Appendix L – Acoustic Assessment Reports for Carlisle and Oats Street Train Stations prepared by ALUA

Package 104 – Noise & Vibration (Acoustic) Report CR Station

LXR-ALUA-NV-RPT-00004 (PTA DOCUMENT NUMBER)

Alliance Name	ARMADALE LINE UPGRADE ALLIANCE				
Alliance Document No.	LXR-P1-Z1-CR-SN-EN-RPT-00001				
Alliance Revision	A	**No. of Pages** (Excluding Cover Page)	**39**	**Contract No.**	PTA 200140

PTA Revision	Submission Date	Description	Supplier's Engineering Manager	PTA Coordinating Project Engineer
A	04/08/2022	Issued for Review	John Selfridge	Steven Moran
			IDC Number	**DRN Number**
			LXR-ALUA-EA-IDC-00017	
Please turn page for full revision history				

Status Information			
Deliverable Review Status		**InEight Document Code**	**Description**
☐	**ACCEPTED** (CAT 1)	**ACC**	**EM4P Category 1**. Acknowledgement by PTA that, following a risk-based review, the deliverable appears to be satisfactory. Acceptance by PTA: 1. Indicates that the deliverable appears to comply with the specified requirements, including applicable standards and legislation; 2. Indicates that the deliverable appears to have been produced in accordance with the relevant engineering assurance processes; and 3. Does not remove or alter any duties or responsibilities placed on a party by the Contract, standards or statutory regulations.
☐	**ACCEPTED WITH CLARIFICATION / AMENDMENTS** (CAT 2)	**ACC-AMD**	**EM4P Category 2**. Clarification and written response to comment is required. The design deliverable shall be amended and resubmitted for final acceptance within the time frame specified by PTA in the Review Comment Sheet.
☐	**(NOT ACCEPTED) REVISE AND RESUBMIT** (CAT 3)	**REJ-RSB**	**EM4P Category 3**. The deliverable is non-compliant and introduces risk. It requires the reissue of amended documentation, as well as a written response to the comment. The resubmitted deliverable shall be subject to a further acceptance review as specified by the CPE in order to ensure compliance of the deliverable, and accepted by the PE and CPE.

CARLISLE STATION – ACOUSTIC ASSESSMENT REPORT – Reference Design

Victoria Park – Canning Level Crossing Removal Program

DOCUMENT NUMBER: LXR-ALUA-Z1-CR-SN-EN-RPT-00001

PTA DOCUMENT NUMBER: LXR-ALUA-NV-RPT-00004

Document Control Record

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Document Control						
Report Title	Carlisle Station – Acoustic Assessment Report – Reference Design					
Client	Office of Major Transport Infrastructure Delivery (OMTID)					
Rev	**Date**	**Revision Details / Status**	**Author**	**Reviewer**	**Approver**	**SEM**
A	18-07-22	Reference Design	Rachel Foster	David Peoples	Ben Hoy / Ian Stanger	John Selfridge
Current Revision	A					

Approval			
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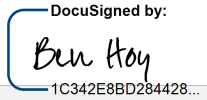
Approver Signature	DocuSigned by:  1C342E8BD284428...	SEM Signature	
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1 Introduction

1.1 Project overview

The Armadale Line Upgrade Alliance (ALUA) has been engaged to deliver the Victoria Park - Canning Level Crossing Removal (LXR) Project as part of METRONET on behalf of the Australian and Western Australian Governments.

The LXR Project involves modification to seven (7) kilometres of existing tracks on the existing Armadale Line to remove five (5) level crossing by constructing three new elevated viaduct structures. The viaduct structures are:

- Viaduct 1 (the Mint Street-Oats Street Viaduct) – Mint Street to Oats Street.
- Viaduct 2 (the Welshpool Viaduct) – Existing and future Welshpool Road interchanges.
- Viaduct 3 (the Wharf Street Viaduct) – Hamilton Street to Cannington Station.

The viaducts are interlinked with ballasted track at-grade in between. The Victoria Park - Canning level Removal Project will create Perth's first major elevated rail designed to improve public transport safety, create new and versatile public spaces for the community and reduce traffic congestion around Perth's inner suburbs.

1.2 Project Location

The project is located southeast of Perth Central Business District (CBD) and spreads across the Local Government Authority (LGA) boundaries of City of Victoria Park and City of Canning. The extent of the LXR project is shown in

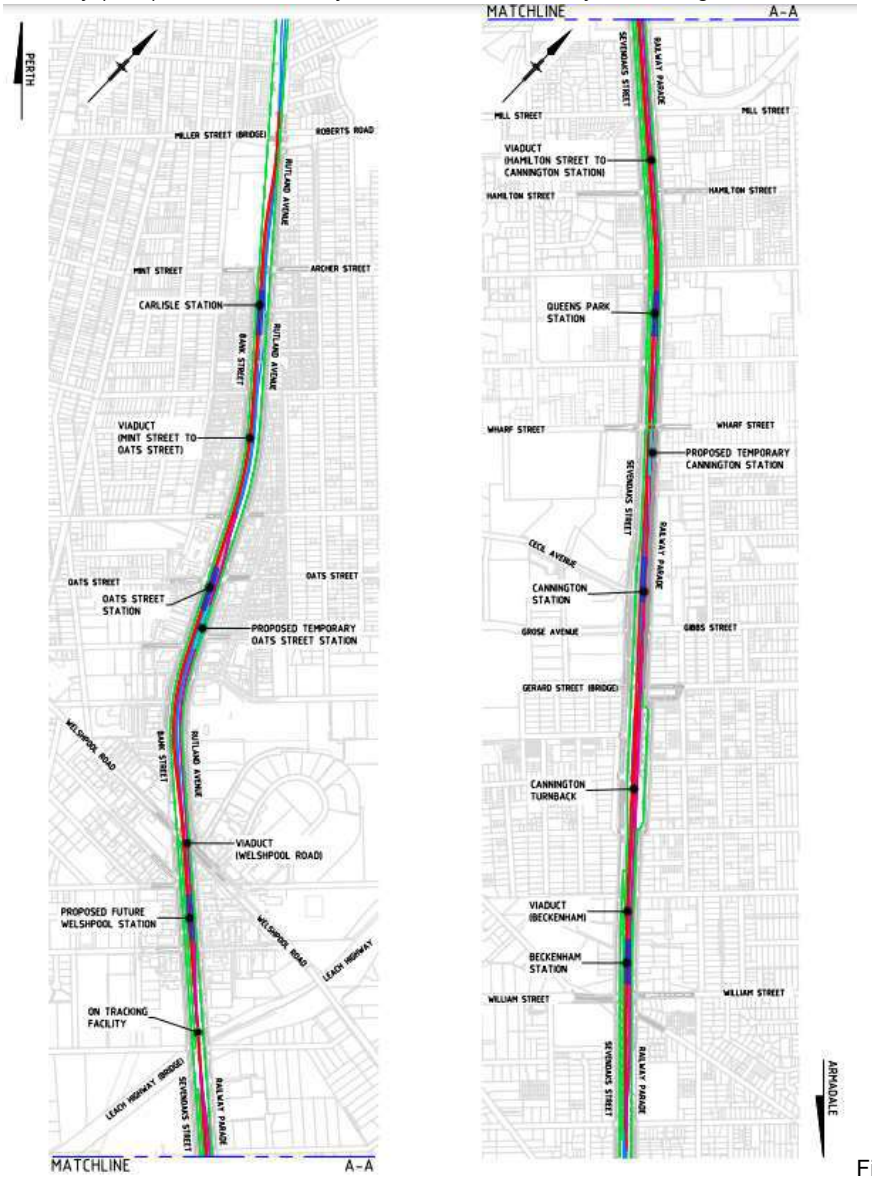


Figure 1.

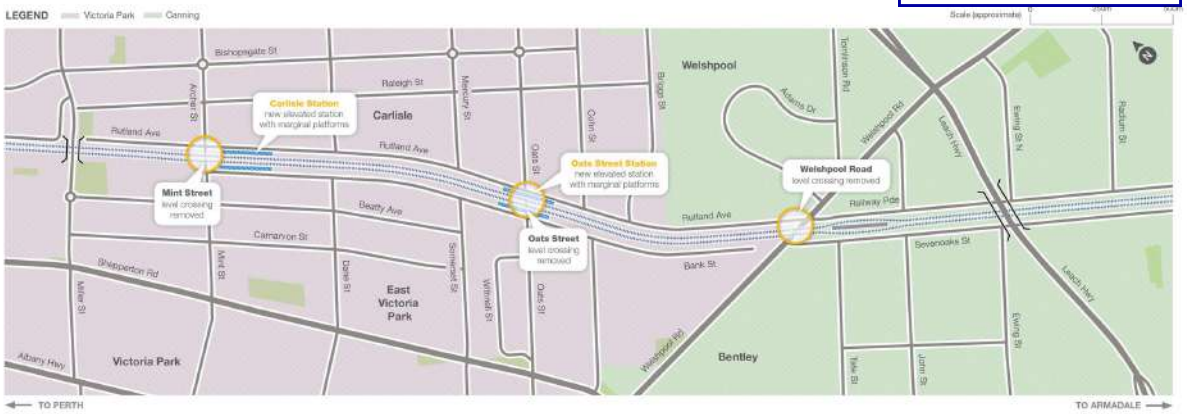


FIGURE 1 LXR OVERVIEW

1.3 Project scope details and boundaries

The overall scope of work for the LXR project is defined within the *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* (SWTC). The project involves the removal of level crossings on the inner section of the Armadale Line, which has been identified as the priority across the Perth metropolitan passenger rail network. The level crossings proposed for removal include:

- Removal of the Mint Street/Archer Street, Oats Street and Welshpool Road level crossings.
- Elevation of the Carlisle and Oats Street stations.
- Future proofing of Welshpool Station.
- Removal of the Wharf Street and Hamilton Street level crossings.
- Elevation of the Queens Park and Cannington stations.
- Construction of a new double-ended centre line turnback between Cannington Station and William Street.

1.4 Audience and Applicability

This report outlines the acoustic design development of the LXR to the stakeholders. The report is intended to supplement an understanding of the design development and how the proposed acoustic solutions were developed for the Carlisle Station to the respective delivery managers, project managers and engineers.

1.5 Document Applicability

The report is intended to provide information to the Office of Major Transport Infrastructure Delivery (OMTID) and the Public Transport Authority (PTA) to demonstrate that the Carlisle Station is compliant with design standards, specifications, and the SWTC. It highlights some design issues identified in the Reference Design (RD) and which require further assessment in the next design stage.

1.6 Document Exclusions

This report encompasses the acoustic design for the Carlisle Station only. The acoustic assessment for other stations is provided in separate reports. The acoustic assessment of rail and road noise and vibration as part of the LXR project is the focus of a separate study.

This report represents the acoustic assessment for the Reference Design phase of the project.

The following items are excluded from this design document, which will be addressed in separate packages:

- Construction methodology.
- Commissioning.

1.7 Relevant Design Documents and Packages

This design document shall be read in conjunction with the following documents summarised in Table 1.

TABLE 1 RELEVANT DESIGN DOCUMENTS

DOCUMENT NUMBER	DOCUMENT NAME
	Engineering Management Plan
	Safety Management Plan
	Digital Engineering Management Plan
LXR-MNO-SLR-NV-RPT-0001	Inner Armadale Line Level Crossing Removal Project – Operational Noise and Vibration Assessment

The following design packages which interface with the acoustic design are summarised in Table 2.

TABLE 2 RELEVANT DESIGN PACKAGES

IDENTIFICATION ID	DESIGN PACKAGE NAME
BD	Station Buildings
RS	Rail Systems

1.8 Interface with existing non-compliances

None known at this Reference Design project phase.

1.9 Related / interfacing projects

The project interfaces with the following projects:

- Leach Highway and Welshpool Road Interchange (Leach Highway Alliance).
- Duplication and modification of the existing Leach Highway bridge which overpasses the project alignment.
- Victoria Park Station Platform Extension.
- Thornlie Cockburn Link (NEWest Alliance).
    - The Thornlie Cockburn Link (TCL) is currently duplicating the Thornlie Line from Beckenham Junction to Thornlie Station, as well as extending the line to Cockburn Station on the Mandurah Line.
- Byford Rail Extension (MetCONNX Alliance)

- The Byford Rail Extension is currently extending the Armadale Line 8 kilometres southwards to provide rail services to the Byford area.

1.10 Abbreviations and Acronyms

ABBREVIATION	DESCRIPTION
AD	Alliance Development
AS	Australian Standard
EPNR	Environmental Protection (Noise) Regulations
EST	Essential Supply Transformer
FDD	Final Design Development
FSL	Finished Surface Level
HAZID	Hazard Identification
IDC	Interdisciplinary Design Check
IDD	Intermediate Design Development
IDR	Interdisciplinary Design Review
IFC	Issued for Construction
IV	Independent Verifier
LLPA	Long Line Public Address
LWA	Leach Highway and Welshpool Road Alliance
MCR	Main Cable Route
N&I	Network and Infrastructure
N&V	Noise & Vibration
NGCoP	Narrow Gauge Code of Practice
OLE	Over Head Line Equipment
OSHR	Occupational Safety and Health Regulations
PTA	Public Transport Authority
RDD	Reference Design Development
RFI	Request for Information
SER	Signalling Equipment Room
SFAIRP	So Far As Is Reasonably Practicable
SiD	Safety in Design
SPP5.4	State Planning Policy 5.4
SWTC	Scope of Works and Technical Criteria

1.11 Terminologies and Definitions

TERM	MEANING
'A' weighted	Frequency filter applied to measured noise levels to represent how humans hear sounds.
Ambient sound	The all-encompassing sound at a point being a composite of sounds from near and far.
Background sound	The ambient sound in the absence of the sound under investigation.
'C' weighted	Frequency filter which does not discriminate against low frequencies and measures uniformly over the frequency range of 30 to 10,000 Hz
dB	The decibel (dB) is a logarithmic unit of measurement that is commonly used to express sound pressure level. An increase of 3 dB corresponds to an approximate doubling of sound power. When applied to sound, an increase of 10 dB corresponds approximately to a perceived doubling of loudness; typically 0 dB is the threshold of hearing and 120 dB is the threshold of pain.
dB(A)	'A' weighted overall sound pressure level.
D_w	Weighted Level Difference – Single number that represents the noise reduction for sound passing between two adjoining enclosed spaces. It is a field measurement that relates to the R_w laboratory measurement for the dividing partition, but also includes all building elements and flanking paths and acoustic absorption in the receiving room. The result includes the actual noise reduction for

TERM	MEANING
	the installed partition and ceiling systems. The higher the D_W, the greater the noise isolation between enclosed spaces. D_W has superseded NIC as the Australian Standard for acoustically rating room to room noise isolation.
$D_{nc,w}$ / CAC	Weighted ceiling noise reduction index/ceiling attenuation class. This is the ability of a ceiling to prevent the transmission of sound. The $D_{nc,w}$/CAC is a measure of sound reduction between rooms with a common ceiling plenum (or space).
$D_{nt,w}$	Weighted standardised field level difference: the D_W rating normalised to a standard room volume and room absorption (or reverberation time). The higher the $D_{nt,w}$ rating, the better the insulation performance.
Flanking transmission	The noise transmission between two rooms sharing a common partition via all paths except that through the common partition.
Free field	A sound field sufficiently far from solid objects, other than the ground, so as to be free from the effects of sound reflections.
Frequency (Hz)	The human ear responds to sound in the frequency range of 20 hertz (Hz) to 20,000 Hz. A combination of sound pressure and frequency determine perceived loudness. The centre frequency of an octave is double the frequency of the lower octave. Sound measurements are usually taken at 16 one-third octave bands between 50 Hz and 5,000 Hz.
Impact sound transmission level	In a given frequency band, between two rooms situated one above the other: the average octave band sound pressure level, throughout the lower room, produced by impacts delivered by a standard tapping machine to the floor of the upper room.
Intermittent noise	A noise whose sound pressure level suddenly drops to the background level several times during the period of observation, the time during which the level remains at a constant value different from that of the background level being of the order of 1 s or more.
$L'_{nt,w}$	The single number quantity used to characterise the impact sound insulation of floors over a range of frequencies. See bs EN ISO140-7:1998
L_{10}	Noise level exceeded for 10% of the measurement period. This represents the upper intrusive noise level and is often used to represent traffic or music noise.
L_{90}	Noise level exceeded for 90% of the measurement period. This represents the background noise level excluding nearby sources. The L_{90} level is commonly referred to as the background noise level.
$L_{Aeq,8h}$	The 8-hour equivalent continuous a-weighted sound pressure level in decibels (dB(A)) i.e. The steady noise level which would, in the course of an 8-hour period, cause the same a-weighted sound energy which would be caused by the actual noise during an actual working day.
$L_{C,peak}$	The C-weighted peak noise level.
L_{eq}	Energy averaged noise level over the measurement period. This measure is commonly used when comparing the noise level with relevant standards for air conditioning noise.

1.12 Scope of this report

This report comprises the acoustic deliverable for the Carlisle Station. The contents of the report will serve to:

- Inform the architectural discipline as to appropriate wall/partition/door/window constructions to achieve the required acoustic separation and external noise ingress requirements.
- Inform the acoustic discipline as to appropriate surface materials and treatments to achieve the required reverberation control requirements.
- Work with the communications consultant to determine appropriate public address (PA) speaker locations to achieve appropriate speech intelligibility requirements.
- Inform the building services disciplines (mechanical, electrical, hydraulic) as to noise mitigation requirements to achieve the internal noise level requirements.
- Inform the traffic and civil design disciplines as to noise mitigation requirements to achieve the acoustic standards for car parks and bus movements.
- Inform the project as to controls required to achieve appropriate noise emission from the station to adjacent noise-sensitive premises.

2 Design Development

2.1 Key Changes

2.1.1 Alliance Design (AD) to Reference Design (RD)

The project Reference Design (RD) has been developed based on the Alliance Design developed previously. The project design development from the AD to the RD is summarised below:

- Removal of Beckenham Station, Beckenham viaduct and its associated requirements from the project scope.
- Carlisle Station has been moved 20 m away from the east kerb of Mint Street. In addition, the clearance to the soffit in the station has been reduced from 6 m to 5 m.

Specific to the acoustic inputs into the Reference Design, design team meetings have been held weekly through the design process, with interfacing disciplines. This acoustic report addresses the design development from AD to RD associated with:

- Architecture
- Building services
- Pedestrian modelling
- Traffic modelling
- PA system design

2.1.2 Reference Design (RD) to Interim Design (ID)

This section will be developed following the completion of the Reference Design development.

2.1.3 Interim Design (ID) to Final Design (FD)

This section will be developed following the completion of the Interim Design development.

2.1.4 Final Design (FD) to Issued for Construction (IFC)

This section will be developed following the completion of the Final Design development.

2.2 Critical Issues

2.2.1 Reference Design

The following critical issues identified in the Reference Design (RD) stage in relation to acoustics for the Carlisle Station which require further works are:

- Rail noise and vibration modelling is progressing concurrently and is unable to be considered in the Reference Design (RD) submission. Rail noise and vibration assessment based on the RD alignment is expected in the Intermediate Detailed Design (IDD) stage, which will be considered in the rail alignment.
- Building services (mechanical, hydraulics) are not sufficiently progressed at this Reference Design phase to enable acoustic assessment of potential noise impacts to adjacent noise-sensitive receivers.
- Details of car park vehicle and bus movements are not currently available and potential noise impacts from these will be addressed in the next design phase.
- The PA system design is not sufficiently progressed at this Reference Design phase to enable acoustic assessment of potential noise impacts to adjacent noise-sensitive receivers.

2.2.2 Deviations

No non-compliances with standards in relation to acoustics are currently anticipated.

2.2.3 Departures

Expected departures from the SWTC requirements identified are listed below:

- SWTC Book 4 Part 3 Section 13.8.2 “Noise Criteria for Ambient Noise Levels within Passenger Station Areas” as follows:

Area	Scenario	Maximum acceptable noise level (dB)
Platforms, at any position within 1.5m of platform edge or centreline (whichever is closer to track), and more than 8 metres from portals	Moving trains	L_{ASmax} 80

Previous studies have identified that the maximum acceptable noise level (L_{Amax} 80 dB) cannot be reasonably or practicably achieved at all locations on the platforms.

2.3 Design Assumptions and Limitations

The following assumptions influence the acoustic design for the Carlisle Station:

Station

- Acoustic advice outlined in this report relating to partition construction and material selection for reverberation control will be implemented in the architectural package.

Permanent Way

- Fastening system (Slab Track) – The fastening system on slab track has been assumed to be Pandrol's VIPA FASTCLIP for the Reference Design (RD). However, the fastening system used is subject to construction procurement.
- Fastening system (Ballasted Track) – The fastening system on ballasted track has been assumed to be Pandrol's e-2000 clips for the Reference Design (RD). However, the fastening system used is subject to construction procurement.

Future Requirement

- Acoustic barriers controlling rail noise, potentially influencing rail noise ingress into the station, will be compatible with the future rail quadruplication.

2.4 Outstanding Items

As interdisciplinary packages are developing concurrently, the following outstanding design inputs are required to finalise the track permanent way design.

Project information

- Survey Data (by the Alliance).
- Outstanding RFI responses in relation to train types, volumes and speeds.

Stations and Places

- Confirmation of elevated station heights.

Rail Noise and Vibration

- Rail noise and vibration assessment and modelling is progressing concurrently. Noise and vibration compliance with the SWTC requirements will be assessed in the next design stage.

2.5 Design Constraints

The project alignment corridor consists of various existing infrastructures, such as bridges, utilities. Major constraints which influence the acoustic design for Carlisle Station are outlined below:

- Minimum clearance requirements below elevated stations, including Carlisle Station. The minimum clearance requirement is summarised in Table 3.

TABLE 3 MINIMUM CLEARANCES REQUIRED BELOW STATIONS

Station Name	Minimum Clearance Requirement
Carlisle Station	6m

3 Acoustic Scope and Standards

3.1 Acoustic Scope

The objective of the acoustic design is to provide an appropriate degree of acoustic comfort for the users, public and operators alike, as well as control of station and bus/parking noise to nearby noise-sensitive receivers. To achieve this, several items were considered:

- Key acoustic materials and finishes within the station building fabric.
- Partition construction (internal and external).
- Building services (mechanical/hydraulic/electrical) as appropriate.
- Public address (PA) systems.
- Station patrons.
- Car park vehicle movements.
- Bus movements within the station area.
- Car park vehicles and bus movements connecting to the wider traffic network.

The design is developed in accordance with the PTA and SWTC requirements, the relevant Australian Standards and the requirements of the *Environmental Protection (Noise) Policy*.

3.2 Design Standards and Codes

In addition to the *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* (SWTC) and the Public Transit Authority of Western Australia (PTA)-specific requirements referenced**Error! Reference source not found.**, the codes and standards required to develop the acoustic design include the following:

TABLE 4 DESIGN STANDARDS AND CODES

Reference	Title
AS 1428.2-1992	Design for access and mobility Part 2: Enhanced and additional requirements - Buildings and Facilities
AS 1670.4 (2018)	Fire detection, warning, control and intercom systems – System design, installation and commissioning Part 4: Emergency warning and intercom systems
AS NZS 1668.1 -1998	*The use of ventilation and air conditioning in buildings Part 1: Fire and smoke control in multicompartment buildings*
AS / NZS 2107:2016	Acoustics - Recommended design sound levels and reverberation times for building interiors
AS 2436-2010	Guide to noise and vibration control on construction, maintenance and demolition sites
AS 2670.1	Evaluation of human exposure to whole-body vibration - General requirements
AS 2670.2	Evaluation of human exposure to whole-body vibration - Continuous and shock-induced vibration in buildings (1 to 80 Hz)
AS/RISSB 7532:2016	Railway Rolling Stock - Audible Warning Devices
EPNR 1997	Western Australia Environmental Protection (Noise) Regulations
BS 6472	Evaluation of Human Exposure Vibration in Buildings (1 Hz to 80 Hz)

Reference	Title
BS 7385.2	Evaluation and Measurement for Vibrations in Buildings – Part 2 Guide to Damage Levels from Ground-Borne Vibration
CR NOI TSI	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
DevWA Development Policy 3	Development Policy 3 – Sound and Vibration Attenuation
DIN 4150.3	Part 3: Structural Vibration in Buildings: Effects on Structures
ISO GUIDE 98-3	Uncertainty of measurement — Part 3:Guide to the expression of uncertainty in measurement (GUM:1995)
ISO 3095	Acoustics - Railway applications - Measurement of noise emitted by railbound vehicles - Third Edition, August 2013
ISO 3381	Railway applications - Acoustics - Measurement of noise inside railbound vehicles
ISO 8041	Human response to vibration – Measuring instrumentation
ISO 14837	Mechanical vibration - Ground-borne noise and vibration arising from rail systems
ISO/IEC Guide 98-3	Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (ISO GUM:1995)
NCC	National Construction Code
NSWRING	New South Wales Rail Infrastructure Noise Guideline, NSW EPA, May 2013
OSHR 1996	Western Australia Occupational Safety and Health Regulations
SPP5.4	State Planning Policy No. 5.4 Road and Rail Noise 2019
SPP5.4 Road and Rail Noise Guidelines	Road and Rail Noise Guidelines, September 2019
8190-600-009	American Railway Engineering and Maintenance-of-Way Association (AREMA) Communications and Signals Manual

The above list is not exhaustive but is provided to note the key guides and standards to which the design shall align.

4 Acoustic Criteria

4.1 Noise Criteria for Impacts to Surrounding Noise-Sensitive Premises

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *Stations and associated infrastructure (e.g. carparks, plant rooms etc) must be designed to comply with the requirements of the Environmental Protection (Noise) Regulations 1997 (WA).*

Noise criteria for both steady-state and discrete noise emission from the Carlisle Station are nominated in this section. The setting of noise emission criteria is intended to protect the acoustic amenity of nearby sensitive receivers.

Environmental noise impacts resulting from the Carlisle Station are addressed through the Environmental Protection Act 1986 with the prescribed standards detailed in the Western Australia *Environmental Protection (Noise) Regulations* 1997 (EPNR) as shown in Table 5. The regulations are based on maximum allowable noise levels termed the 'assigned noise level'. The regulations require that:

> *Noise emitted from any premises when received at other premises must not cause, or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind.*

A noise emission is taken to 'significantly contribute to' a level of noise if the noise emission exceeds a value which is 5 dB below the assigned level at the point of reception.

TABLE 5 ASSIGNED LEVELS BY THE WESTERN AUSTRALIAN ENVIRONMENTAL PROTECTION (NOISE) REGULATION 1997

Type of premises receiving noise	Time of Day	Environmental Emission Criterion Level dB(A)		
		$L_{A,10}$	$L_{A,1}$	$L_{A,max}$
Nearest noise sensitive receiver: highly sensitive area	0700 to 1900 hours Monday to Saturday	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + influencing factor	45 + influencing factor	55 + influencing factor
Noise sensitive premises: any area other than highly sensitive area	All hours	60	75	80
Commercial Premises	All hours	60	75	80
Industrial premises	All hours	65	80	90

The regulations also apply penalties on noise levels that contain annoying characteristics such as tonal components. Where these characteristics do exist and cannot be practicably removed, then the measured levels are adjusted according to the penalties as follows:

- Where tonality is present: +5 dB.
- Where modulation is present: +5 dB.
- Where impulsiveness is present: +10 dB.

The noise adjustments apply up to a maximum cumulative total of 15 dB.

The influencing factor is applied to account for higher noise areas as a result of nearby industrial and commercial areas and major roads. The influencing factor is determined by considering the land use within two circles having a radius of 100 m and 450 m from the noise sensitive premises of concern and proximity to major and minor roads as defined in the EPNR. The nearest noise sensitive receivers on each side of the Carlisle Station have been identified and are summarised below in Table 6.

TABLE 6 ENVIRONMENTAL DESIGN CRITERIA – NOISE-SENSITIVE RECEIVERS

Location	Noise Sensitive Receiver	Receiver Type
West	57 Bank Street, Victoria Park	Residential
East	Goodstart Early Learning Carlisle	Childcare

Note: Selection of noise-sensitive premises is based on Schedule 1 – Part C of the EPNR

It is noted that the Carlisle Hotel is closer to the Carlisle Station to the east than the Goodstart Early Learning, however the residential accommodation portion of the hotel is set further back than the façade of the Goodstart Early Learning facility.

FIGURE 2 ENVIRONMENTAL DESIGN CRITERIA – LOCATION OF NOISE-SENSITIVE RECEIVERS

Transport factors of 6 dB(A) and 2 dB(A) are applied to noise-sensitive receivers if major roads are located within 100 m and 450 m respectively. A transport factor of 2 dB(A) is applied to noise sensitive receivers if a secondary road is located within 100 m of a noise-sensitive receiver.

A major road is defined as having vehicle traffic flows in excess of 15,000 vehicles per day. A secondary road is defined as having traffic flows of 6,000 to 15,000 vehicles per day.

The major roads and secondary roads within 100 m and 450 m of the noise-sensitive receivers are identified below in Table 7.

TABLE 7 ENVIRONMENTAL DESIGN CRITERIA – MAJOR / SECONDARY ROADS

Location	Major Road Within 100 m	Secondary Road Within 100 m	Major Road Within 450 m
West	-	Mint Street / Archer Street	-

Location	Major Road Within 100 m	Secondary Road Within 100 m	Major Road Within 450 m
East	-	Mint Street / Archer Street Street	-

The area surrounding the Carlisle Station is predominantly residential, with educational (Goodstart Early Learning, East Victoria Park Primary School) and community (Harold Hawthorne Community Centre and Harold Hawthorne Social Activity Centre) premises and some commercial properties adjacent to the rail corridor on Rutland Avenue. The road and rail reserves associated with the existing rail corridor, Rutland Avenue and Mint Street / Archer Street are considerable. The zoning plans for the Town of Victoria Park have been used to identify the zoning around the station. To determine the influencing factor, existing roads and land uses have been considered. The influencing factors at the nearest noise sensitive receivers are summarised in Table 8, and the corresponding environmental noise criteria as given in Table 9.

TABLE 8 ENVIRONMENTAL DESIGN CRITERIA – INFLUENCING FACTORS

Location	% Industrial Area Use		% Commercial Area Use		Transport Factor	Influencing Factor
	100 m	450 m	100 m	450 m		
West	21.5	7.5	10	7.5	2	6
East	23	6	28.5	8.5	2	7

TABLE 9 ENVIRONMENTAL DESIGN CRITERIA – CARLISLE STATION ASSIGNED NOISE LEVEL, dB(A)

Premises receiving noise	Time of Day	Environmental Emission Criterion Level dB(A)		
		$L_{A,10}$	$L_{A,1}$	$L_{A,max}$
West	0700 to 1900 hours Monday to Saturday	51	61	71
	0900 to 1900 hours Sunday and public holidays	46	56	71
	1900 to 2200 hours all days	46	56	61
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	41	51	61
East	0700 to 1900 hours Monday to Saturday	52	62	72
	0900 to 1900 hours Sunday and public holidays	47	57	72
	1900 to 2200 hours all days	47	57	62
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	42	52	62

Note: A noise emission from a premises is considered to not significantly contribute to the noise at a receiver if the noise emission is 5 dB below the overall noise emission criteria for the area.

It is noted that the EPNR does not specifically identify that the above environmental noise criteria are applicable to noise from rail passengers and patrons of the Carlisle Station; however, an assessment is made to quantify the likely impacts of these sources to adjacent noise-sensitive receivers.

4.2 Noise Criteria for Impacts from Station Entry Roads and Bus Movements

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *The Alliance must design roads works 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).*

Table 10 sets out the environmental noise criteria referred to.

TABLE 10 ENVIRONMENTAL DESIGN CRITERIA – NEW AND UPGRADED PUBLIC ROADS AND BUS LANES

Type of premises receiving noise	Time of Day	New Road	Upgraded Road
Noise-sensitive land use (existing and planned development)	Day (6 am–10 pm)	$L_{Aeq\ (Day)}$ = 55 dB(A)	$L_{Aeq\ (Day)}$ = 60 dB(A)
	Night (10 pm–6 am)	$L_{Aeq\ (Night)}$ = 50 dB(A)	$L_{Aeq\ (Night)}$ = 55 dB(A)

For the Carlisle Station, this includes bus movements into and out of the station precinct. It is noted that there is no bus interchange at Carlisle Station.

It is noted that the assessment of rail noise to adjacent noise-sensitive receivers is being addressed separately for the LXR project, and does not form part of this scope.

4.3 Noise Criteria for Ambient Noise Levels within Passenger Station Areas

The following criteria are based on the requirements set out in the document *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria.*

Current NCC, environmental or industry standard criteria at the time of detailed design shall apply, in addition to the indicative criteria summarised in Table 11.

TABLE 11 INTERNAL DESIGN CRITERIA - NOISE

Source	Receiver	Noise criterion, dB(A)
Building services and plant noise	Ticket sales areas	L_{Aeq} 45
	General office areas	L_{Aeq} 45
	Staff crib rooms	L_{Aeq} 45
	Public waiting areas, kiosks	L_{Aeq} 45
	Toilets and amenities	L_{Aeq} 45 - 55
	Parking and waste storage areas	L_{Aeq} 65
	Plantrooms	L_{Aeq} 85 at 1 m from plant L_{Aeq} 65 overall
	All other areas	Table 1, AS/NZS 2107:2000 'Satisfactory' values plus 5dB

Source	Receiver	Noise criterion, dB(A)
Stationary trains, auxiliary equipment operating as normal	Platforms, at any position within 1.5 m of platform edge or centreline (whichever is closer to track), and more than 8 metres from portals	L_{Aeq} 70
Moving trains		L_{ASmax} 80
Building services and plant (ventilation, etc.)		L_{Aeq} 55
Emergency smoke fan systems		L_{Aeq} 85
Hydraulic services in amenities	Publicly accessible area	Inaudible
Hand dryers in amenities	2 m from amenity entrance	Inaudible

4.4 Noise and Vibration Ingress into Passenger Station Areas

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *The Alliance must comply with the following requirements:*
>
> - *External noise ingress from all associated road and rail traffic sources controlled according to the requirements of the 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 not exceed $L_{v,RMS,1s}$ 112 dB.*
> - *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.*

SPP5.4 provides noise targets for residential buildings. For other noise-sensitive land use and/or development, such as passenger station areas, the SPP5.4 states that indoor noise targets may be reasonably drawn from Table 1 of AS/NZS 2107:2016.

4.5 Reverberation within Passenger Station Areas

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *The Alliance must 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.*

Therefore, the reverberation time criteria applicable to the Carlisle Station are as shown in Table 12.

TABLE 12 INTERNAL DESIGN CRITERIA - REVERBERATION TIME

Criterion	Receiver	Reverberation time criteria at 500 Hz and 1 kHz, seconds
Reverberation	General office	0.4 - 0.6

Criterion	Receiver	Reverberation time criteria at 500 Hz and 1 kHz, seconds
	Retail	Minimised as far as practicable
	All circulation, back of house areas	-
	Toilets and amenities	-
	Ticket sales areas	0.6 – 0.8
	Platform areas	1.3 with 100 patrons present 1.6 when empty
	Staff crib rooms	< 0.8
	Public waiting areas, kiosks	Minimised as far as practicable

4.6 Public Address Systems within Passenger Station Areas

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *The Alliance must 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.*

AS 1670.4 requires that the A-weighted sound pressure level shall:

- Exceed the ambient sound pressure level by 10 dB(A) when averaged over a period of 60 seconds.
- Shall not be less than 65 dB(A).
- Shall not be more than 105 dB(A).
- When under stand-by power source operation shall not cause audible emergency signals to fall by more than 6 dB sound pressure level below the required sound level when tested after 24 hours of quiescent operation.

Additionally, AS 1670.4 requires that:

- Where ambient noise figures are less than 85 dB(A), the speech transmission index (STI) shall be ≥ 0.5.
- The average speech SPL shall not exceed 100 dB(A).
- When under stand-by power source operation the CIS index is not to fall below 0.65 (0.45 STI) when tested after 24 hours of quiescent operation.

4.7 Acoustic Sound Insulation within Passenger Station Areas

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *Airborne sound insulation targets are given in terms of the weighted level difference, Dw between two spaces. The Alliance must ensure that design complies with the following general in-situ airborne sound insulation targets:*
>
> *Dw ≥ 35dB between normally occupied enclosed spaces.*
>
> *Dw ≥ 28dB between normally occupied spaces where the common partition includes a door.*

The SWTC also presents criteria which 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. These are given in Table 13.

TABLE 13 INTERNAL DESIGN CRITERIA – ACOUSTIC SOUND INSULATION

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

The D_W rating is the 'weighted standardised field level difference' and represents the required installed performance between two spaces to achieve the different levels of acoustic separation, inclusive of all flanking paths.

The D_W rating relates to the final installed acoustic performance measured on site. Accordingly, the result will include contribution from noise leaking along flanking paths such as joints between walls and ceilings, joints between walls and other external and internal walls, leakage associated with services penetrations, along ductwork and via glazing and doors.

The difference between the result tested in a laboratory (R_W), and the result achieved on site (D_W) normally varies between 3 and 8 dB depending on how well the flanking paths can be controlled, and the receiving room size and absorptive characteristics. Flanking paths tend to have a greater impact on higher performing partitions – i.e. the impact is likely to be greater for an R_W 50 partition than for an R_W 40 partition.

In order to account for the likely degradation in performance arising from this leakage, a laboratory performance (R_W) has been recommended that is approximately 5 dB higher than the typically required field performance.

In addition to the above separation requirements, walls and doors should be designed to limit noise transmission from noise generating spaces, such as plant rooms, to meet the noise levels presented in Section 4.3.

4.8 Occupational Safety and Health

The Western Australia *Occupational Safety and Health Regulations 1996* (OSHR) provides the following exposure standards for noise:

- $L_{Aeq,8h}$ of 85 dB(A).
- $L_{C,peak}$ of 140 dB(C).

These standards are applicable at a measurement position of a person's ear without taking into account any protection which may be provided to the person by personal hearing protectors.

4.9 Construction Noise and Vibration

The EPNR clarifies that the environmental noise criteria outlined in Table 6 are not applicable to noise emitted from a construction site where works are carried out between 0700 hours and 1900 hours on any day which is not a Sunday or public holiday if it is shown that the construction works are generally carried out in accordance with the controls identified in Section 4 of AS 2436-2010 *Guide to noise and vibration control on construction, maintenance and demolition sites* and if construction work is carried out in accordance with an approved management plan.

It is noted that a specific construction noise and vibration management plan is being addressed separately for the LXR project, which will include relevant site clearing and construction works associated with the Carlisle Station, and does not form part of this scope.

5 Acoustic Solutions

5.1 Noise Impacts to Surrounding Noise-Sensitive Premises

The area surrounding the Carlisle Station is predominantly residential, with educational (Goodstart Early Learning, East Victoria Park Primary School) and community (Harold Hawthorne Community Centre and Harold Hawthorne Social Activity Centre) premises and some commercial properties adjacent to the rail corridor on Rutland Avenue.

These noise-sensitive residences in the vicinity of the Carlisle Station are already affected by noise from the existing passenger railway line, station and station car park, and from road traffic on Mint Street / Archer Street (and to a lesser extent Rutland Avenue). It is noted that the new Carlisle Station is further to the north than the existing station, and therefore those receivers potentially-affected by the existing station are not necessarily those most potentially-affected by the new station. However, the environmental noise emissions from the station and associated car parking / bus movements will need to be considered for receivers adjacent to the new station.

5.1.1 Building Services

Mechanical services plant selections for the Carlisle Station comprise:

- Small ducted exhaust fans to ablution facilities and electrical plant spaces.
- Small outdoor air fans.
- Plant room, pump room and electrical room extract systems.
- Air conditioning to comms room and electrical rooms incorporating split systems with wall-mounted indoor units, external condensing units.
- 50/75/100 kVA Essential Supply Transformer (EST).

The proposed equipment locations and layout are as shown in the following mechanical services drawings:

- LXR-P1-Z1-CR-SN-ME-DWG-00004
- LXR-P1-Z1-CR-SN-ME-DWG-00005
- LXR-P1-Z1-CR-SN-ME-DWG-00006
- LXR-P1-Z1-CR-SN-ME-DWG-00007

Mechanical services plant selections for the Carlisle Station have not been determined at this stage. It is expected that noise emission from these plant items will meet the relevant environmental noise emission requirements with minimal acoustic treatment e.g. internal duct lining.

The acoustic performance requirements presented in Section 5.7 provide the minimum acoustic ratings for partitions and doors to control environmental noise emission from the transformers to meet the relevant environmental noise requirements.

5.1.2 Public Address (PA) System

The design of the public address system will be described in detail in the Communications reporting, but will essentially consist of PTA's preferred Biamp Vocia Long Line Public Address (LLPA) system.

The LLPA system design for Carlisle Station is not sufficiently progressed at this stage of design to undertake an assessment of potential noise spill from the station to surrounding noise-sensitive areas.

The PTA's design guidelines 8803-700-005 *GUIDELINE Public Address and Voice Evacuation for PTA Facilities* for these systems include procedural mitigation to manage the use of PA speakers when passenger numbers are low (as would be expected outside of daytime hours). Specifically, the Guidelines state that:

> *The Passenger Information Network (PIN) uses the timetable and track sensors to estimate when a train is arriving/departing at a station and controls the PA system to play automated messages. This system is turned off when the station is frequented by fewer than 5 passengers / 30 minutes.*

This will be taken into account during the assessment undertaken during the next design phase.

5.1.3 Car Park

The car parking associated with the Carlisle Station is proposed to have a maximum capacity of over 90 bays. At this level of design, the maximum day and night 15-minute vehicle trips are not available. Data is currently being sought from the PTA's 'SmartParker' system to inform this data.

Noise levels will take into account a full parking movement, including vehicle movement, shunting, door/boot opening/closing and engine start-up. Where feasible, estimated car park noise levels will take into account the effects of any acoustic barriers which the project may be required to construct to meet rail noise criteria as defined in the SWTC.

Noise from the car park will be taken into account during the assessment undertaken during the next design phase.

5.1.4 Passenger Noise

The Carlisle Station is anticipated to have around 2390 passengers per day by 2051. The highest passenger volume is expected during the morning peak hour period, with 111 boardings and 9 alightings between 07:45 and 08:00 a.m. This equates to around 120 passengers on the station platform for the peak 15-minute period.

The highest passenger volume for the night-time period occurs from 06:45a.m. to 07:00a.m., having 40 boardings. There is currently no data for alightings, although this is expected to be minimal.

On the basis that the gender split is 50%/50%, and that half the passengers would be speaking in normal voices at any one point in time, the predicted noise levels from passengers at the nearest noise-sensitive receptors are as given in Table 14.

TABLE 14 PREDICTED PASSENGER NOISE LEVELS

Location	Predicted Noise Level $L_{Aeq,15min}$ (Day)	Predicted Noise Level $L_{Aeq,15min}$ (Night)
West	40 dB(A)	35 dB(A)
East	36 dB(A)	31 dB(A)

These predicted noise levels are well below the day-time and night time environmental noise criteria, and therefore noise from passengers on the Carlisle Station platform is not expected to cause disturbance to the nearby noise-sensitive receivers.

5.1.5 Total Station Noise Impact

The total predicted noise levels at the nearest noise-sensitive receivers to the Carlisle Station will be assessed during the next design phase, and compared against the day-time and night time environmental noise criteria presented in Table 9.

5.2 Noise Impacts from Bus Movements

The bus movements through the Carlisle Station are required to be assessed against the road traffic requirements of the SPP 5.4. It is noted that there is no bus interchange at Carlisle Station. Noise from the estimated 2051 bus movements through the Carlisle Station parking area will be assessed during the next design phase, and compared against the day-time and night time environmental noise criteria presented in Table 9.

5.3 Ambient Noise Levels within Passenger Station Areas

Ambient noise levels within the Carlisle Station areas will be dominated by road and rail traffic noise intrusion and by building services such as fans and air conditioning.

The mechanical services being provided to the Carlisle Station are identified in Section 5.1.1. Mechanical services plant selections for the Carlisle Station have not been determined at this stage, however, it is expected that standard noise control measures such as internal duct lining will be sufficient to control mechanical services plant noise in order to meet the required ambient noise levels within station areas.

Where an absorptive ceiling is required (such as a mineral fibre tile, as discussed in Section 5.5), it may be necessary to acoustically lag the services ductwork and/or provide a solid (e.g. plasterboard) backing to the ceiling tiles to control noise breakout from ceiling-mounted equipment.

5.4 Noise and Vibration Ingress into Passenger Station Areas

The acoustic performance requirements presented in Section 5.7 provide the minimum acoustic ratings for partitions and doors to control noise ingress from road and rail noise to meet the relevant internal noise level requirements.

It is expected that the vibration impacts on the Carlisle Station passenger areas will be similar to that experienced in the existing passenger areas at the existing Carlisle Station and therefore significant acoustic treatment is unlikely to be required.

It is noted that previous studies have identified that the maximum acceptable noise level (L_{Amax} 80 dB) cannot be reasonably or practicably achieved at all locations on the platforms.

5.5 Reverberation within Passenger Station Areas

To provide optimum internal acoustic environments for the internal spaces of the station, consideration needs to be given to the layout of spaces, the types of material finishes applied and their proposed locations within the spaces. These factors will all influence the acoustic environment and have the potential to effect occupant comfort and the functional use of spaces.

To control the build-up of sound within a space, acoustically absorptive treatments are typically applied to wall and ceiling surfaces. Absorptive materials are typically soft, fibrous materials, which present a tortuous path to incident sound waves, causing them to lose acoustic energy to heat on passing through the material. Examples of common acoustically absorptive treatments include glasswool or polyester batts, acoustic foams and compressed mineral fibre ceiling tiles.

Due to their inherent soft composition, acoustically absorptive materials are often faced with a perforated, rigid facing material, such as timber or metal, which provides protection from mechanical damage and also typically satisfies aesthetic aims. Absorptive materials can also be fabric faced, for example, by stretching an open weave fabric across a stud frame with glasswool or polyester batts installed in the cavity behind.

Acoustically absorptive treatments are specified in terms of their Noise Reduction Coefficient (NRC), a measure of the sound energy they absorb. NRC values range between 0 and 1, with 0 being completely reflective (no absorption) and 1 being highly absorptive.

Acoustically absorbent finishes suggested for the Carlisle Station are as follows:

- Coruline soffit lining with acoustic insulation above to platform and concourse areas, as has been applied to the Aubin Grove Station and is currently being proposed for the stations associated with the METRONET project (Thornlie-Cockburn Link and Yanchep Rail Extension). The Coruline soffit lining (minimum 15% open area) with minimum 50 mm acoustic insulation above should provide an NRC in excess of 0.8. This should be sufficient to meet the reverberation time criteria for new spaces when applied to the extent outlined below.
- Mineral fibre tiles to occupied spaces such as offices and CSO booths, having minimum NRC 0.5 performance.

Alternative absorptive finishes are acceptable, however, must meet minimum NRC performance requirements and should be approved by the acoustic consultant prior to implementation.

The extent of acoustically-absorptive absorptive ceiling required will be confirmed in conjunction with the Communications discipline during the next design phase, to ensure that PA announcements and speech intelligibility requirements are met.

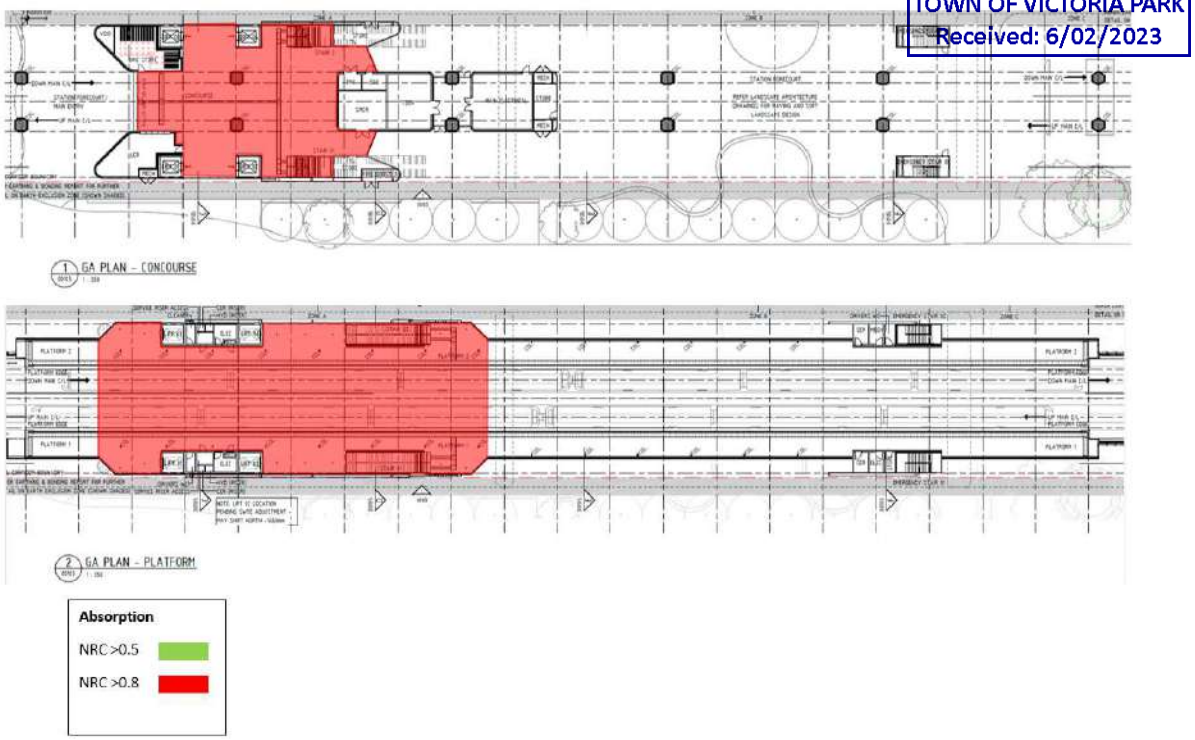


FIGURE 3 ACOUSTICALLY ABSORPTIVE FINISHES

5.6 Public Address Systems within Passenger Station Areas

Public address system design will be developed during the next stage of the design development to meet the requirement outlined in Section 4.6.

5.7 Acoustic Sound Insulation

Minimum Weighted Sound Reduction (R_w) ratings to meet acoustic separation requirements are provided for partitions and doors below.

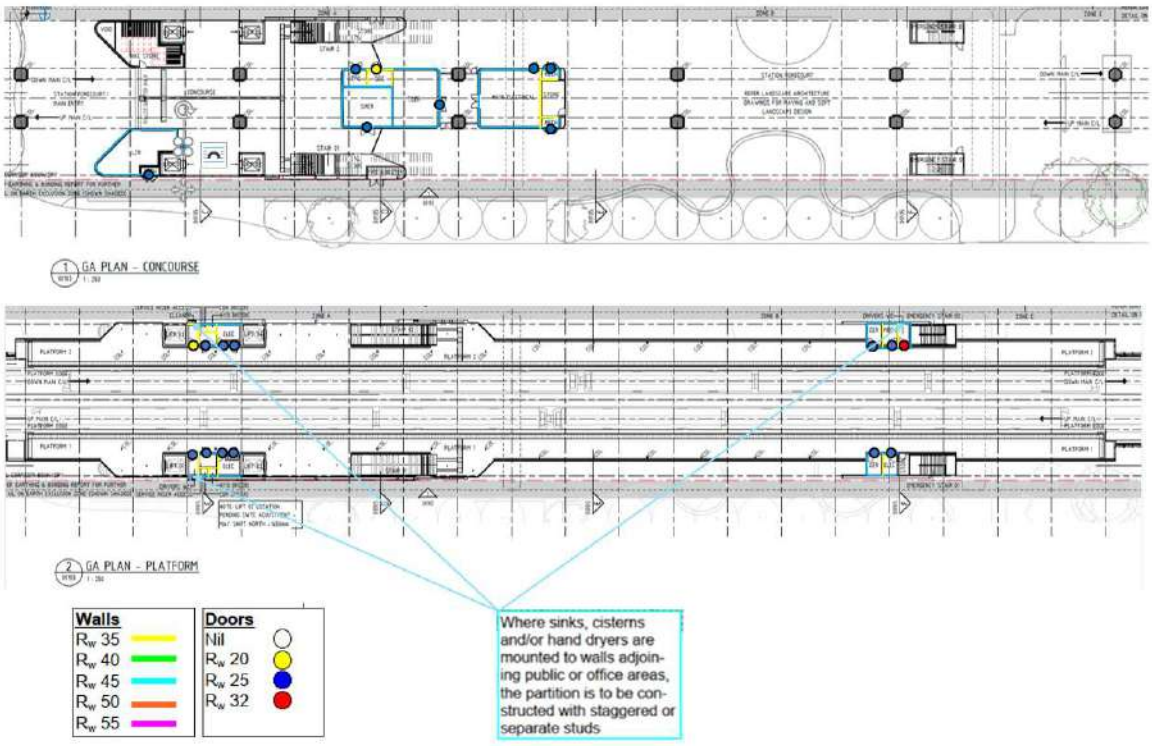


FIGURE 4 MINIMUM R_W REQUIRMENTS

Recommended partition constructions to meet the minimum R_w ratings presented above are presented in Table 15.

The following general notes on construction detailing for internal partitions should be read in conjunction with specific details and requirements outlined in the body of this report.

Continuous elements

A saw cut must be provided in lightweight linings (e.g. plasterboard) that are continuous across the partition line between spaces with a high performance wall i.e. R_W 50 and above. That is, one sheet of plasterboard or similar should not span continuously across two spaces. This note also applies to internal perimeter cladding, bulkheads and ceiling plasterboard margins.

Sheeting installation

In addition to the manufacturer's installation instructions, ensure the following:

- Joints are to be offset by a minimum 300 mm on opposing sides when not backed by a nogging AND for two layer sheeting the joints on the second layer are to be offset by 300 mm from the joints of the first.
- All joints between sheets or between sheets and any adjoining construction must be taped and set.

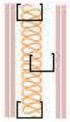
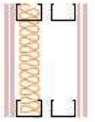
Sealing

- An airtight seal should be provided between partition edges and other building elements by means of a flexible sealant.
- All acoustically rated walls should be sealed at the head and base with flexible caulking compound and backing rods as required. The flexible sealant may be acrylic, polyurethane or silicone based. Any other proposed acoustic sealant should be first approved by the acoustic consultant.

Penetrations for Services

- For mechanical services, it must be ensured that there are no flexible ductwork penetrations in full height walls and that gaps around any rigid duct penetrations are sealed air-tight with a flexible sealant; also ensure that ducts do not run along the line of full height partitions or partitions with acoustic baffles.
- The gaps around cable tray penetrations should be filled with compacted acoustic grade insulation or fire pillows as per manufacturer's instructions.

TABLE 15 RECOMMENDED PARTITION CONSTRUCTIONS

Construction Element	Nominal Acoustic Rating					
	Standard R_w 35	**Medium** R_w 40	**High** R_w 45	**Very High / ASL-3** R_w 50	**Audio Secure / ASL-4 / ASL-3 with speech reinforcement** R_w 55	**Audio Secure Plus / ASL-5 / ASL-4 with speech reinforcement** R_w 60
	(Yellow)	(Green)	(Blue)	(Red)	(Purple)	(Purple)
Base Partition	 92 mm steel studs. 13 mm plasterboard each side. Cavity insulation not required.	 92 mm steel studs. 13 mm plasterboard each side. Cavity insulation (minimum 75 mm, 14 kg/m^3)	 92 mm steel studs. 2x 13 mm plasterboard to one side. 1x 13 mm plasterboard to other side. Cavity insulation (minimum 75 mm, 14 kg/m^3)	 92 mm steel studs. 2x 13 mm fire-rated plasterboard to side. 1x 13 mm fire-rated plasterboard other side. Cavity insulation (minimum 75 mm, 14 kg/m^3)	 Staggered 64mm steel studs in a 92mm steel track. 2x 13 mm fire-rated plasterboard each side. Cavity insulation (minimum 75 mm, 14 kg/m^3)	 Double 92mm steel studs separated by minimum 20mm. 2x 13 mm fire-rated plasterboard each side. Cavity insulation (minimum 75 mm, 14 kg/m^3)
Glazing (partitions without a door)	10.38mm laminated glazing to achieve R_w 35	Proprietary acoustic glazing system with an R_W 40 rating, (e.g. 12.5 mm Viridian 'VLam Hush' with the appropriate seals and frame) Or, Sealed double glazed R_W 40 unit (e.g. 6 / 13 / 10.38)	R_W 44 double-glazing system (e.g. 10.38 mm laminated / 50 mm cavity / 6.38 mm laminated)	R_W 48 double-glazing system (e.g. 12.76 mm laminated / 100 mm cavity / 10.38 mm laminated)	Glazing generally not permitted, specific instances must be reviewed. R_W 52 double-glazing system (e.g. 12.76 mm laminated / 250 mm cavity / 10.38 mm laminated)	Glazing not permitted.
Glazing (when co-located with a door)	Single layer of 6 mm float or 6.38 mm laminated glazing to achieve R_W 30	10.38mm laminated glazing to achieve R_W 35	Proprietary acoustic glazing system with an R_W 40 rating, (e.g. 12.5 mm Viridian 'VLam Hush' with the appropriate seals and frame) Or, Sealed double-glazed R_W 40 unit (e.g. 6 / 13 / 10.38)	R_W 44 double glazing system (e.g. 10.38 mm laminated / 50 mm cavity / 6.38 mm laminated) ***For ASL-3 designated spaces R_W 48 double glazing must be used.***	10.38 mm laminated vision panels may be permitted in end walls of airlock (subject to security requirements). Area of glazing should be strictly limited.	12.76 mm laminated vision panels may be permitted in end walls of airlock (subject to security requirements). Area of glazing should be strictly limited.
Doors	40mm solid timber core door to achieve R_w 25 with seals to the head and jamb	40 mm solid timber core door Or, 6.38mm laminated glazed door with acoustic seals to achieve R_w 30	Proprietary door system with frame and seals to achieve R_w 35.	Airlock entry with 44 mm solid timber core doors and acoustic seals to achieve minimum R_w 32 for each door Or, High performance proprietary door achieving minimum R_w 45, with high attention to onsite detailing during construction.	Airlock entry with 44 mm solid timber core doors and acoustic seals to achieve minimum R_w 32 for each door	Airlock entry with 44 mm solid timber core doors and acoustic seals to achieve minimum R_w 32 for each door
Ceiling Junction	Create an airtight seal at the ceiling join by means of two closed cell foam strips along top edge of plasterboard.	Partition to penetrate ceiling line by at least 100 mm, with air-tight seal between ceiling edge and partition linings using a flexible caulking compound.	Partition to penetrate ceiling line by at least 100 mm, with air-tight seal between ceiling edge and partition linings using a flexible caulking compound. Lay 1200 mm wide strip of 50 mm thick acoustic insulation with a	Minimum one layer of plasterboard on each side of the partition is to penetrate the ceiling and continue to the underside of the soffit or roof deck with an airtight seal.	Minimum one layer of plasterboard on each side of the partition is to penetrate the ceiling, and continue to the underside of the soffit or roof deck above with an airtight seal.	Minimum one layer of plasterboard on each side of the partition is to penetrate the ceiling, and continue to the underside of the soffit or roof deck above with an airtight seal.

Construction Element	Nominal Acoustic Rating					
	Standard R_w 35	Medium R_w 40	High R_w 45	Very High / ASL-3 R_w 50	Audio Secure / ASL-4 / ASL-3 with speech reinforcement R_w 55	Audio Secure Plus / ASL-5 / ASL-4 with speech reinforcement R_w 60
	(Yellow)	(Green)	(Blue)	(Red)	(Purple)	(Purple)
			minimum density of 32 kg/m^3 on either side of the partition line.	*For ASL designated spaces all linings should extend full height*	*For SCIF or ASL designated spaces all linings should extend full height*	*For SCIF or ASL designated spaces all linings should extend full height*

Table notes:

i. Recommended plasterboard thicknesses and stud depths are minimum requirements. These may be increased, as required to meet structural or other requirements.

ii. Timber studs will reduce the performance of the partition by approximately 3 to 5 dB and where proposed alternative constructions will need to be considered to maintain the acoustic performance.

iii. Where insulation is recommended to be laid on top of the ceiling, a suitable insulation product is 50 mm thick Tontine 'Acoustisorb 2'.

iv. Any pipework within partition cavities should be fixed only to the wet / toilet side of the partition.

v. Where a door is incorporated into an acoustically rated partition, the overall performance of the partition will be reduced. The partition including the door is expected to achieve an acoustic rating 5 – 7 dB below the nominal R_W rating given in the table above.

vi. Note in our experience a proprietary door system may not achieve the nominated performance when installed on site, and as such we typically recommend that a sound lock lobby be used for ASL-3 spaces.

vii. Ceiling junctions based on acoustic ceiling tiles with CAC (Ceiling Attenuation Class) or $D_{nC,w}$ (Weighted Ceiling Noise Reduction Index) rating ≥ 40. The above ceiling partition treatments would need to be upgraded in areas where the ceiling does not achieve this performance (e.g. standard ceiling tiles, perforated ceilings, etc.).

viii. Where return air slots are located within 1.5 metres of a partition, they will need to be treated with acoustically lined return air boots or blanked off.

ix. Penetrations in full-height wall elements should be avoided within the ceiling void (e.g. for building services). Where penetrations cannot be avoided, all penetrations must be acoustically sealed and lagging of services may also be required.

x. Wall linings may in general be substituted with alternative products, as long as the surface mass of each leaf is maintained. For example:

- 13 mm plasterboard may be substituted with 6 mm fibre-cement sheet, or 13 mm impact-rated plasterboard.
- 16 mm fire-rated plasterboard may be substituted with 9 mm fibre-cement sheet.

6 Risks and opportunities

A list of risks and opportunities identified in the RD alignment were noted in an alliance wide register. The register, showing risk and opportunities relevant to the track alignment may be referred to in **Error! Reference source not found.** of the stations design report.

7 Systems Engineering

7.1 Safety in design

Safety in Design and Hazard Workshops for RD are held as the design progresses. A list of Safety in Design workshops is summarised in Table 16. The purpose of the workshops is to identify and eliminate preliminary risks during the RD phase arising from the station design, that may result in hazards to personnel in the Construction and O&M phases; and if it is not reasonably practicable to eliminate risk, to minimise those risk so far as is reasonably practicable (SFAIRP).

TABLE 16 SAFETY IN DESIGN WORKSHOPS

SiD Session	Safety in Design
HAZID and Analysis Workshop 01 – Stations – RD (11th May, 2022)	Safety in Design (SiD) and Hazard Identification (HAZID) / analysis for RD Stations.

7.2 Reliability, Availability and Maintainability RAMS

Reliability, Available and Maintainability (RAM) analysis is a systems engineering process in place to ensure that the design life, durability, maintenance and progressive degradation of permanent works items are adequate.

RAM analysis does not form part of the Acoustic scope of works.

7.3 Human Factors

Human Factors (HF) integration does not form part of the Acoustic scope of works.

8 Quality Management

Design verification has been undertaken with the requirements outlined in the Engineering Management Plan (LXR-ALUA-EA-PLN-00001).

8.1 Design Review Process

The design review process for the Reference Design is summarised in Table 17.

TABLE 17 DESIGN REVIEW PROCESS

Review Process	Duration [working day(s)]	Dates (close of business)
Verification	10	
IDC	Day 10	
Update	3	
IV/ISA	10	
Comment Closeout	3	

8.2 Interdisciplinary Design Coordination

The Interfacing Design Coordination (IDC) is scheduled to be held on the 29 July 2022. The IDC certificate will be attached in Appendix C of the design report when available.

OATS STREET STATION – ACOUSTIC ASSESSMENT REPORT – Reference Design

Victoria Park – Canning Level Crossing Removal Program

DOCUMENT NUMBER: LXR-PW-Z2-OT-SN-EN-RPT-00001

PTA DOCUMENT NUMBER: LXR-ALUA-NV-RPT-00002

Document Control Record

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Document Control						
Report Title	Oats Street Station – Acoustic Assessment Report – Reference Design					
Client	Office of Major Transport Infrastructure Delivery (OMTID)					
Rev	**Date**	**Revision Details / Status**	**Author**	**Reviewer**	**Approver**	**SEM**
A	05-07-22	Reference Design	Rachel Foster	David Peoples	Ben Hoy / Ian Stanger	John Selfridge
Current Revision	A					

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1 Introduction

1.1 Project overview

The Armadale Line Upgrade Alliance (ALUA) has been engaged to deliver the Victoria Park - Canning Level Crossing Removal (LXR) Project as part of METRONET on behalf of the Australian and Western Australian Governments.

The LXR Project involves modification to seven (7) kilometres of existing tracks on the existing Armadale Line to remove five (5) level crossing by constructing three new elevated viaduct structures. The viaduct structures are:

- Viaduct 1 (the Mint Street-Oats Street Viaduct) – Mint Street to Oats Street.
- Viaduct 2 (the Welshpool Viaduct) – Existing and future Welshpool Road interchanges.
- Viaduct 3 (the Wharf Street Viaduct) – Hamilton Street to Cannington Station.

The viaducts are interlinked with ballasted track at-grade in between. The Victoria Park - Canning level Removal Project will create Perth's first major elevated rail designed to improve public transport safety, create new and versatile public spaces for the community and reduce traffic congestion around Perth's inner suburbs.

1.2 Project Location

The project is located southeast of Perth Central Business District (CBD) and spreads across the Local Government Authority (LGA) boundaries of City of Victoria Park and City of Canning. The extent of the LXR project is shown in Figure 1.

FIGURE 1 ALXR OVERVIEW

1.3 Project scope details and boundaries

The overall scope of work for the LXR project is defined within the Victoria Park-Canning Level Crossing Removal *Scope of Works and Technical Criteria* (SWTC). The project involves the removal of level crossings on the inner section of the Armadale Line, which has been identified as the priority across the Perth metropolitan passenger rail network. The level crossings proposed for removal include:

- Removal of the Mint Street/Archer Street, Oats Street and Welshpool Road level crossings.
- Elevation of the Carlisle and Oats Street stations.
- Future proofing of Welshpool Station.
- Removal of the Wharf Street and Hamilton Street level crossings.
- Elevation of the Queens Park and Cannington stations.

- Construction of a new double-ended centre line turnback between Cannington Station and William Street.

1.4 Audience and Applicability

This report outlines the acoustic design development of the LXR to the stakeholders. The report is intended to supplement an understanding of the design development and how the proposed acoustic solutions were developed for the Oats Street Station to the respective delivery managers, project managers and engineers.

1.5 Document Applicability

The report is intended to provide information to the Office of Major Transport Infrastructure Delivery (OMTID) and the Public Transport Authority (PTA) to demonstrate that the Oats Street Station is compliant with design standards, specifications, and the SWTC. It highlights some design issues identified in the Reference Design (RD) and which require further assessment in the next design stage.

1.6 Document Exclusions

This report encompasses the acoustic design for the Oats Street Station only. The acoustic assessment for other stations is provided in separate reports. The acoustic assessment of rail and road noise and vibration as part of the ALXR project is the focus of a separate study.

This report represents the acoustic assessment for the Reference Design phase of the project.

The following items are excluded from this design document, which will be addressed in separate packages:

- Construction methodology.
- Commissioning.

1.7 Relevant Design Documents and Packages

This design document shall be read in conjunction with the following documents summarised in Table 1.

TABLE 1 RELEVANT DESIGN DOCUMENTS

DOCUMENT NUMBER	DOCUMENT NAME
	Engineering Management Plan
	Safety Management Plan
	Digital Engineering Management Plan
LXR-MNO-SLR-NV-RPT-0001	Inner Armadale Line Level Crossing Removal Project – Operational Noise and Vibration Assessment

The following design packages which interface with the acoustic design are summarised in Table 2.

TABLE 2 RELEVANT DESIGN PACKAGES

IDENTIFICATION ID	DESIGN PACKAGE NAME
BD	Station Buildings
RS	Rail Systems

1.8 Interface with existing non-compliances

None known at this Reference Design project phase.

1.9 Related / interfacing projects

The project interfaces with the following projects:

- Leach Highway and Welshpool Road Interchange (Leach Highway Alliance)
- Duplication and modification of the existing Leach Highway bridge which overpasses the project alignment
- Victoria Park Station Platform Extension
- Thornlie Cockburn Link (NEWest Alliance)

- The Thornlie Cockburn Link (TCL) is currently duplicating the Thornlie Line from Beckenham Junction to Thornlie Station, as well as extending the line to Cockburn Station on the Mandurah Line.

- Byford Rail Extension (MetCONNX Alliance)
  - The Byford Rail Extension is currently extending the Armadale Line 8 kilometres southwards to provide rail services to the Byford area.

1.10 Abbreviations and Acronyms

ABBREVIATION	DESCRIPTION
AD	Alliance Development
AS	Australian Standard
EPNR	Environmental Protection (Noise) Regulations
EST	Essential Supply Transformer
FDD	Final Design Development
FSL	Finished Surface Level
HAZID	Hazard Identification
IDC	Interdisciplinary Design Check
IDD	Intermediate Design Development
IDR	Interdisciplinary Design Review
IFC	Issued for Construction
IV	Independent Verifier
LLPA	Long Line Public Address
LWA	Leach Highway and Welshpool Road Alliance
MCR	Main Cable Route
N&I	Network and Infrastructure
N&V	Noise & Vibration
NGCoP	Narrow Gauge Code of Practice
OLE	Overhead Line Equipment
OMTID	Office of Major Transport Infrastructure Delivery
OSHR	Occupational Safety and Health Regulations
PTA	Public Transport Authority
RDD	Reference Design Development
RFI	Request for Information
SER	Signalling Equipment Room
SFAIRP	So Far As Is Reasonably Practicable
SiD	Safety in Design
SPP 5.4	State Planning Policy 5.4
SWTC	Scope of Works and Technical Criteria

1.11 Terminologies and Definitions

TERM	MEANING
'A' weighted	Frequency filter applied to measured noise levels to represent how humans hear sounds.
Ambient sound	The all-encompassing sound at a point being a composite of sounds from near and far.
Background sound	The ambient sound in the absence of the sound under investigation.
'C' weighted	Frequency filter which does not discriminate against low frequencies and measures uniformly over the frequency range of 30 to 10,000 Hz
dB	The decibel (dB) is a logarithmic unit of measurement that is commonly used to express sound pressure level. An increase of 3 dB corresponds to an approximate doubling of sound power. When applied to sound, an increase of 10 dB corresponds approximately to a perceived doubling of loudness; typically 0 dB is the threshold of hearing and 120 dB is the threshold of pain.

TERM	MEANING
dB(A)	'A' weighted overall sound pressure level.
D_W	Weighted Level Difference – Single number that represents the noise reduction for sound passing between two adjoining enclosed spaces. It is a field measurement that relates to the R_W laboratory measurement for the dividing partition, but also includes all building elements and flanking paths and acoustic absorption in the receiving room. The result includes the actual noise reduction for the installed partition and ceiling systems. The higher the D_W, the greater the noise isolation between enclosed spaces. D_W has superseded NIC as the Australian Standard for acoustically rating room to room noise isolation.
$D_{nc,w}$ / CAC	Weighted ceiling noise reduction index/ceiling attenuation class. This is the ability of a ceiling to prevent the transmission of sound. The $D_{nc,w}$/CAC is a measure of sound reduction between rooms with a common ceiling plenum (or space).
$D_{nt,w}$	Weighted standardised field level difference: the D_W rating normalised to a standard room volume and room absorption (or reverberation time). The higher the $D_{nt,w}$ rating, the better the insulation performance.
Flanking transmission	The noise transmission between two rooms sharing a common partition via all paths except that through the common partition.
Free field	A sound field sufficiently far from solid objects, other than the ground, so as to be free from the effects of sound reflections.
Frequency (Hz)	The human ear responds to sound in the frequency range of 20 hertz (Hz) to 20,000 Hz. A combination of sound pressure and frequency determine perceived loudness. The centre frequency of an octave is double the frequency of the lower octave. Sound measurements are usually taken at 16 one-third octave bands between 50 Hz and 5,000 Hz.
Impact sound transmission level	In a given frequency band, between two rooms situated one above the other: the average octave band sound pressure level, throughout the lower room, produced by impacts delivered by a standard tapping machine to the floor of the upper room.
Intermittent noise	A noise whose sound pressure level suddenly drops to the background level several times during the period of observation, the time during which the level remains at a constant value different from that of the background level being of the order of 1 s or more.
$L'_{nt,w}$	The single number quantity used to characterise the impact sound insulation of floors over a range of frequencies. See bs EN ISO140-7:1998
L_{10}	Noise level exceeded for 10% of the measurement period. This represents the upper intrusive noise level and is often used to represent traffic or music noise.
L_{90}	Noise level exceeded for 90% of the measurement period. This represents the background noise level excluding nearby sources. The L_{90} level is commonly referred to as the background noise level.
$L_{Aeq,8h}$	The 8-hour equivalent continuous a-weighted sound pressure level in decibels (dB(A)) i.e. The steady noise level which would, in the course of an 8-hour period, cause the same a-weighted sound energy which would be caused by the actual noise during an actual working day.
$L_{C,peak}$	The C-weighted peak noise level.
L_{eq}	Energy averaged noise level over the measurement period. This measure is commonly used when comparing the noise level with relevant standards for air conditioning noise.

1.12 Scope of this report

This report comprises the acoustic deliverable for the Oats Station. The contents of the report will serve to:

- Inform the architectural discipline as to appropriate wall/partition/door/window constructions to achieve the required acoustic separation and external noise ingress requirements.
- Inform the acoustic discipline as to appropriate surface materials and treatments to achieve the required reverberation control requirements.
- Work with the communications consultant to determine appropriate public address (PA) speaker locations to achieve appropriate speech intelligibility requirements.
- Inform the building services disciplines (mechanical, electrical, hydraulic) as to noise mitigation requirements to achieve the internal noise level requirements.
- Inform the traffic and civil design disciplines as to noise mitigation requirements to achieve the acoustic standards for car parks and bus movements.
- Inform the project as to controls required to achieve appropriate noise emission from the station to adjacent noise-sensitive premises.

2 Design Development

2.1 Key Changes

2.1.1 Alliance Design (AD) to Reference Design (RD)

The project Reference Design (RD) has been developed based on the Alliance Design developed previously. The project design development from the AD to the RD is summarised below:

- Removal of Beckenham Station, Beckenham viaduct and its associated requirements from the project scope.

Specific to the acoustic inputs into the Reference Design, design team meetings have been held weekly through the design process, with interfacing disciplines. This acoustic report addresses the design development from AD to RD associated with:

- Architecture.
- Building services.
- Pedestrian modelling.
- Traffic modelling.
- PA system design.

2.1.2 Reference Design (RD) to Interim Design (ID)

This section will be developed following the completion of the Reference Design development.

2.1.3 Interim Design (ID) to Final Design (FD)

This section will be developed following the completion of the Interim Design development.

2.1.4 Final Design (FD) to Issued for Construction (IFC)

This section will be developed following the completion of the Final Design development.

2.2 Critical Issues

2.2.1 Reference Design

The following critical issues identified in the Reference Design (RD) stage in relation to acoustics for the Oats Street Station which require further works are:

- Rail noise and vibration modelling is progressing concurrently and is unable to be considered in the Reference Design (RD) submission. Rail noise and vibration assessment based on the RD alignment is expected in the Interim Design (ID) stage, which will be considered in the rail alignment.
- Building services (mechanical, hydraulics) are not sufficiently progressed at this Reference Design phase to enable acoustic assessment of potential noise impacts to adjacent noise-sensitive receivers.
- Details of car park vehicle and bus movements are not currently available and potential noise impacts from these will be addressed in the next design phase.
- The PA system design is not sufficiently progressed at this Reference Design phase to enable acoustic assessment of potential noise impacts to adjacent noise-sensitive receivers.

2.2.2 Deviations

No non-compliances with standards in relation to acoustics are currently anticipated.

2.2.3 Departures

Expected departures from the SWTC requirements identified are listed below:

- SWTC Book 4 Part 3 Section 13.8.2 “Noise Criteria for Ambient Noise Levels within Passenger Station Areas” as follows:

Area	Scenario	Maximum acceptable noise level (dB)
Platforms, at any position within 1.5m of platform edge or centreline (whichever is closer to track), and more than 8 metres from portals	Moving trains	L_{ASmax} 80

It is noted that previous studies have identified that the maximum acceptable noise level (L_{Amax} 80 dB) cannot be reasonably or practicably achieved at all locations on the platforms.

2.3 Design Assumptions and Limitations

The following assumptions influencing the acoustic design for the Oats Street Station are:

Station

- Acoustic advice outlined in this report relating to partition construction and material selection for reverberation control will be implemented in the architectural package.

Permanent Way

- Fastening system (Slab Track) – The fastening system on slab track has been assumed to be Pandrol's VIPA FASTCLIP for the Reference Design (RD). However, the fastening system used is subject to construction procurement.
- Fastening system (Ballasted Track) – The fastening system on ballasted track has been assumed to be Pandrol's e-2000 clips for the Reference Design (RD). However, the fastening system used is subject to construction procurement.

Future Requirement

- Acoustic barriers controlling rail noise, potentially influencing rail noise ingress into the station, will be compatible with the future rail quadruplication.

2.4 Outstanding Items

As interdisciplinary packages are developing concurrently, the following outstanding design inputs are required to finalise the track permanent way design.

Project information

- Survey Data (by the Alliance).
- Outstanding RFI responses in relation to train types, volumes and speeds.

Stations and Places

- Confirmation of Elevated Station heights.

Noise and Vibration

- Rail noise and vibration assessment and modelling is progressing concurrently. Noise and vibration compliance with the SWTC requirements will be assessed in the next design stage.

2.5 Design Constraints

The project alignment corridor consists of various existing infrastructures, such as bridges, utilities. Major constraints which influenced the rail alignment design are outlined below:

- Minimum clearance requirements below elevated stations, including Oats Street Station. The minimum clearance requirement is summarised in Table 3.

TABLE 3 MINIMUM CLEARANCES REQUIRED BELOW STATIONS

Station Name	Minimum Clearance Requirement
Oats Street Station	6m

3 Acoustic Scope and Standards

3.1 Acoustic Scope

The objective of the acoustic design is to provide an appropriate degree of acoustic comfort for the users, public and operators alike, as well as control of station and bus/parking noise to nearby noise-sensitive receivers. To achieve this, several items were considered:

- Key acoustic materials and finishes within the station building fabric.
- Partition construction (internal and external).
- Building services (mechanical/hydraulic/electrical) as appropriate.
- Public address (PA) systems.
- Station patrons.
- Car park vehicle movements.
- Bus movements within the station area.
- Car park vehicles and bus movements connecting to the wider traffic network.

The design is developed in accordance with the PTA and SWTC requirements, the relevant Australian Standards and the requirements of the *Environmental Protection (Noise) Policy*.

3.2 Design Standards and Codes

In addition to the *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* (SWTC) and the Public Transit Authority of Western Australia (PTA)-specific requirements referenced**Error! Reference source not found.**, the codes and standards required to develop the acoustic design include the following:

TABLE 4 DESIGN STANDARDS AND CODES

Reference	Title
AS 1428.2-1992	Design for access and mobility Part 2: Enhanced and additional requirements - Buildings and Facilities
AS 1670.4 (2018)	Fire detection, warning, control and intercom systems – System design, installation and commissioning Part 4: Emergency warning and intercom systems
AS NZS 1668.1 -1998	*The use of ventilation and air conditioning in buildings Part 1: Fire and smoke control in multicompartment buildings*
AS / NZS 2107:2016	Acoustics - Recommended design sound levels and reverberation times for building interiors
AS 2436-2010	Guide to noise and vibration control on construction, maintenance and demolition sites
AS 2670.1	Evaluation of human exposure to whole-body vibration - General requirements
AS 2670.2	Evaluation of human exposure to whole-body vibration - Continuous and shock-induced vibration in buildings (1 to 80 Hz)
AS/RISSB 7532:2016	Railway Rolling Stock - Audible Warning Devices
EPNR 1997	Western Australia Environmental Protection (Noise) Regulations
BS 6472	Evaluation of Human Exposure Vibration in Buildings (1 Hz to 80 Hz)

Reference	Title
BS 7385.2	Evaluation and Measurement for Vibrations in Buildings – Part 2 Guide to Damage Levels from Ground-Borne Vibration
CR NOI TSI	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
DevWA Development Policy 3	Development Policy 3 – Sound and Vibration Attenuation
DIN 4150.3	Part 3: Structural Vibration in Buildings: Effects on Structures
ISO GUIDE 98-3	Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)
ISO 3095	Acoustics - Railway applications - Measurement of noise emitted by railbound vehicles - Third Edition, August 2013
ISO 3381	Railway applications - Acoustics - Measurement of noise inside railbound vehicles
ISO 8041	Human response to vibration – Measuring instrumentation
ISO 14837	Mechanical vibration - Ground-borne noise and vibration arising from rail systems
ISO/IEC Guide 98-3	Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (ISO GUM:1995)
NCC	National Construction Code
NSWRING	New South Wales Rail Infrastructure Noise Guideline, NSW EPA, May 2013
OSHR 1996	Western Australia Occupational Safety and Health Regulations
SPP5.4	State Planning Policy No. 5.4 Road and Rail Noise 2019
SPP5.4 Road and Rail Noise Guidelines	Road and Rail Noise Guidelines, September 2019
8190-600-009	American Railway Engineering and Maintenance-of-Way Association (AREMA) Communications and Signals Manual

The above list is not exhaustive but is provided to note the key guides and standards to which the design shall align.

4 Acoustic Criteria

4.1 Noise Criteria for Impacts to Surrounding Noise-Sensitive Premises

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *Stations and associated infrastructure (e.g. carparks, plant rooms etc) must be designed to comply with the requirements of the Environmental Protection (Noise) Regulations 1997 (WA).*

Noise criteria for both steady-state and discrete noise emission from the Oats Street Station are nominated in this section. The setting of noise emission criteria is intended to protect the acoustic amenity of nearby sensitive receivers.

Environmental noise impacts resulting from the Oats Street Station are addressed through the Environmental Protection Act 1986 with the prescribed standards detailed in the Western Australia *Environmental Protection (Noise) Regulations* 1997 (EPNR) as shown in Table 5. The regulations are based on maximum allowable noise levels termed the 'assigned noise level'. The regulations require that:

> *Noise emitted from any premises when received at other premises must not cause, or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind.*

A noise emission is taken to 'significantly contribute to' a level of noise if the noise emission exceeds a value which is 5 dB below the assigned level at the point of reception.

TABLE 5 ASSIGNED LEVELS BY THE WESTERN AUSTRALIAN ENVIRONMENTAL PROTECTION (NOISE) REGULATION 1997

Type of premises receiving noise	Time of Day	Environmental Emission Criterion Level dB(A)		
		$L_{A,10}$	$L_{A,1}$	$L_{A,max}$
Nearest noise sensitive receiver: highly sensitive area	0700 to 1900 hours Monday to Saturday	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + influencing factor	45 + influencing factor	55 + influencing factor
Noise sensitive premises: any area other than highly sensitive area	All hours	60	75	80
Commercial Premises	All hours	60	75	80
Industrial premises	All hours	65	80	90

The regulations also apply penalties on noise levels that contain annoying characteristics such as tonal components. Where these characteristics do exist and cannot be practicably removed, then the measured levels are adjusted according to the penalties as follows:

- Where tonality is present: +5 dB.
- Where modulation is present: +5 dB.
- Where impulsiveness is present: +10 dB.

The noise adjustments apply up to a maximum cumulative total of 15 dB.

The influencing factor is applied to account for higher noise areas as a result of nearby industrial and commercial areas and major roads. The influencing factor is determined by considering the land use within two circles having a radius of 100 m and 450 m from the noise sensitive premises of concern and proximity to major and minor roads as defined in the EPNR. The nearest noise sensitive receivers on each side of the Oats Street Station have been identified and are summarised below in Table 6.

TABLE 6 ENVIRONMENTAL DESIGN CRITERIA – NOISE-SENSITIVE RECEIVERS

Location	Noise Sensitive Receiver	Receiver Type
East	248 Rutland Avenue, Carlisle	Residential
West	South Metropolitan TAFE Carlisle Campus	Educational Establishment
South east	Cuddles Early Learning & Childcare Carlisle	Child Care Premises

Note: Selection of noise-sensitive premises is based on Schedule 1 – Part C of the EPNR

FIGURE 2 ENVIRONMENTAL DESIGN CRITERIA – LOCATION OF NOISE-SENSITIVE RECEIVERS

Transport factors of 6 dB(A) and 2 dB(A) are applied to noise-sensitive receivers if major roads are located within 100 m and 450 m respectively. A transport factor of 2 dB(A) is applied to noise sensitive receivers if a secondary road is located within 100 m of a noise-sensitive receiver.

A major road is defined as having vehicle traffic flows in excess of 15,000 vehicles per day. A secondary road is defined as having traffic flows of 6,000 to 15,000 vehicles per day.

The major roads and secondary roads within 100 m and 450 m of the noise-sensitive receivers are identified below in Table 7.

TABLE 7 ENVIRONMENTAL DESIGN CRITERIA – MAJOR / SECONDARY ROADS

Location	Major Road Within 100 m	Secondary Road Within 100 m	Major Road Within 450 m
East	-	Oats Street	-
West	-	Oats Street	-
South east	-	Oats Street	-

The area surrounding the Oats Street Station is predominantly residential, with educational (South Metropolitan TAFE Carlisle Campus, Cuddles Early Learning & Childcare) and community (AquaLife) premises and some commercial properties south of Oats Street. The road and rail reserves associated with the existing rail corridor, Oats Street and Rutland Avenue are considerable. The zoning plans for the Town of Victoria Park have been used to identify the zoning around the station. To determine the influencing factor, existing roads and land uses have been considered. The influencing factors at the nearest noise sensitive receivers are summarised in Table 8, and the corresponding environmental noise criteria as given in Table 9

TABLE 8 ENVIRONMENTAL DESIGN CRITERIA – INFLUENCING FACTORS

Location	% Industrial Area Use		% Commercial Area Use		Transport Factor	Influencing Factor
	100 m	450 m	100 m	450 m		
East	25 %	23.5 %	6.5 %	6 %	2	8
West	42 %	33.5 %	3.5 %	0 %	2	10
South east	23 %	34 %	25 %	5 %	2	9

TABLE 9 ENVIRONMENTAL DESIGN CRITERIA – OATS STREET STATION ASSIGNED NOISE LEVEL, dB(A)

Premises receiving noise	Time of Day	Environmental Emission Criterion Level dB(A)		
		$L_{A,10}$	$L_{A,1}$	$L_{A,max}$
East	0700 to 1900 hours Monday to Saturday	53	63	73
	0900 to 1900 hours Sunday and public holidays	48	58	73
	1900 to 2200 hours all days	48	58	63
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	43	53	63
West	0700 to 1900 hours Monday to Saturday	55	65	75
	0900 to 1900 hours Sunday and public holidays	50	60	75
	1900 to 2200 hours all days	50	60	65
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	45	55	65
South east	0700 to 1900 hours Monday to Saturday	54	64	74

Premises receiving noise	Time of Day	Environmental Emission Criterion Level dB(A)		
		$L_{A,10}$	$L_{A,1}$	$L_{A,max}$
	0900 to 1900 hours Sunday and public holidays	49	59	74
	1900 to 2200 hours all days	49	59	64
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	44	54	64

Note: A noise emission from a premises is considered to not significantly contribute to the noise at a receiver if the noise emission is 5 dB below the overall noise emission criteria for the area.

It is noted that the EPNR does not specifically identify that the above environmental noise criteria are applicable to noise from rail passengers and patrons of the Oats Street Station; however, an assessment is made to quantify the likely impacts of these sources to adjacent noise-sensitive receivers.

4.2 Noise Criteria for Impacts from Station Entry Roads and Bus Movements

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *The Alliance must design roads works 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).*

Table 10 sets out the environmental noise criteria referred to.

TABLE 10 ENVIRONMENTAL DESIGN CRITERIA – NEW AND UPGRADED PUBLIC ROADS AND BUS LANES

Type of premises receiving noise	Time of Day	New Road	Upgraded Road
Noise-sensitive land use (existing and planned development)	Day (6 am–10 pm)	$L_{Aeq\ (Day)}$ = 55 dB(A)	$L_{Aeq\ (Day)}$ = 60 dB(A)
	Night (10 pm–6 am)	$L_{Aeq\ (Night)}$ = 50 dB(A)	$L_{Aeq\ (Night)}$ = 55 dB(A)

For the Oats Street Station, this includes bus movements into and out of the station precinct.

It is noted that the assessment of rail noise to adjacent noise-sensitive receivers is being addressed separately for the LXR project, and does not form part of this scope.

4.3 Noise Criteria for Ambient Noise Levels within Passenger Station Areas

The following criteria are based on the requirements set out in the document *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria.*

Current NCC, environmental or industry standard criteria at the time of detailed design shall apply, in addition to the indicative criteria summarised in Table 11.

TABLE 11 INTERNAL DESIGN CRITERIA - NOISE

Source	Receiver	Noise criterion, dB(A)
Building services and plant noise	Ticket sales areas	L_{Aeq} 45
	General office areas	L_{Aeq} 45

Source	Receiver	Noise criterion, dB(A)
	Staff crib rooms	L_{Aeq} 45
	Public waiting areas, kiosks	L_{Aeq} 45
	Toilets and amenities	L_{Aeq} 45 - 55
	Parking and waste storage areas	L_{Aeq} 65
	Plantrooms	L_{Aeq} 85 at 1 m from plant L_{Aeq} 65 overall
	All other areas	Table 1, AS/NZS 2107:2000 'Satisfactory' values plus 5dB
Stationary trains, auxiliary equipment operating as normal	Platforms, at any position within 1.5 m of platform edge or centreline (whichever is closer to track), and more than 8 metres from portals	L_{Aeq} 70
Moving trains		L_{ASmax} 80
Building services and plant (ventilation, etc.)		L_{Aeq} 55
Emergency smoke fan systems		L_{Aeq} 85
Hydraulic services in amenities	Publicly accessible area	Inaudible
Hand dryers in amenities	2 m from amenity entrance	Inaudible

4.4 Noise and Vibration Ingress into Passenger Station Areas

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *The Alliance must comply with the following requirements:*
>
> - *External noise ingress from all associated road and rail traffic sources controlled according to the requirements of the 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 not exceed $L_{v,RMS,1s}$ 112 dB.*
> - *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.*

The SPP 5.4 provides noise targets for residential buildings. For other noise-sensitive land use and/or development, such as passenger station areas, the SPP 5.4 states that indoor noise targets may be reasonably drawn from Table 1 of AS/NZS 2107:2016.

4.5 Reverberation within Passenger Station Areas

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *The Alliance must 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.*

Therefore, the reverberation time criteria applicable to the Oats Street Station are as shown in Table 12.

TABLE 12 INTERNAL DESIGN CRITERIA - REVERBERATION TIME

Criterion	Receiver	Reverberation time criteria at 500 Hz and 1 kHz, seconds
Reverberation	General office	0.4 - 0.6
	Retail	Minimised as far as practicable
	All circulation, back of house areas	-
	Toilets and amenities	-
	Ticket sales areas	0.6 – 0.8
	Platform areas	1.3 with 100 patrons present 1.6 when empty
	Staff crib rooms	< 0.8
	Public waiting areas, kiosks	Minimised as far as practicable

4.6 Public Address Systems within Passenger Station Areas

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

> *The Alliance must 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.*

AS 1670.4 requires that the A-weighted sound pressure level shall:

- Exceed the ambient sound pressure level by 10 dB(A) when averaged over a period of 60 seconds.
- Shall not be less than 65 dB(A).
- Shall not be more than 105 dB(A).
- When under stand-by power source operation shall not cause audible emergency signals to fall by more than 6 dB sound pressure level below the required sound level when tested after 24 hours of quiescent operation.

Additionally, AS 1670.4 requires that:

- Where ambient noise figures are less than 85 dB(A), the speech transmission index (STI) shall be ≥ 0.5.
- The average speech SPL shall not exceed 100 dB(A).
- When under stand-by power source operation the CIS index is not to fall below 0.65 (0.45 STI) when tested after 24 hours of quiescent operation.

4.7 Acoustic Sound Insulation within Passenger Station Areas

The *Victoria Park-Canning Level Crossing Removal Scope of Work and Technical Criteria* states the following:

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

D_W ≥ 35dB between normally occupied enclosed spaces.

D_W ≥ 28dB between normally occupied spaces where the common partition includes a door.

The SWTC also presents criteria which 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. These are given in Table 13.

TABLE 13 INTERNAL DESIGN CRITERIA – ACOUSTIC SOUND INSULATION

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

The D_W rating is the 'weighted standardised field level difference' and represents the required installed performance between two spaces to achieve the different levels of acoustic separation, inclusive of all flanking paths.

The D_W rating relates to the final installed acoustic performance measured on site. Accordingly, the result will include contribution from noise leaking along flanking paths such as joints between walls and ceilings, joints between walls and other external and internal walls, leakage associated with services penetrations, along ductwork and via glazing and doors.

The difference between the result tested in a laboratory (R_W), and the result achieved on site (D_W) normally varies between 3 and 8 dB depending on how well the flanking paths can be controlled, and the receiving room size and absorptive characteristics. Flanking paths tend to have a greater impact on higher performing partitions – i.e. the impact is likely to be greater for an R_W 50 partition than for an R_W 40 partition.

In order to account for the likely degradation in performance arising from this leakage, a laboratory performance (R_W) has been recommended that is approximately 5 dB higher than the typically required field performance.

In addition to the above separation requirements, walls and doors should be designed to limit noise transmission from noise generating spaces, such as plant rooms, to meet the noise levels presented in Section 4.3.

4.8 Occupational Safety and Health

The Western Australia *Occupational Safety and Health Regulations 1996* (OSHR) provides the following exposure standards for noise:

- $L_{Aeq,8h}$ of 85 dB(A).
- $L_{C,peak}$ of 140 dB(C).

These standards are applicable at a measurement position of a person's ear without taking into account any protection which may be provided to the person by personal hearing protectors.

4.9 Construction Noise and Vibration

The EPNR clarifies that the environmental noise criteria outlined in Table 9 are not applicable to noise emitted from a construction site where works are carried out between 0700 hours and 1900 hours on any day which is not a Sunday or public holiday if it is shown that the construction works are generally carried out in accordance with the controls identified in Section 4 of AS 2436-2010 *Guide to noise and vibration control on construction, maintenance and demolition sites* and if construction work is carried out in accordance with an approved management plan.

It is noted that a specific construction noise and vibration management plan is being addressed separately for the LXR project, which will include relevant site clearing and construction works associated with the Oats Street Station, and does not form part of this scope.

5 Acoustic Solutions

5.1 Noise Impacts to Surrounding Noise-Sensitive Premises

The area surrounding the Oats Street Station is predominantly residential, with educational (South Metropolitan TAFE Carlisle Campus, Cuddles Early Learning & Childcare) and community (AquaLife) premises and some commercial properties south of Oats Street.

These noise-sensitive residences in the vicinity of the Oats Street Station are already affected by noise from the existing passenger railway line, station and station car park, and from road traffic on Oats Street. However, the environmental noise emissions from the station and associated car parking / bus movements will need to be considered for these receivers adjacent to the station.

5.1.1 Building Services

Mechanical and electrical services plant selections for the Oats Street Station comprise:

- Small ducted exhaust fans to ablution facilities and electrical plant spaces.
- Small outdoor air fans.
- Plant room, pump room and electrical room extract systems.
- Air conditioning to comms room, electrical room and offices incorporating split systems with wall-mounted indoor units, external condensing units.
- 50/75/100 kVA Essential Supply Transformer (EST).
- Western Power 630 kVA transformer.
- 630 kVA isolation transformer.

The proposed equipment locations and layout are as shown in the following mechanical services drawings:

- LXR-P1-Z2-OT-SN-ME-00101
- LXR-P1-Z2-OT-SN-ME-00102
- LXR-P1-Z2-OT-SN-ME-00103
- LXR-P1-Z2-OT-SN-ME-00104
- LXR-P1-Z2-OT-SN-ME-00105
- LXR-P1-Z2-OT-SN-ME-00106

Mechanical and electrical services plant selections for Oats Street Station have not been determined at this stage. It is expected that noise emission from these plant items will meet the relevant environmental noise emission requirements with minimal acoustic treatment e.g. internal duct lining.

The acoustic performance requirements presented in Section 5.7 provide the minimum acoustic ratings for partitions and doors to control environmental noise emission from the transformers to meet the relevant environmental noise requirements.

5.1.2 Public Address (PA) System

The design of the public address system will be described in detail in the Communications reporting, but will essentially consist of PTA's preferred Biamp Vocia Long Line Public Address (LLPA) system.

The LLPA system design for Oats Station is not sufficiently progressed at this stage of design to undertake an assessment of potential noise spill from the station to surrounding noise-sensitive areas.

The PTA's design guidelines 8803-700-005 *GUIDELINE Public Address and Voice Evacuation for PTA Facilities* for these systems include procedural mitigation to manage the use of PA speakers when passenger numbers are low (as would be expected outside of daytime hours). Specifically, the Guidelines state that:

> *The Passenger Information Network (PIN) uses the timetable and track sensors to estimate when a train is arriving/departing at a station and controls the PA system to play automated messages. This system is turned off when the station is frequented by fewer than 5 passengers / 30 minutes.*

This will be taken into account during the assessment undertaken during the next design phase.

5.1.3 Car Park

The car parking associated with the Oats Street Station is proposed to have a maximum capacity of over 100 bays. At this level of design, the maximum day and night 15-minute vehicle trips are not available. Data is currently being sought from the PTA's 'SmartParker' system to inform this data.

Noise levels will take into account a full parking movement, including vehicle movement, shunting, door/boot opening/closing and engine start-up. Where feasible, estimated car park noise levels will take into account the effects of any acoustic barriers which the project may be required to construct to meet rail noise criteria as defined in the SWTC.

Noise from the car park will be taken into account during the assessment undertaken during the next design phase.

5.1.4 Passenger Noise

The Oats Street Station is anticipated to have around 13,170 passengers per day by 2051. The highest passenger volume is expected during the morning peak hour period, with 323 boardings and 345 alightings between 08:00 and 08:15 a.m. This equates to around 668 passengers on the station platform for the peak 15-minute period.

The highest passenger volume for the night-time period occurs from 06:45a.m. to 07:00a.m., having 129 boardings and 68 alightings. This equates to around 197 passengers on the station platform for this 15-minute period.

On the basis that the gender split is 50%/50%, and that half the passengers would be speaking in normal voices at any one point in time, the predicted noise levels from passengers at the nearest noise-sensitive receptors are as given in Table 14.

TABLE 14 PREDICTED PASSENGER NOISE LEVELS

Location	Predicted Noise Level $L_{Aeq,15min}$ (Day)	Predicted Noise Level $L_{Aeq,15min}$ (Night)
East	42 dB(A)	37 dB(A)
West	46 dB(A)	41 dB(A)
South east	46 dB(A)	41 dB(A)

These predicted noise levels are below the day-time and night time environmental noise criteria for all receivers and therefore noise from passengers on the Oats Street Station platform is not expected to cause disturbance to the nearby noise-sensitive receivers.

5.1.5 Total Station Noise Impact

The total predicted noise levels at the nearest noise-sensitive receivers to the Oats Street Station will be assessed during the next design phase, and compared against the day-time and night time environmental noise criteria presented in Table 9.

5.2 Noise Impacts from Bus Movements

The bus movements through the Oats Street Station are required to be assessed against the road traffic requirements of the SPP 5.4. Noise from the estimated 2051 bus movements through the Oats Street Station area will be assessed during the next design phase, and compared against the day-time and night time environmental noise criteria presented in Table 9.

5.3 Ambient Noise Levels within Passenger Station Areas

Ambient noise levels within the Oats Street Station areas will be dominated by road and rail traffic noise intrusion and by building services such as fans and air conditioning.

The mechanical services being provided to the Oats Street Station are identified in Section 5.1.1. Mechanical services plant selections for Oats Street Station have not been determined at this stage, however, it is expected that standard noise control measures such as internal duct lining will be sufficient to control mechanical services plant noise in order to meet the required ambient noise levels within station areas.

Where an absorptive ceiling is required to control reverberation times (such as a mineral fibre tile, as discussed in Section 5.5), it may be necessary to acoustically lag the services ductwork and/or provide a solid (e.g. plasterboard) backing to the ceiling tiles to control noise breakout from ceiling-mounted equipment.

5.4 Noise and Vibration Ingress into Passenger Station Areas

The acoustic performance requirements presented in Section 5.7 provide the minimum acoustic ratings for partitions and doors to control noise ingress from road and rail noise to meet the relevant internal noise level requirements.

It is expected that the noise impacts on the Oats Street Station passenger areas will be similar to that experienced in the existing passenger areas at the existing Oats Street Station and therefore significant acoustic treatment is unlikely to be required.

It is noted that previous studies have identified that the maximum acceptable noise level (L_{Amax} 80 dB) cannot be reasonably or practicably achieved at all locations on the platforms.

The assessment of rail vibration to passenger areas is being assessed concurrently and will be presented during the next design phase.

5.5 Reverberation within Passenger Station Areas

To provide optimum internal acoustic environments for the internal spaces of the station, consideration needs to be given to the layout of spaces, the types of material finishes applied and their proposed locations within the spaces. These factors will all influence the acoustic environment and have the potential to effect occupant comfort and the functional use of spaces.

To control the build-up of sound within a space, acoustically absorptive treatments are typically applied to wall and ceiling surfaces. Absorptive materials are typically soft, fibrous materials, which present a tortuous path to incident sound waves, causing them to lose acoustic energy to heat on passing through the material. Examples of common acoustically absorptive treatments include glasswool or polyester batts, acoustic foams and compressed mineral fibre ceiling tiles.

Due to their inherent soft composition, acoustically absorptive materials are often faced with a perforated, rigid facing material, such as timber or metal, which provides protection from mechanical damage and also typically satisfies aesthetic aims. Absorptive materials can also be fabric faced, for example, by stretching an open weave fabric across a stud frame with glasswool or polyester batts installed in the cavity behind.

Acoustically absorptive treatments are specified in terms of their Noise Reduction Coefficient (NRC), a measure of the sound energy they absorb. NRC values range between 0 and 1, with 0 being completely reflective (no absorption) and 1 being highly absorptive.

Acoustically absorbent finishes suggested for the Oats Street Station are as follows:

- Coruline soffit lining with acoustic insulation above to platform and concourse areas, as has been applied to the Aubin Grove Station and is currently being proposed for the stations associated with the METRONET project (Thornlie-Cockburn Link and Yanchep Rail Extension). The Coruline soffit lining (minimum 15% open area) with minimum 50 mm acoustic insulation above should provide an NRC in excess of 0.8. This should be sufficient to meet the reverberation time criteria for new spaces when applied to the extent outlined below.
- Mineral fibre tiles to occupied spaces such as offices and CSO booths, having minimum NRC 0.5 performance.

Alternative absorptive finishes are acceptable, however, must meet minimum NRC performance requirements and should be approved by the acoustic consultant prior to implementation.

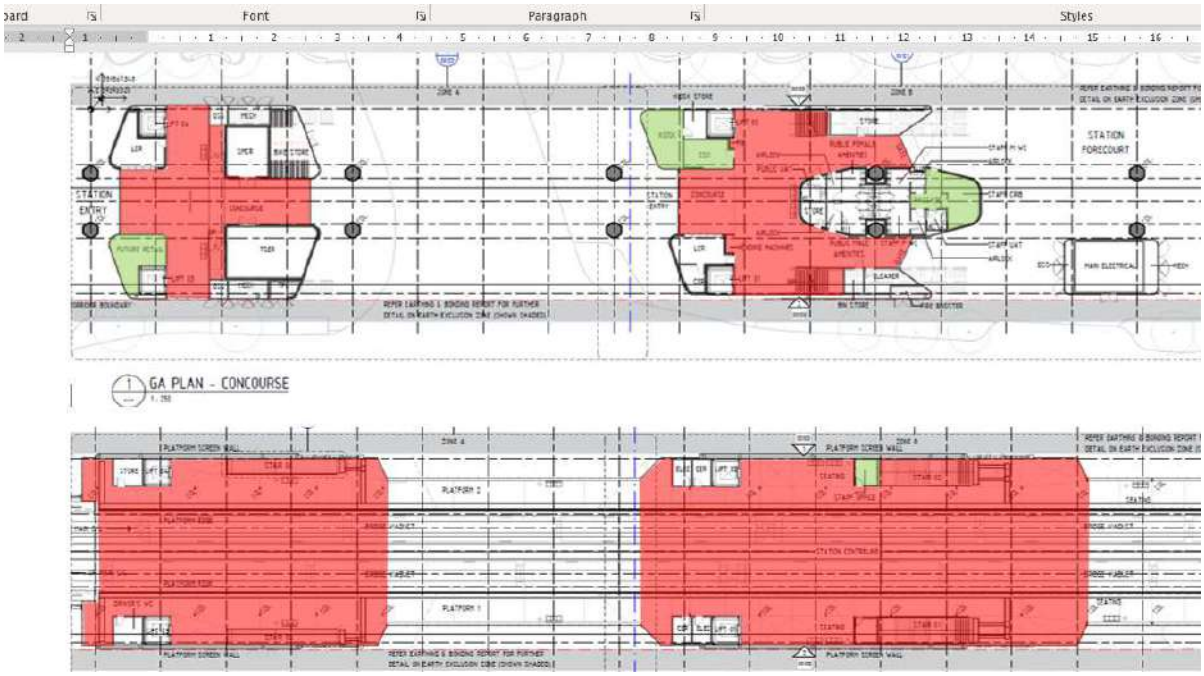


FIGURE 3 ACOUSTICALLY ABSORPTIVE FINISHES

5.6 Public Address Systems within Passenger Station Areas

Public address system design will be developed in conjunction with the Communications discipline during the next stage of the design development to meet the requirement outlined in Section 4.6.

5.7 Acoustic Sound Insulation

Minimum Weighted Sound Reduction (R_w) ratings to meet acoustic separation requirements are provided for partitions and doors below.

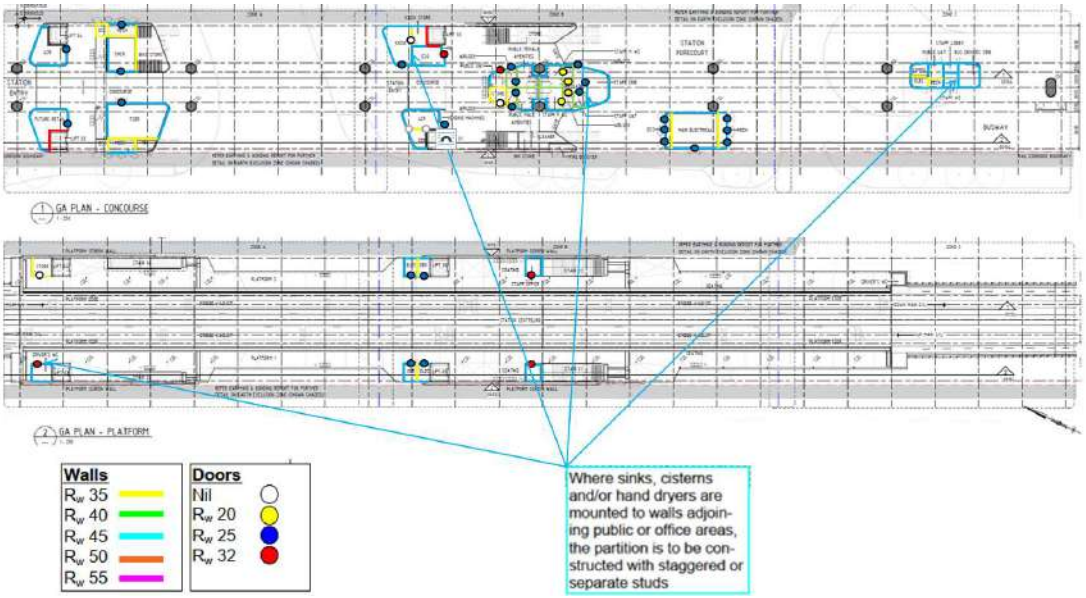


FIGURE 4 MINIMUM R_W REQUIRMENTS

Recommended partition constructions to meet the minimum R_w ratings presented above are presented in Table 15.

The following general notes on construction detailing for internal partitions should be read in conjunction with specific details and requirements outlined in the body of this report.

Continuous elements

A saw cut must be provided in lightweight linings (e.g. plasterboard) that are continuous across the partition line between spaces with a high performance wall i.e. R_W 50 and above. That is, one sheet of plasterboard or similar should not span continuously across two spaces. This note also applies to internal perimeter cladding, bulkheads and ceiling plasterboard margins.

Sheeting installation

In addition to the manufacturer's installation instructions, ensure the following:

- Joints are to be offset by a minimum 300 mm on opposing sides when not backed by a nogging AND for two layer sheeting the joints on the second layer are to be offset by 300 mm from the joints of the first.
- All joints between sheets or between sheets and any adjoining construction must be taped and set.

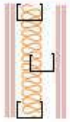
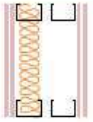
Sealing

- An airtight seal should be provided between partition edges and other building elements by means of a flexible sealant.
- All acoustically rated walls should be sealed at the head and base with flexible caulking compound and backing rods as required. The flexible sealant may be acrylic, polyurethane or silicone based. Any other proposed acoustic sealant should be first approved by the acoustic consultant.

Penetrations for Services

- For mechanical services, it must be ensured that there are no flexible ductwork penetrations in full height walls and that gaps around any rigid duct penetrations are sealed air tight with a flexible sealant; also ensure that ducts do not run along the line of full height partitions or partitions with acoustic baffles.
- The gaps around cable tray penetrations should be filled with compacted acoustic grade insulation or fire pillows as per manufacturer's instructions.

TABLE 15 RECOMMENDED PARTITION CONSTRUCTIONS

Construction Element	Nominal Acoustic Rating					
	Standard R_w 35	**Medium** R_w 40	**High** R_w 45	**Very High / ASL-3** R_w 50	**Audio Secure / ASL-4 / ASL-3 with speech reinforcement** R_w 55	**Audio Secure Plus / ASL-5 / ASL-4 with speech reinforcement** R_w 60
	(Yellow)	(Green)	(Blue)	(Red)	(Purple)	(Purple)
Base Partition	 92 mm steel studs. 13 mm plasterboard each side. Cavity insulation not required.	 92 mm steel studs. 13 mm plasterboard each side. Cavity insulation (minimum 75 mm, 14 kg/m^3)	 92 mm steel studs. 2x 13 mm plasterboard to one side. 1x 13 mm plasterboard to other side. Cavity insulation (minimum 75 mm, 14 kg/m^3)	 92 mm steel studs. 2x 13 mm fire-rated plasterboard to side. 1x 13 mm fire-rated plasterboard other side. Cavity insulation (minimum 75 mm, 14 kg/m^3)	 Staggered 64mm steel studs in a 92mm steel track. 2x 13 mm fire-rated plasterboard each side. Cavity insulation (minimum 75 mm, 14 kg/m^3)	 Double 92mm steel studs separated by minimum 20mm. 2x 13 mm fire-rated plasterboard each side. Cavity insulation (minimum 75 mm, 14 kg/m^3)
Glazing (partitions without a door)	10.38mm laminated glazing to achieve R_w 35	Proprietary acoustic glazing system with an R_W 40 rating, (e.g. 12.5 mm Viridian 'VLam Hush' with the appropriate seals and frame) Or, Sealed double glazed R_W 40 unit (e.g. 6 / 13 / 10.38)	R_W 44 double-glazing system (e.g. 10.38 mm laminated / 50 mm cavity / 6.38 mm laminated)	R_W 48 double-glazing system (e.g. 12.76 mm laminated / 100 mm cavity / 10.38 mm laminated)	Glazing generally not permitted, specific instances must be reviewed. R_W 52 double-glazing system (e.g. 12.76 mm laminated / 250 mm cavity / 10.38 mm laminated)	Glazing not permitted.
Glazing (when co-located with a door)	Single layer of 6 mm float or 6.38 mm laminated glazing to achieve R_W 30	10.38mm laminated glazing to achieve R_W 35	Proprietary acoustic glazing system with an R_W 40 rating, (e.g. 12.5 mm Viridian 'VLam Hush' with the appropriate seals and frame) Or, Sealed double-glazed R_W 40 unit (e.g. 6 / 13 / 10.38)	R_W 44 double glazing system (e.g. 10.38 mm laminated / 50 mm cavity / 6.38 mm laminated) ***For ASL-3 designated spaces R_W 48 double glazing must be used.***	10.38 mm laminated vision panels may be permitted in end walls of airlock (subject to security requirements). Area of glazing should be strictly limited.	12.76 mm laminated vision panels may be permitted in end walls of airlock (subject to security requirements). Area of glazing should be strictly limited.
Doors	40mm solid timber core door to achieve R_w 25 with seals to the head and jamb	40 mm solid timber core door Or, 6.38mm laminated glazed door with acoustic seals to achieve R_w 30	Proprietary door system with frame and seals to achieve R_w 35.	Airlock entry with 44 mm solid timber core doors and acoustic seals to achieve minimum R_w 32 for each door Or, High performance proprietary door achieving minimum R_w 45, with high attention to onsite detailing during construction.	Airlock entry with 44 mm solid timber core doors and acoustic seals to achieve minimum R_w 32 for each door	Airlock entry with 44 mm solid timber core doors and acoustic seals to achieve minimum R_w 32 for each door
Ceiling Junction	Create an airtight seal at the ceiling join by means of two closed cell foam strips along top edge of plasterboard.	Partition to penetrate ceiling line by at least 100 mm, with air-tight seal between ceiling edge and partition linings using a flexible caulking compound.	Partition to penetrate ceiling line by at least 100 mm, with air-tight seal between ceiling edge and partition linings using a flexible caulking compound. Lay 1200 mm wide strip of 50 mm thick acoustic insulation with a	Minimum one layer of plasterboard on each side of the partition is to penetrate the ceiling and continue to the underside of the soffit or roof deck with an airtight seal.	Minimum one layer of plasterboard on each side of the partition is to penetrate the ceiling, and continue to the underside of the soffit or roof deck above with an airtight seal.	Minimum one layer of plasterboard on each side of the partition is to penetrate the ceiling, and continue to the underside of the soffit or roof deck above with an airtight seal.

Construction Element	Nominal Acoustic Rating					
	Standard R_w 35	Medium R_w 40	High R_w 45	Very High / ASL-3 R_w 50	Audio Secure / ASL-4 / ASL-3 with speech reinforcement R_w 55	Audio Secure Plus / ASL-5 / ASL-4 with speech reinforcement R_w 60
	(Yellow)	(Green)	(Blue)	(Red)	(Purple)	(Purple)
			minimum density of 32 kg/m^3 on either side of the partition line.	*For ASL designated spaces all linings should extend full height*	*For SCIF or ASL designated spaces all linings should extend full height*	*For SCIF or ASL designated spaces all linings should extend full height*

Table notes:

i. Recommended plasterboard thicknesses and stud depths are minimum requirements. These may be increased, as required to meet structural or other requirements.

ii. Timber studs will reduce the performance of the partition by approximately 3 to 5 dB and where proposed alternative constructions will need to be considered to maintain the acoustic performance.

iii. Where insulation is recommended to be laid on top of the ceiling, a suitable insulation product is 50 mm thick Tontine 'Acoustisorb 2'.

iv. Any pipework within partition cavities should be fixed only to the wet / toilet side of the partition.

v. Where a door is incorporated into an acoustically rated partition, the overall performance of the partition will be reduced. The partition including the door is expected to achieve an acoustic rating 5 – 7 dB below the nominal R_W rating given in the table above.

vi. Note in our experience a proprietary door system may not achieve the nominated performance when installed on site as such we typically recommend that a sound lock lobby be used for ASL-3 spaces.

vii. Ceiling junctions based on acoustic ceiling tiles with CAC (Ceiling Attenuation Class) or $D_{nC,w}$ (Weighted Ceiling Noise Reduction Index) rating ≥ 40. The above ceiling partition treatments would need to be upgraded in areas where the ceiling does not achieve this performance (e.g. standard ceiling tiles, perforated ceilings, etc.).

viii. Where return air slots are located within 1.5 metres of a partition, they will need to be treated with acoustically lined return air boots or blanked off.

ix. Penetrations in full-height wall elements should be avoided within the ceiling void (e.g. for building services). Where penetrations cannot be avoided, all penetrations must be acoustically sealed and lagging of services may also be required.

x. Wall linings may in general be substituted with alternative products, as long as the surface mass of each leaf is maintained. For example:

- 13 mm plasterboard may be substituted with 6 mm fibre-cement sheet, or 13 mm impact-rated plasterboard.
- 16 mm fire-rated plasterboard may be substituted with 9 mm fibre-cement sheet.

6 Risks and opportunities

A list of risks and opportunities identified in the RD alignment were noted in an alliance wide register..

7 Systems Engineering

7.1 Safety in design

Safety in Design and Hazard Workshops for RD are held as the design progresses. A list of Safety in Design workshops is summarised in Table 16. The purpose of the workshops is to identify and eliminate preliminary risks during the RD phase arising from the station design, that may result in hazards to personnel in the Construction and O&M phases; and if it is not reasonably practicable to eliminate risk, to minimise those risk so far as is reasonably practicable (SFAIRP).

TABLE 16 SAFETY IN DESIGN WORKSHOPS

SiD Session	Safety in Design
HAZID and Analysis Workshop 01 – Stations – RD (11th May, 2022)	Safety in Design (SiD) and Hazard Identification (HAZID) / analysis for RD Stations.

7.2 Reliability, Availability and Maintainability RAMS

Reliability, Available and Maintainability (RAM) analysis is a systems engineering process in place to ensure that the design life, durability, maintenance and progressive degradation of permanent works items are adequate.

RAM analysis does not form part of the Acoustic scope of works.

7.3 Human Factors

Human Factors (HF) integration does not form part of the Acoustic scope of works.

8 Quality Management

Design verification has been undertaken with the requirements outlined in the Engineering Management Plan (LXR-ALUA-EA-PLN-00001).

8.1 Design Review Process

The design review process for the Reference Design is summarised in Table 17.

TABLE 17 DESIGN REVIEW PROCESS

Review Process	Duration [working day(s)]	Dates (close of business)
Verification	10	
IDC	Day 10	
Update	3	
IV/ISA	10	
Comment Closeout	3	

8.2 Interdisciplinary Design Coordination

The Interfacing Design Coordination (IDC) is scheduled to be held on the 15 July 2022. The IDC certificate will be attached in Appendix C of the design report when available.