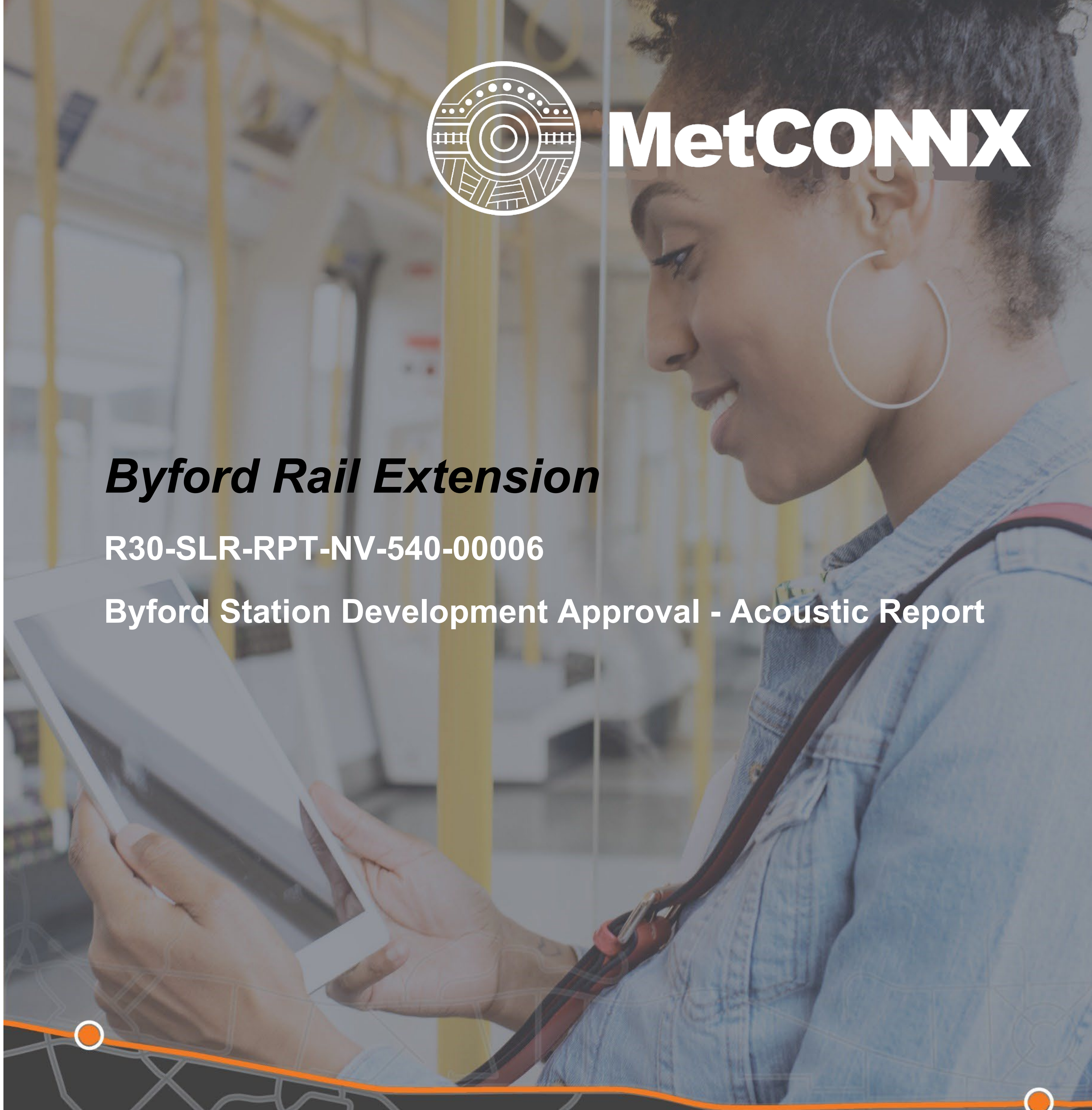
Appendix L: Acoustics Report



MetCONNX

Byford Rail Extension

R30-SLR-RPT-NV-540-00006

Byford Station Development Approval - Acoustic Report

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METRONET

BYFORD RAIL EXTENSION

Document details	
Title	Byford Station Development Approval - Acoustic Report
Project	Byford Rail Extension (BRE) Design and Construction Project
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Client	Public Transport Authority of Western Australia
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1.0 Executive Summary

An assessment of environmental noise emissions from the proposed Byford Station and associated station facilities has been undertaken to support development approval.

Predicted noise emissions from the station have been compared with targets derived from a review of relevant state noise policies and industry guidelines.

The predicted results indicate that external noise emissions from the proposed Byford Station and associated station facilities are compliant with applicable state noise policy at all existing and anticipated future noise sensitive receptors.

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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.

2.0 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.

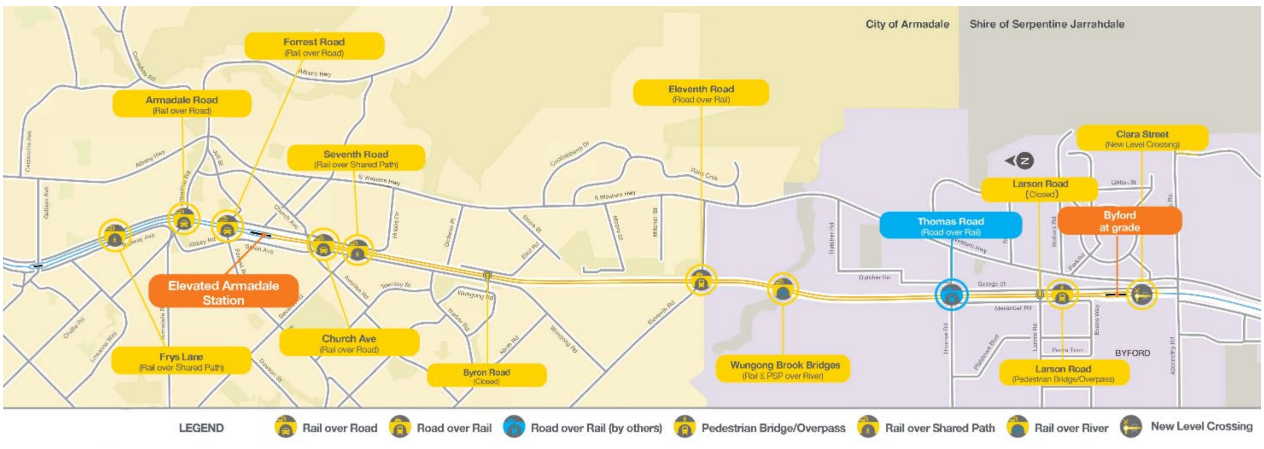

Figure 1: METRONET Byford Rail Extension Project

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 Byford station to the newly created Byford station, with a dedicated platform for the Australind line
- Removal of level crossings between the Armadale and Byford 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 Purpose

This report presents an assessment of environmental noise emission to support development approval of Byford Station and associated facilities.

This report provides the noise emission assessment of the external noise sources associated with the station.

The extent of the station and study area is indicated in **Figure 2.**

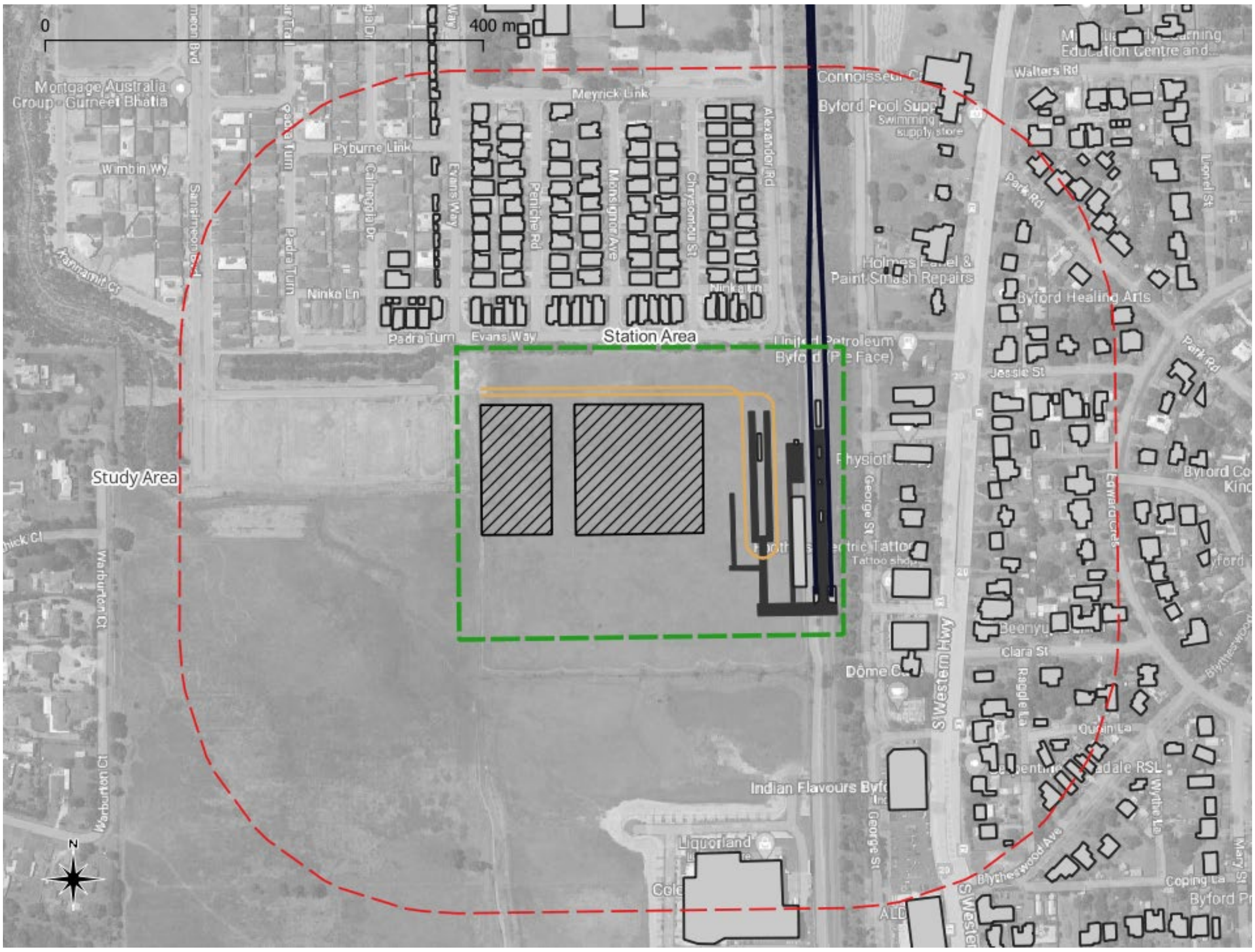

Figure 2: Annotated aerial image indicating extent of study area, Byford station

Key terms used in this assessment are provided in **Appendix A**.

2.4 Structure

Section 3 presents a summary of relevant design criteria used. **Section 4** present assessments of environmental noise from the identified noise sources associated with the Byford Station.

3.0 Design criteria

3.1 State Planning Policy 5.4

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

Table 1 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 1: Road and rail noise criteria

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

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, childcare premises, hospital, nursing home, corrective institution; or place of worship; 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.

Note that the criteria excludes recreational parks, commercial and industrial premises along the alignment – results will be determined for these locations, but mitigation may not be required under the SWTC.

3.2 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 Byford 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 2**, 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 2: 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 3**, and are further defined in Regulation 9(1) of the *Environmental Protection (Noise) Regulations 1997*.

Note that the following adjustments (**Table 3**) generally apply to fixed plant and infrastructure only.

Table 3: 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
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.

4.0 Assessments and discussion

4.1 Bus interchange

Noise emissions from bus vehicle movements associated with the station are considered assessable under SPP5.4. Bus vehicles have been modelled using Nord2000 methodologies with the following parameters:

- Bus movements of up to 4 buses per stand per hour during the day (up to a maximum total of 20 buses per hour), and 0.5 bus per stand per hour during the night (up to a maximum total of 3 buses / hour) has been assumed for the assessment.
- Changes in level from arriving / idling / departure at stations (as assessed at nearest noise sensitive location) have been determined insignificant and not modelled. Publicly accessible road sections beyond the loop or its intersections are not included.
- Ground class F (compacted dense ground).
- Category 2a vehicles (up to 12.5m length and 2 axles, e.g. Volgren OC500LE), approximately L_{Amax} 75dB, L_{AE} 78dB at 7.5m and 35km/hr.
- Traffic case F (35km/hr max).
- Asphalt concrete surface, any increases in noise level due to gradients was included on the basis of the ground topography provided.

The proposed new bus interchange has large offset distance from the adjacent existing residential properties, approximately 50 meters, and therefore are not predicted to contribute to any excessive noise level at these sensitive receivers.

From figures presented in **Appendix B**, predicted levels are compliant at all existing noise sensitive locations.

4.2 Passenger car park

The proposed new Park 'N' Ride carpark will consist of 393 car bays and proposed future carpark will consist of 128 car bays.

EU Parking Area Noise 2007[1] guidelines have been used to provide an indicative level of noise emissions on surrounding areas.

- Vehicle movement rate for P&R facilities over 20km from CBD. A vehicle entering or exiting a parking bay is one movement, so the same vehicle arriving and departing on the same day completes two movements.
- 0.30 per hour per parking bay (6am to 10pm).
- 0.10 per hour per parking bay (10pm to 6am).
- Random fill across all parking lots.[2]
- Impulse correction K_I 4dB.
- L_{w0} 63dB (standardised vehicle sound power level).

The predicted noise levels from the proposed car park operation as presented in **Appendix B** are compliant at all existing noise sensitive locations.

4.3 Crowd/ Patron noise

The arrangement of the station has passenger waiting areas on the platform, busway waiting areas and pick up points at distances over 80 metres from residences and/or generously spaced open environments.

Providing this level of distance separation and low crowd densities is expected to ensure that any sustained crowd / patron noise levels (conversations, walking) as individually L_{Aeq} 60dB at 1 metre and below L_{Aeq} 30dB at 80 metres will be at a cumulative level that is inaudible at nearby residential locations against other background environmental noise.

On this basis, crowd noise levels in the context of the design criteria and other environmental noise sources are considered insignificant.

[1] Bayer, Landesamt für Umwelt 2007, Parking Area Noise - Recommendations for the Calculation of Sound Emissions of Parking Areas, Motorcar Centers and Bus Stations as well as of Multi-Storey Car Parks and Underground Car Parks, Bayerisches Landesamt für Umwelt, Parkplatzlämstudie 6, Aufl., August 2007.

[2] Random fill assumed in the absence of a specific car parking traffic analysis. Fill patterns in practice may vary due to proximity to train station, and presence of ticketed parking and/or reserved parking.

4.4 Public Address systems

The public address system will need to be designed to be sufficiently audible (involving both sound level and speech intelligibility) to meet relevant provisions of Australia Standard 1670.4*, Fire Detection, Warning, Control and Intercom Systems - System Design, Installation and Commissioning - Sound Systems and Intercom Systems for Emergency Purposes* (AS 1670.4) such that patrons can be advised in case of emergencies.

By inspection of the station arrangement and distancing to the nearest noise sensitive receivers, it can be seen that there is a range of sound levels which can meet both the minimum sound level limit requirements of AS 1670.4 and maximum noise level limits.

Consideration should be given to active PA systems which regulate speaker volumes depending on actual ambient sound level conditions to maintain intelligibility.

4.5 Mechanical plant

The supplied drawings indicate that the outdoor mechanical plant comprise condenser units. Based on rooms served, each would have capacities the order of 6 kW or less (similar to domestic residential air conditioning systems).

Refer to **Appendix B** for predicted noise levels from the mechanical plant associated with the Byford Station.

From the contour maps, it can be seen that predictions are between well below 35 dBA at the nearest noise sensitive receivers. Therefore, the units assessed in cumulative terms, are considered compliant with the assigned noise levels defined in **Section 3.2** at the nearest existing and future noise sensitive premises.

4.6 Electrical and hydraulic plant

From the supplied drawings, it can be seen that the electrical and hydraulic plant associated with the station are located internally within the station building and bus interchange facility services rooms, therefore are expected to be inaudible at all existing and future noise sensitive locations.

5.0 Summary

An assessment of environmental noise has been undertaken to support development approval of Byford Station and associated station facilities.

Predicted noise emissions from the station have been compared with targets derived from a review of relevant state noise policies and industry guidelines.

The predicted results indicate that external noise emissions from the proposed Byford Station and associated station facilities are compliant with applicable state noise policy at all existing anticipated future noise sensitive receptors.

Appendix A: Key terms

Terms used

The following table describes key terms used in this report.

Table 4: Terms used

Parameter	Comment
dB	Decibel, a unit of sound or vibration which is described as a ratio of the result to a fixed reference value. All sound pressure levels (LpA, LA, LAeq etc.) quoted in this report are referenced to 20 micro Pascals (dB re 20μPa).
	Vibration velocity levels (Lv) quoted in this report are referenced to 1 nanometre per second (dB re 10-9 m/s), noting that some US criteria use dB re 10-6 in/s.
Guidelines	Implementation Guidelines for State Planning Policy 5.4 Road and Rail Transport Noise
LAmax	The maximum A-weighted noise level associated with a sampling period.
LAmax,95%	The “typical maximum noise level” for a train pass-by event. For operational rail noise, LAmax refers to the maximum noise level not exceeded for 95% of rail pass-by events measured using the ‘slow’ (sometimes denoted by subscript ‘S’) response setting on a sound level meter.
LA1	The A-weighted noise level exceeded for 1% of a given measurement period. This parameter is often used to represent the typical maximum noise level in a given period.
LA10	The A-weighted noise level exceeded for 10% of a given measurement period and is utilised normally to characterise average maximum noise levels.
LAeq	The A-weighted average noise level. It is defined as the steady noise level that contains the same amount of acoustical energy as a given time-varying noise over the same measurement period.
LA90	The A-weighted noise level exceeded for 90% of a given measurement period and is representative of the average minimum background noise level (in the absence of the source under consideration), or simply the “background” level.
Lv	Unweighted vibration velocity level, see dB.
Lv,RMS,1s	Maximum unweighted RMS vibration velocity level over a 1 second period.
Policy	State Planning Policy 5.4 – Road and Rail Transport Noise (2019)
RMS	Root Mean Square, a parameter used to estimate the average energy level of a continuous signal.

Noise

The terms “sound” and “noise” are almost interchangeable, except that in common usage “noise” is often used to refer to unwanted sound. Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The following table presents examples of typical noise levels.

The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms. The symbol ‘A’ represents A-weighted sound pressure level (SPL): the weighting is designed to better represent the hearing ability of the average listener at each frequency.

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

Table 5: Guide to sound pressure level ranges for selected environments (dB re 20μPa)

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

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

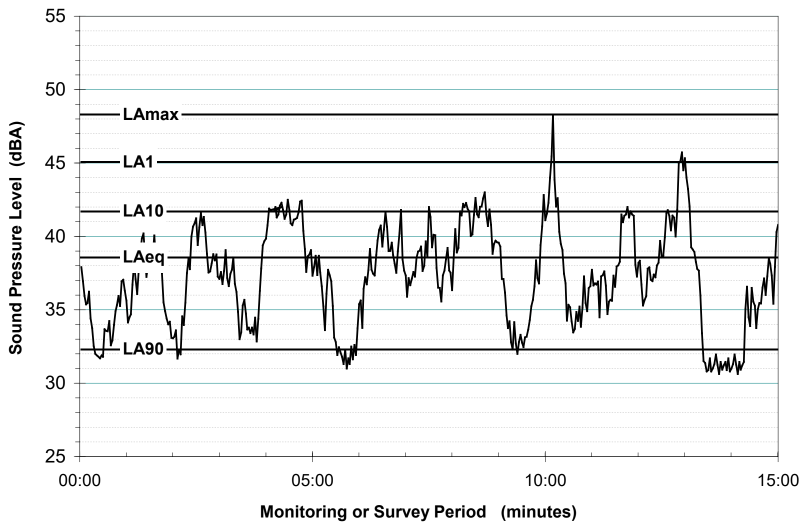

Figure 3: Example of typical noise indices (1 second logging)

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

Vibration

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

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

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

- LvSmax: The “typical maximum vibration level” for a train passby event, being the highest 1 second maximum root-mean square (RMS) value in dB re 1 nm/s. For operational rail GBV, this similarly refers to the 5th highest percentile of LvSmax results.

- LAsmax: The “typical maximum noise level” for a train passby event, in dB re 20 μPa. For operational rail GBN, LASmax refers to the maximum noise level not exceeded for 95% of rail passby events measured using the sound level meter ‘slow’ (1 second) response setting. Statistically this is the 5th highest percentile of LASmax results. The subscript “A” indicates that the noise levels are filtered to match normal human hearing characteristics (i.e. A-weighted).

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

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

Table 6: Guide to one-second maximum RMS floor vibration level ranges for selected environments

<table>
<tr><th>Typical response</th><th>mm/s</th><th>dB re 1nm/s</th><th>Comments / Examples</th></tr>
<tr><td rowspan="3">Visible response in building items, structural damage risk</td><td>16</td><td>144</td><td rowspan="4">High impact events such as blasting or dynamic compaction in close proximity to structures.</td></tr>
<tr><td>10</td><td>140</td></tr>
<tr><td>8.0</td><td>138</td></tr>
<tr><td rowspan="2">Cosmetic damage to some buildings possible over extended periods</td><td>5.0</td><td>134</td></tr>
<tr><td>3.0</td><td>130</td><td rowspan="2">Impact pile driving, 15 metres.
Freight trains at 80 km/h, ~10 metres.</td></tr>
<tr><td rowspan="4">Noticeable. Minor cosmetic damage is feasible to buildings that are in fragile condition / an existing state of disrepair</td><td>2.0</td><td>126</td></tr>
<tr><td>1.0</td><td>120</td><td>Rock breaking at 15 metres. Vibratory roller at 10 metres.</td></tr>
<tr><td>0.8</td><td>118</td><td>Typical target for workshops.</td></tr>
<tr><td>0.4</td><td>112</td><td rowspan="2">Freight trains at 80 km/h, ~40 metres. Regenerated noise highly likely in typical residential buildings.</td></tr>
<tr><td rowspan="2">Barely noticeable</td><td>0.3</td><td>110</td></tr>
<tr><td>0.2</td><td>106</td><td>Typical residential daytime target for continuous vibration.</td></tr>
</table>

Typical response	mm/s	dB re 1nm/s	Comments / Examples
Threshold of human perception to vibration	0.15	104	Passenger trains at 80 km/h, ~30 metres.
Not felt	0.10	100	Operating rooms, surgeries.

Appendix B: Result Figures

The following figures present results for identified properties in terms of air-borne noise (ABN).

Airborne noise contours, bus movements, Day period

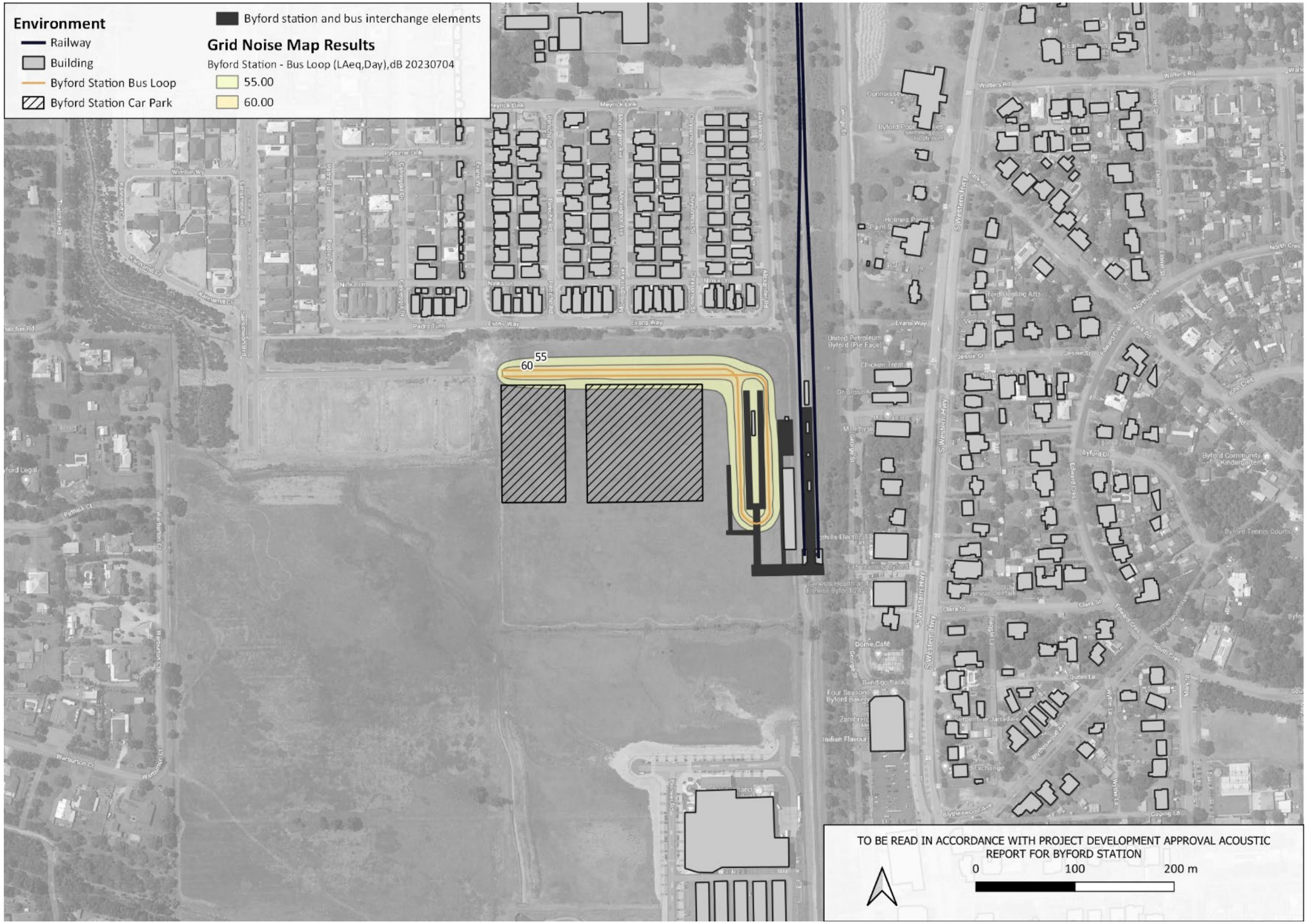

Figure 4: Predicted distribution in day period noise ($L_{Aeq,day}$) levels due to bus movements, dB.

Airborne noise contours, bus movements, Night period

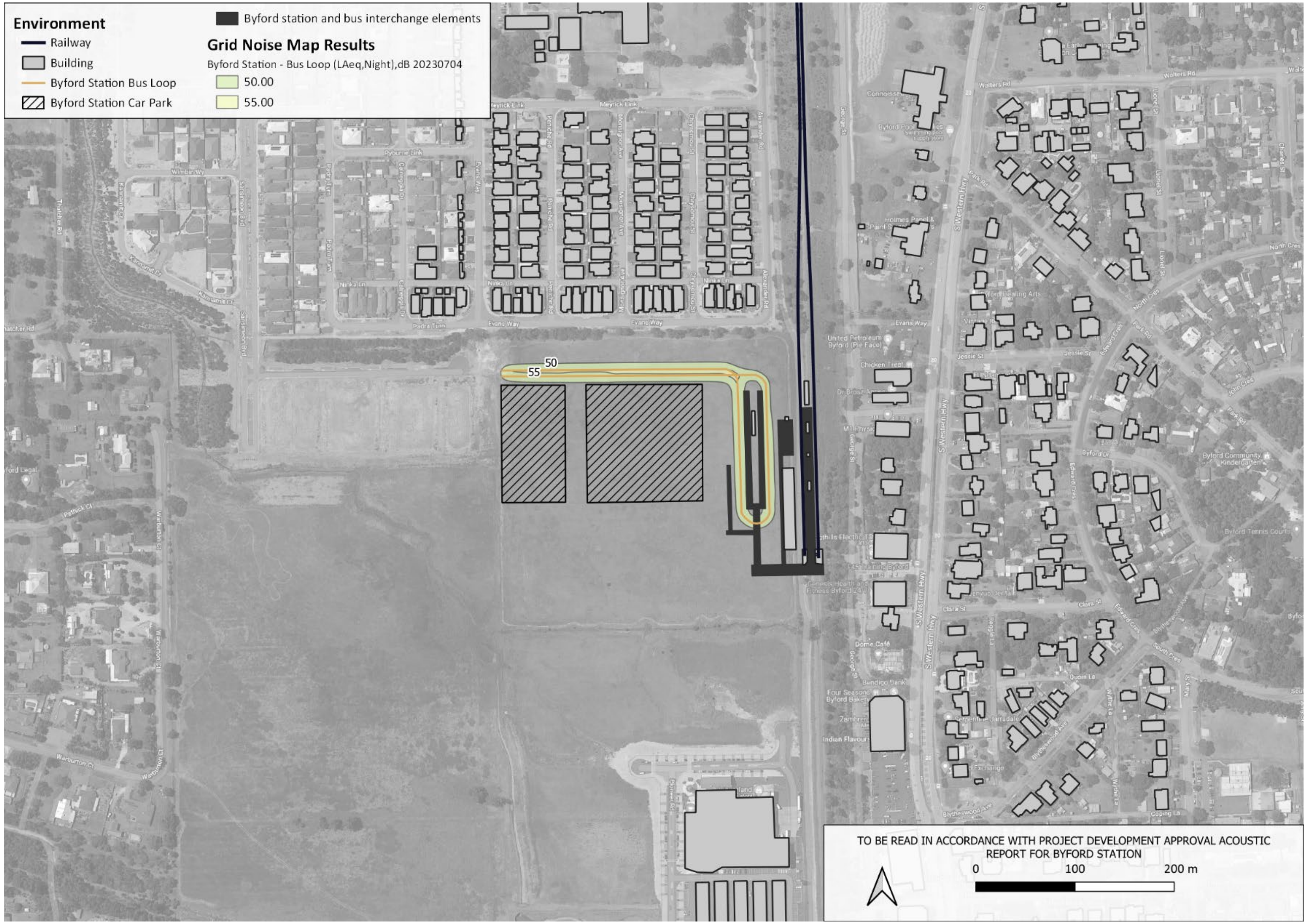

Figure 5: Predicted distribution in night period noise ($L_{Aeq,night}$) levels due to bus movements, dB.

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Airborne noise contours, car parking, Day period

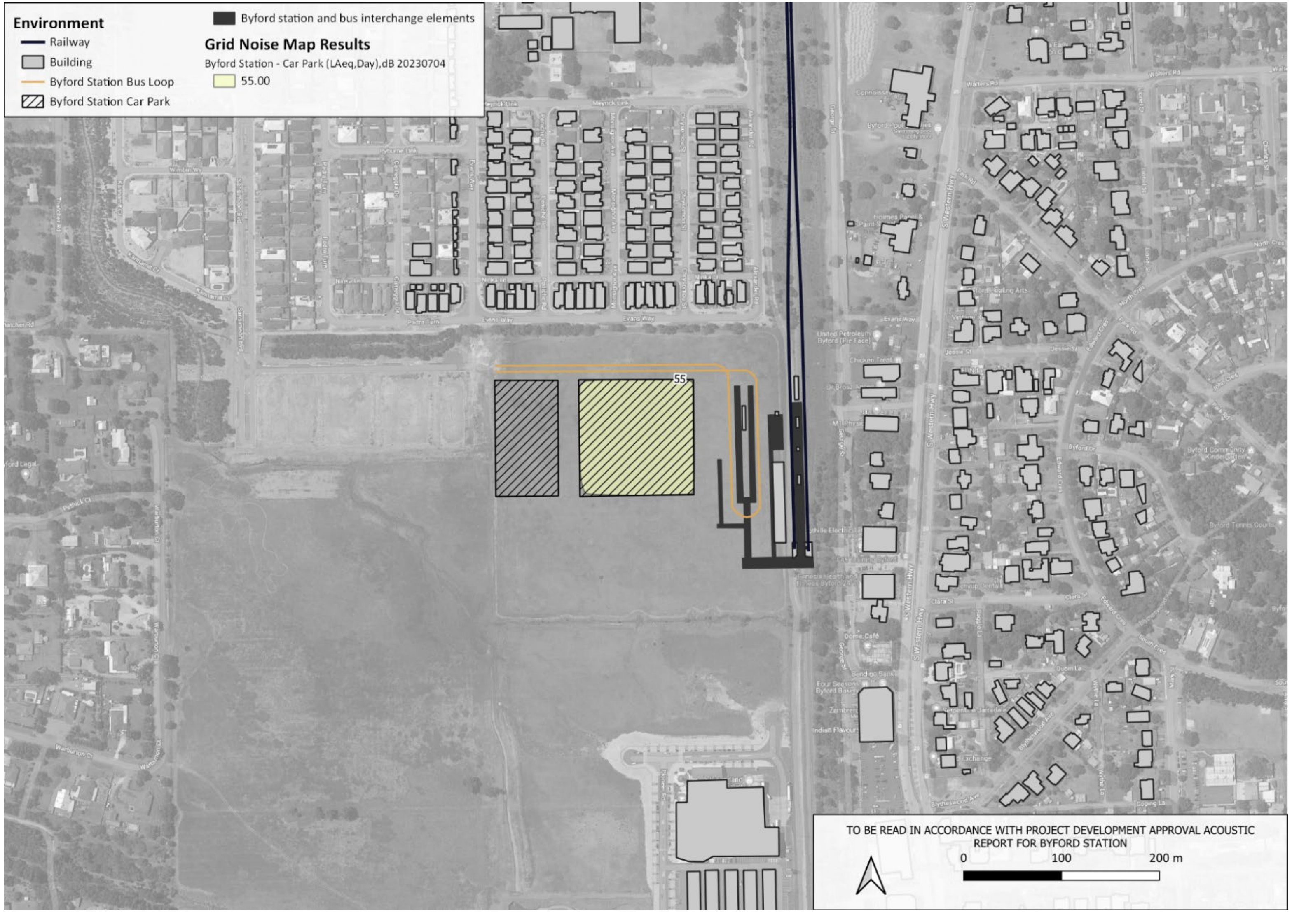

Figure 6: Predicted distribution in day period noise ($L_{Aeq,day}$) levels due to car parking movements, dB.

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Airborne noise contours, car parking, Night period

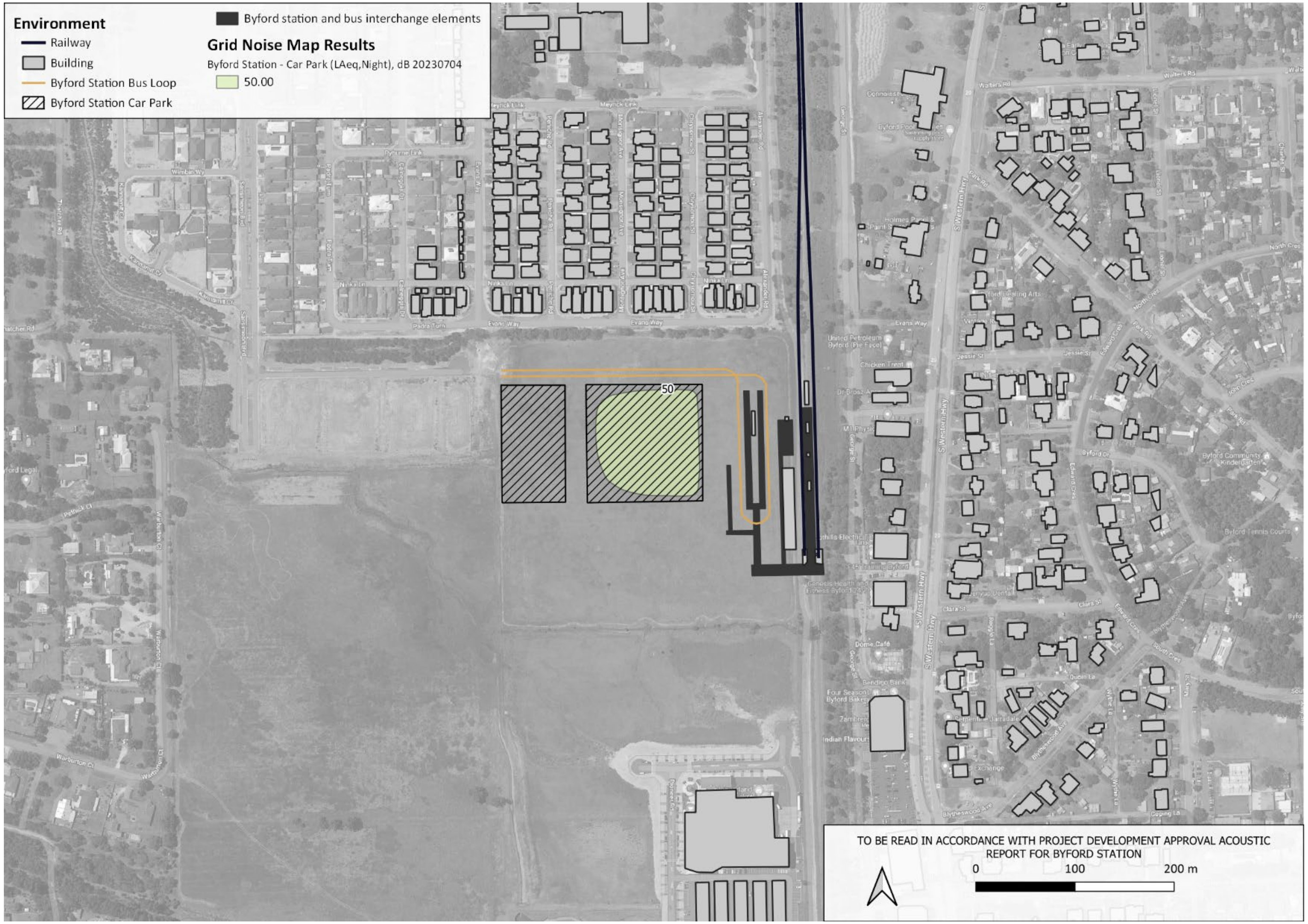

Figure 7: Predicted distribution in night period noise ($L_{Aeq,night}$) levels due to car parking movements, dB.

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Airborne noise contours, mechanical services, 24-hour period

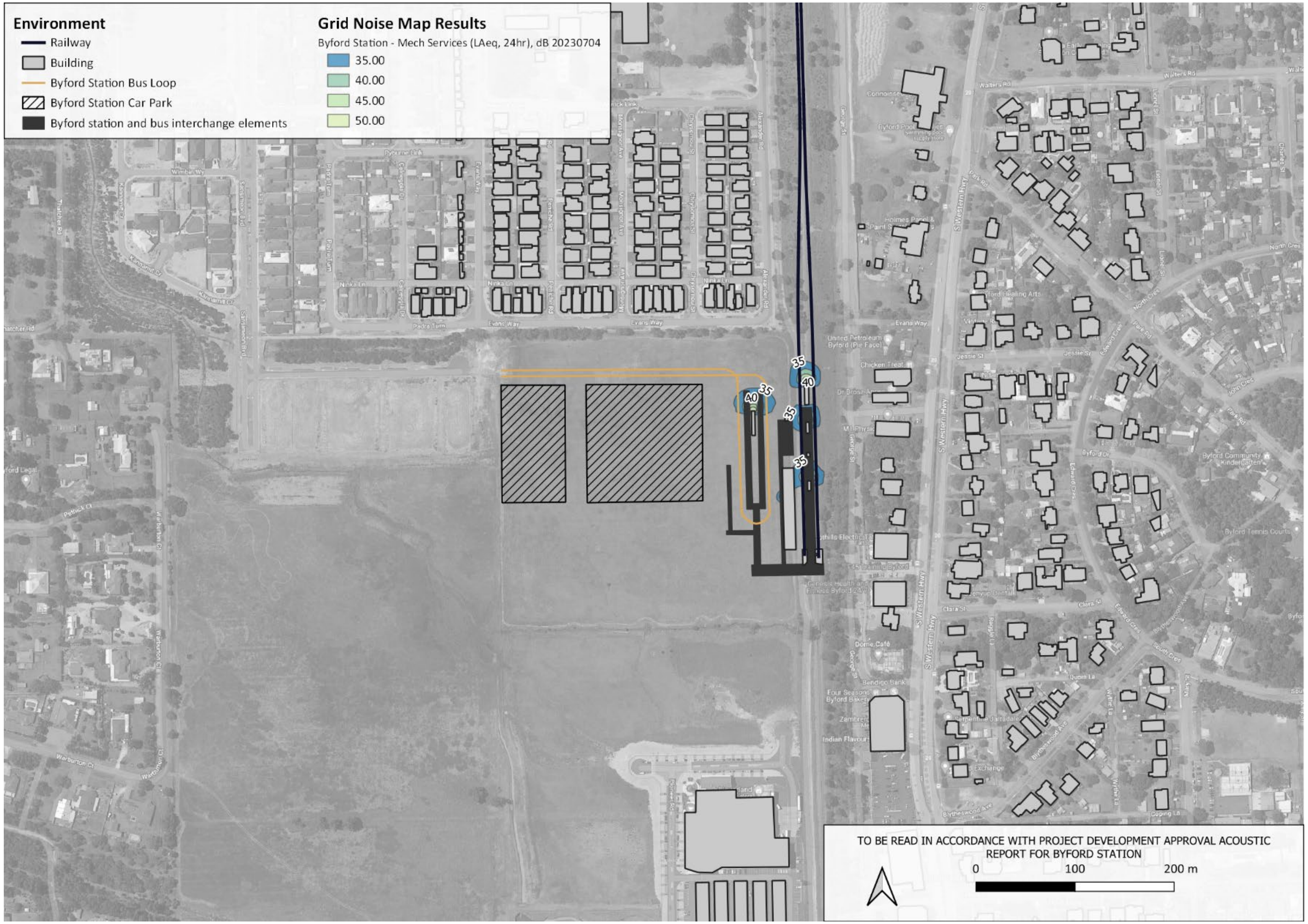

Figure 8: Predicted distribution in continuous noise (L_{Aeq}) levels due to mechanical services, dB.

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