Appendix N: Operational Noise and Vibration Report

Byford Rail Extension

R30-SLR-RPT-NV-540-00007

Operational Noise and Vibration Design Report

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Byford Rail Extension

Document details	
Title	Design Report – Operational Noise and Vibration
Project	Byford Rail Extension (BRE) Design and Construction Project
Laing O'Rourke Project No.	R30
Client	Public Transport Authority of Western Australia
Client contract No.	PTA200142
MetCONNX Document No.	R30-SLR-RPT-NV-540-00007

Rev	Date	Revision Description	Prepared by	Reviewed by	Approved by
A.	16-Sep-2022	Issued for Review	Arvind Deivasigamani	Luke Zoontjens	Alyssa Edwards
B.01	18-Jan-2023	Issued for IDD IDC	Ying Liu	Luke Zoontjens	Alyssa Edwards
B.02	30-Mar-2023	Issued for IDD for IV	Ying Liu	Luke Zoontjens	Alyssa Edwards

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1. Executive Summary

This document is designed to address the requirements for the Operational Noise and Vibration Design Report (ONVDR) detailed in SWTC Book 4, Section 13.

This ONVDR details the investigations and detailed analyses undertaken to determine the future noise and vibration levels associated with the operation of the proposed railway and its associated infrastructure.

The report covers the necessary mitigations to be implemented to comply with the SWTC requirements. These covered in the sections below.

No specific road traffic noise mitigation is anticipated at this stage, based on detailed modelling of the future road alignments. Detailed noise contour maps for key roads (such as Eleventh Road) will be included in a future revision once detailed design information is developed.

Air-borne noise mitigations are recommended in the form of rail web damper and noise protection wall. The recommended extents of rail web damper and noise protection walls are listed in Appendix F.1 and 2, respectively.

Ground-borne noise and vibration mitigation is recommended in the form of under sleeper pads (USPs) or under ballast mats (UBMs). The recommended extents are provided in Appendix F.3.

These mitigation extents will be further reviewed once the detail in the design further develops.

Results

Noise

With the noise wall extents detailed above, it is predicted that:

- Noise levels are not predicted to exceed the day-time threshold values ($L_{Aeq,day}$ 60 dB) at any of the sensitive residential receivers.
- Noise levels are not predicted to exceed the night-time threshold values ($L_{Aeq,night}$ 55 dB) at any of the sensitive residential receivers.
- Noise levels are not predicted to exceed the maximum passby target (L_{Amax} 80 dB) at any of the sensitive residential receivers.

The predicted noise and vibration exceedances are based on 95% certainty of outcome and will be further investigated during detailed design.

Vibration

With the vibration mitigation extents detailed above, it is predicted that:

- Ground borne vibration levels are not predicted to exceed the corresponding threshold values at any of the sensitive receivers.
- Ground borne noise levels at majority of the receivers are not predicted to exceed the corresponding threshold values ($L_{Amax,night}$), except 3 residential receivers at 59 Eleventh Rd (+1 dB), 11 Woodstock Pl (+2 dB), 2123 Thomas St (+3 dB), Darling Downs.

In using a 95% certainty design position, with a 1-2 dB margin there is reasonable likelihood of compliant actual levels during commissioning. In addition, considering the widespread locations of these three properties along the alignment, applying further vibration mitigation may not be considered as a cost-effective solution. These will be further investigated as part of detailed design.

Acknowledgment of Country

MetCONNX acknowledges the Whadjuk People and the Gnala Karla Booja People as the Traditional Custodians of the land and waters on which Byford Rail Extension Project is located.
We pay our respects to Elders, past, present and emerging, and thank them for their continuing connection to country, culture and community.

2. Project overview

2.1 METRONET Vision and Objectives

As one of the largest single investments in Perth's public transport, METRONET will transform the way the people of Perth commute and connect. It will create jobs and business opportunities and stimulate local communities and economic development to assist communities to thrive. The METRONET vision is for a well-connected Perth with more transport, housing and employment choices. In delivering METRONET, the WA Government has considered peoples' requirements for work, living and recreation within future urban centres with a train station at the heart.

The objectives are to:

- Support economic growth with better-connected businesses and greater access to jobs
- Deliver infrastructure that promotes easy and accessible travel and lifestyle options
- Create communities that have a sense of belonging and support Perth's growth and prosperity
- Plan for Perth's future growth by making the best use of our resources and funding
- Lead a cultural shift in the way government, private sector and industry work together to achieve integrated land use and transport solutions for the future of Perth.

2.2 Byford Rail Extension Overview

The Byford Rail Extension (BRE) Project has been identified as an essential component of the METRONET program. The Project will extend the electrified passenger rail service from Armadale to Byford, providing a strong transport connection between these two centres, supporting economic growth and providing greater access to jobs. The Project has been developed in line with policy objectives for highly integrated transport and land use planning.

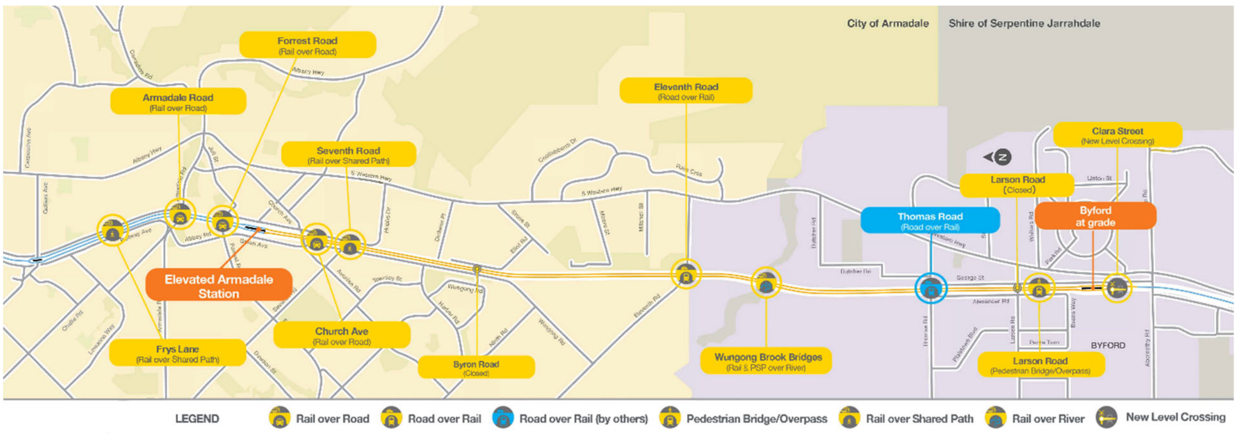


Figure 2: METRONET Byford Rail Extension Project

2.2.1 Project features

Transport infrastructure works for the BRE Project include:

- Demolition of existing station at Armadale and construction of a new elevated station
- Construction of a new Byford station at grade (Base Case)
- Construction of approximately 8km of dual track narrow gauge electrified passenger railway line extending from Armadale station to the newly created Byford station, with a dedicated platform for the Australind line
- Removal of level crossings between the Byford and Armadale stations
- Construction of PSPs and associated infrastructure (including 'rail over road' and 'road over rail' bridges and roads)
- Parking areas at Armadale and Byford stations
- Bus interchange at Armadale and Byford stations
- Upgrade of local roads surrounding both Armadale and Byford stations.

2.2.2 General scope of works

The Project's general scope of works includes designing, procuring, manufacturing, constructing, installing and commissioning all rail infrastructure and ancillary works to support an electrified operational passenger rail between Armadale and Byford Stations. Also, in the case of the Australind train service, tying into the non-electrified rail network south of Byford Station.

The Project activities include all site investigation, design, planning, scheduling, procurement, cost control, approvals, construction, OH&S management, environmental management, quality management, testing and commissioning, Entry Into Service (EIS), training and operational readiness required to tie the rail extension to Byford into the existing rail network including the associated road, utilities and other required works to interface with adjacent works and contracts. This will include bulk earthworks and retaining structures, grade separations, roads, and drainage, the demolition and removal and treatment of waste material and contaminated material resulting from construction of the Works, and temporary works constructed for the purpose of facilitating the Works.

The project scope also includes any new road works, modifications to existing roads and signalised intersections, utilities (diversion, protection, and new installation) and any other ancillary works to enable the BRE Project.

2.2.3 Future Proofing the works

As part of the Project, space must be allowed within the rail corridor for the option of a 4-track scenario for a potential high-speed regional service from Bunbury. The additional 2 tracks shall be constructed in the eastern half of the rail corridor, so that future infrastructure can be constructed without impacting on existing rail operations. The Project should also allow for the possibility of future extension of the electrified line south of Byford to Mundijong, and a future stabling yard south of Abernethy Road.

2.3 Alliance Vision and Delivery Approach

The BRE Project will be delivered under an alliance contract to support the management of project and stakeholder interfaces and to mitigate project risks. A collaborative alliance approach will see the Works carried out in a cooperative, coordinated and efficient manner, in compliance with the Alliance Principles.

MetCONNX understands that the successful delivery of the Project is critically linked to meeting the PTA's Key Project Objectives. These objectives have shaped our vision for the Project that is around delivering a high-quality product and creating exceptional value-for-money. We are committed to a no-blame culture and to the prompt and mutual resolution of any issues that may arise.

During the AD Stage, an interactive ALT Visioning Workshop was held with representatives from the PTA and MetCONNX to develop a suitable Alliance Vision for the Project, refer Figure 3.

Figure 3: AD Stage Alliance Vision Development Outcomes (developed with the PTA)

To support the realisation of this vision, we will develop a robust and highly collaborative alliance culture in which everyone challenges 'business-as-usual' and pursues better outcomes in the design and construction of the Project. In line with this, during the AD Stage the MetCONNX team refined their priorities for the Project as being:

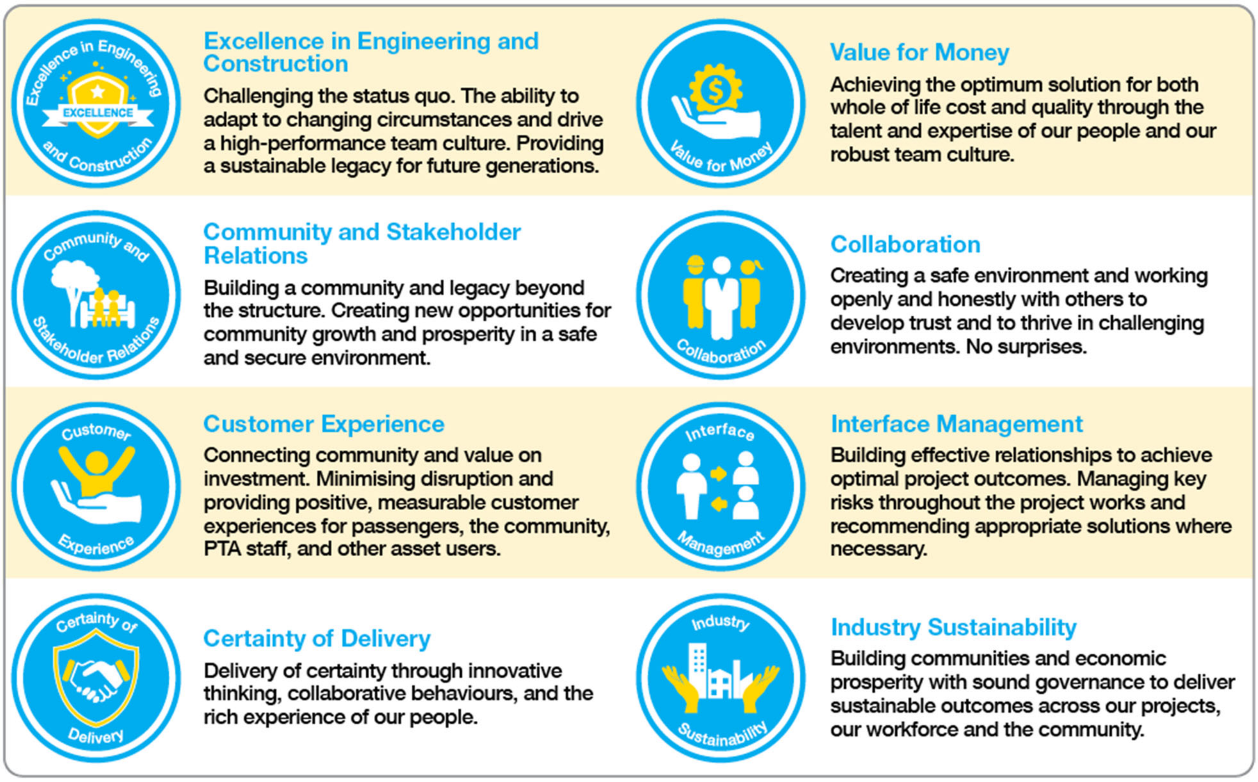


Figure 4: MetCONNX Priorities aligned with Key Project Objectives

2.4 Purpose of the Report

This Design Report presents the design proposals for the Noise and Vibration package (540) associated with line-wide permanent way operational aspects of the project. This report shall provide the design's rationale and context of the noise and vibration assessment for review by the PTA and stakeholders.

The purpose of this report is to document the path to compliance with SWTC Book 4, Section 13 Noise and Vibration:

- Detail all investigations and detailed analysis to determine existing and future noise and vibration levels for the operation of the Project (rail and road noise). Apply best practice methods consistent with the relevant standards, codes of practice and requirements contained in the SWTC.
- Design advice of engineering and administrative measures around construction and operation of the Works compliant with the noise and vibration criteria.
- Provide design requirements for mechanical services to meet the criteria specified.
- Design advice for a complete, integrated Permanent Way system to meet all relevant Technical Criteria requirements.
- Design advice for the BRE stations system and associated infrastructure to meet all the Technical Criteria requirements.

The output from this report is expected to be accommodated within the relevant design packages.

3. Design Description

3.1 Scope of this Design Package

The scope of this Design Package is outlined as follows:

- A schedule of recommended controls to be considered and reviewed for design optimisation and design/statutory planning approval within the packages described in section 3.2.
- No development of software and application data for systems.
- No specific computer hardware resources including processor type, operating systems, development environment, capacity, interfaces and timing diagrams.

The design modelled consists of:

- Solid walls / fences at specific locations for the purposes of suitable noise control compliant with PTA Specification 8880-450-069 (Noise Walls), and
- Under Sleeper Pads (USPs) or Under Ballast Mats (UBMs) at specific locations for suitable vibration control.

3.2 Relationship with other Design Packages

The relationship and/or reliance of this design package on other BRE design packages is derived from the design structure and is outlined in Table 1.

Table 1: Relationship with other design packages

Design Package	Description/Title	Interface Elements
TR100	Permanent Way – Alignment Design	Trackform Noise walls Rail web dampers Under sleeper pads
CI155	Permanent Way – Earthworks and Drainage	Noise walls Under sleeper pads
CI160	Linewide - Flood and Hydrology	Noise walls Under sleeper pads

Design Package	Description/Title	Interface Elements
ST170	Linewide - Viaduct	Noise walls Trackform
CI200	Armadale Precinct - Earthworks	Noise walls
CI210	Armadale Precinct - Drainage	Noise walls
AR225	Armadale Precinct - Architecture	Noise walls
LA230	Armadale Precinct - Landscaping	Noise walls
ST235	Armadale Precinct - Station Structures	Noise walls
CI300	Byford Precinct - Earthworks	Noise walls
CI305	Byford Precinct - Drainage	Noise walls
AR325	Byford Precinct - Architecture	Noise walls
LA330	Byford Precinct - Landscaping	Noise walls
ST335	Byford Precinct - Station Structures	Noise walls
CI400	External to precincts - Earthworks	Noise walls Under sleeper pads
CI405	Eleventh Road Civil (Earthworks, Drainage, Roads & Pavement)	Noise walls
CI410	External to precincts - Drainage	Noise walls Under sleeper pads
ST430	External to precincts – On Viaduct Structures	Noise Walls
ST431	External to precincts – Off Viaduct Structures	Noise Walls

3.3 External Interfaces

Not applicable to this design stage.

3.4 Changes Since Previous Design Submission

3.4.1 Alliance Development (AD) Phase to Reference Design (RD) Phase

The AD phase noise and vibration advice was based on qualitative estimates predominantly based on PTA's Reference Design noise and vibration assessment, with consideration to the AD phase rail alignment proposal options.

Since the AD phase, noise and vibration assessment has been undertaken to further estimate the extents of noise and vibration mitigation. The assessment has utilised 3-D acoustic modelling with Nord2000 modelling algorithm in an attempt to more accurately estimate the noise emissions. The details of the assessment and outcomes are presented in this report.

3.4.2 Reference Design (RD) Phase to IDC Phase

Since the RD phase, the following key changes are noted:

- Revised speed profiles 'BYF P2-SHE' and 'SHE-BYF P2' from BRED-PTAWA-GCOR-00942 received in October 2022.
- Ballasted track sections were revised from HDPE to rubber rail pads, which has the effect of increasing airborne noise emissions and slightly reducing vibration emissions.
- Revision to rail vertical alignment in the Byford area;
- Addition of a large subdivision south of Wungong (~34km);
- Revision of civil design / locations of drains etc.

No change in vibration mitigation extents recommended to suit SWTC requirements

4. Design Inputs

4.1 Project Design Requirements

The following design inputs, loads combinations, standards and other key design inputs have been used in preparation of this report.

4.1.1 SWTC Requirements

Key SWTC requirements as they relate to the design are listed in Section 4.5.

Author(s) and reviewer(s) of this report are qualified acoustics engineers with over ten years of professional experience in the modelling and assessment of railway noise and vibration emissions as required by SWTC ID 1458225.

4.1.2 Operational Scenario

This assessment refers to the 'Build' (including mitigation) scenario that represents the scenario approximately 20 years after completion of the BRE project, nominally the design year 2044.

Table 2: Rail operational volumes by scenario

Scenario, Year	Service	Train type	Volumes[1] Day / Night[2]	Comments, Rationale
Build year 2044	Perth – Byford (DN)	Series B (6-car)	82 / 7	Based on PTA Concept Train Operating Plan, with up to +5% tolerance.
		Series B (3-car)	9 / 9	
	Byford – Perth (UP)	Series B (6-car)	82 / 7	
		Series B (3-car)	9 / 9	

Note 1 Excludes the Australind services to Bunbury – See Section 4.1.3.5
Note 2 Normal Monday to Friday services, one way. Day period refers to 6 am to 10 pm period; Night refers to 10 pm to 6 am period.

4.1.3 Railway

4.1.3.1 Rolling Stock

Design is based on the Series B Electrical Multiple Units (EMU) rolling stock. The design also accommodates future Series C EMUs on the basis that the wheel and rolling stock design parameters that are relevant to noise and vibration emissions are effectively equivalent to Series B.

The Australind service to Bunbury, using a Diesel Multiple Unit (DMU), is not modelled. This is because:

- the DMUs, along with the first and last trains (referred to as positioning runs) with a non-stop pattern are considered to constitute less than 5% of all traffic. This means that the maximum noise level objectives adopted (which are based on the 5th highest percentile event or averaged over significant time periods) are not sensitive to those events; and
- DMU emission levels at speed are considered similar to EMU levels, as the noise generated at the wheels and rails (rolling noise) is more significant than that from the diesel engine. The Australind services typically operate only during the day period (after 6 am and before 7 pm) within the study area, and hence the noise level from the DMU is not considered critical from a sleep disturbance or SWTC compliance perspective.

Selected properties of the rolling stock are provided in the following table. Note that these values are provided for informative purposes and only used to calculate the effect of any proposed changes in trackform from ballasted track, such as the use of revised track fasteners, rail web dampers or under ballast matting. In other words, the modelled noise and vibration levels for ballasted track are validated using actual field data as per Section 4.8.1.3, not the values in Table 3.

Table 3: Selected rolling stock details (Source: SLR)

Parameter	'Series B'
Configuration	3 or 6 car sets
TARE Train Weight	120,865 kg (3 car set)
TARE Vehicle Mass (Heaviest Car)	41,125 kg
TARE Axle Load	10,281 kg
Maximum Vehicle Mass	53,725 kg
Maximum Static Axle Load	13,431 kg
Unsprung Mass (Motor Axle)	1,800 kg
Unsprung Mass (Non-Motored Axle)	1,400 kg
Vertical centre of Gravity, zcg (z=0 top of rail)	1.83 m (DMA/DMB) 1.69 m (TM)
Bogie Wheelbase	2.5 m
Bogie Centres	17 m
Wheel Diameter, worn	760 mm
Wheel Diameter, Full	840 mm
Primary Lateral Stiffness Per Wheelset	24.56 MN/m
Primary Vertical Stiffness Per Wheelset	2 MN/m
Primary Longitudinal Stiffness Per Wheelset	17.36 MN/m
Secondary Lateral Stiffness Per Bogie	0.32 MN/m
Secondary Vertical Stiffness per bogie	0.56 MN/m

4.1.3.2 Track Form Types

The permanent way is modelled with two types of trackform, referred to here as simply ballasted and slab track. Table 4 lists out key details for these modelled track types. As per the previous section, these values are provided for informative purposes and only used to calculate the effect of any proposed changes in trackform from default conditions.

Table 4: Track types and conditions

Parameter	Ballasted track	Slab track, direct fix
Locations	Generally (excluding turn outs)	As per Table 5
Track structure	Ballasted on grade track, typ. 200-250 mm depth. Concrete monobloc sleepers, 700 mm centres.	Direct slab fix, 700 mm centres
Rail	AS50kg	AS60kg
Rail fastener system	Rail clip with cast-in shoulder, 8-8.5mm rubber pad (Pandrol RP65221)	Pandrol VIPA Cat C/D
Modelled dynamic vertical stiffness (Note [2])	129 MN/m +/- 10%	25 MN/m +/- 10%
Width of sleeper / support measured on foot of rail:	200 mm	400 mm

Parameter	Ballasted track	Slab track, direct fix
Width of sleeper space at rail foot:	500 mm	-
Length of fastening at baseplate:	-	300 mm
Length of sleeper at foot of sleeper	2,050 mm	-
Width of sleeper at foot of sleeper	263 mm	-
Height of rail web:	84 mm	93 mm
Rail surface condition	The assessment relies on the track to be continuously welded and ground smooth to the same specification as existing network average (or better), taken to be ISO 3095, maintained to be free of defects.	

Note 1 These are dynamic stiffness values for the key frequencies of interest, allowing for ageing and in-service. These are likely to be higher than advertised static or dynamic stiffness values.

Noise levels from slab track sections are likely to be higher than typical ballasted track, due to the use of relatively softer rail supports and no ballast to provide sound absorption.

It has been assumed that 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 levels.

Table 5 lists the modelled locations of slab track. 'DN' refers the Down main line, and 'UP' is the Up main line.

Table 5: Slab track sections modelled

Location	Line	Chainage, m	Length, m	Details, Notes
		Start	**End**	
Armadale Precinct	BRE DN	28020	29805	Slab track has length of 1785 m, which starts on tangent track on approach to viaduct and ends at the end of viaduct. Viaduct is from chainage of 28240 to 29770.
	BRE UP	28020	29805	

4.1.3.3 Viaducts

Viaduct structures are modelled for the Armadale section track slab locations defined in Table 5. Viaducts are modelled with the same cross-sectional geometry as that defined in the Civil Permanent Way Typical Cross Sections.

4.1.3.4 Turnouts

Turnouts/switch points have been modelled at the positions indicated in the following table.

Table 6: Turnout locations modelled

#	Line	Frog chainage, m	Type
1	BRE DN	BRE DN 28825	Fixed frog crossing (FFX)
2	BRE UP	BRE UP 28948	Fixed frog crossing (FFX)
3	BRE DN	BRE DN 29368	Fixed frog crossing (FFX)
4	BRE UP	BRE UP 29472	Fixed frog crossing (FFX)
5	BRE UP	BRE UP 35354	Fixed frog crossing (FFX)
6	BRE UP	BRE UP 35610	Fixed frog crossing (FFX)
7	BRE DN	BRE DN 35628	Fixed frog crossing (FFX)
8	BRE DN	BRE DN 35688	Fixed frog crossing (FFX)
9	BRE UP	BRE UP 35715	Fixed frog crossing (FFX)

Fixed frog crossings (FFX) present a small fixed gap at the intersection of two running rails within a turnout, and are modelled with a +10 dB increase in local noise and vibration emissions up to 5 metres either side of the section containing the gap.

Swing nose crossing (SNX) type use a movable 'frog' at the intersection of two running rails to provide support for wheels and passageways for their flanges, are typically modelled with +6 dB increase for up to 5 m on either side.

4.1.3.5 Speed

Train speed has a critical influence on noise and vibration emissions. Modelled speeds for each line are provided in Figure 5 and represent a stopping pattern at proposed stations based on profiles 'BYF_P1_(UP)-SHE' & 'SHE-BYF_P2_(DN)' from project correspondence BRED-PTAWA-GCOR-01496 received in December 2022.

Note that a minimum of 30 km/hr is applied within the modelling algorithm to account for onboard plant (pneumatics, air conditioning) that become significant noise sources at lower speeds.

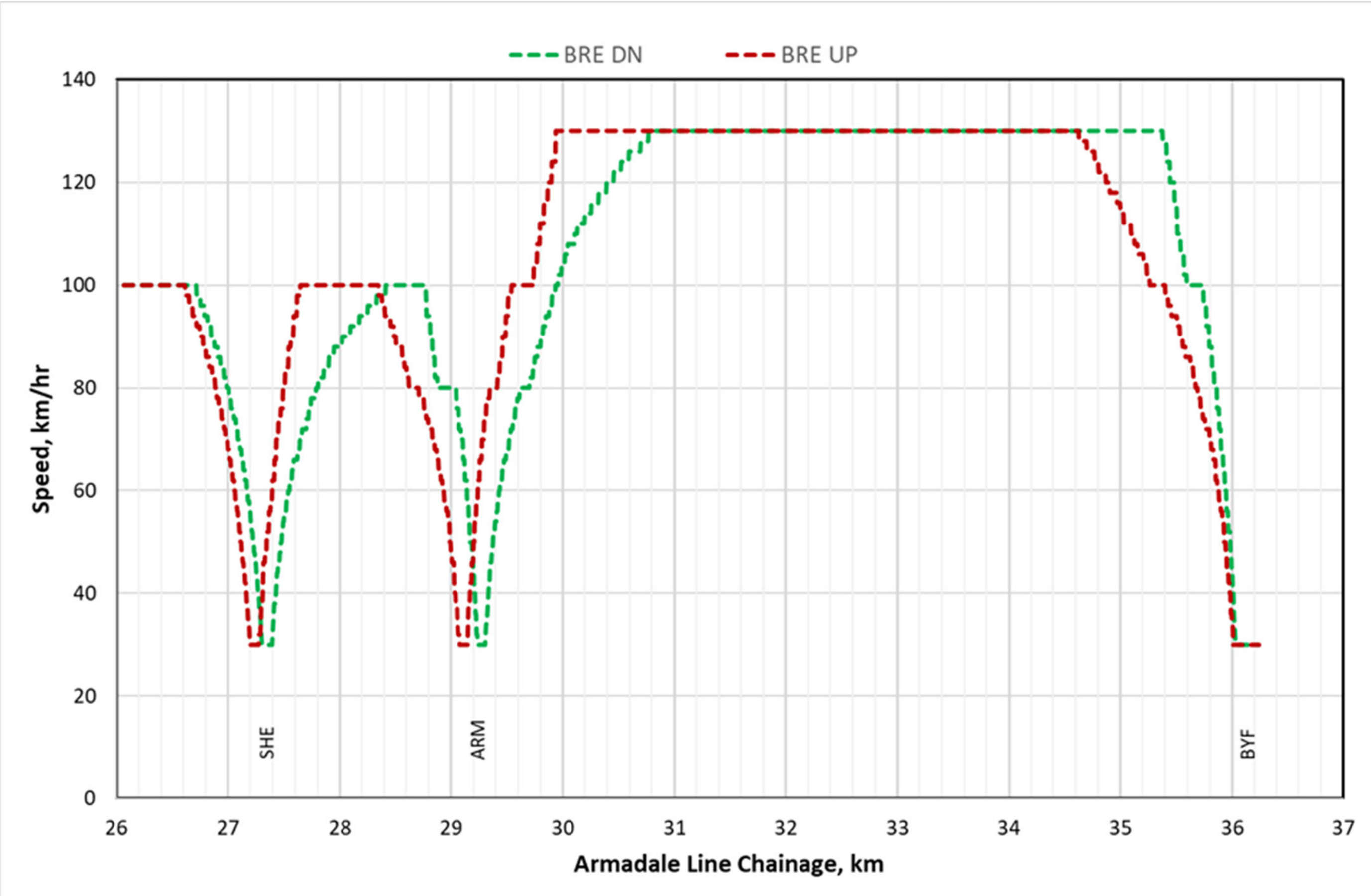


Figure 5: BRE Speed profile as modelled

4.1.3.6 Rail Condition

The track condition is a key factor that influences source noise and vibration levels.

Forecasts are based on the BRE track condition being equivalent or better than that typically measured on the Perth network (or otherwise meeting the requirements of ISO 3095).

4.1.4 Stations and Infrastructure

Refer to the station design reports listed in Table 7 for relevant inputs relating to stations and associated infrastructure. The design of noise and vibration mitigation considers the effects of the operation of these stations and their associated infrastructure.

Table 7: Station reports

Reference	Supplier
R30-SLR-RPT-NV-540-00005	Armadale Station Development Approval Acoustic Report
R30-SLR-RPT-NV-540-00006	Byford Station Development Approval Acoustic Report
R30-SLR-RPT-NV-540-00009	Fixed Infrastructure Noise Assessment

4.1.5 Road Traffic

Road traffic noise levels for estimating ambient noise levels and compliance with SPP5.4 requirements have been predicted based on publicly available Main Roads data. The difference in traffic volumes between day and night periods, and percentage of heavy vehicles are estimated from relevant vehicle count data provided on the Main Roads WA website.

The calculated road traffic noise levels at single receivers are listed in Appendix E.1 and the grid noise maps of road traffic are presented in Appendix C.6 and 7.

Future road traffic noise levels are predicted on the basis of adding +2dB to L_{Aeq} results, representing a 40% increase over 2022 volumes.

4.2 Design Software used for this Package

Computer software used to develop this package is outlined in the Table below.

Table 8: Software list

Reference	Supplier	Usage
ANSYS Mechanical v18.2, Acoustics ACT Extension	LEAP Australia with proprietary SLR code	Computation of vibratory modes associated with Perth wheel
EASE (Enhanced Acoustic Simulator for Engineers)	Ahnert Feistel Media Group (AFMG)	Modelling of acoustical conditions within stations
MOTIV	ISVR	Vibration emissions from various track forms
MS Office 2013	Microsoft Inc. (with proprietary SLR code)	Calculation of in-car noise levels Calculation of 3D receiver distances Calculation of 1D vibration propagation Consolidation and presentation of results 1D propagation / noise analyses
Scilab	Open source Requires proprietary SLR code	Processing of vibration and acoustic signal field data into results for comparison with criteria
SoundPLAN v8.1	SoundPLAN GmbH	Calculation of site wide airborne noise emissions according to prescribed standards
STARDAMP	Vibratec.fr	Prediction of component noise emissions from wheel and rail, and forecasting of the effect of rail web dampers

4.3 Applicable Codes and Standards

Applicable standards, codes and guidelines to this design package (at time of project commencement) including identification of specific provisions, criteria and classifications are provided in the Table below.

Table 9: Applicable codes and standards

Reference	Description/Title
Australian and Other Standards and Guidelines	
CR NOI TSI:2011	Technical specification for interoperability relating to the subsystem 'rolling stock – noise' of the trans-European conventional rail system, adopted by the Commission Decision 2011/229/EU, April 2011
SPP5.4:2019	State Planning Policy No. 5.4 Road and Rail Noise 2019
AS 2670.1:2001	Evaluation of human exposure to whole-body vibration - General requirements
AS 2670.2:2001	Evaluation of human exposure to whole-body vibration - Continuous and shock-induced vibration in buildings (1 to 80 Hz)
AS/NZS ISO 717.1	Acoustics — Rating of sound insulation in buildings and of building elements, Part 1: Airborne sound insulation
BS 6472:2008	Evaluation of Human Exposure Vibration in Buildings (1 Hz to 80 Hz)
BS 7385.2:1993	Evaluation and Measurement for Vibrations in Buildings – Part 2 Guide to Damage Levels from Ground-Borne Vibration
DIN 4150.3:2016	Part 3: Structural Vibration in Buildings: Effects on Structures
ISO GUIDE 98-3:1995	Uncertainty of measurement — Part 3:Guide to the expression of uncertainty in measurement (GUM:1995)
ISO 3095:2013	Acoustics - Railway applications - Measurement of noise emitted by railbound vehicles - Third Edition, August 2013
ISO 3381:2021	Railway applications - Acoustics - Measurement of noise inside railbound vehicles
ISO 8041:2017	Human response to vibration – Measuring instrumentation
ISO 14837:2005	Mechanical vibration - Ground-borne noise and vibration arising from rail systems
ISO 2631-1:1997	Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 1: General requirements.
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).
ASHRAE:2011	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc, 2011 ASHRAE Handbook - Heating, Ventilating, and Air-Conditioning APPLICATIONS - SI Edition, Atlanta GA http://www.ashrae.org
FTA:2006	C.E. Hanson, D.A. Towers, and L.D. Meister 2006, Transit Noise and Vibration Impact Assessment, Office of Planning and Environment, Federal Transit Administration, Report FTA-VA-90-1003-06, Washington DC
Nord 2000	Jonasson HG, Storeheier S. Nord 2000. New Nordic prediction method for rail traffic noise [Internet]. 2001. (SP Rapport).
Green Star, 2020	Green Star Design and As-built Requirements for Railway Stations (v1.1)
ISCA, 2018	Infrastructure Sustainability Council of Australia (ISv2.0) Design and As Built
PTA Standards and Specifications	
5650-200-007	Personnel Access and Refuge at Bridges, Tunnels and Confined Localities Minimum Requirements

Reference	Description/Title
8880-450-069	Public Transport Authority Specification: Fences and Noise Walls

4.4 Reference Information

The project specific reference information and reports that have been used as inputs into the development of the detailed design are included in the table below.

Table 10: Key referenced documents

Document Reference	Description/Title	Date
R30-MET-MDL-TR-100-00210	Chainage model	05/05/2022
R30-MET-MDL-SV-000-00002	Existing alignment and land survey	05/05/2022
R30-MET-MDL-TR-100-00100	Proposed rail alignment	05/05/2022
20220422_BRE_HORIZONTAL PLAN_COMBINED	Track and structure extents	05/05/2022

4.5 Design Criteria

The design criteria utilised in the development of this design package are outlined below.

4.5.1 Permanent Way

4.5.1.1 Airborne Noise

SWTC 13.6.1-3 states that:

The Alliance must design and construct the operating passenger railway and any associated noise mitigation controls to meet the requirements of "State Planning Policy No. 5.4 Road and Rail Noise (SPP 5.4)" (WAPC, 2019).

The Alliance must design and construct the operating passenger railway to ensure that the L_{Amax} applicable to the 95th percentile train passby event is 80 dB or less at buildings with a noise sensitive use located on noise sensitive premises.

The table below outlines the adopted noise objective levels in regard to airborne noise during road and rail operations. Noise mitigation must be provided where the noise level is above these targets.

Table 11: Airborne noise criteria

Metric	Application	Value(s)	Notes
Period average noise levels	Major upgrade of existing railway *(Applicable to this project)*	LAeq,day 60 dB	SPP5.4
		LAeq,night 55 dB	
Maximum noise levels	Line wide	LAmax 80 dB	95% of trains (5th percentile). SWTC

These objectives are assessed outdoors, 1 metre from the main building on a lot associated with a noise sensitive usage. Consistent with SPP5.4, the criteria are assessed:

- Only at premises that are occupied or designed for occupation or use for residential purposes (including dwellings, residential buildings or short-stay accommodation), caravan parks, camping grounds, educational establishments, child care premises, hospital, nursing home, corrective institution; or place of worship (Note that this excludes recreational parks, commercial and industrial premises along the alignment – results will be determined for these locations, but mitigation would not be recommended); and

- at all floor levels where identified from surveys, noting that sufficient mitigation (in the context of the targets) may not reasonable or practicable at higher floors.

4.5.1.2 Vibration

SWTC 13.6.1-3 states that

The Alliance must design and construct the operating passenger railway to comply with the vibration criteria detailed in Table 29: Project Rail Operations Vibration Criteria.

Table 12: Vibration criteria

Parameter	Criterion[1]	Value
Rail Operations – Design Level	Vibration levels from rail operations will be managed as low as is reasonably practicable.	Demonstrated
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 as amended or AS ISO 2631.2:2014 .	
	Medical clinical treatment, surgery or recovery areas, or facilities operating precision equipment	Curve 1 (LvSmax 100dB)
	Residential and hotel accommodation	Curve 2 (LvSmax 106dB)
	Commercial premises, public buildings, Churches and community centres and the like	Curve 4 (LvSmax 112dB)
	Light and general industrial buildings	Curve 8 (LvSmax 118dB)
Rail Operations Regenerated Noise/Ground-Borne Noise 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.	
	Residential and hotel accommodation, 10pm to 6am	LASmax 35dB
	Residential and hotel accommodation, 6am to 10pm	LASmax 40dB
	Commercial buildings, public buildings, Churches and community centres and the like	LASmax 45dB
	Retail and point of sale areas, occupiable light and general industrial buildings	LASmax 50dB

[1] Airborne noise criteria are referenced to 20 microPascals (dB re 20μPa). Vibration criteria 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.

4.5.2 Green Star

Green Star – Railway Stations Credit 14 under Green Star Design and As-built Requirements for Railway Stations (v1.1) have four (4) points available under Acoustic Comfort. These relate to:

- 14.1 Internal Noise Levels
- 14.2 Reverberation
- 14.3 Audibility
- 14.4 Hearing Loop Coverage.

An additional point is available under the Innovation category for achieving better than the minimum environmental benchmarks.

4.5.3 ISCA

The Infrastructure Sustainability (ISv2.0) Design and As Built requirements cover two credits for noise and vibration (Env-2 for noise, and Env-3 for vibration). Both these criteria relate to the construction and operational phases of the project and have three levels of credit to target depending on the project's intent.

Env-2 is an As-Built requirement (i.e. need verification post project completion) whilst Env-3 is a Design credit, both relating to construction and operational phases of the project.

Acoustic design for Station buildings with the intent to achieve Green Star Credits 14.1 (Internal Noise Levels) and 14.2 (Reverberation)

- Acoustic advice in relation to speaker positions, tappings and orientations on platforms, concourses and waiting rooms (as applicable) with the intent to achieve Green Star Credit 14.3 (Audibility)
- Baseline monitoring for noise and vibration along the alignment prior to construction to assist with ISCA Env-2 and Env-3 Level 1 (for operational phase only)
- Predictive noise and vibration modelling for the operation of the proposed rail line, and recommendation of mitigation measures (as required) to mitigate noise and vibration and meet the established project criteria – These are required prior to achieving Level 1 criteria under ISCA Env-2 and Env-3.

4.5.4 Stations and Fixed Infrastructure

4.5.4.1 <u>Station Facilities External Noise</u>

SPP-5.4

The following criteria is used to assess the noise emission from bus interchange and car parks associated with the Armadale Station.

Table 13**Table 13** below outlines the adopted noise objective levels in regard to airborne noise during road and rail operations. Noise mitigation is recommended where noise levels from designed rail assets are above these targets.

Table 13: Road and rail noise criteria

Metric	Application	Value(s)
Period average noise levels	New road/railway	$L_{Aeq,day}$ 55 dB
		$L_{Aeq,night}$ 50 dB

Environmental Protection (Noise) Regulations 1997

The following criteria has been used to assess the noise emission from the station facilities, including mechanical and electrical services plant, crowd and public address system noise associated with the Armadale Station.

Environmental noise emissions (excluding trains and some emissions from road vehicles) from various premises to nearby noise receiving premises are covered by legislation in the form of the *Western Australia Environmental Protection (Noise) Regulations 1997,* which operate under the *Environmental Protection Act 1986*. For this project, these regulations apply to stations and ancillary operational equipment, and specifically do not apply to trains.

To achieve compliance, received noise levels at nearby premises including noise sensitive premises (for example, residential, commercial and industrial premises) are not to exceed specified noise limits in the form of assigned noise levels.

The assigned noise levels, as shown in Table 14, vary for each noise sensitive receiver, as they are determined from consideration of Influencing Factors (IF) which takes into account the amount of commercial, industrial and road transport infrastructure within specific distances to the receiving noise sensitive premises.

Table 14: Table of Assigned Noise Levels, dB

Part of premises receiving noise	Time of day	LA10	LA1	LAmax
Noise Sensitive premises at locations within 15 metres of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	45 + IF	55 + IF	65 + IF
	0900 to 1900 hours Sunday and public holidays	40 + IF	50 + IF	65 + IF
	1900 to 2200 hours all days	40 + IF	50 + IF	55 + IF
	2200 hours on any day to 0700 Monday to Saturday and 0900 hours Sunday and public holidays	35 + IF	45 + IF	55 + IF
Noise Sensitive premises at locations further than 15 metres from a building directly associated with a noise sensitive use	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial and utility premises	All hours	65	80	90

Regulation 7 of the *Environmental Protection (Noise) Regulations 1997* requires that, if noise emitted from any premises when received at any other premises cannot reasonably be free of intrusive characteristics of tonality, modulation and impulsiveness, then a series of adjustments must be added to the emitted levels (measured or calculated) and the adjusted level must comply with the assigned level. The adjustments are detailed in **Table 15**, and are further defined in Regulation 9(1) of the *Environmental Protection (Noise) Regulations 1997*.

Note that the following adjustments (**Table 15**) generally apply to fixed plant and infrastructure only.

Table 15: Table of adjustments for intrusive characteristics

Noise characteristic	Definition	Adjustment if present (Note [1])
Tones	Where the difference between the A weighted sound pressure level in any one third octave ban and the arithmetic average of the A weighted sound pressure levels in the two adjacent one third octave bands is greater than 3 dB in terms of $L_{Aeq,T}$ where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as L_{ASlow} levels.	+5 dB

Noise characteristic	Definition	Adjustment if present (Note [1])
Modulation	A variation in the emission of noise that – • Is more than 3 dB L_{AFast} or is more than 3 dB L_{AFast} in any one third octave band; • Is present for at least 10% of the representative assessment period; and, Is regular, cyclic and audible.	+5 dB
Impulsiveness	Present where the difference between the L_{APeak} and L_{Amax} is more than 15 dB when determined for single representative event.	+10 dB

Note 1 Where noise emission is not music, these adjustments are cumulative to a maximum of 15 dB.

During the assessment process the above adjustments have been applied to relevant noise sources, taking into account specific intrusive characteristics of these noise sources based on SLR's in-house noise database. It is unlikely that modulation or impulsiveness characteristics would apply to PTA fixed assets being typically electrical power transformers or air handling plant. A tonal correction of 5 dB would typically apply to electrical transformers.

Unless specifically stated otherwise, these corrections are included in the presented results.

4.5.4.2 Stations and Infrastructure Internal Acoustics

Ambient Noise Levels with Passenger Station Areas

Section 13.8 of SWTC Book 4 details the requirements for the design and operation of the station and associated infrastructure, and includes the following statements:

[13.8-2] The Alliance shall address noise and vibration impacts associated with station noise impacts, inclusive of any bus interchanges, car parks and any new road infrastructure to service the stations, to surrounding sensitive receivers, occupational health and amenity for PTA staff and patrons.

[13.8.2] The Alliance shall design station areas to comply with the noise levels values set out int Table 29: Station Nosie Design Criteria, where defined in AS 1055.1:1997 and assessed according to AS/NZS 2107:2000.

Section 13.8.2 of the SWTC also states that:

For enclosed rooms containing plant, equipment and electrical power Assets, noise levels shall be assessed at no less than 1 metre from any item of equipment; and noise levels from mechanical ventilation systems serving the room must not exceed L_{Aeq} 65dB.

The criteria listed above in this section do not apply to systems or components operating in emergency mode. In this situation, noise generated by the systems or their components must comply with AS 1670.4 and AS 1668.1, and not exceed levels that affect speech intelligibility in egress paths, evacuation assembly areas, or operational or emergency control rooms or areas.

Table 16**Table 16** presents internal noise level criteria from Table 29 designed to address the above requirements.

In order to be consistent with the SWTC, the 2000 version of AS/NZS 2107 is followed in this assessment and not the more recent 2016 version. However, the internal noise and reverberation requirements in the 2016 version are similar with no significant changes to recommended values that are relevant to this project. As such, no compromise to acoustic amenity is anticipated in using the SWTC requirements (which references the 2000 version).

Table 16: Ambient noise level criteria (Table 29 from SWTC Book 4)

Area	Scenario	Minimum acceptable noise level (dB)	Maximum acceptable noise level (dB)
Ticket sales area	Building services and plant	-	L_{Aeq} 45
General office areas	Building services and plant	-	L_{Aeq} 45
Staff crib rooms	Building services and plant	-	L_{Aeq} 45
Public waiting areas, kiosks	Building services and plant	-	L_{Aeq} 45
Toilets and amenities	Building services and plant	L_{Aeq} 45	L_{Aeq} 55
Parking and waste storage areas	Building services and plant	-	L_{Aeq} 65
Platforms, at any position within 1.5m of platform edge or centreline (whichever is closer to track), and more than 8 metres from Portals	Stationary trains, auxiliary equipment operating as normal	-	L_{Aeq} 70
	Moving trains	-	L_{ASmax} 80
	Building services and plant (ventilation, escalators, etc.)	-	L_{Aeq} 55
	Emergency smoke fan systems	-	L_{Aeq} 85
Plantrooms	Building services and plant	-	L_{Aeq} 85
All other areas	All	-	Table 1, AS/NZS 2107:2000 'Satisfactory' values plus 5dB

<u>Noise and Vibration Ingress into Passenger Station Areas</u>

Section 13.8.3 of the SWTC states that the Alliance shall comply with the following requirements:

External noise ingress from all associated road and rail traffic sources controlled according to the requirements of the WAPC State Planning Policy No 5.4 Road and Rail Noise (SPP 5.4) (WAPC 2019).

Floor vibration levels within publicly accessible areas from plant, equipment or external sources to not exceed $L_{v,RMS,1s}$ *112dB.*

Section 23.10 also states that *The NOP shall provide shelters that reduce noise and wind as far as is practical and achievable, with particular attention to the platform, concourse, and entry building areas.*

This is interpreted to mean that where the NOP provides shelters that reduce wind, they must be effective at reducing railway noise as far as is practical and reasonable, with particular attention to the platform, concourse, and entry building areas.

<u>Reverberation within Passenger Station Areas</u>

Section 13.8.4 of the SWTC states that the Alliance shall comply with the following requirements:

Within platform areas, the spatial average reverberation time (RT60) values for the full octave bands with centre frequencies 500Hz and 1kHz not exceed 1.3 seconds for the scenario where 100 patrons are present, or 1.6 seconds when empty.

At all other areas, spatial average reverberation time (RT60) values for the full octave bands with centre frequencies 500Hz and 1 kHz be in accordance with AS/NZS 2107:2000 given the usage of each space.

<u>Public Address Systems within Passenger Station Areas</u>

Section 13.8.5 of the SWTC states that:

The Alliance shall ensure that the PA systems achieve the minimum sound level and speech intelligibility requirements of clause 4.3.4 and 4.3.6 of AS 1670.4 for all representative locations, environmental conditions and passenger levels.

External noise ingress from adjacent road traffic sources must be assessed and considered when designing and constructing all stations to ensure that the public address systems within passenger station Areas achieve the minimum sound level and speech intelligibility requirements of clause 4.3.4 and 4.3.6 of AS 1670.4 for all representative locations, environmental conditions and passenger levels.

Acoustic Sound Insulation within Passenger Station Areas

Section 13.8.6 of the SWTC states that:

Airborne sound insulation targets are given in terms of the weighted level difference, D_W between two spaces. The Alliance shall ensure that design complies with the following general in-situ airborne sound insulation targets:

$D_W \geq 35$dB between normally occupied enclosed spaces.

$D_W \geq 28$dB between normally occupied spaces where the common partition includes a door.

The following table presents criteria that supersede these general requirements for specific occupied spaces. Where two different space types are adjacent to one another, the Alliance must ensure that the more onerous target applies.

Table 17: Sound insultation criteria (SWTC Book 4 Table 30: Airborne Sound Insulation Requirements)

	Space Type / Occupancy	Minimum Weighted Sound Level Difference, D_W, dB
Between normally occupied back of house offices and crib rooms	Generally	40
	Where the common partition at the interface includes a door	30
Toilets and amenities to nearby public areas	Generally	42
	Where the common partition at the interface includes a door	25
	Where the common partition at the interface has no door	16

SWTC 13.8.6 also states that:

Where receiving spaces are not fully enclosed, the closest point of assessment must be at least 4 metres from the nearest door or window or the nearest scheduled seating position, whichever is closest.

Noise from hydraulic services associated with toilet amenities (e.g. flushing) must not be audible in any other publicly accessible area.

Noise from hand dryers within toilets and amenities should not be audible at any position more than 2 metres from the entrance and must not be audible at any commercial retail or patron seating areas.

4.6 Design Life

Refer to packages ST430 and ST431 for noise wall design wall requirements, and package TR100 for rail fixing design life requirements.

4.7 Durability Requirements

Not applicable at this design stage.

4.8 Specialist Technical Inputs

4.8.1 Railway Airborne Noise Predictions

4.8.1.1 Results (Including Impact of Road Traffic)

Predictions of airborne noise from rail operation (including the mitigation modelled as scheduled in Appendix F) are provided as contour maps in Appendix C, and as individual table results in Appendix E.

From these plots and table including the Appendix F mitigation modelled, the following results are noted:

- Noise levels are not predicted to exceed the day-time threshold values ($L_{Aeq,day}$ 60 dB) at any of the sensitive residential receivers.
- Noise levels are not predicted to exceed the night-time threshold values ($L_{Aeq,night}$ 55 dB) at any of the sensitive residential receivers.
- Noise levels are not predicted to exceed the maximum passby target (L_{Amax} 80 dB) at any of the sensitive residential receivers.

The predicted noise and vibration exceedances are based on 95% certainty of outcome and will be further investigated during detailed design.

4.8.1.2 Overview and Modelling Process

There are many factors influencing rolling noise and vibration levels in practice, including:

- **Number of trains per period**. This is as per the SWTC and described in Section 4.1.2.
- **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. The number of measurements and locations at which these measurements were taken is considered sufficient to remove the influence of recent track maintenance or rectification (grinding) on any individual results.
- **Speed**. The 'Nord2000' formulation is used to estimate the variation in noise emissions with speed. The speed at each chainage is modelled as per Section 4.1.3.5.
- **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). From an airborne noise emission viewpoint (i.e. noise radiated by the wheels, rails or sleepers), there is no significant differentiation between slab track founded on embankment and track slab founded on structure such as bridge structural slab. Track slab is considered in terms of structural noise (radiated by the structure itself) and vibration emissions via its supports.
- **Local features** such as turnouts can introduce discontinuities or sudden changes which increase noise emissions.
- **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).

- **Rolling stock**, e.g. wheel defects. The baseline measurements have been undertaken over a significant number of days at each location to reduce the influence of individual trains and represent the existing fleet.

A suitably validated model is required to estimate the relative difference where a direct comparison of noise emissions through field measurements is not yet practicable.

The Track Wheel Interaction Noise Software (TWINS) code was developed in the 1990s and has been extensively validated by various research institutes including the Institute of Sound and Vibration Research (ISVR) at the University of Southampton, in cooperation with several European railway and rolling stock companies. It is a recognised calculation model for assessing the acoustic effects of wheel and track design on railway rolling noise.

In this study, STARDAMP v1.4 software was used to compare the relative change in performance according to speed and measured track decay rate. As indicated in the figure below, the STARDAMP tool implements licenced TWINS prediction methodologies designed to evaluate the effect of wheel and rail dampers on pass-by rolling noise on a straight track, but it can also be used to compare changes to various input properties such as the trackform.

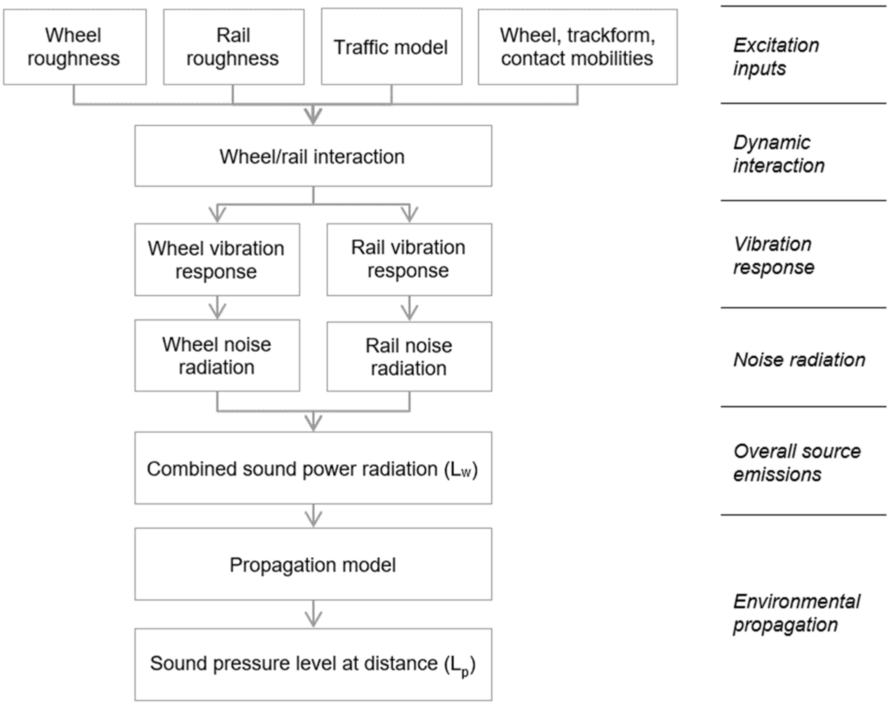


Figure 6: Overview of STARDAMP modelling process

Table 18 presents key inputs into the software, based on the information provided to date including Table 4.

Table 18: STARDAMP settings

Aspect	Ballasted	Slab track	Source / Reference
Traffic mix	Other: 5.1t wheel load 20 m length 4 wheelsets	Other: 5.1t wheel load 20 m length 4 wheelsets	Default, Series B
Wheel model	Perth wheel 840mm	Perth wheel 840mm	As supplied by PTA
Wheel Roughness	Disc-braked	Disc-braked	Default

Aspect	Ballasted	Slab track	Source / Reference
Rail roughness	ISO 3095 Curve	ISO 3095 Curve	-
Track type	Ballasted	Slab track	Default
Sleeper type, boot stiffness MN/m	Concrete monobloc, 280 kg	-	Default
Rail type	UIC54	UIC60	Default
Rail pad damping loss factor	0.2 ('Normal')		Default
Sleeper weight, kg	140	-	
Cross receptance factor, dB	-12		Default
Track decay rate	Adjusted based on field data		SLR, 2018

Note that there are several known limitations with the model which could lead to some error, including:

- The rail type, sleeper type, wheel roughness, rail pad damping loss factor and rail vehicle properties are all defined within the software and have limited alternative options – selections were made on the closest available.
- The sleepers are assumed to be of slightly different radiating area (e.g. top surface of ~0.4 m2) than that typically installed on the existing network.
- The rail pad damping loss factor is not defined as frequency dependent.
- The vertical and lateral dynamic stiffnesses have not been directly evaluated and are based on estimates according to available information and measured data of similar trackforms.

4.8.1.3 Source Levels

The reference noise emission values are developed based on

- 2021 baseline measurements of the existing Joondalup and Mandurah line railways, and
- 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. On this basis, typical levels at 15 metres distance and 80 km/h speed are provided in the following table.

Table 19: Base railway noise emission levels, 15 m from rail track @ 80 km/h

Trackform	Train Type	Without rail dampers		With rail dampers	
		L_{AE}	L_{Amax}	L_{AE}	L_{Amax}
Ballasted (HDPE)	Series B (6 car)	86	85	85	84
Ballasted (Rubber)	Series B (6 car)	89	88	85	84
Slab track	Series B (6 car)	92	91	87	86

To account for variations in length, 3 car trains are modelled as having 3 dB lower L_{AE} values, but the same L_{Amax} values at the reference distance.

The elevation between top of rail centreline and the hard reflecting plane below is modelled as 600 mm for ballasted track, and 300 mm for slab track.

4.8.1.4 Track Features/Discontinuities

Local features such as turnouts can introduce discontinuities or sudden changes which increase noise and 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.

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 consistent with SLR's experience on similar projects.

4.8.1.5 Curving Noise

It is noted that trains entering turnouts and passing loops may navigate relatively sharp curvature which under certain conditions can generate 'curving noise'. Curving noise is here considered to include two forms of noise, 'flanging' or 'wheel squeal'.

- Flanging noise (a hissy, grating or "tish-tish" noise) is emitted when the wheel flange rubs against the rail, often on the high or outer rail. It has been described as sounding more or less like loud pronunciation of the letters 'F' and 'S'. Flanging noise is generally quieter (lower maximum level), more frequent and more broadband in content than squeal noise, usually comprising several tones across multiple frequencies.
- Wheel squeal noise (a single sharp pitch, "high pitched scream" or "finger nails down a blackboard" type of noise). Squeal noise is usually associated with a particular resonance of the wheel. Often the source of this noise is the wheel moving on the low rail (the inside rail of the curve). It is the more severe and louder form of curving noise but far less common, observable at a small number of sections on the Perth network with particularly tight curves.

To minimise the risk of curving noise, care must be taken to maximise the curvature of track where practicable and consider the use of superelevation to assist with steering at the design speed. If there are issues during service, typical local controls in practice involve wayside friction modifier ('lubricator') systems and close-fitting noise walls.

On curved track sections, wear patterns on the rail and vehicle steering characteristics can affect the source emissions at the wheel-rail interface. The risk of poor rail condition (such as corrugation) is also greater on curves than on straights, as is the risk of other effects, such as wheel flanging.

The following corrections to the source noise levels are generally made based on SLR guidelines and SPP5.4 guidelines to account for the risks of flanging noise and increased wear. Given the relatively low rate of occurrence, it is not designed to fully represent wheel squeal noise levels.

- Curves < 300 m radius: Add 8 dB to the LAE and LAmax.
- Curves ≥ 300m and < 500 m radius: Add 3 dB to the LAE and LAmax.

The project design sections do not have rail curves less than 500 m radius within the study area. In this regard, no curve noise corrections have been applied.

4.8.1.6 Path Attenuation Factors

The outer edge walls on the viaduct at Armadale are modelled as 1.5 m, with an effective height of 1.2 m from top of rail (assuming the base concrete surface is 0.3 m below top of rail). Where the concrete upstands / beam heights are already at 1.2 m above the top of rail, no additional noise walls are required. Where the upstands are lower, additional noise wall elements are required to meet the overall height of 1.5 m.

Noise walls have been modelled as per the schedule provided in Appendix F.2.

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

- Topography dataset of existing conditions for the assessment area was sourced from Landgate and adapted to the provided alignment in 3D dwg format.
- Given the relatively short propagation distances, weather conditions for each time period were considered neutral, with 20°C ambient temperature and no prevailing wind or temperature gradient effects.
- Existing property fence heights and locations were 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.
- Individual point results are assessed at 1.5 metres above floor level.

4.8.1.7 Air Attenuation and Diffraction

The propagation of railway noise from source to nearby sensitive areas has been estimated using industry standard numerical code that has been validated through field measurements.

- 'N2k': The Nord2000 Rail prediction method is based on advancements in the late 1990s. The main advantage over the model used in the Reference Design 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 regard to the design of noise walls, because their effectiveness is strongly frequency dependent – the noise reduction at higher frequencies is generally better than at low frequencies.
- The ISO 9613 Industrial Prediction Model has been used for predicting noise from stationary assets with noise sources including sirens and bells. Various weather conditions can be considered in this modelling algorithm.

Stationary noise sources are modelled according to the parameters outlined in Table 20. These sources are generally those assessed under the Regulations, such as crowd noise, public address systems, fixed mechanical plant and idling buses not on public roads.

Table 20: Weather conditions modelled

Parameter	Day period	Night period
Wind speed	Nil (ISO 9613, C_{met} = 0dB)	Nil (ISO 9613, C_{met} = 0dB)
Temperature inversion lapse rate	Nil (ISO 9613)	Nil (ISO 9613)
Temperature	20°C	15°C
Relative humidity	50%	50%
Mean barometric pressure	1013hPa	1013hPa

4.8.1.8 Ground Absorption

For source to receiver distances of interest, noise modelling was validated with ground as absorptive to get attenuation rates reasonably in line with field data.

4.8.1.9 Validation of Airborne Noise Forecasts

The following figures present comparison of measured levels with that forecasted.

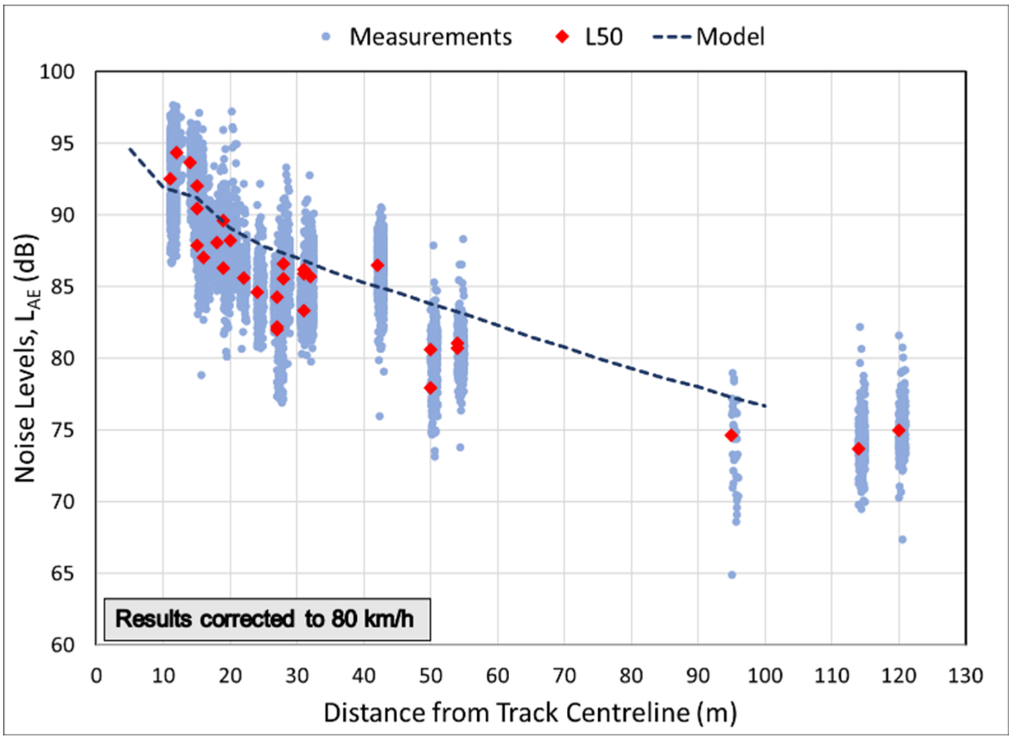


Figure 7: Rolling stock noise emissions LAE values versus distance from track, measured versus forecast

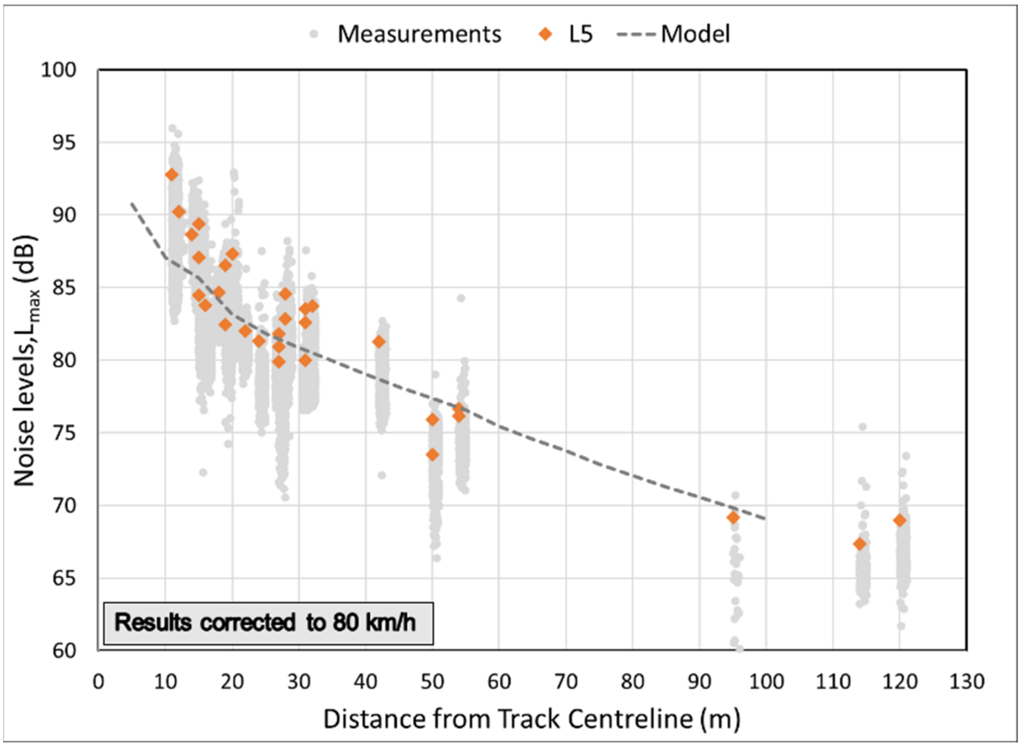


Figure 8: Rolling stock noise emissions Lmax values versus distance from track, measured versus forecast

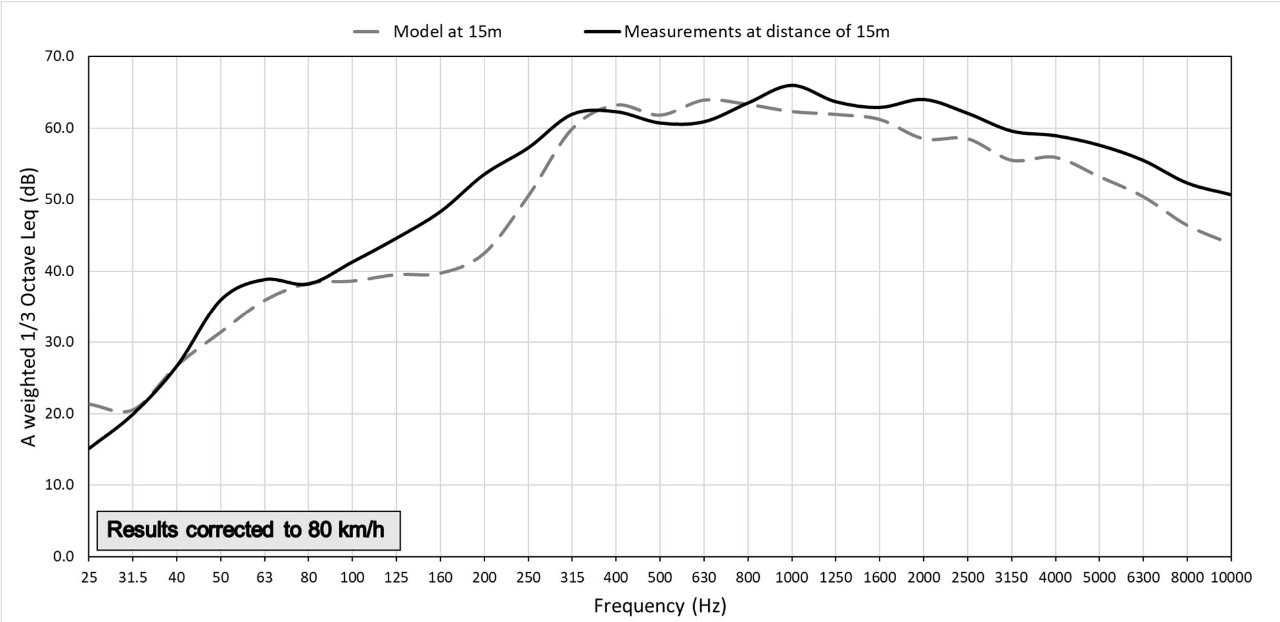


Figure 9: Median Leq values versus frequency, 15 metres distance

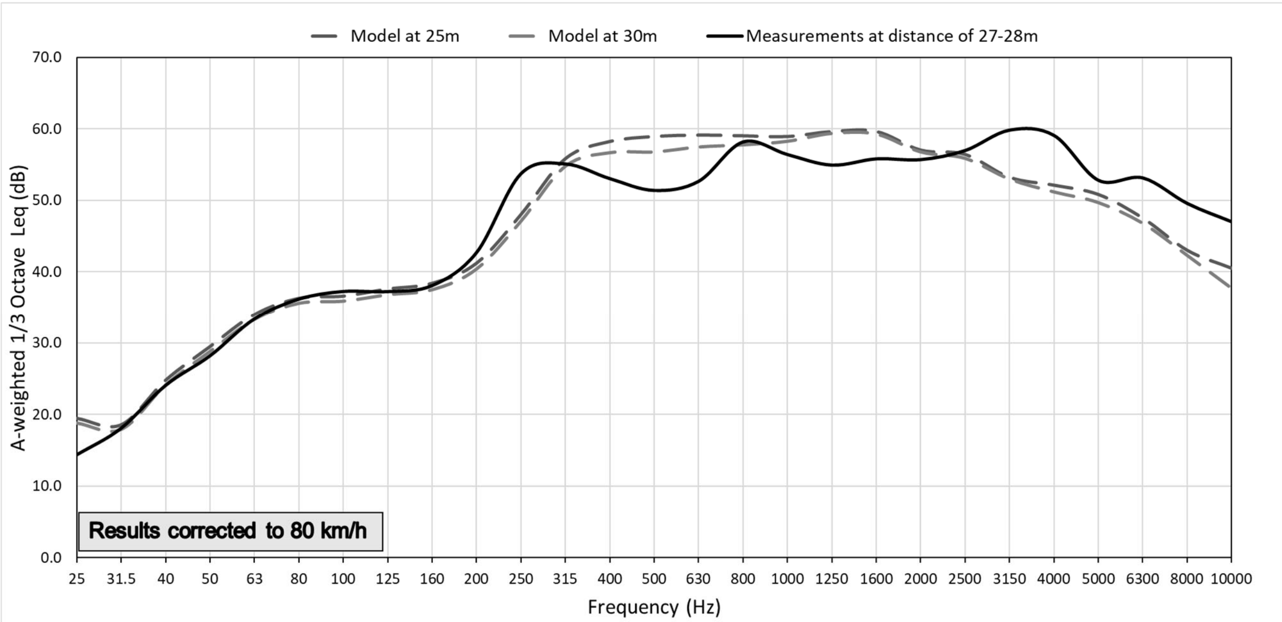


Figure 10: Median Leq values versus frequency, around 30 metres distance

4.8.2 Railway Vibration Predictions

4.8.2.1 Results

Figure 11 and Figure 12 present the forecasted ground-borne noise and vibration at the nearest residential receivers along the railway. These results are also presented as maps in Appendix C.4 and C.5. Individual results and calculation of design margins is provided in Appendix E.2 with the mitigation implement. The forecasted results show that, the implementation of UBM or USP (as provided in the schedule in Appendix F) provided the similar performance in mitigating the ground-borne noise with 9 dB reduction compared with the untreated ballast track with rubber fastener. However, the UBM performs better in mitigating ground-borne vibration levels.

With the vibration mitigation extents detailed above, it is predicted that:

- Ground borne vibration levels are not predicted to exceed the corresponding threshold values at any of the sensitive receivers.
- Ground borne noise levels at majority of the receivers are not predicted to exceed the corresponding threshold values ($L_{Amax,night}$), except 3 residential receivers at 59 Eleventh Rd (+1 dB), 11 Woodstock Pl (+2 dB), 2123 Thomas St (+3 dB), Darling Downs.

In using a 95% certainty design position, with a 1-2 dB margin there is reasonable likelihood of compliant actual levels during commissioning. In addition, considering the widespread locations of these three properties along the alignment, applying further vibration mitigation may not be considered as a cost-effective solution. These will be further investigated as part of detailed design.

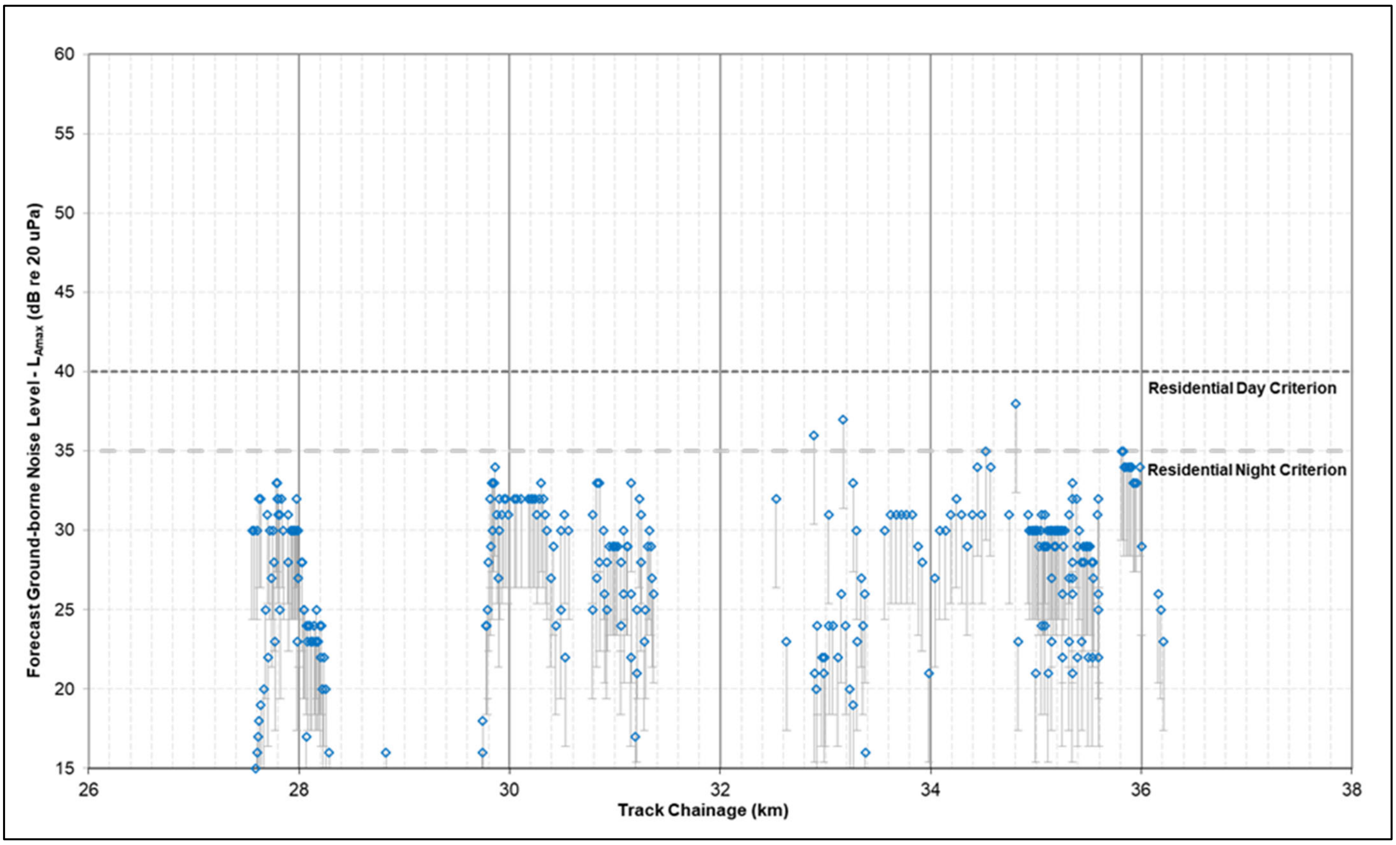


Figure 11: Forecasted ground-borne noise level LAmax values at nearest residential receivers along the track

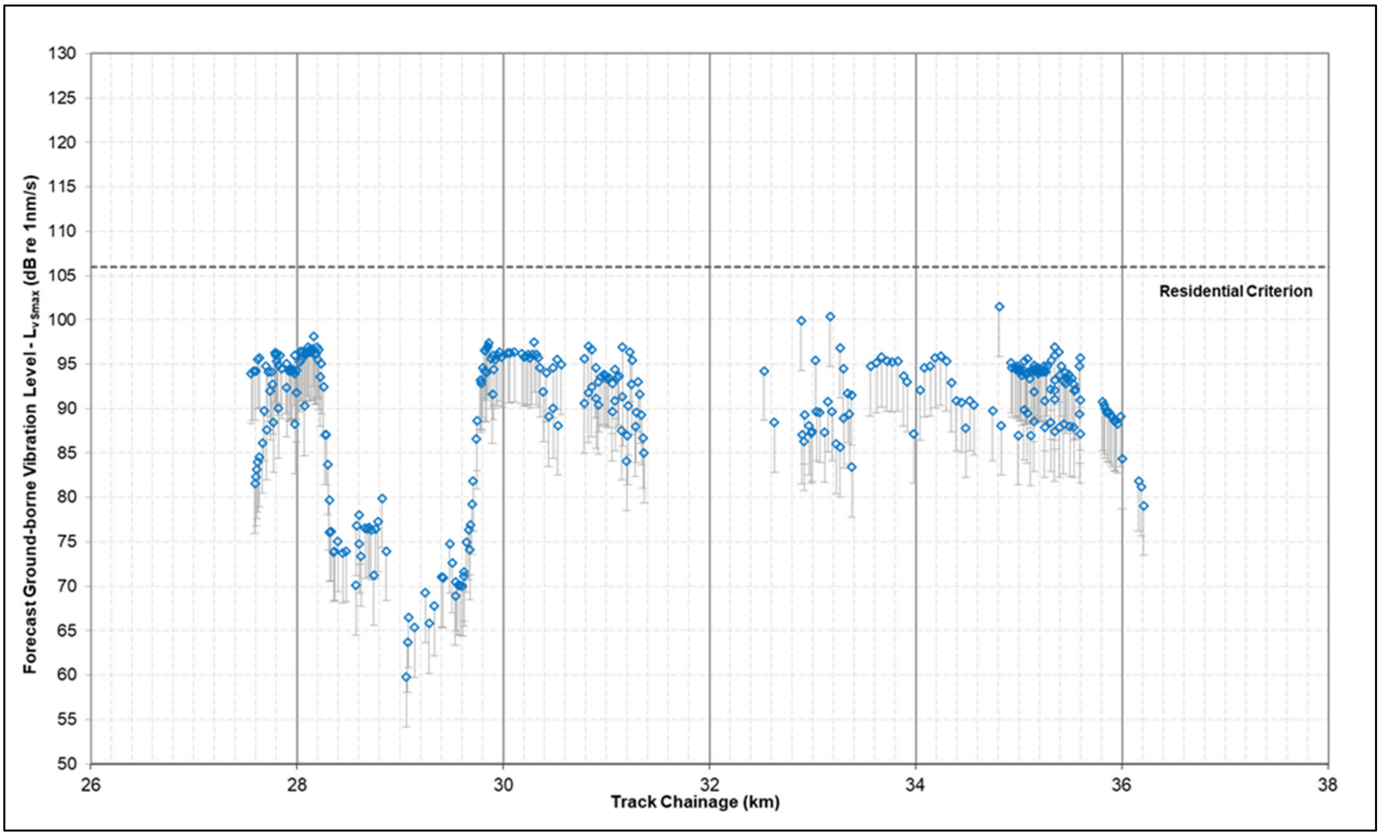


Figure 12: Forecasted ground-borne vibration level LvSmax values at nearest residential receivers along the track

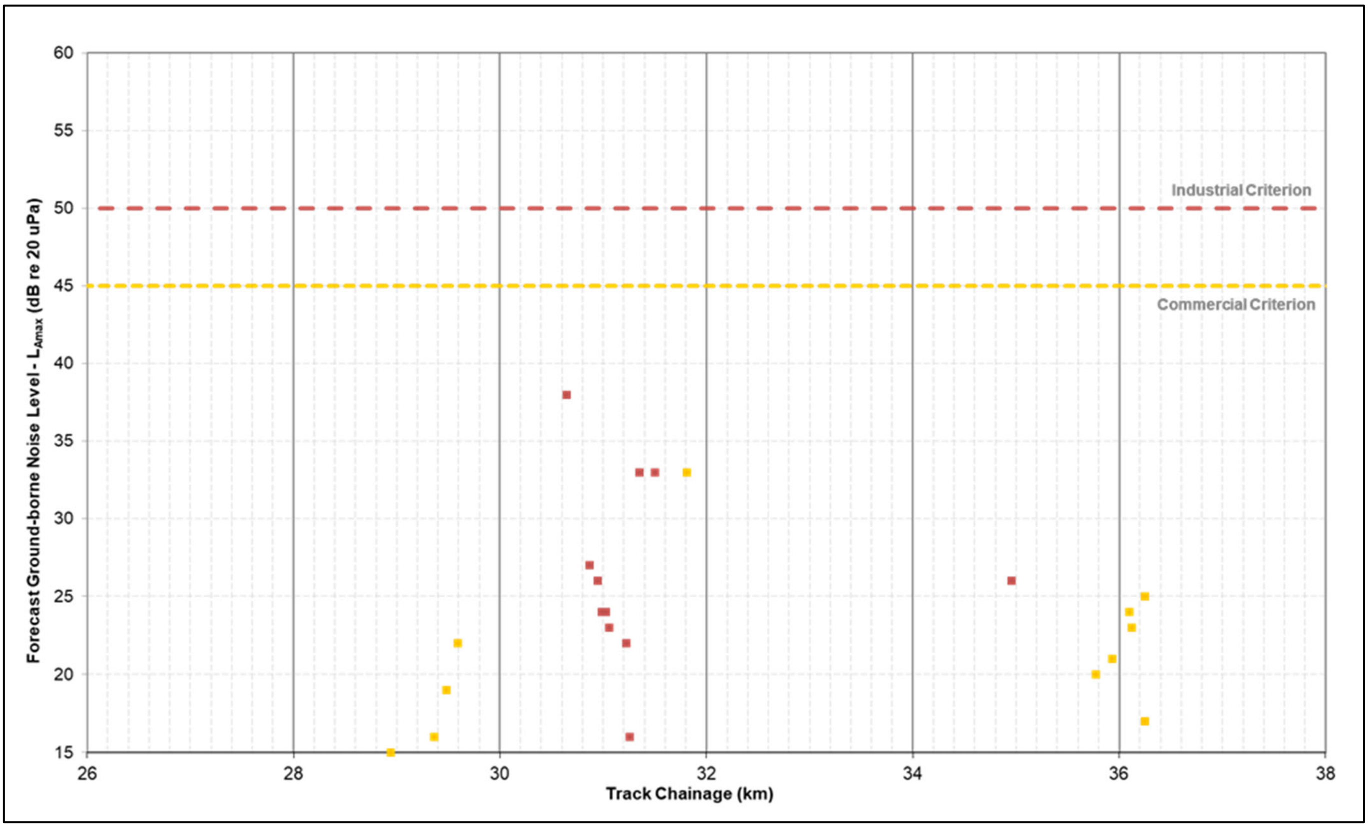


Figure 13: Forecasted ground-borne noise level L_{Amax} values at nearest non-residential receivers along the track

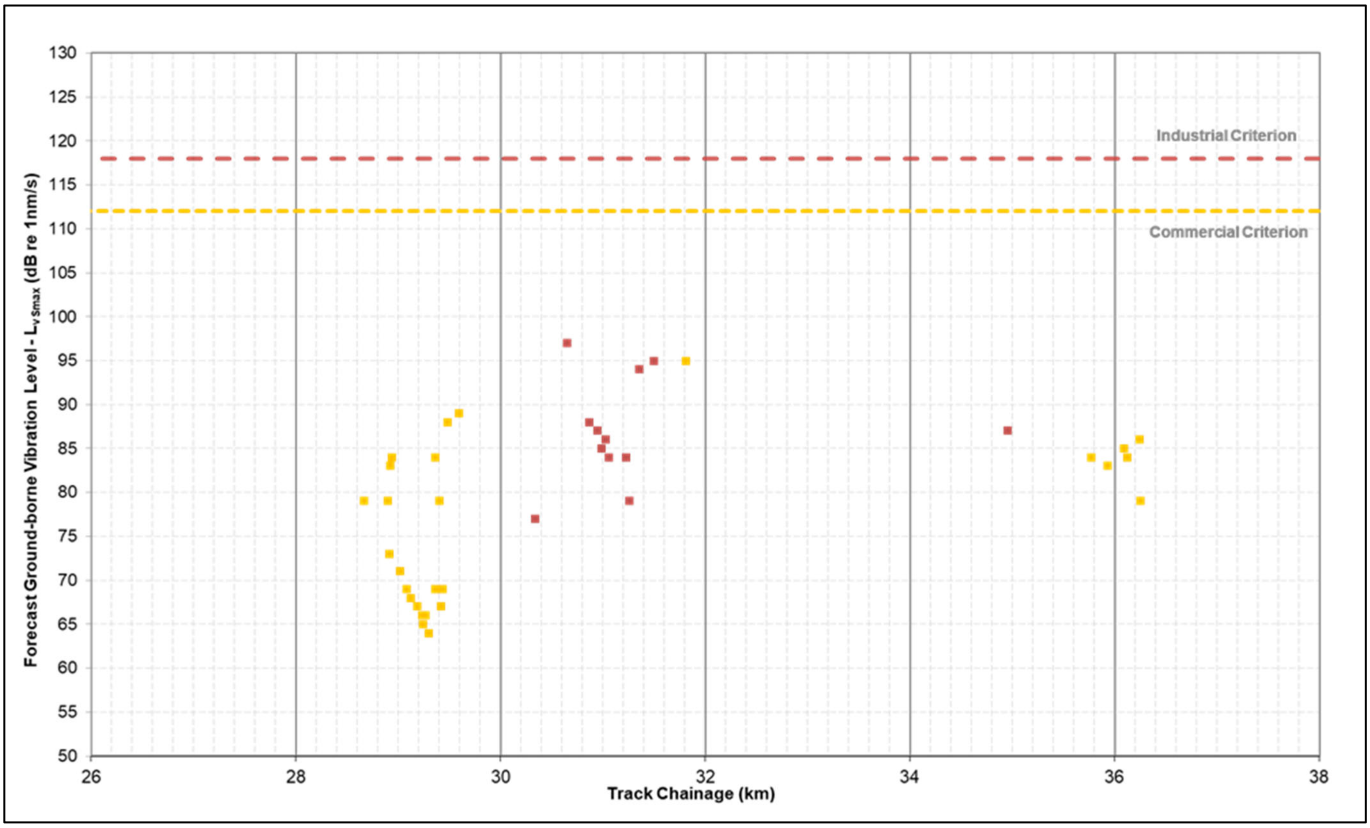


Figure 14: Forecasted ground-borne vibration level L_{vSmax} values at nearest non-residential receivers along the track

4.8.2.2 Overview

The prediction of ground-borne noise (GBN) and vibration (GBV) from rail systems is a complex and constantly developing technical field. Whilst much research has been undertaken into various aspects associated with forecasting GBN and GBV 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).

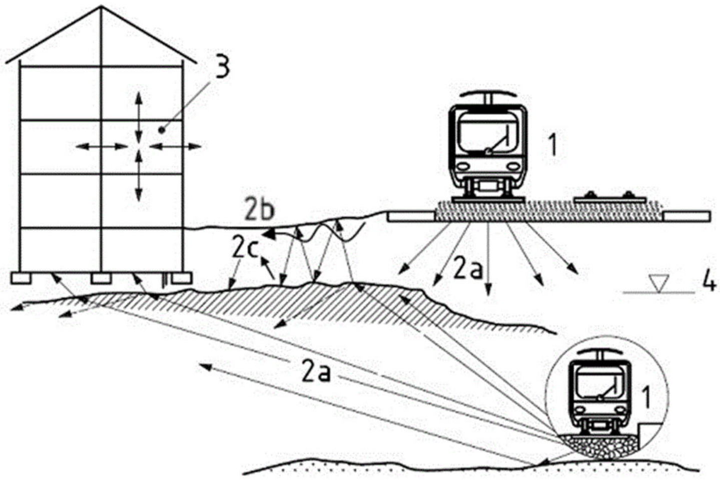
International Standard ISO 14837-1 2005 "Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General guidance" provides useful guidance in relation to the extent of assessment that is typically required for new rail systems including:

- 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, a Detailed Design Model has been adopted using baseline data obtained in the area, along with historical data from similar trackforms and ground conditions in the Perth metropolitan area.

An overview of the source to receiver pathways is illustrated in **Figure 15**. Modelling of these pathways considers source vibration levels, the vibration propagation between the tunnel and nearby building foundations, and the propagation of vibration within the ground-soil and internal building elements.

In accordance with the ISO standard, modelling for this project was conducted using the proprietary code MOTIV for determining source levels, and SLR-developed code for estimating propagation losses between the railway and nearby sensitive receivers. 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.



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 15: Example of Rail Vibration Source, Propagation and Receiver System (ISO 14837)

4.8.2.3 Source Levels

Vibration emissions are estimated for four types of trackform:

- **Ballasted:** as measured on the Perth network and described in Table 4, corrected using MOTIV.
- **Ballasted with under sleeper pad (USP):** Under Sleeper Pads (USPs) similar to that shown in Figure 16 are seen as a lower cost option to under ballast matting (UBM), however they have other declared benefits in regard to extending track service life and reducing costs of maintenance. Key advantages of using USPs in ballasted tracks include vibration isolation, protection of ballast, stabilisation of track geometry and reductions in rail corrugation growth rates / reduced costs of maintenance.

  The forecasted source vibration levels of Ballast with USP and UBM using MOTIV are much lower than the level of Ballast with UBM (with standard limestone capping preparation). The USP is modelled with static modulus C_{stat} of 200 MN/m^3. With reference to Section 4.15.6 Uncertainty of Prediction, conservative adjustments have been applied to account for variations in practice such that in lieu of further field data, USP is limited in terms of performance to UBM.

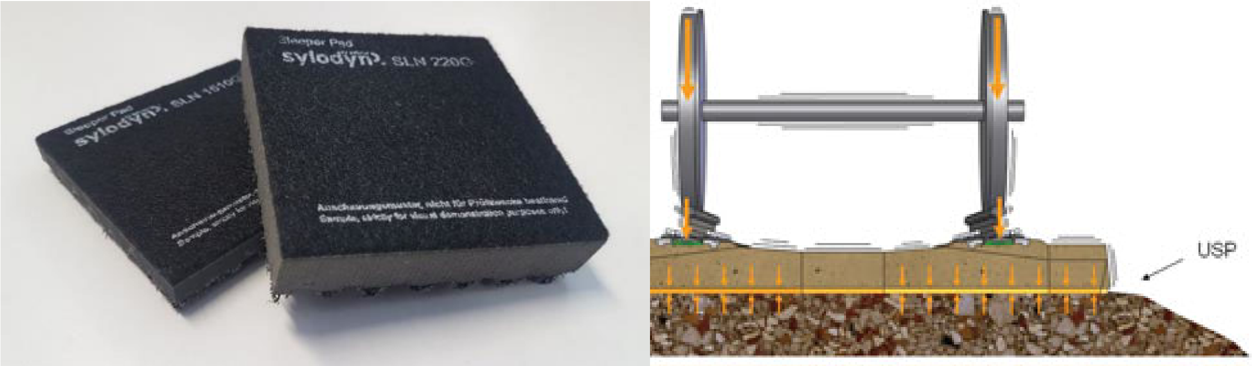


Figure 16: Example under sleeper pad (USP) products, Sylodyn 220G and 1510G; (right) location of USP relative to wheel, sleeper and ballast[2]

- **Ballasted with under ballast matting (UBM):** The detailed design and selection of under ballast matting must be undertaken in conjunction with civil and geotechnical studies and may require stiffening of sub-base / capping ground layers (refer Section 4.8.2). Various product grades are commercially available, however the under-ballast matting is modelled to have a vertical stiffness modulus C_{stat} of 100 MN/m^3 considering the compliance of rail deflection.
- **Slab track:** as described in Table 4 and estimated based on past measurements near slab track sections on the Perth network (Pandrol VIPA, VANGUARD).

Figure 17 below presents modelled source vibration levels at a set distance and speed, based on the following subsections.

[2] Loy, H. 2008, 'Under Sleeper Pads: improving track quality while reducing operational costs', Global Railway Review, Issue 4, https://www.globalrailwayreview.com/article/671/under-sleeper-pads-improving-track-quality-while-reducing-operational-costs/

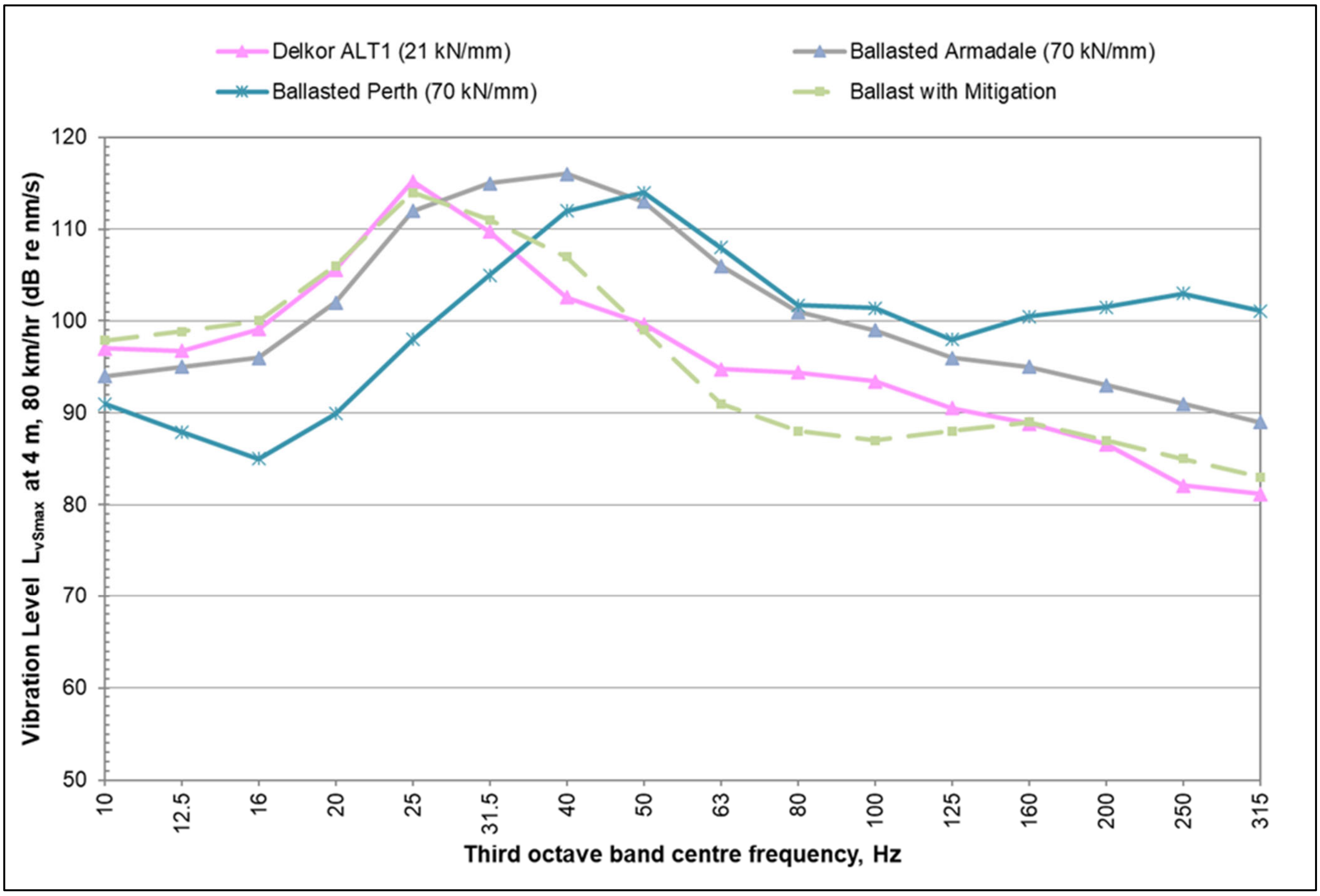


Figure 17: Source reference vibration levels LvSmax modelled at 4 m from railway centreline, 80 km/hr

4.8.2.4 Ground Conditions

The ground (supporting the ballast) outside slab track sections has been modelled as a 500 mm layer of compacted limestone on top of homogenous dense sand. It is understood that the compacted limestone is ~220 mm and not 500 mm, the model assumes the compaction process to affect properties over a depth of the equivalent of 500 mm.

The ground parameters used in the MOTIV software are presented in the following table. It is important to note that performance is highly dependent on these properties, particularly in the application of under ballast matting and under sleeper pads.

Table 21: Ground parameters used in the model for vibration source level prediction

Soil type	Capping layer (0.5 m thickness) (Compacted limestone)	Underlying soil (Sand – Dense)
Density (kg/m3)	2,070	2,070
Young's modulus (MPa)	300	80
Poisson ratio	0.3	0.3
P-wave speed (m/s)	442	228
S-wave speed (m/s)	236	122
Damping loss factor	0.1	0.1

4.8.2.5 Track Form Types

The assessed railway section includes ballasted track form and slab track. Key input values are presented below.

Table 22: Parameters of trackform in the vibration model

Component	Aspect	Values	
Track	Type	Ballasted	Slab track
	Width of track/ground interaction area (m)	3	3
Rail (per rail)	Type	AS50	AS60
	Mass per unit length (kg/m)	50.6	60.6
	Moment of inertia (cm^4)	2,010	2,926
	Young's modulus (GPa)	205	205
	Roughness	SLR historical measurements on Midland line (5.3km)	
Rail fastener (per fastener)	Configuration	Pandrol e-clip, RP65221 8.5 mm studded rubber pad	Delkor ALT.1 / Pandrol VIPA Cat C/D
	Rail type	AS50	AS60
	Spacing (m)	0.7	0.7
	Dynamic stiffness (kN/mm)	129	25
	Damping loss factor	0.2	0.2
Sleeper	Mass (kg)	168	-
Ballast	Mass per unit length (kg/m)	840	-
	Stiffness per unit length (MN/m^2)	4,640	-
	Damping loss factor	0.04	-

4.8.2.6 Track Features

Local features such as turnouts can introduce discontinuities or sudden changes which increase vibration emissions. An adjustment of +6 dB was applied for track sections within 5 m of turnouts.

4.8.2.7 Curving Gail

No adjustments were applied for vibration emissions from curved sections as per Section 4.8.1.5.

4.8.2.8 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. 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 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. GBN and vibration levels could theoretically increase 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 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.).

4.8.2.9 Vibration 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.

4.8.2.10 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 using the slant distance between each point source and the receiver location.

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 18 based on Nelson (1987).

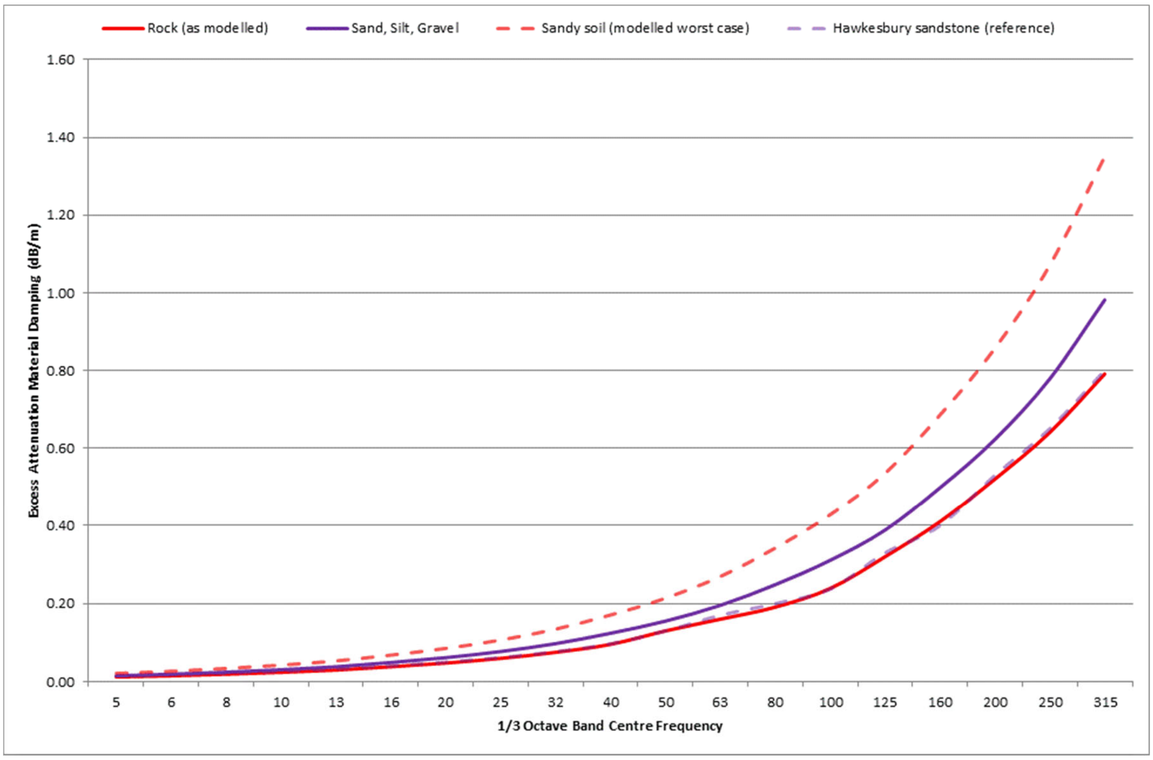


Figure 18: Modelled ground damping loss rate, dB per metre

4.8.2.11 Viaducts

Viaducts are conservatively modelled to provide 10dB of vibration attenuation compared to surface ballasted track, to account for losses via bridge bearings and structural footings.

4.8.2.12 Effects of Highway/Crash Barrier/Noise Walls

The bulk of vibration energy propagation from surface track is considered to be at or near the surface. Therefore, structures with large foundations or heavy soil compaction associated with road civil works is considered to provide some level of attenuation. However, these effects are not currently considered to remain conservative at this stage, and due to the uncertainty of the final noise wall design at the time of this assessment.

4.8.2.13 Receivers

Vibration incident on building structures will undergo a frequency-dependent ‘coupling’ loss as it enters the structure, 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) for various building scales and extrapolated to include frequency bands below 16 Hz. The majority of receivers are typically either one to two storey established residences. Vibration levels attenuate by approximately 2 dB per floor for the first 4 floors and by approximately 1 dB per floor thereafter.

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 -32 dB in line with ANC guidelines[3].

Historically, a more conservative adjustment of -27 dB has been used. However, it is considered reasonable to use the more recent adjustment based on how the uncertainty of measurement is added to forecast results as per Section 4.15.6.

4.8.2.14 Validation of Ground Borne Vibration Forecasts

The following figure present the comparison of measured levels with that forecasted.

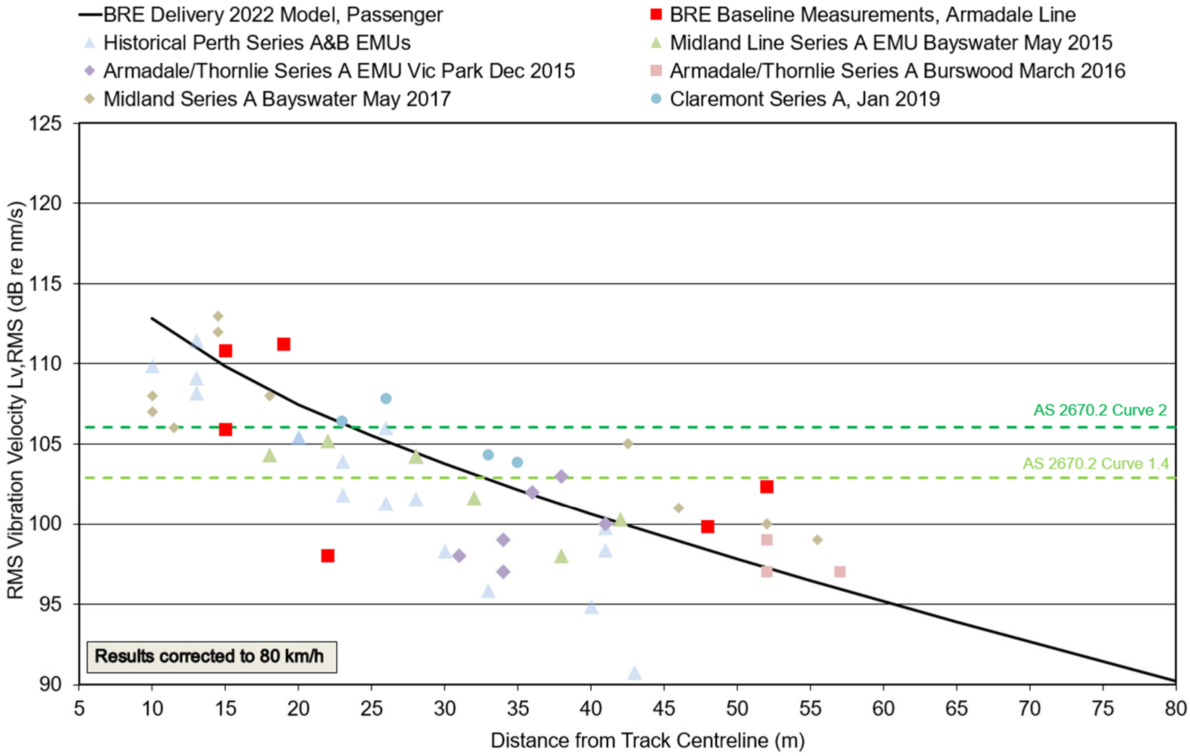


Figure 19: Rolling stock vibration levels LvSmax values versus distance from track, measured versus forecast (at free space)

4.8.3 Station Facilities External Noise Predictions

To be included in IDD report pending December 2022 updates to station arrangement.

[3] Association of Noise Consultants 2012, ANC Guidelines – Measurement and Assessment of Groundbourne Noise & Vibration, 2nd Ed., St Albans UK.

4.8.4 Assessment of Acoustics and Vibration within Station Areas

4.8.4.1 Ambient Noise Levels within Passenger Station Areas

Initial reviews of the station layout and anticipated mechanical services does not identify any areas where the above criteria are not practicable.

For shelters, noise is considered to be reduced as far as reasonable and practicable where panels are constructed solid airtight and structurally suitable for wind loading.

It is noted that short term noise from trains at the station are likely to be a source of subjective annoyance. Therefore, a commercial framing suite with heavy glazing meeting a D_W 30 dB requirement is recommended as indicated in **Figure 22** to reduce noise from idle trains (air compressor units) entering platform level Office cubicle areas.

4.8.4.2 Noise and Vibration Ingress into Passenger Station Areas

Noise

In regard to airborne noise, inspection of the results presented in **Appendix A** and **E** indicate that incident passenger station levels are around $L_{Aeq,day}$ 60 dB or less. This aligns to the requirements of SPP5.4 since internal levels would then meet the relevant requirements of AS/NZS 2107:2016 and the ambient noise level targets listed in **Table 16**.

Vibration

In regard to vibration levels, reference is made to **Figure 19** which lists expected floor vibration levels with distance, at a speed of 80 km/hr. At this speed, the figure indicates a floor vibration level of $L_{v,RMS,1s}$ 119 dB including a design margin of 5.6 dB.

On the basis that trains are estimated to be up to 30 km/hr as they enter the platform area and the methodology in Appendix C, maximum platform vibration levels are estimated to be $L_{v,RMS,1s}$ 110 dB.

4.8.4.3 Reverberation within Passenger Station Areas

Reverberation is controlled by the addition of acoustically absorptive room finishes. The absorption characteristics of a ceiling, floor or wall can be defined by the weighted sound absorption coefficient, α_w, as defined in AS ISO 11654. α_w is similar to the NRC metric (Noise Reduction Co-efficient) and has a value between 0 and 1.00. Zero represents no absorption (total reflection) and 1.00 represents total absorption of the incident sound. This coefficient may be used to easily compare one product against another.

Table 23 presents predicted reverberation levels for selected spaces without specific sound absorptive controls. Where spaces are predicted to be above targets, control options are provided.

Table 23: Reverberation time predictions for selected spaces and recommended controls, Armadale Station

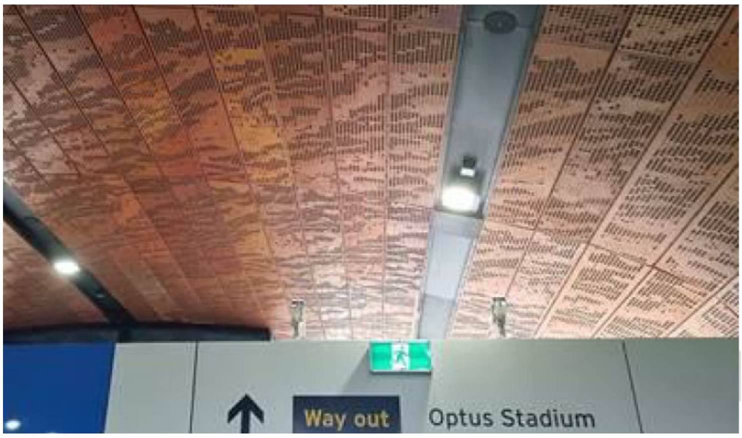
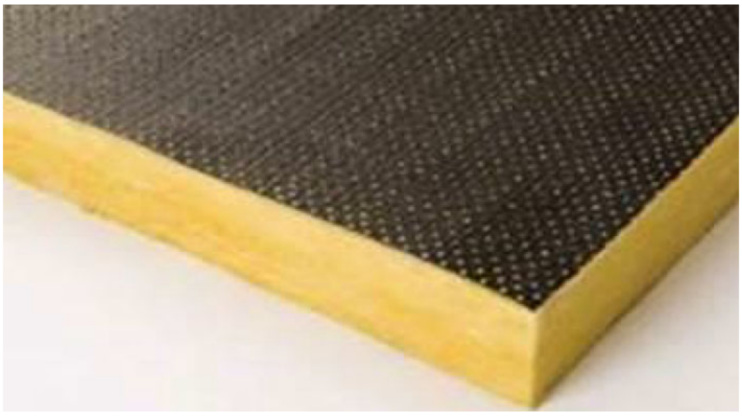
Location	Space	SWTC Target	Untreated RT60, s	Recommended controls
Concourse Level	Concourse, 100 people	1.3	3.3	60% of ceiling area of EN ISO 11654 Class A or B treatment
Concourse Level	CSO	< 0.8	1.5	Mineral fibre tile ceiling or 80% floor area equivalent of sound absorptive panels to walls meeting ISO 11654 min. Class B
Concourse Level	Booking Office	< 0.8	1.5	
Concourse Level	Office	< 0.6	1.6	
Concourse Level	Staff Sign-in	< 0.6	2.6	
Concourse Level	Staff Crib Room	< 0.6	3.0	
Concourse Level	Kiosk	See Note 1	4.0	

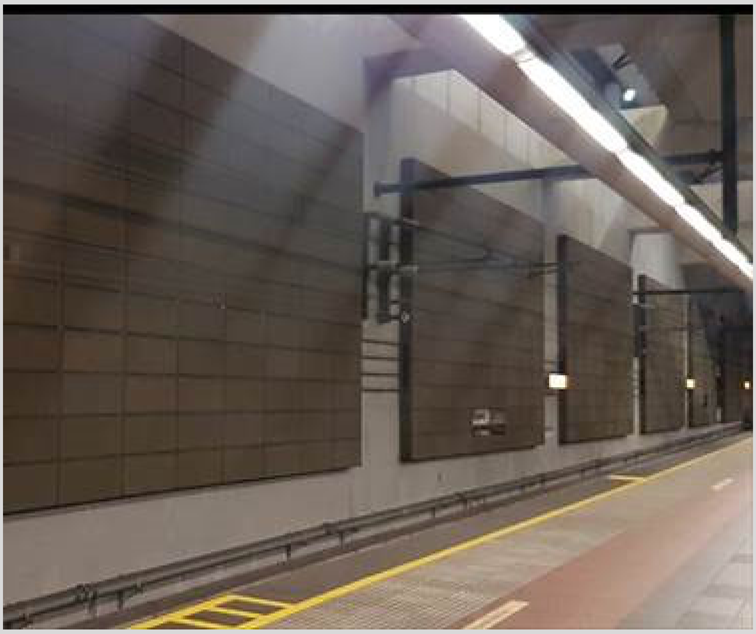
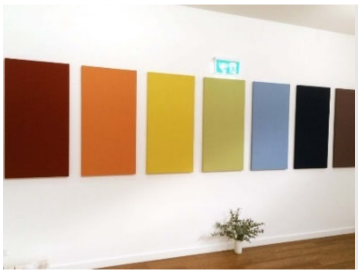
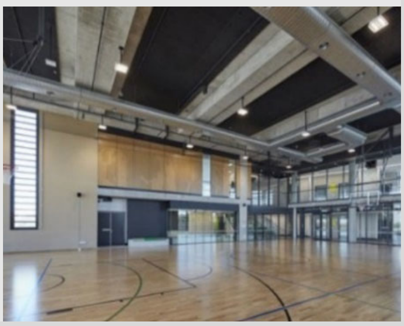
Location	Space	SWTC Target	Untreated RT60, s	Recommended controls
Platform Level	Office Cubicle	< 0.6	1.3	
Bus Interchange Facility	Crib Room	< 0.6	2.6	

Note 1: Reverberation time should be minimised for noise control.

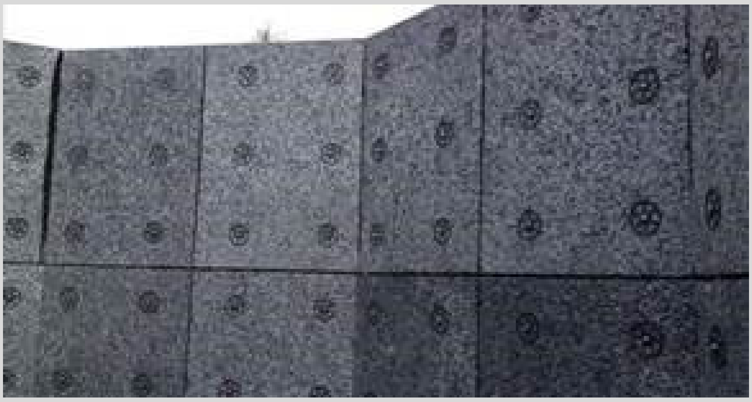
The table refers to absorptive finishes achieving Class A or B according to EN ISO 11654, or minimum α_W 0.80, which is similar to a Noise Reduction Coefficient NRC of 0.80. The following table provides various examples of such products. Lower grade products (e.g. Class C) can be used, however more of the material is needed to generally achieve the same bulk reverberation time.

Table 24: Examples of sound absorptive products

Name	Image(s), link	Description
Lasercut / perforated metal with Fibretex 350 BMF	  www.bradfordinsulation.com.au/	32-48 kg/m3 glasswool, polyester or mineral fibre with mesh fabric facing Manufactured by spinning molten glass, containing up to 80% recycled material, into fine fibres which are then bonded together using a thermosetting resin. Typical density of 48 to 60 kg/m^3. Non-flammable, non-toxic material which is not affected by moisture. Typically installed in perforated sheet metal enclosures with an additional spun bonded cloth film to protect from dust and moisture. Industrial product with relatively long product life.

Name	Image(s), link	Description
Quietstone Standard, or Pyrotek Reapor		Porous recycled glass material designed primarily for direct fixing to walls and ceilings. Non-toxic, non-flammable and not affected by moisture. Non fibrous material. Can be cleaned with a high pressure hose. Classified Class A according to EN ISO 11654 (50 mm+) Used in various Perth train stations already (Elizabeth Quay, Joondalup etc.) Main downside is risk of friable silica dust when broken / handled.
Acoufelt	    https://acoufelt.com/products/panels/	Can be self-adhesive backed (Direct fix) or mechanically fixed Can be ordered with hi resolution image print Low resistance to damage EN ISO 11654 Class C (α_w 0.70-0.75) or better 25 to 100 mm thick polyester with fabric facing Non-toxic, Non-allergenic,Non-irritant
Pyrotek Echohush	  https://www.pyroteknc.com/products/echohush/echohush-board/	EN ISO 11654 Class C (α_w 0.70-0.75) or better 25 to 100 mm thick polyester with fabric facing Direct fix installation Recyclable, various colour options Can be used to pin / Velcro items on Non-toxic, Non-allergenic, Non-irritant

Name	Image(s), link	Description
CSR Martini DECO Quiet Panel	  http://www.csrmartini.com.au/products/decorative-acoustic-products	Effectively equivalent to Pyrotek Echohush
Stratocell Whisper FR	 http://www.soundblock.com.au/sound-absorbers/stratocell-whisper	EN ISO 11654 Class C (α_w 0.70-0.75) or better 25 to 100 mm thick Polyethylene foam (unpainted) Lightweight and easily cut into shapes, affix to walls or hang
Asona Triton	 http://www.asona.co.nz/	EN ISO 11654 Class B (α_w 0.80-0.85) 25 to 100 mm thick glass fibre with fabric facing Direct fix installation Recyclable, various colour options
Renhurst RenAcoustic Baffles	 http://renhurst.com/renacoustic-baffles/	EN ISO 11654 Class C (α_w 0.70-0.75) or better Rigid fibreglass core and a fine textured fleece Lightweight with various suspension options
Himmel Ecophon Solo Panels	  https://www.himmel.com.au/product-listing/2016/07/13/ecophon-solo-panels	Suspended colour panels Likely limited extent due to ceiling fan / air movement needs Glass fibre reinforced for rigidity

Name	Image(s), link	Description
Stratocell Whisper	 www.soundblock.com.au/sound-absorbers/stratocell-whisper	Claimed to be resilient to water and humidity Flame retardant and/or Group 1 fire rating. Claimed self-extinguishing material (Class B2) to DIN 4101 series Light weight and non-corrosive. Easy to fix and fasten, pinned or glued Sheet size is 2400 x 1200 x 50mm thick Classified Class A according to EN ISO 11654

4.8.4.4 Public Address Systems with Passenger Station Areas

With the control of reverberation as per **Section 4.8.4.3** it is anticipated that the PA intelligibility requirements can be achieved through careful speaker system design within the concourse, as discussed in the following subsection.

Modelling of public address systems is being undertaken by the Comms designer.

4.8.4.5 Acoustic Sound Insulation within Passenger Station Areas

Figure 20, Figure 21 and Figure 22 present an overview of these sound insulation requirements, on the basis of supplied layouts.

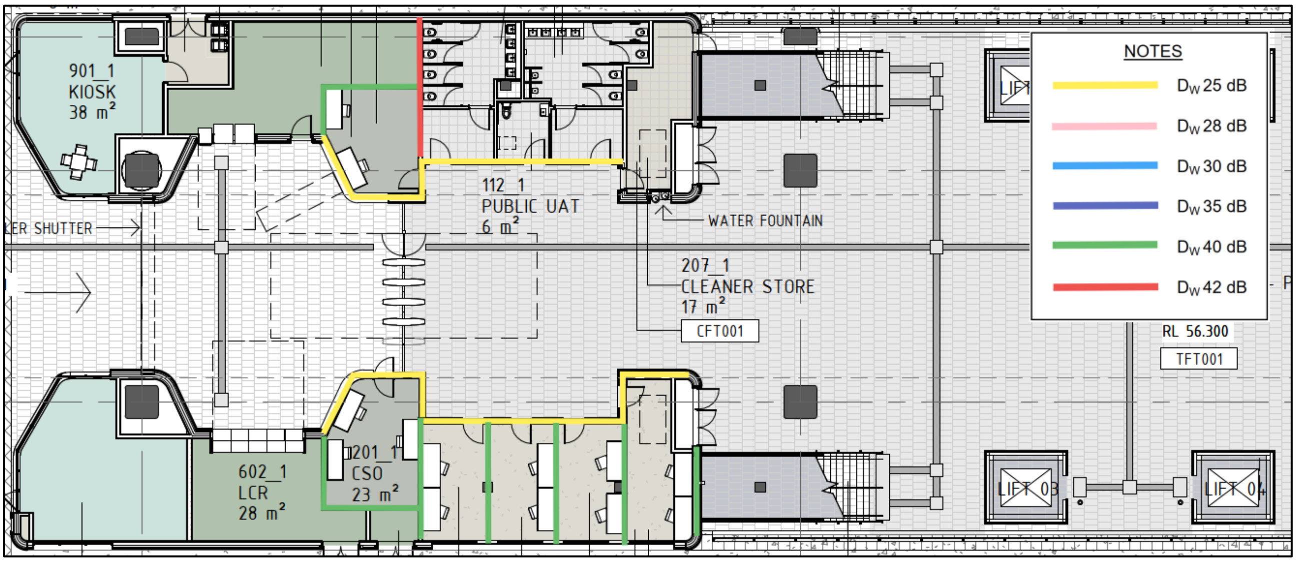


Figure 20: Annotated drawing extract indicating sound insulation requirements, Armadale Station Concourse (Ground) Level, north

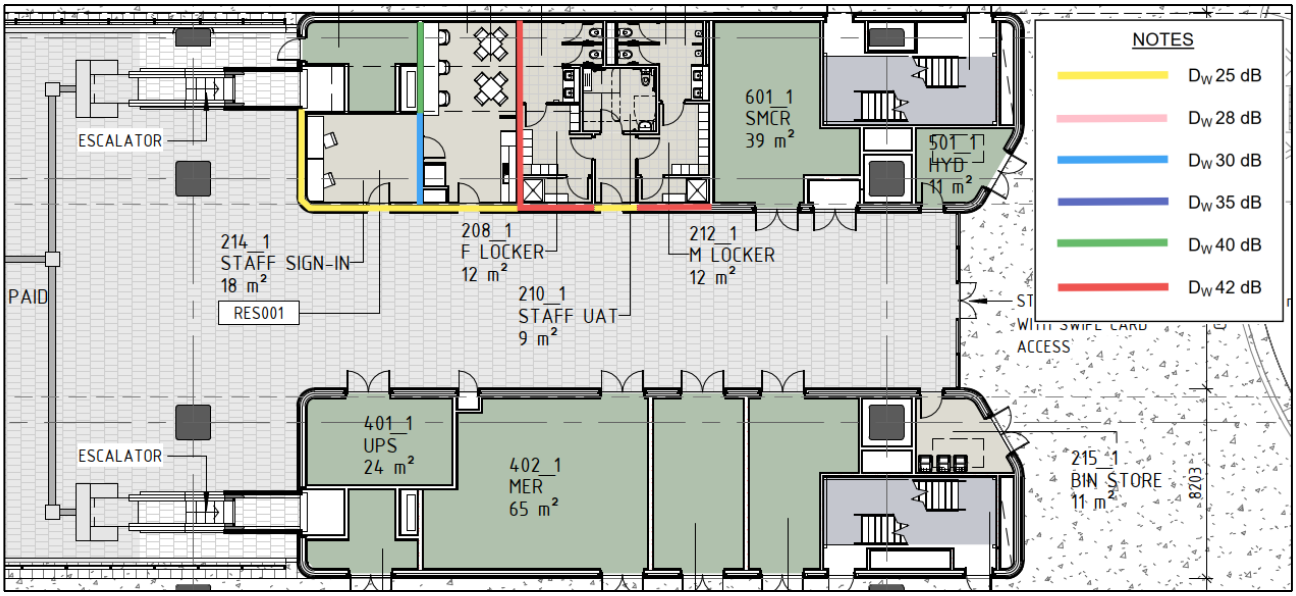


Figure 21: Annotated drawing extract indicating sound insulation requirements, Armadale Station Concourse (Ground) Level, south

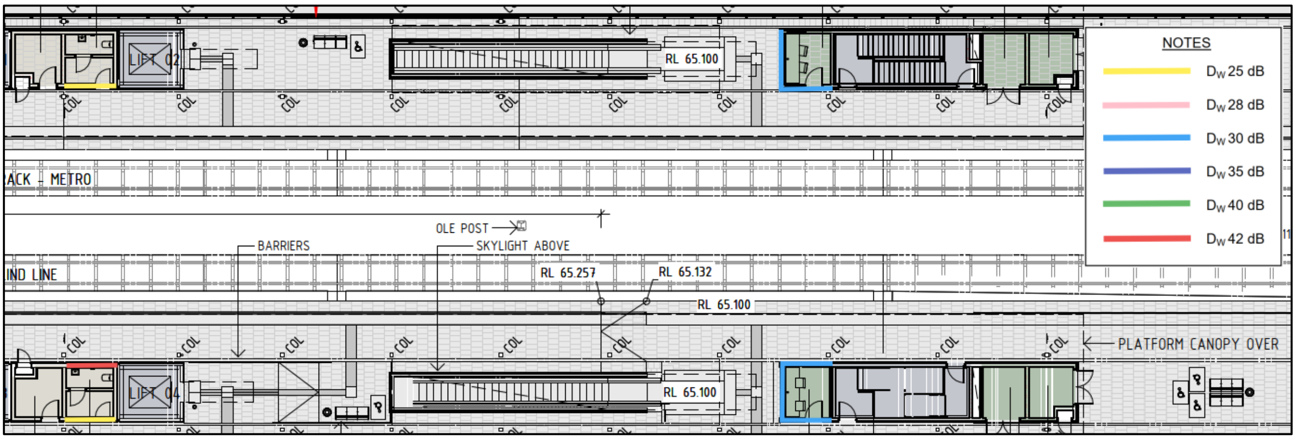


Figure 22: Annotated drawing extract indicating sound insulation requirements, Armadale Station Platform Level

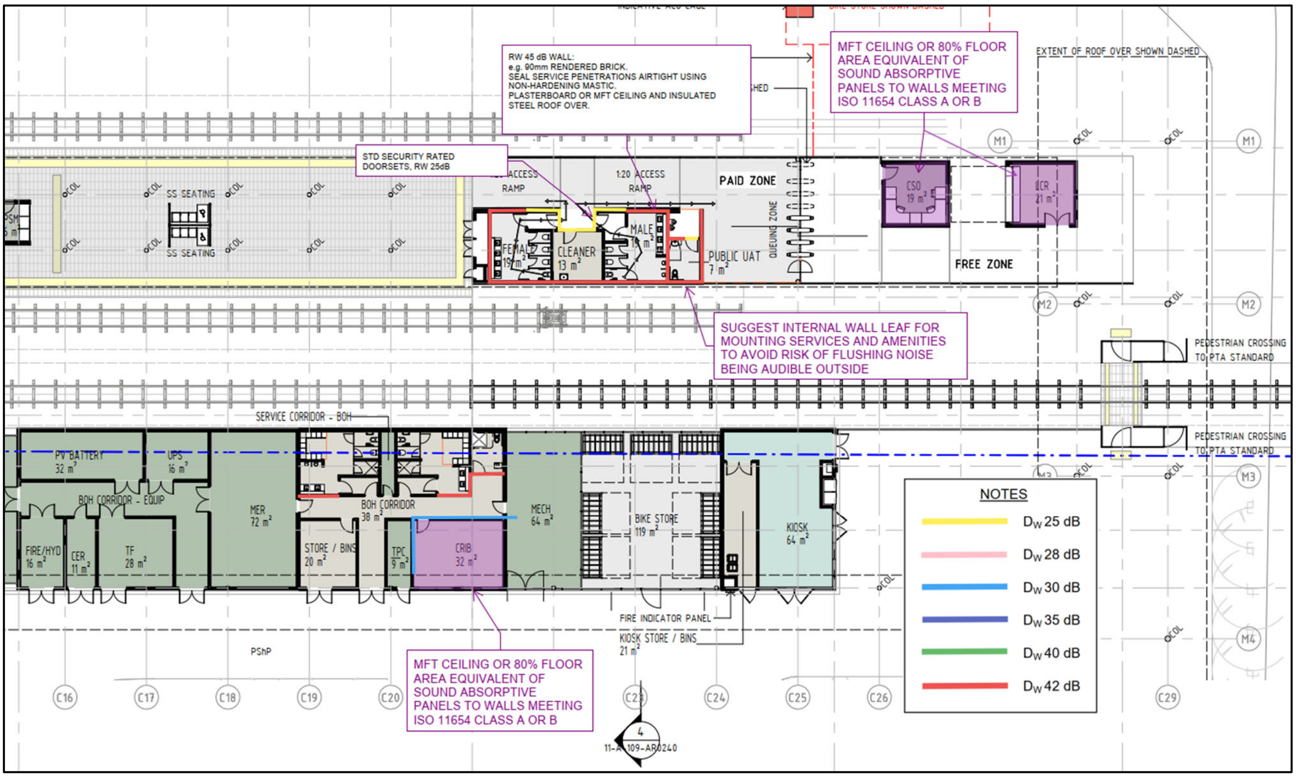


Figure 23: Annotated drawing extract indicating sound insulation requirements, Byford Station Platform Level

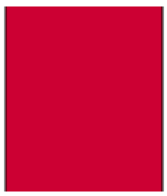
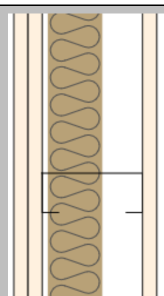
Recommendations

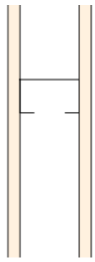
The following sections provide construction options to meet the above requirements for internal separation. Match the D_W value in **Figure 20**, **Figure 21** and **Figure 22** with the construction element.

4.8.5 Internal Walls

Suitable wall systems are listed in **Table 25:** Note that walls between wet areas / toilets and amenities should use a double stud wall arrangement to minimise the risk of flushing / water pipe noise.

Table 25: Sound isolation performance and recommended partition construction

Site sound level difference target D_W dB	Wall sound reduction target, R_W dB	Example usages	Example minimum wall construction	Partition extent
42	47	Toilets	-110mm rendered brick - Top and bottom and service penetrations sealed with non-hardening continuous acoustic sealant	
40	45	Private offices	-2 x 13mm sound or fire rated plasterboard (12 kg/m^2 per layer) to one side, all joints to be sealed and plastered -92mm steel studs at 600mm centres -50mm insulation (min. 11 kg/m^3) in wall cavity -1 x 13mm standard plasterboard (8.5kg/m^2 per layer) to other side	

Site sound level difference target D_W dB	Wall sound reduction target, R_W dB	Example usages	Example minimum wall construction	Partition extent
			-Top and bottom and service penetrations sealed with non-hardening continuous acoustic sealant	
30	35	Crib rooms, Offices and Toilet room frontages	-1 x 13mm standard plasterboard (8.5kg/m^2 per layer) to both sides -64mm steel stud at 600mm centres -no insulation	

4.8.6 Internal Glazing

Table 26: lists the performance recommendation for glazed partitions. Reduced thicknesses can be used for reduced areas of glazing in the separating wall.

Table 26: Sound insulation performance requirements and recommended internal glazing constructions

Site sound level difference target D_W dB	Wall sound reduction target, R_W dB	Example usages	Typical arrangement
30	35	Office cubicle	-10 mm toughened glass or -8.38mm laminated glass

Note: Glazing ratings based on Technical Briefing for Viridian glass.

4.8.7 Doors

Internal door performance requirements per application are presented in **Table 27**. By necessity, the door ratings are less than the R_W rating of the surrounding partition.

The overall resultant R_W will be a composite sum of room frontage partition and door within it. Any performance equivalent performing door system can be used.

For these applications, door grills or undercuts must be avoided as this would adversely affect the acoustic performance. Suitably treated ducting via the ceiling should instead be implemented to provide a return air path and allow pressure equalisation across each door.

Table 27: Door sound insulation performance requirements

Site sound level difference target D_W dB	Door sound reduction target, R_W dB	Type	Door leaf thickness	Example seals
29	35	Single Hinged	Min. 10mm glazing (framed and sealed) or 44mm (nominal) solid core timber (630 kg/m^3)	Perimeter: RP120, RP520 Threshold/bottom: RP8Si, RP99Si
25	30	Single Hinged	Min. 8mm glazing (framed and sealed) or	Perimeter: RP10/RP10Si Bottom: RP99Si

Site sound level difference target D_W dB	Door sound reduction target, R_W dB	Type	Door leaf thickness	Example seals
			35mm (nominal) solid core timber (360 kg/m^3)	

Note: Solid core door ratings based on Raven catalogue. Alternative products to that suggested are acceptable where performance equivalent.

4.9 Constructability Requirements

4.9.1 Noise walls

Noise walls are modelled as providing a weighted sound reduction index (R_w) plus traffic correction (C_{tr}) of R_w+C_{tr} 25 dB, as defined in AS/NZS ISO 717.1:2004. This can be achieved with a construction which

- meets relevant civil and structural requirements for a freestanding structure,
- is continuous without gap (air tight), and
- has a surface density not less than 12 kg/m^2.

Unless specifically noted, noise walls are modelled as sealing airtight to the ground beneath and any adjacent structures.

Alternative constructions to PTA Specification 8880-450-069 (PTA - N&I - Specification: Fences and Noise Walls) may be acceptable to the PTA, for noise and vibration purposes subject to the design meeting the above requirements.

As per SWTC Book 3 Part A clause 23.1, noise and vibration mitigation measures need to minimise visual impacts so far as is reasonably practicable. This lacks objective definition, so is here interpreted to mean that noise and vibration measures

- must be optimised in terms of height (not excessively taller or wider than considered necessary to meet the relevant noise and vibration goals),
- if within the railway reserve, must not exceed five metres in height (relative to reasonable judgement of local finished level anywhere within 500 mm of the wall top edges) within the railway reserve, and
- if over three metres height within 500 mm of a residential boundary (referenced to residential side ground level), must comply with noise and vibration criteria if constructed using 25 mm transparent acrylic panelling from 2.7 metres height to top of wall.

The nominated extents meet these requirements.

4.10 Environmental & Sustainability Design Criteria

4.10.1 Risk and Opportunities Assessment

4.10.1.1 Recycled Content

Vibration isolation systems such as under ballast matting can be manufactured with recycled content. However, recycled rubber products (depending on specification and grade) can provide inferior performance if the aggregate is hard and brittle. Whilst there is strong preference for sustainably produced virgin materials on this basis, products with recycled content may be considered provided that performance requirements are met over the life of the asset.

Similarly, noise walls could be installed with recycled plastic content, subject to it meeting the density requirements and PTA specifications as mentioned in Section 4.9.

4.10.1.2 Track stiffness

As per SWTC Book 4 Part A clause 16.2.8, The noise attenuation measure must not compromise the track structure/modulus.

4.11 Future Proofing

Mitigation has been provided without consideration of

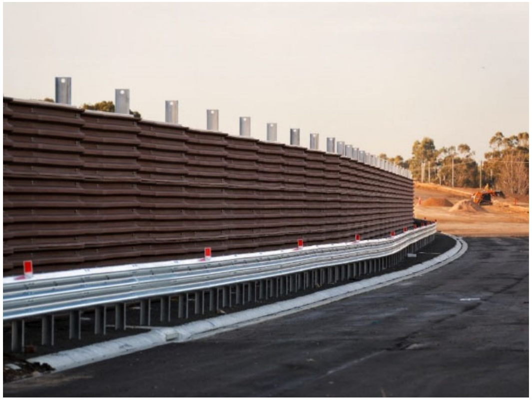
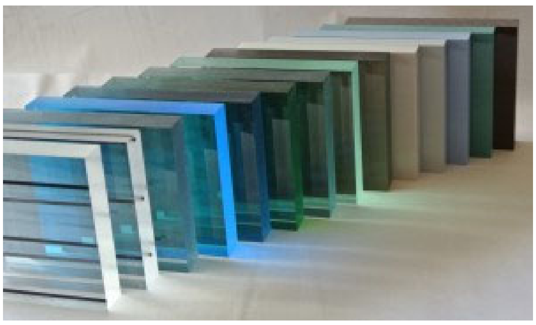
- future development/s along the line, and/or potential reflections off noise walls to future developments where noise wall is only proposed on one side of the line to suit existing developments – this is because later such development may incorporate its own mitigation strategy as required under State Planning Policy 5.4;
- The potential impact of the future Bunbury high-speed rail services - since the alignment with respect to Byford is not confirmed, environmental criteria are not necessarily known, and nothing would prevent that project from implementing additional mitigation to achieve its own requirements.

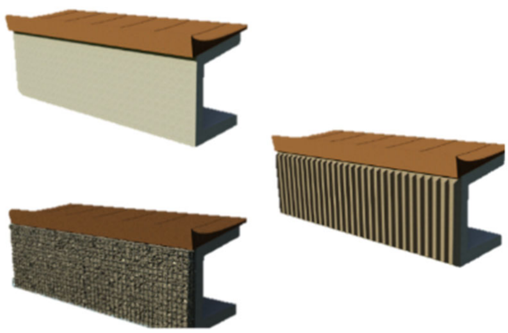
4.12 Value Engineering

The following table outlines alternative noise wall constructions that could meet the minimum performance requirements.

Table 28: Examples of suitable noise walls

Facing	Base material	Image	Description / Comments
Hard reflective	Autoclaved aerated concrete (AAC), e.g. Hebel		Reflective – 50-75mm autoclaved aerated concrete (AAC) reflective modular concrete noise wall, usually rated up to 2.4 metres height. Note that if increased above this height the structural requirements will demand substantially Option for embossed detailed finished such as in the ‘Sound Absorptive’ category below.
Hard reflective	Modular steel fence (Impact Resistant Panel)		110mm impact resistant (Mainroads WA compliant) modular aluminium and steel wall system up to 2.1 metres with design life of 50 years.

Facing	Base material	Image	Description / Comments
Hard reflective	Modular steel fence (Impact Resistant Panel)	 Images courtesy modularwalls.com.au	Option for a lighter weight, 75mm non-impact rated fence.
Hard reflective	Modular recycled plastic with steel posts	 Image courtesy: https://bigbuild.vic.gov.au/projects/mrpv/mordialloc-freeway	Option for sustainable material, subject to design meeting PTA and design requirements.
Hard reflective, clear	Plexiglas SoundStop	 Image courtesy https://www.plastral.com.au/ 	Available in clear / opaque vision, various colours and also striped versions to avoid birdstrikes. Generally 25 mm thickness used for structural reasons, 12.5 mm variants may also be used if curved. Commonly used with road noise barriers to reduce apparent visual scale and increase access to light.

Facing	Base material	Image	Description / Comments
Sound absorptive	Corten Acoustic wall with Stratocell Whisper planks (absorptive)	 leebrothersfencing.com.au	Built in 4 metre sections and premade 'planks' are manually dropped in by hand. Photo is of an installed section approved by Vicroads. Promo videos here, note that we have not verified the performance claims: https://m.youtube.com/watch?v=fmP7b783ffI https://youtu.be/EHb5fZ6xmJ0
Sound absorptive	Autoclaved aerated concrete (AAC), e.g. Hebel	 Gunnedah NSW / ARTC. Images courtesy hebel.com.au	Absorptive – As above but with 50mm Quietstone or Reapor recycled glass facing. Alternatively laser-cut mesh can be used, although a minimum open area of 20% should be preserved.
Sound absorptive	Diffractive waveguide walls, e.g. 'Whisswall' (absorptive)	  Images courtesy 4silence.com	Relatively low height noise wall with top edge diffractor and diffusive (e.g. Gabion wall, 25mm textured concrete) facing. Design heights to be determined based on application. Note that the performance claims made are feasible and supported by literature, but they have not been verified in Australia. Excellent for reducing visual impact of noise wall mitigation Requires hard level ground, but does not require structural retention and relatively quick to install (dropped into place). Low maintenance. Key downsides are width (~1 metre wide) is that in order to provide improved noise reduction, sound is redirected upwards, limiting usefulness in areas with multi-storey residential development nearby. Claimed earthing options for diffracting part: Weathering steel, aluminium, galvanised, coated. Could include reclaimed ballast. Substructure: Absorbent concrete, reflective concrete, Gabion wall, stone strips, green wall. https://www.4silence.com/railways/

Facing	Base material	Image	Description / Comments
Sound absorptive	Modular steel fence (Impact Resistant Panel)		As per reflective modular steel fence but with perforated facing and sound absorptive properties. Can be affixed to existing concrete structures. The Perth bus station bus-only ramp entry off Wellington Street is an example of such panelling.

4.13 Third Party Operational Stakeholders

Not applicable at this design stage.

4.14 Design Input from Stakeholders and Community Involvement Process

Not applicable at this design stage.

4.15 Design Assumptions, Dependencies, and Constraints (ADC's)

Detailed of design risks, assumptions, issues, dependencies, opportunities and constraints are outlined below.

4.15.1 Design Risk Register

Design risks related to this design package are detailed in the Table below;

Table 29: Noise and vibration risk register

#ID	Description	Status	Evidence of Validation
1	The minimum extent modelled as compliant with the Specification is arguably less than that which the community may expect and does not 'future-proof' against new development in areas currently unoccupied. The community may provide feedback that as a result of the noise wall extents being reduced to suit visual concerns, noise targets may not be met in the ultimate case. There is a risk being transferred to the operator that the PTA may receive noise complaints and consider retroactively installing noise walls in the future if the community point of view changes or new residents move in. Advice on community expectations should be obtained and increases to extents to minimise the potential for complaint should be considered on a case by case basis.	Open	

4.15.2 Design Assumptions

Design assumptions related to this design package are detailed in the Table below.

Table 30: Design assumptions

#ID	Description	Status	Evidence of Validation
1	Condition of track at the location of and during the time of source measurements is representative of future track condition on BRE.	Open	

#ID	Description	Status	Evidence of Validation
2	Ground conditions affecting vibration along the entire alignment may be reasonably approximated by ground at the location of and during the time of source measurements.	Open	
3	Noise and vibration emissions are based upon the track being maintained at least to the conditions that existed at the time and location of source measurements. If rail roughness levels are allowed to degrade over time, higher vibration levels will result. Commissioning of the track should require that the track longitudinal profile is consistent with ISO 3095.	Open	
4	Impact of road network on the noise level are considered based on the different in annual average traffic volumes and heavy vehicle mix for the main roads within the project area.	Open	
5	Rough / diffusive wall finishes. If walls are hard reflective, then wall extents may need to be revised.	Open	
6	Existing residential walls and noise walls relevant to the report outcomes are maintained to be acoustically sound (continuous and without gaps).	Open	
7	Under-sleeper pads (USPs) (which are vibration isolation pads cast into the base of each sleeper and installed with the sleeper as one unit) are considered feasible.	Open	
8	Operational speed profile is as described in Section 0, and unlikely to increase in practice.	Open	

4.15.3 Design Dependencies

Design dependencies related to this design package are detailed in the Table below;

Table 31: Design dependencies

#ID	Description	Status	Evidence of Validation
1	Noting the speaker layouts and design of Armadale and Byford Stations may be undertaken by another design consultancy, and hence would not be the responsibility of SLR to ensure compliance against STI requirements.	Open	

4.15.4 Design Opportunities

Design opportunities related to this design package are detailed in the Table below;

Table 32: Design opportunities

#ID	Description	Status	Evidence of Validation
1	The minimum extent modelled as compliant with the Specification is arguably less than what the community may expect and does not 'future-proof' against new development in areas currently unoccupied. Overall it may be less expensive to apply the treatment over a greater extent than manage long term vibration issues following construction.	Open	
2	It is understood that there is currently an alternative noise wall material solution under consideration by PTA which utilises recycled plastic. Subject to the satisfaction of PTA and design requirements (see Section 4.9), the solution may lead to a better sustainable outcome.	Open	

4.15.5 Design Constraints

Design constraints related to this design package are detailed in the Table below;

Table 33: Design constraints

#ID	Description	Status	Evidence of Validation
	The SWTC requires that the Alliance must consider the cumulative noise impact from road traffic and the operating passenger railway when designing and constructing any noise mitigation measures. We note that this is further to the requirements of SPP5.4 and modelling of road network within the project area is required.	Open	
1	The Alliance must consult with residents in the vicinity of any proposed noise walls/barriers and take into account their feedback when determining the location, height, materials, design and colour of noise walls/barriers. This feedback may constrain otherwise reasonable and practicable options for effective noise mitigation.	Open	
2	Advanced vibration modelling (based on local field measurements and geotechnical data) during the detailed design phase can be undertaken to improve certainty in outcome and identify other options for vibration mitigation, such as ground stiffening, deep barriers or groundsoil reinforcement techniques. Whilst detailed modelling based on local field measurements is required to determine potential benefits with reasonable certainty, given the above it is expected to be impracticable to achieve an internal LAmax 35 dB at all locations. The relatively large difference between forecast results and design trigger levels suggests that at a minimum, practicable options with track slewing such as resilient ballast matting should be budgeted for in order to address reasonable expectations of quality.	Open	

4.15.6 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 per the following subsections.

Uncertainty is usually described in two-sided terms (half ranges), e.g. an uncertainty of U_{95} 5 dB and mean estimate of say L_{vSmax} = 30 dB indicates that for 95 out of 100 repeated events, the true value of L_{vSmax} is between 25 and 35 dB (5 dB half range). For the remaining 5 out of 100 events, the value of L_{vSmax} is outside this range: 2.5% will be above 35 dB and the other 2.5% below 25 dB, so the L_{vSmax} value would be compliant with (equal to or less than) a 35 dB target for 97.5 % of events. Figure 24 presents an example of these concepts.

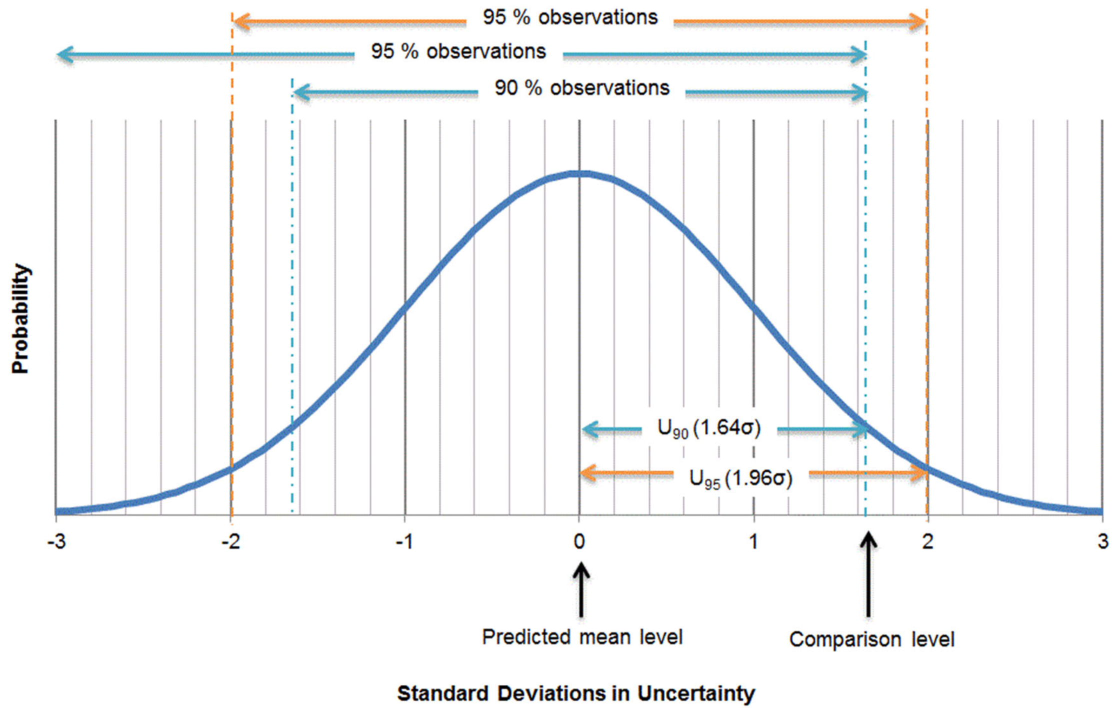


Figure 24: Example of Uncertainty Terms and Concepts

Therefore, to compare a value against a maximum (or minimum) target to be met 95 out of 100 events, U_{90} is here determined such that 5 % (the allowable excess rate) would be above the determined mean plus U_{90}. In this figure, the design safety factor is therefore the difference between the level which represents 95% of observations (predicted mean level plus 1.64σ), and the limit applicable.

It is important to understand that some of the initial data collected is already defined in terms of the 5th percentile results rather than the mean, and corrections have been applied to ensure consistent terms in outcome.

4.15.6.1 <u>Airborne Noise</u>

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 LAE results, as speeds along the alignment will vary.
- Variation of in train-car length with respect to variability LAE 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 34: Uncertainty of prediction, airborne noise

Parameter	System	U_{95} (Note)	Student's t-factor
LAeq, LAmax	Nord2000	4 dB	2.00

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 faults 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.

Section 4.15.6 describes how the design uncertainty has been used to address input parameters and predictions. Uncertainties in these remaining aspects will therefore be removed with commissioning measurements.

4.15.6.2 Vibration

The accuracy of the prediction methodologies as outlined for ground-borne vibration (L_{vSmax}, 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 limits defined in ISO3095.
  - 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.
  - 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 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[ ] guidelines.
- 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[ ] 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.
- Excluded / Other Sources of Error
  - The following items are not included in the above estimate of uncertainty:
  - Local track faults 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.

Section 4.15.6 describes how the design uncertainty has been used to address input parameters and predictions. Uncertainties in these remaining aspects will therefore be removed with commissioning measurements.

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

Table 35: Uncertainty of prediction, regenerated noise

Parameter	System	U_{95} (Note)	Student's t-factor
LvSmax	SLR numerical code	5 dB	2.00

4.16 Requests for Information (RFI)

None at time of writing.

5. Design Outputs

5.1 Design Reviews and CE Deliverables List

Not applicable at this design stage.

5.2 Specifications

Draft specifications relevant to this design package is provided in Appendix B of this report.

5.3 Standard Reference Drawings

Not applicable.

5.4 System Coordination Drawings and Models

No drawings are associated with this report. Sketches of noise and vibration modelling results are provided in Appendix C.

5.5 Type Approvals

Not applicable at this design stage. Type Approvals may be required for Under Sleeper Pads.

5.6 Calculations

Calculations are provided in Appendix E of this report which present the level of modelled compliance with project criteria.

5.7 Schedules

Schedules for this design package are provided in Appendix F of this report.

6. Design Reviews and Certification

6.1 Interdisciplinary Design Coordination (IDC) Review

An Interdisciplinary Design Check (IDC) review has been carried out as outlined in the Table below.

Table 36: IDC check

Reference	Design Stage	Description/Scope	Evidence
IDC-001	Reference Design	Not applicable.	-

Reference	Design Stage	Description/Scope	Evidence
IDC-002	Interim Detailed Design	ONVDR	R30-MET-FRM-EM-000-00003_NV-540_BRE Comments Sheet
IDC-003	Final Detailed Design		

6.2 IDC Certificate

Refer to Appendix G.

6.3 Design Checking and Verification

Not applicable at this design stage.

6.4 Independent Verification

Not applicable at this design stage.

6.5 BCA

Not applicable.

6.6 DDA

Not applicable.

6.7 PTA Design Submission Reviews.

Not applicable.

7. Safety Assurance

7.1 Hazard Analysis

7.1.1 Overview

The project has implemented a Safety Assurance process for this design package, which encompasses industry standards and best practice compliant to the Public Transport Authority (PTA) Safety Management System (SMS). This is detailed in the Systems Safety Assurance Management Plan (BRE-MET-PLN-EA-00002), which describes how the project will meet its safety obligations and the requirements within the Scope of Work and Technical Criteria (SWTC).

7.1.2 Hazard Analysis Activities

The following safety hazards were originally identified in workshops for other design packages (TR100 - Permanent Way - Alignment Design, ST170 – Viaduct, ST450 - Wungong Bridge (Rail)), but were also deemed appropriate to NV540:

- BRE-HAZ-251 – Noise / vibration due to inadequate stiffness transition between ballast track / slab track
- BRE-HAZ-276 – Induced vibration to assets on the viaduct
- BRE-HAZ-277 – Noise & vibration to properties adjacent to the viaduct

The workshops focused on identifying hazards for different aspects of safety, along with the causes, consequences, and potential safety controls to mitigate the risk, if elimination of the risk was not possible. There were no NV-540 related risk controls identified during the Hazard Analysis process that required incorporation into the design solution or design. These 3 hazards present a low safety risk to passengers or members of the public, and hence do not require additional risk assessment (refer to Section 7.4).

There are no safety implications associated with the Design Assumptions, Dependencies and Constraints (ADC) summarized in Section 4.15.

The following table provides a preliminary summary of potential risks identified during the Initial Detailed Design (IDD) phase, which will be explored in detail as the design progresses. A risk assessment workshop is planned to be conducted with the relevant stakeholders to identify any hazards for different aspects of safety related to this design package's scope along with the causes, consequences, and potential safety controls to mitigate the risk, if elimination of the risk is not possible. The outputs of this workshop will be documented in the next revision of the NV-540 Design Report, in the Project Hazard Log (PHL) (Appendix P:), and within the meeting minutes, forming the Hazard Workshop Report (Appendix Q:).

Table 37. Potential Safety Risks

#	Hazard	Risk	Design Action / Control Measures	Residual risk	Owner	Contractors (or others) measures
1	Risk of safe egress around pedestrian railway crossings with noise walls	Walls in close proximity to crossings. Upon approaching train that does not stop, pedestrians need path(s) of egress. Security risks of people hiding behind walls on approaches	Installed opening in wall to ensure egress not impacted. Ensure suitable lighting throughout area. Use of transparent vision sections to reduce opportunities for hiding.	Yes TBD	PTA	Inductions, training, lighting, signage on both approaches
2	Restricted access or sightlines for workers within the rail corridor due to noise walls	Reduced visibility of incoming trains due to noise walls or mitigation treatments	Ensure noise wall is as close as practicable to railway to reduce required height. Add high visibility signage / markings to any poles or structures which may further reduce trafficable space. Angle walls and provide open overlaps to improve sight paths in the direction of travel.	Yes TBD	PTA	Civil works to maximise foot and vehicle trafficable areas as required
3	Material handling during construction	Heavy materials and awkward site area	Will require specific construction plan approved by the PTA	No	Contractor	Safe working and management plans
4	Construction within railway reserve	Train movements, electrical shock	Will require specific construction plan approved by the PTA	No	Contractor	Safe working and management plans

7.1.3 Safety Interfaces

Refer Section 3.2.

7.2 Hazard Management

A Project Hazard Log (PHL) has been maintained for the project, which covers the full scope of the project. The baseline set of hazards has been developed which is reflective of the current PTA suite of technical standards, as extracted from the SWTC. A Preliminary Hazard Analysis (PHA) exercise has been conducted to build this baseline set of hazards which has included review of the BRE-PTAWA-Byford Rail Extension Project Hazard Log (BRE-PTAWA-SA-REG-0002) and AD stage PHA findings captured in the Byford Rail Extension (BRE) Preliminary Hazard Analysis Report (BRED-PTAWA-GCOR-0300-0835-120-001).

An extract of the Project Hazard Log identifying hazards relevant to this design package is included in Appendix P: . As of December 2022, the PHL has been imported into DOORS for ongoing management. The PHL is a live document that is progressively updated to capture all risks as a result of the workshops, as well as derived safety requirements as the design packages develop in maturity. Refer to the System Safety Assurance Management Plan (SSAMP) (R30-MET-PLN-SA-000-00002) for details about the Derived Safety Requirement Management Process.

7.3 Management of Safety Requirements

In accordance with the Legislative Provision for Western Australia, notably the Occupational Safety and Health (OSH) Act 1984, Section 23 and OSH Regulations and Guidance, we advise that as far as reasonably practicable, we have adopted safe design practices in identifying unusual hazards and either eliminating or minimizing the attendant risks to building users.

While there has not been a Hazard Analysis Workshop specific to the NV-540 scope, hazards and controls identified in other Design Package Workshops are captured in the Project Hazard Log (Appendix P:), and are allocated to the relevant design package owners, with the intent to consider integrating them into the design. Controls identified will continue to be reviewed and assessed for integration into the design following IDD.
There are 3 hazards associated with NV-540 identified through other Design Package Workshops, however all controls linked to these hazards are outside the scope of the NV-540 Design Package, and are hence allocated to other control owners.

Subsequent to the workshops, as part of the design process, hazard controls are assessed and classified as either Adopted, Existing / In Place, Transferred, or Rejected:

- **Adopted** signifies proposed, implemented, or to be implemented
- **Existing / In Place** signifies PTA Operations & Maintenance (O&M) procedures
- **Transferred** signifies that agreement has been reached between relevant stakeholders to transfer the control.
- **Rejected** signifies that the control is not implemented; reasons for rejection recorded at Safety Control Verification Reference column in the PHL.

7.3.1 Requirements Allocation Traceability Matrix

Requirements allocated to design package NV-540 are included in Appendix O: (RATM Extract).

7.4 Risk Profile

The aim of the risk management process for the BRE Project is to eliminate hazards, however, it is often unfeasible to remove hazards altogether. As such, all hazards have been reviewed with the aim to reduce all risk levels So Far As Is Reasonably Practicable (SFAIRP), prioritising hazards with ‘Very High’ and ‘High’ risk rankings over those with ‘Medium’ and ‘Low’ risk rankings.

7.4.1 Hazard Summary

All risks associated with the hazards identified at this stage are assessed using the PTA risk matrix. Risks undergo a qualitative assessment based on likelihood and consequence provides an overall risk rating/profile. The risk rating/profile is then measured against the PTA's risk acceptance table to confirm the appropriate course of action.

The table below presents a summary of all hazards identified to date, which have been documented in the Project Hazard Log (Appendix P:), and their initial ranking according to the PTA's risk criteria.

Table 38: NV-540 – Initial Risk Profile

Initial Risk Ranking Vs Hazard Status					
Hazard Status	**Very High**	**High**	**Medium**	**Low**	**Total**
Open	0	0	1	2	3
Closed	0	0	0	0	0
Managed	0	0	0	0	0
Resolved	0	0	0	0	0
Transferred	0	0	0	0	0
Total	**0**	**0**	**1**	**2**	**3**

Initial assessments of the residual risk rankings of all hazards have been undertaken and are summarised in the table below. There are no hazards with a “High” or “Very High” risk ranking.

Table 39: NV-540 – Residual Risk Profile

Residual Risk Ranking Vs Hazard Status					
Hazard Status	**Very High**	**High**	**Medium**	**Low**	**Total**
Open	0	0	0	3	3
Closed	0	0	0	0	0
Managed	0	0	0	0	0
Resolved	0	0	0	0	0
Transferred	0	0	0	0	0
Total	**0**	**0**	**0**	**3**	**3**

All identified hazards have a residual risk ranking of “Low”. Design Supply Responsible Engineers (SREs) have reviewed the PHL entries, including hazard causes and risk rankings, and agreed that the associated controls proposed to be implemented will be effective in mitigating the risk in accordance with SFAIRP principles.

7.4.2 Control Summary

There are no NV-540 related risk controls identified during the Hazard Analysis process that require incorporation into the design solution or design.

7.5 Transfer of Residual Risks and Safety Related Operation Conditions

Once all controls associated with a hazard have been implemented with verification evidence or rejected with suitable SFAIRP justification, the hazard status will be changed to “Managed” in the PHL. Residual hazards will then be transferred to the relevant Hazard Owners for acceptance. PTA owned controls will be transferred in accordance with the PTA Project Hazard Transfer Procedure (8810-000-008).

Any risks subjected to transfers will be formally reviewed and agreed upon by all parties and will be indicated on the Project Hazard Log with the status as “Transferred” as per **Error! Reference source not found.**. At this point in time, no hazards or Safety Related Application Conditions (SRACs) have been identified for transfer.

7.6 Safety Assurance Strategy

Not applicable.

7.7 Outstanding Issues

The following outstanding issues/actions are ongoing activities, which will continue to be developed as the design progresses:

- Risk assessment to be undertaken at Final Detailed Design (FDD) to identify hazards and safety implications associated with the items in Table 37. Potential Safety Risks.

7.8 Safety Summary Statement

Further progression of the design from a safety assurance will occur following closure of outstanding items listed in Section 7.7.

Safety assurance evidence contained in this design report will support the progressive safety argument provided in the Safety Assurance Report (SAR), which will consolidate the safety case and provide a cumulative safety argument for the overall system. (Refer Section 7.6).

8. Systems Engineering

8.1 Sub-system Allocation

Not in use for NV-540.

8.2 Requirements Management

Requirements management occurs throughout the lifecycle of the project and is described in the Requirements Management Plan (ReMP). The project's requirements are managed and tracked inside the BRE Delivery DOORS database. The database is managed from the identification and allocation stages through to verification for contract (SWTC) requirements and derived requirements, such as safety and Human Factors requirements from hazard analysis.

In the Reference Design phase, the SWTC requirements issued by PTA were allocated to the applicable design package(s). These requirements have been assigned a criticality level to help focus verification and review efforts, and were also allocated to one or more project gates at which verification evidence would be required. Both the criticality and the project gates have been agreed upon by both the Suppliers Responsible Engineer and applicable Project Engineer(s).

During the Interim Detailed Design and Final Detailed Design phases these allocated requirements will be refined into the system and subsystem requirements. This refinement is yet to occur for NV-540. These requirements will capture what the various systems and subsystems of the Byford Rail Extension need to achieve to satisfy the source SWTC requirements. Further derived requirements from sources including external stakeholder engagement, interface workshops, safety and hazard workshops, and human factors workshops will also be refined into system and subsystem requirements. This work is still in progress for NV-540. When complete, these derived requirements will then be managed in the same way as those refined from the SWTC.

8.3 Requirements Allocation Traceability Matrix

An extract of the Requirements Allocation Traceability Matrix (RATM) for the NV-540 package is provided in Appendix O. This extract shows the requirements allocated to this package as well as an initial assessment of the criticality, applicable project gates and reference to the verification evidence. The criticality and project gate allocation has been reviewed and agreed with PTA.

8.4 Outstanding Issues

Incoming safety controls from safety workshops require workshopping with the design SRE(s) to develop derived safety requirements where controls are not already covered by extant requirements.

8.5 Sub-system Allocation

Not applicable.

8.6 Requirements Management

8.6.1 Requirements Allocation Traceability Matrix

Not applicable

8.7 Outstanding Issues

Not applicable

9. Sustainability in Design

Noise walls could be constructed using recycled or otherwise sustainable materials. Refer to Table 28 for examples.

10. Human Factors

Systems must be designed and implemented in a way that takes human capabilities, limitations and other human characteristics into account. Adequate integration of Human Factors (HF) in all phases of a system's development lifecycle ensures its safety, performance and fitness for purpose. The aim is to identify, capture then mitigate and prevent HF-related risks and ensure that human-system interactions are optimised for system performance and safety. That is, any hazard or control that can impact (either positively or adversely) on human behaviour in order to provide for safe and effective human performance.

Effective HF Integration (HFI) and the ability to provide assurance that HFI requirements have been addressed for the Project are reliant on proactive management of the HF activities. The MetCONNX HF Lead is responsible for overseeing the application of the HF activities described in the Project's Human Factors Integration Plan (HFIP).

These aspects are discussed in the following subsections. Refer to Appendix R for further detail on terms used to relate noise and vibration to human factors.

10.1 Early Human Factors Analysis (EHFA)

EHFA aims to provide a high-level overview of the potential HF issues for a project. The EHFA is produced to identify the focus for HF integration for a change event or project. The purpose of the EHFA is to identify the high-level HF issues and risks associated with the Project, and to inform the areas of HF focus and guide the Project's Alliance/Contractor in the content and focus of their own HFIP.

In accordance with PTA's HF Integration Procedure (7810-700-017, Rev 0, 22/11/2019), PTA conducted an EHFA for the BRE Project (BRE-MNO-HFI-SA-RPT-0001, Rev 0, 22/02/2021), as is required for every METRONET Project. This was however prior to the AD phase and did not consider the elevated solutions. A subsequent EHFA was conducted by PTA in conjunction with the Armadale Level Crossing Removal (ALXR) project, which identified generic viaduct HF issues. Reviewing the original BRE EHFA was out of scope for the ALXR EHFA.

To provide a consolidated starting point for the now-elevated BRE scope, both these EHFAs from PTA were combined by the MetCONNX HF Lead and used to generate the BRE Project HF Issues Register (HFIR). The HFIR is one of the key assurance deliverables to demonstrate progressive HF assurance and to capture HF design decisions and trade-offs. The HFIR is used to capture and prioritise any HF analysis and design review activities. This will ensure that analysis focuses on the most critical aspects of the design. The MetCONNX HF Lead is responsible for managing and maintaining the BRE Project's HFIR.

10.2 Safety in Design (SiD) and Hazard Analyses – HF input

Providing HF support to Safety in Design (SiD) workshops not only supports complementary work streams, but also serves to provide further input to identify the detailed HF issues associated with the changes introduced by the BRE Project scope and/or PTA network.

The aim is to identify then control and prevent HF-related risk and ensure that human-system interactions are optimised for system performance and safety. That is, any hazard or control that can impact (either positively or adversely) on human behaviour in order to provide for safe and effective human performance. The aim is to identify and eliminate HF issues where possible through influencing the design during these early stages.

No Safety-in-Design (SiD) or Interface Hazard Analysis (IHA) coordination workshops have been conducted for NV-540. Workshops for other design packages may identify issues specific to NV-540. Any HF-related safety aspects will be incorporated into the PHL against the appropriate hazard and/or cause, with a cross-reference to the corresponding issue within the HFIR. The MetCONNX HF Lead will also participate in informal and formal Interdisciplinary design checks/reviews throughout the Project lifecycle.

10.3 Key HF considerations

No design-specific HF-related issues relating to NV-540 have been recorded during this design phase. This may change upon review and as the design progresses, given noise and vibration risk management is focused primarily on mitigating their respective impact on humans.

Derived requirements from sources including external stakeholder engagement, interface workshops, safety & hazard workshops and human factors workshops will be refined into system and subsystem requirements. Derived HF requirements (if applicable) will be recorded within the HFIR against the specific HF issue from which they have been derived. They will then be transferred to the RATM (managed in DOORS) for management under the requirements management process.

11. Reliability, Availability and Maintainability (RAM)

RAM assessment for this Design Package is not required. This work package is an operational, noise & vibration study document and no relevant RAM assessment is required.

11.1 System Analysis Results

No relevant analysis is required for this work package.

11.2 Outstanding Issues

No relevant analysis is required for this work package.

11.3 RAM Issues Log

No relevant analysis is required for this work package.

11.4 Overall Assessment

No relevant analysis is required for this work package.

12. Construction Methodology

Not applicable at this design stage.

12.1 Construction Methods

Not applicable.

12.2 Operational Staging

Not applicable.

12.3 Works in Track Occupancies

Not applicable.

13. Asset Operations Strategy

Not applicable at this design stage.

13.1 RTO Assets

Not applicable.

13.2 Other Assets

Not applicable.

14. Asset Operations Strategy

Not applicable at this design stage.

Appendix A: Drawing and Model List (Not in use)

Appendix B: Specifications

B1 Under Ballast Matting

Correct procurement and installation is critical to long term effectiveness**. Table 40** presents an initial specification[4] of physical properties which should be carefully revised and updated as part of a specific procurement process, noting that:

- For formation applications, the ballast mat must be of a closed cellular structure without grooves, profiles or channels. The width of the UBM must extend past the effective loading interface between the ballast and compacted base. The compacted base must be suitably stiff in order to avoid compromising the performance of the UBM.
- For slab or structural surfaces, the ballast mat can be closed cellular structure or profiled rubber or similar.
- The upper surface must have an integral / bonded layer or cover of ballast resistance material to provide high abrasion resistance and resistance to oils and normal ballast contaminants. This protective layer or cover can be a means of joining the ballast mat.

Table 40: Performance specification of under ballast matting

Trackform	Property	Value	Basis
Material properties	Mechanical fatigue resistance	MUST PASS	DIN 45673-5:2010-08
	Tensile strength	> 0.8 N/mm^2	DIN 53455
	Elongation at rupture	> 250%	DIN 53455
	Water absorption by resilient layer – by volume (%)	< 15%	DIN 45673-5:2010-08
	Water resistance – tensile strength reduction (%)	< 10%	
	Ageing change of C_{stat}	Δ C_{stat} < 10%	
Performance properties	Nominal specific static stiffness C_{stat} between 0.02 and 0.10 N/mm²	TBA	DIN 45673-5:2010-08
	Specific dynamic stiffness ratio for determination of track dynamics:	[C_{dyn} / C_{stat}]	
	C_{dyn1} (5 Hz)	< 1.3	
	C_{dyn1} (10 Hz)	< 1.3	
	C_{dyn1} (20 Hz)	< 1.3	
	C_{dyn1} (30 Hz)	< 1.3	
	Low frequency dynamic stiffening K_{dyn1} (10 Hz)	< 1.3	
	High frequency dynamic stiffening:	[C_{dyn} / C_{stat}]	

[4] Adapted from correspondence with Peter Schonstein dated June 7, 2019. email: peter (at) schonstein.com.au

Trackform	Property	Value	Basis
	K^{dyn2} (20 Hz) at preload 0.03 N/mm^2	< 1.4	
	K^{dyn2} (20 Hz) at preload 0.06 N/mm^2	< 1.3	
	K_{dyn2} (20 Hz) at preload 0.10 N/mm^2	< 1.3	

B.2 Under Sleeper Pad

Under Sleeper Pads (USPs) are elastic layers which are attached to the underside of sleepers in ballasted track, which influence the properties and the behaviour of the rail track. USPs are usually manufactured from materials including polyurethane (PUR), rubber or ethylenvinylacetate (EVA). Generally there are four different methods of attaching the USP to the underside of the sleeper:

- **Preferred** – Interlocking layer (e.g. extruded knobs, wire mesh, geo-membrane, fine-grained gravel) which is set into wet concrete;
- Placing directly on to the unset concrete (during sleeper production);
- Coating by spraying or painting onto hardened concrete; and
- Gluing to hardened concrete.

The CEN Standard (TC 256 WI00256597:2012) defines the test procedures and their acceptance criteria which applicable to concrete sleepers or bearers with USP physically bonded to concrete used in ballast track. It also defines the specific test procedures for USP with or without concrete sleepers and bearers:

- Fatigue tests;
- Tests of capability for stacked stocking of concrete sleepers or bearers fitted with USP
- Pull-out test
- Severe environmental condition test.

A classification of the USP stiffness has been introduced by UIC as follows:

Table 41: A classification of USP stiffness levels (DIN 45673-1)

USP	Stiffness
Stiff	0.25 N/mm^3 < C_{stat} ≤ 0.35 N/mm^3
Medium stiff	0.15 N/mm^3 < C_{stat} ≤ 0.25 N/mm^3
Soft	0.10 N/mm^3 < C_{stat} ≤ 0.15 N/mm^3
Very soft	C_{stat} ≤ 0.10 N/mm^3

The material properties used in the prediction model for ground borne vibration and noise levels are listed as follows:

Table 42: Material properties of under sleeper pad

Material properties	Values	Test method
Static bedding modulus C_{stat} between 0,02 N/mm² and 0,048 N/mm²	TBA	DIN 45673-1
Tearing strength of the connection Under Sleeper Pad-concrete sleeper	Min. 0.25 N/mm^2	DBS 918 145-1
Fatigue test	Passed	DBS 918 145-1
Resistance to water	excellent resistance	DIN 53428

Material properties	Values	Test method
Resistance to chemical agents	good resistance	DIN 53428
Resistance to fire	B2 class E	DIN 4102 EN ISO 11925-2
Resistance to hydrocarbons	good resistance	DIN 53428
Resistance to ozone	excellent resistance	DIN 53428
Low frequency dynamic bedding modulus C_{dyn} for determination of track dynamics $C_{dyn,5Hz}$ $C_{dyn,10Hz}$	TBA	DIN EN 16730
Higher frequency dynamic bedding modulus CH	TBA	DIN EN 16730
Tensile strength σ	TBA	ISO 527-3
Fatigue test ΔC_{stat} $\Delta C_{dyn, 5Hz}$	TBA	DIN EN 16730
Capability for stacked stocking of sleepers with USP	TBA	DIN EN 16730
Effect of severe environmental conditions ΔC_{stat} $\Delta C_{dyn, 5Hz}$ σ_{min} σ_{av}	TBA	DIN EN 16730

Appendix C: Drawings and Sketches

Results are based on rubber rail pads with agreed mitigation extents in Appendix F.

C.1 Mitigated Noise Railway Results – Daytime L_{Aeq} Contour Map

C.2 Mitigated Noise Railway Results – Night-time L_{Aeq} Contour Map

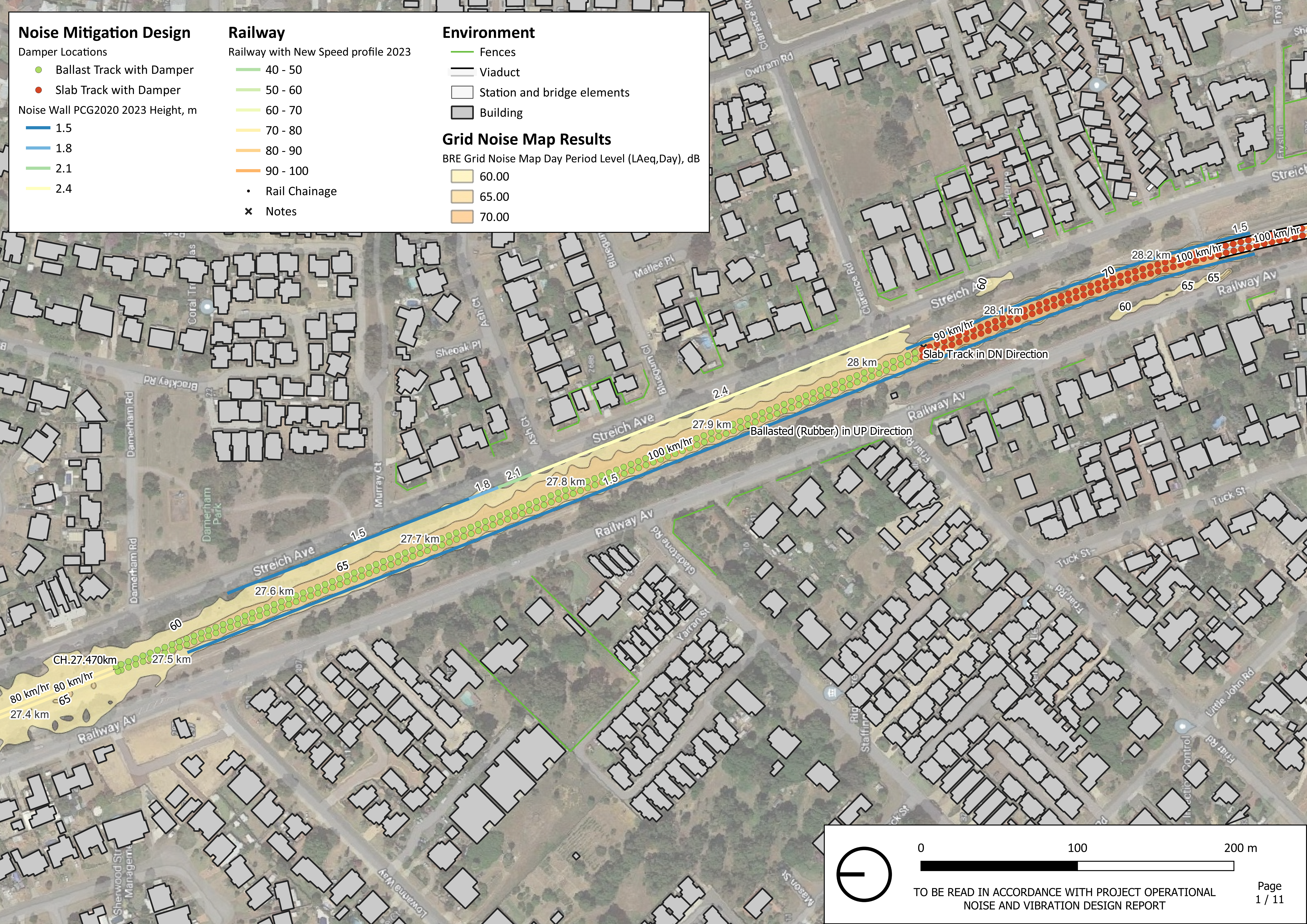
C.3 Mitigated Noise Railway Results – L_{Amax} Contour Map

C.4 Predicted Ground-borne Noise Results – L_{ASmax}

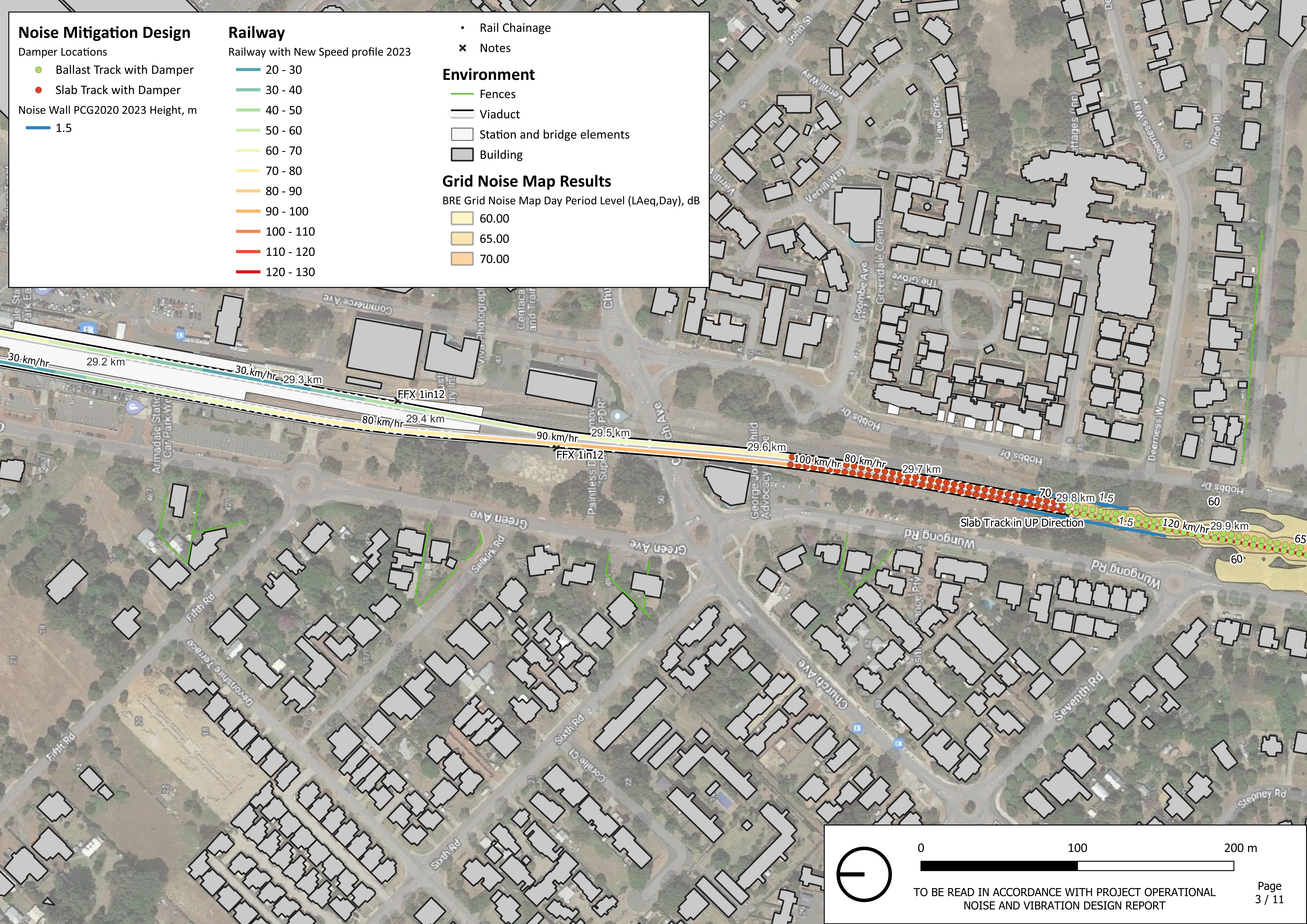
C.5 Predicted Vibration Results – Lv,RMS,1s

C.6 Existing Road Traffic Noise Results – Daytime L_{Aeq} Contour Map

C.7 Existing Road Traffic Noise Results – Night-time L_{Aeq} Contour Map


Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Slab Track with Damper
Noise Wall PCG2020 2023 Height, m
1.5
1.8
2.1
2.4
Railway
Railway with New Speed profile 2023
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Noise Map Day Period Level (LAeq,Day), dB
60.00
65.00
70.00
Slab Track in DN Direction
Ballasted (Rubber) in UP Direction
CH.27.470km
27.4 km
27.5 km
27.6 km
27.7 km
27.8 km
27.9 km
28 km
28.1 km
28.2 km
80 km/hr
80 km/hr
90 km/hr
100 km/hr
100 km/hr
100 km/hr
Streich Ave
Railway Av
Owtram Rd
Clarence Rd
Mallee Pl
Sheoak Pl
Brackley Rd
Damerham Rd
Damerham Park
Murray Ct
Ash Ct
Bluegum Ct
Gladstone Rd
Yarran St
Friar Rd
Tuck St
Little John Rd
Lowanna Way
Mason St
Sherwood St
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Slab Track with Damper
Noise Wall PCG2020 2023 Height, m
1.5
Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
100 - 110
110 - 120
120 - 130
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Noise Map Day Period Level (LAeq,Day), dB
60.00
65.00
70.00
30 km/hr
29.2 km
30 km/hr
29.3 km
FFX 1in12
80 km/hr
29.4 km
90 km/hr
29.5 km
FFX 1in12
29.6 km
100 km/hr
80 km/hr
29.7 km
70
29.8 km
1.5
Slab Track in UP Direction
1.5
120 km/hr
29.9 km
60
65
60
Commerce Ave
Green Ave
Wungong Rd
Hobbs Dr
Church Ave
Fifth Rd
Sixth Rd
Seventh Rd
Devonshire Terrace
Coralie Ct
Stepney Rd
Selkirk Rd
Verrill Way
John St
Law Cres
Coombe Ave
The Grove
Rice Pl
Deerness Way
0
100
200 m
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Page
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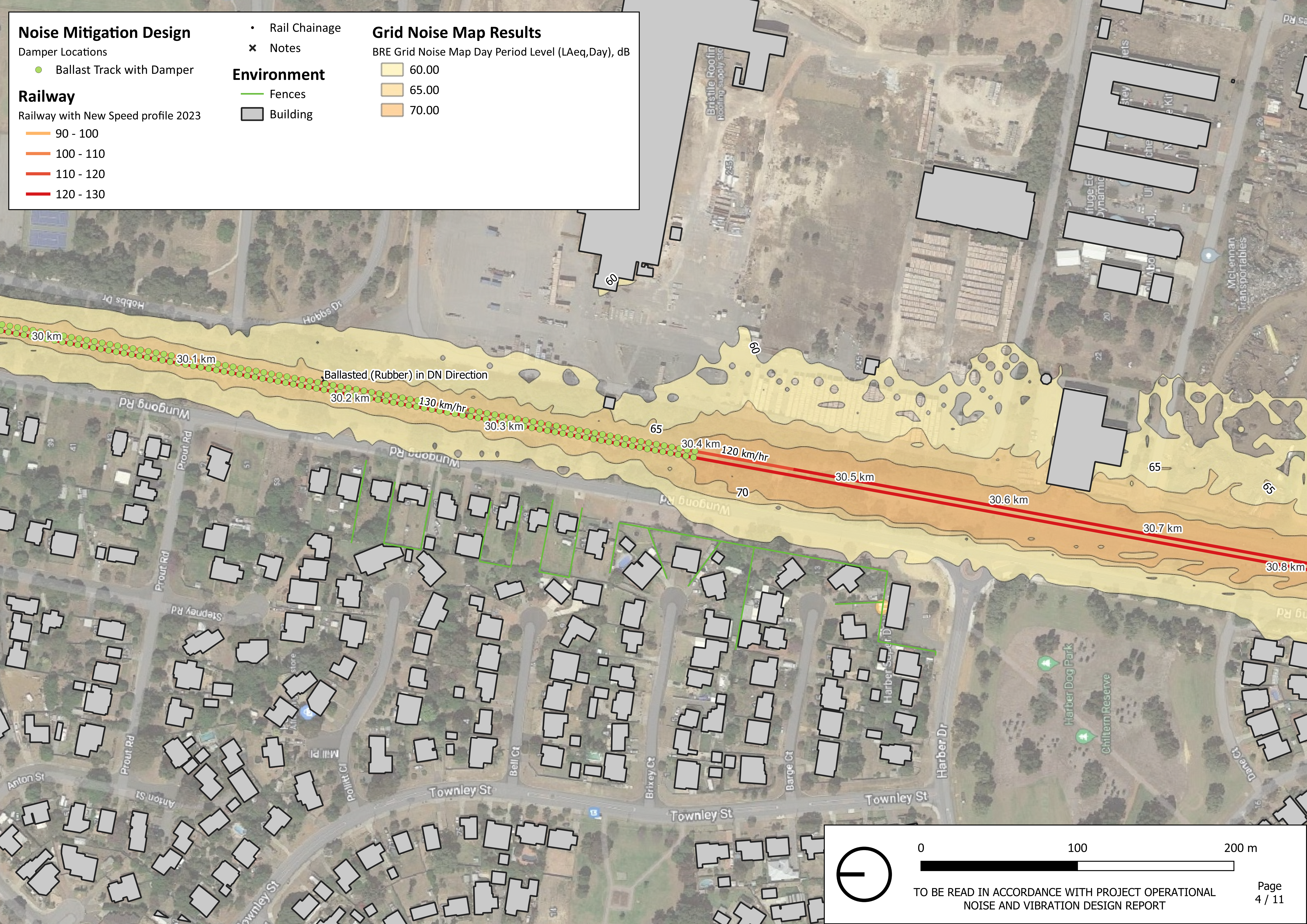

Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Railway
Railway with New Speed profile 2023
90 - 100
100 - 110
110 - 120
120 - 130
Rail Chainage
Notes
Environment
Fences
Building
Grid Noise Map Results
BRE Grid Noise Map Day Period Level (LAeq,Day), dB
60.00
65.00
70.00
30 km
30.1 km
Ballasted (Rubber) in DN Direction
30.2 km
130 km/hr
30.3 km
30.4 km
120 km/hr
30.5 km
30.6 km
30.7 km
30.8 km
60
65
70
Hobbs Dr
Wungong Rd
Prout Rd
Stepney Rd
Townley St
Anton St
Bell Ct
Brixey Ct
Barge Ct
Harber Dr
Harber Dog Park
Chiltern Reserve
McLennan Transportables
0
100
200 m
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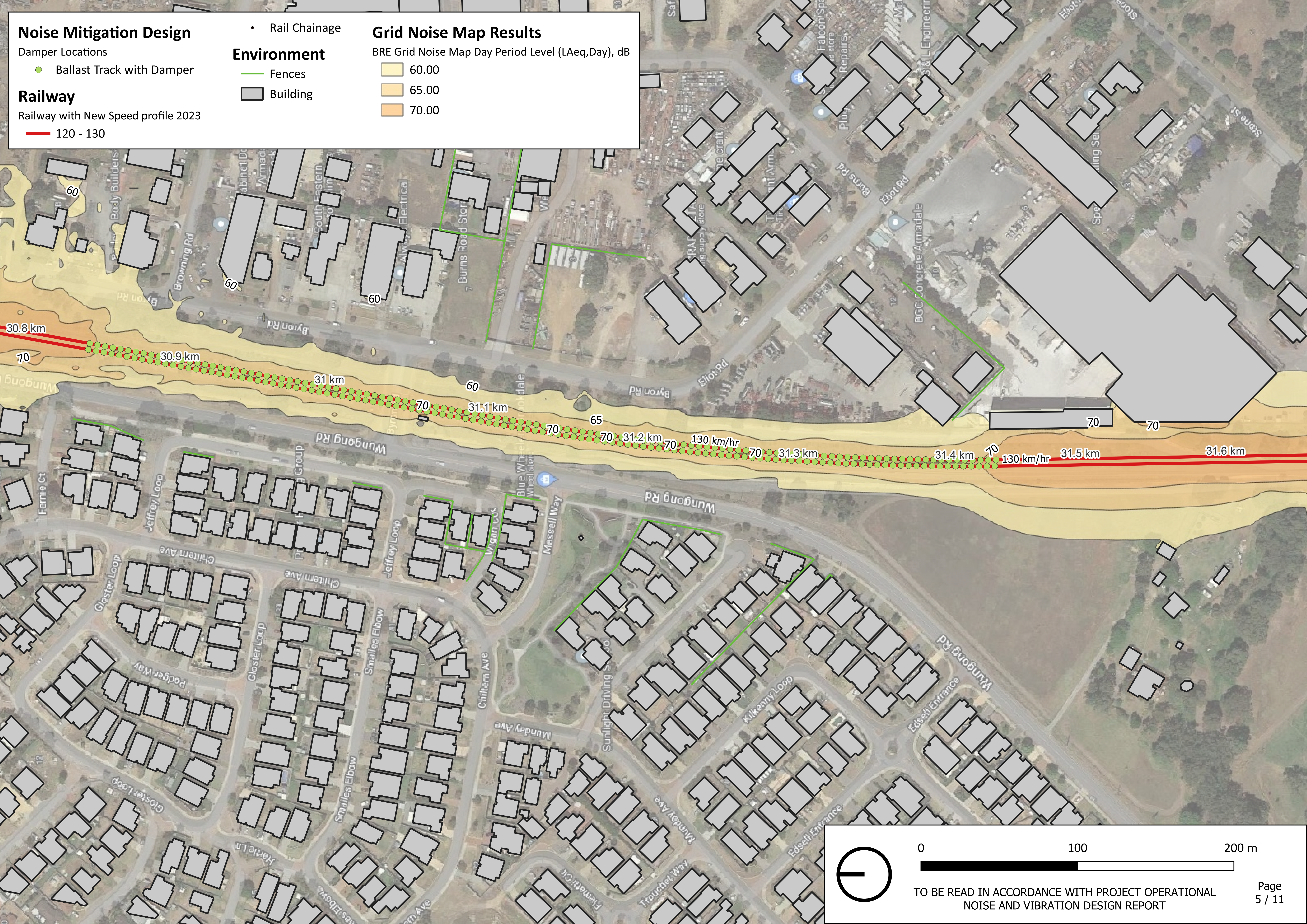
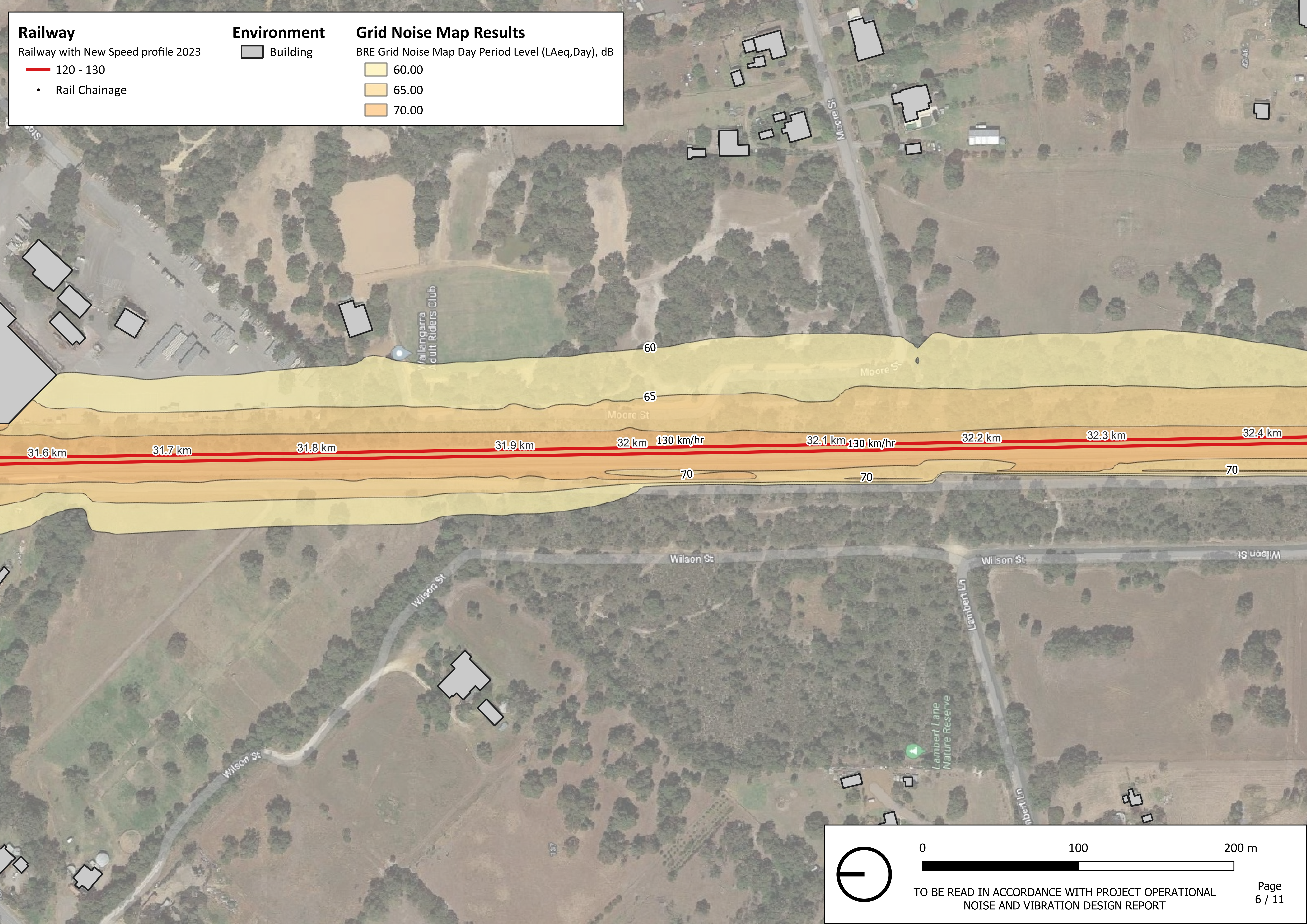

Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Building
Grid Noise Map Results
BRE Grid Noise Map Day Period Level (LAeq,Day), dB
60.00
65.00
70.00
30.8 km
30.9 km
31 km
31.1 km
31.2 km
31.3 km
31.4 km
31.5 km
31.6 km
130 km/hr
130 km/hr
Byron Rd
Wungong Rd
Eliot Rd
Burns Rd
Stone St
Browning Rd
Ferrie Ct
Jeffrey Loop
Chiltern Ave
Gloster Loop
Podger Way
Smailes Elbow
Wigan Cct
Massell Way
Munday Ave
Kilkenny Loop
Edsell Entrance
Troucher Way
Flematti Cir
Harle Ln
Sunlight Driving School
0
100
200 m


Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Building
Grid Noise Map Results
BRE Grid Noise Map Day Period Level (LAeq,Day), dB
60.00
65.00
70.00
Moore St
Wallangarra Adult Riders Club
60
65
70
31.6 km
31.7 km
31.8 km
31.9 km
32 km
130 km/hr
32.1 km
32.2 km
32.3 km
32.4 km
Wilson St
Lambert Ln
Lambert Lane Nature Reserve
0
100
200 m
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Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Noise Wall PCG2020 2023 Height, m
1.5
1.8
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Noise Map Day Period Level (LAeq,Day), dB
60.00
65.00
70.00
32.4 km
32.5 km
32.6 km
32.7 km
32.8 km
32.9 km
33 km
33.1 km
33.2 km
33.3 km
33.4 km
130 km/hr
Eleventh Rd
Bruns Dr
Woodstock Pl
Rivose Cres
Todman Grove
Paradise Rendo
0
100
200 m
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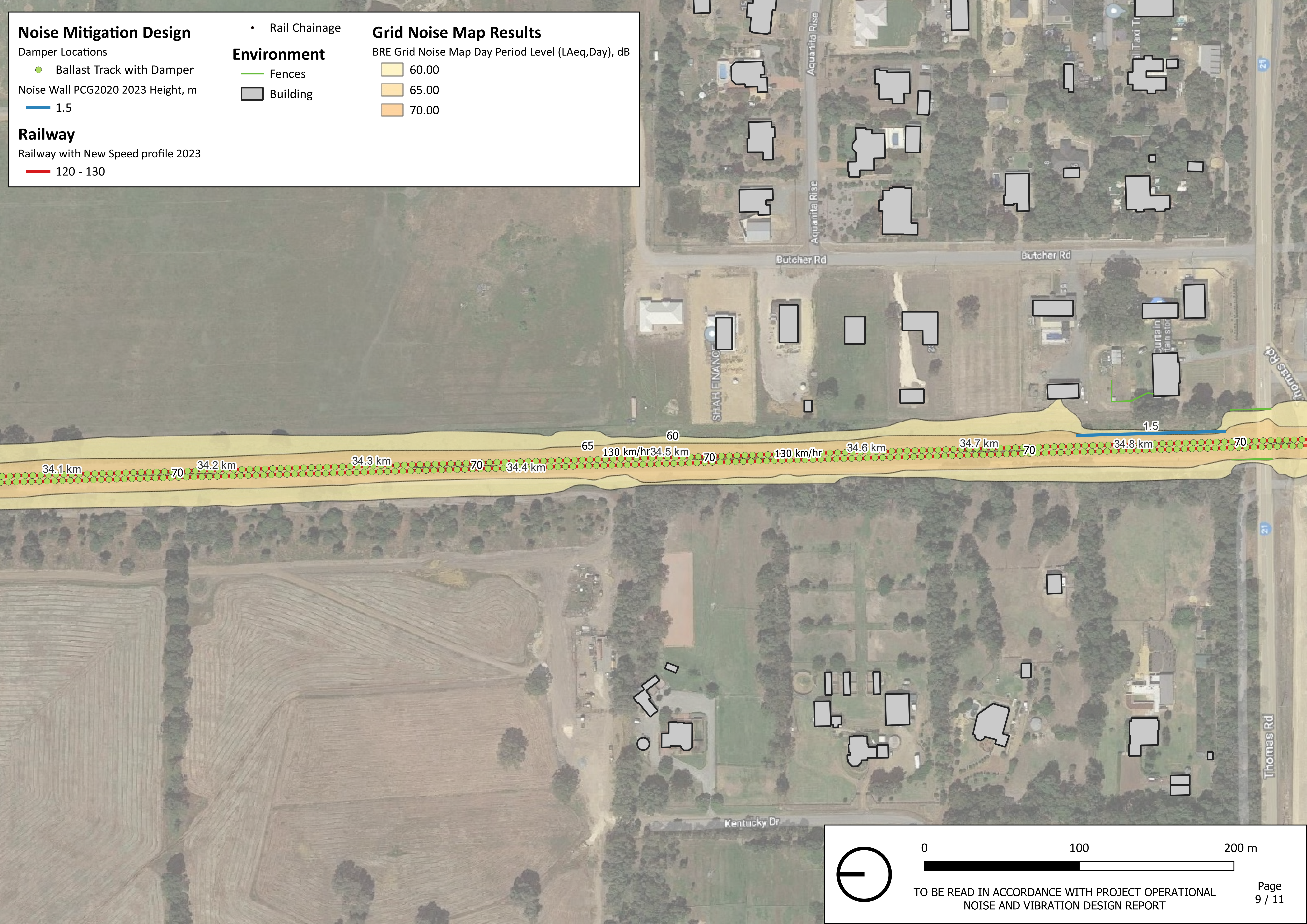
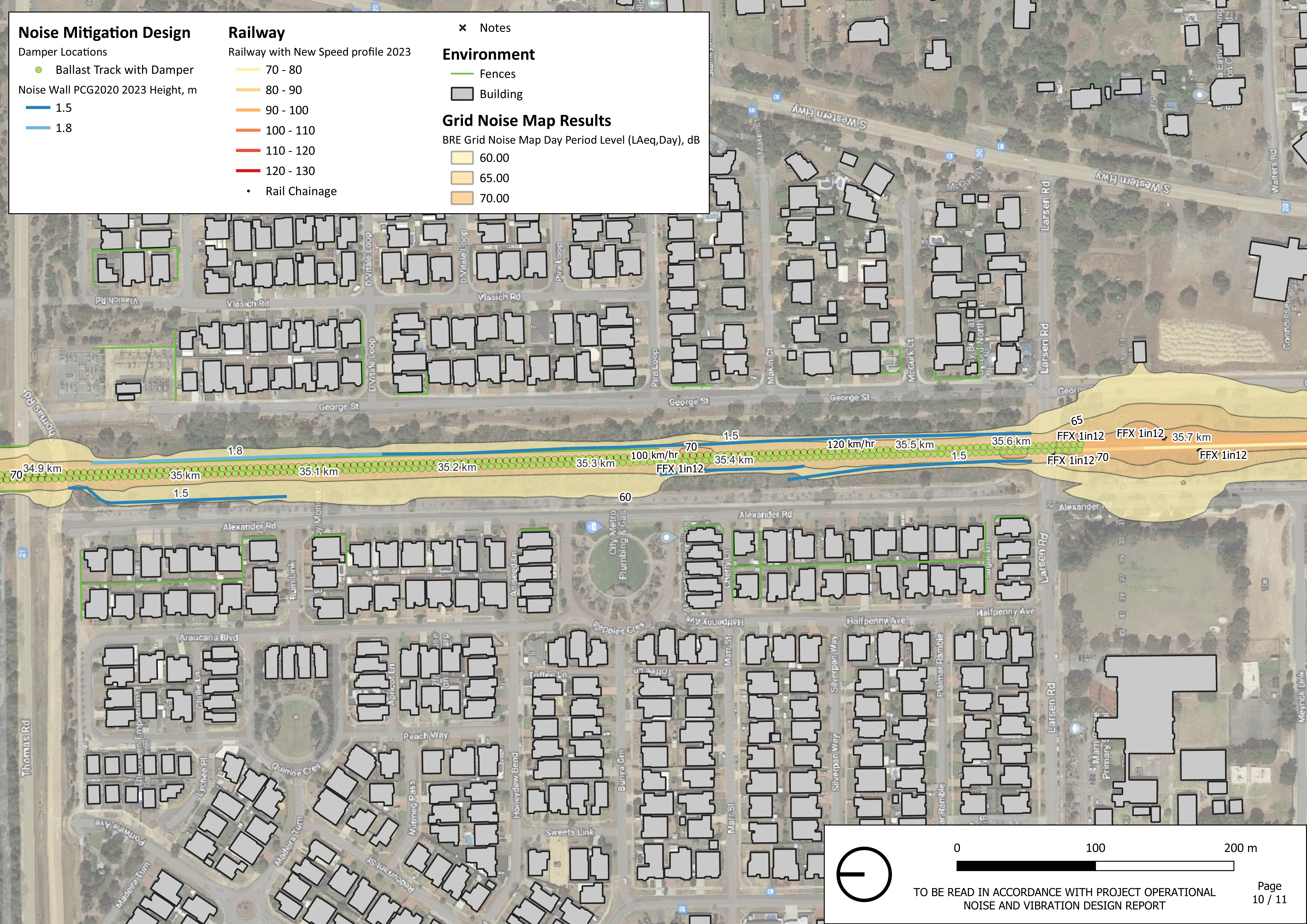

Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Noise Wall PCG2020 2023 Height, m
1.5
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Building
Grid Noise Map Results
BRE Grid Noise Map Day Period Level (LAeq,Day), dB
60.00
65.00
70.00
Aquanita Rise
Butcher Rd
Thomas Rd
Kentucky Dr
SHAH FINANCE
34.1 km
34.2 km
34.3 km
34.4 km
34.5 km
34.6 km
34.7 km
34.8 km
130 km/hr
130 km/hr
60
65
70
1.5
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT
Page 9 / 11



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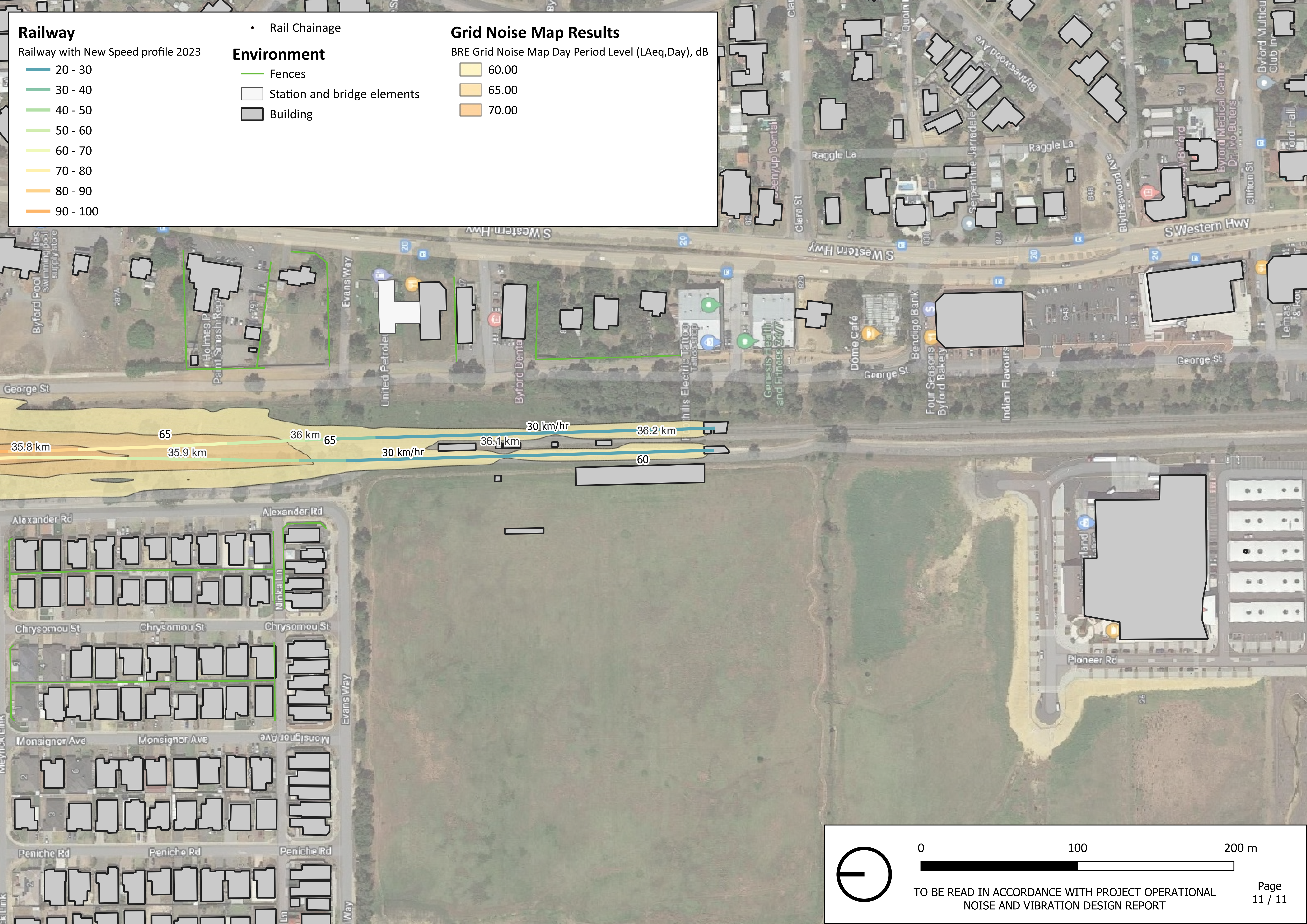
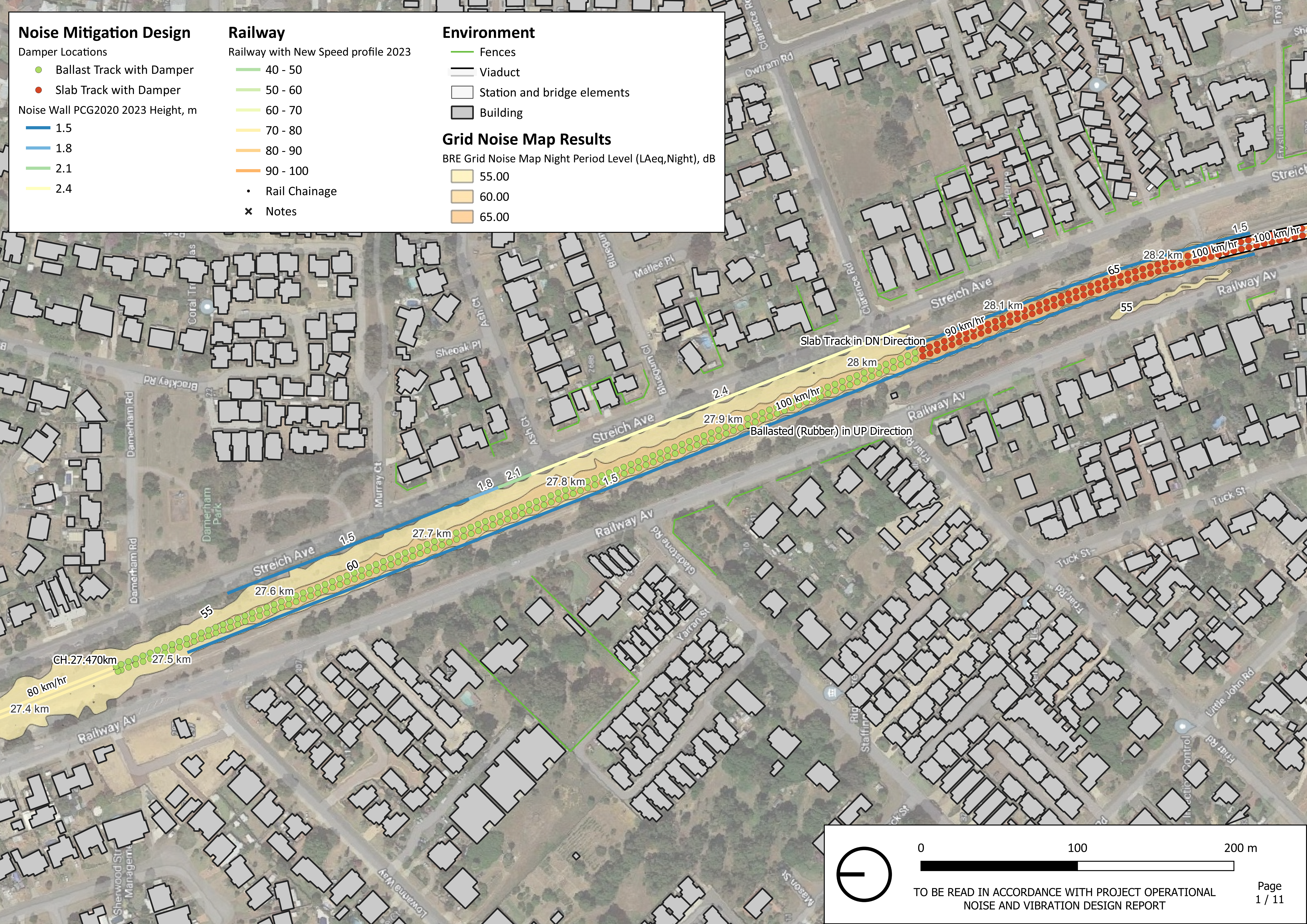

Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Environment
Fences
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Noise Map Day Period Level (LAeq,Day), dB
60.00
65.00
70.00
S Western Hwy
Raggle La
George St
Alexander Rd
Chrysomou St
Monsignor Ave
Peniche Rd
Pioneer Rd
Evans Way
Clara St
Clifton St
Blytheswood Ave
35.8 km
35.9 km
36 km
36.1 km
36.2 km
30 km/hr
30 km/hr
65
65
60
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Slab Track with Damper
Noise Wall PCG2020 2023 Height, m
1.5
1.8
2.1
2.4
Railway
Railway with New Speed profile 2023
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Noise Map Night Period Level (LAeq,Night), dB
55.00
60.00
65.00
Slab Track in DN Direction
Ballasted (Rubber) in UP Direction
CH.27.470km
27.4 km
27.5 km
27.6 km
27.7 km
27.8 km
27.9 km
28 km
28.1 km
28.2 km
80 km/hr
90 km/hr
100 km/hr
Streich Ave
Railway Av
Owtram Rd
Clarence Rd
Mallee Pl
Sheoak Pl
Brackley Rd
Damerham Rd
Damerham Park
Murray Ct
Ash Ct
Bluegum Cl
Gladstone Rd
Tuck St
Friar Rd
Little John Rd
Yarran St
Lowanna Way
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL
NOISE AND VIBRATION DESIGN REPORT
Page
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Noise Mitigation Design
Damper Locations
Slab Track with Damper
Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
28.3 km
100 km/hr
28.4 km
28.5 km
28.6 km
100 km/hr
80 km/hr
80 km/hr
28.7 km
FFX 1in12
28.9 km
FFX 1in12
29 km
80 km/hr
29.1 km
30 km/hr
Orchard Ave
Orchard Ave
Memorial Park
Neerigen St
Neerigen St
Aragon Court
Aragon Court
Armadale Rd
Armadale Rd
Railway Av
Abbey Rd
Abbey Rd
Abbey Rd
Abbey Rd
Abbey Rd
Little John Rd
Tuck St
Forrest Rd
Forrest Rd
Forest Cct
Richard Pl
Robin Ct
Castle Pl
Green Ave
Tudor Rd
Netley Pl
Sherbourne Way
Leich Ave
Third Rd
Jull St
Jull St
Armadale Station Park(East)
Auto Masters Armadale
Muzz Buzz
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT
Page
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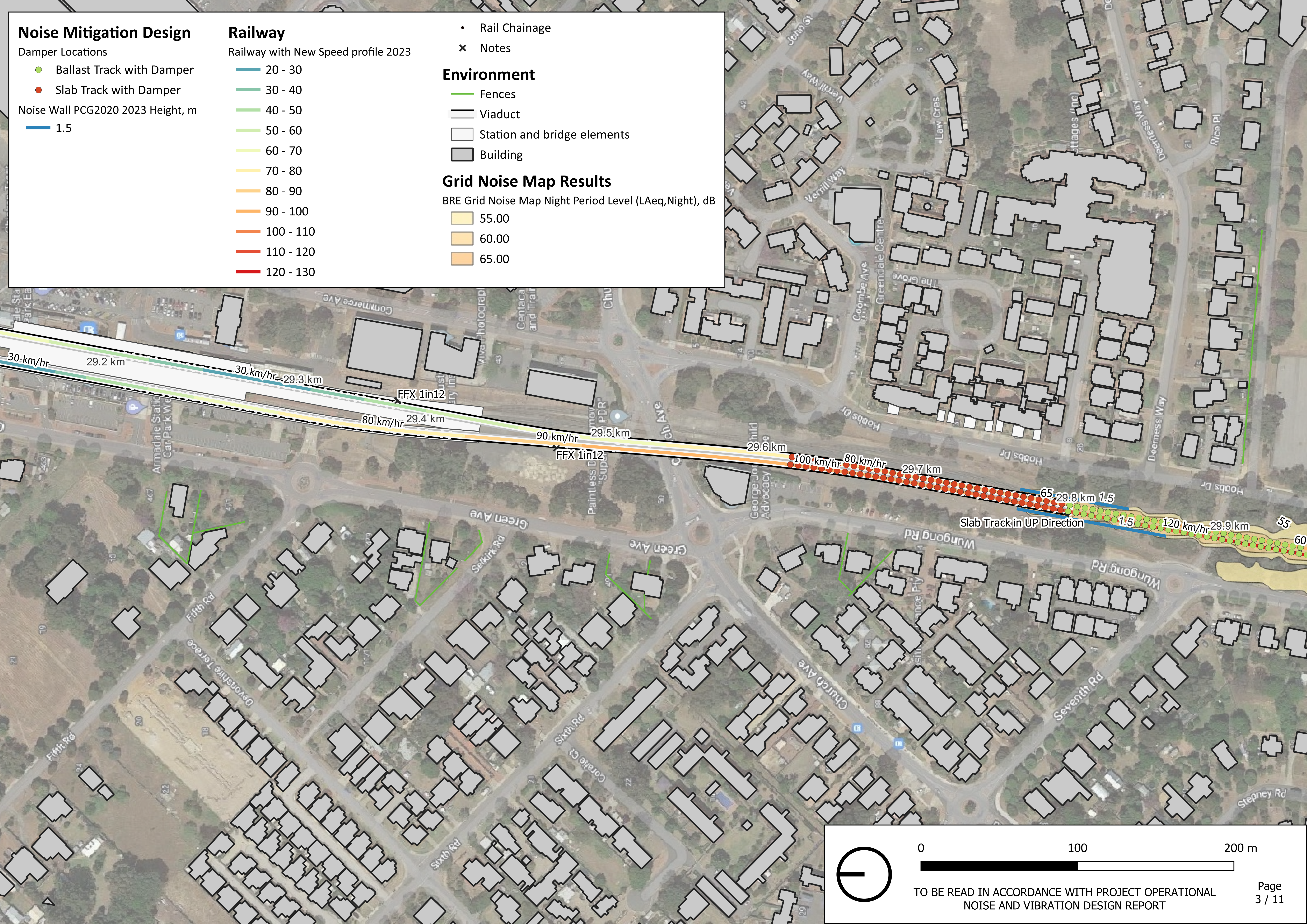
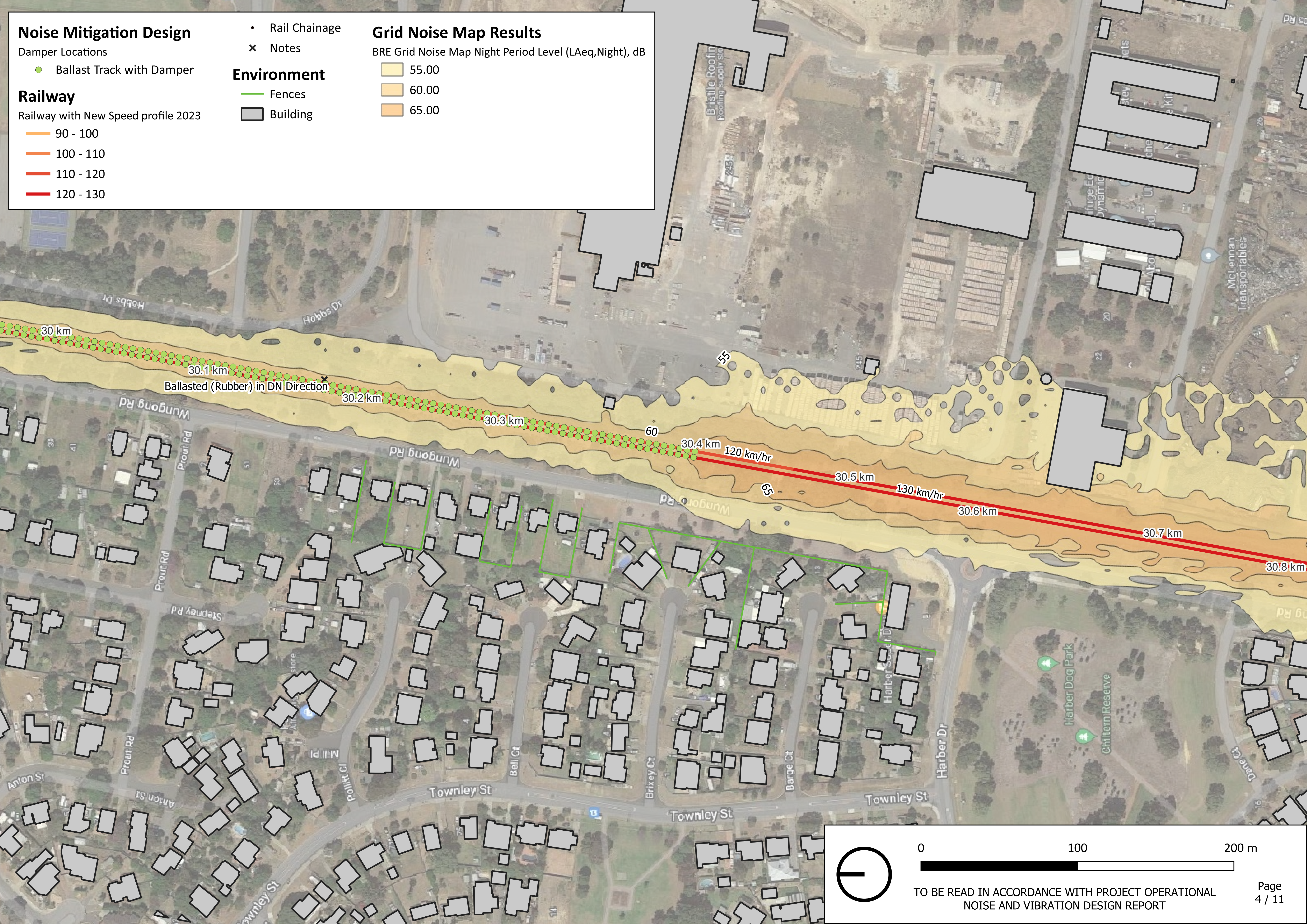
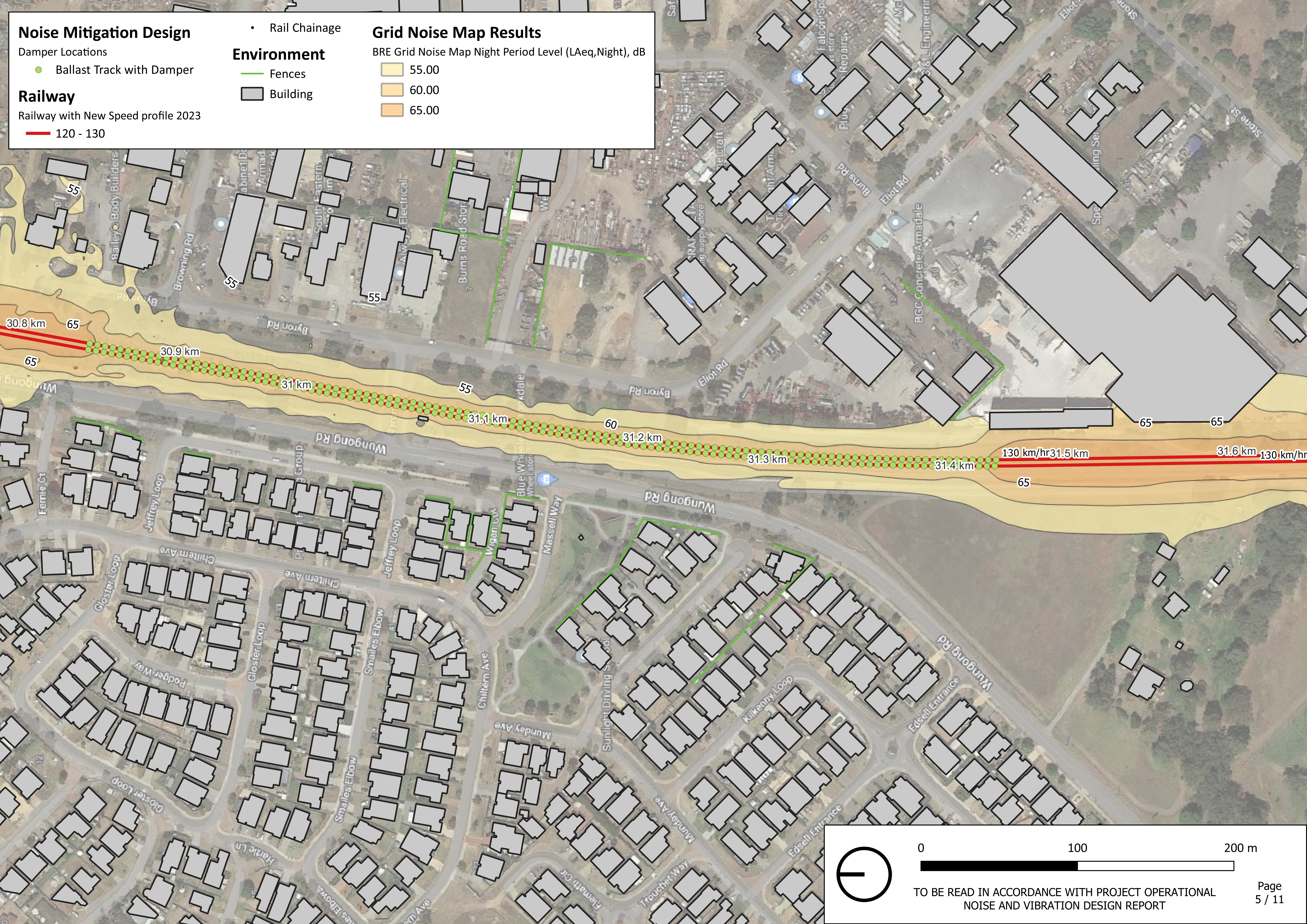
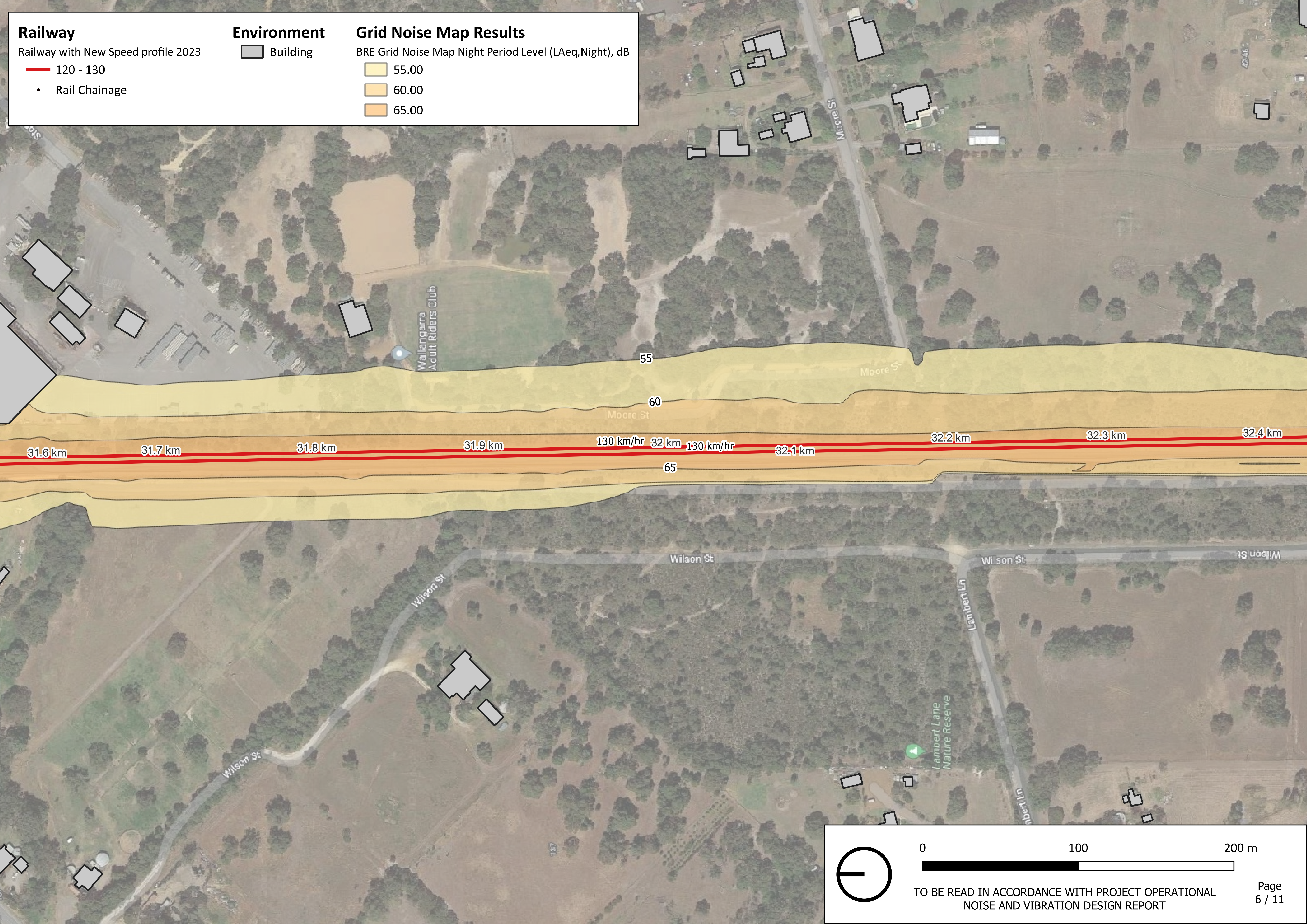

Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Slab Track with Damper
Noise Wall PCG2020 2023 Height, m
1.5
Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
100 - 110
110 - 120
120 - 130
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Noise Map Night Period Level (LAeq,Night), dB
55.00
60.00
65.00
30 km/hr
29.2 km
30 km/hr
29.3 km
FFX 1in12
80 km/hr
29.4 km
90 km/hr
29.5 km
FFX 1in12
29.6 km
100 km/hr
80 km/hr
29.7 km
65
29.8 km
1.5
Slab Track in UP Direction
1.5
120 km/hr
29.9 km
55
60
Commerce Ave
Green Ave
Wungong Rd
Hobbs Dr
Church Ave
Fifth Rd
Sixth Rd
Seventh Rd
Devonshire Terrace
Coralie Ct
Stepney Rd
Selkirk Rd
Coombe Ave
Greendale Centre
The Grove
Deerness Way
Rice Pl
Verrill Way
Law Cres
John St
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

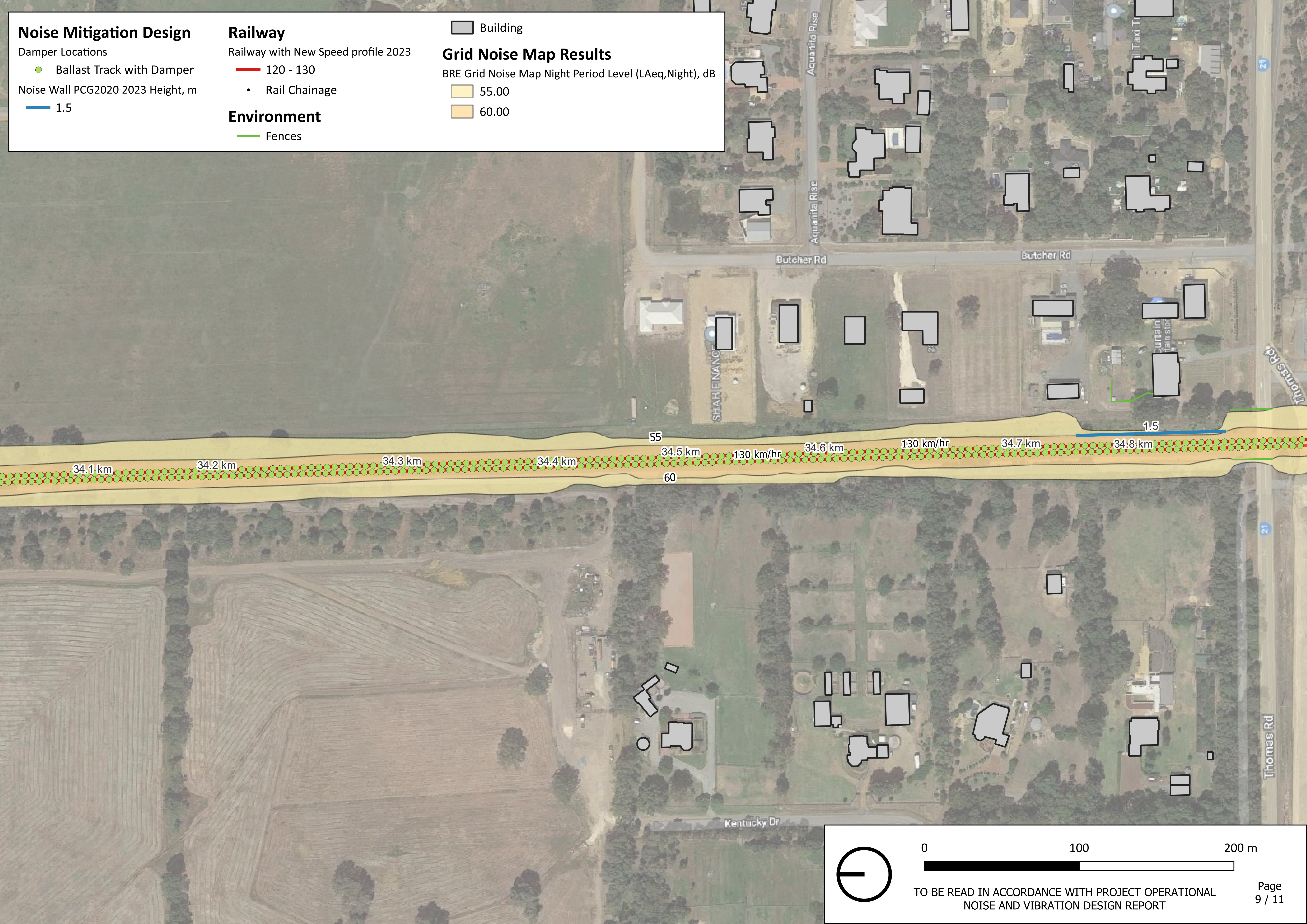

Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Railway
Railway with New Speed profile 2023
90 - 100
100 - 110
110 - 120
120 - 130
Rail Chainage
Notes
Environment
Fences
Building
Grid Noise Map Results
BRE Grid Noise Map Night Period Level (LAeq,Night), dB
55.00
60.00
65.00
30 km
30.1 km
Ballasted (Rubber) in DN Direction
30.2 km
30.3 km
30.4 km
120 km/hr
30.5 km
130 km/hr
30.6 km
30.7 km
30.8 km
55
60
65
Hobbs Dr
Wungong Rd
Prout Rd
Stepney Rd
Anton St
Townley St
Pollitt Cl
Mill Pl
Bell Ct
Brixey Ct
Barge Ct
Harber Dr
Harber Dog Park
Chiltern Reserve
McLennan Transportables
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Building
Grid Noise Map Results
BRE Grid Noise Map Night Period Level (LAeq,Night), dB
55.00
60.00
65.00
30.8 km
30.9 km
31 km
31.1 km
31.2 km
31.3 km
31.4 km
31.5 km
31.6 km
130 km/hr
55
60
65
Byron Rd
Wungong Rd
Eliot Rd
Burns Rd
Stone St
Browning Rd
Burns Road Store
Chiltern Ave
Jeffrey Loop
Gloster Loop
Smailes Elbow
Munday Ave
Kilkenny Loop
Edsell Entrance
Massell Way
Wigan Ct
Podger Way
Harle Ln
Flematti Cir
Troucher Way
Sunlight Driving School
Fernie Ct
BGC Concrete Armadale
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL
NOISE AND VIBRATION DESIGN REPORT

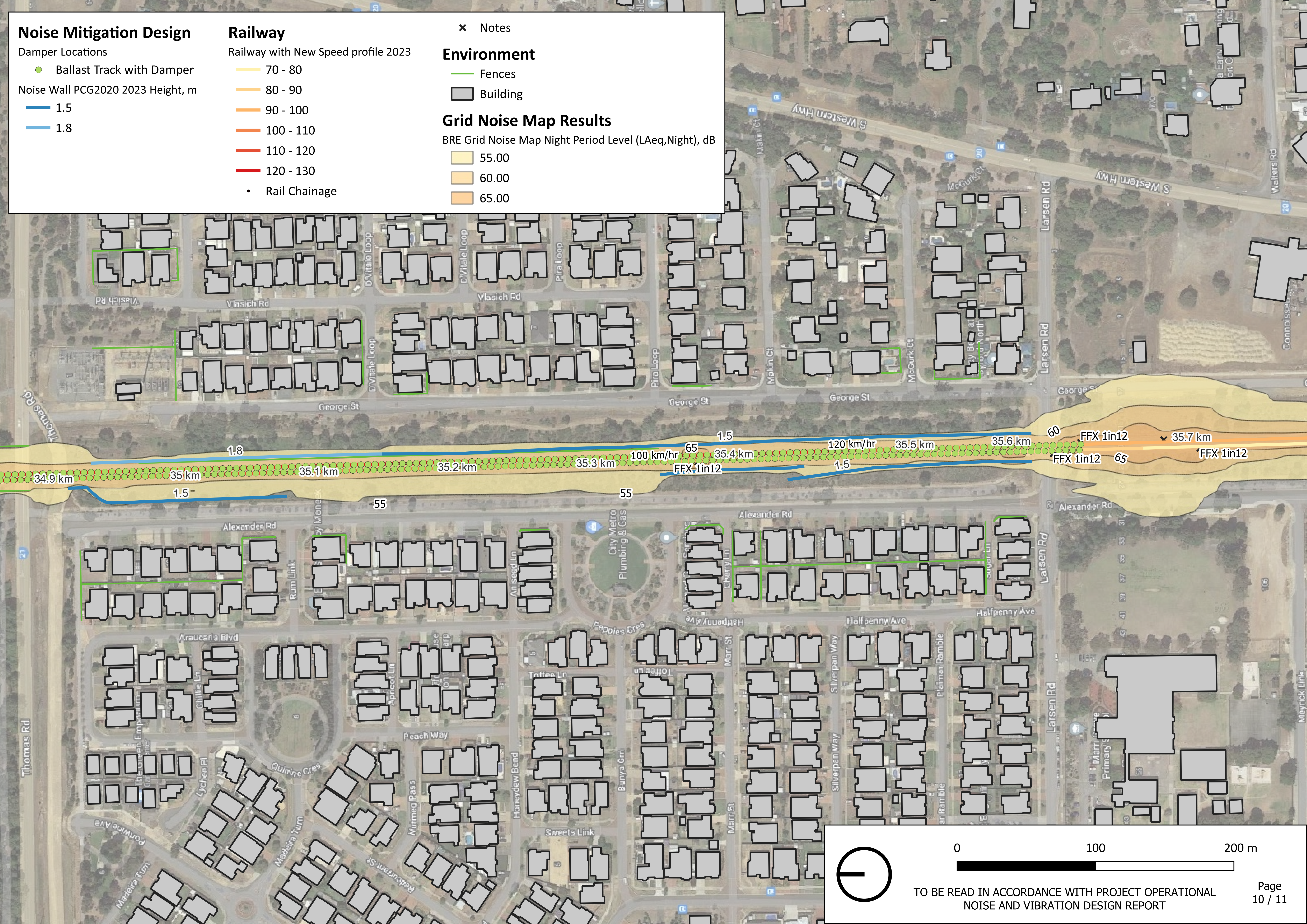

Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Building
Grid Noise Map Results
BRE Grid Noise Map Night Period Level (LAeq,Night), dB
55.00
60.00
65.00
Moore St
Wallangarra Adult Riders Club
55
60
65
31.6 km
31.7 km
31.8 km
31.9 km
130 km/hr
32 km
130 km/hr
32.1 km
32.2 km
32.3 km
32.4 km
Wilson St
Lambert Ln
Lambert Lane Nature Reserve
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Noise Wall PCG2020 2023 Height, m
1.5
1.8
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Noise Map Night Period Level (LAeq,Night), dB
55.00
60.00
65.00
32.4 km
32.5 km
32.6 km
32.7 km
32.8 km
32.9 km
33 km
33.1 km
33.2 km
33.3 km
33.4 km
130 km/hr
65
60
55
Eleventh Rd
Woodstock Pl
Bruns Dr
Rivose Cres
Todman Grove
Paradise Rendo
Pumps Perth
Bores
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT
Page
7 / 11

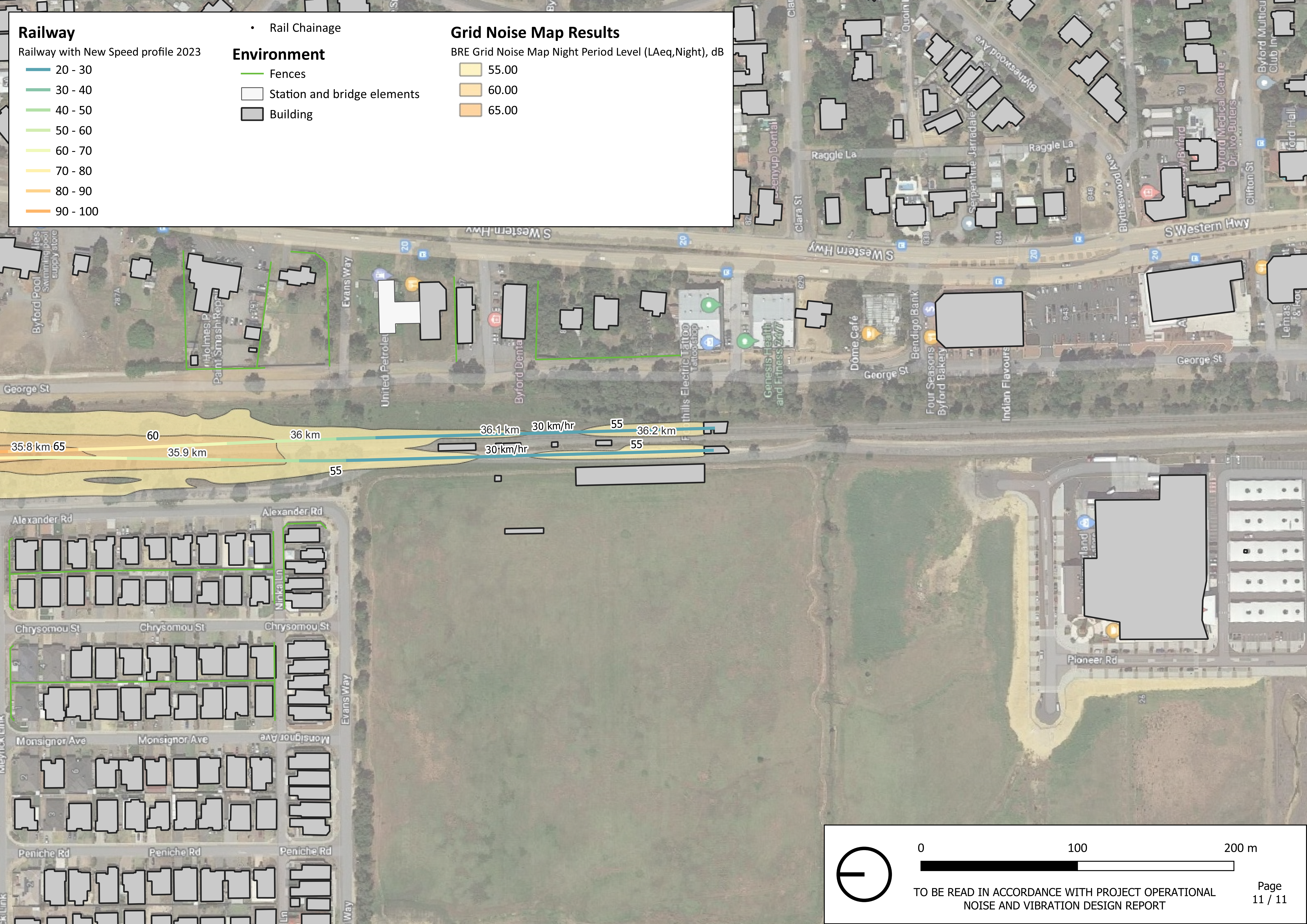

Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Building
Grid Noise Map Results
BRE Grid Noise Map Night Period Level (LAeq,Night), dB
55.00
60.00
130 km/hr
33.5 km
33.6 km
33.7 km
33.8 km
130 km/hr
55
60
33.9 km
34 km
34.1 km
34.2 km
Dalray Ct
Winx Avenue
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Environment
Fences
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Noise Map Night Period Level (LAeq,Night), dB
55.00
60.00
65.00
35.8 km
65
60
36 km
35.9 km
55
36.1 km
30 km/hr
55
36.2 km
30 km/hr
55
S Western Hwy
George St
Raggle La
Evans Way
Alexander Rd
Chrysomou St
Monsignor Ave
Peniche Rd
Pioneer Rd
Clara St
Blytheswood Ave
Clifton St
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

Noise Mitigation Design

Damper Locations
- Ballast Track with Damper
- Slab Track with Damper

Noise Wall PCG2020 2023 Height, m
- 1.5
- 1.8
- 2.1
- 2.4

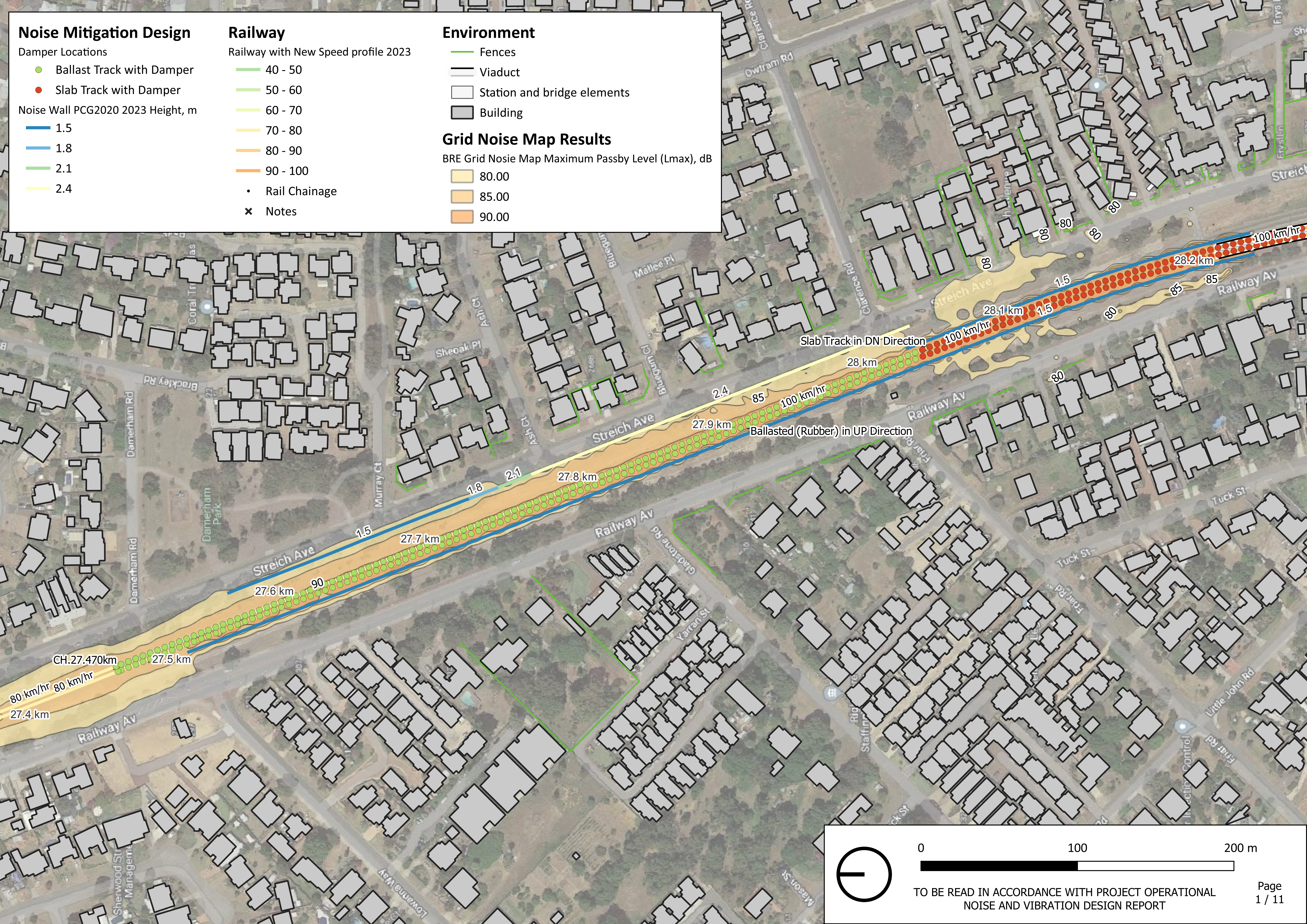
Railway

Railway with New Speed profile 2023
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- Rail Chainage
- Notes

Environment
- Fences
- Viaduct
- Station and bridge elements
- Building

Grid Noise Map Results

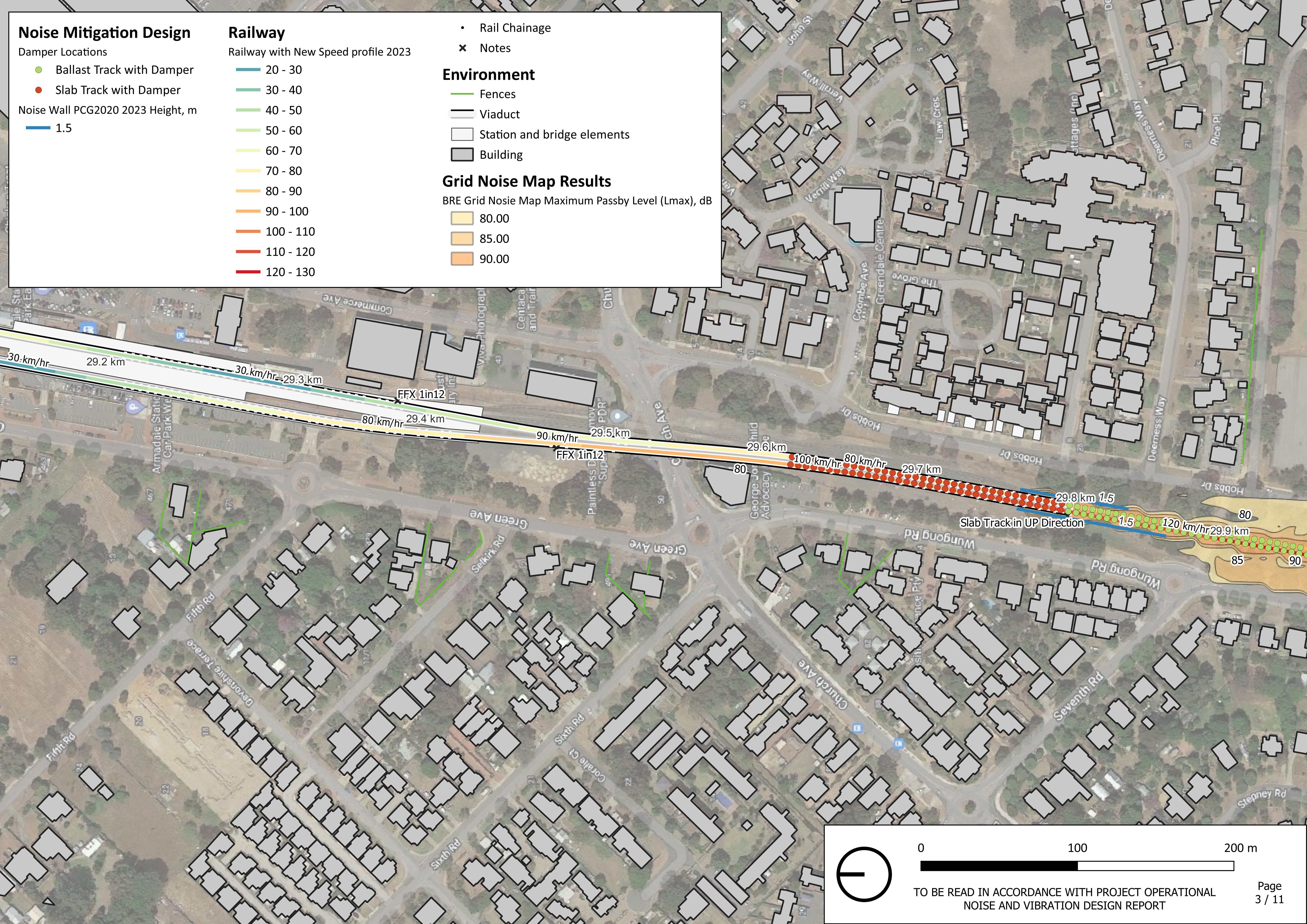
BRE Grid Nosie Map Maximum Passby Level (Lmax), dB
- 80.00
- 85.00
- 90.00

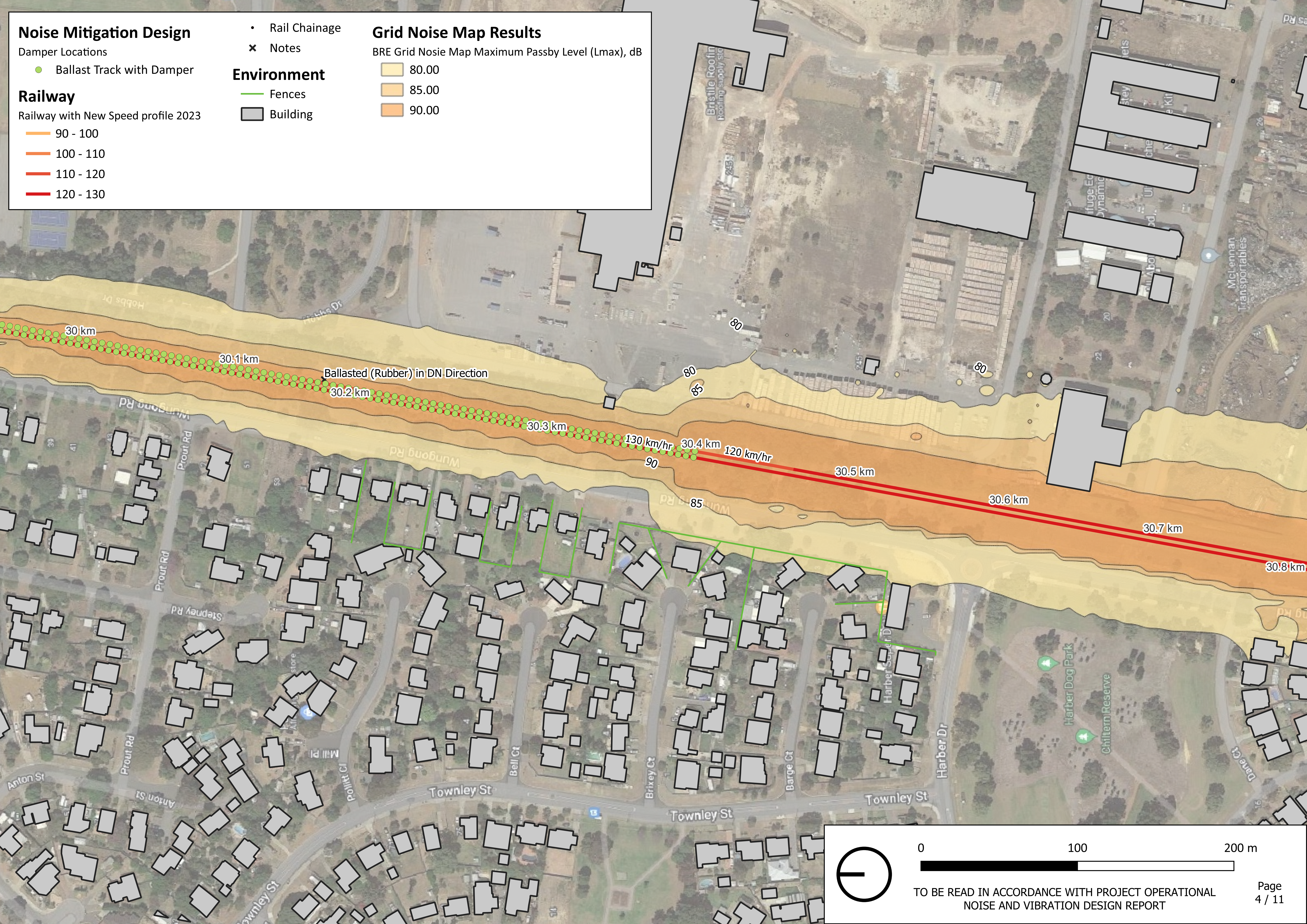


0 100 200 m

TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Noise Mitigation Design
Damper Locations
Slab Track with Damper
Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Nosie Map Maximum Passby Level (Lmax), dB
80.00
85.00
90.00
28.3 km
100 km/hr
28.4 km
28.5 km
100 km/hr
28.6 km
80 km/hr
80 km/hr
28.7 km
28.8 km
FFX 1in12
28.9 km
29 km
80 km/hr
FFX 1in12
29.1 km
30 km/hr
80
Orchard Ave
Memorial Park
Neerigen St
Aragon Court
Railway Av
Armadale Rd
Abbey Rd
Little John Rd
Tuck St
Forest Rd
Forest Ct
Richard Pl
Green Ave
Tudor Rd
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Slab Track with Damper
Noise Wall PCG2020 2023 Height, m
1.5
Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
100 - 110
110 - 120
120 - 130
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Nosie Map Maximum Passby Level (Lmax), dB
80.00
85.00
90.00
30 km/hr
29.2 km
30 km/hr
29.3 km
FFX 1in12
80 km/hr
29.4 km
90 km/hr
29.5 km
FFX 1in12
29.6 km
80
100 km/hr
80 km/hr
29.7 km
29.8 km
1.5
Slab Track in UP Direction
1.5
120 km/hr
29.9 km
80
85
90
Commerce Ave
Green Ave
Green Ave
Wungong Rd
Wungong Rd
Hobbs Dr
Church Ave
Church Ave
Fifth Rd
Sixth Rd
Seventh Rd
Devonshire Terrace
Coralie Ct
Stepney Rd
Deerness Way
Rice Pl
Verrill Way
John St
Law Cres
Coombe Ave
Greendale Centre
The Grove
Selkirk Rd
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Railway
Railway with New Speed profile 2023
90 - 100
100 - 110
110 - 120
120 - 130
Rail Chainage
Notes
Environment
Fences
Building
Grid Noise Map Results
BRE Grid Nosie Map Maximum Passby Level (Lmax), dB
80.00
85.00
90.00
30 km
30.1 km
Ballasted (Rubber) in DN Direction
30.2 km
30.3 km
130 km/hr
30.4 km
120 km/hr
30.5 km
30.6 km
30.7 km
30.8 km
80
85
90
Hobbs Dr
Wungong Rd
Prout Rd
Stepney Rd
Anton St
Townley St
Pollitt Cl
Mill Pl
Bell Ct
Brixey Ct
Barge Ct
Harber Dr
Harber Dog Park
Chiltern Reserve
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT
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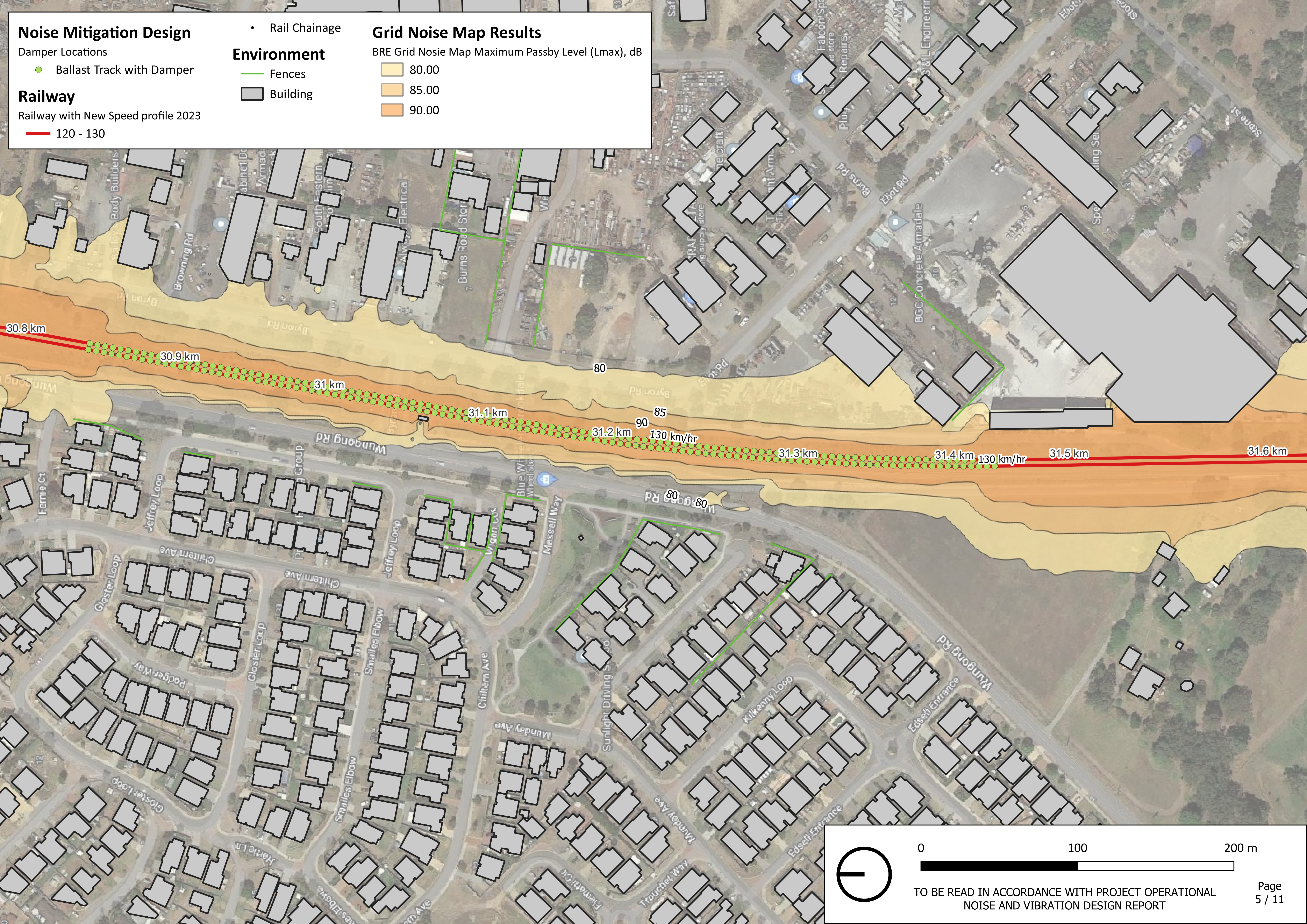
Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Building
Grid Noise Map Results
BRE Grid Nosie Map Maximum Passby Level (Lmax), dB
80.00
85.00
90.00
30.8 km
30.9 km
31 km
31.1 km
31.2 km
31.3 km
31.4 km
31.5 km
31.6 km
130 km/hr
130 km/hr
80
85
90
80
80
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL
NOISE AND VIBRATION DESIGN REPORT
Page
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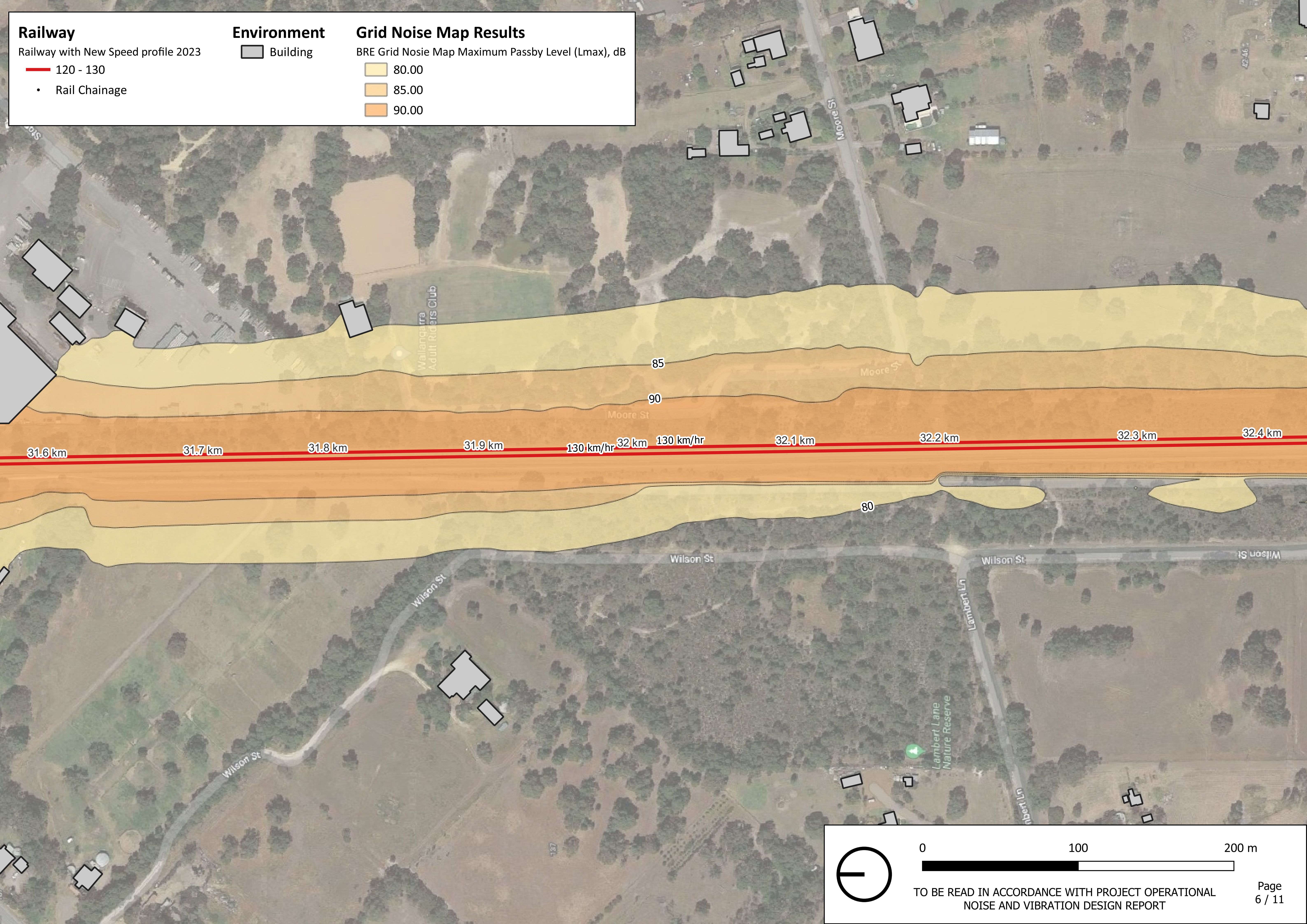
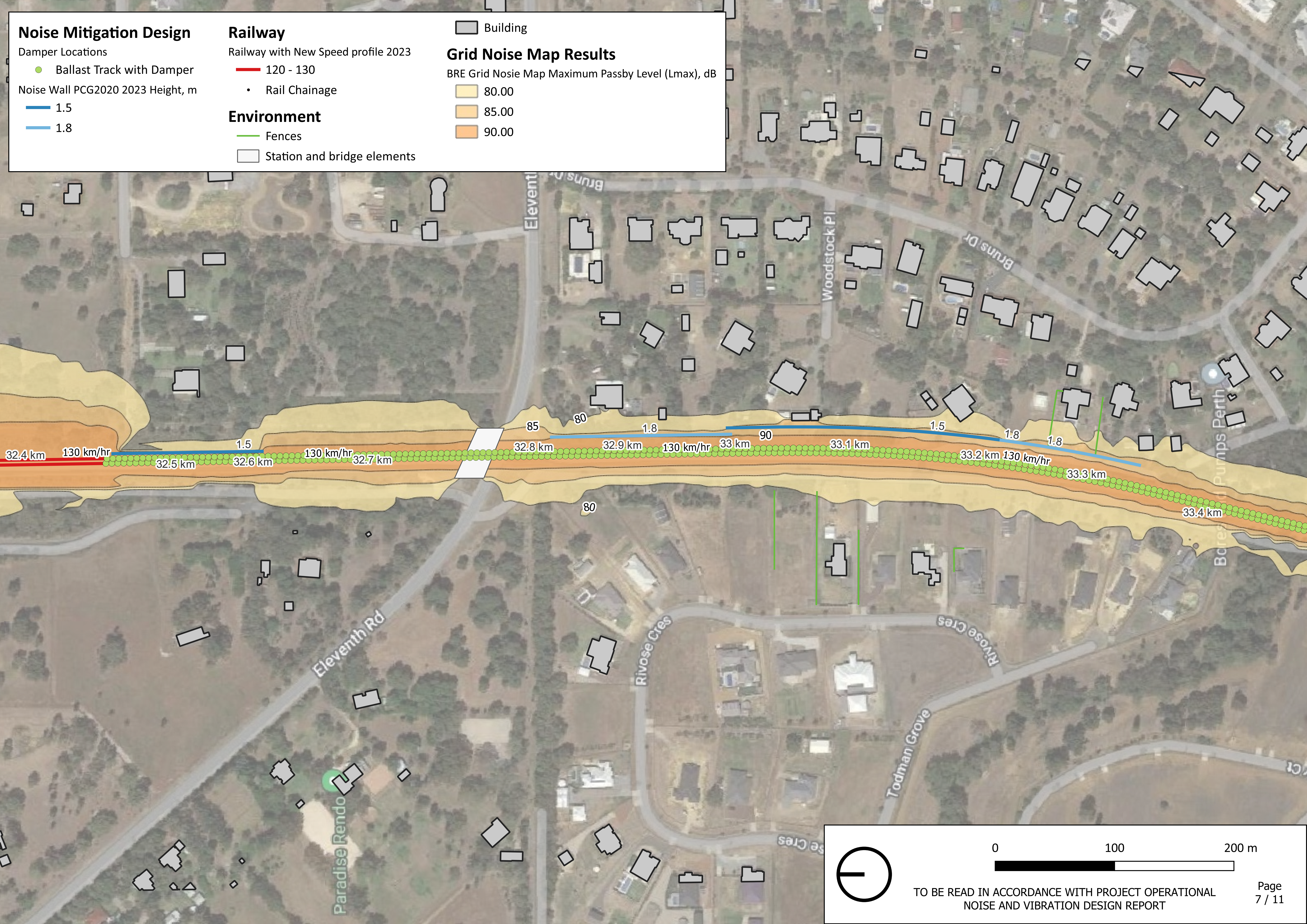
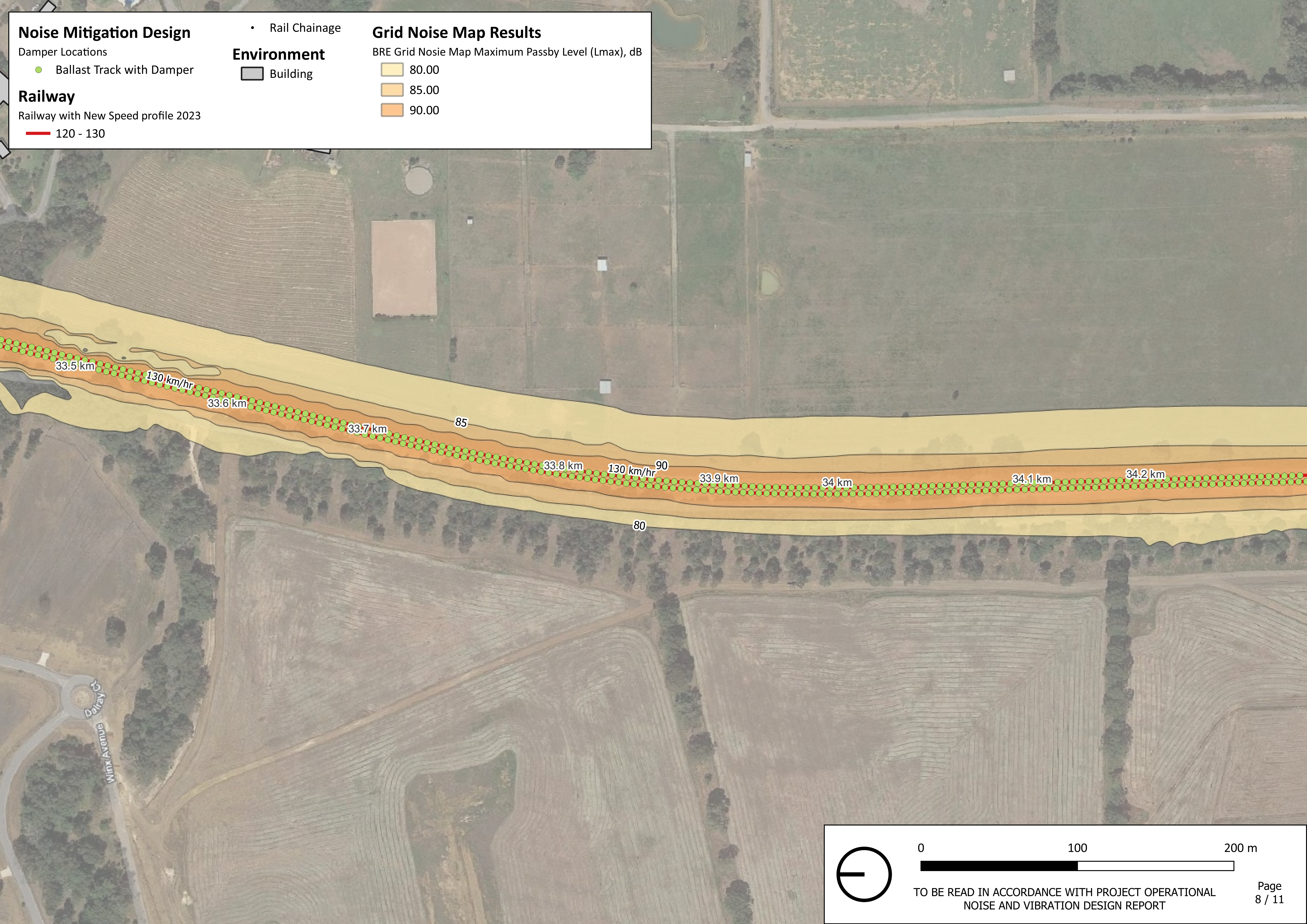


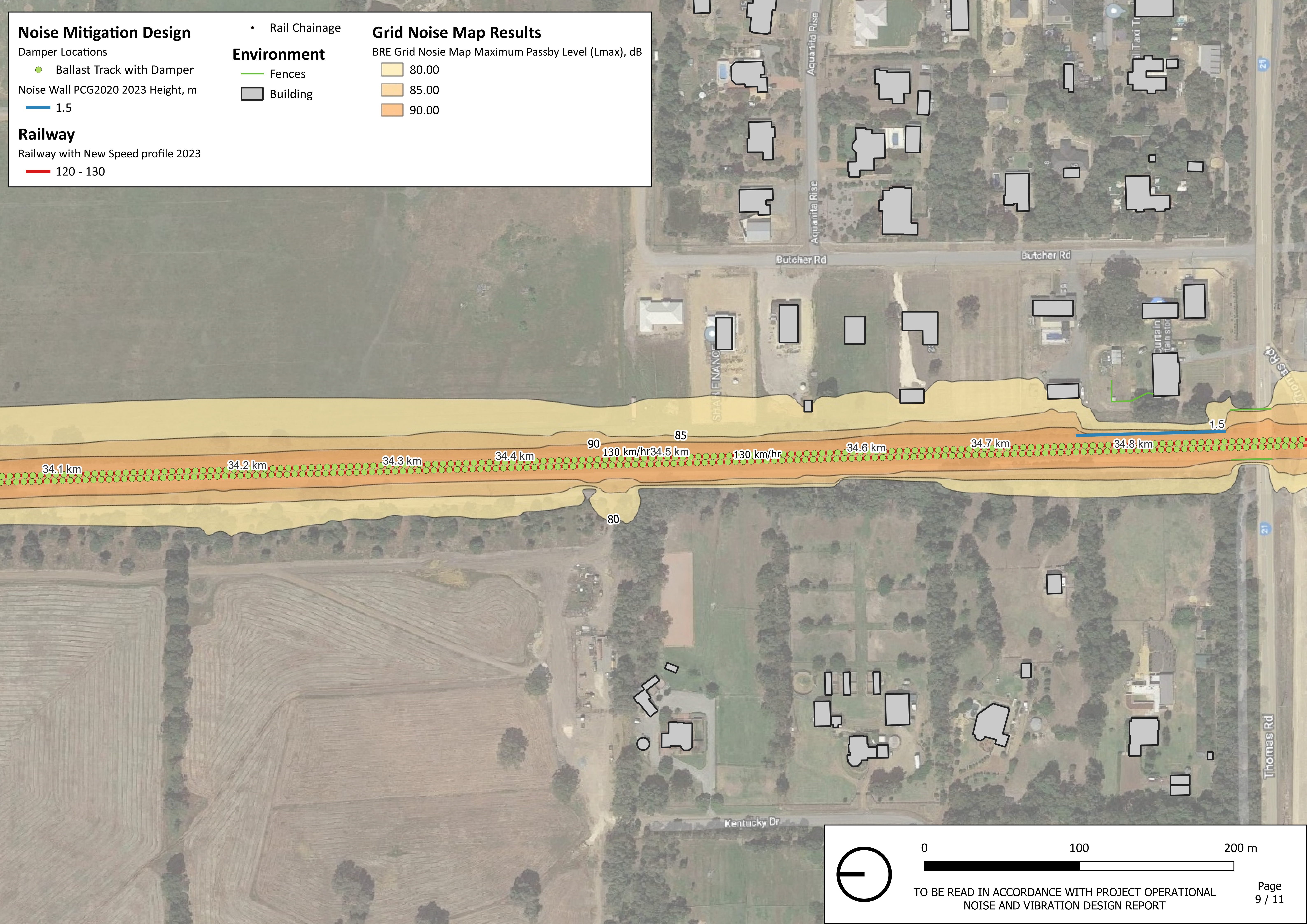
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Noise Wall PCG2020 2023 Height, m
1.5
1.8
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Nosie Map Maximum Passby Level (Lmax), dB
80.00
85.00
90.00
32.4 km
130 km/hr
32.5 km
1.5
32.6 km
130 km/hr
32.7 km
85
80
32.8 km
1.8
32.9 km
130 km/hr
33 km
90
33.1 km
1.5
1.8
1.8
33.2 km
130 km/hr
33.3 km
33.4 km
80
Bruns Dr
Woodstock Pl
Eleventh Rd
Rivose Cres
Todman Grove
Paradise Rendo
Pumps Perth
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT
Page 7 / 11



Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Building
Grid Noise Map Results
BRE Grid Nosie Map Maximum Passby Level (Lmax), dB
80.00
85.00
90.00
33.5 km
130 km/hr
33.6 km
33.7 km
85
33.8 km
130 km/hr
90
33.9 km
34 km
34.1 km
34.2 km
80
Dalray Ct
Winx Avenue
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Noise Mitigation Design
Damper Locations
Ballast Track with Damper
Noise Wall PCG2020 2023 Height, m
1.5
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Building
Grid Noise Map Results
BRE Grid Nosie Map Maximum Passby Level (Lmax), dB
80.00
85.00
90.00
Aquanita Rise
Butcher Rd
Thomas Rd
Kentucky Dr
34.1 km
34.2 km
34.3 km
34.4 km
34.5 km
34.6 km
34.7 km
34.8 km
130 km/hr
130 km/hr
90
85
80
1.5
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

Noise Mitigation Design

Damper Locations

- Ballast Track with Damper

Noise Wall PCG2020 2023 Height, m

- 1.5
- 1.8

Railway

Railway with New Speed profile 2023

- 70 - 80
- 80 - 90
- 90 - 100
- 100 - 110
- 110 - 120
- 120 - 130
- Rail Chainage

× Notes

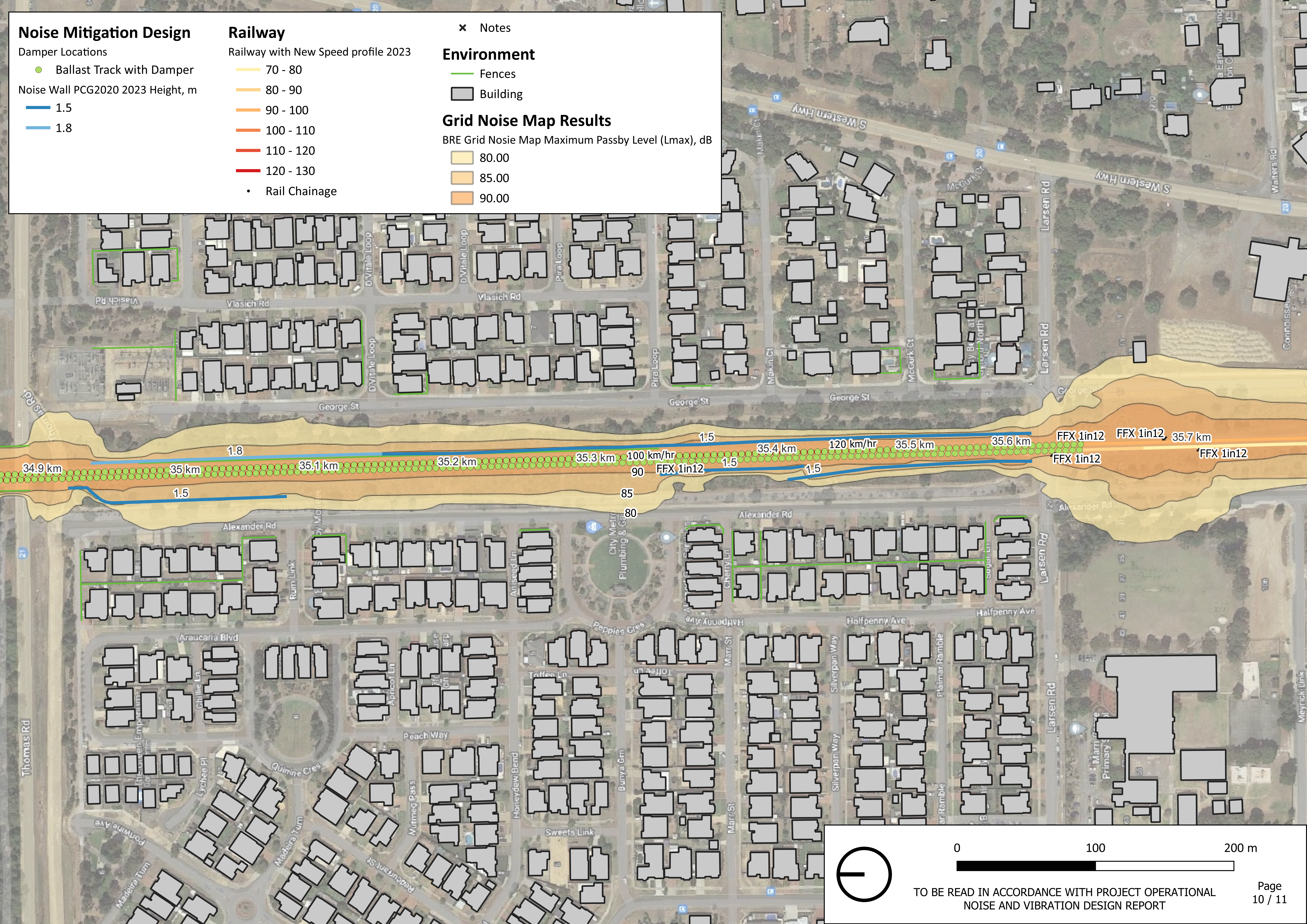
Environment

- Fences
- Building

Grid Noise Map Results

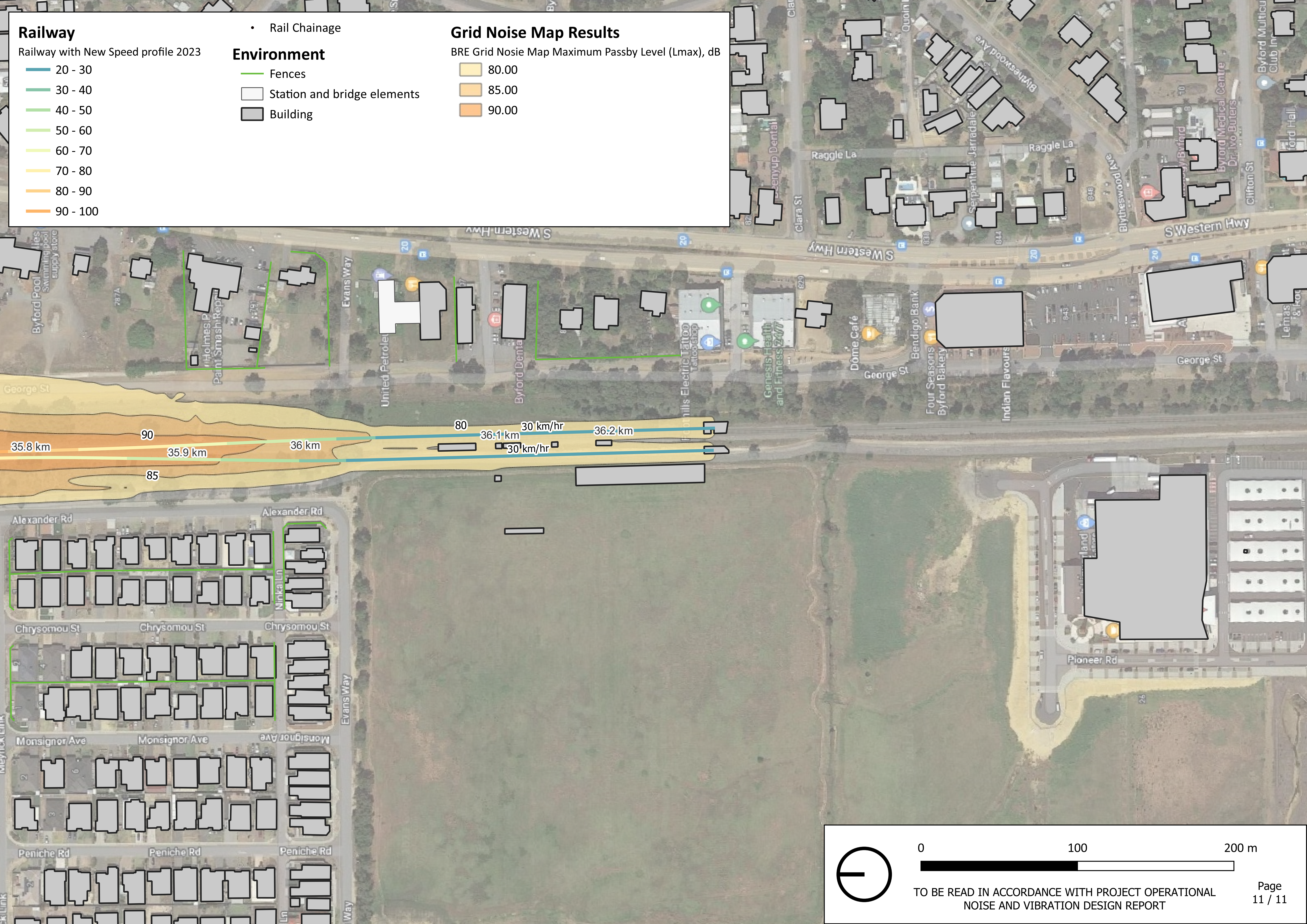
BRE Grid Nosie Map Maximum Passby Level (Lmax), dB

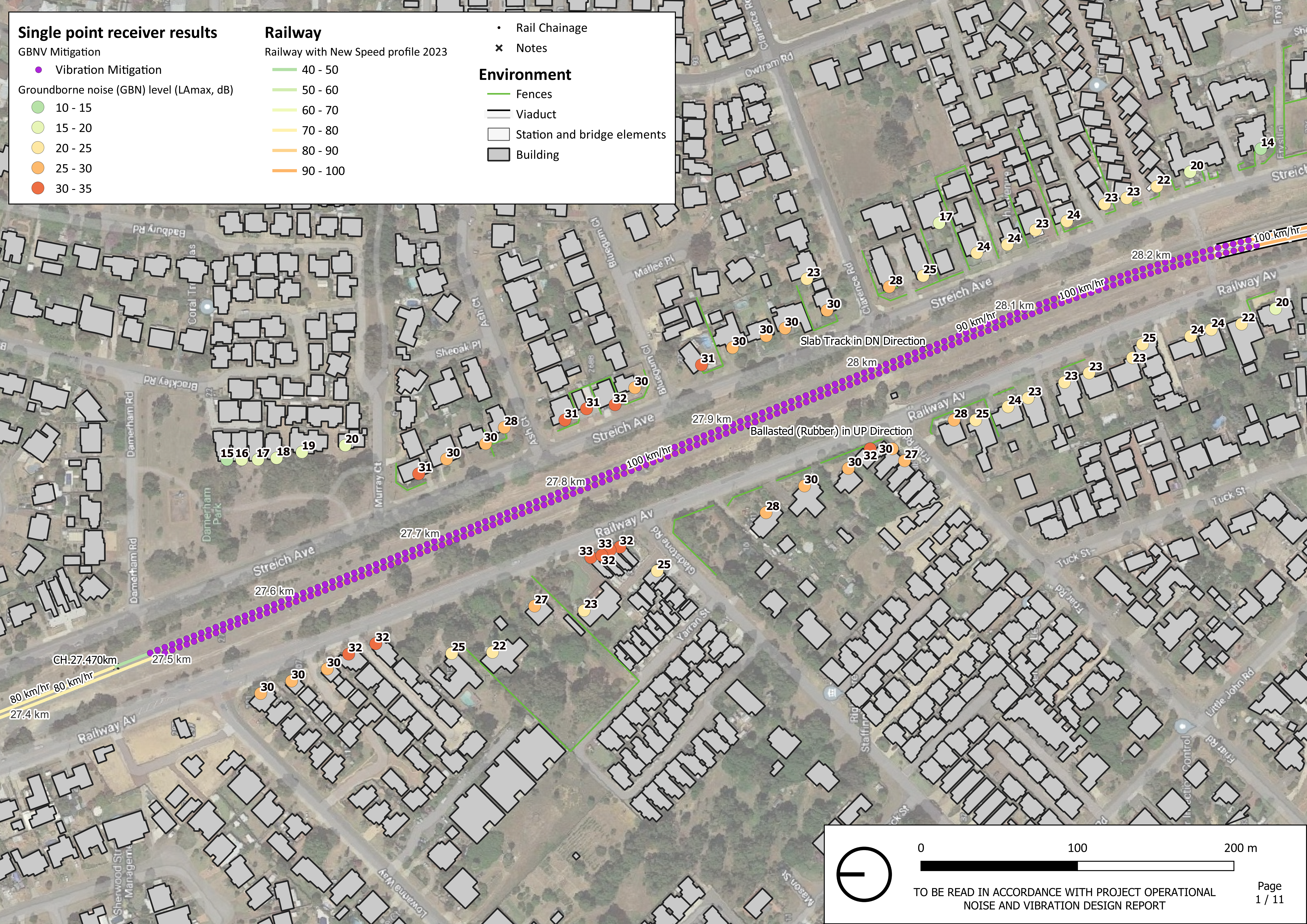
- 80.00
- 85.00
- 90.00



0 100 200 m

TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Environment
Fences
Station and bridge elements
Building
Grid Noise Map Results
BRE Grid Nosie Map Maximum Passby Level (Lmax), dB
80.00
85.00
90.00
35.8 km
35.9 km
36 km
36.1 km
36.2 km
30 km/hr
30 km/hr
90
85
80
S Western Hwy
George St
Alexander Rd
Chrysomou St
Monsignor Ave
Peniche Rd
Evans Way
Raggle La
Clara St
Pioneer Rd
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



Single point receiver results
GBNV Mitigation
Vibration Mitigation
Groundborne noise (GBN) level (LAmax, dB)
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
Railway
Railway with New Speed profile 2023
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
Slab Track in DN Direction
Ballasted (Rubber) in UP Direction
CH.27.470km
27.4 km
27.5 km
27.6 km
27.7 km
27.8 km
27.9 km
28 km
28.1 km
28.2 km
80 km/hr
80 km/hr
90 km/hr
100 km/hr
100 km/hr
100 km/hr
Streich Ave
Railway Av
Owtram Rd
Baldry Rd
Brackley Rd
Sheoak Pl
Mallee Pl
Bluegum Cl
Ash Ct
Murray Ct
Damerham Rd
Damerham Park
Clarence Rd
Gladstone Rd
Tuck St
Friar Rd
Little John Rd
Yarran St
Lowanna Way
Mason St
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT
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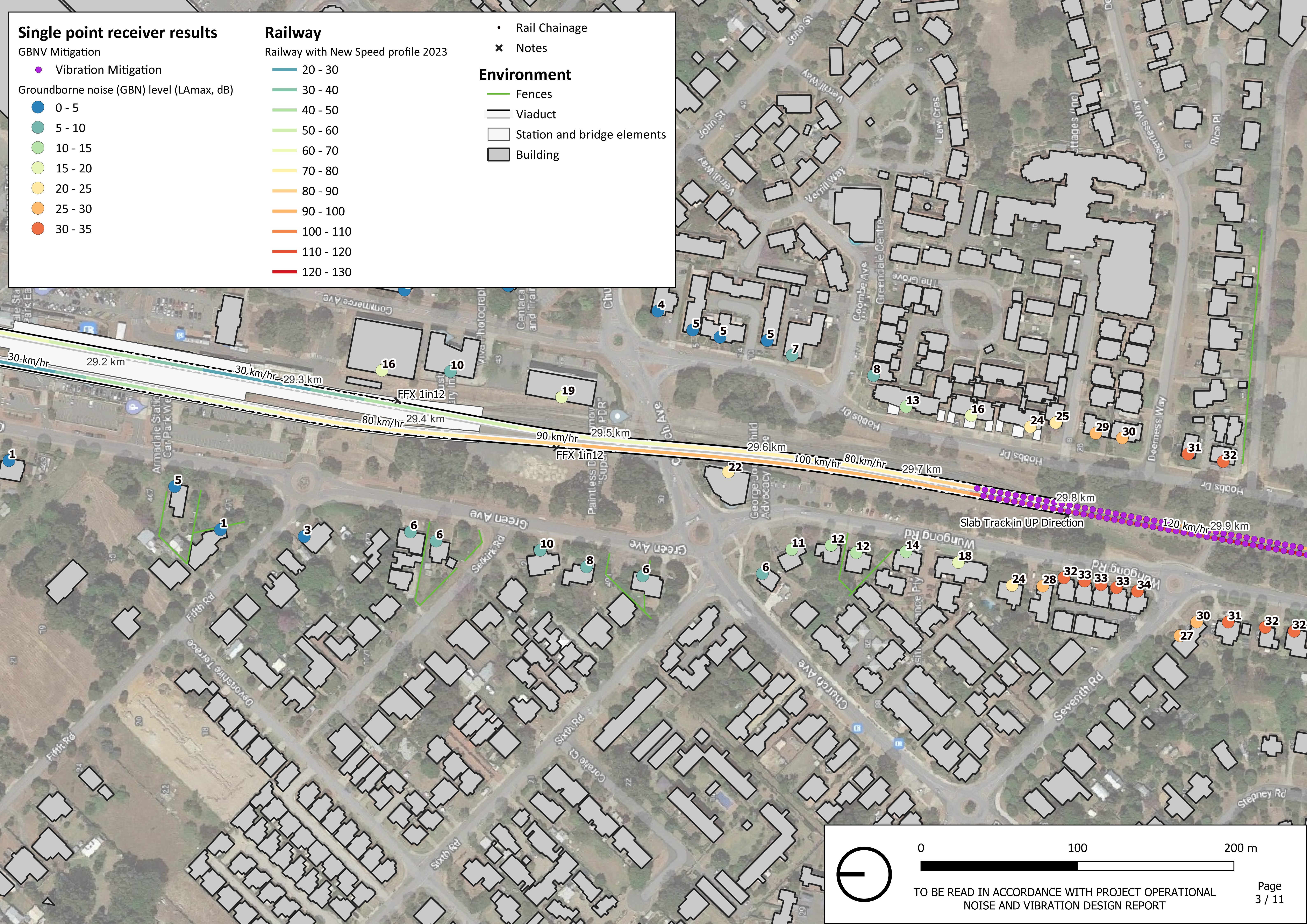
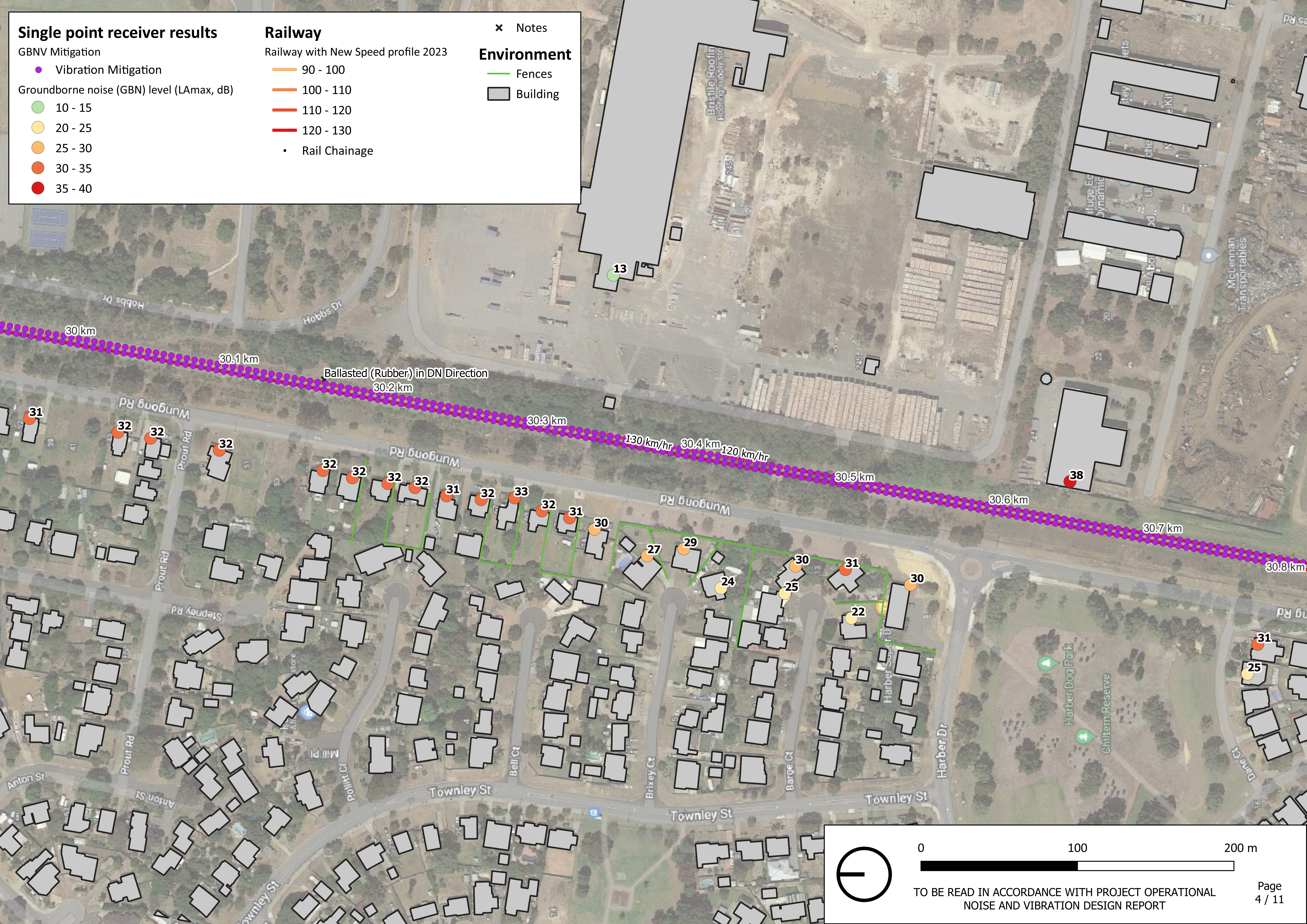
Single point receiver results
Groundborne noise (GBN) level (LAmax, dB)
0 - 5
5 - 10
10 - 15
15 - 20
Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
28.3 km
100 km/hr
28.4 km
28.5 km
28.6 km
100 km/hr
80 km/hr
80 km/hr
28.7 km
FFX 1in12
28.9 km
80 km/hr
29 km
FFX 1in12
29.1 km
30 km/hr
Orchard Ave
Memorial Park
Neerigen St
Aragon Court
Armadale Rd
Railway Av
Abbey Rd
Tuck St
Little John Rd
Forrest Rd
Green Ave
Tudor Rd
Sherbourne Way
Netley Pl
Auto Masters Armadale
Richard Pl
Forest Ct
Robin Ct
Castle Pl
Third Rd
0
100
200 m



Single point receiver results
GBNV Mitigation
Vibration Mitigation
Groundborne noise (GBN) level (LAmax, dB)
0 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
100 - 110
110 - 120
120 - 130
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
30 km/hr
29.2 km
29.3 km
FFX 1in12
80 km/hr
29.4 km
90 km/hr
29.5 km
29.6 km
100 km/hr
29.7 km
29.8 km
Slab Track in UP Direction
120 km/hr
29.9 km
Commerce Ave
Green Ave
Hobbs Dr
Wungong Rd
Church Ave
Seventh Rd
Sixth Rd
Fifth Rd
Devonshire Terrace
Selkirk Rd
Coralie Ct
Stepney Rd
John St
Verrill Way
Coombe Ave
The Grove
Law Cres
Deerness Way
Rice Pl
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Single point receiver results
GBNV Mitigation
Vibration Mitigation
Groundborne noise (GBN) level (LAmax, dB)
10 - 15
20 - 25
25 - 30
30 - 35
35 - 40
Railway
Railway with New Speed profile 2023
90 - 100
100 - 110
110 - 120
120 - 130
Rail Chainage
Notes
Environment
Fences
Building
Ballasted (Rubber) in DN Direction
130 km/hr
120 km/hr
30 km
30.1 km
30.2 km
30.3 km
30.4 km
30.5 km
30.6 km
30.7 km
30.8 km
Wungong Rd
Hobbs Dr
Prout Rd
Stepney Rd
Anton St
Pollitt Cl
Bell Ct
Brixey Ct
Barge Ct
Harber Dr
Townley St
Harber Dog Park
Chiltern Reserve
Dunce Ct
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT
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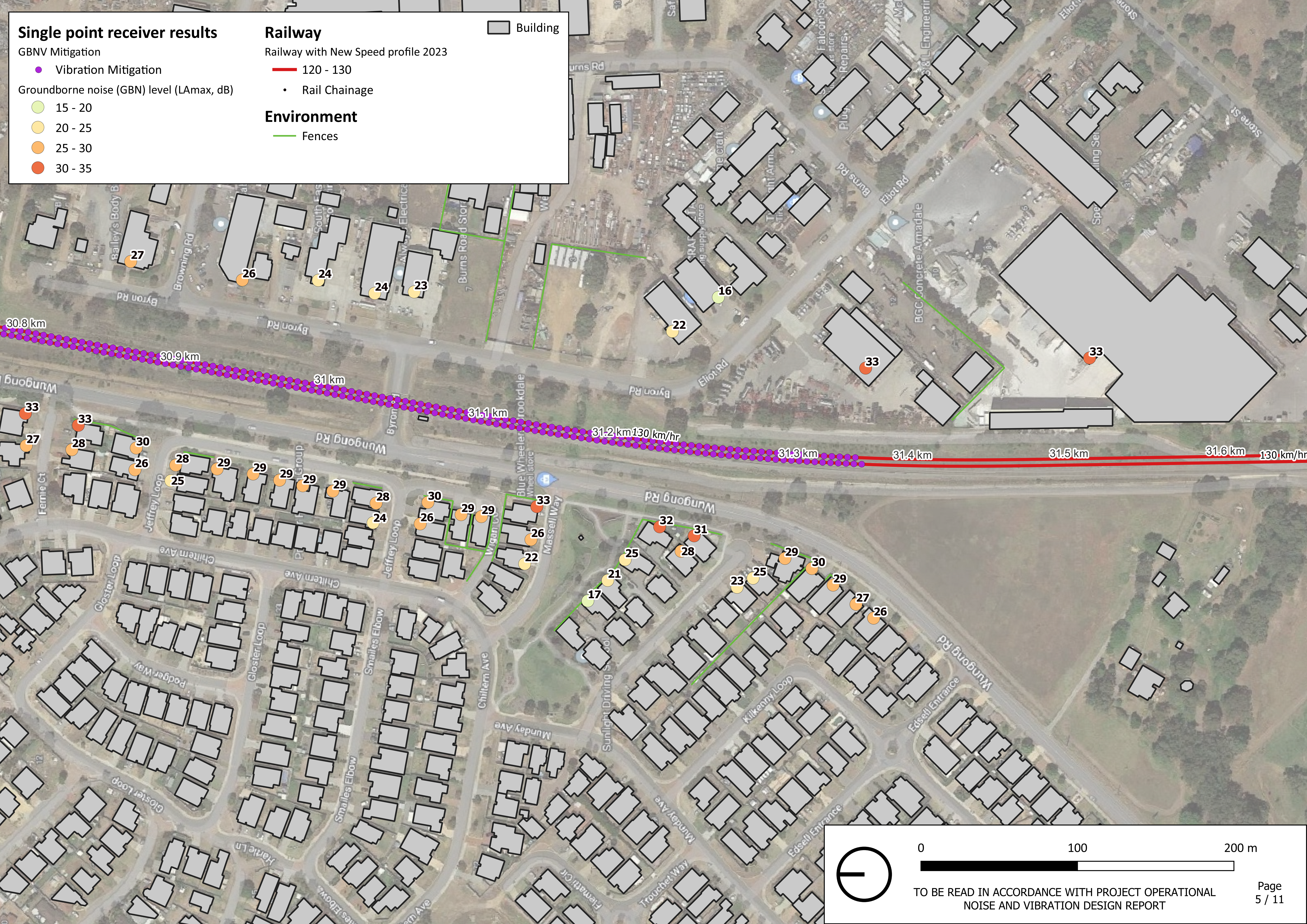
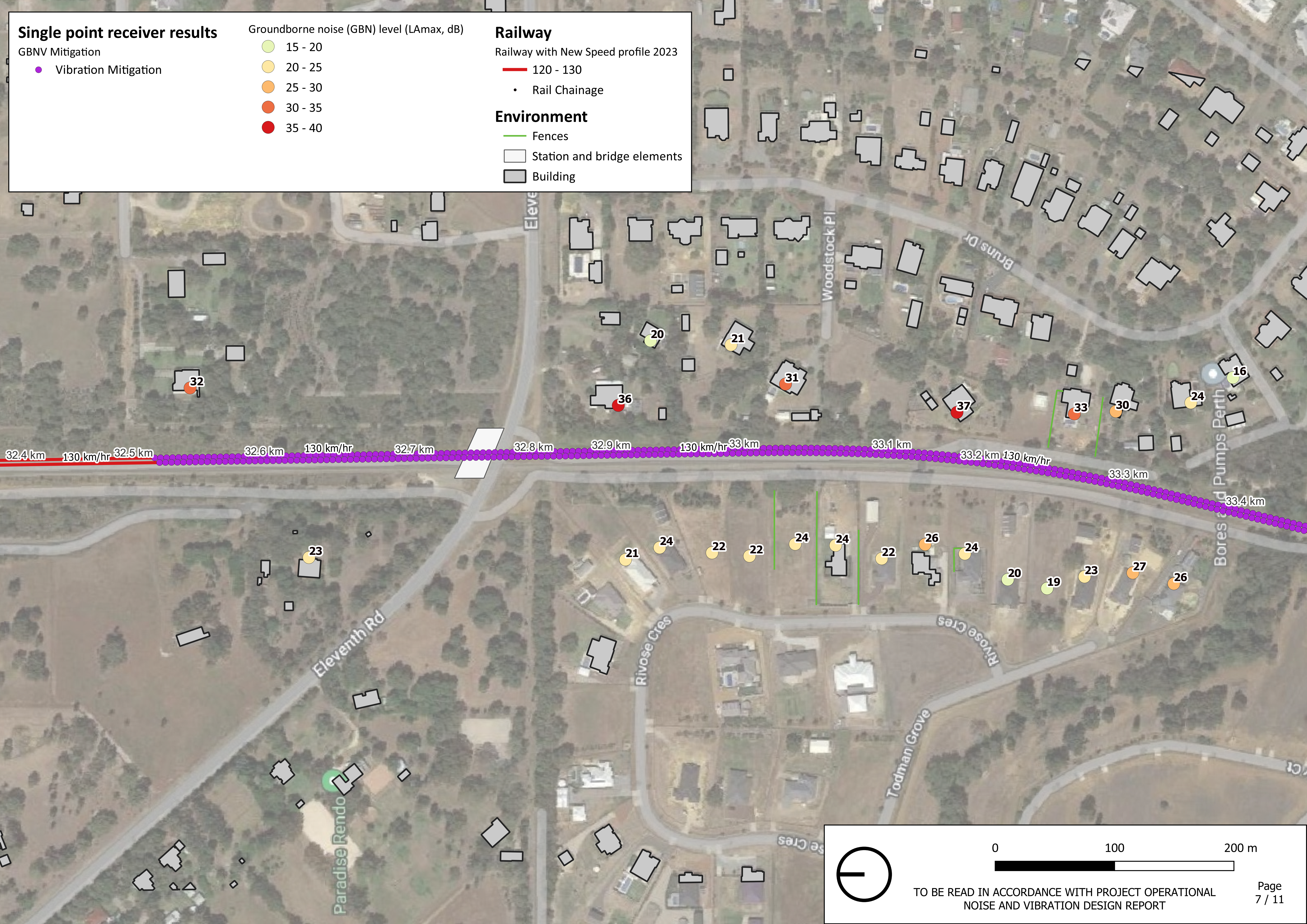
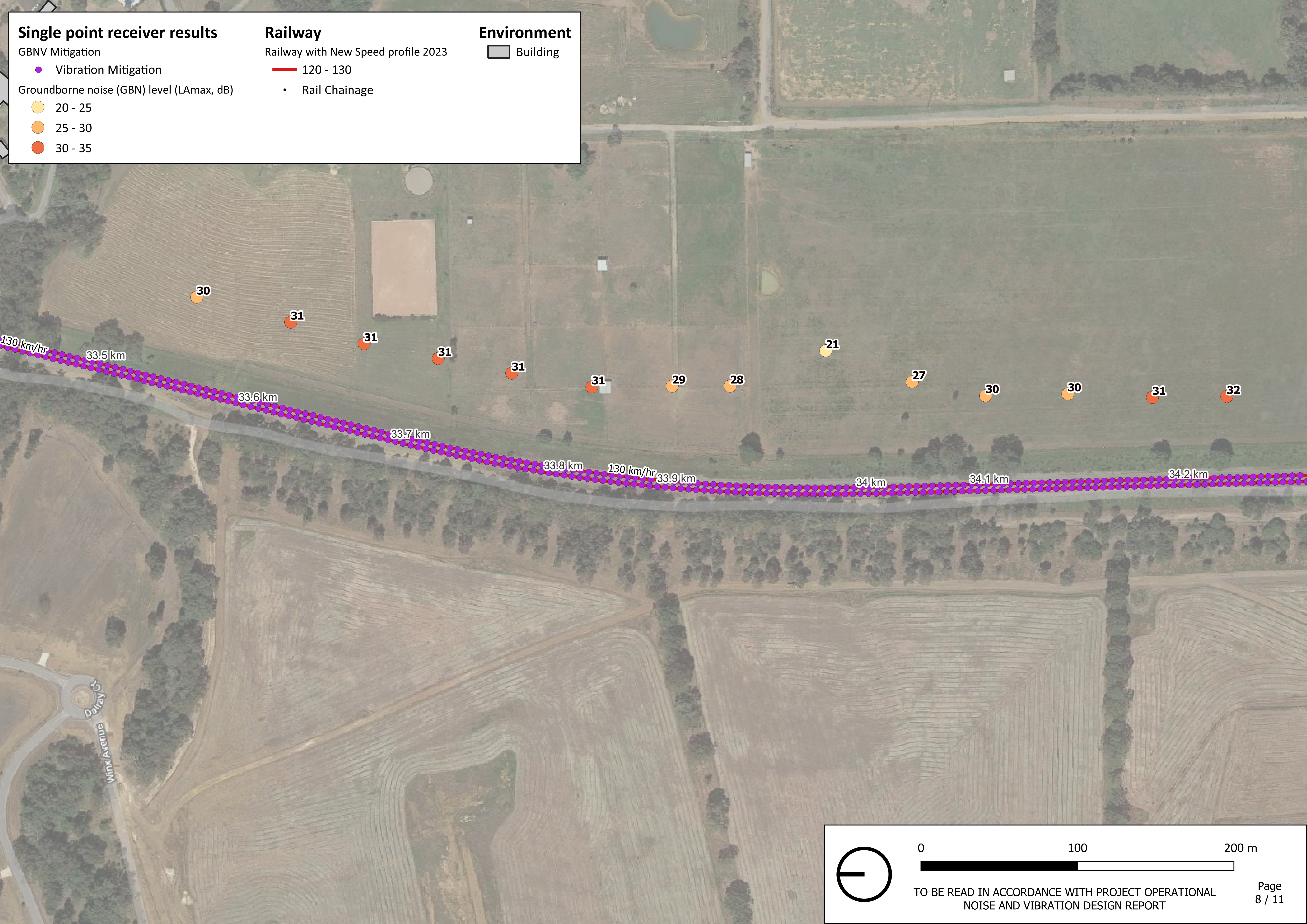


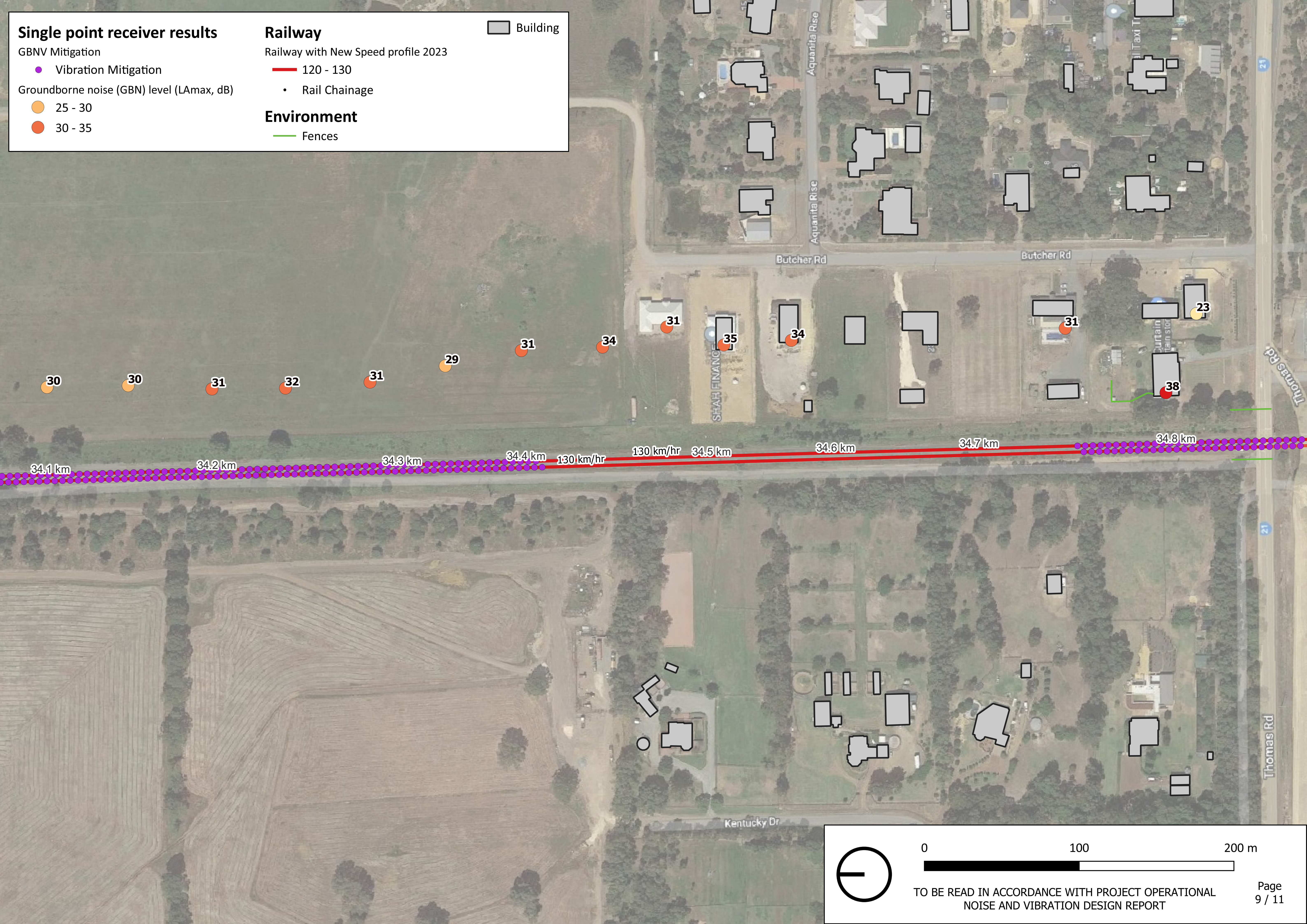
Single point receiver results
GBNV Mitigation
Vibration Mitigation
Groundborne noise (GBN) level (LAmax, dB)
15 - 20
20 - 25
25 - 30
30 - 35
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Building
30.8 km
30.9 km
31 km
31.1 km
31.2 km
130 km/hr
31.3 km
31.4 km
31.5 km
31.6 km
130 km/hr
Byron Rd
Wungong Rd
Burns Rd
Eliot Rd
Stone St
Browning Rd
Fernie Ct
Jeffrey Loop
Chiltern Ave
Gloster Loop
Smailes Elbow
Podger Way
Munday Ave
Massell Way
Wigan Cl
Kilkenny Loop
Edsell Entrance
Sunlight Driving School
Trouchet Way
Flematti Cir
Harle Ln
27
26
24
24
23
16
22
33
33
33
33
27
28
30
26
28
25
29
29
29
29
29
28
24
30
26
29
29
33
26
22
32
31
25
28
21
17
29
30
25
23
29
27
26
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

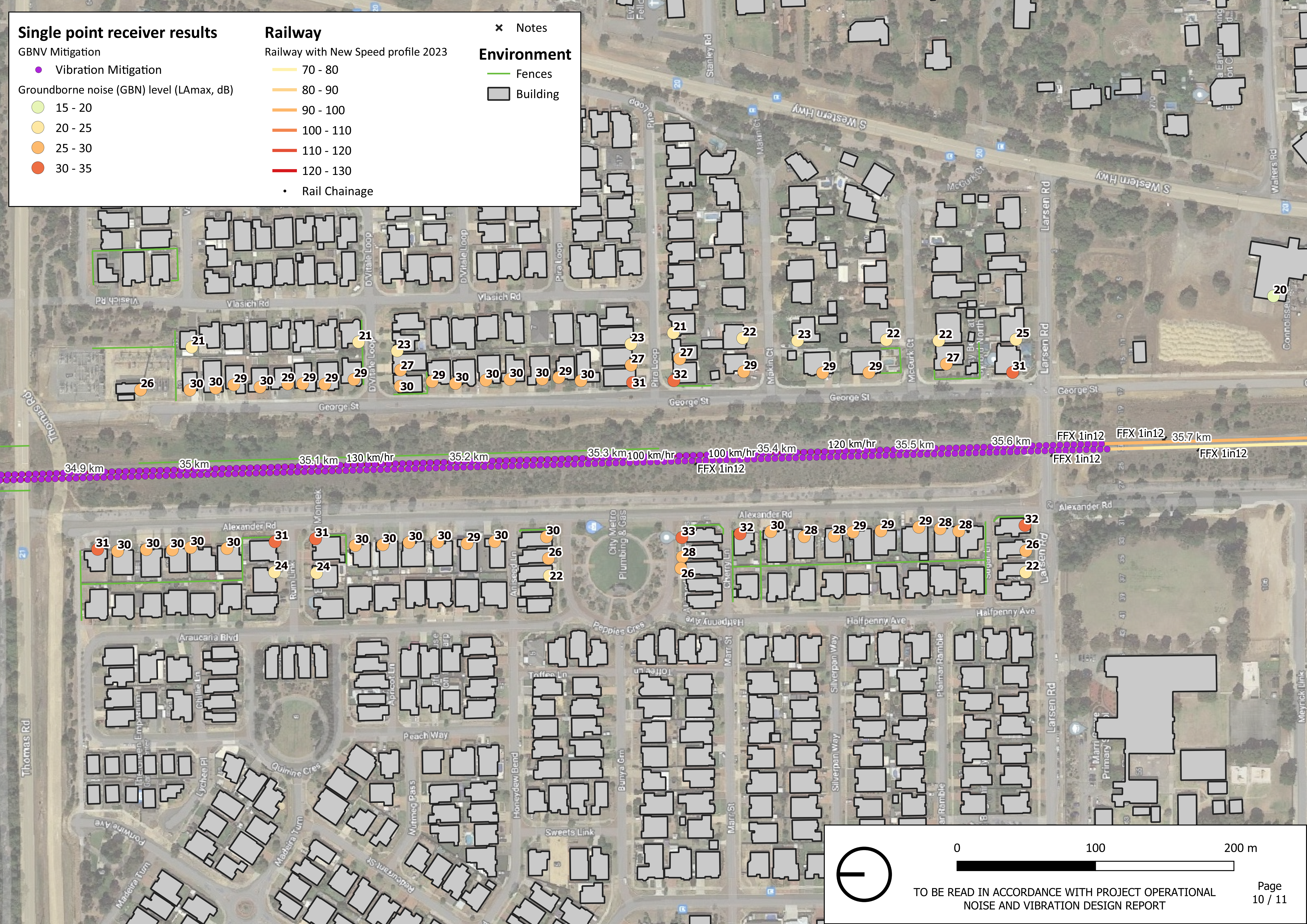


TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

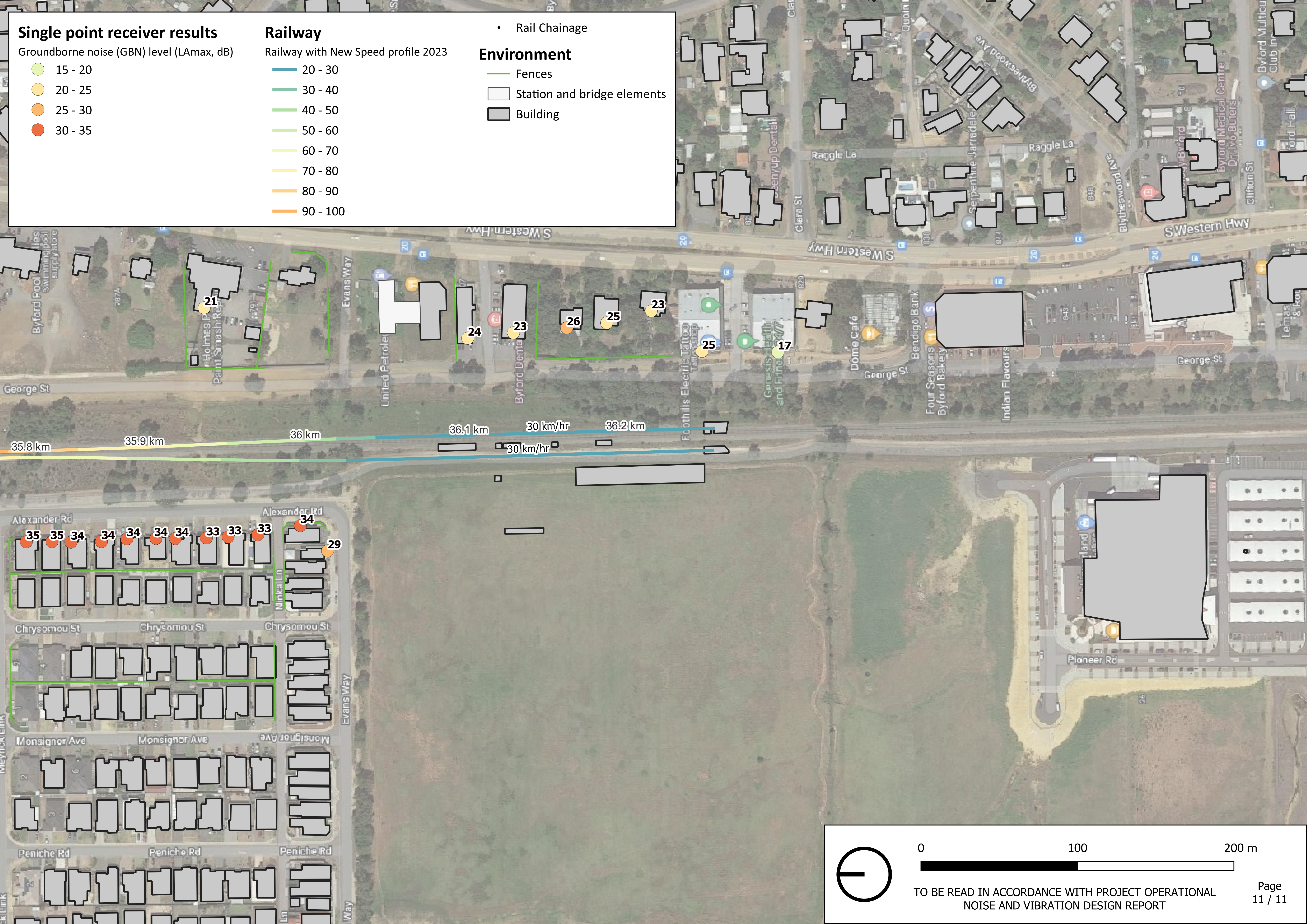

Single point receiver results
GBNV Mitigation
Vibration Mitigation
Groundborne noise (GBN) level (LAmax, dB)
20 - 25
25 - 30
30 - 35
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Building
30
31
31
31
31
31
29
28
21
27
30
30
31
32
130 km/hr
33.5 km
33.6 km
33.7 km
33.8 km
130 km/hr
33.9 km
34 km
34.1 km
34.2 km
Dalray Ct
Winx Avenue
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT
Page 8 / 11



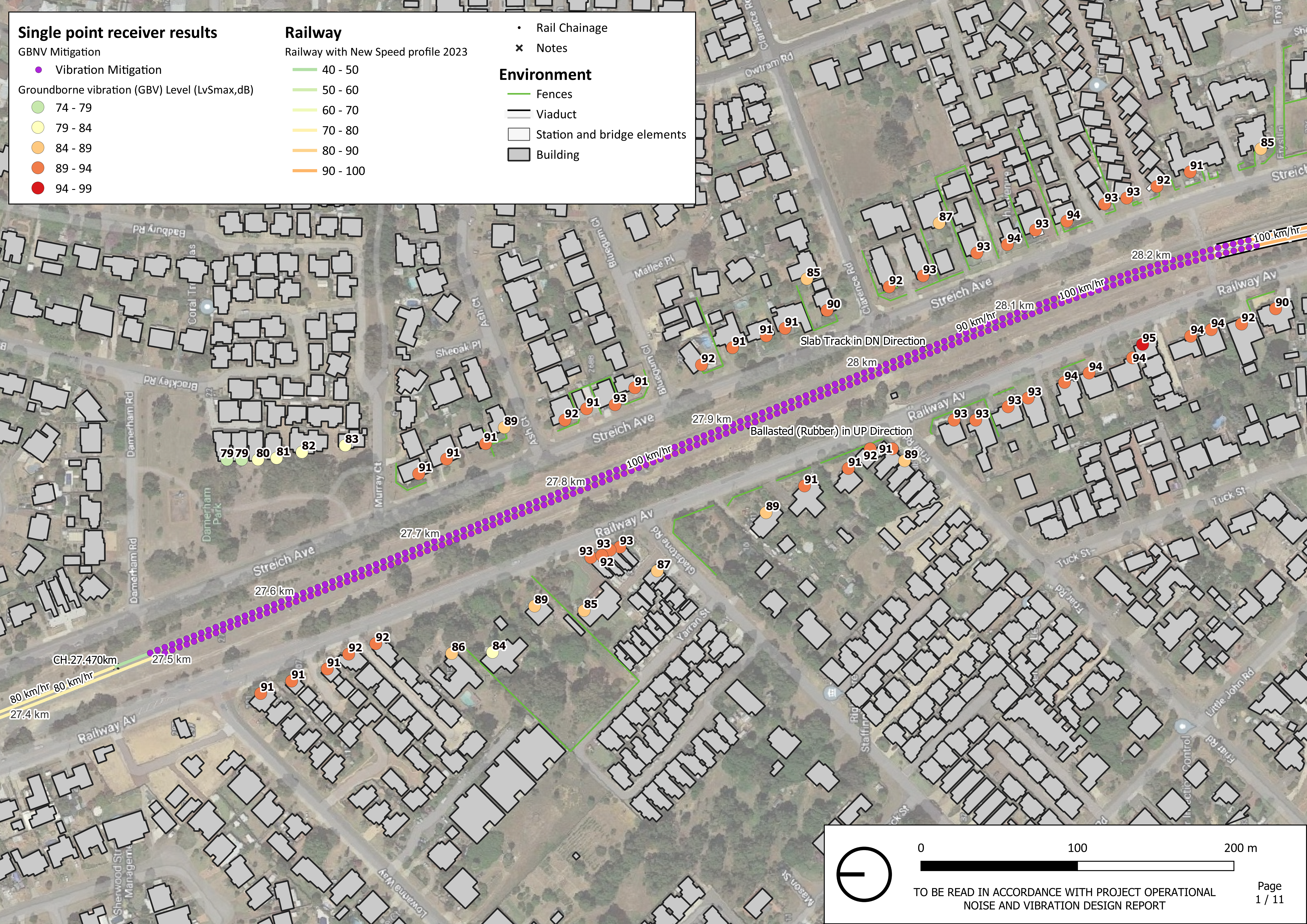
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



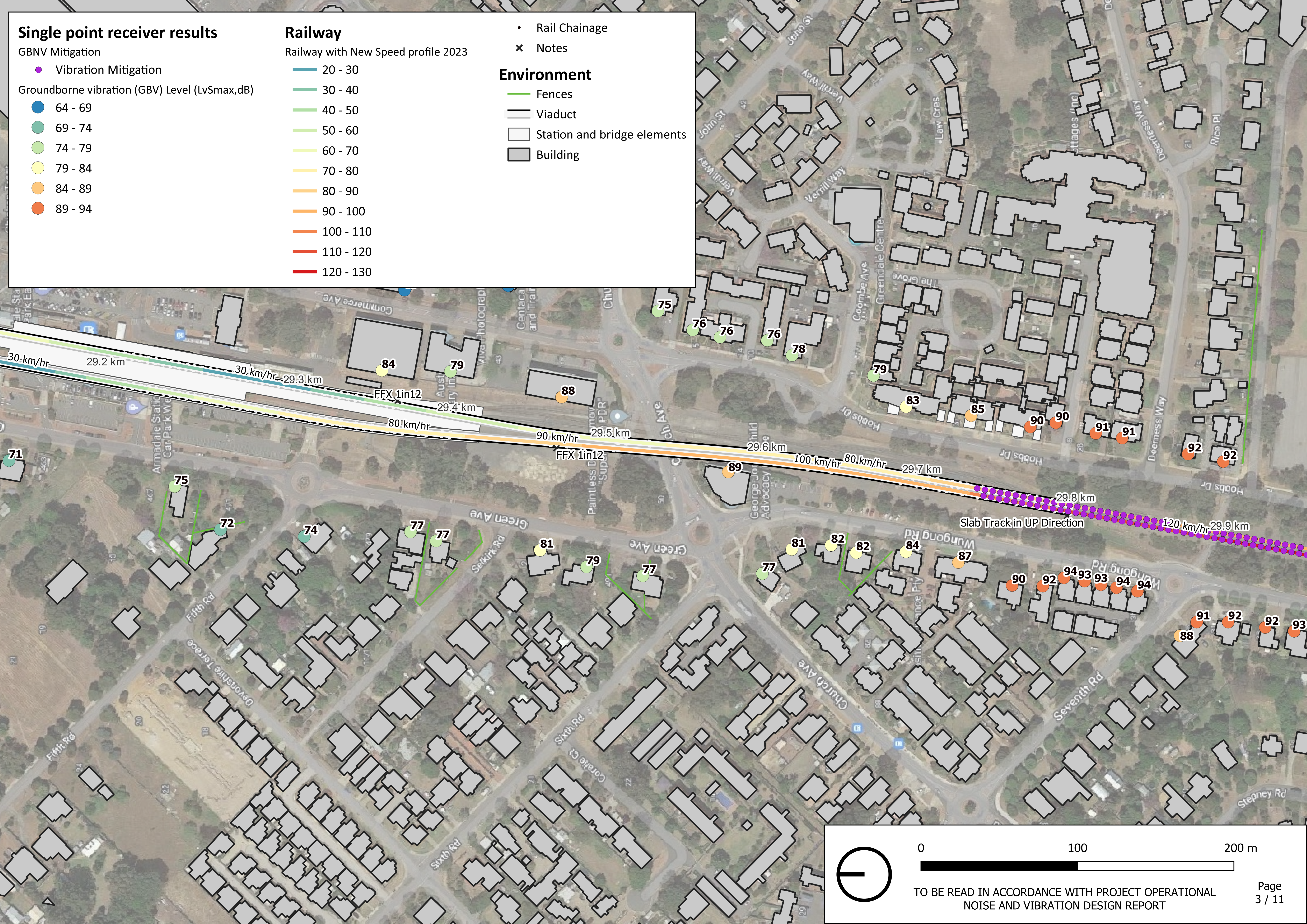
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



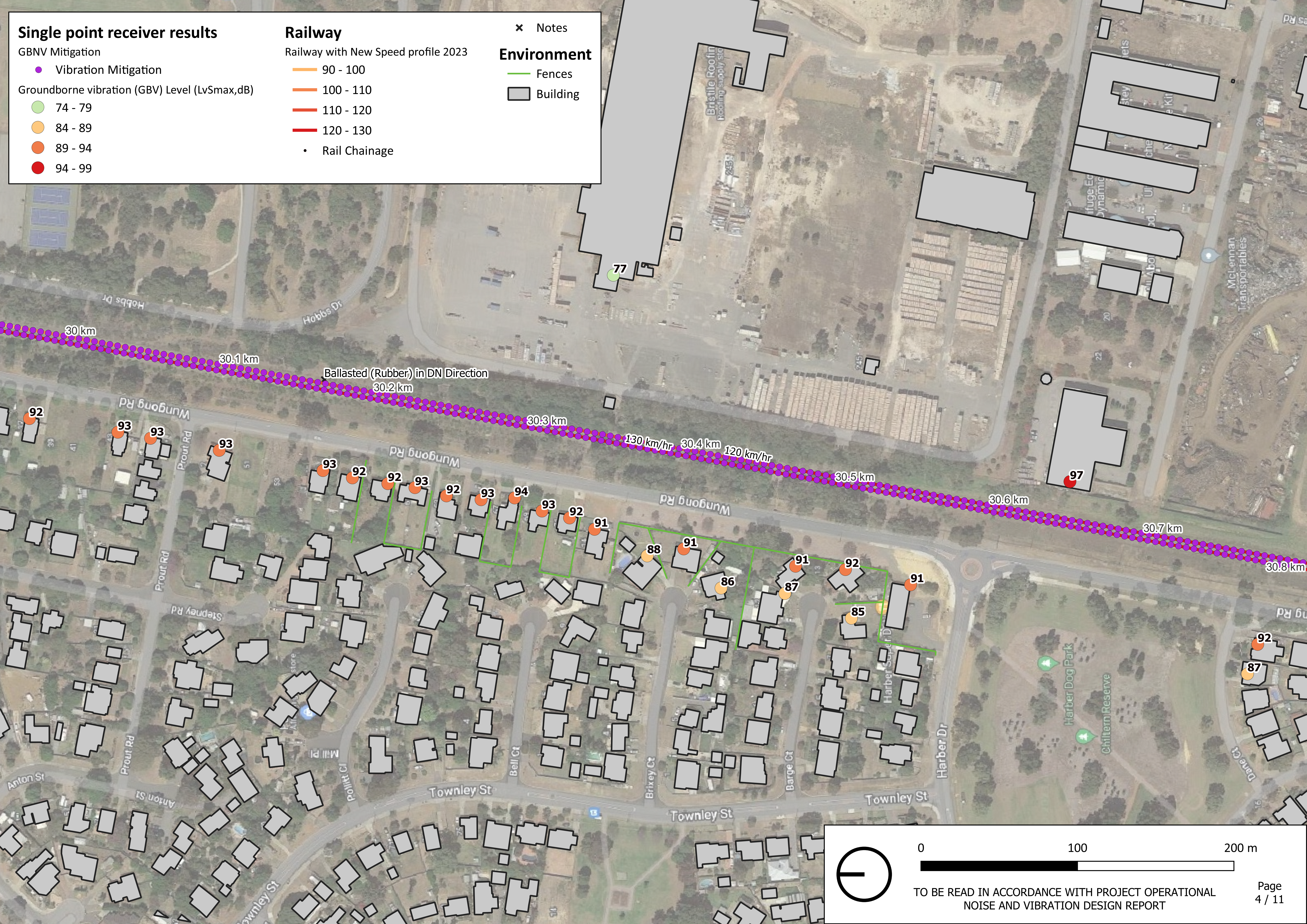
Single point receiver results
Groundborne noise (GBN) level (LAmax, dB)
15 - 20
20 - 25
25 - 30
30 - 35
Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Environment
Fences
Station and bridge elements
Building
S Western Hwy
George St
Alexander Rd
Chrysomou St
Monsignor Ave
Peniche Rd
Evans Way
Raggle La
Pioneer Rd
35.8 km
35.9 km
36 km
36.1 km
36.2 km
30 km/hr
30 km/hr
21
24
23
26
25
23
25
17
35
35
34
34
34
34
34
33
33
33
34
29
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Single point receiver results
GBNV Mitigation
Vibration Mitigation
Groundborne vibration (GBV) Level (LvSmax,dB)
74 - 79
79 - 84
84 - 89
89 - 94
94 - 99
Railway
Railway with New Speed profile 2023
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
Slab Track in DN Direction
Ballasted (Rubber) in UP Direction
CH.27.470km
27.4 km
27.5 km
27.6 km
27.7 km
27.8 km
27.9 km
28 km
28.1 km
28.2 km
80 km/hr
100 km/hr
90 km/hr
Streich Ave
Railway Av
Owtram Rd
Clarence Rd
Bluegum Cl
Mallee Pl
Sheoak Pl
Ash Ct
Murray Ct
Brackley Rd
Bradbury Rd
Damerham Rd
Damerham Park
Coral Tr
Gladstone Rd
Yarran St
Tuck St
Friar Rd
Little John Rd
Lowanna Way
Mason St
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT
Page 1 / 11

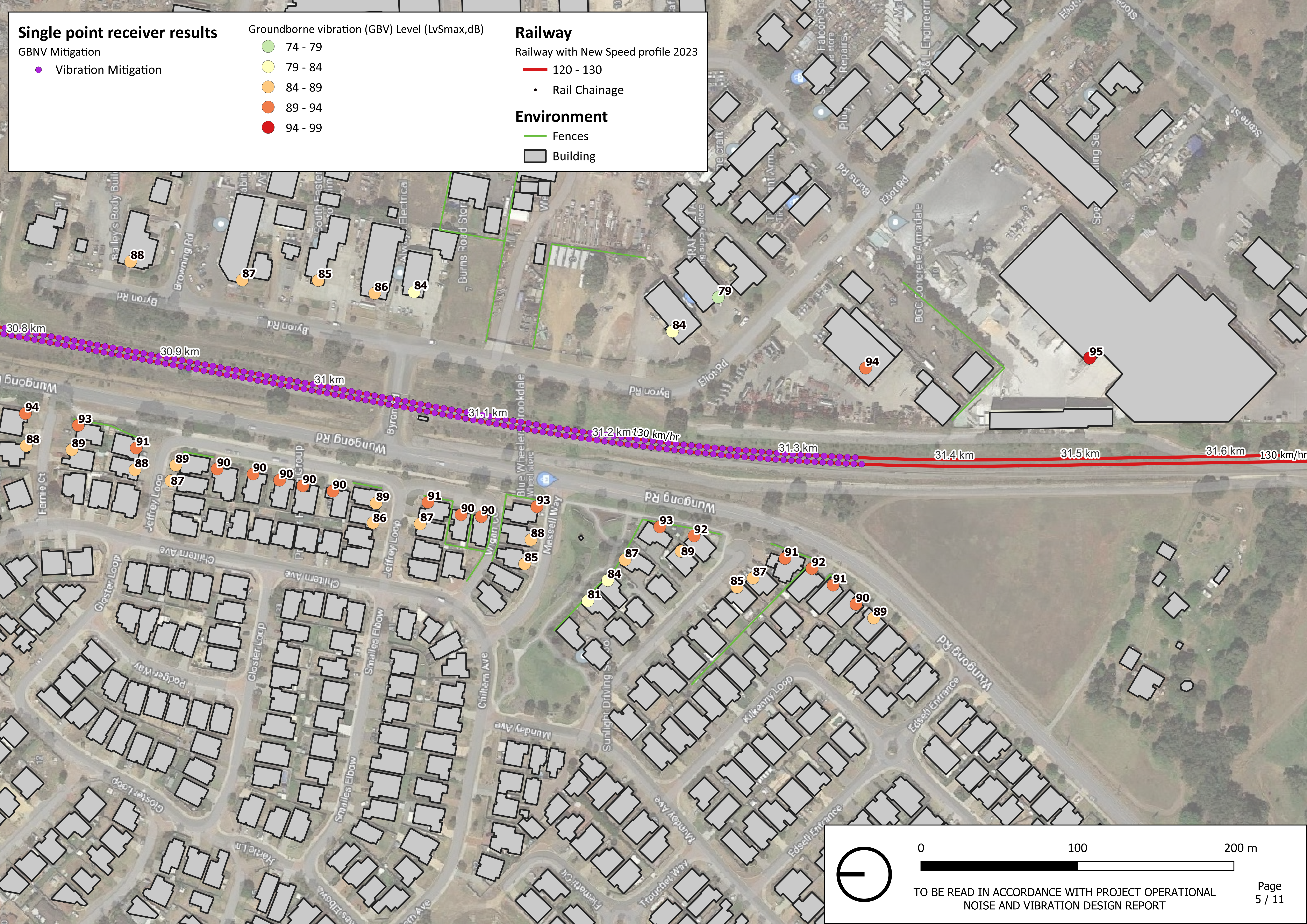

Single point receiver results
Groundborne vibration (GBV) Level (LvSmax,dB)
64 - 69
69 - 74
74 - 79
79 - 84
84 - 89
Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Notes
Environment
Fences
Viaduct
Station and bridge elements
Building
28.3 km
28.4 km
28.5 km
28.6 km
28.7 km
28.9 km
29 km
29.1 km
100 km/hr
80 km/hr
30 km/hr
FFX 1in12
Aragon Court
Neerigen St
Armadale Rd
Abbey Rd
Railway Av
Orchard Ave
Memorial Park
Sherbourne Way
Tuck St
Little John Rd
Forrest Rd
Green Ave
Tudor Rd
Richard Pl
Forest Ct
Castle Pl
Robin Ct
Third Rd
Jull St
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



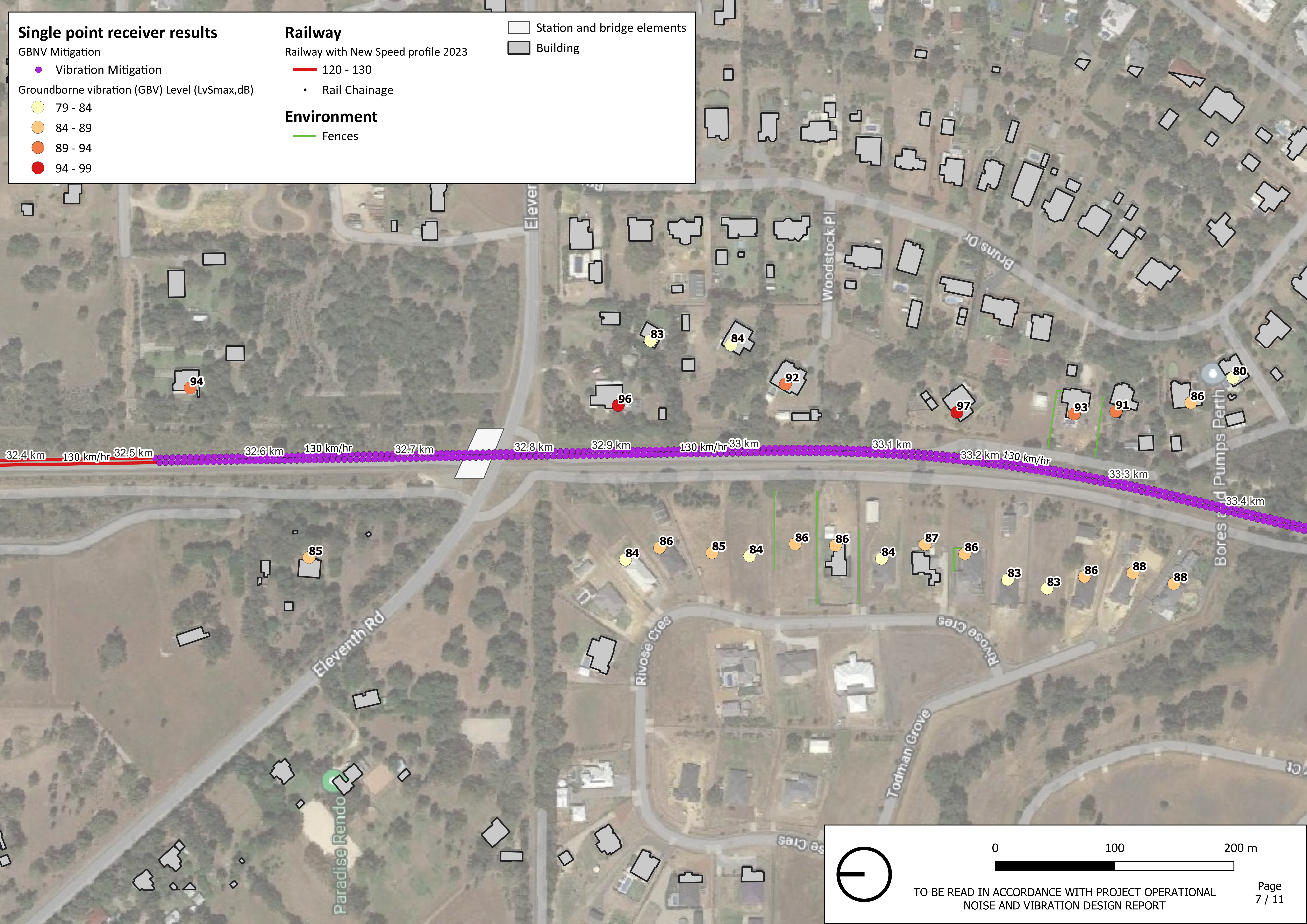
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

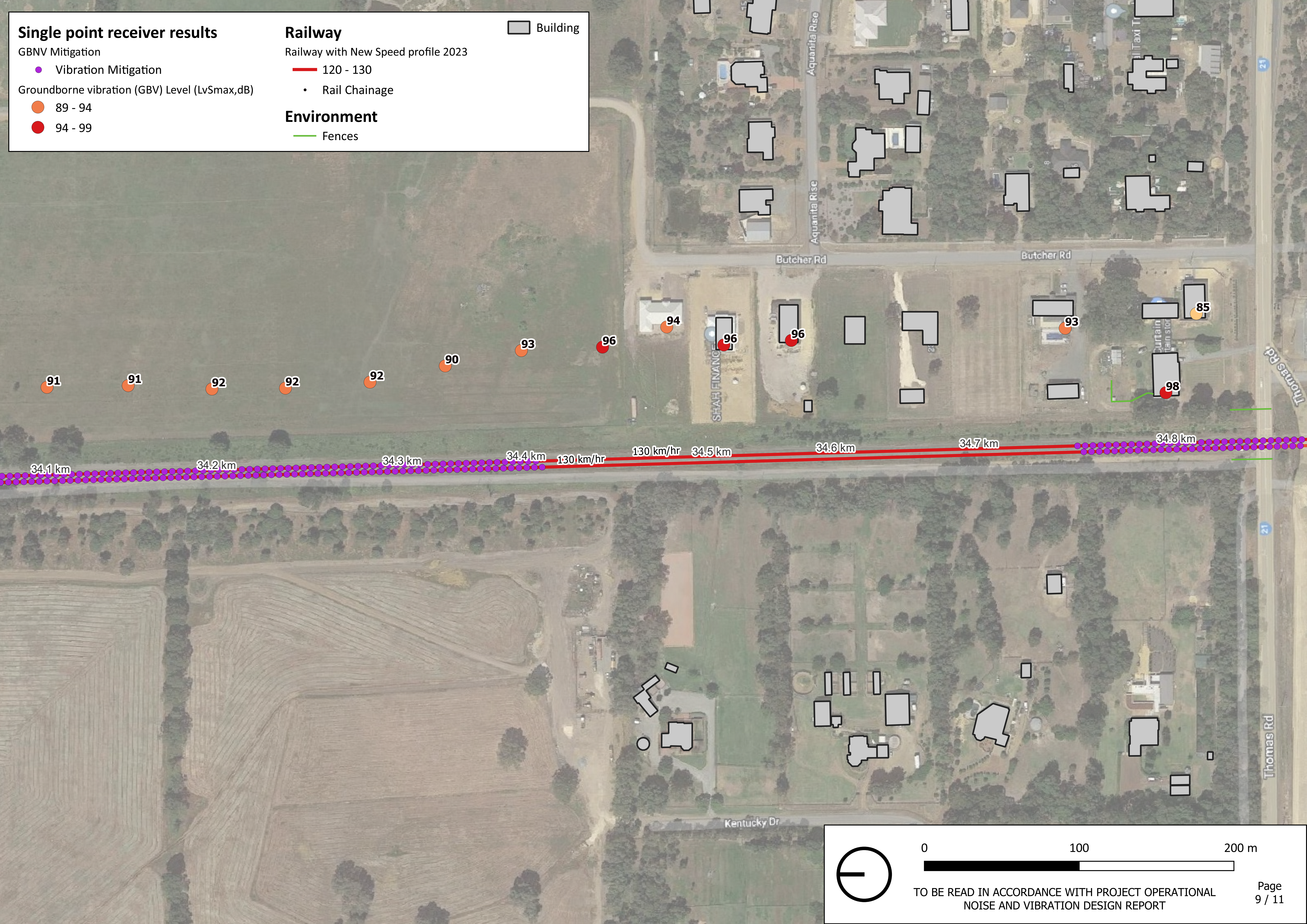

Single point receiver results
GBNV Mitigation
Vibration Mitigation
Groundborne vibration (GBV) Level (LvSmax,dB)
74 - 79
79 - 84
84 - 89
89 - 94
94 - 99
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Building
30.8 km
30.9 km
31 km
31.1 km
31.2 km
31.3 km
31.4 km
31.5 km
31.6 km
130 km/hr
Byron Rd
Wungong Rd
Eliot Rd
Burns Rd
Stone St
Browning Rd
Jeffrey Loop
Fernie Ct
Chiltern Ave
Gloster Loop
Smailes Elbow
Podger Way
Munday Ave
Massell Way
Kilkenny Loop
Edsell Entrance
Trouchet Way
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL
NOISE AND VIBRATION DESIGN REPORT


Single point receiver results
Groundborne vibration (GBV) Level (LvSmax,dB)
94 - 99
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Building
95
Wallangarra Adult Riders Club
Moore St
Stone St
Wilson St
Lambert Ln
Lambert Lane Nature Reserve
31.6 km
31.7 km
31.8 km
31.9 km
130 km/hr
32 km
130 km/hr
32.1 km
32.2 km
32.3 km
32.4 km
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

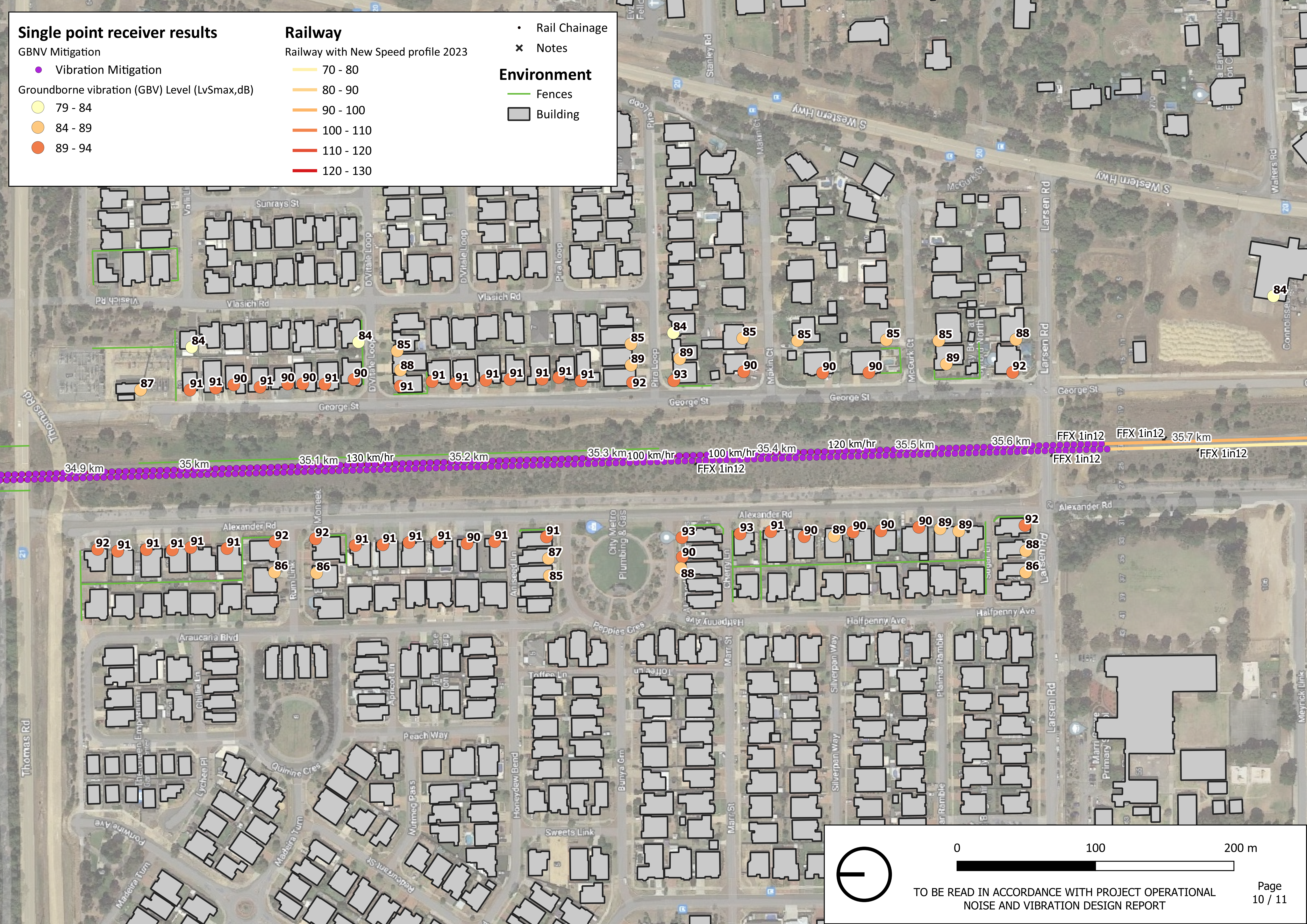


Single point receiver results
GBNV Mitigation
Vibration Mitigation
Groundborne vibration (GBV) Level (LvSmax,dB)
79 - 84
84 - 89
89 - 94
94 - 99
Railway
Railway with New Speed profile 2023
120 - 130
Rail Chainage
Environment
Fences
Station and bridge elements
Building
32.4 km
130 km/hr
32.5 km
32.6 km
32.7 km
32.8 km
32.9 km
33 km
33.1 km
33.2 km
33.3 km
33.4 km
Eleventh Rd
Woodstock Pl
Bruns Dr
Rivose Cres
Todman Grove
Paradise Rendo
Bores
Pumps Perth
94
96
83
84
92
97
93
91
86
80
85
84
86
85
84
86
86
84
87
86
83
83
86
88
88
0
100
200 m

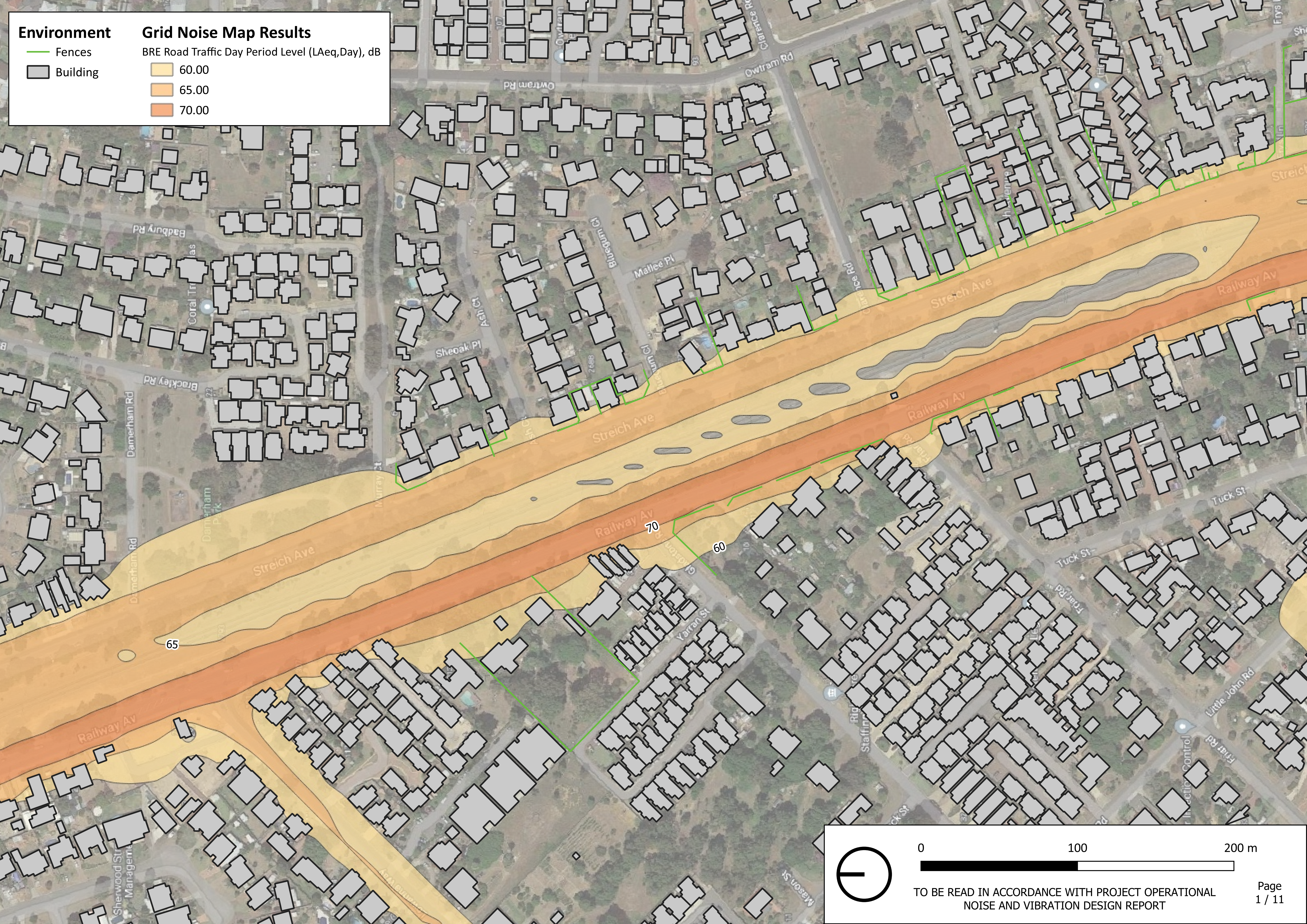
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Single point receiver results
GBNV Mitigation
Vibration Mitigation
Groundborne vibration (GBV) Level (LvSmax,dB)
79 - 84
84 - 89
89 - 94
Railway
Railway with New Speed profile 2023
70 - 80
80 - 90
90 - 100
100 - 110
110 - 120
120 - 130
Rail Chainage
Notes
Environment
Fences
Building
34.9 km
35 km
35.1 km
130 km/hr
35.2 km
35.3 km
100 km/hr
35.4 km
120 km/hr
35.5 km
35.6 km
35.7 km
FFX 1in12
George St
Alexander Rd
Vlasich Rd
Sunrays St
Larsen Rd
Thomas Rd
S Western Hwy
Halfpenny Ave
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

Single point receiver results
Groundborne vibration (GBV) Level (LvSmax,dB)
74 - 79
79 - 84
84 - 89
89 - 94
94 - 99
Railway
Railway with New Speed profile 2023
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Rail Chainage
Environment
Fences
Station and bridge elements
Building
35.8 km
35.9 km
36 km
36.1 km
36.2 km
30 km/hr
30 km/hr
83
85
84
87
87
85
86
79
96
96
96
95
95
95
94
94
94
94
95
90
S Western Hwy
George St
Alexander Rd
Chrysomou St
Monsignor Ave
Peniche Rd
Evans Way
Raggle La
Clara St
Pioneer Rd
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



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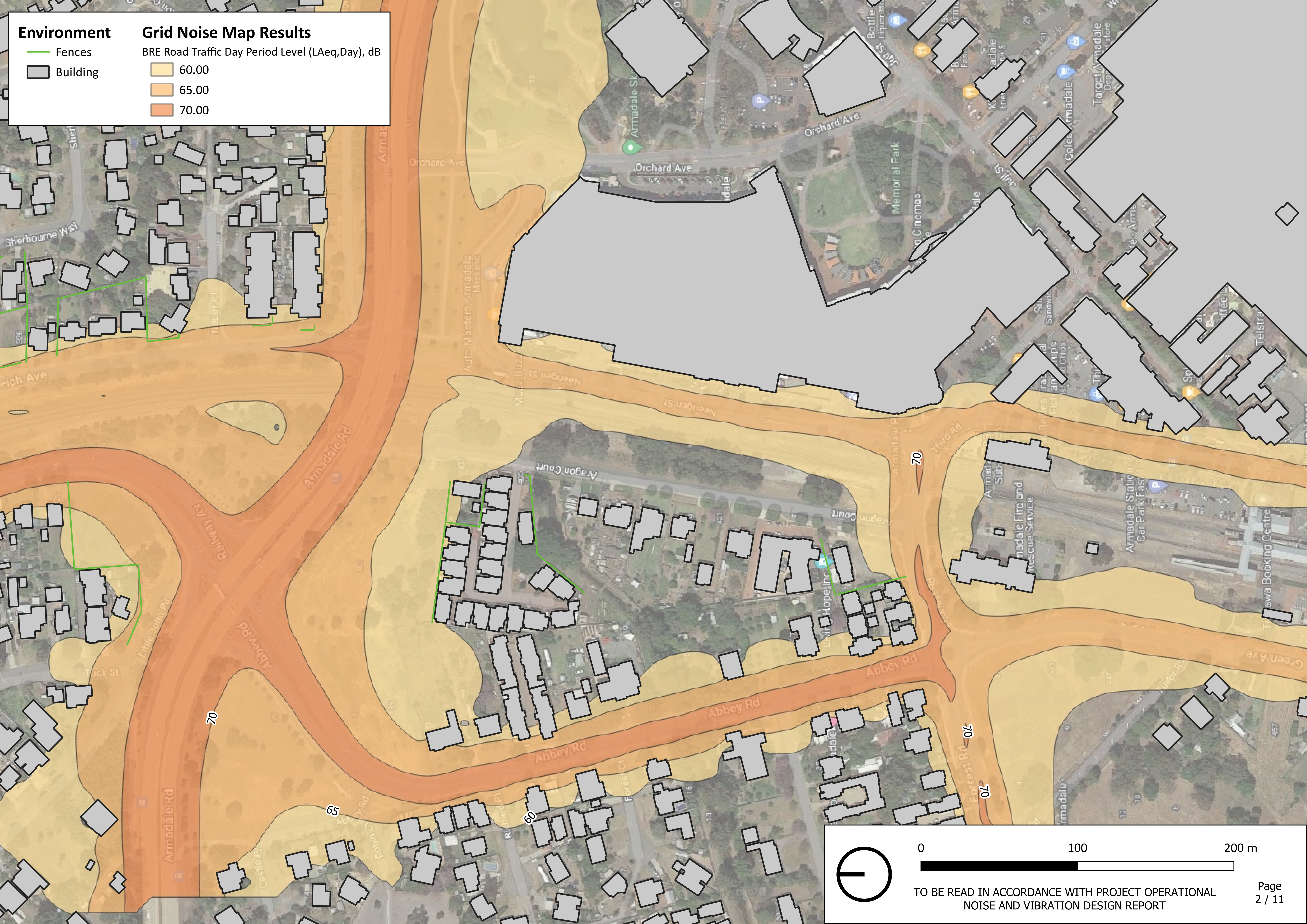
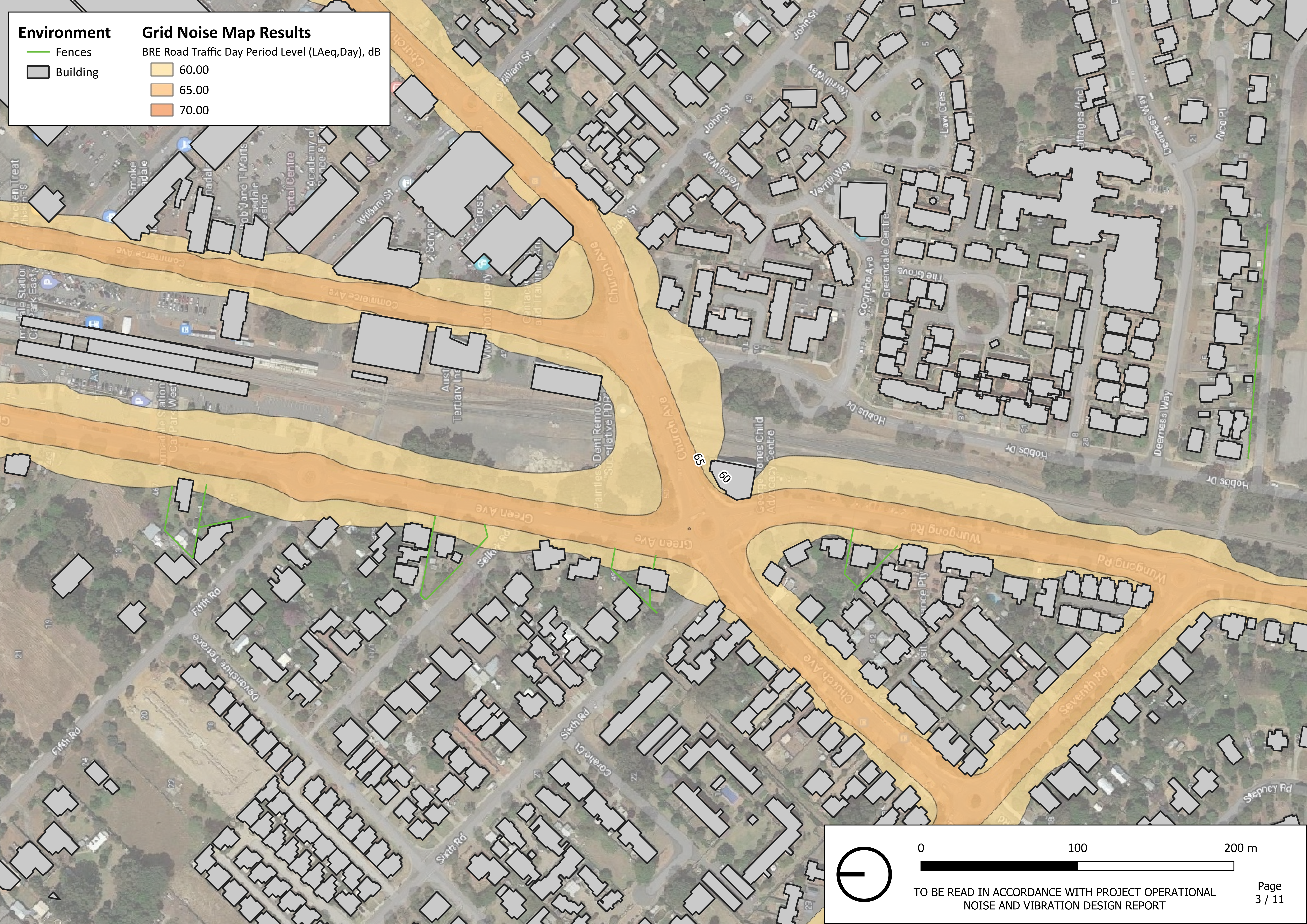
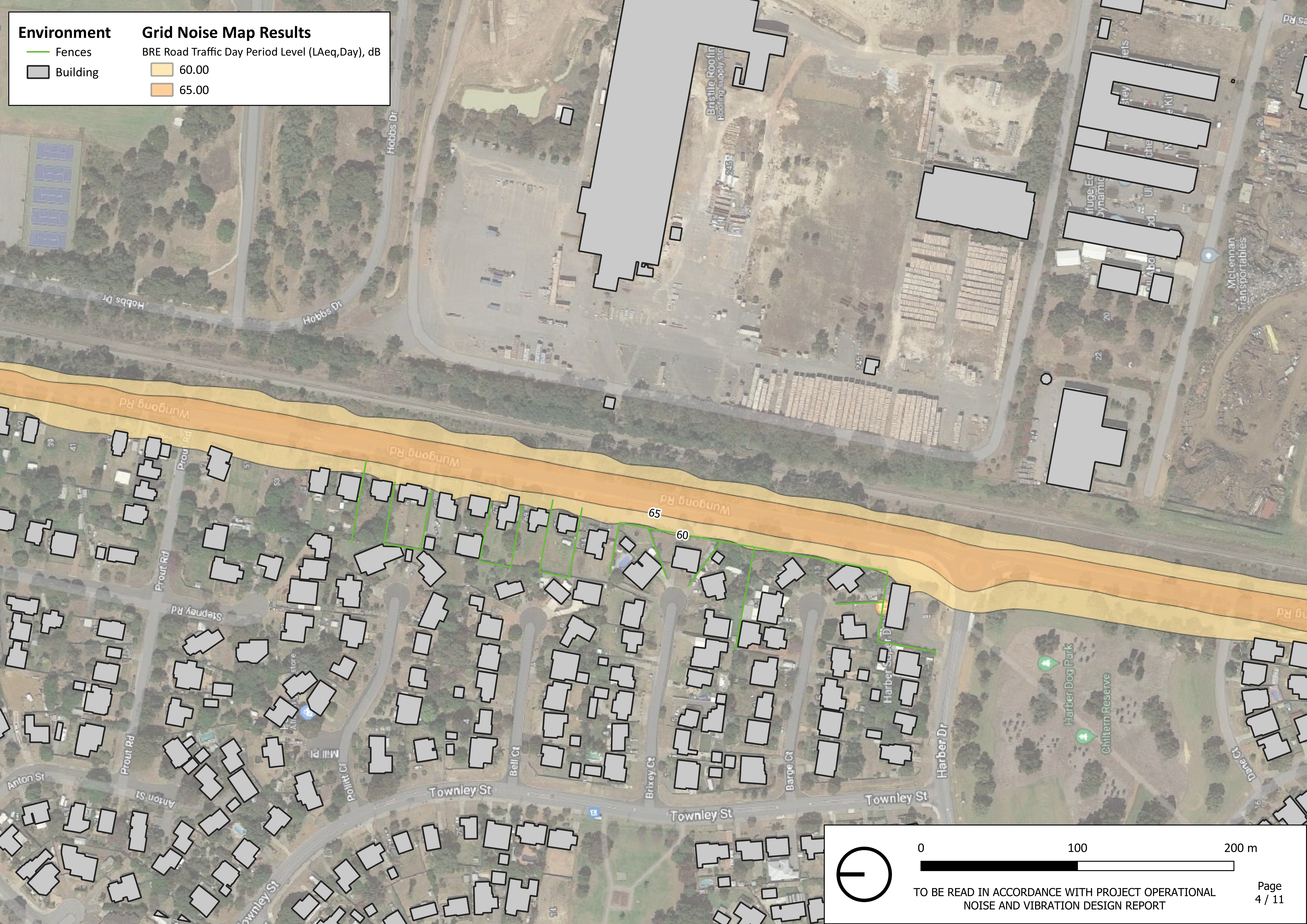

Environment
Fences
Building
Grid Noise Map Results
BRE Road Traffic Day Period Level (LAeq,Day), dB
60.00
65.00
70.00
Orchard Ave
Sherbourne Way
Neerigen St
Aragon Court
Armadale Rd
Railway Av
Abbey Rd
Forrest Rd
Green Ave
Memorial Park
70
65
60
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Environment
Fences
Building
Grid Noise Map Results
BRE Road Traffic Day Period Level (LAeq,Day), dB
60.00
65.00
70.00
Church Ave
Commerce Ave
Green Ave
Wungong Rd
Hobbs Dr
John St
William St
Verrill Way
Law Cres
Coombe Ave
The Grove
Greendale Centre
Deerness Way
Rice Pl
Selkirk Rd
Fifth Rd
Devonshire Terrace
Sixth Rd
Seventh Rd
Stepney Rd
65
60
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



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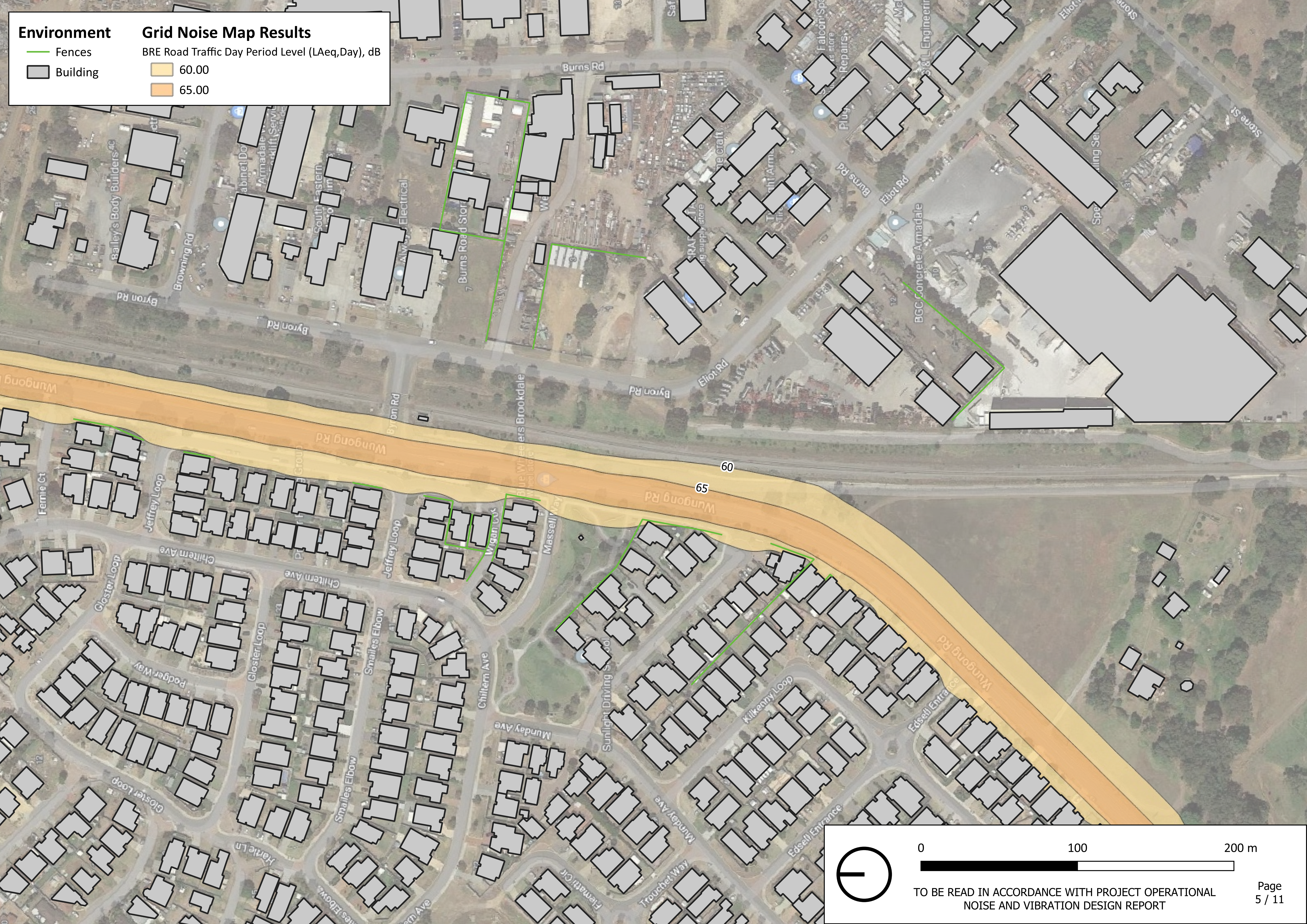
Environment
Fences
Building
Grid Noise Map Results
BRE Road Traffic Day Period Level (LAeq,Day), dB
60.00
65.00
60
65
Wungong Rd
Byron Rd
Burns Rd
Eliot Rd
Stone St
Chiltern Ave
Gloster Loop
Jeffrey Loop
Smailes Elbow
Munday Ave
Kilkenny Loop
Edsell Entrance
Fernie Ct
Browning Rd
Podger Way
Massell Way
Wigan Cove
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL
NOISE AND VIBRATION DESIGN REPORT
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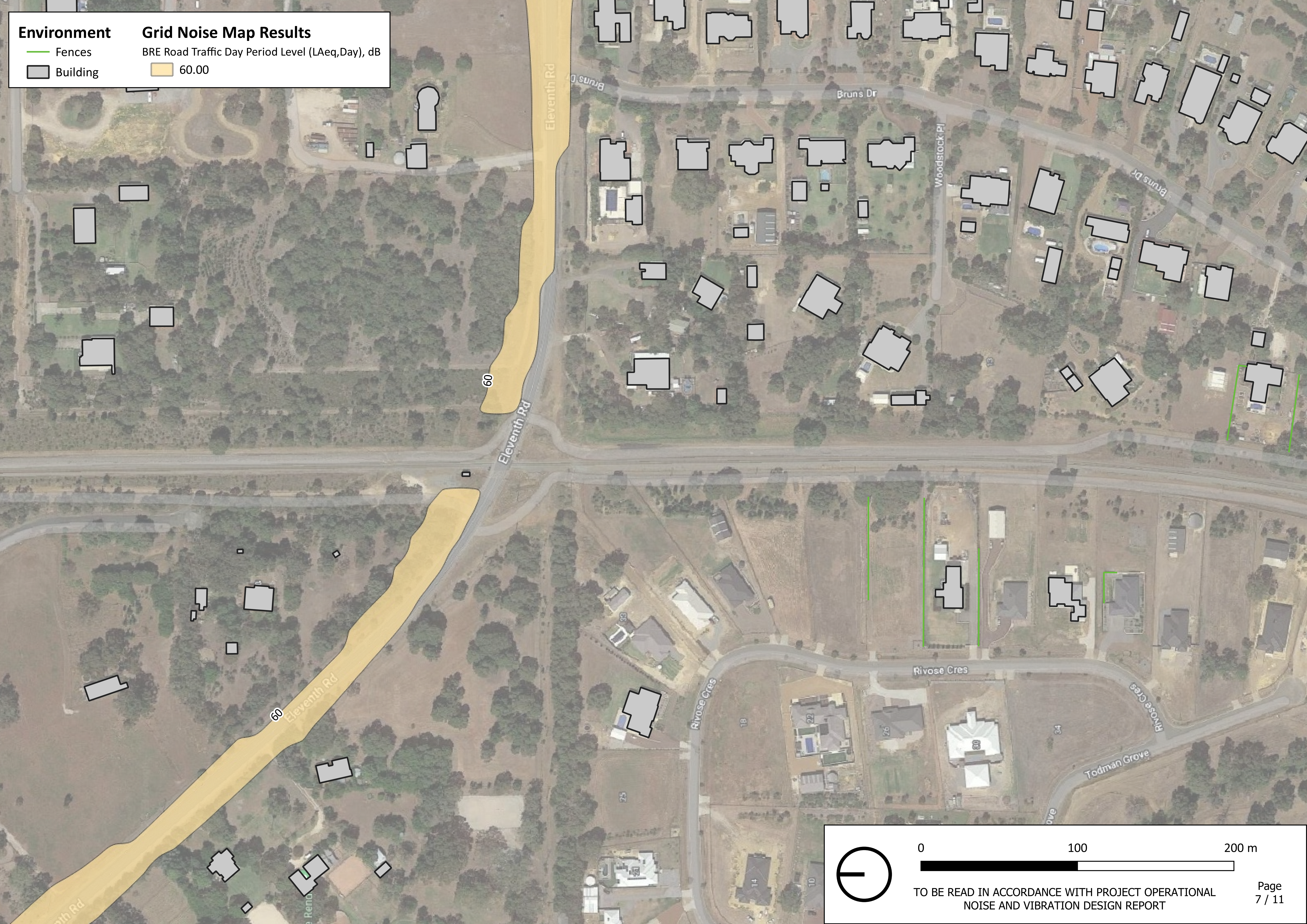
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Environment
Fences
Building
Grid Noise Map Results
BRE Road Traffic Day Period Level (LAeq,Day), dB
60.00
Eleventh Rd
Bruns Dr
Woodstock Pl
Rivose Cres
Todman Grove
60
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL
NOISE AND VIBRATION DESIGN REPORT

TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

Environment

- Fences
- Building

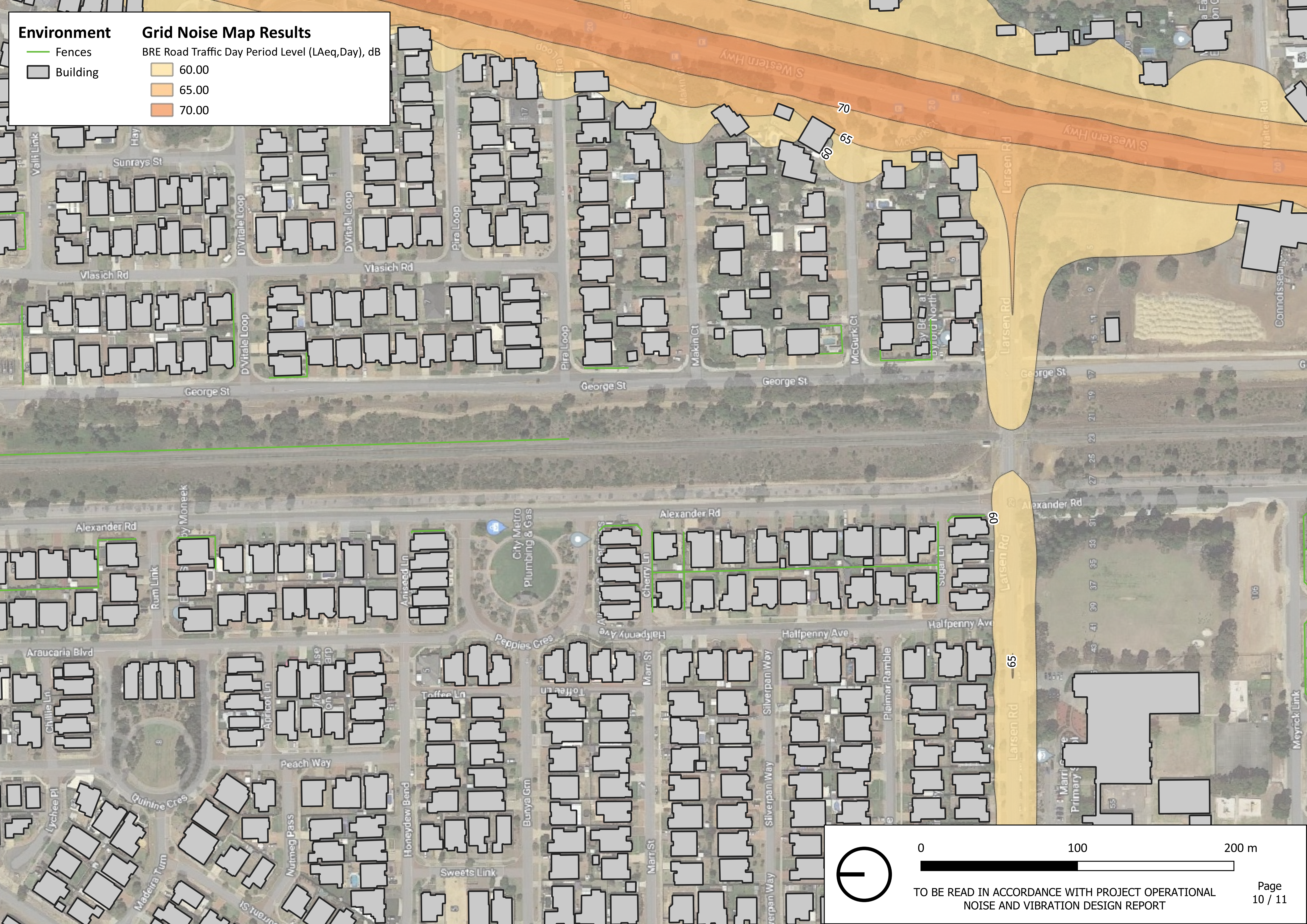
Grid Noise Map Results

BRE Road Traffic Day Period Level (LAeq,Day), dB

- 60.00
- 65.00
- 70.00

0 100 200 m

TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



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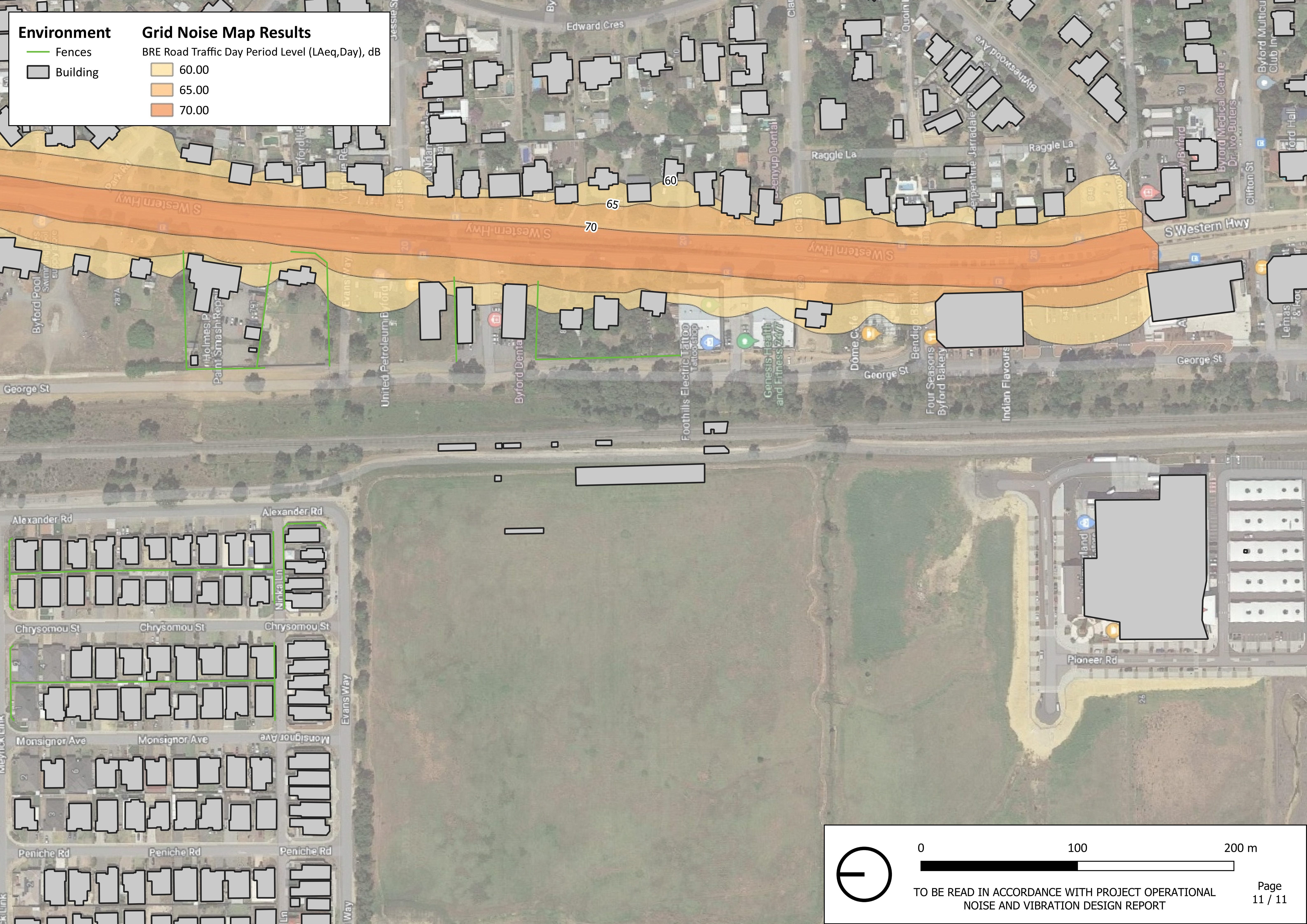

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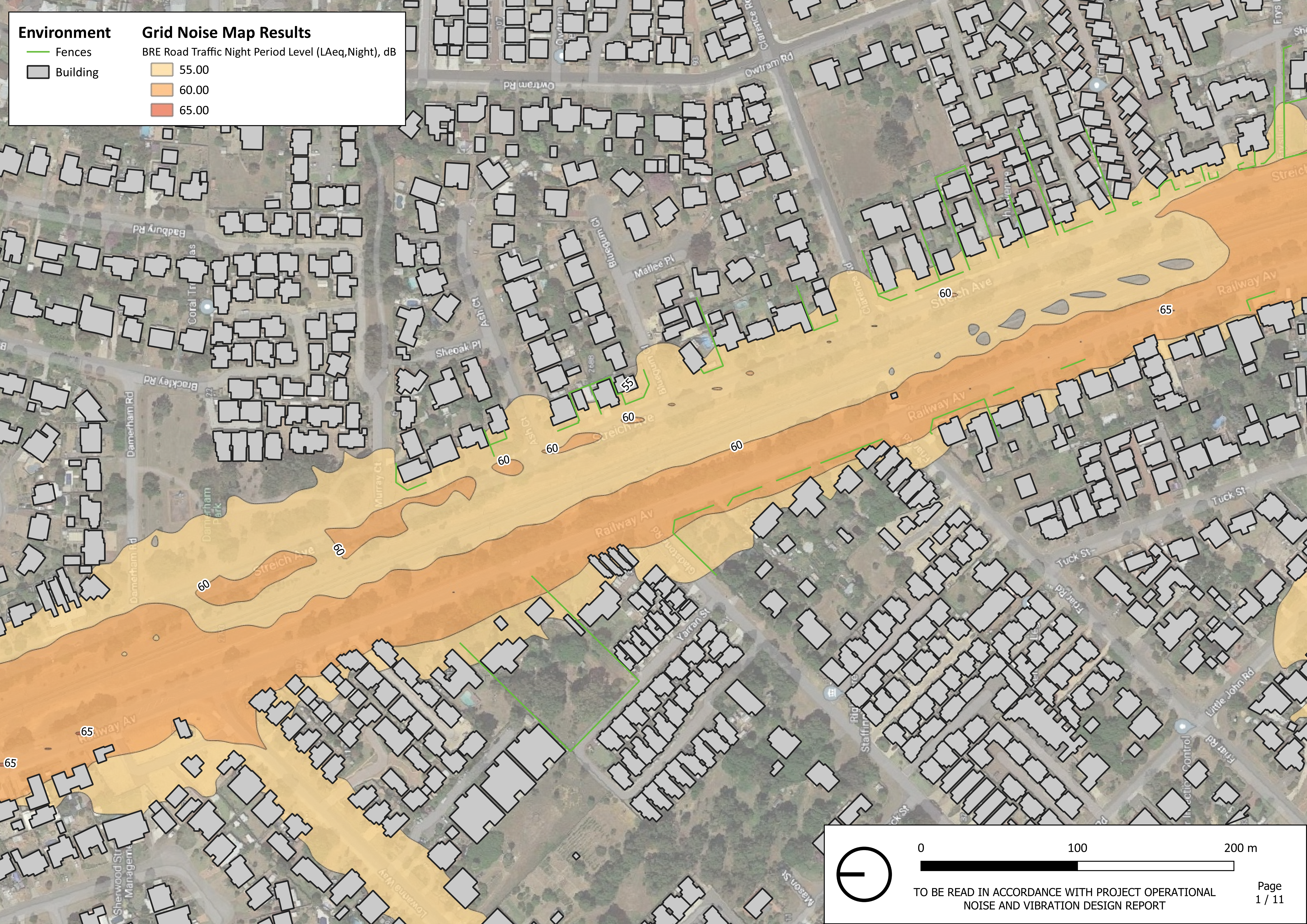

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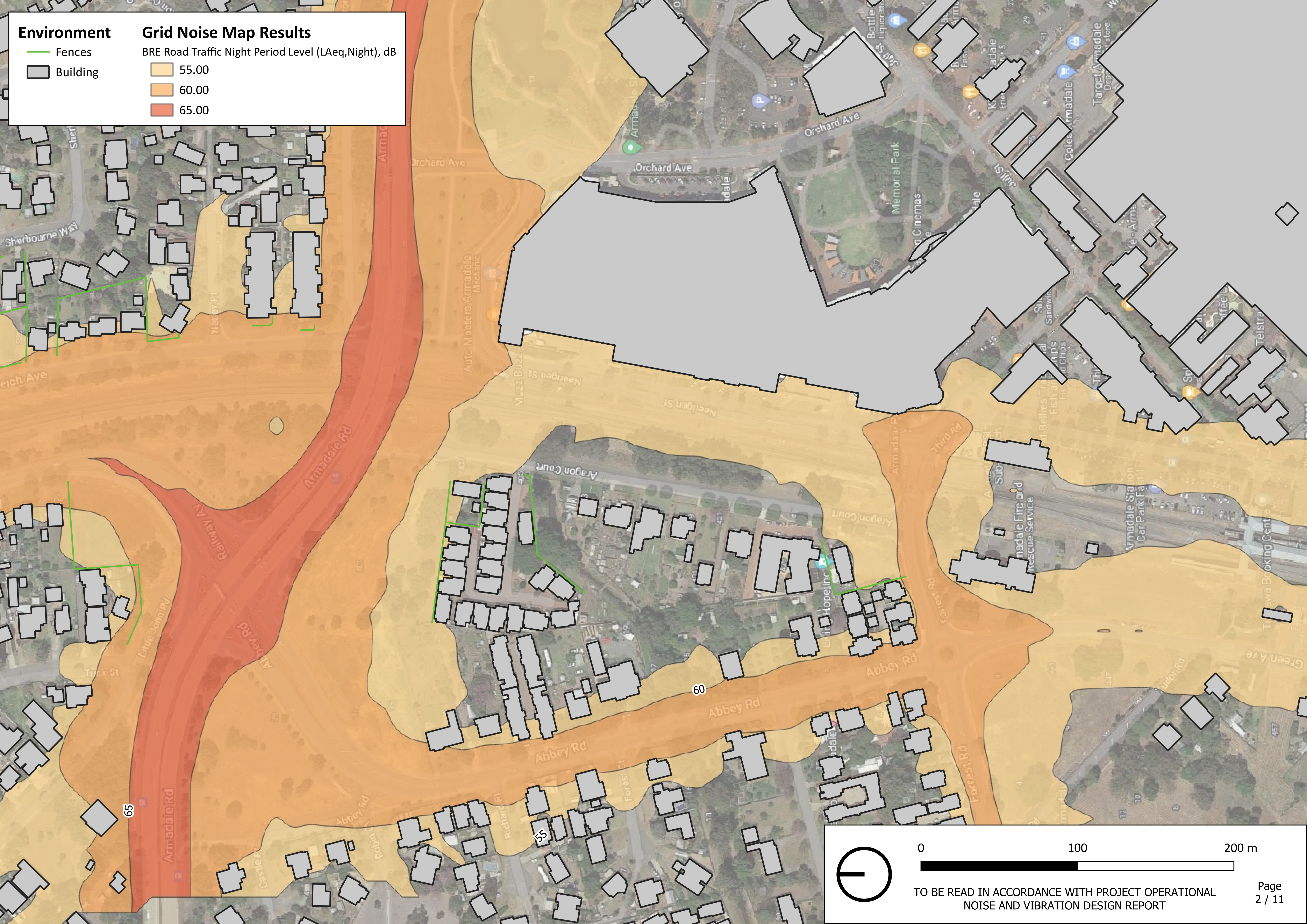
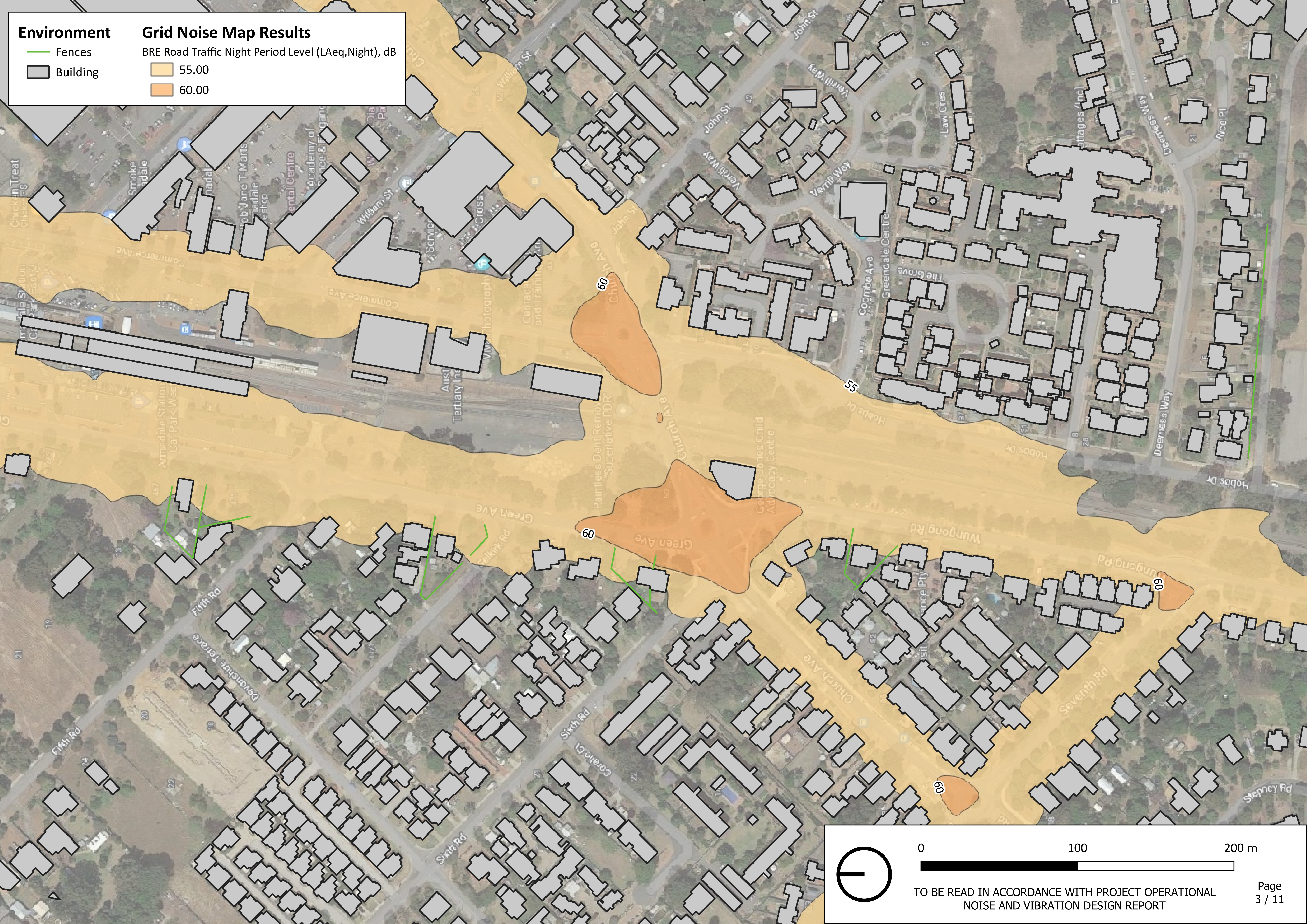
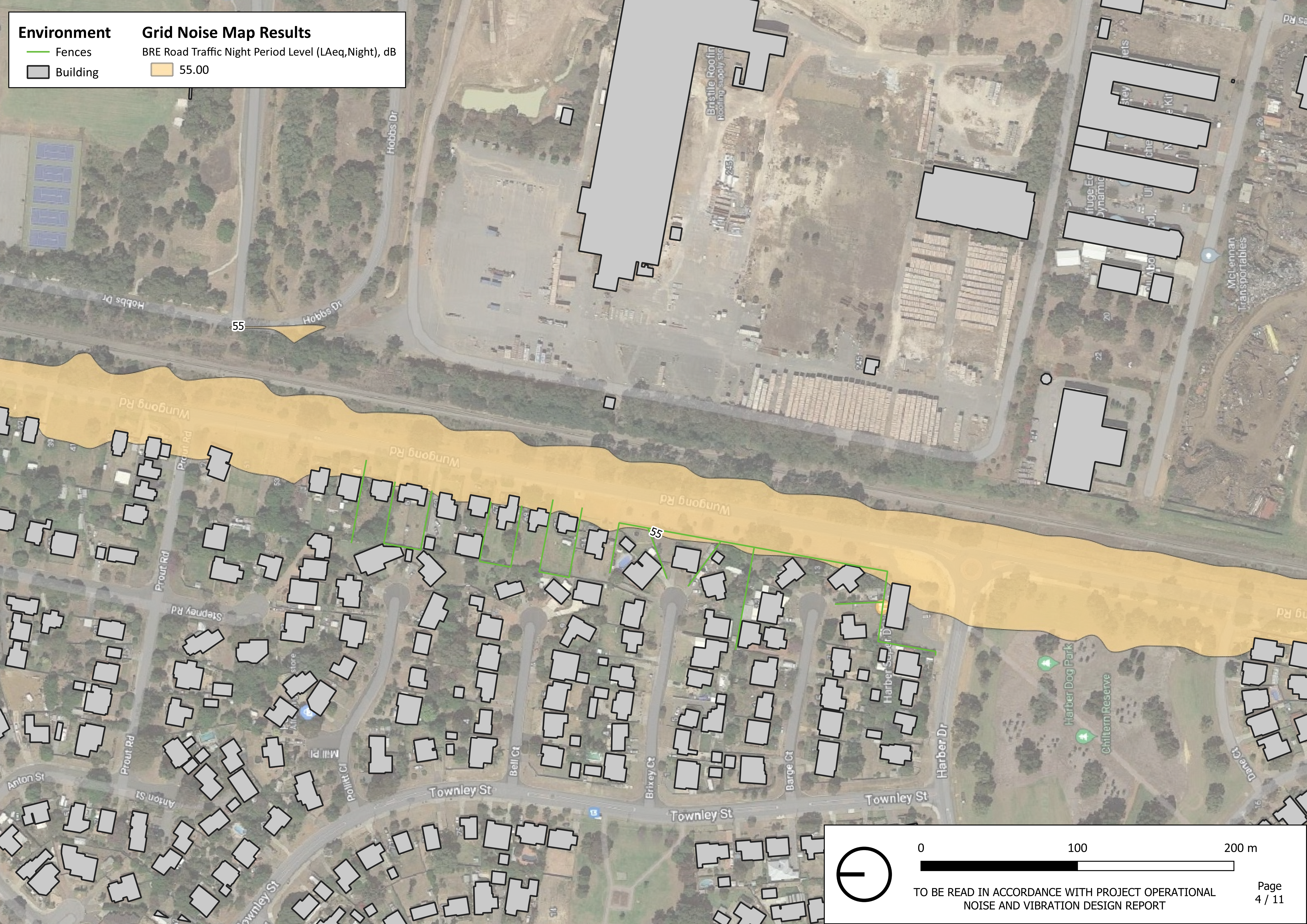


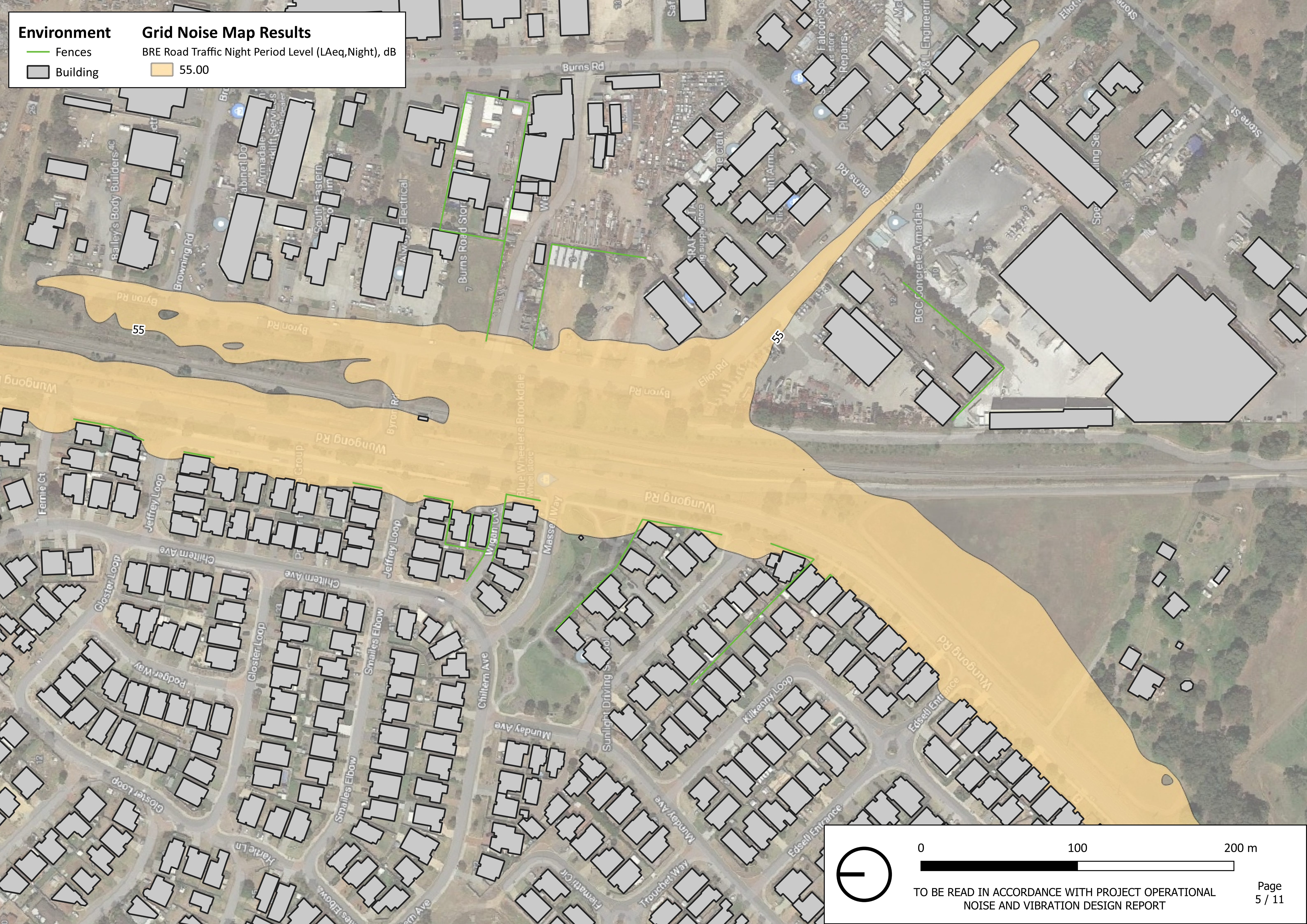
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



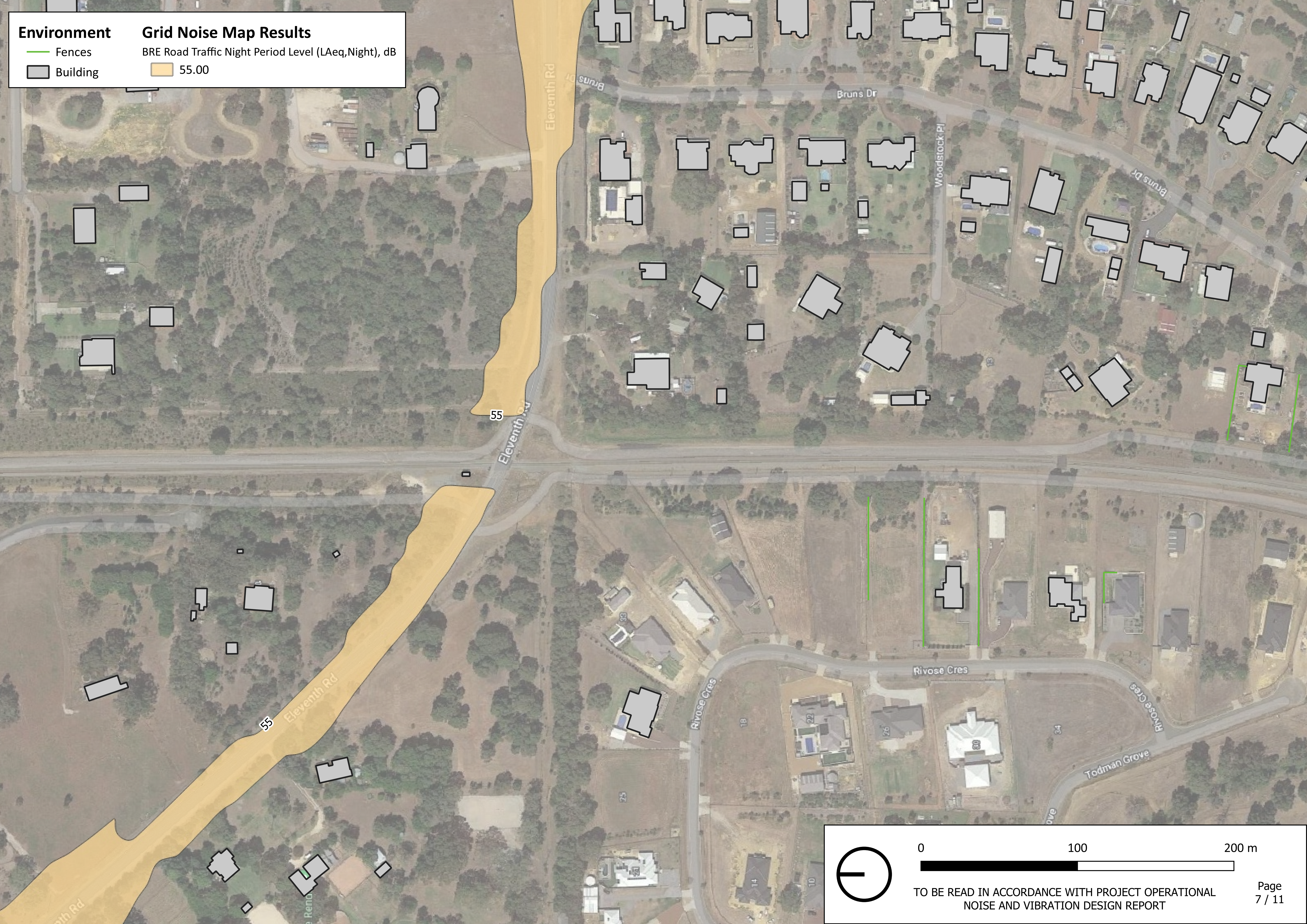
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT



TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

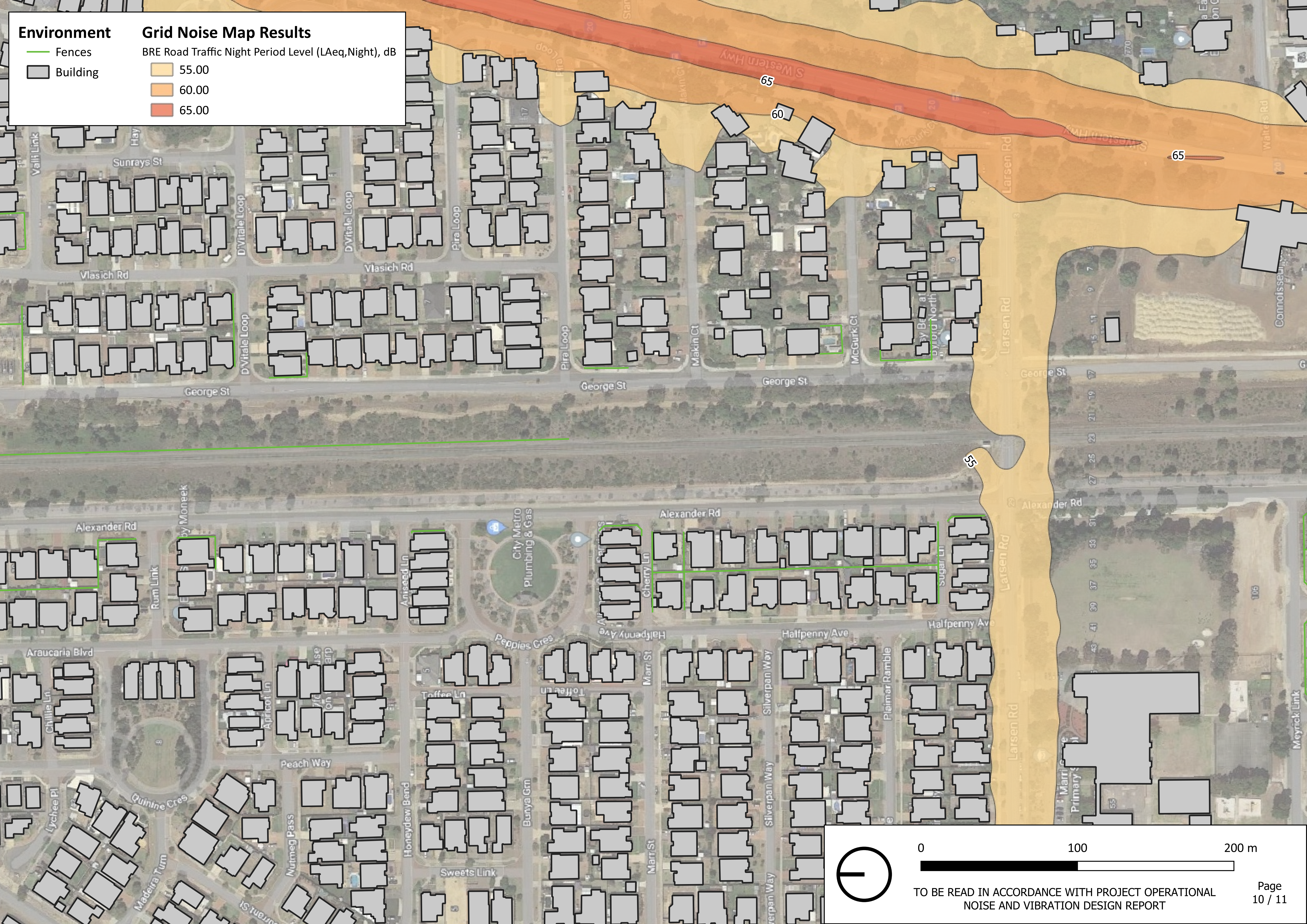

Environment
Fences
Building
Grid Noise Map Results
BRE Road Traffic Night Period Level (LAeq,Night), dB
55.00
55
Burns Rd
Byron Rd
Wungong Rd
Eliot Rd
Burns Road Stor
Browning Rd
Bailey's Body Builders
South Eastern
Electrical
BGC Concrete Armadale
Stone St
Blue Wheelers Brookdale
Fernie Ct
Jeffrey Loop
Chiltern Ave
Gloster Loop
Podger Way
Smailes Elbow
Wigan Cl
Massey Way
Sunlight Driving School
Kilkenny Loop
Munday Ave
Edsell Entrance
Trouchet Way
Marie Ln
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

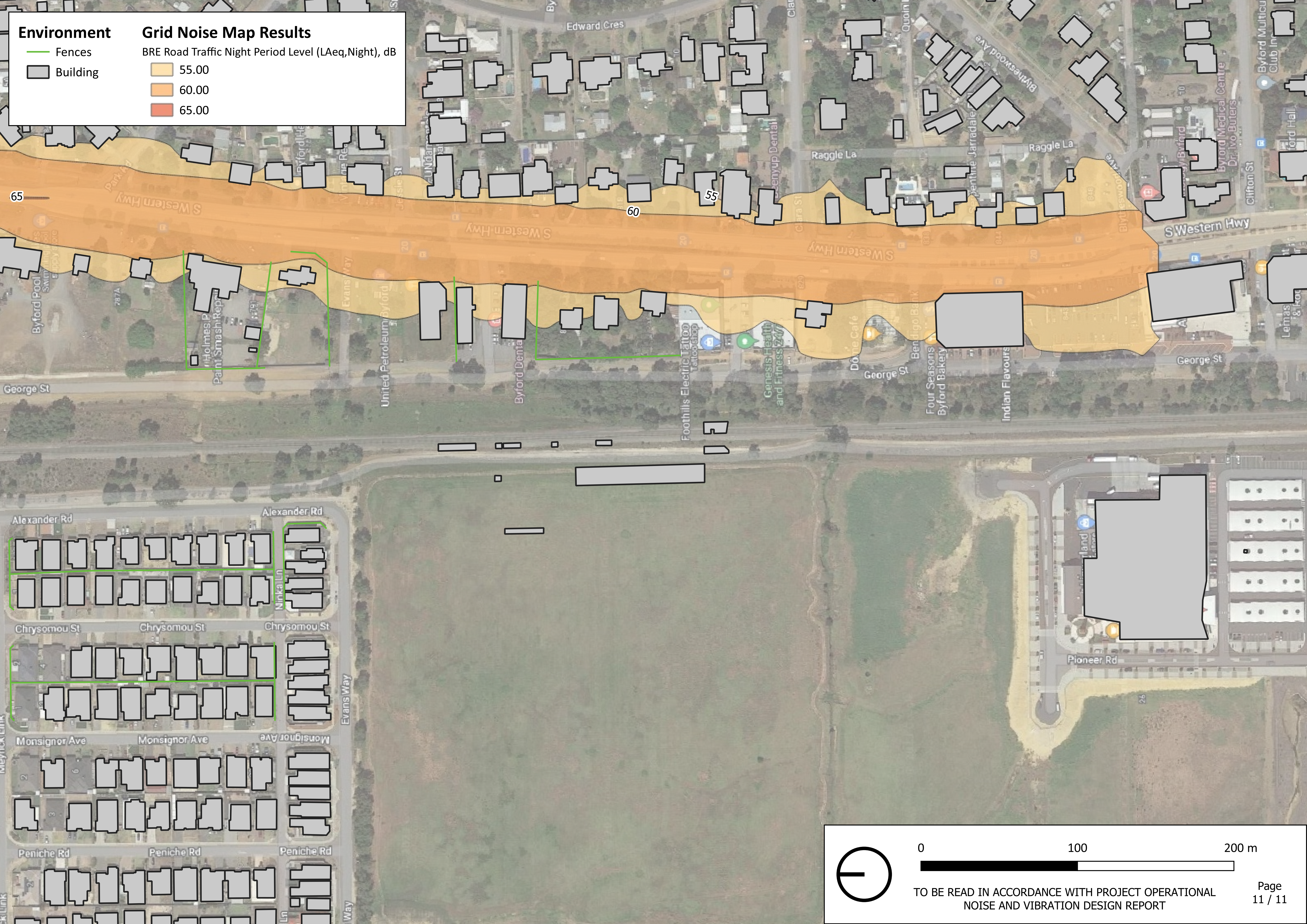
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Environment
Fences
Building
Grid Noise Map Results
BRE Road Traffic Night Period Level (LAeq,Night), dB
55.00
Eleventh Rd
Bruns Dr
Woodstock Pl
55
Rivose Cres
Todman Grove
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT

TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Environment
Fences
Building
Grid Noise Map Results
BRE Road Traffic Night Period Level (LAeq,Night), dB
55.00
60.00
Aquanita Rise
Butcher Rd
Vlasich Rd
Thomas Rd
Kentucky Dr
60
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Environment
Fences
Building
Grid Noise Map Results
BRE Road Traffic Night Period Level (LAeq,Night), dB
55.00
60.00
65.00
S Western Hwy
65
60
55
Sunrays St
Vlasich Rd
George St
Alexander Rd
Halfpenny Ave
Larsen Rd
Pira Loop
D'Vitale Loop
Makin Ct
McGurk Ct
Araucaria Blvd
Peppies Cres
Toffee Ln
Peach Way
Quinine Cres
Sweets Link
Marr St
Silverpan Way
Honeydew Bend
Bunya Grn
Nutmeg Pass
Cherry Ln
Sugar Ln
Rum Link
Aniseed Ln
Apricot Ln
Chillie Ln
Lychee Pl
Madeira Turn
Plaimar Ramble
Meyrick Link
City Metro Plumbing & Gas
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT


Environment
Fences
Building
Grid Noise Map Results
BRE Road Traffic Night Period Level (LAeq,Night), dB
55.00
60.00
65.00
65
60
55
S Western Hwy
Edward Cres
Raggle La
Blytheswood Ave
George St
Alexander Rd
Chrysomou St
Monsignor Ave
Peniche Rd
Evans Way
Ninka Ln
Pioneer Rd
0
100
200 m
TO BE READ IN ACCORDANCE WITH PROJECT OPERATIONAL NOISE AND VIBRATION DESIGN REPORT
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Appendix D: Engineering Change Approvals (Not in use)

Appendix E: Calculations

Results below are based on rubber rail pads – to be updated with agreed mitigation extents in Appendix F.

E.1 Mitigated Noise Results

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
1	1 ASH CT ARMADALE	27.79	RES	GF	60	47	60	-13	56	42	55	-13	62	80	-18	OK
2	1 COMMERCE AVE ARMADALE	28.92	COM	GF	56	53	-	-	52	48	-	-	73	-	-	-
3	1 DEERNESS WAY ARMADALE	29.87	RES	GF	54	58	60	-2	53	53	55	-2	74	80	-6	OK
4	1 FRIAR RD ARMADALE	27.97	RES	GF	66	52	60	-8	60	46	55	-9	66	80	-14	OK
5	1 HARBER ARMADALE	30.56	RES	GF	57	53	60	-7	53	47	55	-8	73	80	-7	OK
6	1 MAKIN CT BYFORD	35.44	RES	GF	45	50	60	-10	41	44	55	-11	68	80	-13	OK
7	1 MASSELL WAY BROOKDALE	31.14	RES	GF	56	50	60	-10	53	44	55	-11	68	80	-12	OK
8	1 MCGURK CT BYFORD	35.54	RES	GF	45	44	60	-16	44	38	55	-17	60	80	-20	OK
9	1 PEPPIES CR BYFORD	35.35	RES	GF	47	46	60	-14	43	41	55	-14	65	80	-15	OK
10	1 PIRA LP BYFORD	35.31	RES	GF	46	49	60	-11	43	43	55	-12	67	80	-13	OK
11	1 RUM LINK BYFORD	35.07	RES	GF	49	49	60	-11	43	44	55	-11	68	80	-12	OK
12	2 BLUEGUM CL ARMADALE	27.84	RES	GF	58	48	60	-12	54	42	55	-13	63	80	-17	OK
13	2 BROWNING RD ARMADALE	30.87	IND	GF	56	64	-	-	54	59	-	-	78	-	-	-
13	2 BROWNING RD ARMADALE	30.87	IND	F 1	56	63	-	-	54	57	-	-	80	-	-	-
14	2 DEERNESS WAY ARMADALE	29.83	RES	GF	54	56	60	-5	53	50	55	-5	70	80	-10	OK
15	2 D'VITALE LOOP BYFORD	35.13	RES	GF	49	51	60	-9	42	45	55	-10	70	80	-10	OK
16	2 FRIAR RD ARMADALE	28.03	RES	GF	64	54	60	-7	59	48	55	-7	72	80	-8	OK
17	2 HOBBS DR ARMADALE	29.53	RES	GF	61	50	60	-10	58	44	55	-11	66	80	-14	OK
18	2 MAKIN CT BYFORD	35.39	RES	GF	49	42	60	-18	45	37	55	-19	59	80	-21	OK
19	2 MCGURK CT BYFORD	35.48	RES	GF	46	49	60	-11	39	44	55	-12	67	80	-13	OK

MetCONNX

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
20	2 NETLEY PL ARMADALE	28.40	RES	GF	64	55	60	-6	60	49	55	-6	75	80	-5	OK
21	2 PROUT ARMADALE	30.11	RES	GF	62	59	60	-1	57	53	55	-2	74	80	-6	OK
22	2 RUM LINK BYFORD	35.05	RES	GF	45	48	60	-12	39	42	55	-13	67	80	-13	OK
23	2 SELKIRK RD ARMADALE	29.47	RES	GF	64	53	60	-7	58	48	55	-7	73	80	-8	OK
24	2 SEVENTH ARMADALE	29.90	RES	GF	63	53	60	-7	59	48	55	-7	70	80	-10	OK
25	2 TUDOR RD ARMADALE	29.08	RES	GF	61	49	60	-11	57	43	55	-12	66	80	-14	OK
26	2 WUNGONG RD ARMADALE	29.60	COM	GF	60	55	-	-	57	49	-	-	74	-	-	-
26	2 WUNGONG RD ARMADALE	29.60	COM	F 1	60	53	-	-	57	47	-	-	74	-	-	-
27	3 ABBEY RD ARMADALE	28.86	RES	GF	66	51	60	-9	60	45	55	-10	67	80	-13	OK
28	3 BUTCHER RD DARLING DOWNS	34.83	RES	GF	63	46	60	-14	56	41	55	-14	64	80	-16	OK
29	3 FERNIE CT BROOKDALE	30.82	RES	GF	53	54	60	-6	50	48	55	-7	70	80	-10	OK
30	3 MAKIN CT BYFORD	35.42	RES	GF	50	43	60	-17	43	37	55	-18	60	80	-20	OK
31	3 MASSELL WAY BROOKDALE	31.15	RES	GF	55	50	60	-10	52	45	55	-11	68	80	-12	OK
32	3 MCGURK CT BYFORD	35.53	RES	GF	50	42	60	-18	44	37	55	-18	59	80	-21	OK
33	3 NETLEY PL ARMADALE	28.47	RES	GF	65	54	60	-6	61	49	55	-6	74	80	-6	OK
34	3 PEPPIES CR BYFORD	35.34	RES	GF	46	50	60	-10	41	44	55	-11	67	80	-13	OK
35	3 PIRA LP BYFORD	35.31	RES	GF	47	47	60	-13	43	41	55	-14	65	80	-15	OK
36	3 RUM LINK BYFORD	35.07	RES	GF	47	47	60	-13	41	41	55	-14	66	80	-14	OK
37	3 WUNGONG RD ARMADALE	29.63	RES	GF	61	51	60	-9	59	45	55	-10	69	80	-11	OK
38	3A FRIAR RD ARMADALE	27.99	RES	GF	65	53	60	-8	60	47	55	-8	67	80	-13	OK
39	3B FRIAR RD ARMADALE	27.99	RES	GF	62	52	60	-8	58	47	55	-9	67	80	-13	OK
40	3C TUCK ST ARMADALE	28.32	RES	GF	60	47	60	-13	56	42	55	-13	63	80	-17	OK
41	4 D'VITALE LOOP BYFORD	35.13	RES	GF	48	50	60	-10	42	44	55	-11	69	80	-11	OK
42	4 ALEXANDER RD BYFORD	34.92	RES	GF	58	54	60	-7	51	48	55	-7	71	80	-9	OK
43	4 ASH CT ARMADALE	27.75	RES	GF	60	50	60	-10	56	45	55	-10	66	80	-15	OK
44	4 FERNIE CT BROOKDALE	30.85	RES	GF	53	56	60	-4	47	50	55	-5	73	80	-7	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
45	4 FIFTH RD ARMADALE	29.33	RES	GF	54	41	60	-19	51	36	55	-19	56	80	-24	OK
46	4 JEFFREY LP BROOKDALE	30.89	RES	GF	54	48	60	-12	47	42	55	-13	65	80	-15	OK
47	4 MAKIN CT BYFORD	35.39	RES	GF	50	41	60	-19	44	36	55	-19	59	80	-21	OK
48	4 MCGURK CT BYFORD	35.49	RES	GF	52	41	60	-19	46	35	55	-20	56	80	-24	OK
49	4 PIRA LP BYFORD	35.36	RES	GF	46	43	60	-17	43	37	55	-18	62	80	-19	OK
50	4 RUM LINK BYFORD	35.05	RES	GF	44	45	60	-15	40	40	55	-16	64	80	-16	OK
51	4 SEVENTH ARMADALE	29.89	RES	GF	62	54	60	-6	58	48	55	-7	71	80	-9	OK
52	4 TUDOR RD ARMADALE	29.06	RES	GF	59	46	60	-14	53	41	55	-14	58	80	-22	OK
53	5 SELKIRK RD ARMADALE	29.40	RES	GF	62	50	60	-10	58	45	55	-10	68	80	-12	OK
54	5 FERNIE CT BROOKDALE	30.82	RES	GF	59	55	60	-5	55	49	55	-6	73	80	-7	OK
55	5 HOBBS DR ARMADALE	29.55	RES	GF	59	51	60	-9	58	45	55	-10	68	80	-12	OK
56	5 JEFFREY LP BROOKDALE	30.92	RES	GF	53	51	60	-9	47	45	55	-10	63	80	-17	OK
57	5 MASSELL WAY BROOKDALE	31.15	RES	GF	52	51	60	-9	48	45	55	-10	68	80	-12	OK
58	5 NETLEY PL ARMADALE	28.44	RES	GF	62	55	60	-6	59	49	55	-6	73	80	-7	OK
59	5 PEPPIES CR BYFORD	35.34	RES	GF	46	50	60	-10	41	44	55	-11	68	80	-12	OK
60	5 PIRA LP BYFORD	35.31	RES	GF	46	46	60	-14	40	40	55	-15	64	80	-16	OK
61	5 WUNGONG RD ARMADALE	29.66	RES	GF	62	51	60	-9	58	45	55	-10	69	80	-11	OK
62	5A GLADSTONE RD ARMADALE	27.82	RES	GF	61	49	60	-11	57	43	55	-12	62	80	-18	OK
63	6 ALEXANDER RD BYFORD	34.93	RES	GF	56	55	60	-5	50	49	55	-6	74	80	-6	OK
64	6 D'VITALE LOOP BYFORD	35.13	RES	GF	48	47	60	-13	42	42	55	-13	65	80	-15	OK
65	6 FERNIE CT BROOKDALE	30.85	RES	GF	58	54	60	-6	55	49	55	-7	74	80	-6	OK
66	6 JEFFREY LP BROOKDALE	30.89	RES	GF	57	46	60	-14	54	40	55	-15	65	80	-15	OK
67	6 PIRA LP BYFORD	35.34	RES	GF	47	43	60	-17	41	37	55	-18	60	80	-20	OK
68	6 TUDOR RD ARMADALE	29.06	RES	GF	54	47	60	-13	47	42	55	-14	62	80	-18	OK
69	6 WIGAN BROOKDALE	31.12	RES	GF	58	51	60	-9	56	45	55	-10	71	80	-9	OK
70	7 HOBBS DR ARMADALE	29.57	RES	GF	58	52	60	-8	57	46	55	-9	69	80	-11	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
71	7 JEFFREY LP BROOKDALE	30.92	RES	GF	56	50	60	-10	54	44	55	-11	65	80	-15	OK
72	7 WUNGONG RD ARMADALE	29.68	RES	GF	61	52	60	-9	57	46	55	-9	69	80	-11	OK
73	8 ALEXANDER RD BYFORD	34.96	RES	GF	55	56	60	-4	48	50	55	-5	75	80	-5	OK
74	8 COMMERCE AVE ARMADALE	29.01	COM	GF	64	50	-	-	57	44	-	-	68	-	-	-
74	8 COMMERCE AVE ARMADALE	29.01	COM	F 1	64	51	-	-	57	45	-	-	68	-	-	-
75	8 DANE COU DANE CT BROOKDALE	30.77	RES	GF	54	51	60	-9	51	45	55	-10	68	80	-12	OK
76	8 HOBBS DR ARMADALE	29.62	RES	GF	57	51	60	-9	55	45	55	-10	68	80	-13	OK
76	8 HOBBS DR ARMADALE	29.62	RES	F 1	58	53	60	-7	55	48	55	-7	68	80	-12	OK
77	8 LARSEN RD BYFORD	35.59	RES	GF	60	52	60	-8	57	47	55	-8	69	80	-11	OK
78	8 PIRA LP BYFORD	35.34	RES	GF	45	42	60	-18	40	37	55	-19	59	80	-21	OK
79	8 WIGAN BROOKDALE	31.10	RES	GF	58	52	60	-8	56	46	55	-9	71	80	-9	OK
80	9 BARGE CT ARMADALE	30.52	RES	GF	48	51	60	-10	47	45	55	-10	68	80	-12	OK
81	9 BYRON RD ARMADALE	31.05	IND	GF	54	56	-	-	53	51	-	-	75	-	-	-
81	9 BYRON RD ARMADALE	31.05	IND	F 1	55	56	-	-	53	51	-	-	75	-	-	-
82	9 FIFTH RD ARMADALE	29.28	RES	GF	55	47	60	-13	54	41	55	-14	64	80	-16	OK
83	9 JEFFREY LP BROOKDALE	30.95	RES	GF	59	52	60	-8	56	47	55	-8	69	80	-11	OK
84	9 WUNGONG RD ARMADALE	29.71	RES	GF	64	51	60	-9	58	46	55	-9	70	80	-11	OK
85	9 WUNGONG RD ARMADALE	29.74	RES	GF	63	52	60	-8	58	46	55	-9	70	80	-10	OK
86	10 ALEXANDER RD BYFORD	34.97	RES	GF	53	56	60	-4	47	50	55	-5	75	80	-5	OK
87	10 DANE CT BROOKDALE	30.78	RES	GF	58	56	60	-4	55	50	55	-5	75	80	-5	OK
88	10 LARSEN RD BYFORD	35.58	RES	GF	53	54	60	-6	52	48	55	-7	70	80	-10	OK
89	10 ORCHARD AVE ARMADALE	28.68	COM	GF	63	56	-	-	57	51	-	-	75	-	-	-
89	10 ORCHARD AVE ARMADALE	28.68	COM	F 1	63	57	-	-	58	51	-	-	76	-	-	-
90	10 TROTMAN CT BROOKDALE	31.19	RES	GF	41	41	60	-19	35	35	55	-20	57	80	-23	OK
91	10 WOODSTOCK PL DARLING DOWNS	32.98	RES	GF	42	51	60	-9	43	45	55	-10	70	80	-10	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
92	11 BARGE CT ARMADALE	30.51	RES	GF	54	53	60	-7	52	47	55	-8	72	80	-8	OK
93	11 BYRON RD ARMADALE	31.02	IND	GF	55	57	-	-	54	51	-	-	76	-	-	-
93	11 BYRON RD ARMADALE	31.02	IND	F 1	56	57	-	-	54	51	-	-	76	-	-	-
94	11 COOMBE AVE ARMADALE	29.66	RES	GF	54	48	60	-12	52	42	55	-13	66	80	-14	OK
95	11 ELIOT RD ARMADALE	31.25	IND	GF	54	56	-	-	53	50	-	-	72	-	-	-
95	11 ELIOT RD ARMADALE	31.25	IND	F 1	55	55	-	-	54	50	-	-	72	-	-	-
96	11 JEFFREY LP BROOKDALE	30.97	RES	GF	59	53	60	-8	56	47	55	-8	69	80	-11	OK
97	11 MURRAY CT ARMADALE	27.61	RES	GF	59	53	60	-7	56	47	55	-8	62	80	-18	OK
98	11 MURRAY CT ARMADALE	27.63	RES	GF	59	53	60	-7	56	47	55	-8	63	80	-17	OK
99	11 MURRAY CT ARMADALE	27.66	RES	GF	59	51	60	-9	53	46	55	-9	64	80	-16	OK
100	11 WOODSTOCK PL DARLING DOWNS	33.15	RES	GF	39	55	60	-5	33	49	55	-6	74	80	-6	OK
101	12 ALEXANDER RD BYFORD	34.99	RES	GF	53	56	60	-4	46	50	55	-5	75	80	-5	OK
102	12 BARGE CT ARMADALE	30.48	RES	GF	47	48	60	-12	46	42	55	-13	64	80	-16	OK
103	12 HOBBS DR ARMADALE	29.60	RES	GF	56	51	60	-9	55	45	55	-10	68	80	-12	OK
104	12 WOODSTOCK PL DARLING DOWNS	33.02	RES	GF	42	52	60	-9	36	46	55	-9	70	80	-10	OK
105	13 BRIXEY CT ARMADALE	30.44	RES	GF	49	50	60	-10	43	44	55	-11	69	80	-12	OK
106	13 BUTCHER RD DARLING DOWNS	34.73	RES	GF	53	51	60	-9	46	45	55	-10	70	80	-10	OK
107	13 BYRON RD ARMADALE	30.98	IND	GF	55	61	-	-	54	55	-	-	76	-	-	-
107	13 BYRON RD ARMADALE	30.98	IND	F 1	56	59	-	-	55	53	-	-	75	-	-	-
108	13 ELIOT RD ARMADALE	31.22	IND	GF	54	58	-	-	54	52	-	-	75	-	-	-
108	13 ELIOT RD ARMADALE	31.22	IND	F 1	55	57	-	-	54	51	-	-	75	-	-	-
109	13 GEORGE ST BYFORD	34.99	RES	GF	51	55	60	-6	44	49	55	-6	74	80	-6	OK
110	13 JEFFREY LP BROOKDALE	30.99	RES	GF	59	51	60	-9	56	45	55	-10	69	80	-11	OK
111	13 TROTMAN CT BROOKDALE	31.27	RES	GF	54	50	60	-10	47	44	55	-11	70	80	-11	OK
112	14 ALEXANDER RD BYFORD	35.01	RES	GF	51	56	60	-4	45	50	55	-5	75	80	-5	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
113	14 BRIXEY CT ARMADALE	30.35	RES	GF	59	59	60	-1	56	53	55	-2	73	80	-7	OK
114	15 GEORGE ST BYFORD	35.00	RES	GF	51	54	60	-6	44	48	55	-7	73	80	-7	OK
115	15 JEFFREY LP BROOKDALE	31.01	RES	GF	59	51	60	-10	56	45	55	-10	69	80	-11	OK
116	15 TROTMAN CT BROOKDALE	31.28	RES	GF	55	52	60	-8	52	46	55	-9	71	80	-9	OK
117	15 TROTMAN CT BROOKDALE	31.29	RES	GF	57	52	60	-9	55	46	55	-9	70	80	-10	OK
118	16 BRIXEY CT ARMADALE	30.38	RES	GF	50	47	60	-13	48	42	55	-13	64	80	-16	OK
119	16 ELIOT RD ARMADALE	31.35	IND	GF	52	58	-	-	52	53	-	-	78	-	-	-
119	16 ELIOT RD ARMADALE	31.35	IND	F 1	53	58	-	-	52	52	-	-	77	-	-	-
120	16 LARSEN RD BYFORD	35.59	RES	GF	60	55	60	-5	56	49	55	-6	73	80	-8	OK
121	16 TROTMAN CT BROOKDALE	31.20	RES	GF	48	43	60	-17	41	37	55	-18	62	80	-18	OK
122	17 BYRON RD ARMADALE	30.94	IND	GF	56	56	-	-	54	51	-	-	76	-	-	-
122	17 BYRON RD ARMADALE	30.94	IND	F 1	56	57	-	-	54	51	-	-	75	-	-	-
123	17 GEORGE ST BYFORD	35.02	RES	GF	49	55	60	-5	43	49	55	-6	74	80	-6	OK
124	17 JEFFREY LP BROOKDALE	31.03	RES	GF	58	51	60	-9	56	45	55	-10	69	80	-11	OK
125	17 WUNGONG RD ARMADALE	29.78	RES	GF	60	51	60	-9	56	45	55	-10	70	80	-10	OK
126	18 BRIXEY CT ARMADALE	30.41	RES	GF	54	53	60	-7	53	48	55	-8	72	80	-8	OK
127	18 JEFFREY LP BROOKDALE	31.08	RES	GF	57	49	60	-12	55	43	55	-12	68	80	-12	OK
128	18 LARSEN RD BYFORD	35.59	RES	GF	60	53	60	-7	56	47	55	-8	71	80	-9	OK
129	18 TROTMAN CT BROOKDALE	31.21	RES	GF	50	45	60	-15	48	40	55	-15	65	80	-15	OK
130	19 GEORGE ST BYFORD	35.04	RES	GF	49	55	60	-6	43	49	55	-6	74	80	-6	OK
131	19 JEFFREY LP BROOKDALE	31.05	RES	GF	57	48	60	-12	55	42	55	-13	67	80	-14	OK
132	19 VLASICH RD BYFORD	35.11	RES	GF	46	39	60	-21	40	34	55	-22	61	80	-19	OK
133	19 WUNGONG RD ARMADALE	29.80	RES	GF	60	51	60	-9	56	45	55	-10	71	80	-9	OK
134	20 JEFFREY LP BROOKDALE	31.07	RES	GF	54	47	60	-13	47	41	55	-14	66	80	-14	OK
135	20 LARSEN RD BYFORD	35.59	RES	GF	60	51	60	-9	56	45	55	-10	69	80	-11	OK
136	21 BRACKLEY RD ARMADALE	27.60	RES	GF	59	53	60	-7	52	47	55	-8	62	80	-18	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
137	21 BRACKLEY RD ARMADALE	27.59	RES	GF	59	53	60	-7	52	47	55	-8	62	80	-19	OK
138	21 BRACKLEY RD ARMADALE	27.58	RES	GF	58	53	60	-7	54	47	55	-8	61	80	-20	OK
139	21 GEORGE ST BYFORD	35.06	RES	GF	48	55	60	-6	42	49	55	-6	74	80	-6	OK
140	21 JEFFREY LP BROOKDALE	31.05	RES	GF	54	49	60	-11	47	43	55	-12	64	80	-16	OK
141	21 WUNGONG RD ARMADALE	29.81	RES	GF	64	52	60	-8	58	47	55	-8	72	80	-8	OK
142	21 WUNGONG RD ARMADALE	29.82	RES	GF	65	51	60	-9	58	46	55	-10	71	80	-9	OK
143	22 TROTMAN CT BROOKDALE	31.23	RES	GF	55	49	60	-11	52	44	55	-11	69	80	-11	OK
144	23 GEORGE ST BYFORD	35.07	RES	GF	48	55	60	-5	42	49	55	-6	75	80	-5	OK
145	23 PEPPIES CR BYFORD	35.25	RES	GF	44	47	60	-13	41	42	55	-14	66	80	-15	OK
146	23 WUNGONG RD ARMADALE	29.86	RES	GF	65	52	60	-8	59	47	55	-8	70	80	-10	OK
147	23 WUNGONG RD ARMADALE	29.83	RES	GF	64	51	60	-9	58	45	55	-10	68	80	-12	OK
148	23 WUNGONG RD ARMADALE	29.85	RES	GF	64	51	60	-9	58	45	55	-10	67	80	-13	OK
149	24 DICKENS PL ARMADALE	30.65	IND	GF	53	69	-	-	51	64	-	-	89	-	-	-
149	24 DICKENS PL ARMADALE	30.65	IND	F 1	54	71	-	-	52	65	-	-	91	-	-	-
150	24 TROTMAN CT BROOKDALE	31.24	RES	GF	51	47	60	-13	50	41	55	-14	66	80	-14	OK
151	25 GEORGE ST BYFORD	35.08	RES	GF	46	55	60	-5	39	49	55	-6	75	80	-5	OK
152	25 PEPPIES CR BYFORD	35.25	RES	GF	44	49	60	-11	38	43	55	-12	68	80	-13	OK
153	26 COMMERCE AVE ARMADALE	29.22	COM	GF	65	46	-	-	58	41	-	-	60	-	-	-
153	26 COMMERCE AVE ARMADALE	29.22	COM	F 1	65	49	-	-	58	43	-	-	62	-	-	-
154	26 TROTMAN CT BROOKDALE	31.24	RES	GF	54	48	60	-12	52	42	55	-13	67	80	-13	OK
155	27 GEORGE ST BYFORD	35.10	RES	GF	46	55	60	-5	39	49	55	-6	75	80	-5	OK
156	27 PEPPIES CR BYFORD	35.24	RES	GF	45	50	60	-10	42	44	55	-11	69	80	-11	OK
157	28 COMMERCE AVE ARMADALE	29.24	COM	GF	65	45	-	-	58	40	-	-	58	-	-	-
158	28 HOBBS DR ARMADALE	29.81	RES	GF	54	56	60	-4	54	50	55	-5	72	80	-8	OK
159	29 BUTCHER RD DARLING DOWNS	34.56	RES	GF	48	55	60	-5	41	49	55	-6	74	80	-6	OK
160	30 COMMERCE AVE ARMADALE	29.26	COM	GF	65	46	-	-	58	40	-	-	56	-	-	-

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
160	30 COMMERCE AVE ARMADALE	29.26	COM	F 1	65	49	-	-	58	43	-	-	58	-	-	-
161	30 HOBBS DR ARMADALE	29.79	RES	GF	55	54	60	-7	53	48	55	-7	69	80	-11	OK
161	30 HOBBS DR ARMADALE	29.79	RES	F 1	56	56	60	-5	54	50	55	-5	72	80	-8	OK
162	31 GEORGE ST BYFORD	35.16	RES	GF	43	54	60	-6	37	48	55	-7	74	80	-7	OK
163	31 HOBBS DR ARMADALE	29.77	RES	GF	56	55	60	-5	54	49	55	-6	72	80	-8	OK
163	31 HOBBS DR ARMADALE	29.77	RES	F 1	57	56	60	-4	55	50	55	-5	73	80	-7	OK
164	31 WUNGONG RD ARMADALE	29.92	RES	GF	62	50	60	-10	57	44	55	-11	65	80	-15	OK
165	33 CLARENCE RD ARMADALE	27.98	RES	GF	55	55	60	-5	53	49	55	-6	67	80	-13	OK
166	33 GEORGE ST BYFORD	35.18	RES	GF	45	54	60	-6	38	48	55	-7	73	80	-7	OK
167	33 STONE ST ARMADALE	31.49	IND	GF	43	41	-	-	42	35	-	-	58	-	-	-
167	33 STONE ST ARMADALE	31.49	IND	F 1	44	46	-	-	43	40	-	-	60	-	-	-
168	33 VLASICH RD BYFORD	34.98	RES	GF	49	42	60	-19	42	36	55	-19	61	80	-19	OK
169	33 WUNGONG RD ARMADALE	29.94	RES	GF	62	51	60	-9	57	45	55	-10	67	80	-14	OK
170	34 HOBBS DR ARMADALE	29.73	RES	GF	56	51	60	-9	53	45	55	-10	70	80	-10	OK
170	34 HOBBS DR ARMADALE	29.73	RES	F 1	57	54	60	-7	53	48	55	-7	71	80	-9	OK
171	35 BUTCHER RD DARLING DOWNS	34.52	RES	GF	46	56	60	-4	40	50	55	-5	75	80	-5	OK
172	35 CLARENCE RD ARMADALE	27.98	RES	GF	60	55	60	-5	56	50	55	-6	68	80	-12	OK
173	35 GEORGE ST BYFORD	35.20	RES	GF	43	54	60	-6	37	48	55	-7	73	80	-7	OK
174	35 WUNGONG RD ARMADALE	29.96	RES	GF	62	48	60	-12	57	42	55	-13	67	80	-13	OK
175	36-40 COMMERCE AVE ARMADALE	29.34	COM	GF	64	49	-	-	58	43	-	-	59	-	-	-
175	36-40 COMMERCE AVE ARMADALE	29.34	COM	F 1	64	50	-	-	58	44	-	-	63	-	-	-
176	36 HOBBS DR ARMADALE	29.90	RES	GF	54	60	60	0	53	54	55	-1	75	80	-5	OK
177	37 GEORGE ST BYFORD	35.22	RES	GF	45	53	60	-7	38	47	55	-8	72	80	-8	OK
178	37 RIVOSE CR DARLING DOWNS	32.89	RES	GF	44	50	60	-10	38	45	55	-10	70	80	-10	OK
179	37 WUNGONG RD ARMADALE	29.98	RES	GF	61	51	60	-9	57	46	55	-9	68	80	-12	OK
180	39 BUTCHER RD DARLING DOWNS	34.48	RES	GF	47	54	60	-6	41	49	55	-6	73	80	-7	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
181	39 GEORGE ST BYFORD	35.24	RES	GF	43	53	60	-7	36	47	55	-8	72	80	-8	OK
182	39 RIVOSE CR DARLING DOWNS	32.92	RES	GF	44	52	60	-8	38	46	55	-9	70	80	-10	OK
183	41 COMMERCE AVE ARMADALE	29.40	COM	GF	49	52	-	-	49	47	-	-	69	-	-	-
183	41 COMMERCE AVE ARMADALE	29.40	COM	F 1	52	51	-	-	52	45	-	-	67	-	-	-
183	41 COMMERCE AVE ARMADALE	29.40	COM	F 2	54	53	-	-	53	47	-	-	69	-	-	-
184	41 COMMERCE AVE ARMADALE	29.36	COM	GF	50	54	-	-	48	48	-	-	71	-	-	-
184	41 COMMERCE AVE ARMADALE	29.36	COM	F 1	53	54	-	-	50	48	-	-	72	-	-	-
185	41 GEORGE ST BYFORD	35.26	RES	GF	44	53	60	-7	39	47	55	-8	72	80	-9	OK
186	41 RIVOSE CR DARLING DOWNS	32.96	RES	GF	42	54	60	-6	36	48	55	-7	73	80	-7	OK
187	42 ALEXANDER RD BYFORD	35.10	RES	GF	48	53	60	-7	42	47	55	-8	72	80	-8	OK
188	42 COMMERCE AVE ARMADALE	29.41	COM	GF	58	51	-	-	54	46	-	-	64	-	-	-
189	43 GEORGE ST BYFORD	35.27	RES	GF	45	52	60	-8	39	47	55	-8	71	80	-9	OK
190	43 WUNGONG RD ARMADALE	30.04	RES	GF	62	55	60	-5	57	49	55	-6	70	80	-10	OK
191	44 ALEXANDER RD BYFORD	35.13	RES	GF	49	53	60	-7	44	47	55	-8	72	80	-8	OK
192	45 COMMERCE AVE ARMADALE	29.47	COM	GF	54	54	-	-	54	48	-	-	72	-	-	-
192	45 COMMERCE AVE ARMADALE	29.47	COM	F 1	56	56	-	-	55	50	-	-	72	-	-	-
193	45 RIVOSE CR DARLING DOWNS	33.00	RES	GF	42	52	60	-8	36	47	55	-8	71	80	-9	OK
194	45 WUNGONG RD ARMADALE	30.06	RES	GF	62	56	60	-4	57	51	55	-4	71	80	-9	OK
195	46 ALEXANDER RD BYFORD	35.15	RES	GF	49	53	60	-7	44	47	55	-8	72	80	-8	OK
196	48 ALEXANDER RD BYFORD	35.16	RES	GF	48	53	60	-7	42	48	55	-8	73	80	-7	OK
197	48 BRUNS DR DARLING DOWNS	33.25	RES	GF	40	52	60	-8	34	47	55	-8	71	80	-9	OK
198	49 RIVOSE CR DARLING DOWNS	33.03	RES	GF	41	49	60	-11	35	43	55	-12	68	80	-12	OK
199	49 WILLIAN ST ARMADALE	29.30	COM	GF	53	47	-	-	49	41	-	-	59	-	-	-
199	49 WILLIAN ST ARMADALE	29.30	COM	F 1	54	52	-	-	50	47	-	-	65	-	-	-
200	50 ALEXANDER RD BYFORD	35.19	RES	GF	48	52	60	-8	41	47	55	-8	72	80	-8	OK
201	51 JOHN ST ARMADALE	29.42	COM	GF	59	51	-	-	57	45	-	-	66	-	-	-

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
202	52 ALEXANDER RD BYFORD	35.21	RES	GF	48	51	60	-9	43	46	55	-10	71	80	-9	OK
203	53 MITCHELL ST WUNGONG	32.52	RES	GF	47	53	60	-7	40	48	55	-7	70	80	-10	OK
204	53 RIVOSE CR DARLING DOWNS	33.06	RES	GF	41	47	60	-13	35	41	55	-14	64	80	-16	OK
205	54 BRUNS DR DARLING DOWNS	33.29	RES	GF	39	52	60	-8	32	46	55	-9	70	80	-10	OK
206	55 ELEVENTH RD DARLING DOWNS	32.91	RES	GF	45	50	60	-10	41	44	55	-11	69	80	-12	OK
207	55 RIVOSE CR DARLING DOWNS	33.11	RES	GF	39	53	60	-7	33	47	55	-8	71	80	-9	OK
208	55 WUNGONG RD ARMADALE	30.17	RES	GF	61	59	60	-1	57	54	55	-2	75	80	-6	OK
209	56 BRUNS DR DARLING DOWNS	33.35	RES	GF	40	53	60	-7	34	47	55	-8	71	80	-9	OK
210	57 RIVOSE CR DARLING DOWNS	33.14	RES	GF	39	50	60	-10	33	44	55	-11	69	80	-11	OK
211	57 WUNGONG RD ARMADALE	30.19	RES	GF	60	59	60	-1	56	53	55	-2	74	80	-6	OK
212	58 BRUNS DR DARLING DOWNS	33.37	RES	GF	35	49	60	-11	29	43	55	-12	69	80	-12	OK
213	58 FOURTH RD ARMADALE	29.17	COM	GF	62	49	-	-	57	43	-	-	63	-	-	-
214	59 ELEVENTH RD DARLING DOWNS	32.88	RES	GF	44	55	60	-5	44	49	55	-6	74	80	-6	OK
215	59 RIVOSE CR DARLING DOWNS	33.19	RES	GF	40	53	60	-7	34	47	55	-8	71	80	-9	OK
216	59 WUNGONG RD ARMADALE	30.21	RES	GF	61	59	60	-2	57	53	55	-2	74	80	-6	OK
217	61 RIVOSE CR DARLING DOWNS	33.23	RES	GF	40	52	60	-8	34	46	55	-9	71	80	-9	OK
218	61 WUNGONG RD ARMADALE	30.23	RES	GF	61	59	60	-1	57	53	55	-2	74	80	-6	OK
219	62 HOBBS DR ARMADALE	29.69	RES	GF	57	51	60	-9	54	45	55	-10	69	80	-11	OK
219	62 HOBBS DR ARMADALE	29.69	RES	F 1	58	53	60	-7	55	48	55	-7	71	80	-10	OK
220	63 RIVOSE CR DARLING DOWNS	33.26	RES	GF	39	52	60	-8	32	47	55	-8	71	80	-9	OK
221	63 WUNGONG RD ARMADALE	30.25	RES	GF	61	58	60	-2	56	53	55	-2	74	80	-6	OK
222	65 TODMAN GR DARLING DOWNS	33.29	RES	GF	40	54	60	-6	34	48	55	-7	72	80	-8	OK
223	65 WUNGONG RD ARMADALE	30.27	RES	GF	61	59	60	-1	57	54	55	-1	75	80	-5	OK
224	66 ALEXANDER RD BYFORD	35.38	RES	GF	48	51	60	-9	43	46	55	-9	69	80	-11	OK
225	67 TODMAN GR DARLING DOWNS	33.33	RES	GF	39	52	60	-8	33	47	55	-8	71	80	-9	OK
226	67 WUNGONG RD ARMADALE	30.30	RES	GF	63	59	60	-1	57	54	55	-1	75	80	-5	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
227	68 ALEXANDER RD BYFORD	35.41	RES	GF	49	50	60	-10	43	44	55	-11	68	80	-12	OK
228	69 TODMAN GR DARLING DOWNS	33.37	RES	GF	42	53	60	-7	35	47	55	-8	72	80	-8	OK
229	69 WUNGONG RD ARMADALE	30.31	RES	GF	60	59	60	-1	56	53	55	-2	74	80	-6	OK
230	70 ALEXANDER RD BYFORD	35.43	RES	GF	48	49	60	-11	42	43	55	-12	68	80	-12	OK
231	71 WUNGONG RD ARMADALE	30.33	RES	GF	60	54	60	-6	56	48	55	-7	73	80	-7	OK
232	72 ALEXANDER RD BYFORD	35.45	RES	GF	47	49	60	-11	44	43	55	-12	68	80	-12	OK
233	74 ALEXANDER RD BYFORD	35.47	RES	GF	49	50	60	-10	46	44	55	-11	68	80	-12	OK
234	74 CHURCH AVE ARMADALE	29.61	RES	GF	62	51	60	-9	58	45	55	-10	70	80	-10	OK
235	73 WUNGONG RD ARMADALE	30.48	RES	GF	54	55	60	-5	52	49	55	-6	74	80	-6	OK
236	76 ALEXANDER RD BYFORD	35.49	RES	GF	50	49	60	-11	47	44	55	-11	68	80	-13	OK
237	78 ALEXANDER RD BYFORD	35.51	RES	GF	51	50	60	-10	47	44	55	-11	68	80	-12	OK
238	80 ALEXANDER RD BYFORD	35.52	RES	GF	51	50	60	-10	47	45	55	-11	67	80	-13	OK
239	81 EVANS WAY BYFORD	36.00	RES	GF	47	41	60	-20	44	35	55	-20	55	80	-26	OK
240	82 ALEXANDER RD BYFORD	35.55	RES	GF	52	52	60	-8	45	46	55	-9	68	80	-12	OK
241	83 EVANS WAY BYFORD	35.99	RES	GF	47	41	60	-19	43	35	55	-20	54	80	-26	OK
242	92 THIRD RD ARMADALE	28.91	COM	GF	65	52	-	-	59	46	-	-	70	-	-	-
242	92 THIRD RD ARMADALE	28.91	COM	F 1	65	54	-	-	59	49	-	-	70	-	-	-
243	108 ALEXANDER RD BYFORD	35.81	RES	GF	51	53	60	-7	44	48	55	-8	70	80	-10	OK
244	110 ALEXANDER RD BYFORD	35.82	RES	GF	51	52	60	-8	45	47	55	-9	69	80	-11	OK
245	110 WILSON ST WUNGONG	32.62	RES	GF	49	54	60	-6	43	48	55	-7	73	80	-7	OK
246	112 ALEXANDER RD BYFORD	35.83	RES	GF	51	51	60	-9	45	45	55	-10	68	80	-12	OK
247	114 ALEXANDER RD BYFORD	35.85	RES	GF	50	50	60	-10	48	44	55	-11	66	80	-14	OK
248	116 ALEXANDER RD BYFORD	35.87	RES	GF	50	49	60	-11	48	43	55	-12	65	80	-15	OK
249	118 ALEXANDER RD BYFORD	35.89	RES	GF	50	48	60	-12	48	42	55	-13	64	80	-16	OK
250	120 ALEXANDER RD BYFORD	35.90	RES	GF	50	48	60	-13	48	42	55	-13	64	80	-17	OK
251	122 ALEXANDER RD BYFORD	35.92	RES	GF	50	47	60	-13	43	41	55	-14	63	80	-17	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
252	124 ALEXANDER RD BYFORD	35.94	RES	GF	49	46	60	-14	49	40	55	-15	62	80	-18	OK
253	126 ALEXANDER RD BYFORD	35.95	RES	GF	50	46	60	-14	49	40	55	-15	61	80	-19	OK
254	131 LOWANNA WAY ARMADALE	27.55	RES	GF	68	52	60	-8	62	46	55	-9	67	80	-13	OK
255	195 WUNGONG RD BROOKDALE	31.33	RES	GF	60	53	60	-7	55	47	55	-8	72	80	-8	OK
256	197 WUNGONG RD BROOKDALE	31.34	IND	GF	61	52	-	-	56	46	-	-	70	-	-	-
257	199 WUNGONG RD BROOKDALE	31.35	RES	GF	61	51	60	-9	56	45	55	-10	70	80	-10	OK
258	201 WUNGONG RD BROOKDALE	31.36	RES	GF	62	51	60	-9	57	45	55	-10	68	80	-12	OK
259	224 JULL ST ARMADALE	29.12	COM	GF	61	50	-	-	56	44	-	-	66	-	-	-
260	234 JULL ST ARMADALE	29.07	COM	GF	61	49	-	-	56	43	-	-	67	-	-	-
261	245 SOUTH WESTERN HWY BYFORD	30.34	IND	GF	47	61	-	-	40	56	-	-	68	-	-	-
261	245 SOUTH WESTERN HWY BYFORD	30.34	IND	F 1	48	61	-	-	42	55	-	-	72	-	-	-
262	260 STREICH AV ARMADALE	27.69	RES	GF	61	52	60	-8	57	47	55	-8	64	80	-16	OK
263	262 STREICH AV ARMADALE	27.71	RES	GF	64	55	60	-5	59	49	55	-6	72	80	-8	OK
264	264 STREICH AV ARMADALE	27.74	RES	GF	63	53	60	-8	58	47	55	-8	68	80	-12	OK
265	268 STREICH AV ARMADALE	27.81	RES	GF	63	51	60	-9	57	46	55	-10	67	80	-13	OK
266	270 STREICH AV ARMADALE	27.83	RES	GF	65	51	60	-9	59	45	55	-10	68	80	-12	OK
267	272 STREICH AV ARMADALE	27.88	RES	GF	61	50	60	-10	57	44	55	-11	66	80	-14	OK
268	274 STREICH AV ARMADALE	27.91	RES	GF	62	53	60	-7	58	47	55	-8	69	80	-12	OK
269	276 STREICH AV ARMADALE	27.94	RES	GF	63	55	60	-5	58	49	55	-6	69	80	-11	OK
270	278 STREICH AV ARMADALE	27.95	RES	GF	63	53	60	-7	58	48	55	-8	69	80	-11	OK
271	298 STREICH AV ARMADALE	28.04	RES	GF	58	52	60	-8	55	47	55	-9	68	80	-12	OK
272	298 STREICH AV ARMADALE	28.03	RES	GF	58	55	60	-5	55	49	55	-6	70	80	-10	OK
273	302 STREICH AV ARMADALE	28.06	RES	GF	52	56	60	-4	52	50	55	-5	71	80	-9	OK
274	304A STREICH AV ARMADALE	28.08	RES	GF	62	57	60	-3	57	51	55	-4	74	80	-6	OK
275	306 STREICH AV ARMADALE	28.10	RES	GF	62	57	60	-3	58	51	55	-4	75	80	-6	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
276	307 RAILWAY AV ARMADALE	27.57	RES	GF	67	53	60	-8	61	47	55	-8	64	80	-16	OK
277	307 RAILWAY AV ARMADALE	27.59	RES	GF	67	48	60	-12	61	43	55	-12	65	80	-16	OK
278	308 STREICH AV ARMADALE	28.12	RES	GF	62	56	60	-4	58	50	55	-5	74	80	-6	OK
279	309 RAILWAY AV ARMADALE	27.61	RES	GF	69	53	60	-7	63	47	55	-8	66	80	-14	OK
280	309 RAILWAY AV ARMADALE	27.63	RES	GF	69	53	60	-7	62	47	55	-8	66	80	-14	OK
281	312 STREICH AV ARMADALE	28.14	RES	GF	59	57	60	-3	55	52	55	-3	74	80	-6	OK
282	312 STREICH AV ARMADALE	28.16	RES	GF	60	57	60	-3	56	51	55	-4	74	80	-6	OK
283	313 RAILWAY AV ARMADALE	27.67	RES	GF	63	51	60	-9	59	45	55	-10	63	80	-17	OK
284	316 STREICH AV ARMADALE	28.18	RES	GF	61	55	60	-5	57	49	55	-6	72	80	-8	OK
285	316 STREICH AV ARMADALE	28.20	RES	GF	60	55	60	-6	57	49	55	-6	72	80	-8	OK
286	317 RAILWAY AV ARMADALE	27.70	RES	GF	61	49	60	-11	57	43	55	-12	62	80	-18	OK
287	321 RAILWAY AV ARMADALE	27.73	RES	GF	64	50	60	-10	59	44	55	-11	63	80	-17	OK
288	322 STREICH AV ARMADALE	28.22	RES	GF	61	55	60	-5	58	49	55	-6	73	80	-7	OK
289	324 STREICH AV ARMADALE	28.26	RES	GF	60	54	60	-6	57	48	55	-7	69	80	-11	OK
290	327 RAILWAY AV ARMADALE	27.76	RES	GF	60	49	60	-11	57	43	55	-12	62	80	-18	OK
291	328 STREICH AV ARMADALE	28.30	RES	GF	64	53	60	-7	60	47	55	-8	69	80	-11	OK
292	330 STREICH AV ARMADALE	28.32	RES	GF	64	53	60	-7	60	47	55	-8	71	80	-9	OK
293	331 RAILWAY AV ARMADALE	27.79	RES	GF	69	50	60	-10	62	44	55	-11	66	80	-14	OK
294	331 RAILWAY AV ARMADALE	27.78	RES	GF	68	52	60	-8	62	46	55	-9	66	80	-14	OK
295	331 RAILWAY AV ARMADALE	27.78	RES	GF	69	50	60	-10	62	44	55	-11	66	80	-14	OK
296	331 RAILWAY AV ARMADALE	27.80	RES	GF	69	52	60	-8	62	46	55	-9	66	80	-14	OK
297	332 STREICH AV ARMADALE	28.35	RES	GF	64	54	60	-6	60	48	55	-7	71	80	-9	OK
298	334 STREICH AVE ARMADALE	28.36	RES	GF	64	55	60	-5	60	49	55	-6	73	80	-7	OK
299	341 RAILWAY AV ARMADALE	27.89	RES	GF	62	47	60	-13	58	41	55	-14	61	80	-19	OK
300	343 RAILWAY AV ARMADALE	27.92	RES	GF	64	49	60	-11	59	43	55	-12	64	80	-17	OK
301	347 RAILWAY AV ARMADALE	27.95	RES	GF	63	49	60	-11	59	44	55	-11	63	80	-17	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
302	355 RAILWAY AV ARMADALE	28.04	RES	GF	62	54	60	-6	58	49	55	-6	72	80	-8	OK
303	357 RAILWAY AV ARMADALE	28.06	RES	GF	65	55	60	-5	60	50	55	-5	74	80	-6	OK
304	359 RAILWAY AV ARMADALE	28.08	RES	GF	66	56	60	-5	60	50	55	-5	73	80	-7	OK
305	361 RAILWAY AV ARMADALE	28.10	RES	GF	66	56	60	-5	60	50	55	-5	74	80	-6	OK
306	363 RAILWAY AV ARMADALE	28.12	RES	GF	65	55	60	-5	60	50	55	-5	73	80	-7	OK
307	365 RAILWAY AV ARMADALE	28.15	RES	GF	65	57	60	-3	60	51	55	-4	72	80	-8	OK
308	367A RAILWAY AV ARMADALE	28.16	RES	GF	68	56	60	-5	61	50	55	-5	71	80	-9	OK
309	369 RAILWAY AV ARMADALE	28.19	RES	GF	66	54	60	-6	60	49	55	-6	69	80	-11	OK
310	371 RAILWAY AV ARMADALE	28.21	RES	GF	66	54	60	-6	60	49	55	-7	72	80	-9	OK
311	373 RAILWAY AV ARMADALE	28.23	RES	GF	65	55	60	-5	60	49	55	-6	72	80	-8	OK
312	375 RAILWAY AV ARMADALE	28.25	RES	GF	65	54	60	-6	60	48	55	-7	73	80	-8	OK
313	377 RAILWAY AV ARMADALE	28.28	RES	GF	66	54	60	-7	61	48	55	-7	72	80	-8	OK
314	379 RAILWAY AV ARMADALE	28.29	RES	GF	65	53	60	-7	60	47	55	-8	72	80	-8	OK
315	405 ARAGON CT ARMADALE	28.60	RES	GF	49	51	60	-9	50	45	55	-10	68	80	-12	OK
316	405 ARAGON CT ARMADALE	28.56	RES	GF	60	50	60	-10	55	44	55	-11	67	80	-13	OK
317	405 ARAGON CT ARMADALE	28.62	RES	GF	52	53	60	-7	49	47	55	-8	70	80	-10	OK
318	405 ARAGON CT ARMADALE	28.60	RES	GF	51	53	60	-7	51	48	55	-7	71	80	-9	OK
319	407 RAILWAY AV ARMADALE	28.57	RES	GF	59	55	60	-5	54	49	55	-6	73	80	-7	OK
320	413 ARAGON CT ARMADALE	28.66	RES	GF	55	55	60	-6	51	49	55	-6	72	80	-8	OK
321	415 ARAGON CT ARMADALE	28.68	RES	GF	55	55	60	-6	50	49	55	-6	73	80	-7	OK
322	417 ARAGON CT ARMADALE	28.70	RES	GF	55	55	60	-5	50	49	55	-6	73	80	-7	OK
323	419 ARAGON CT ARMADALE	28.72	RES	GF	55	54	60	-6	50	49	55	-7	72	80	-8	OK
324	421 ARAGON CT ARMADALE	28.74	RES	GF	50	52	60	-8	47	46	55	-9	68	80	-12	OK
325	423 ARAGON CT ARMADALE	28.76	RES	GF	55	54	60	-6	50	49	55	-7	71	80	-9	OK
326	425 ARAGON CT ARMADALE	28.78	RES	GF	55	54	60	-6	51	48	55	-7	71	80	-9	OK
327	431 RAILWAY AV ARMADALE	28.82	RES	GF	57	54	60	-6	55	49	55	-7	70	80	-10	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
328	438 GREEN AVE ARMADALE	28.90	COM	GF	60	52	-	-	57	46	-	-	68	-	-	-
328	438 GREEN AVE ARMADALE	28.90	COM	F 1	61	52	-	-	58	46	-	-	68	-	-	-
329	438 GREEN AVE ARMADALE	28.94	COM	GF	55	54	-	-	52	49	-	-	72	-	-	-
330	459 GREEN AVE ARMADALE	29.13	RES	GF	62	48	60	-12	57	43	55	-12	61	80	-19	OK
331	469 GREEN AVE ARMADALE	29.24	RES	GF	63	51	60	-9	58	45	55	-10	68	80	-12	OK
332	483 GREEN AVE ARMADALE	29.41	RES	GF	61	51	60	-9	57	45	55	-10	69	80	-11	OK
333	489 GREEN AVE ARMADALE	29.50	RES	GF	62	51	60	-9	58	45	55	-10	70	80	-10	OK
334	495 GREEN AVE ARMADALE	29.53	RES	GF	62	51	60	-9	59	45	55	-10	70	80	-10	OK
335	777 SOUTH WESTERN HWY BYFORD	35.77	COM	GF	46	53	-	-	43	47	-	-	69	-	-	-
335	777 SOUTH WESTERN HWY BYFORD	35.77	COM	F 1	47	56	-	-	44	51	-	-	73	-	-	-
336	797 SOUTH WESTERN HWY BYFORD	35.92	COM	GF	44	47	-	-	45	41	-	-	63	-	-	-
336	797 SOUTH WESTERN HWY BYFORD	35.92	COM	F 1	47	54	-	-	47	48	-	-	70	-	-	-
337	807 SOUTH WESTERN HWY BYFORD	36.09	COM	GF	44	49	-	-	44	44	-	-	64	-	-	-
338	809 SOUTH WESTERN HWY BYFORD	36.12	COM	GF	43	49	-	-	46	43	-	-	64	-	-	-
339	811 SOUTH WESTERN HWY BYFORD	36.15	RES	GF	44	40	60	-20	47	34	55	-21	54	80	-26	OK
340	813 SOUTH WESTERN HWY BYFORD	36.17	RES	GF	44	40	60	-20	47	34	55	-21	54	80	-26	OK
341	815 SOUTH WESTERN HWY BYFORD	36.21	RES	GF	53	38	60	-22	53	33	55	-22	52	80	-28	OK
342	821 SOUTH WESTERN HWY BYFORD	36.24	COM	GF	45	48	-	-	47	42	-	-	64	-	-	-
343	829 SOUTH WESTERN HWY BYFORD	36.24	COM	GF	47	42	-	-	48	36	-	-	58	-	-	-
344	2313 THOMAS ST DARLING DOWNS	34.80	RES	GF	56	54	60	-7	50	48	55	-7	72	80	-8	OK
345	FUTURE DEVELOPMENT 100	34.43	RES	GF	48	53	60	-7	41	47	55	-8	72	80	-8	OK

ID	Address	Chainage (km)	Usage	Floor	LAeq,day, dB				LAeq, night, dB				LAmax, dB			Expected outcome
					Env. Road	Predicted Lvl	Design Lvl	Margin	Env. Road	Predicted Lvl	Design Lvl	Margin	Predicted Lvl	Design Lvl	Margin	
346	FUTURE DEVELOPMENT 101	34.38	RES	GF	48	53	60	-7	41	48	55	-7	72	80	-8	OK
347	FUTURE DEVELOPMENT 102	34.33	RES	GF	48	55	60	-6	41	49	55	-6	73	80	-7	OK
348	FUTURE DEVELOPMENT 103	34.28	RES	GF	47	56	60	-5	41	50	55	-5	75	80	-5	OK
349	FUTURE DEVELOPMENT 104	34.23	RES	GF	47	56	60	-4	41	50	55	-5	75	80	-5	OK
350	FUTURE DEVELOPMENT 105	34.18	RES	GF	47	56	60	-4	40	50	55	-5	75	80	-5	OK
351	FUTURE DEVELOPMENT 106	34.13	RES	GF	47	56	60	-4	40	50	55	-5	75	80	-5	OK
352	FUTURE DEVELOPMENT 107	34.07	RES	GF	47	55	60	-5	40	50	55	-6	74	80	-6	OK
353	FUTURE DEVELOPMENT 108	34.03	RES	GF	46	54	60	-6	40	48	55	-7	73	80	-7	OK
354	FUTURE DEVELOPMENT 109	33.97	RES	GF	46	52	60	-8	40	46	55	-9	70	80	-10	OK
355	FUTURE DEVELOPMENT 110	33.92	RES	GF	46	54	60	-6	39	49	55	-7	73	80	-7	OK
356	FUTURE DEVELOPMENT 111	33.87	RES	GF	46	55	60	-5	39	49	55	-6	74	80	-6	OK
357	FUTURE DEVELOPMENT 112	33.81	RES	GF	46	55	60	-5	39	50	55	-6	74	80	-6	OK
358	FUTURE DEVELOPMENT 113	33.76	RES	GF	45	55	60	-5	39	49	55	-6	74	80	-6	OK
359	FUTURE DEVELOPMENT 114	33.71	RES	GF	45	55	60	-5	38	49	55	-6	74	80	-6	OK
360	FUTURE DEVELOPMENT 115	33.66	RES	GF	45	55	60	-5	38	49	55	-6	74	80	-6	OK
361	FUTURE DEVELOPMENT 116	33.61	RES	GF	45	54	60	-6	38	49	55	-6	74	80	-6	OK
362	FUTURE DEVELOPMENT 117	33.55	RES	GF	44	54	60	-6	38	48	55	-7	74	80	-6	OK
363	GEORGE ST BYFORD	34.95	IND	GF	51	52	-	-	45	46	-	-	71	-	-	-
364	WALLANGARRA ADULT RIDERS CLUB	31.81	COM	GF	44	59	-	-	38	53	-	-	78	-	-	-

E.2 Mitigated Vibration Results

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
1	1 COMMERCE AVE ARMADALE	28.92	COM	23	83	112	-29	14	45	-31	OK
2	1 DEERNESS WAY ARMADALE	29.87	RES	46	92	106	-14	31	35	-4	OK
3	1 MAKIN CT BYFORD	35.44	RES	57	90	106	-16	29	35	-6	OK
4	1 MCGURK CT BYFORD	35.54	RES	61	89	106	-17	27	35	-8	OK
5	1 PEPPIES CR BYFORD	35.35	RES	55	93	106	-13	33	35	-2	OK
6	1 PIRA LP BYFORD	35.31	RES	54	92	106	-14	31	35	-4	OK
7	1 RUM LINK BYFORD	35.07	RES	49	92	106	-14	31	35	-4	OK
8	5 NETLEY PL ARMADALE	28.44	RES	59	80	106	-26	9	35	-26	OK
9	2 MAKIN CT BYFORD	35.39	RES	59	90	106	-16	29	35	-6	OK
10	2 MCGURK CT BYFORD	35.48	RES	56	90	106	-16	29	35	-6	OK
11	2 PROUT ARMADALE	30.11	RES	50	93	106	-13	32	35	-3	OK
12	2 RUM LINK BYFORD	35.05	RES	50	92	106	-14	31	35	-4	OK
13	2 SELKIRK RD ARMADALE	29.47	RES	69	81	106	-25	10	35	-25	OK
14	2 TUDOR RD ARMADALE	29.08	RES	61	72	106	-34	2	35	-33	OK
15	3 FERNIE CT BROOKDALE	30.82	RES	68	88	106	-18	27	35	-8	OK
16	3 MASSELL WAY BROOKDALE	31.15	RES	69	88	106	-18	26	35	-9	OK
17	3 NETLEY PL ARMADALE	28.47	RES	58	80	106	-26	10	35	-25	OK
18	3 PEPPIES CR BYFORD	35.34	RES	69	90	106	-16	28	35	-7	OK
19	3 PIRA LP BYFORD	35.31	RES	66	89	106	-17	27	35	-8	OK
20	3 RUM LINK BYFORD	35.07	RES	73	86	106	-20	24	35	-11	OK
21	3 WUNGONG RD ARMADALE	29.63	RES	54	81	106	-25	11	35	-24	OK
22	4 ALEXANDER RD BYFORD	34.92	RES	52	92	106	-14	31	35	-4	OK
23	4 FERNIE CT BROOKDALE	30.85	RES	65	89	106	-17	28	35	-7	OK
24	4 FIFTH RD ARMADALE	29.33	RES	75	74	106	-32	3	35	-32	OK
25	8 HOBBS DR ARMADALE	29.62	RES	65	78	106	-28	7	35	-28	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
26	4 JEFFREY LP BROOKDALE	30.89	RES	70	88	106	-18	26	35	-9	OK
27	4 MAKIN CT BYFORD	35.39	RES	84	85	106	-21	22	35	-13	OK
28	4 MCGURK CT BYFORD	35.49	RES	79	85	106	-21	22	35	-13	OK
29	4 RUM LINK BYFORD	35.05	RES	72	86	106	-20	24	35	-11	OK
30	2 DEERNESS WAY ARMADALE	29.83	RES	48	91	106	-15	30	35	-5	OK
31	5 FERNIE CT BROOKDALE	30.82	RES	47	94	106	-12	33	35	-2	OK
32	5 JEFFREY LP BROOKDALE	30.92	RES	73	87	106	-19	25	35	-10	OK
33	5 MASSELL WAY BROOKDALE	31.15	RES	85	85	106	-21	22	35	-13	OK
34	5 PEPPIES CR BYFORD	35.34	RES	77	88	106	-18	26	35	-9	OK
35	5 PIRA LP BYFORD	35.31	RES	82	85	106	-21	23	35	-12	OK
36	5 SELKIRK RD ARMADALE	29.40	RES	64	77	106	-29	6	35	-29	OK
37	5 WUNGONG RD ARMADALE	29.66	RES	48	82	106	-24	12	35	-23	OK
38	6 ALEXANDER RD BYFORD	34.93	RES	53	91	106	-15	30	35	-5	OK
39	6 D'VITALE LOOP BYFORD	35.13	RES	81	85	106	-21	23	35	-12	OK
40	6 FERNIE CT BROOKDALE	30.85	RES	49	93	106	-13	33	35	-2	OK
41	6 JEFFREY LP BROOKDALE	30.89	RES	56	91	106	-15	30	35	-5	OK
42	6 TUDOR RD ARMADALE	29.06	RES	98	66	106	-40	-	35	-	OK
43	34 HOBBS DR ARMADALE	29.73	RES	45	85	106	-21	16	35	-19	OK
44	6 WIGAN BROOKDALE	31.12	RES	60	90	106	-16	29	35	-6	OK
45	7 JEFFREY LP BROOKDALE	30.92	RES	63	89	106	-17	28	35	-7	OK
46	30 HOBBS DR ARMADALE	29.79	RES	50	90	106	-16	25	35	-10	OK
47	7 WUNGONG RD ARMADALE	29.68	RES	50	82	106	-24	12	35	-23	OK
48	8 ALEXANDER RD BYFORD	34.96	RES	53	91	106	-15	30	35	-5	OK
49	425 ARAGON CT ARMADALE	28.78	RES	45	83	106	-23	13	35	-22	OK
50	8 DANE COU DANE CT BROOKDALE	30.77	RES	72	87	106	-19	25	35	-10	OK
51	8 PIRA LP BYFORD	35.34	RES	89	84	106	-22	21	35	-14	OK
52	8 WIGAN BROOKDALE	31.10	RES	61	90	106	-16	29	35	-6	OK
53	9 BARGE CT ARMADALE	30.52	RES	83	85	106	-21	22	35	-13	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
54	9 FIFTH RD ARMADALE	29.28	RES	80	72	106	-34	1	35	-34	OK
55	9 JEFFREY LP BROOKDALE	30.95	RES	60	90	106	-16	29	35	-6	OK
56	9 WUNGONG RD ARMADALE	29.71	RES	45	87	106	-19	18	35	-17	OK
57	9 WUNGONG RD ARMADALE	29.71	RES	44	84	106	-22	14	35	-21	OK
58	10 ALEXANDER RD BYFORD	34.97	RES	54	91	106	-15	30	35	-5	OK
59	423 ARAGON CT ARMADALE	28.76	RES	44	82	106	-24	12	35	-23	OK
60	10 DANE CT BROOKDALE	30.78	RES	53	92	106	-14	31	35	-4	OK
61	10 LARSEN RD BYFORD	35.58	RES	53	92	106	-14	31	35	-4	OK
62	10 WOODSTOCK PL DARLING DOWNS	32.98	RES	87	84	106	-22	21	35	-14	OK
63	11 BARGE CT ARMADALE	30.51	RES	53	92	106	-14	31	35	-4	OK
64	13 BRIXEY CT ARMADALE	30.44	RES	79	86	106	-20	24	35	-11	OK
65	11 JEFFREY LP BROOKDALE	30.97	RES	59	90	106	-16	29	35	-6	OK
66	12 ALEXANDER RD BYFORD	34.99	RES	52	91	106	-15	30	35	-5	OK
67	12 WOODSTOCK PL DARLING DOWNS	33.02	RES	54	92	106	-14	31	35	-4	OK
68	FUTURE DEVELOPMENT 100	34.43	RES	72	96	106	-10	34	35	-1	OK
69	13 GEORGE ST BYFORD	34.99	RES	57	91	106	-15	30	35	-5	OK
70	13 TROTMAN CT BROOKDALE	31.27	RES	83	85	106	-21	23	35	-12	OK
71	14 ALEXANDER RD BYFORD	35.01	RES	54	91	106	-15	30	35	-5	OK
72	419 ARAGON CT ARMADALE	28.72	RES	42	82	106	-24	12	35	-23	OK
73	73 WUNGONG RD ARMADALE	30.48	RES	57	91	106	-15	30	35	-5	OK
74	14 BRIXEY CT ARMADALE	30.35	RES	57	91	106	-15	30	35	-5	OK
75	15 GEORGE ST BYFORD	35.00	RES	58	91	106	-15	30	35	-5	OK
76	11 COOMBE AVE ARMADALE	29.66	RES	59	79	106	-27	8	35	-27	OK
77	15 TROTMAN CT BROOKDALE	31.28	RES	77	87	106	-19	25	35	-10	OK
78	417 ARAGON CT ARMADALE	28.70	RES	41	83	106	-23	13	35	-22	OK
79	16 BRIXEY CT ARMADALE	30.38	RES	67	88	106	-18	27	35	-8	OK
80	16 LARSEN RD BYFORD	35.59	RES	53	92	106	-14	32	35	-3	OK
81	5 HOBBS DR ARMADALE	29.55	RES	75	76	106	-30	5	35	-30	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
82	17 GEORGE ST BYFORD	35.02	RES	60	90	106	-16	29	35	-6	OK
83	17 WUNGONG RD ARMADALE	29.78	RES	53	90	106	-16	24	35	-11	OK
84	415 ARAGON CT ARMADALE	28.68	RES	42	82	106	-24	12	35	-23	OK
85	18 BRIXEY CT ARMADALE	30.41	RES	59	91	106	-15	29	35	-6	OK
86	224 JULL ST ARMADALE	29.12	COM	79	68	112	-44	-	45	-	OK
87	18 JEFFREY LP BROOKDALE	31.08	RES	57	91	106	-15	30	35	-5	OK
88	18 LARSEN RD BYFORD	35.59	RES	72	88	106	-18	26	35	-9	OK
89	12 HOBBS DR ARMADALE	29.60	RES	72	76	106	-30	5	35	-30	OK
90	19 GEORGE ST BYFORD	35.04	RES	58	91	106	-15	30	35	-5	OK
91	19 JEFFREY LP BROOKDALE	31.05	RES	64	89	106	-17	28	35	-7	OK
92	19 WUNGONG RD ARMADALE	29.80	RES	50	92	106	-14	28	35	-7	OK
93	413 ARAGON CT ARMADALE	28.66	RES	42	83	106	-23	12	35	-23	OK
94	31 HOBBS DR ARMADALE	29.77	RES	45	90	106	-16	24	35	-11	OK
95	20 JEFFREY LP BROOKDALE	31.07	RES	71	87	106	-19	26	35	-9	OK
96	2 HOBBS DR ARMADALE	29.53	RES	85	75	106	-31	4	35	-31	OK
97	20 LARSEN RD BYFORD	35.59	RES	87	86	106	-20	22	35	-13	OK
98	21 GEORGE ST BYFORD	35.06	RES	60	90	106	-16	29	35	-6	OK
99	21 JEFFREY LP BROOKDALE	31.05	RES	76	86	106	-20	24	35	-11	OK
100	21 WUNGONG RD ARMADALE	29.81	RES	42	93	106	-13	33	35	-2	OK
101	21 WUNGONG RD ARMADALE	29.81	RES	42	94	106	-12	32	35	-3	OK
102	22 TROTMAN CT BROOKDALE	31.23	RES	50	93	106	-13	32	35	-3	OK
103	23 GEORGE ST BYFORD	35.07	RES	60	90	106	-16	29	35	-6	OK
104	23 PEPPIES CR BYFORD	35.25	RES	80	85	106	-21	22	35	-13	OK
105	23 WUNGONG RD ARMADALE	29.86	RES	42	94	106	-12	33	35	-2	OK
106	23 WUNGONG RD ARMADALE	29.86	RES	42	93	106	-13	33	35	-2	OK
107	23 WUNGONG RD ARMADALE	29.86	RES	42	94	106	-12	34	35	-1	OK
108	405 ARAGON CT ARMADALE	28.60	RES	36	84	106	-22	14	35	-21	OK
109	405 ARAGON CT ARMADALE	28.60	RES	56	79	106	-27	9	35	-26	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
110	405 ARAGON CT ARMADALE	28.60	RES	50	81	106	-25	10	35	-25	OK
111	24 TROTMAN CT BROOKDALE	31.24	RES	64	89	106	-17	28	35	-7	OK
112	25 GEORGE ST BYFORD	35.08	RES	59	91	106	-15	29	35	-6	OK
113	25 PEPPIES CR BYFORD	35.25	RES	68	87	106	-19	26	35	-9	OK
114	407 RAILWAY AV ARMADALE	28.57	RES	41	83	106	-23	13	35	-22	OK
115	26 COMMERCE AVE ARMADALE	29.22	COM	71	66	112	-46	-	45	-	OK
116	26 TROTMAN CT BROOKDALE	31.24	RES	53	92	106	-14	31	35	-4	OK
117	27 GEORGE ST BYFORD	35.10	RES	62	90	106	-16	29	35	-6	OK
118	27 PEPPIES CR BYFORD	35.24	RES	52	91	106	-15	30	35	-5	OK
119	28 COMMERCE AVE ARMADALE	29.24	COM	73	65	112	-47	-	45	-	OK
120	29 BUTCHER RD DARLING DOWNS	34.56	RES	73	96	106	-10	34	35	-1	OK
121	30 COMMERCE AVE ARMADALE	29.26	COM	72	66	112	-46	-	45	-	OK
122	28 HOBBS DR ARMADALE	29.81	RES	48	91	106	-15	29	35	-6	OK
123	31 GEORGE ST BYFORD	35.16	RES	59	91	106	-15	29	35	-6	OK
124	31 WUNGONG RD ARMADALE	29.92	RES	51	92	106	-14	31	35	-4	OK
125	33 GEORGE ST BYFORD	35.18	RES	57	91	106	-15	30	35	-5	OK
126	33 WUNGONG RD ARMADALE	29.94	RES	50	92	106	-14	32	35	-3	OK
127	35 BUTCHER RD DARLING DOWNS	34.52	RES	72	96	106	-10	35	35	0	OK
128	35 GEORGE ST BYFORD	35.20	RES	58	91	106	-15	30	35	-5	OK
129	35 WUNGONG RD ARMADALE	29.96	RES	49	93	106	-13	32	35	-3	OK
130	37 GEORGE ST BYFORD	35.22	RES	59	91	106	-15	30	35	-5	OK
131	37 RIVOSE CR DARLING DOWNS	32.89	RES	88	84	106	-22	21	35	-14	OK
132	37 WUNGONG RD ARMADALE	29.98	RES	52	92	106	-14	31	35	-4	OK
133	36 HOBBS DR ARMADALE	29.90	RES	45	92	106	-14	32	35	-3	OK
134	39 BUTCHER RD DARLING DOWNS	34.48	RES	84	94	106	-12	31	35	-4	OK
135	39 GEORGE ST BYFORD	35.24	RES	58	91	106	-15	30	35	-5	OK
136	39 RIVOSE CR DARLING DOWNS	32.92	RES	78	86	106	-20	24	35	-11	OK
137	7 HOBBS DR ARMADALE	29.57	RES	71	76	106	-30	5	35	-30	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
138	41 COMMERCE AVE ARMADALE	29.40	COM	27	79	112	-33	10	45	-35	OK
139	41 COMMERCE AVE ARMADALE	29.40	COM	20	84	112	-28	16	45	-29	OK
140	41 GEORGE ST BYFORD	35.26	RES	59	91	106	-15	29	35	-6	OK
141	42 ALEXANDER RD BYFORD	35.10	RES	54	91	106	-15	30	35	-5	OK
142	42 COMMERCE AVE ARMADALE	29.41	COM	95	67	112	-45	-	45	-	OK
143	43 GEORGE ST BYFORD	35.27	RES	56	91	106	-15	30	35	-5	OK
144	43 WUNGONG RD ARMADALE	30.04	RES	50	93	106	-13	32	35	-3	OK
145	44 ALEXANDER RD BYFORD	35.13	RES	54	91	106	-15	30	35	-5	OK
146	45 COMMERCE AVE ARMADALE	29.47	COM	24	88	112	-24	19	45	-26	OK
147	45 WUNGONG RD ARMADALE	30.06	RES	50	93	106	-13	32	35	-3	OK
148	46 ALEXANDER RD BYFORD	35.15	RES	53	91	106	-15	30	35	-5	OK
149	62 HOBBS DR ARMADALE	29.69	RES	43	83	106	-23	13	35	-22	OK
150	48 ALEXANDER RD BYFORD	35.16	RES	53	91	106	-15	30	35	-5	OK
151	48 BRUNS DR DARLING DOWNS	33.25	RES	48	93	106	-13	33	35	-2	OK
152	50 ALEXANDER RD BYFORD	35.19	RES	55	90	106	-16	29	35	-6	OK
153	51 JOHN ST ARMADALE	29.42	COM	88	69	112	-43	-	45	-	OK
154	52 ALEXANDER RD BYFORD	35.21	RES	54	91	106	-15	30	35	-5	OK
155	54 BRUNS DR DARLING DOWNS	33.29	RES	57	91	106	-15	30	35	-5	OK
156	55 ELEVENTH RD DARLING DOWNS	32.91	RES	92	83	106	-23	20	35	-15	OK
157	55 RIVOSE CR DARLING DOWNS	33.11	RES	87	84	106	-22	22	35	-13	OK
158	55 WUNGONG RD ARMADALE	30.17	RES	51	93	106	-13	32	35	-3	OK
159	56 BRUNS DR DARLING DOWNS	33.35	RES	78	86	106	-20	24	35	-11	OK
160	57 WUNGONG RD ARMADALE	30.19	RES	52	92	106	-14	32	35	-3	OK
161	58 BRUNS DR DARLING DOWNS	33.37	RES	107	80	106	-26	16	35	-19	OK
162	59 ELEVENTH RD DARLING DOWNS	32.88	RES	38	96	106	-10	36	35	1	1 dB
163	59 WUNGONG RD ARMADALE	30.21	RES	52	92	106	-14	32	35	-3	OK
164	61 WUNGONG RD ARMADALE	30.23	RES	51	93	106	-13	32	35	-3	OK
165	63 WUNGONG RD ARMADALE	30.25	RES	53	92	106	-14	31	35	-4	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
166	61 RIVOSE CR DARLING DOWNS	33.23	RES	93	83	106	-23	20	35	-15	OK
167	65 TODMAN GR DARLING DOWNS	33.29	RES	80	86	106	-20	23	35	-12	OK
168	65 WUNGONG RD ARMADALE	30.27	RES	51	93	106	-13	32	35	-3	OK
169	66 ALEXANDER RD BYFORD	35.38	RES	54	93	106	-13	32	35	-3	OK
170	67 TODMAN GR DARLING DOWNS	33.33	RES	68	88	106	-18	27	35	-8	OK
171	67 WUNGONG RD ARMADALE	30.30	RES	46	94	106	-12	33	35	-2	OK
172	68 ALEXANDER RD BYFORD	35.41	RES	53	91	106	-15	30	35	-5	OK
173	69 TODMAN GR DARLING DOWNS	33.37	RES	69	88	106	-18	26	35	-9	OK
174	69 WUNGONG RD ARMADALE	30.31	RES	51	93	106	-13	32	35	-3	OK
175	70 ALEXANDER RD BYFORD	35.43	RES	57	90	106	-16	28	35	-7	OK
176	71 WUNGONG RD ARMADALE	30.33	RES	52	92	106	-14	31	35	-4	OK
177	72 ALEXANDER RD BYFORD	35.45	RES	57	89	106	-17	28	35	-7	OK
178	74 ALEXANDER RD BYFORD	35.47	RES	55	90	106	-16	29	35	-6	OK
179	74 CHURCH AVE ARMADALE	29.61	RES	71	77	106	-29	6	35	-29	OK
180	76 ALEXANDER RD BYFORD	35.49	RES	54	90	106	-16	29	35	-6	OK
181	78 ALEXANDER RD BYFORD	35.51	RES	53	90	106	-16	29	35	-6	OK
182	80 ALEXANDER RD BYFORD	35.52	RES	54	89	106	-17	28	35	-7	OK
183	92 THIRD RD ARMADALE	28.91	COM	65	73	112	-39	2	45	-43	OK
184	108 ALEXANDER RD BYFORD	35.81	RES	54	96	106	-10	35	35	0	OK
185	110 ALEXANDER RD BYFORD	35.82	RES	54	96	106	-10	35	35	0	OK
186	110 WILSON ST WUNGONG	32.62	RES	82	85	106	-21	23	35	-12	OK
187	112 ALEXANDER RD BYFORD	35.83	RES	54	96	106	-10	34	35	-1	OK
188	114 ALEXANDER RD BYFORD	35.85	RES	53	95	106	-11	34	35	-1	OK
189	116 ALEXANDER RD BYFORD	35.87	RES	51	95	106	-11	34	35	-1	OK
190	118 ALEXANDER RD BYFORD	35.89	RES	51	95	106	-11	34	35	-1	OK
191	120 ALEXANDER RD BYFORD	35.90	RES	51	94	106	-12	34	35	-1	OK
192	122 ALEXANDER RD BYFORD	35.92	RES	50	94	106	-12	33	35	-2	OK
193	126 ALEXANDER RD BYFORD	35.95	RES	48	94	106	-12	33	35	-2	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
194	195 WUNGONG RD BROOKDALE	31.33	RES	68	92	106	-14	30	35	-5	OK
195	197 WUNGONG RD BROOKDALE	31.34	RES	78	91	106	-15	29	35	-6	OK
196	199 WUNGONG RD BROOKDALE	31.35	RES	90	90	106	-16	27	35	-8	OK
197	201 WUNGONG RD BROOKDALE	31.36	RES	98	89	106	-17	26	35	-9	OK
198	234 JULL ST ARMADALE	29.07	COM	79	69	112	-43	-	45	-	OK
199	334 STREICH AVE ARMADALE	28.36	RES	58	80	106	-26	10	35	-25	OK
200	2 NETLEY PL ARMADALE	28.40	RES	53	81	106	-25	11	35	-24	OK
201	438 GREEN AVE ARMADALE	28.90	COM	22	84	112	-28	15	45	-30	OK
202	438 GREEN AVE ARMADALE	28.90	COM	33	79	112	-33	9	45	-36	OK
203	459 GREEN AVE ARMADALE	29.13	RES	61	71	106	-35	1	35	-34	OK
204	469 GREEN AVE ARMADALE	29.24	RES	58	75	106	-31	5	35	-30	OK
205	483 GREEN AVE ARMADALE	29.41	RES	68	77	106	-29	6	35	-29	OK
206	489 GREEN AVE ARMADALE	29.50	RES	77	79	106	-27	8	35	-27	OK
207	495 GREEN AVE ARMADALE	29.53	RES	80	77	106	-29	6	35	-29	OK
208	777 SOUTH WESTERN HWY BYFORD	35.77	COM	103	84	112	-28	20	45	-25	OK
209	797 SOUTH WESTERN HWY BYFORD	35.92	COM	87	83	112	-29	21	45	-24	OK
210	807 SOUTH WESTERN HWY BYFORD	36.09	COM	62	85	112	-27	24	45	-21	OK
211	809 SOUTH WESTERN HWY BYFORD	36.12	COM	65	84	112	-28	23	45	-22	OK
212	811 SOUTH WESTERN HWY BYFORD	36.15	RES	67	87	106	-19	26	35	-9	OK
213	813 SOUTH WESTERN HWY BYFORD	36.17	RES	69	87	106	-19	25	35	-10	OK
214	815 SOUTH WESTERN HWY BYFORD	36.21	RES	76	85	106	-21	23	35	-12	OK
215	WALLANGARRA ADULT RIDERS CLUB	31.81	COM	77	95	112	-17	33	45	-12	OK
216	379 RAILWAY AV ARMADALE	28.29	RES	43	85	106	-21	14	35	-21	OK
217	377 RAILWAY AV ARMADALE	28.28	RES	41	86	106	-20	16	35	-19	OK
218	375 RAILWAY AV ARMADALE	28.25	RES	42	90	106	-16	20	35	-15	OK
219	373 RAILWAY AV ARMADALE	28.23	RES	47	92	106	-14	22	35	-13	OK
220	371 RAILWAY AV ARMADALE	28.21	RES	45	94	106	-12	24	35	-11	OK
221	369 RAILWAY AV ARMADALE	28.19	RES	46	94	106	-12	24	35	-11	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
222	367A RAILWAY AV ARMADALE	28.16	RES	42	95	106	-11	25	35	-10	OK
223	365 RAILWAY AV ARMADALE	28.15	RES	48	94	106	-12	23	35	-12	OK
224	363 RAILWAY AV ARMADALE	28.12	RES	48	94	106	-12	23	35	-12	OK
225	361 RAILWAY AV ARMADALE	28.10	RES	48	94	106	-12	23	35	-12	OK
226	359 RAILWAY AV ARMADALE	28.08	RES	49	93	106	-13	23	35	-12	OK
227	357 RAILWAY AV ARMADALE	28.06	RES	50	93	106	-13	24	35	-11	OK
228	355 RAILWAY AV ARMADALE	28.04	RES	50	93	106	-13	25	35	-10	OK
229	2 FRIAR RD ARMADALE	28.03	RES	45	93	106	-13	28	35	-7	OK
230	1 FRIAR RD ARMADALE	27.97	RES	43	92	106	-14	32	35	-3	OK
231	3A FRIAR RD ARMADALE	27.99	RES	48	91	106	-15	30	35	-5	OK
232	3B FRIAR RD ARMADALE	27.99	RES	58	89	106	-17	27	35	-8	OK
233	343 RAILWAY AV ARMADALE	27.92	RES	49	91	106	-15	30	35	-5	OK
234	347 RAILWAY AV ARMADALE	27.95	RES	49	91	106	-15	30	35	-5	OK
235	341 RAILWAY AV ARMADALE	27.89	RES	56	89	106	-17	28	35	-7	OK
236	5A GLADSTONE RD ARMADALE	27.82	RES	66	87	106	-19	25	35	-10	OK
237	331 RAILWAY AV ARMADALE	27.79	RES	43	93	106	-13	32	35	-3	OK
238	331 RAILWAY AV ARMADALE	27.79	RES	42	93	106	-13	33	35	-2	OK
239	327 RAILWAY AV ARMADALE	27.76	RES	72	85	106	-21	23	35	-12	OK
240	331 RAILWAY AV ARMADALE	27.79	RES	42	93	106	-13	33	35	-2	OK
241	331 RAILWAY AV ARMADALE	27.79	RES	43	92	106	-14	32	35	-3	OK
242	321 RAILWAY AV ARMADALE	27.73	RES	58	89	106	-17	27	35	-8	OK
243	317 RAILWAY AV ARMADALE	27.70	RES	76	84	106	-22	22	35	-13	OK
244	309 RAILWAY AV ARMADALE	27.61	RES	43	92	106	-14	32	35	-3	OK
245	309 RAILWAY AV ARMADALE	27.61	RES	43	92	106	-14	32	35	-3	OK
246	307 RAILWAY AV ARMADALE	27.57	RES	47	91	106	-15	30	35	-5	OK
247	131 LOWANNA WAY ARMADALE	27.55	RES	46	91	106	-15	30	35	-5	OK
248	307 RAILWAY AV ARMADALE	27.57	RES	46	91	106	-15	30	35	-5	OK
249	21 BRACKLEY RD ARMADALE	27.60	RES	97	79	106	-27	15	35	-20	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
250	21 BRACKLEY RD ARMADALE	27.60	RES	94	79	106	-27	16	35	-19	OK
251	21 BRACKLEY RD ARMADALE	27.60	RES	90	80	106	-26	17	35	-18	OK
252	11 MURRAY CT ARMADALE	27.61	RES	86	81	106	-25	18	35	-17	OK
253	11 MURRAY CT ARMADALE	27.61	RES	84	82	106	-24	19	35	-16	OK
254	11 MURRAY CT ARMADALE	27.61	RES	78	83	106	-23	20	35	-15	OK
255	260 STREICH AV ARMADALE	27.69	RES	44	91	106	-15	31	35	-4	OK
256	262 STREICH AV ARMADALE	27.71	RES	46	91	106	-15	30	35	-5	OK
257	264 STREICH AV ARMADALE	27.74	RES	46	91	106	-15	30	35	-5	OK
258	4 ASH CT ARMADALE	27.75	RES	51	89	106	-17	28	35	-7	OK
259	1 ASH CT ARMADALE	27.79	RES	42	92	106	-14	31	35	-4	OK
260	268 STREICH AV ARMADALE	27.81	RES	43	91	106	-15	31	35	-4	OK
261	270 STREICH AV ARMADALE	27.83	RES	39	93	106	-13	32	35	-3	OK
262	2 BLUEGUM CL ARMADALE	27.84	RES	45	91	106	-15	30	35	-5	OK
263	274 STREICH AV ARMADALE	27.91	RES	46	91	106	-15	30	35	-5	OK
264	276 STREICH AV ARMADALE	27.94	RES	45	91	106	-15	30	35	-5	OK
265	278 STREICH AV ARMADALE	27.95	RES	45	91	106	-15	30	35	-5	OK
266	35 CLARENCE RD ARMADALE	27.98	RES	46	90	106	-16	30	35	-5	OK
267	302 STREICH AV ARMADALE	28.06	RES	71	87	106	-19	17	35	-18	OK
268	304A STREICH AV ARMADALE	28.08	RES	45	93	106	-13	24	35	-11	OK
269	306 STREICH AV ARMADALE	28.10	RES	43	94	106	-12	24	35	-11	OK
270	308 STREICH AV ARMADALE	28.12	RES	45	93	106	-13	23	35	-12	OK
271	312 STREICH AV ARMADALE	28.14	RES	44	94	106	-12	24	35	-11	OK
272	312 STREICH AV ARMADALE	28.14	RES	47	93	106	-13	23	35	-12	OK
273	316 STREICH AV ARMADALE	28.18	RES	46	93	106	-13	23	35	-12	OK
274	316 STREICH AV ARMADALE	28.18	RES	48	92	106	-14	22	35	-13	OK
275	322 STREICH AV ARMADALE	28.22	RES	51	91	106	-15	20	35	-15	OK
276	324 STREICH AV ARMADALE	28.26	RES	55	85	106	-21	14	35	-21	OK
277	328 STREICH AV ARMADALE	28.30	RES	54	81	106	-25	11	35	-24	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
278	330 STREICH AV ARMADALE	28.32	RES	57	80	106	-26	10	35	-25	OK
279	332 STREICH AV ARMADALE	28.35	RES	58	80	106	-26	9	35	-26	OK
280	405 ARAGON CT ARMADALE	28.60	RES	72	76	106	-30	5	35	-30	OK
281	3 ABBEY RD ARMADALE	28.86	RES	57	80	106	-26	9	35	-26	OK
282	1 HARBER ARMADALE	30.56	RES	55	91	106	-15	30	35	-5	OK
283	1 MASSELL WAY BROOKDALE	31.14	RES	48	93	106	-13	33	35	-2	OK
284	2 D'VITALE LOOP BYFORD	35.13	RES	56	91	106	-15	30	35	-5	OK
285	2 WUNGONG RD ARMADALE	29.60	COM	9	89	112	-23	22	45	-23	OK
286	3 BUTCHER RD DARLING DOWNS	34.83	RES	83	85	106	-21	23	35	-12	OK
287	3 MAKIN CT BYFORD	35.42	RES	81	85	106	-21	23	35	-12	OK
288	3 MCGURK CT BYFORD	35.53	RES	78	85	106	-21	22	35	-13	OK
289	4 D'VITALE LOOP BYFORD	35.13	RES	67	88	106	-18	27	35	-8	OK
290	4 PIRA LP BYFORD	35.36	RES	54	93	106	-13	32	35	-3	OK
291	2 SEVENTH ARMADALE	29.90	RES	55	91	106	-15	30	35	-5	OK
292	6 PIRA LP BYFORD	35.34	RES	70	89	106	-17	27	35	-8	OK
293	8 LARSEN RD BYFORD	35.59	RES	77	88	106	-18	25	35	-10	OK
294	9 BYRON RD ARMADALE	31.05	IND	70	84	118	-34	23	50	-27	OK
295	10 ORCHARD AVE ARMADALE	28.68	COM	46	79	112	-33	9	45	-36	OK
296	10 TROTMAN CT BROOKDALE	31.19	RES	102	81	106	-25	17	35	-18	OK
297	11 BYRON RD ARMADALE	31.02	IND	64	86	118	-32	24	50	-26	OK
298	11 ELIOT RD ARMADALE	31.25	IND	96	79	118	-39	16	50	-34	OK
299	11 WOODSTOCK PL DARLING DOWNS	33.15	RES	36	97	106	-9	37	35	2	2 dB
300	12 BARGE CT ARMADALE	30.48	RES	75	87	106	-19	25	35	-10	OK
301	13 BYRON RD ARMADALE	30.98	IND	66	85	118	-33	24	50	-26	OK
302	13 ELIOT RD ARMADALE	31.22	IND	71	84	118	-34	22	50	-28	OK
303	13 JEFFREY LP BROOKDALE	30.99	RES	60	90	106	-16	29	35	-6	OK
304	15 JEFFREY LP BROOKDALE	31.01	RES	61	90	106	-16	29	35	-6	OK
305	15 TROTMAN CT BROOKDALE	31.28	RES	63	91	106	-15	29	35	-6	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
306	16 ELIOT RD ARMADALE	31.35	IND	57	94	118	-24	33	50	-17	OK
307	16 TROTMAN CT BROOKDALE	31.20	RES	88	84	106	-22	21	35	-14	OK
308	17 BYRON RD ARMADALE	30.94	IND	57	87	118	-31	26	50	-24	OK
309	17 JEFFREY LP BROOKDALE	31.03	RES	61	90	106	-16	29	35	-6	OK
310	18 TROTMAN CT BROOKDALE	31.21	RES	73	87	106	-19	25	35	-10	OK
311	19 VLASICH RD BYFORD	35.11	RES	89	84	106	-22	21	35	-14	OK
312	2 BROWNING RD ARMADALE	30.87	IND	56	88	118	-30	27	50	-23	OK
313	24 DICKENS PL ARMADALE	30.65	IND	24	97	118	-21	38	50	-12	OK
314	58 FOURTH RD ARMADALE	29.17	COM	73	67	112	-45	-	45	-	OK
315	33 STONE ST ARMADALE	31.49	IND	64	95	118	-23	33	50	-17	OK
316	33 VLASICH RD BYFORD	34.98	RES	88	84	106	-22	21	35	-14	OK
317	36-40 COMMERCE AVE ARMADALE	29.34	COM	73	69	112	-43	-	45	-	OK
318	49 WILLIAN ST ARMADALE	29.30	COM	85	64	112	-48	-	45	-	OK
319	53 MITCHELL ST WUNGONG	32.52	RES	58	94	106	-12	32	35	-3	OK
320	53 RIVOSE CR DARLING DOWNS	33.06	RES	77	86	106	-20	24	35	-11	OK
321	57 RIVOSE CR DARLING DOWNS	33.14	RES	72	87	106	-19	26	35	-9	OK
322	81 EVANS WAY BYFORD	36.00	RES	58	90	106	-16	29	35	-6	OK
323	82 ALEXANDER RD BYFORD	35.55	RES	56	89	106	-17	28	35	-7	OK
324	83 EVANS WAY BYFORD	35.99	RES	42	95	106	-11	34	35	-1	OK
325	124 ALEXANDER RD BYFORD	35.94	RES	49	94	106	-12	33	35	-2	OK
326	8 COMMERCE AVE ARMADALE	29.01	COM	73	71	112	-41	-	45	-45	OK
327	245 SOUTH WESTERN HWY BYFORD	30.34	IND	101	77	118	-41	13	50	-37	OK
328	829 SOUTH WESTERN HWY BYFORD	36.24	COM	67	79	112	-33	17	45	-28	OK
329	821 SOUTH WESTERN HWY BYFORD	36.24	COM	49	86	112	-26	25	45	-20	OK
330	2313 THOMAS ST DARLING DOWNS	34.80	RES	33	98	106	-8	38	35	3	3 dB
331	GEORGE ST BYFORD	34.95	IND	59	87	118	-31	26	50	-24	OK
332	313 RAILWAY AV ARMADALE	27.67	RES	67	86	106	-20	25	35	-10	OK
333	272 STREICH AV ARMADALE	27.88	RES	43	92	106	-14	31	35	-4	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
334	298 STREICH AV ARMADALE	28.04	RES	45	92	106	-14	28	35	-7	OK
335	298 STREICH AV ARMADALE	28.04	RES	44	93	106	-13	25	35	-10	OK
336	33 CLARENCE RD ARMADALE	27.98	RES	69	85	106	-21	23	35	-12	OK
337	3C TUCK ST ARMADALE	28.32	RES	86	76	106	-30	4	35	-31	OK
338	4 TUDOR RD ARMADALE	29.06	RES	77	70	106	-36	-	35	-	OK
339	431 RAILWAY AV ARMADALE	28.82	RES	43	86	106	-20	16	35	-19	OK
340	421 ARAGON CT ARMADALE	28.74	RES	68	77	106	-29	6	35	-29	OK
341	63 RIVOSE CR DARLING DOWNS	33.26	RES	95	83	106	-23	19	35	-16	OK
342	41 RIVOSE CR DARLING DOWNS	32.96	RES	83	85	106	-21	22	35	-13	OK
343	59 RIVOSE CR DARLING DOWNS	33.19	RES	77	86	106	-20	24	35	-11	OK
344	45 RIVOSE CR DARLING DOWNS	33.00	RES	86	84	106	-22	22	35	-13	OK
345	FUTURE DEVELOPMENT 101	34.38	RES	72	93	106	-13	31	35	-4	OK
346	FUTURE DEVELOPMENT 102	34.33	RES	63	90	106	-16	29	35	-6	OK
347	FUTURE DEVELOPMENT 103	34.28	RES	54	92	106	-14	31	35	-4	OK
348	FUTURE DEVELOPMENT 104	34.23	RES	52	92	106	-14	32	35	-3	OK
349	FUTURE DEVELOPMENT 105	34.18	RES	53	92	106	-14	31	35	-4	OK
350	FUTURE DEVELOPMENT 106	34.13	RES	56	91	106	-15	30	35	-5	OK
351	FUTURE DEVELOPMENT 107	34.07	RES	57	91	106	-15	30	35	-5	OK
352	FUTURE DEVELOPMENT 108	34.03	RES	67	89	106	-17	27	35	-8	OK
353	FUTURE DEVELOPMENT 109	33.97	RES	88	84	106	-22	21	35	-14	OK
354	FUTURE DEVELOPMENT 110	33.92	RES	63	89	106	-17	28	35	-7	OK
355	FUTURE DEVELOPMENT 111	33.87	RES	61	90	106	-16	29	35	-6	OK
356	FUTURE DEVELOPMENT 112	33.81	RES	54	92	106	-14	31	35	-4	OK
357	FUTURE DEVELOPMENT 113	33.76	RES	55	92	106	-14	31	35	-4	OK
358	FUTURE DEVELOPMENT 114	33.71	RES	54	92	106	-14	31	35	-4	OK
359	FUTURE DEVELOPMENT 115	33.66	RES	52	92	106	-14	31	35	-4	OK
360	FUTURE DEVELOPMENT 116	33.61	RES	55	92	106	-14	31	35	-4	OK
361	FUTURE DEVELOPMENT 117	33.55	RES	56	91	106	-15	30	35	-5	OK

ID	Address	Chainage (km)	Usage	Distance	GBV			GBN			Expected outcome
					Build+M	Target	Build margin	Build+M	Target	Build margin	
362	13 BUTCHER RD DARLING DOWNS	34.73	RES	76	93	106	-13	31	35	-4	OK
363	4 SEVENTH ARMADALE	29.89	RES	65	88	106	-18	27	35	-8	OK
364	49 RIVOSE CR DARLING DOWNS	33.03	RES	76	86	106	-20	24	35	-11	OK

Appendix F: Schedules

F.1 Modelled Rail Damper Extent

Applies to all main line tracks at each chainage. Refer Appendix C for the aerial image of locations.

ID	Chainage From (km)	Chainage To (km)	Distance (m)	Track form
TBC	27.47	28.02	550	Ballast track with damper
TBC	28.02	28.35	330	Slab track with damper
TBC	29.625	29.805	180	Slab track with damper
TBC	29.805	30.405	600	Ballast track with damper
TBC	30.85	31.435	585	Ballast track with damper
TBC	32.455	35.63	3175	Ballast track with damper

F.2 Modelled Noise Wall Extent

Refer Appendix C for the aerial image of locations.

ID	Chainage(km)		Distance (m)	Height	Distance from nearest CL	Side of Track	Comment
	Start	End					
1	27.52	28.245	725	1.5	5m (as request between chainage 27.5-27.78)	Western	Formation to be widened by 1m to accommodate (especially the chainage between 27.780-28.245, or further mitigation may need). Height measured from 0.6 m below TOR - ballasted track (north end of viaduct)
2	27.555	28.025	470	1.5-2.4	17m (as request between chainage 27.5-28)	Eastern	On boundary - due to equipment, MCR, drainage Height measured from the elevation level of updated civil input
3	28.02	28.245	225	1.5	5m	Eastern	Formation needs to be widened by 1m to accommodate, or further mitigation may need. Height measured from 0.6 m below TOR - ballasted track (north end of viaduct)
4	29.78	29.88	100	1.5	4.1m	Western	Civil to widen formation if required Height measured from 0.6 m below TOR - ballasted track (south end of viaduct)
5	29.78	29.85	70	1.5	4.4m	Eastern	Civil to widen formation if required Height measured from 0.6 m below TOR - ballasted track (south end of viaduct)
6	32.47	32.59	120	1.5	4m	Eastern	Civil to widen formation if required Height measured from 0.6 m below TOR - ballasted track
7	32.83	32.98	150	1.8	12m (as request between chainage 32.83-33)	Eastern	Moved to be clear of drain up to Culvert 8 Height measured from the elevation level of updated civil input
8	32.975	33.32	345	1.5-1.8	18m at boundary (as request between chainage 33-33.45)	Eastern	Due to proposed drain diverting TSER and LGA drain Height measured from the elevation level of updated civil input
9	34.72	34.84	120	1.5	around 7m (follow the updated civil input)	Eastern	Height measured from the elevation level of updated civil input
10	34.9	35.06	160	1.5	Around 6-16m (follow the updated civil input)	Western	Height measured from the elevation level of updated civil input
11	35.33	35.6	270	1.5	Around 6m (follow the updated civil input)	Western	Two pieces to follow the civil Height measured from the elevation level of updated civil input
12	34.92	35.6	680	1.5-1.8	Around 6m (follow the updated civil input)	Eastern	Height measured from the elevation level of updated civil input

F.3 Modelled Vibration Mitigation Extent

Applies to all main line tracks at each chainage. Refer Appendix C for the aerial image of locations.

ID	Chainage (km)		Distance (m)
	Start	End	
TBC	27.5	28.25	750
TBC	29.75	31.35	1600
TBC	32.5	34.4	1900
TBC	34.75	35.65	900

Appendix G: IDC Certificates

Refer to Appendix G.

Appendix H: Independent Verification Certificates (Not in use)

Appendix I: PTA Comments Review Register (Not in use)

Appendix J: Third Party Approvals (Not in use)

Appendix K: RFIs (Not in use)

Appendix L: Project Interfaces (Not in use)

Please refer to Table 1 under Section 3.2

Appendix M: Departures (Not in use)

Appendix N: Deviations (Not in use)

Appendix O: RATM Extract

Refer to Appendix O.

Appendix P: Project Hazard Log

Refer to Appendix P.

Appendix Q: Hazard Workshop Report (Not in use)

Appendix R: Human Factors

1. Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that 'noise' often refers to unwanted sound.

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

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

2. 'A' Weighted Sound Pressure Level

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

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Different sources having the same dB level generally sound about equally loud.

A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst 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. The table below lists examples of typical noise levels.

Sound Pressure Level (dB)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear' or 'Z' weighted.

3. Sound Power Level

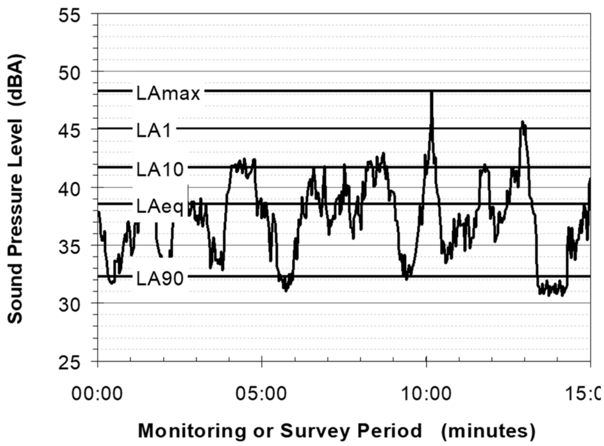
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are also expressed in decibels (dB), but in practice may be identified with a 'w' subscript, e.g. SWL, PWL or L_W, and by the reference unit 10^{-12} W.

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

4. Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

LA1 The noise level exceeded for 1% of the 15 minutes interval.

LA10 The noise level exceeded for 10% of the 15 minutes interval. This is commonly referred to as the average maximum noise level.

LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

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

5. Frequency Analysis

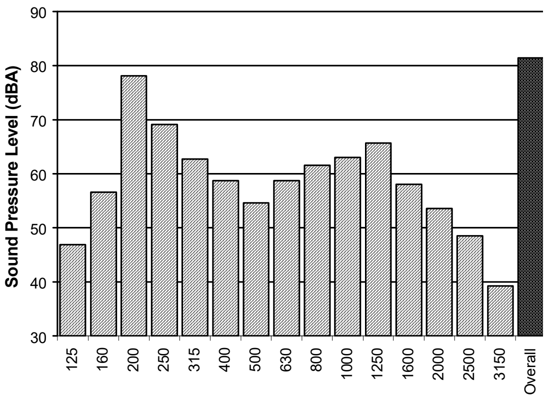
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

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

Frequency analysis can be in:

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

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



6. Annoying Noise (Special Audible Characteristics)

A louder noise will generally be more annoying to nearby receivers than a quieter one. However, noise is often also found to be more annoying and result in larger impacts where the following characteristics are apparent:

- **Tonality** - tonal noise contains one or more prominent tones (ie differences in distinct frequency components between adjoining octave or 1/3 octave bands), and is normally regarded as more annoying than 'broad band' noise.
- **Impulsiveness** - an impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.
- **Intermittency** - intermittent noise varies in level with the change in level being clearly audible. An example would include mechanical plant cycling on and off.
- **Low Frequency Noise** - low frequency noise contains significant energy in the lower frequency bands, which are typically taken to be in the 10 to 160 Hz region.

7. Vibration

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

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

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements (ie vertical, longitudinal and transverse).

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/Vo), where Vo is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used.

8. Human Perception of Vibration

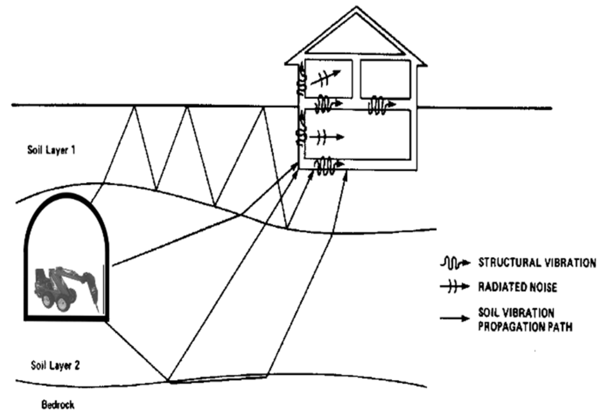
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience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

9. Ground-borne Noise, Structure-borne Noise and Regenerated Noise

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

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

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



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

Appendix S: Reliability, Availability, Maintainability (Not in use)

Appendix T: Durability Assessment (Not in use)

Appendix U: Sustainability (Not in use)

Appendix V: ITP Strategy (Not in use)

Appendix W: Subsystem Allocation (Not in use)

Appendix X: BCA Certificates (Not in use)

Appendix Y: DDA Certification (Not in use)

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