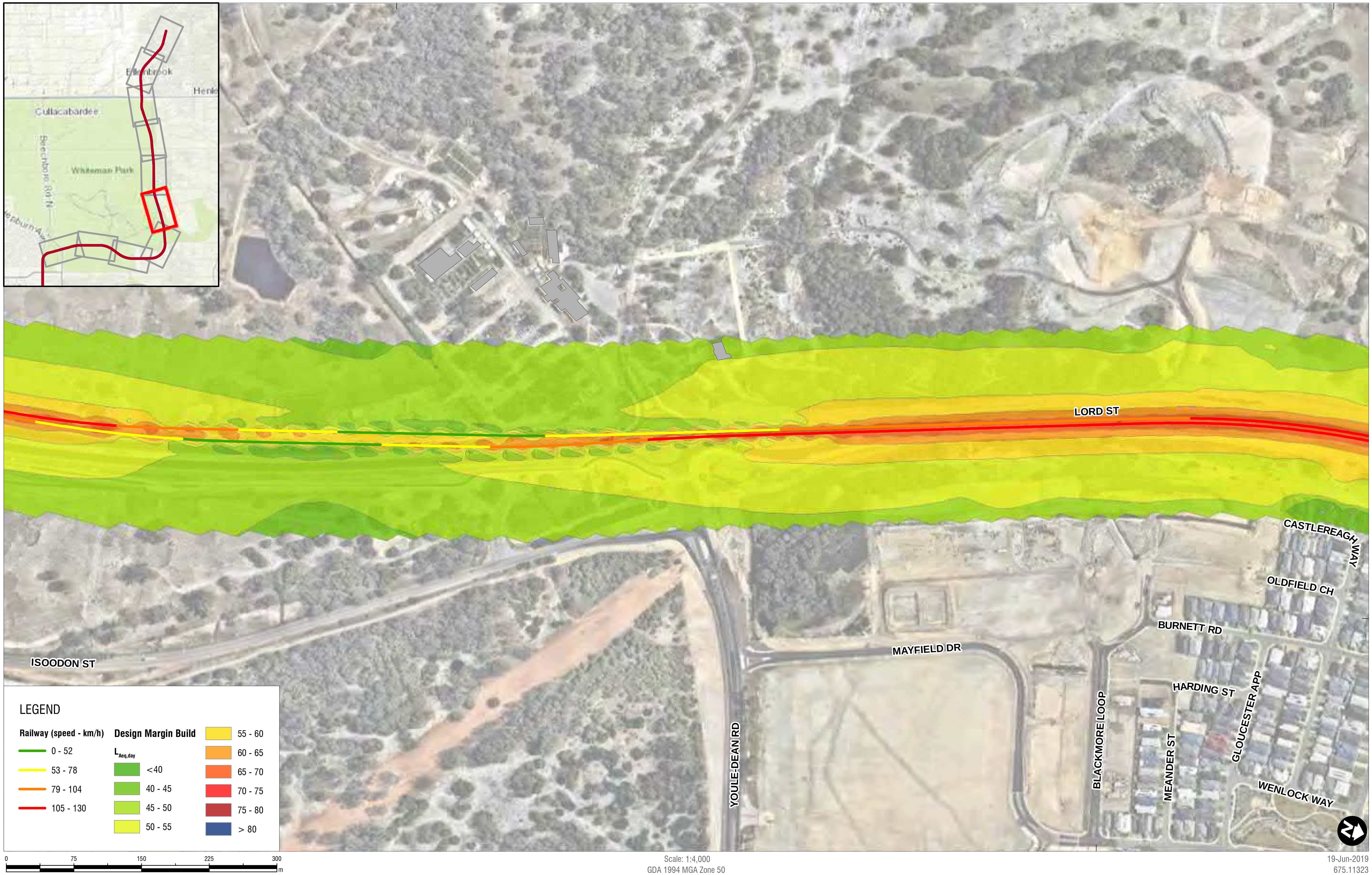
Note: To be read in conjunction with SLR report 675.11323.00200

MEL Operations Section B– Airborne Noise – Build – Day period – Prior to mitigation

SLR67511323_ABN_Day_B - 4



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19-Jun-2019
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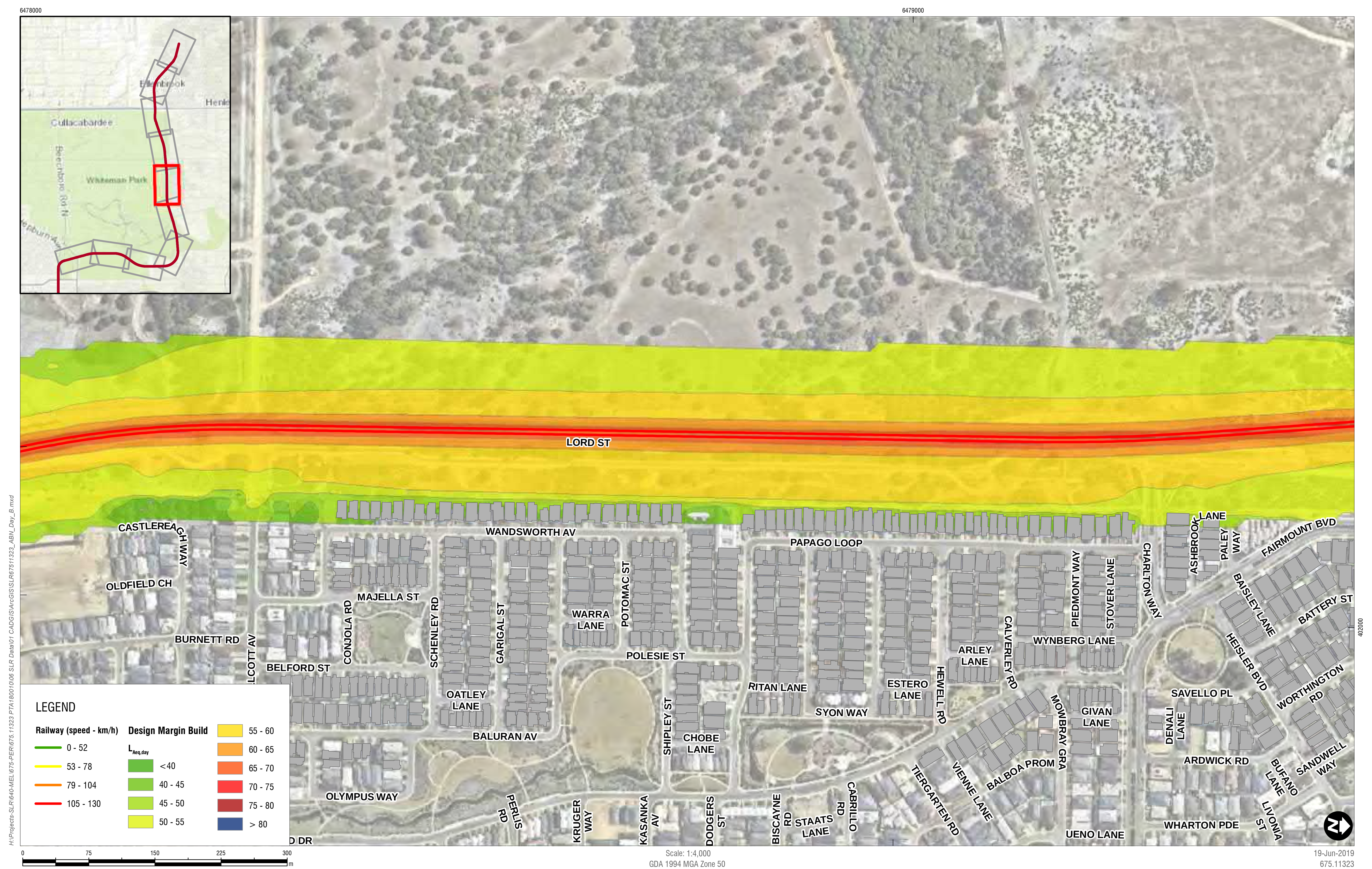
MEL Operations Section B– Airborne Noise – Build – Day period – Prior to mitigation

SLR67511323_ABN_Day_B - 5



Note: To be read in conjunction with SLR report 675.11323.00200

**MEL Operations Section B–
Airborne Noise –
Build – Day period –
Prior to mitigation**

SLR67511323_ABN_Day_B - 6

Sheet Size : A3

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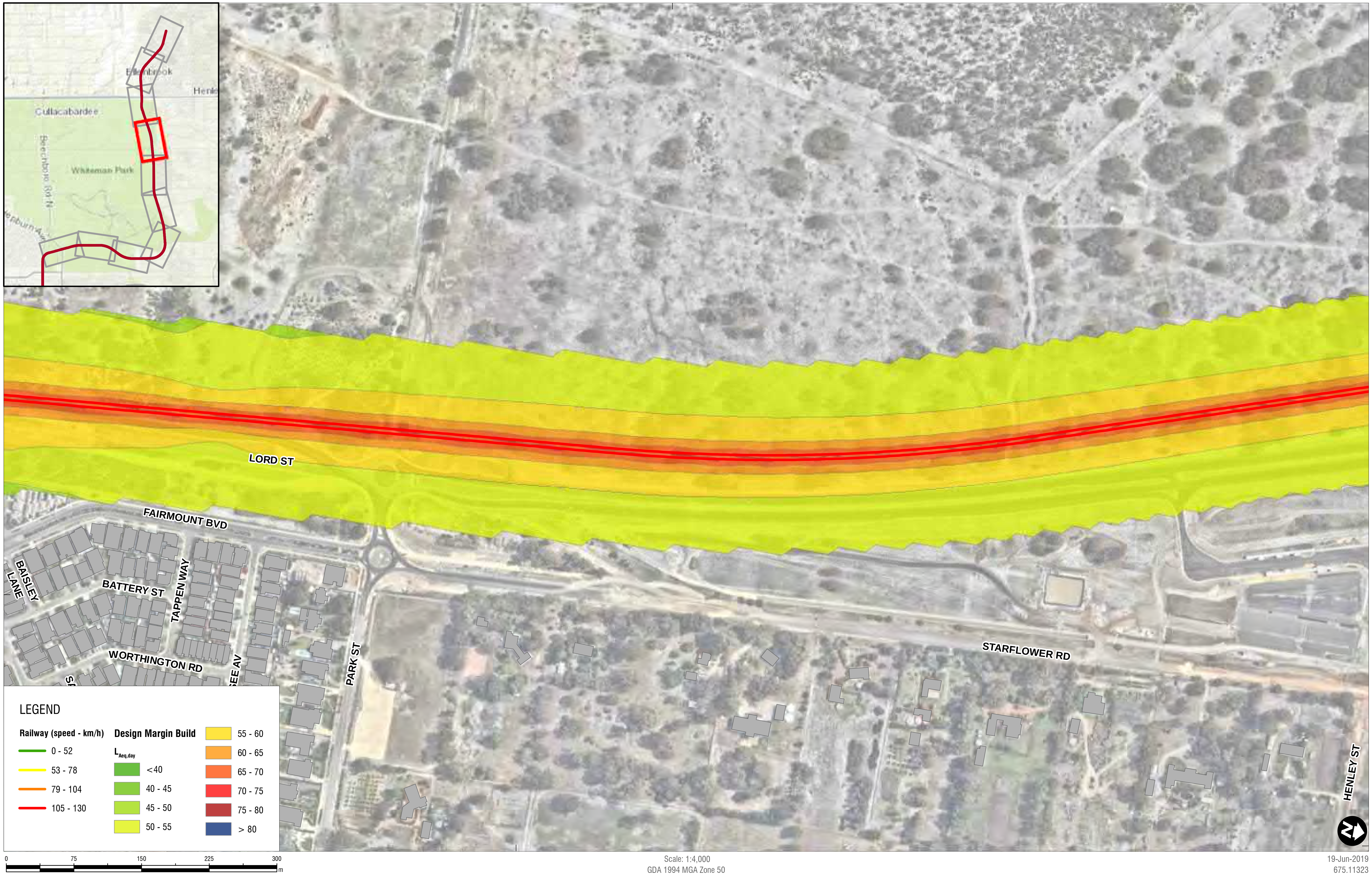

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GDA 1994 MGA Zone 50

19-Jun-2019
675.11323

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Sheet Size : A3

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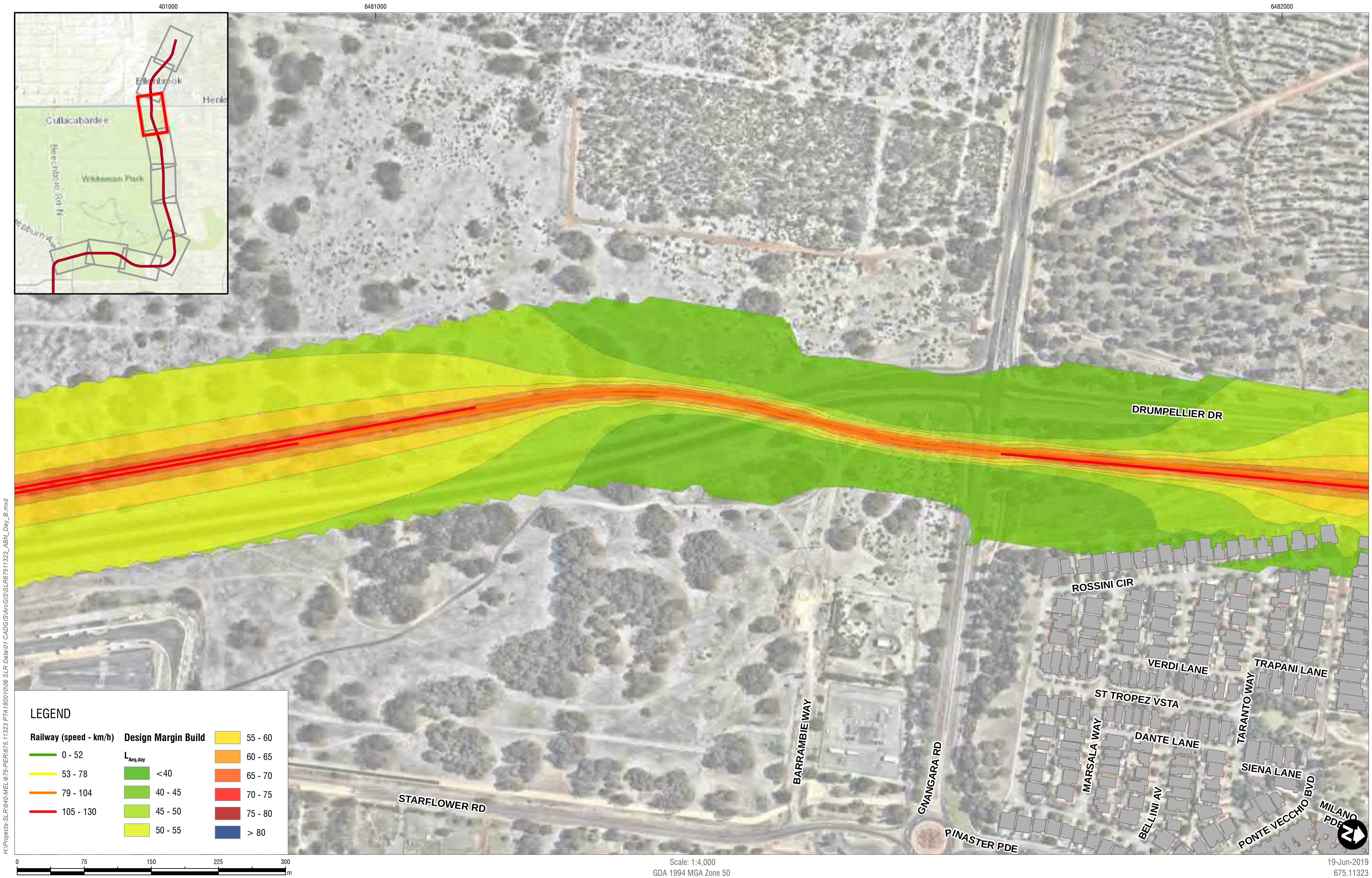
Note: To be read in conjunction with SLR report 675.11323.00200

MEL Operations Section B– Airborne Noise – Build – Day period – Prior to mitigation

SLR67511323_ABN_Day_B - 7



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GDA 1994 MGA Zone 50

19-Jun-2019
675.11323

Sheet Size : A3

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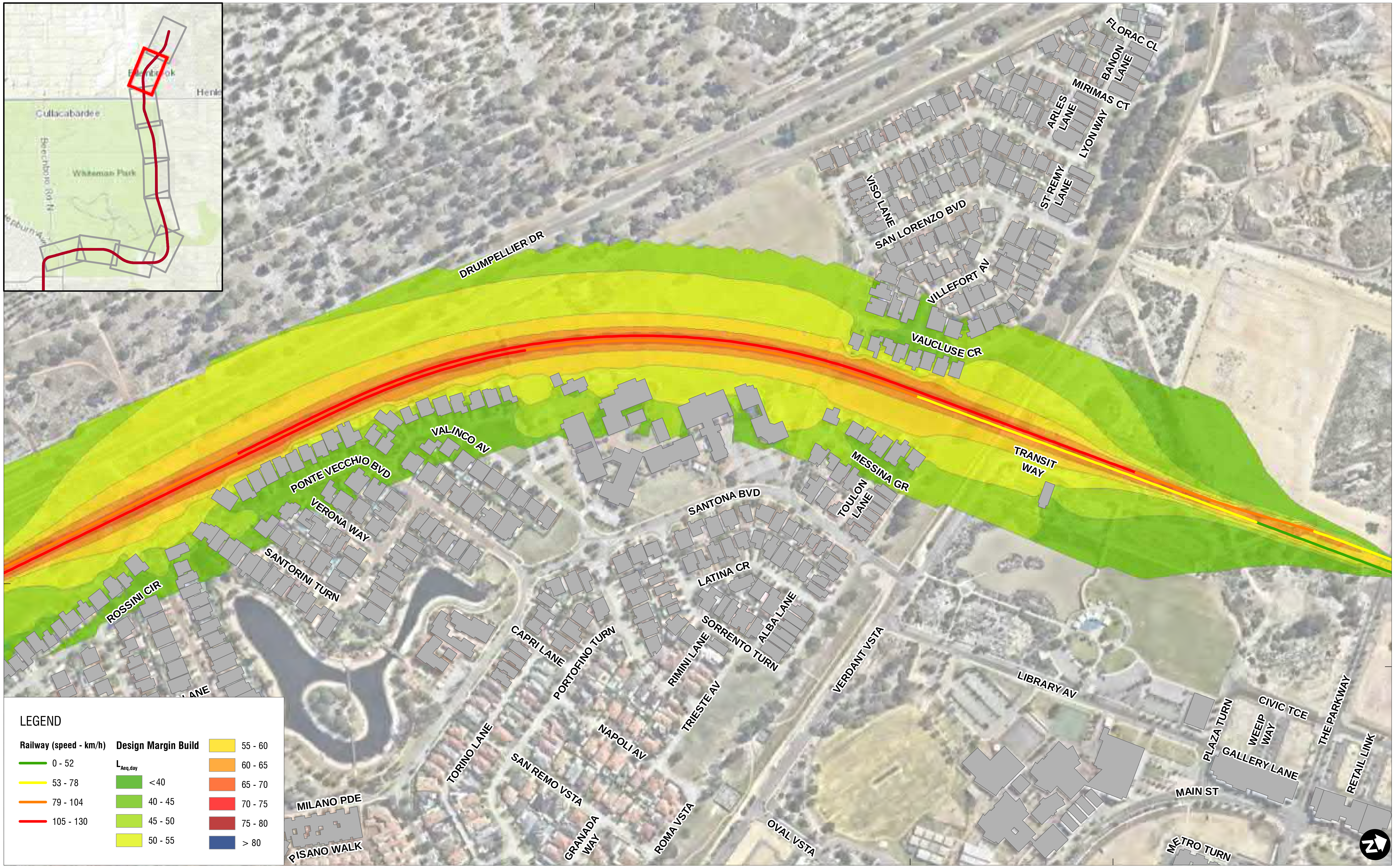
Note: To be read in conjunction with SLR report 675.11323.00200

MEL Operations Section B–
Airborne Noise –
Build – Day period –
Prior to mitigation

SLR67511323_ABN_Day_B - 8



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Scale: 1:4,000
GDA 1994 MGA Zone 50

19-Jun-2019
675.11323

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Note: To be read in conjunction with SLR report 675.11323.00200

**MEL Operations Section B–
Airborne Noise –
Build – Day period –
Prior to mitigation**

SLR67511323_ABN_Day_B - 9