Transport
for NSW

Central Precinct Renewal Program

Noise and Vibration Assessment

July 2022

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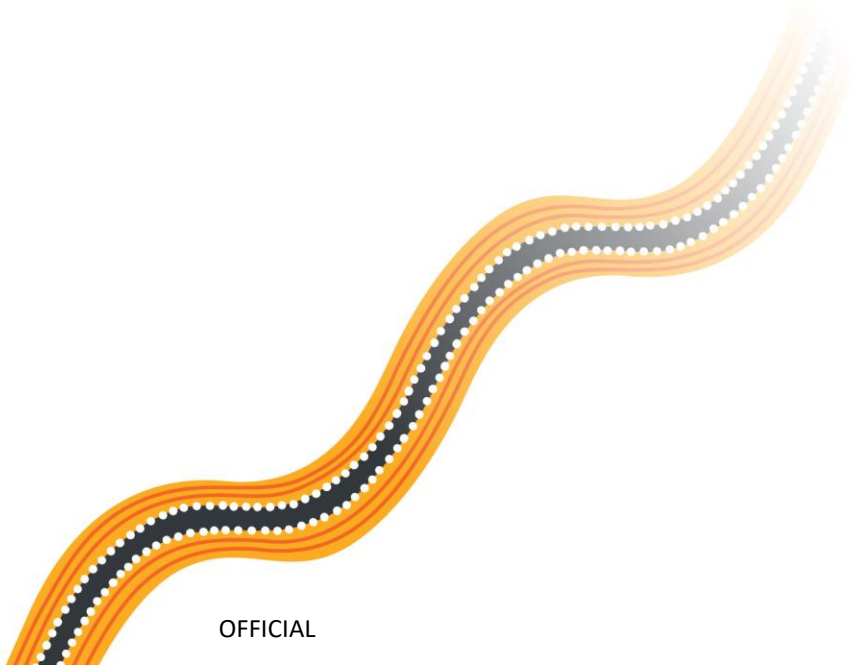
NSW GOVERNMENT

Acknowledgement of Country

We respectfully acknowledge the Traditional Custodians of the Central Precinct, the Gadigal and recognise the importance of place to Aboriginal people and their continuing connection to Country and culture. We pay our respect to Elders past, present and emerging.



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Document control

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Approved by	Transport for NSW
Branch	IP Development
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Versions

Version	Amendment notes
0.1	Final for CPRP Public Exhibition 2022

Abbreviations

Abbreviation	Definition
ABS	Australian Bureau of Statistics
CIV	Capital investment value
CoS	City of Sydney Council
DA	Development application
dB	Decibel. A unit of measure of sound pressure that compresses a large range of numbers into a more meaningful scale. Hearing tests indicate that the lowest audible pressure is approximately 2 x 10-5 Pa (0 dB), while the sensation of pain is approximately 2 x 102 Pa (120dB). Generally, an increase of 10 dB is perceived as twice as loud.
dBA	A-weighted decibels. The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the “A” filter. A sound level measured with this filter switched on is denoted as dBA or dBA. Practically all noise is measured using the A filter.
dBZ	Z-weighted decibels. This is a flat frequency response between 10Hz and 20kHz plus/minus 1.5dB excluding microphone response.
DPE	NSW Department of Planning and Environment
EPI	Environmental planning instrument
Frequency (Hz)	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
GANSW	Government Architect NSW
GSC	Greater Sydney Commission
Hz	Hertz
kHz	Kilohertz
km/h	Kilometres per hour
kW	Kilowatts
L_{A10}	The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time.
L_{A90}	The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.
L_{AE}	The L_{AE} level is a logarithmic measure of the sound exposure of a sound relative to a reference value. It is equivalent to the L_{Aeq} (see below) as the total sound energy is integrated over the measurement period.
L_{Aeq}	The A-weighted equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent

Abbreviation	Definition
	to the level of a constant noise which contains the same energy as the varying noise environment. This measure is a common measure of environmental noise and road traffic noise.
L_{AFmax}	The A-weighted maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.
LEP	Local environmental plan
LGA	The City of Sydney local government area
m	Metres
m/s	Metres per second
mm	Millimetres
NMLs	Noise Management Levels. Based on the Interim Construction Noise Guideline, the: • 'noise affected' management level represents the level above which there may be some community reaction to noise (calculated by adding 10 dB to the RBL during recommended standard work hours and by adding five dB to the RBL for works outside of recommended standard work hours) • 'highly noise affected' management level represents the level above which there may be strong community reaction to noise.
NPfI	Noise Policy for Industry (2017), which superseded the Industrial Noise Policy (2000)
PCPV	Peak Component Particle Velocity. It is the instantaneous peak of the resultant vector sum of all three axes of motion. Results are expressed in terms of velocity, typically in mm/s.
PRP	Project Review Panel
RBL	The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.
R_w	Acoustical performance of partitions is measured by the Weighted Sound Reduction Index
s	Seconds
SEPP	State Environmental Planning Policy (Transport and Infrastructure) 2021
SPL (Sound Pressure Level)	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
SSP	State Significant Precinct
SWL	Sound power level
VDV	The Vibration Dose Value is the accumulation of energy measured over a given time period, proportional to the root mean quad of acceleration. This is usually measured in each of the three axes of motion. In most cases, vibration tends to be higher in the Z (vertical) axis. This is measured with units of $m/s^{1.75}$.

Definitions

Term	Definition
Amenity	The extent to which a place, experience or service is pleasant, attractive or comfortable. Improved features, facilities or services may contribute to increase amenity.
Central Precinct	Central Precinct State Significant Precinct
Central Sydney	Land identified as Central Sydney under the Sydney Local Environmental Plan 2012 and represents the Metropolitan Centre of Sydney. Central Sydney includes Sydney's Central Business District
Character	The combination of the attributes, characteristics and qualities of a place (GANSW, 2021, Draft Urban Design Guide)
City Plan 2036	City of Sydney local strategic planning statement
Community	Particular types of stakeholders and refers to groups of people in particular places who are both affected by our work and experience the outcomes and benefits of our activities
Control	A numerical standard that is applied in a prescriptive manner
Corridor	A broad, linear geographical area between places
Council	The City of Sydney Council
Customers	Those who use transport networks and services. They include car drivers, heavy vehicle operators, public transport and point to point passengers, pedestrians, cyclists and freight and goods providers
Department	The Department of Planning and Environment
District Plan	means the Eastern City District Plan
Gateway	Cities that provide state level services and facilities to support a broad population catchment while also having international connections through their cities airport and/or port.
Goods Line	The official name for the partly elevated walkway from Central Station to Darling Harbour following the route of a disused railway line
Interchange	A facility to transfer from one mode of transport or one transport service to another. For example, a station with an adjoining light rail stop
Mixed-use	A building or area containing more than one type of land use
Mobility	The ability to move or be moved easily and without constraints
Mortuary Station	The building formerly used as a railway station on the Rookwood Cemetery railway line, now disused
Objective	A statement of a desired future outcome, generally expressed in a qualitative manner that enables merit based assessment
Over rail corridor development or Over Station Development	Development of air space over railway corridors
Place	An intersection of transport infrastructure with social infrastructure and commercial activity. These are the areas within and around transit stops where people live and commute. Places can be created as an outcome of Placemaking
Planning instrument	Means any of the following:

Term	Definition
Precinct	Geographical area with boundaries determined by land use and other unique characteristics. For example, an area where there is an agglomeration of warehouses may be termed a freight precinct
Proponent	Transport for NSW
Proposal	Proposed amendments to the planning framework
Provisions	means a broad term covering objectives and controls
Public spaces	means areas that are publicly accessible where people can interact with each other and make social connections
Rail network	means the rail infrastructure in NSW
Railway corridor	The land within Central Precinct on which a railway is built; comprising all property between property fences, or if no fences, everywhere within 15m from the outermost rails. Under planning legislation rail corridor is defined as land: a) that is owned, leased, managed or controlled by a public authority for the purpose of a railway or rail infrastructure facilities: or b) that is zoned under an environmental planning instrument predominately or solely for development of the purpose of a railway or rail infrastructure facilities
Reference Master Plan	A non-statutory document that shows one way in which the precinct may develop in the future in accordance with the proposed amendments to the planning framework
Region Plan	The Greater Sydney Region Plan - A Metropolis of Three Cities
Siding	A short stretch of rail track used to store rolling stock or enable trains on the same line to pass
Sound Level Meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure level.
Sound Power Level	The logarithmic ratio of the instantaneous sound power (energy) of a noise source to that of an international standard reference power.
Sound Pressure Level (SPL)	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
State	The state of New South Wales
State Significant Precinct	The areas with state or regional planning significance because of their social, economic or environmental characteristics
Strategic Framework	The document prepared by Transport for NSW for Central Precinct in 2021 that addresses key matters including vision, priorities, public space, strategic connections, design excellence, identify sub-precincts for future detailed planning and also outlines the next steps in the State Significant Precinct process for Central Precinct
Strategic plan	The regional strategic plan, district strategic plan or a local strategic planning statement
Sub-precinct	The definable areas within Central Precinct SSP due to its unique local character, opportunities and constraints, either current or future. The Western Gateway is a sub-precinct
Sydney Metro	A fully-automated high frequency rail network connecting Sydney
STC	Sound Transmission Class ratings are numerical values indicating the performance of individual elements – typically walls or floors – in limiting the transmission of sound

Term	Definition
Tech Central	The State government initiative as set out in The Sydney Innovation and Technology Precinct Panel Report 2018. Previously known as the Sydney Innovation and Technology Precinct. Tech Central is located south of the Sydney central business district, surrounded by the suburbs of Redfern, Ultimo, Haymarket, Camperdown, Chippendale, Darlington, Surry Hills and Eveleigh
Transport for NSW	The statutory authority of the New South Wales Government responsible for managing transport services in New South Wales.
Transport interchange	A facility designed for transitioning between different modes, such as a major bus stop or train station
Transport modes	The five public transport modes are metro, trains, buses, ferries and light rail. The two active transport modes are walking and cycling

Executive summary

This report presents an assessment of noise and vibration intrusion into, and operational noise from the Central Precinct Renewal Project (CPRP). Additionally, the report examines the effects of external noise intrusion on CPRP from nearby ambient generators such as road and rail traffic.

Noise and vibration measurements undertaken by GHD and SLR in 2012, 2014 and 2018 have been used to determine the acoustic environment across the CPRP. Additionally, reference is made to the Central Station Main (CSM) Works Construction Noise and Vibration Impact Statement (CNVIS) prepared by ERM in November 2018.

In summary, the assessment identified the following potential acoustic items:

- Existing traffic and urban noise from Pitt Street and Bathurst Street intruding into the CPRP
- Future vibration and ground borne noise associated with the operation of the Sydney Metro
- Noise associated with surrounding commercial premises intruding into the CPRP
- Mechanical services noise emission from the proposed mixed-use building to surrounding sensitive receivers including the Sydney Metro station
- Noise and vibration emission from construction activities and equipment.

This report presents an assessment of the above acoustic components in terms of City of Sydney Council's Development Control Plan (DCP) 2012 1, State Environmental Planning Policy (Transport and Infrastructure) 2021 and Australian Standards.

The measured traffic noise levels at the building facades were used to determine the indicative sound insulation rating requirements for the external elements in accordance with the acoustic criteria nominated for the CPRP.

Acoustic privacy complies with the requirements of the Building Code of Australia (which all new residential development would need to comply) and the City of Sydney's DCP.

This assessment found that building façade elements (such as glazing, external walls, and roof) will require a moderate to high level of acoustic performance to ensure that external noise intrusion goals will be achieved. The required level of performance can be achieved with currently available products and technology.

The required level of detail to fully assess mechanical plant noise emissions does not currently exist. In lieu of this, typical assumptions and equipment selections were made. The assessment concluded that mechanical plant noise emissions will likely comply with required criteria at most receivers within; and external to, the development. Any potential exceedances could be easily mitigated using conventional techniques. Mechanical noise emissions should be reviewed during future stages of the development.

Operational vibration levels from arriving and departing rail traffic has been considered in a previous stage of the project, culminating in the recommendation of a high attenuation track form. With this track form in place, operational vibration levels will achieve the required vibration and structureborne noise criteria in the building within; and external to, the site.

1. Introduction

Located within the heart of Eastern Harbour City, Central Precinct is Australia's busiest transport interchange. The precinct currently holds latent potential with all its inherent advantages of location and transport connections to revitalise Central Sydney. Capitalising on Central Precinct's prime location within Tech Central, a NSW Government commitment to create the biggest technology hub of its kind in Australia, Central Precinct presents the ultimate transformative opportunity to deliver a connected destination for living, creativity and jobs. The renewal of Central Precinct will provide a world-class transport interchange experience, important space for jobs of the future, improved connections with surrounding areas, new and improved public spaces and social infrastructure to support the community.

1.1 Tech Central

1.1.1 Overview

The NSW Government is committed to working with the local community to develop the biggest innovation district of its kind in Australia. Bringing together six neighbourhoods near the Sydney CBD (Haymarket, Ultimo, Surry Hills, Camperdown, Darlington North Eveleigh and South Eveleigh), Tech Central is a thriving innovation ecosystem that includes world-class universities, a world-leading research hospital, 100 + research institutions, investors and a wide range of tech and innovation companies. The vision for Tech Central is for it to be a place where universities, startups, scaleups, high-tech giants and the community collaborate to solve problems, socialise and spark ideas that change our world. It is also for it to be place where centring First Nations voices, low carbon living, green spaces, places for all people and easy transport and digital connections support resilience, amenity, inclusivity, vitality and growth.

Tech Central is an essential component of the Greater Sydney Region Plan's Eastern Harbour City Innovation Corridor. It aims to leverage the existing rich heritage, culture, activity, innovation and technology, education and health institutions within the precinct as well as the excellent transport links provided by the Central and Redfern Station transport interchanges.

The Central Precinct is located within the Haymarket neighbourhood of Tech Central. Planned to become the CBD for Sydney's 21st century, this neighbourhood is already home to The Quantum Terminal (affordable coworking space in the iconic Central Station Sydney Terminal Building) the Scaleup Hub (affordable and flexible workspace for high-growth technology scaleups) and is soon to be the home of Atlassian's headquarters. It is also in close proximity to a number of important education and research institutions.

The planned urban renewal of the Central Precinct has been identified as a key project to achieving the vision for Tech Central.

1.1.2 Background & Context

In August 2018, the NSW Government established the Sydney Innovation and Technology Precinct Panel (the Panel) comprising representatives from various industry, health, education, government agencies and key community members. In December 2018 'The Sydney Innovation and Technology Precinct Panel Report' was produced, setting out the Panel's recommendations for a pathway to delivering a successful innovation and technology district at Tech Central. In February 2019, the NSW Government adopted the Panel's report and committed to delivering the following:

- 25,000 additional innovation jobs
- 25,000 new STEM and life sciences students
- 200,000 m² for technology companies, and
- 50,000 m² of affordable space for startups and scaleups

In February 2019, the Greater Sydney Commission released a Place Strategy for the area that is now known as Tech Central (Camperdown-Ultimo Collaboration Area Place Strategy, GSC). The Place Strategy, developed collaboratively by a range of stakeholders involved in planning for Tech Central's future, was prepared to inform public and private policy and investment decisions by identifying and recognising the complex, place-specific issues inhibiting growth and change. The strategy identifies shared objectives for the place and sets out priorities and actions to realise the vision for the area under the key themes of Connectivity, Liveability, Productivity, Sustainability and Governance.

Both the Panel Report and Place Strategy recognise the importance of the Central Precinct to Tech Central's future.

In July 2019, Central Precinct was declared a nominated State Significant Precinct (SSP) in recognition of its potential to boost investment and deliver new jobs. The SSP planning process for Central Precinct will identify a new statutory planning framework for Central Precinct. This involves two key stages:

- **Stage 1**: Development of a draft Strategic Vision which has since evolved into the Central Precinct Strategic Framework
- **Stage 2**: Preparation of an SSP study with associated technical analysis and community and stakeholder consultation.

In March 2021, the Central Precinct Strategic Framework was adopted representing the completion of Stage 1 of the planning process to develop a new planning framework for Central Precinct. The Strategic Framework outlines the vision, planning priorities, design principles, and the proposed future character of sub-precincts within Central Precinct. This is intended to inform and guide further detailed planning and design investigations as part of this SSP Study (Stage 2 of the SSP planning process).

This SSP Study intends to amend the planning controls applicable to Central Precinct under the SSP SEPP 2005 to reflect the vision and planning priorities set for the Precinct under the Strategic Framework. Study Requirements were issued in December 2020 to guide the investigations and the proposed new planning controls.

1.2 Central Precinct vision

Central Precinct will be a vibrant and exciting place that unites a world-class transport interchange with innovative and diverse businesses and high-quality public spaces. It will embrace design, sustainability and connectivity, celebrate its unique built form and social and cultural heritage and become a centre for the jobs of the future and economic growth.

1.3 Case for change

Over the coming years, Central Station will come under increasing pressure as technological innovations progress, investment in transport infrastructure increases and daily passenger movements increase.

Sydney Metro, Australia's biggest public transport project, will result in the delivery of a new generation of world-class, fast, safe, and reliable trains enabling faster services across Sydney's rail network. In 2024, Sydney Metro's Central Station will open with daily passenger movements forecast to increase from 270,000 persons to 450,000 persons over the next 30 years.

In its current state, Central Station is underperforming as Australia's major transport interchange – it's currently a hole in the heart of Sydney's CBD, lacking connectivity, activation and quality public spaces.

The renewal of Central Precinct will expand and revitalise Central Station and transform this underutilised part of Sydney from a place that people simply move through to one where they want to visit, work, relax, connect and socialise. Its renewal also presents the potential to deliver on the strategic intent and key policies of regional, district and local strategic plans, providing for a city-shaping opportunity that can deliver economic, social and environmental benefit. Specifically, it will:

- make a substantial direct and indirect contribution to achieving the Premier's Priorities by facilitating upgrades to Sydney's largest and most significant public transport interchange, improving the level of service for users and visitors, and supporting the creation of new jobs and housing
- implement the recommendations of the NSW State Infrastructure Strategy 2018-2038, in particular the upgrading of the major transport interchange at Central to meet future customer growth
- contribute to key 'Directions' of the Greater Sydney Region Plan, to deliver 'a city supported by infrastructure', help create 'a city of great places', support 'a well connected city', deliver new 'jobs and skills for the city' and create 'an efficient city'
- implement the outcomes envisaged within the Eastern City District Plan including reinforcing the Harbour CBD's role as the national economic powerhouse of Australia and supporting its continued growth as a Global International City
- deliver on the shared objectives and priorities for Tech Central, the future focal point of Sydney's innovation and technology community, which aims to boost innovation,

economic development and knowledge intensive jobs while creating an environment that foster collaboration and the exchanging of ideas

- deliver an outcome that responds to the overarching vision and objectives of the Central Sydney Planning Strategy. In particular it will assist with implementing a number of 'key moves' outlined in the strategy, including to 'ensure development responds to its context', 'ensure infrastructure keeps pace with growth', 'move people more easily', 'protect, enhance and expand Central Sydney's heritage, public places and spaces', and to 'reaffirm commitment to design excellence.'

1.4 About this report

The purpose of this report is to provide a noise and vibration assessment of the proposed changes, and consider any potential impacts that may result within and surrounding the Central Precinct. This report addresses study requirement 3.2 Noise and Vibration Assessment. The relevant study requirements, considerations and consultation requirements, and location of where these have been responded to is outlined in **Table 1** below.

1.4.1 SSP Study requirements

Table 1: Study requirements, considerations, and consultation requirements

Ref	Requirement or consideration	Summary response	Where addressed
Study requirement			
3.2	Prepare a noise and vibration assessment for the proposal that:		This report
3.2_A	Identifies the existing situation, both within the Precinct and in affected adjacent areas, showing constraints, opportunities and key issues and maps any sensitive receptors	These sections describe the existing acoustic environment and surrounding noise and vibration sensitive receivers identified for the project. A map has been provided in Figure 7. Whilst receivers external to the development are a constraint, noise transmission to these has not been shown to be a limiting factor.	Section 2 and Section 3
3.2_B	Assesses the likely noise and vibration impacts on future development, particularly in relation to over station development	Road and rail noise were found to be the dominant sources affecting the proposed development. These sources were modelled in detail using the best data available on future road and rail traffic volumes.	Section 5
3.2_C	Models and assesses the efficacy of the likely future noise, and vibration measures to minimise negative impacts on comfort and to minimise harm to people or property	Section 5 describes the methodology used to analyse road and rail noise. Section 9.1 provides a combined analysis of likely building elements required to mitigate road and rail noise. The required acoustic performance can be achieved using standard construction materials and techniques.	Section 5 and Section 8
3.2_D	Ensures there that the proposal does not impact the stability of existing rail related structures and infrastructure	There is currently not enough information to conduct a detailed construction noise and vibration impact assessment. However, we have identified the key risks based on the information available to date. The vibration levels expected from construction activities are unlikely to affect the stability of existing rail infrastructure.	Section 7
3.2_D	Recommends appropriate noise, vibration and pollution development standards to be	Section 9.4 identifies future studies that should be considered for future stages of the project. The standards, guidelines, and	Section 9.4

Ref	Requirement or consideration	Summary response	Where addressed
	applied to subsequent development stages.	criteria used in this assessment should continue to apply as discussed.	
Study consideration			
3.2	The noise, vibration and pollution impact assessment should:		
	Identify, map and describe current and approved sensitive receptors	Sections 2 and 3 describe the existing acoustic environment and surrounding noise and vibration sensitive receivers identified for the project. A map has been provided in Figure 7.	Section 2 and Section 3
	Identify map and describe current and likely future noise and vibration affecting the precinct, including sources nature and impact, including potential cumulative impacts	Section 5 details the noise impacts on the development. Section 4.2 discusses the outcome of our previous operational vibration assessment.	Section 4.2 and Section 5
	Include 3D mapping to clearly communicate these impacts	Maps/contours illustrating these impacts are provided in this section.	Section 5.5
	Include noise monitoring results for busy roads such as Cleveland Street and Regent Street, as well as the railyards area within the precinct.	Existing measurements data and a range of unattended and attend measurement results are detailed in this section.	Section 2.1
Consultation			
3	The Studies are to be informed by consultation with:		
	The City of Sydney; particularly in relation to noise and vibration impacts from the operation of the Precinct	Environmental noise into the Precinct will consist of industrial, road and rail traffic noise impacting the internal areas and external areas of the development. Operation noise from the Precinct will include noise from licensed / retail premises. The issues discussed have been included in Section 9.4 of this report.	Section 5 Section 6, Section 9.4
	NSW Environment Protection Authority (where relevant).	Operational noise will also consist of mechanical plant items servicing the development buildings.	Section 6 section 9.4.
	Department of Planning and Environment (DPE)	The main item of concern is associated with noise and vibration impacts to and from Central Precinct.	Section 9.1, Section 9.3
Author			
3.2	The noise and vibration assessment is to be undertaken and signed off by a suitably qualified acoustic and vibration professional(s) with the necessary experience and expertise to undertake the required works.	The noise and vibration assessment (this report) has been prepared by suitably qualified personnel with the necessary experience in similar developments. This has been signed off by a member of the Australian Acoustical Society and RWDI Australia is a member firm of the Association of Australasian Acoustical Consultants. This report has been author by: Remi Larmandieu, Senior Engineer (Noise and Vibration), ME, MIEAust, MAAS Benjamin Lawrence, Senior Technical Director, B.E. (Mech), MIEAust, MAAS	
Guidance Documents			

Ref	Requirement or consideration	Summary response	Where addressed
3	The following documents provide guidance for this Study: • State Environmental Planning Policy (Transport and Infrastructure) 2021 (DPE, 2021); • City of Sydney Open Space, Sports and Recreational Needs Study (CoS, 2016); • Assessing Vibration: A Technical Guideline (DEC, 2006); • Development Near Rail Corridors and Busy Roads – Interim Guideline; • City of Sydney Public Design Manual and Public Domain Design; • Guidelines from NSW Govt Architect and City of Sydney Competitive Design Policy; • Guidelines for Landscape and Visual Impact Assessment (LI & IEMA 2013); • NSW Land and Environment Court photomontage policy; • NSW Green Cover Technical Guidelines; • NSW Greener Spaces; • District and regional Plan Strategies and actions; Study Requirements NSW Department of Planning, Industry and Environment | CM9 Record Number | 15 • Greater Sydney Green Grid Spatial Framework; • Sydney Development Control Plan 2012; • City of Sydney public domain codes including: Streets Code and Technical Specifications, Legible Sydney Wayfinding Strategy & Design Manual, Street Tree Masterplan, Urban Forest Strategy & any other relevant Sydney Code; and • Draft Central Sydney Planning Strategy and draft DCP.	From this list, the following relevant guidance documents have been considered as part of the Noise and Vibration Assessment: • Sydney Development Control Plan 2012; • Assessing Vibration: A Technical Guideline (DEC, 2006); • Development Near Rail Corridors and Busy Roads – Interim Guideline; Refer to the Sections 4, 5, 6 and 7 of this report for a list of additional guidance and policy documents that have been reviewed and used where relevant.	Section 4 Section 5 Section 6 Section 7

1.4.2 Constraints

Current constraints on the project include:

- Noise produced by the surrounding road network;
- Rail noise and vibration generated by train movements in the surrounding corridor; and
- Proximity of sensitive receivers surrounding the site.

1.4.3 Opportunities

None identified that have not already been realised.

1.4.4 Key Issues Identified

The following key issues have been identified for this project.

- Adequately mitigating rail noise from surrounding Sydney Trains operations (suburban, intercity, and interstate).
- Ensuring traffic noise ingress from the surrounding road network is appropriately controlled.
- Ensuring operational noise emissions from mechanical plant comply with relevant criteria at nearby sensitive receivers.
- Mitigating structureborne noise and vibration produced by trains using the new Sydney Yard below the deck to acceptable levels.

1.5 Study Area

Central Precinct is located at the south-east edge of Central Sydney (refer to Figure 1). Central Precinct is surrounded by a number of suburbs including, Haymarket to the north, Chippendale to the south and Surry Hills to the south-east. It is located within the City of Sydney local government area (LGA) with an approximate gross site area of 24 hectares of Government owned land. The precinct comprises land bounded by Pitt Street and Regent Street to the west, Cleveland Street to the south, Eddy Avenue, Hay Street and Goulburn Street to the north and Elizabeth Street and Chalmer Street to the east.

Central Precinct has been an important site for transport operations for over 150 years. Today, Central Station is Australia's busiest transport interchanges and is the anchor of New South Wales's (NSW) rail network. It provides 24 platforms for suburban and Intercity and Regional train connections as well as a direct link to Sydney Airport. The broader transport interchange also caters for light rail, bus, coach and point to point connections such as taxis. The transport interchange will also form part of the Sydney Metro network, with new underground platforms to be provided for Sydney Metro services under Platform 13, 15 and 16 at Central Station. Sydney Metro services will begin in 2024. The precinct also comprises several significant heritage items including the state-heritage listed Sydney Terminal Building and the Clock Tower.

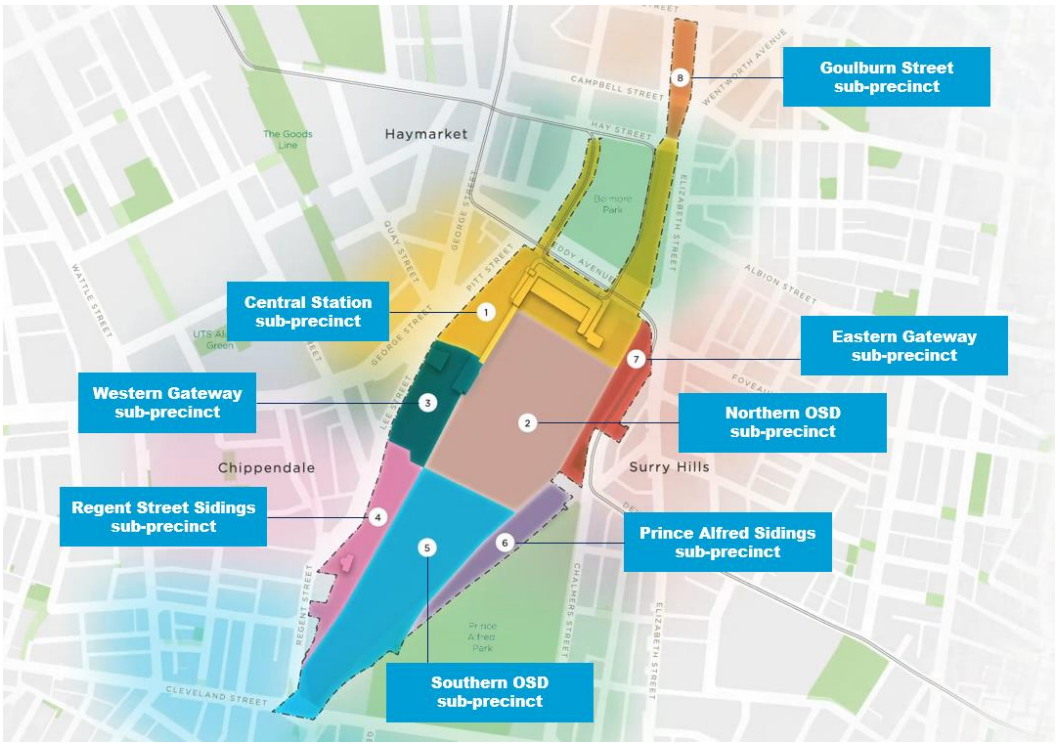
Figure 1: Location plan of Central Precinct

As part of the Strategic Framework, eight sub-precincts have been defined that reflect and positively respond to the varying character of the surrounding areas. These sub-precincts are:

- Central Station
- Northern Over Station Development
- Western Gateway
- Regent Street Sidings
- Southern Over Station Development
- Prince Alfred Sidings
- Eastern Gateway
- Goulburn Street.

The location of these sub-precincts and relevant boundaries is illustrated in **Figure 2**.

Figure 2: Central Precinct and sub-precincts



1.5.1 Planning priorities

To help realise the vision of Central Precinct and the desired local character of the sub-precincts, the following planning priorities have been developed and are grouped into five key themes as outlined in **Table 2** below.

Table 2: Central Precinct planning priorities

Theme	Planning priorities
Place and destination	• Unite the city by reconnecting with the surrounding suburbs • Shape a great place that is vibrant, diverse, active, inclusive and has a high level of amenity • Deliver a precinct which responds to its urban context and embeds design excellence Improve existing and providing additional connected public space in the precinct of high environmental amenity and comfort • Protect and celebrate the Precinct's heritage values • Create a people focussed precinct through a focus on public transport, cycling and walkability • Facilitate the precinct's focus on transport and economic diversity in tourism and across commercial sectors including office, business and retail.
People and community	• Design public spaces that promote health, equality and well-being • Promote social cohesion by providing spaces for gathering, connection, exchange, opportunity and cultural expression • Honour and celebrate the cultural heritage and identity of the Precinct's past and present Aboriginal community • Create a safe and intuitive precinct that promotes social access and inclusion • Support programs and initiatives that benefit communities and people

Theme	Planning priorities
	• Create a precinct that responds to the current and future needs of transport customers, workers, residents and visitors, including those of the broader local community.
Mobility and access	• Provide a world class, integrated and seamless transport interchange • Maintain the precinct's role as NSW's main transport interchange • Improve the transport customer experience, including wayfinding, pedestrian flows and interchange between different transport modes • Facilitate and enhancing connections within and towards key locations in southern Central Sydney • Deliver a people focussed precinct that is walkable, well connected, safe and puts people first • Design infrastructure that will adapt to future changes in transport and mobility.
Economy and innovation	• Advance Sydney's status as a global city • Support the creation of jobs and economic growth including new and emerging industries such as innovation and technology and explore the provision of space for cultural and creative uses and start-ups • Provide an active and diverse commercial hub with a rich network of complementary uses that nurture and support business • Support both the day and night economies of the precinct through diverse complementary uses, promoting liveability and productivity • Foster collaboration between major institutions in the precinct including transport, education, health and business • Create a smart precinct that incorporates digital infrastructure to support research and innovation.

1.5.2 Reference Master Plan

Architectus and Tyrrell Studio have prepared a Place Strategy, Urban Design Framework and a Public Domain Strategy which establishes the Reference Master Plan for Central Precinct. The Urban Design Framework and Public Domain Strategy provides a comprehensive urban design vision and strategy to guide future development of Central Precinct and has informed the proposed planning framework of the SSP Study.

The Reference Master Plan includes:

- Approximately 22,000 sqm of publicly accessible open space comprising:
    - Central Green – a 6,000 square metre publicly accessible park located in immediately south of the Sydney Terminal building
    - Central Square – 7,000 square metre publicly accessible square located at the George Street and Pitt Street junction
    - Mortuary Station Gardens – a 4,470 square metre publicly accessible park (excluding Mortuary Station building) located at Mortuary Station
    - Henry Deane Plaza – a publicly accessible plaza located in the Western Gateway sub-precinct
    - Eddy Avenue Plaza – a 1,680 square metre publicly accessible plaza located in the north-eastern portion of the Sydney Terminal building

  - Western Terminal Extension Building Rooftop - a 970sqm publicly accessible space above the Western Terminal Extension Building Rooftop.

- Approximately 269,500 square metres of office gross floor area (GFA)
- Approximately 22,850 square metres of retail GFA
- Approximately 53,600 square metres of hotel GFA
- Approximately 84,900 square metres of residential accommodation GFA, providing for approximately 850 dwellings (assuming 1 dwelling per 100sqm GFA). The Central Precinct SSP Study will include the commitment to deliver 15 per cent of any new residential floor space as affordable housing.
- Approximately 47,250 square metres of education/tech space GFA
- Approximately 22,500 square metres of student accommodation GFA
- Approximately 14,300 square metres of community/cultural space GFA.

The key features of the Indicative Reference Master Plan, include:

- A network of new and enhanced open spaces linked by green connections. This will include:
  - A Central Green (Dune Gardens) at the north of Central Precinct that will create a new civic public realm extension of the Sydney Terminal building and a new vantage point for Central Sydney
  - A new Central Square which will deliver on the vision for a new public square at Central Station, as one of three major public spaces within Central Sydney connected by a people-friendly spine along George Street
  - Mortuary Station Park at Mortuary Station that will be a key public domain interface between Chippendale and the over-station development. that will draw on the story of Rookwood Cemetery and the Victorian Garden context with the established rail heritage of the Goods Line and the rail lines
  - Henry Deane Plaza which will prioritise the pedestrian experience, improving connectivity and pedestrian legibility within the Western Gateway sub-precinct and provide clear direct links to and from the State heritage listed Central Station and its surrounds
  - Eddy Avenue Plaza – will transform into a high-amenity environment with significant greening and an enhanced interface with the Sydney Terminal building.
- A new network of circulation that will establish a clear layer of legibility and public use of the place. This will include:
  - A 15 - 24 metre wide Central Avenue that is laid out in the spirit of other street layouts within Central Sydney and which responds to the position of the Central clocktower, providing new key landmark views to the clocktower. Central Avenue will be a place for people to dwell and to move through quickly. It brings together the threads of character from the wider city and wraps them
  - Three over-rail connections to enhance access and circulation through Central Precinct, as well as provide pedestrian and bicycle cross connections through the precinct

- The extension of public access along the Goods Line from Mortuary Station Gardens, offering a new connection to Darling Harbour
- New vertical transportation locations throughout the precinct allowing for seamless vertical connections.
- An active recreation system supports health and well-being through its running and cycling loops, fitness stations, distributed play elements, informal sports provision, and additional formal recreation courts.
- a network of fine grain laneways that are open to the sky

The proposed land allocation for Central Precinct is described in **Table 3** below.

Table 3 Breakdown of allocation of land within Central Precinct (note: below figures, except for total Central SSP area, excludes WGP)

Land allocation	Proposed
Open-air rail corridor	101,755 sqm
Developable area	119,619 sqm
Public open space	19,185 sqm / 16% of Developable area
Other publicly accessible open space (Including movement zones, streets and links)	41,773 sqm / 35% of Developable area
Building area	58,661 sqm / 49% of Developable area
Central SSP total area (incl. WGP)	**23.8 ha**

The Indicative Reference Master Plan for Central Precinct is illustrated in **Figure 3** below.

Figure 3: Reference Master Plan

Sub-precinct		Total GFA per sub-precinct (sqm)*
S	Station (terminal building)	15,800
		15,800
A	OSD Block A	165,400
	A1	66,900
	A2	48,900
	A3	39,400
	A4	4,100
	A5	3,000
	A6	3,100
B	OSD Block B	88,900
	B1	42,700
	B2	37,200
	B3	4,000
	B4	5,000
C	OSD Block C	109,700
	C1	32,700
	C2	28,500
	C3	42,800
	C4	3,400
	C5	2,300
D	Regent Street Sidings Block D	65,000
	D1	33,300
	D2	31,700
E	Prince Alfred Sidings Block E	20,900
F	Goulburn St Car Park	49,200
Total GFA (excluding Western Gateway)		514,900
WG	Western Gateway	275,000

***Source**: Architectus and Tyrrell Studio*

2. Existing acoustic environment

The existing noise environment throughout Central Precinct is generally dominated by road traffic and rail noise contributions. Other contributing noise sources include light rail operations and industrial noise consistent with 'urban hum' in an urban context.

It is noted construction noise (mainly relating to Sydney Metro – Central Station works) is also a regular feature within and surrounding the project area. However, construction noise has been excluded from assessment and measurements where possible. The ambient levels and description of various noise sources across the entire project area are outlined below.

2.1 Ambient noise levels

2.1.1 Covid-19 pandemic and its effect on ambient noise levels

Short-term road and rail traffic noise measurements were undertaken prior to the Covid-19 lockdown that started on 26 June 2021. Long-term noise monitoring was considered for a number of locations surrounding the site; however, it was postponed due to the lockdown significantly affecting road traffic noise levels (and to a lesser extent rail traffic) in the area. If monitoring was to proceed at this time, it would present an overly conservative approach and may introduce unwarranted restrictions on the Central Precinct Renewal Project (CPRP).

While it is expected that long-term monitoring will be occurring at a later point in the project once traffic and city occupancy return to pre-COVID-19 levels, historical measurements from past projects were used to quantify ambient noise levels surrounding Central Precinct.

2.1.2 Unattended long-term noise monitoring

In the absence of unattended monitoring results obtained for the purpose of this assessment, additional data has been obtained from other reports for projects in the vicinity of Central Station. These are:

- Laing O'Rourke - Chatswood to Sydenham Environmental Impact Statement (EIS), prepared by SLR, dated April 2016 (SLR 2016)
- Degnan Constructions Pty Ltd - Sydney to Burwood Compressor House Detailed Design Operational Noise Assessment, prepared by GHD Pty Ltd, dated November 2012 (GHD 2012)
- TfNSW - Power supply Upgrade Program - Lee Street Substation Noise and Vibration Assessment prepared by GHD Pty Ltd, dated February 2014 (GHD 2014)
- Sydney Yard Access Bridge - Noise Monitoring Summary Report, prepared by Environmental Resources Management (ERM) Pty Ltd, dated April 2018 (SYAB, 2018).

The 2016 SLR Report provides noise data measured at 101 Chalmers Street, Chippendale and 8/10 Lee Street, Sydney. The 2012 GHD report provides baseline noise data measured in Prince Alfred Park. The 2014 GHD report provides baseline noise data measured at 30 Lee Street, Haymarket. The 2018 SYAB report provides baseline data measured at 54 Regent Street at the base of the Sydney Yard Access Bridge, in the rail corridor off Regent Street.

The Rating Background Level (RBL) collected for the previous projects described above are summarised in **Table 4**. All unattended noise monitoring locations are presented in **Figure 4**.

Table 4: Background monitoring locations and RBL

Location ID	Address	Rating Background Noise Levels (RBL) in dBA		
		Daytime (7am-6pm)	Evening (6pm-10pm)	Night time (10pm-7am)
EIS B.09	101 Chalmers Street, Chippendale	56	53	45
EIS B.10	8/10 Lee Street, Sydney	51	50	49
GHD 2012	Prince Alfred Park, Surry Hills	48	48	45
GHD 2014	30 Lee Street, Haymarket	54	52	46
SYAB 2018	54 Regent Street, Chippendale	50	50	44

***Source**: SLR 2016, GHD 2012, GHD 2014, SYAB 2018*

Figure 4: Unattended noise monitoring locations

Central Precinct Renewal Project
Unattended Monitoring Locations

Map Projection: EPSG:28356. GDA94 / MGA zone 56
Source: Nearmap 2021

Drawn by: APIN	Figure: 1	True North
Approx. Scale:	1:5,033	
Date Revised: Feb 09, 2022		Project 19366

2.1.3 Attended short-term road traffic noise measurements

Attended noise measurements were undertaken at the locations described in **Table 5** and illustrated in **Figure 5**.

Attended measurements were performed using a calibrated Brüel and Kjær 2250 Precision Sound Level Meter (S/N:3008381) or an NTi Audio XL2 Sound Level Meter (S/N: A2A-15945-E0). Wind speeds were less than 5m/s at all times, and all measurements were performed at a height of 1.5 metres above ground level.

Calibration of both sound level meters was checked before and after each measurement and the variation in calibration at all locations was found to be within acceptable limits at all times.

Both sound level meters hold current laboratory calibrations in accordance with NATA and our in-house quality assurance procedures.

The noise environment observed at each of the attended monitoring locations is summarised in **Table 5**.

Table 5: Summary of attended noise monitoring results

ID	Date/Time	Measurement Location	Measured Noise Levels			Description of Ambient Noise Sources Contributions – SPL Level
			L_{A90}	L_{Aeq}	L_{Amax}	
AM1	17/05/2021 5.59pm-6.14pm	300 Elizabeth Street	61	72	96	Regular train pass-bys at 64-66dBA, light rail train flanging/squeal (70-75dBA), light vehicles (63dBA), buses (66-71dBA), Ambulance siren pass-by (80-90dBA).
AM2	17/05/2021 5.59pm-6.14pm	Prince Alfred Park	48	53	64	Train pass-bys (56-58dBA), road noise from Cleveland St (53dBA), tennis players / runners (50dBA).
AM3	17/05/2021 5.59pm-6.14pm	Prince Alfred Park	51	53	63	Train pass-bys (55-58dBA), Cleveland St steady state (52dBA), Tennis/Basketball noise (51dBA), pool public address system (53dBA).
AM4	1/06/2021 11.59am-12.14pm	Eddy Avenue, adjacent Belmore Park	61	67	79	Measurement at 5m from Eddy Avenue curb. Primarily traffic noise.
AM 5	1/06/2021 12.20pm-12.35pm	505-509 Pitt Street, Sydney	62	73	90	Measurement at 4m from Pitt Street curb. Primarily traffic noise.
AM 6	1/06/2021 12.45pm-1.00pm	59 Regent Street, Chippendale	57	71	86	Measurement at 3m from Regent Street curb. Primarily traffic noise.

Figure 5: Attended noise monitoring locations

2.1.4 Short-term railway noise measurement

Attended measurements of train noise levels were conducted to determine the noise emissions from trains entering and departing Central Station.

Attended measurements were performed using a calibrated NTi Audio XL2 Sound Level Meter (S/N: A2A-16735-E0). Wind speeds were less than 5m/s at all times.

Calibration of the sound level meter was checked before and after the measurements and the variation in calibration at all locations was found to be within acceptable limits.

Measurements were conducted adjacent to the Alfred Park tennis courts, between the railway lines and the southernmost tennis court, at a location where all trains entering and departing the northern part of Central Station can be observed and measured.

The measurement location is shown in **Figure 6** and train noise monitoring results are detailed in **Table 6**.

Figure 6: Railway noise monitoring location

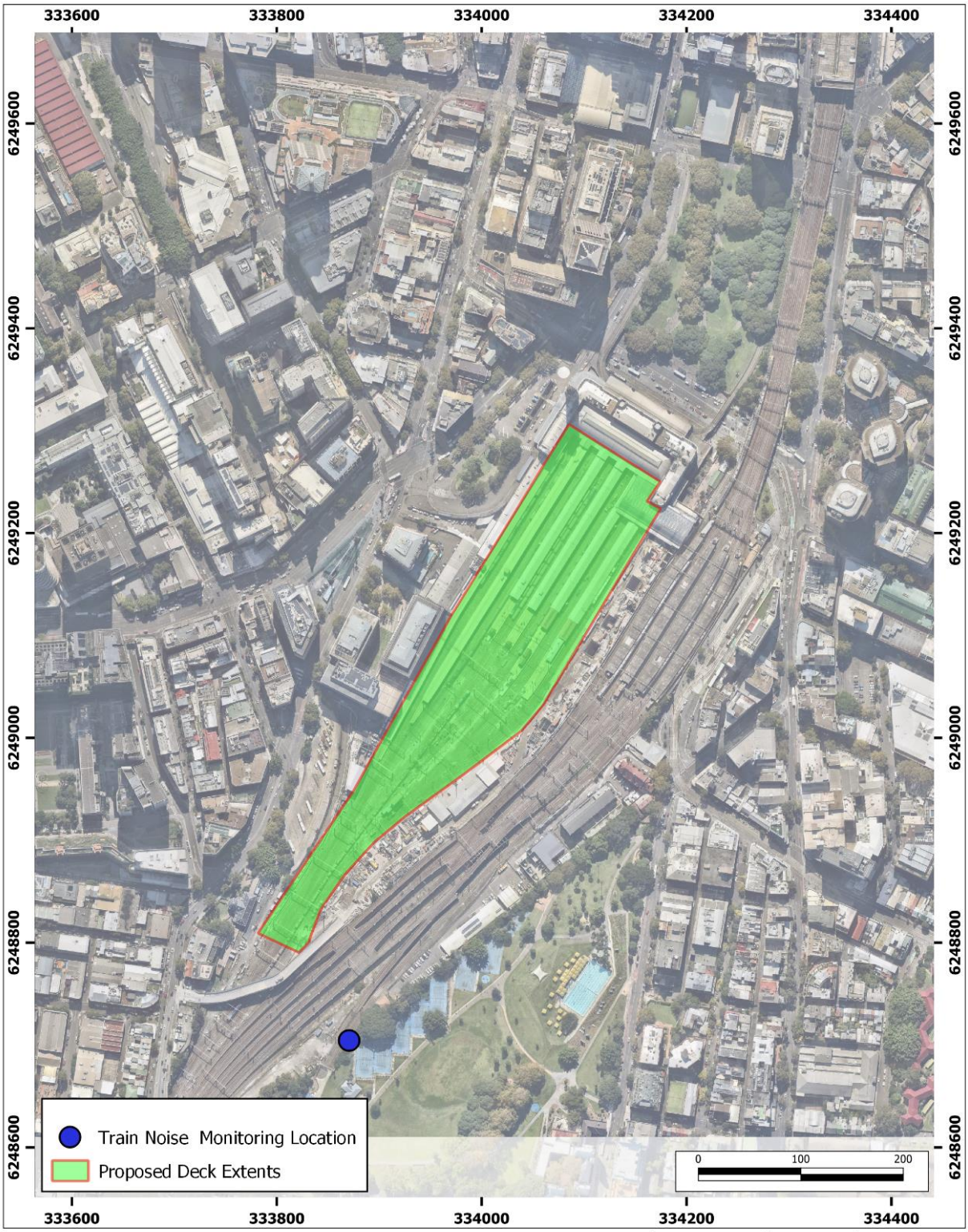


Table 6: Train noise measurement results, 8 September 2021

Train number	Approx. distance from SLM (m)	Time (start)	Duration (s)	L_{Aeq} (dBA)	L_{AFmax} (dBA)	L_{AE} (dBA)	Octave band levels, L_{Zeq}, dB								
							31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Train 1	90	9:50 AM	0:00:21	57	61	70	69	66	60	58	55	52	48	44	43
Train 2	12	9:51 AM	0:00:21	68	73	81	67	68	67	67	66	64	57	51	41
Train 3	19	9:52 AM	0:00:28	76	85	90	66	70	67	64	65	64	66	71	71
Train 4	90	9:53 AM	0:00:21	57	61	71	65	65	58	56	55	51	48	48	45
Train 5	78	9:54 AM	0:00:24	57	63	71	67	67	56	55	54	53	49	45	37
Train 6	115	9:55 AM	0:00:21	68	74	82	69	68	67	67	66	64	58	52	43
Train 7	19	9:56 AM	0:00:24	72	77	86	70	72	69	67	73	66	58	50	42
Train 8	90	9:57 AM	0:00:16	60	63	72	69	68	58	59	58	54	51	48	44
Train 9	115	9:59 AM	0:00:19	55	57	67	69	64	55	56	52	49	45	39	27
Train 10	90	10:00 AM	0:00:21	57	70	70	66	65	56	54	54	52	49	44	33
Train 11	90	10:04 AM	0:00:19	57	63	70	66	64	56	57	54	52	48	45	34
Train 12	90	10:05 AM	0:00:19	58	60	70	68	66	54	58	56	52	48	44	44
Train 13	12	10:06 AM	0:00:21	71	79	84	71	69	66	68	68	66	62	59	57

2.2 Significant noise sources around Central Precinct

2.2.1 Road traffic noise

Central Precinct is surrounded by several major arterial and collector roads.

As the area operates with high pedestrian volumes, vehicle speeds are limited to 50 kilometres per hour and 40 kilometres per hour. Road surfaces have been assumed to be worn Dense-Graded Asphalt (DGA) pavement.

Noise levels observed at the south and south-east of the project boundary are typically dominated by road traffic noise from Cleveland Street and Chalmers Street. Noise levels on the north and north-eastern boundary are typically dominated by road traffic on Elizabeth Street and Eddy Avenue.

Eddy Avenue and Pitt Street operate as a transport hub for interstate and local bus operators which results in large volumes of buses entering, stopping, and leaving the site during the daytime and evening periods.

The overall noise environment throughout the project area is generally dominated by road noise emissions from a number of busy roads, Cleveland Street and Regent Street from the southeast and Eddy Avenue, Chalmers Street and Pitt Street from the northwest.

RWDI was provided with current and future traffic volumes on busy roads surrounding the project site. It is understood that the proposal will impact the traffic on surrounding roads, therefore it is important to understand how traffic volumes will be affected by the project.

Future traffic volumes were provided to RWDI for the year 2036, which aligns with City Plan 2036, a 20-year land use plan from City of Sydney that links state and local strategies with planning controls to guide development. For consistency, future road and rail traffic volumes were assessed and modelled for the year 2036.

Current and future traffic volumes for the major arterial and collector roads surrounding the site have been provided by Arcadis and are presented in **Table 7**.

Table 7: Road traffic volumes – current and future (2036)

Time period	Direction	Current traffic volumes					Future traffic volumes				
		Daytime (7am-10pm)		Night time (10pm-7am)		Comments	Daytime (7am-10pm)		Night time (10pm-7am)		Comments
		Vol.[1]	% HVs[2]	Vol.[1]	% HVs[2]		Vol.[1]	% HVs[2]	Vol.[1]	% HVs[2]	
Lee Street	Northbound	8,700	10%	2,100	8%		600	5%	200	5%	Lee Street assumed closed in future years - local traffic only
	Southbound	3,700	18%	850	12%		600	5%	200	5%	
George Street	Eastbound	15,700	10%	4,000	10%		15,800	8%	4,100	10%	
	Westbound	11,500	13%	2,300	11%		15,400	10%	4,000	11%	
Pitt Street (south of Eddy)	Northbound	19,200	16%	4,200	10%		13,500	15%	1,600	9%	
	Southbound	13,200	17%	2,900	10%		11,800	15%	1,000	9%	
Railway Colonnade Drive	Northbound	400	64%	100	64%		400	60%	100	64%	
	Southbound	600	45%	100	45%		700	40%	100	45%	
Eddy Avenue	Westbound	12,100	16%	2,700	16%		8,500	16%	2,200	16%	
	Eastbound	10,500	14%	2,300	14%		9,400	14%	2,400	14%	
Rawson Place	Westbound	500	100%	100	100%	Buses only	600	100%	100	100%	Buses only
	Eastbound	200	N/A	50	N/A	LR Only	200	N/A	100	N/A	LR Only
Regent Street	Northbound	-		-		No northbound traffic along section	1,900	6%	500	5%	Northbound traffic introduced as part of Lee Street closure
	Southbound	21,600	5%	4,800	5%		18,000	5%	4,600	5%	

Time period	Direction	Current traffic volumes					Future traffic volumes				
		Daytime (7am-10pm)		Night time (10pm-7am)		Comments	Daytime (7am-10pm)		Night time (10pm-7am)		Comments
		Vol.[1]	% HVs[2]	Vol.[1]	% HVs[2]		Vol.[1]	% HVs[2]	Vol.[1]	% HVs[2]	
Regent Street (south of Lee)	Northbound	9,600	4%	2,100	4%		3,400	4%	900	4%	
	Southbound	23,500	5%	5,200	5%		19,700	5%	5,100	5%	
Elizabeth Street	Northbound	24,500	11%	5,400	10%		14,800	10%	3,800	9%	
	Southbound	13,900	11%	3,100	10%		11,200	10%	2,900	9%	
Hay Street	Westbound	2,600	43%	600		High HV% due to buses and coaches	2,900	40%	700	40%	High HV% due to buses and coaches
	Eastbound	1,800	45%	400			2,000	40%	400	40%	
Cleveland Street	Westbound	19,900	2%	4,400	2%		19,200	2%	4,900	2%	
	Eastbound	15,000	4%	3,300	4%		16,500	4%	4,200	4%	
Foveaux Street	Westbound	10,600	8%	2,400	8%	No eastbound traffic along section	9,200	7%	2,400	7%	No eastbound traffic along section
	Eastbound	-		-			-		-		

***Notes**: (1) Total traffic volume*

(2) Percentage of heavy vehicles in total traffic volume

2.2.2 Rail and light rail traffic noise

Locations facing railway lines on either side of Central Station within and surrounding Central Precinct are subject to significant railway noise emissions.

In order to be able to quantify and model the current and future levels of rail traffic noise, RWDI was provided current and future (when the proposal is complete) rail traffic volumes. These are summarised in **Table 8**.

Table 8: Rail traffic volumes

Type of Train	Platforms	Current rail traffic Volumes		Future rail traffic Volumes (2036)	
		Daytime (7am-10pm)	Night Time (10pm-7am)	Daytime (7am-10pm)	Night Time (10pm-7am)
Regional trains	1 to 15	20	2	20	2
Intercity trains	1 to 15	89	26	178	52
Sydney trains	1 to 15	18	2	86	10
Intercity trains	24 to 25	39	8	0	0
Sydney trains	16 to 25	1468	326	1652	367

Noise emissions associated with light rail operations are observable on the eastern and northern side of the project boundary, along Elizabeth Street and Eddy Avenue.

Light rail current and future traffic volumes provided by Arcadis are expected to remain constant and are summarised in **Table 9.**

Table 9: Light rail traffic volumes

Location	Average Daily		Speed
	Daytime (7am-10pm)	Night Time (10pm-7am)	
Eddy Avenue	400	100	25-40km/h
Elizabeth Street	400	100	25-40km/h

2.2.3 Industrial noise

Industrial noise (including fixed mechanical plant) contributes to the ambient noise level across and surrounding the project site. While there is some light industry surrounding the site, there have been no noise generating industrial sources identified that would have a significant impact on the noise environment.

Sensitive noise receivers, typically above street level may experience noise emissions from existing mechanical plant operation, and these have been noted when occurring in measurement locations.

3. Surrounding noise sensitive receivers

A key element in assessing environmental noise impacts is an understanding of the existing ambient and background noise levels in the vicinity of the closest and/or potentially most affected receivers situated in proximity to the site. The noise environment in the vicinity of the Central Precinct Renewal Project (CPRP) receivers is best described as 'urban' - defined by the NSW Environment Protection Authority (EPA) - Noise Policy for Industry (NPfI, 2017)[2], as an area with an acoustical environment that:

- Is dominated by 'urban hum' or industrial source noise, where urban hum means the aggregate sound of many unidentifiable, mostly traffic and/ or industrial related sound sources
- Has through-traffic with characteristically heavy and continuous traffic flows during peak periods
- Is near commercial districts or industrial districts
- Has any combination of the above.

This area may be located in a residential zone as defined on the Local Environmental Plan (LEP) or other planning instruments, and also includes mixed land use zones such as mixed commercial and residential uses.

3.1 Sensitive receivers

Forty-seven receiver locations have been identified to be the closest and / or potentially most affected locations situated near the CPRP, as presented in **Table 10**.

These locations were established based on the review of the previous Environmental Impact Statement (EIS) for the Sydney Metro works (*Chatswood to Sydenham Environmental Impact Statement - Technical Paper 2*, TfNSW, May 2016), along with aerial maps, land use zoning, cadastre data and the results of site visits. These locations do not represent all receivers located in the vicinity of the CPRP works but have been selected for the purposes of this noise and vibration impact assessment; they are considered to be representative of locations that will potentially experience the highest impacts associated with CPRP operations and during the construction phases.

The residential receivers assessed in this report have been identified to occur within 'mixed use' and 'metropolitan centre' zoning areas.

In addition to these locations the vibration assessment has considered potential impacts (cosmetic and structural damage) at the nearby heritage and rail structures throughout Central Precinct, situated around the site at various distances.

The sensitive receiver locations are identified in **Figure 7** and detailed in **Table 10** below.

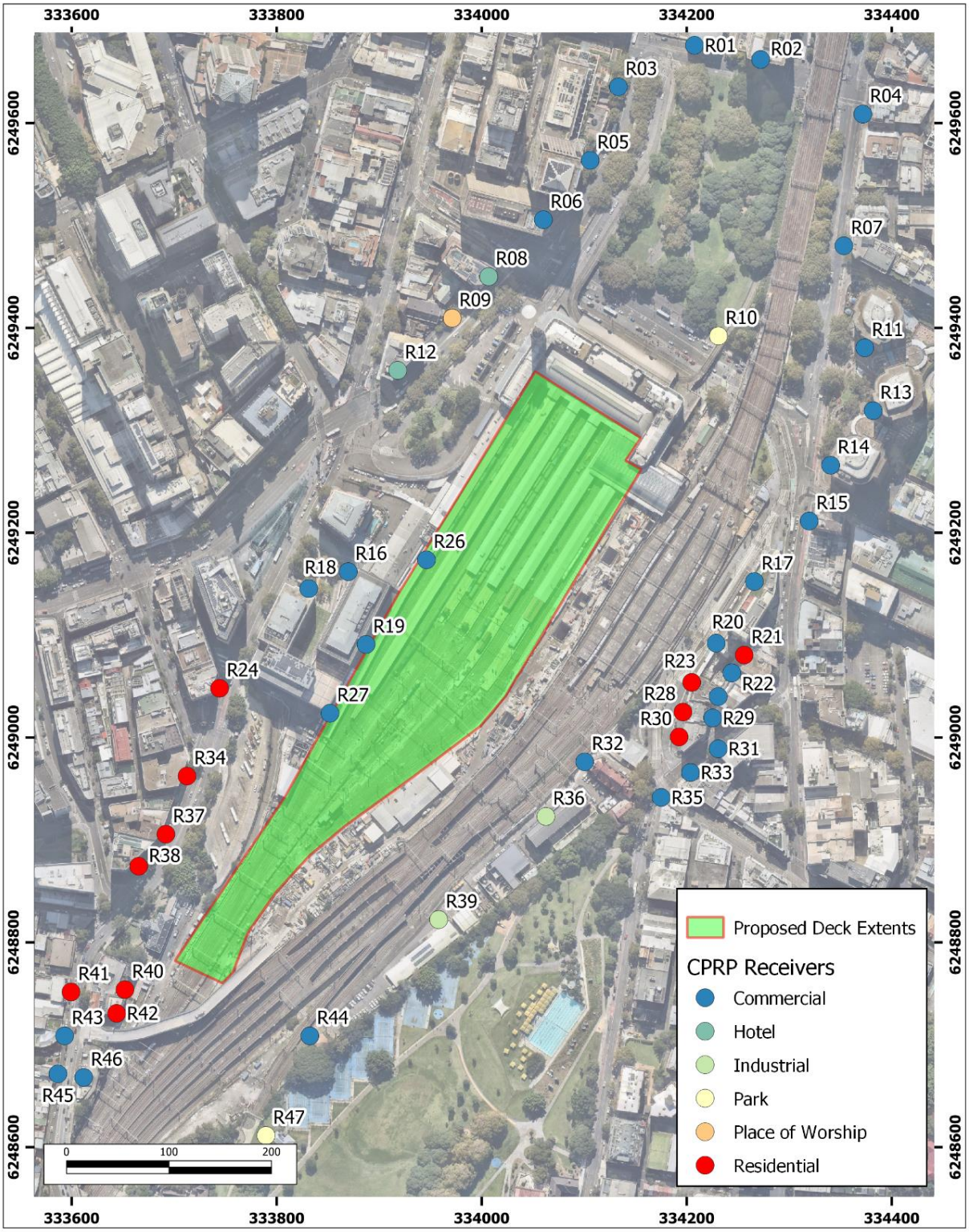
Table 10: Potentially noise sensitive receivers

Location ID	Receptor Type - Address	GPS Co-ordinates (UTM, Zone 56H)	
		Easting	Northing
R01	Commercial - 138 Hay Street	334216	6249695
R02	Commercial - 323 Castlereagh Street	334272	6249683
R03	Commercial - 467 Pitt Street	334152	6249660
R04	Commercial - 228 Elizabeth Street	334358	6249637
R05	Commercial - 477 Pitt Street	334129	6249598
R06	Commercial - 24 Rawson Place	334089	6249548
R07	Commercial - 242 Elizabeth Street	334342	6249526
R08	YHA Hostel - 11 Rawson Place	334043	6249500
R09	Church - 812 George Street	334012	6249465
R10	Recreational - Belmore Park	334237	6249450
R11	Commercial (China Investment Corporation) - 250 Elizabeth Street	334360	6249440
R12	Hostel (Wake up Sydney) - 509 Pitt Street	333967	6249421
R13	Commercial (various) - 280 Elizabeth Street	334367	6249387
R14	Commercial (Various) - 300 Elizabeth Street	334331	6249341
R15	Commercial (Retail; Woolworths) - 302 Elizabeth Street	334313	6249294
R16	Western Gateway Precinct (Block C) - 8-10 Lee Street	333925	6249251.4
R17	Dental Hospital_A (north) - 2 Chalmers Street	334267	6249243
R18	Commercial - Western Gateway Precinct (Block B -office) - 18 Lee Street	333892	6249237
R19	Commercial - Western Gateway Precinct (Block B - North Tower) - 14 Lee Street	333940	6249190
R20	Dental Hospital_B (south) - 2 Chalmers Street	334235	6249191
R21	Residential - 1 Randle Street	334258	6249181
R22	Commercial (Bar; Ding Dong Dang) - 7 Randle Street	334248	6249166
R23	Residential - 30 Chalmers Street	334214	6249158
R24	Residential - 34 Regent Street	333817	6249153
R25	Commercial (Various) - 11 Randle Street	334236	6249146
R26	Western Gateway Precinct (Block A) - 8 -10 Lee Street	333991	6249261.200
R27	Western Gateway Precinct (Block B - East tower) - 26 Lee Street	333910	6249132
R28	Residential - 38 Chalmers Street	334207	6249133
R29	Commercial (Mils Gallery) - 15 Randle Street	334232	6249128

Location ID	Receptor Type - Address	GPS Co-ordinates (UTM, Zone 56H)	
		Easting	Northing
R30	Residential - 46 Chalmers Street	334204	6249112
R31	Commercial - 419 Elizabeth Street	334236	6249102
R32	Commercial (Retail; Interface Australia HQ) - 101 Chalmers Street	334124	6249091
R33	Commercial (Bar; Madison Hotel) - 52 Devonshire Street	334213	6249082
R34	Residential - 53 Regent Street	333789	6249079
R35	Commercial (Bar; Royal Exhibition Hotel) - 88 Chalmers Street	334188	6249061
R36	Industrial (Substation) - Chalmers Street	334091	6249045
R37	Residential - 65 Regent Street	333771	6249030
R38	Residential - 73 Regent Street	333748	6249003
R39	Industrial - Sydney Trains, Chalmers Street	334001	6248958
R40	Residential - 52 Regent Street	333737	6248899
R41	Residential - 105 Regent Street	333691	6248897
R42	Residential - 54 Regent Street	333730	6248879
R43	Commercial (Retail; Cafe Ideas) - 88 Meagher Street	333686	6248860
R44	Commercial - Sydney Trains, Chalmers Street	333893	6248860
R45	Commercial (Bar; Lord Gladstone Hotel) - 115 Regent Street	333680	6248828
R46	Commercial - 70 Regent Street	333702	6248825
R47	Recreational - Prince Alfred Park	333856	6248776

None of the receivers identified are considered to be vibration sensitive based on their distance from site.

Figure 7: Noise sensitive receivers



4. Noise and vibration intrusion criteria

4.1 Road and rail traffic internal noise criteria

4.1.1 Sydney Development Control Plan 2012

Section 4.2 of the Sydney Development Control Plan (DCP) 2012 relates to objectives and provisions for residential flat developments. Part 4.2.3.11 of this section of DCP 2012 outlines the following acoustic controls for new developments affected by traffic noise:

(7) The repeatable maximum $L_{Aeq(1hour)}$ for residential buildings and serviced apartments must not exceed the following levels:

(a) for closed windows and doors:

i) 35dB for bedrooms (10pm-7am); and

ii) 45dB for main living areas (24 hours).

(b) for open windows and doors:

i) 45dB for bedrooms (10pm-7am); and

ii)55dB for main living areas (24 hours).

(8) Where natural ventilation of a room cannot be achieved, the repeatable maximum LAeq (1hour) level in a dwelling when doors and windows are shut and air conditioning is operating must not exceed:

(a) 38dB for bedrooms (10pm-7am); and

(b) 48dB for main living areas (24 hours).

4.1.2 Australian Standard 2107-2016 [3]

AS2107-2016: recommended design sound levels and reverberation times for building interiors specifies allowable internal noise levels for internal spaces within different spaces. **Table 11** (based on Section 5 of AS2107-2016), gives the following maximum internal noise levels for residential buildings near major roads.

Table 11: Recommended design sound level

Space / Activity Type	Recommended Maximum Design Sound Level
Residential / Hotel / Student Accommodation	
Living Areas	45dBA L_{Aeq}, day
Sleeping Areas	40dBA L_{Aeq}, night
Apartment Common Areas	50dBA L_{Aeq} (when in use)
Office Buildings	
Office spaces	45dBA L_{Aeq} (when in use)
Corridor and lobbies	50dBA L_{Aeq} (when in use)

Space / Activity Type	Recommended Maximum Design Sound Level
Meeting Rooms	45dBA L_{Aeq} (when in use)
Commercial Buildings	
Restaurants / Cafés	50dBA $L_{Aeq\ (when\ in\ use)}$
Small retail stores (general)	50dBA $L_{Aeq\ (when\ in\ use)}$
Educational	
Open plan teaching spaces	35 to 40dBA $L_{Aeq\ (when\ in\ use)}$
Lecture rooms up to 50 seats	30 to 35dBA $L_{Aeq\ (when\ in\ use)}$
Office spaces	40 to 45dBA $L_{Aeq\ (when\ in\ use)}$

4.1.3 NSW Department of Planning's 'Development Near Rail Corridors and Busy Roads (Interim Guideline)'[4]

The following surrounding roads have an AADT higher than 20,000 vehicles:

- Cleveland Street;
- George Street;
- Regent Street; and
- Lee Street.

Additionally, as per definition in clause 85, this development is on land or directly adjacent to a rail corridor. Therefore, section 3.5 of the NSW Department of Planning's *Development Near Rail Corridors and Busy Roads – Interim Guideline* (iSEPP) states:

The following provides an overall summary of the assessment procedure to meet the requirements of clauses 87 and 102 of the Infrastructure SEPP. The procedure covers noise at developments for both Road and Rail.

The following provides an overall summary of the assessment procedure to meet the requirements of clauses 87 and 102 of the Infrastructure SEPP. The procedure covers noise at developments for both Road and Rail.

- *If the development is for the purpose of a building for residential use, the consent authority must be satisfied that appropriate measures will be taken to ensure that the following L_{Aeq} levels are not exceeded:*
    - *in any bedroom in the building: 35dB(A) at any time 10pm-7am*
    - *anywhere else in the building (other than a garage, kitchen, bathroom or hallway): 40dB(A) at any time.*

Note that the guideline adopted (iSEPP) still remains current under the new SEPP. Clauses 87 and 102 of the now superseded State Environmental Planning Policy (Infrastructure) 2007 directly correlate to clauses 2.100 and 2.120 of the new SEPP with no change.

4.1.4 Noise Criteria Adopted for this assessment

Both Council DCP and iSEPP requirements have been considered. It is appropriate to use the iSEPP requirements where areas of the development are subject to high levels of traffic and/or rail noise. In areas where this is not the case, the DCP requirements are applicable.

For the purpose of this assessment, the iSEPP requirements have been adopted for residential receivers (35dBA in bedrooms during the evening and 40dBA in living areas).

Commercial receivers and other receiver types have been assessed in accordance with the criteria nominated in AS2107.

4.2 Railway ground-borne noise and vibration criteria

Trains induce ground borne vibration that is transmitted through the subsoil. These vibrations can be perceptible close to railways, as tactile vibrations and as structure borne noise.

4.2.1 Project vibration objectives

4.2.1.1 Tactile vibration

Human comfort is normally assessed with reference to the British Standard BS 7385 Part 2 1993 [5] or Australian Standard AS 2670.2 1990 [6].

The Interim Guideline references the Department of Environment, Climate Change and Water (DECCW) *Assessing Vibration – A technical guideline* [7] which recommends that habitable rooms should comply with the criteria therein which is in line with the requirements of British Standard BS 6472:1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)" [8].

British Standard BS 6472:1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)" is recommended by the Rail Infrastructure Corporation (RIC) and State Rail Authority (SRA) Interim Guidelines for Councils *"consideration of rail noise and vibration in the planning process"* [9] as this standard includes guidance for the assessment of human response to building vibration including intermittent vibrations such as that caused by trains.

Human response to vibration has been shown to be biased at particular frequencies, which are related to the orientation of the person. This standard provides curves of equal annoyance for various orientations. These curves are applied as correction filters such that an overall weighted acceleration level is obtained. As the orientation of the resident is unknown or varying the weighting filter used is based on the combined base curve as given in ISO 2631 & Australian Standard 2670 "Evaluation of Human Exposure to Vibration and Shock in Buildings (1 to 80Hz)" which represents the worst case of the X, Y and Z axes. Filtered measurements are made in all three co-ordinate axes and the highest value axis used.

This standard assesses the annoyance of intermittent vibration by using the Vibration Dose Value (VDV). Alternatively, the VDV may be estimated by the eVDV which is derived by a simpler calculation using an empirical factor. The VDV or eVDV is calculated for the two periods of the day being the "Daytime" (6am-10pm) and "Night Time" (10pm-6am). The overall value is then compared to the levels in **Table 12**.

For this project, the aim will be for a low probability of adverse comment.

Table 12: Vibration Dose Values (m/s$^{1.75}$) above which various degrees of adverse comment may be expected in residential buildings

Place	Low probability of adverse comment	Adverse comment possible	Adverse comment probable
Residential buildings 16hr day (Daytime)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8hr night (Night time)	0.13	0.26	0.51

4.2.1.2 Structureborne noise

The Department of Planning *'Development Near rail Corridors and Busy Road – Interim Guideline'* only requires structure borne noise assessment to be conducted where buildings or adjacent lands are over railway tunnels. Section 3.6.2 of the standard states the following:

"…Where buildings are constructed over or adjacent to land over tunnels, ground-borne noise may be present without the normal masking effects of air borne noise. In such cases, residential buildings should be designed so that the 95th percentile of train pass-bys complies with a ground-borne L_{Amax} noise limit of 40 dB(A)(daytime and 35 dB(A) (night time) measured using the "slow" response time setting on a sound level meter."

5. Precinct assessment – façade requirements

5.1 Modelling Methodology

To assess the potential noise impact from or into the Precinct and define any required mitigation measures, modelling of the project and its surroundings was carried out using the Cadna/A software package, a commercially available implementation of noise propagation algorithms.

Airborne noise impacts from mechanical plant, road and rail traffic activities associated with the proposal were assessed cumulatively by modelling the noise sources, receiver buildings (a receiver building represents an individual building such as house or apartment building) locations, topographical features, and possible noise mitigation measures using a computer noise model developed for this project.

The model calculates the contribution of each noise source to the proposal itself or the each identified noise-sensitive receiver building location surrounding the proposed site.

5.2 Modelling scenarios

To assess the potential impacts of environmental noise on the future buildings, 3D Noise Modelling of the Central Precinct Renewal Project (CPRP) has been completed (**Figure 8**).

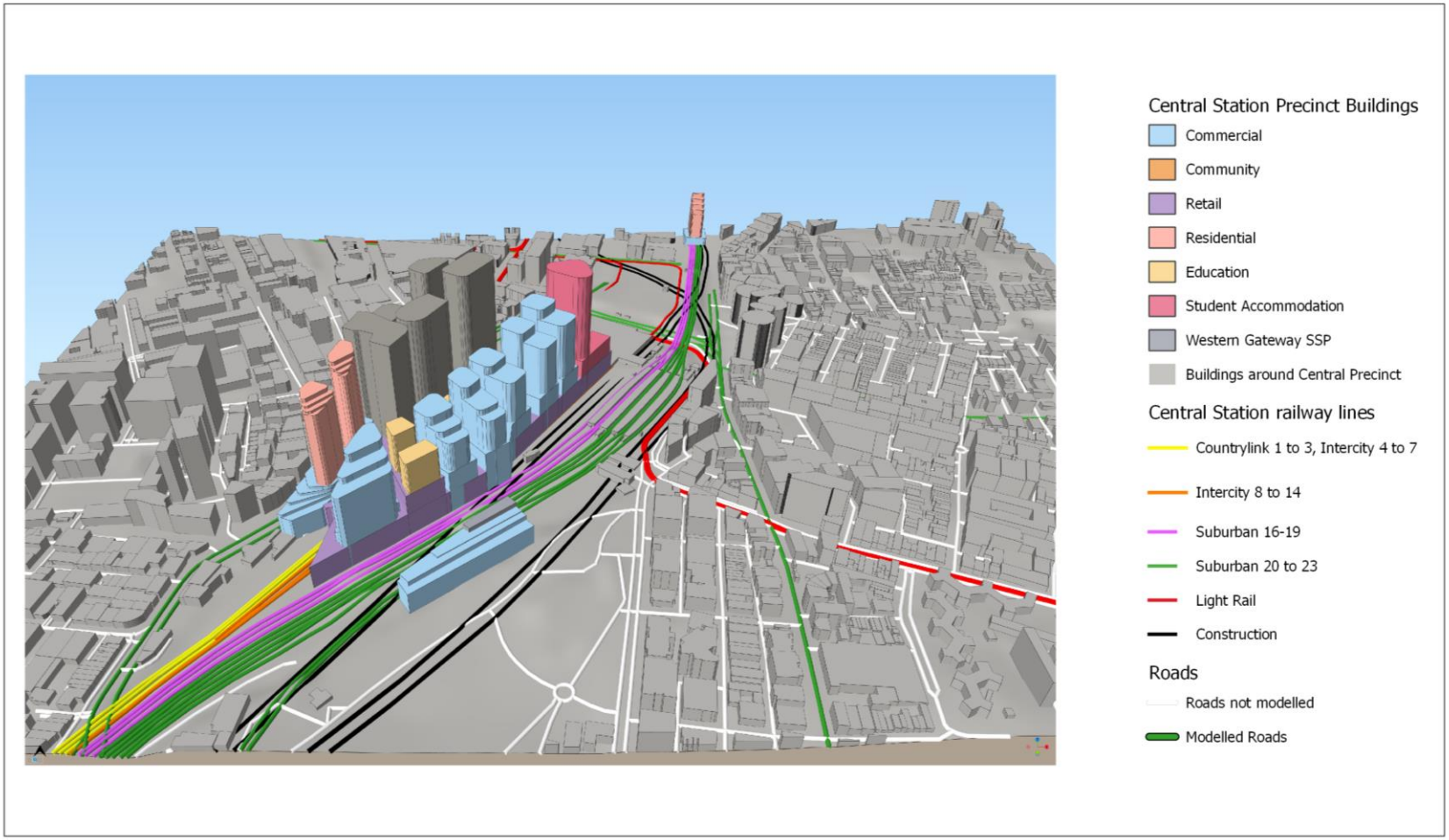
This was performed using CadnaA 2021 MR2.

5.3 Methodology for assessing traffic noise impact

The following factors have been considered during the assessment process:

- Future traffic volumes for the year 2036 on surrounding busy roads and proportions of heavy vehicles
- Vehicle speed
- Road pavement surface types
- Road gradient
- Noise emission levels and source heights for different vehicle types
- Topographical information along and surrounding the CPRP
- Building structures
- Location of potentially affected receiver

Figure 8: 3D view of the noise model



5.4 Noise modelling procedures

Noise levels from the proposed road designs were calculated using procedures based on the CoRTN (*Calculation of Road Traffic Noise* [10]) prediction algorithms. The standard prediction procedures were modified as follows:

- In accordance with the *Interim Traffic Noise Policy* [11], L_{Aeq} values were calculated from the L_{A10} values predicted by the CoRTN algorithms using the well-validated approximation $L_{Aeq,1hr} = L_{A10,1hr} - 3$. It is worth noting the predicted $L_{Aeq,1hr}$ is equivalent to the Las required by the noise criteria since the input is the "average" traffic flow per hour over the given daytime and night time periods.
- Noise source heights were set at 0.5 metres for cars and tyre/road noise from heavy vehicles, 1.5 metres for heavy vehicle engines and 3.6 metres for heavy vehicle exhausts, representative of typical values for Australian vehicles in accordance with the *Model Validation Guideline* [12].
- For light and heavy vehicles, the acoustic energy was distributed as outlined in **Table 13**. Values shown above are based on the ratio 2:4:1 for heavy vehicles. This ratio is based on a fixed speed at around 50 km/hr.

Table 13: Acoustic energy distribution

Vehicle Type	Source Height (m)	Acoustic Energy Ratio	Acoustic Energy Split	
			Percentage (%)	dB
Light	0.5	1:1	100	0
Heavy	0.5	2:7	14	-5.4
	1.5	4:7	57	-2.4
	.6	1:7	29	-8.5

The model was implemented using Cadna/A 2021 MR2 using the CoRTN Australia (NSW) algorithm. **Table 14** summarises other variables used in the noise model.

Table 14: Variables used for noise modelling

Parameter	Comment
Roads	Forecast traffic volumes of busy roads surrounding the project provided by Arcadis were included in the model. These roads are: - Lee Street - George Street - Pitt Street - Railway Colonnade Drive - Eddy Avenue - Rawson Place - Regent Street - Elizabeth Street - Hay Street - Cleveland Street - Foveaux Street
Heavy vehicle percentage	Heavy vehicles percentages were taken into account for each road and time period.

Parameter	Comment
Traffic Speed	Busy roads around the project site were assumed to have sections at 40 and 50 km/h, identical to the existing configuration.
Road surfaces	Road Surface Corrections applied to the 0.5 metre source height: + 0 dBA for Dense Graded Asphalt (DGA).
Terrain	1 metre contours downloaded on the City of Sydney website.
Buildings	Proposed building footprints were provided by Arcadis and shapes were manually drawn in accordance with the Central Precinct Draft SSP Metrics dated 19 November 2021 and loaded in the CadnaA noise model. Surrounding buildings (receivers) were provided by PSMA Australia and loaded in the noise model.
Ground Absorption	Ground absorption factor was set to 0.5 (40 – 59% absorbent ground) for all areas surrounding the site.
L_{A10} to L_{Aeq} conversion	$L_{Aeq} = L_{A10} – 3$dBA
Façade Correction	+2.5 dBA in accordance with *CoRTN*.
Train noise emissions	Train noise levels from measurements detailed in **Section 2.1** were corrected for distance, averaged and applied to the model for each train entering /departing Central Station.

Octave band levels Average sound power level/m per train departing/entering Central Station									**SWL/ mdBA**
31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
92	91	86	86	86	83	80	83	84	90

5.5 Predicted future traffic noise levels

5.5.1 General assessment methodology

Noise level predictions for the opening year have been calculated at each façade and each floor of all buildings within the Precinct. Specifically, 3D views of the modelling results are shown in **Figure 9, Figure 10**, **Figure 11** and **Figure 12** with predicted façade noise levels are presented in **Table 15**.

Table 15: Predicted cumulative façade noise levels (road and rail impacts)

CPRP building	Type	Façade	Predicted noise levels, dBA	
			Daytime ($L_{Aeq\ 15hr}$)	Night Time ($L_{Aeq,\ 9hr}$)
A1	Hotel/Commercial	North East	42-59	39-55
		South East	42-59	39-55
		South West	44-46	40-42
		North West	44-59	40-56
A2	Commercial	North East	42-56	38-53
		South East	42-58	39-54
		South West	41-48	38-44
		North West	43-58	39-54

CPRP building	Type	Façade	Predicted noise levels, dBA	
			Daytime ($L_{Aeq\ 15hr}$)	Night Time ($L_{Aeq,\ 9hr}$)
A3	Commercial	North East	42-59	38-55
		South East	41-56	38-53
		South West	42-47	38-43
		North West	42-60	39-56
A4	Education	North East	45-56	40-50
		South East	44-52	40-48
		South West	45-45	42-42
		North West	47-53	40-46
A5	Commercial	North East	45-53	41-50
		South East	45-50	39-45
		South West	43-43	38-38
		North West	43-51	37-44
A6	Student Accom/Hotel	North East	49-51	42-44
		South East	45-51	39-47
		South West	48-48	42-42
		North West	46-55	41-49
B2	Commercial	North East	41-60	37-56
		South East	44-68	40-66
		South West	42-46	38-42
		North West	42-66	38-63
B3	Student Accom/Hotel	North East	49-56	42-53
		South East	45-56	40-53
		South West	53-53	49-49
		North West	46-55	42-52
B4	Education	North East	44-55	40-50
		South East	51-56	47-53
		South West	44-44	39-39
		North West	48-56	42-53
C1	Commercial	North East	42-62	38-58
		South East	42-61	38-57
		South West	42-51	38-47
		North West	42-62	38-58
C2	Education	North East	38-67	34-64
		South East	39-62	35-58
		South West	39-49	35-45
		North West	38-67	34-64
C3	Retail	North East	42-65	39-62
		South East	43-67	39-63

CPRP building	Type	Façade	Predicted noise levels, dBA	
			Daytime ($L_{Aeq\ 15hr}$)	Night Time ($L_{Aeq,\ 9hr}$)
		South West	42-54	38-50
		North West	42-67	38-63
C4	Commercial	North East	52-57	46-52
		South East	51-60	45-57
		South West	51-51	47-47
		North West	51-59	45-55
C5	Community	North East	37-67	33-64
		South East	37-67	33-64
		South West	37-37	33-33
		North West	37-67	33-64
CP	Retail	North East	37-67	33-64
		South East	37-67	33-64
		South West	37-37	33-33
		North West	37-67	33-64
D1	Residential	North East	36-68	32-64
		South East	36-62	33-59
		South West	37-46	33-42
		North West	38-67	34-63
D2	Residential	North East	40-71	36-67
		South East	40-71	36-67
		South West	40-55	36-51
		North West	40-71	36-67
E1	Commercial	North East	52-66	47-62
		South East	51-66	47-62
		South West	51-63	47-59
		North West	52-66	48-62
F1	Residential	North East	45-71	42-67
		South East	45-73	41-69
		South West	46-57	42-53
		North West	46-73	42-69
F2	Residential	North East	52-69	48-64
		South East	54-68	50-64
		South West	50-63	47-59
		North West	50-68	47-64

Figure 9: 3D Facade map A to D – north-east side

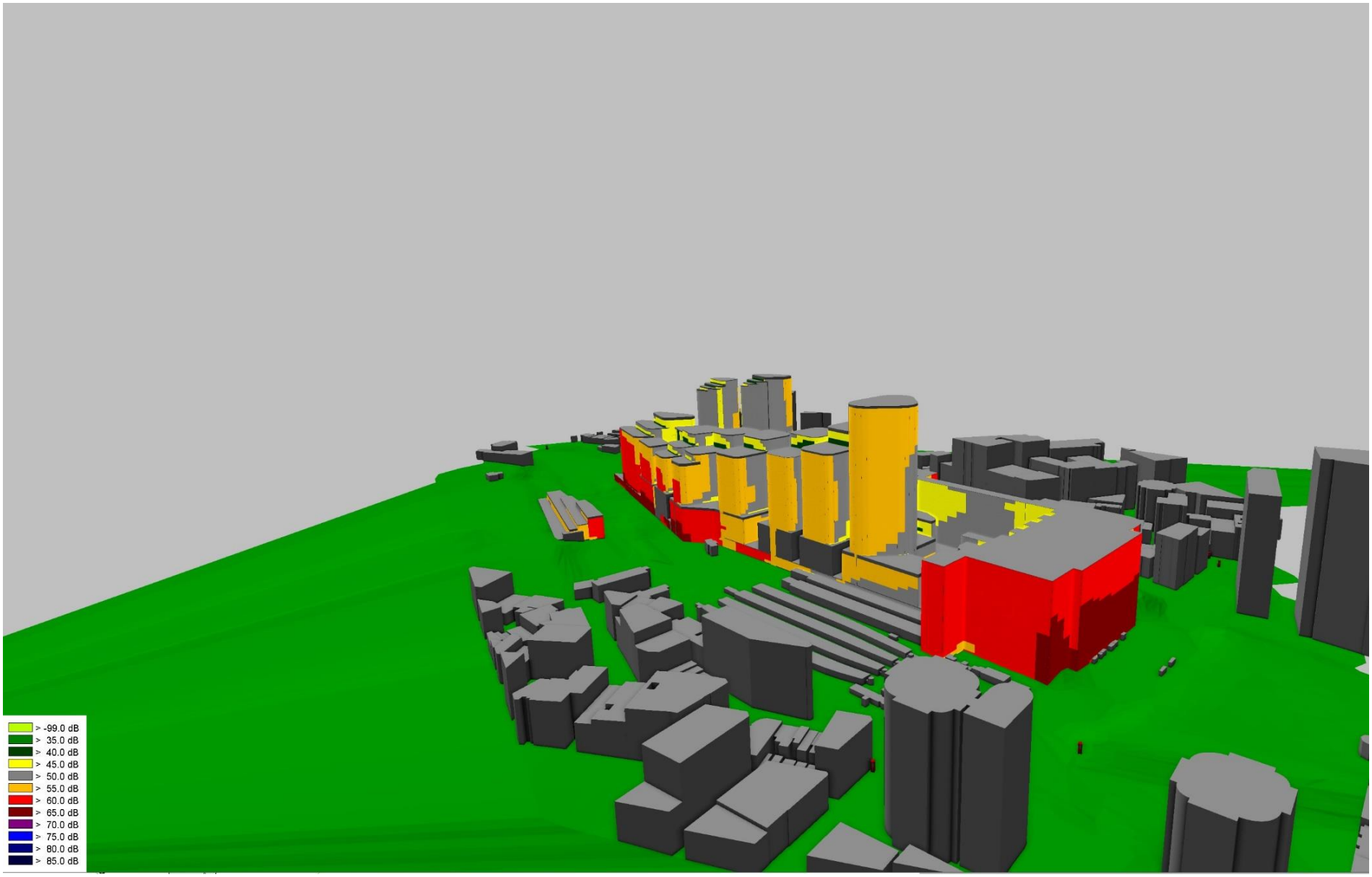


Figure 10: 3D Facade map A to D – north-west side

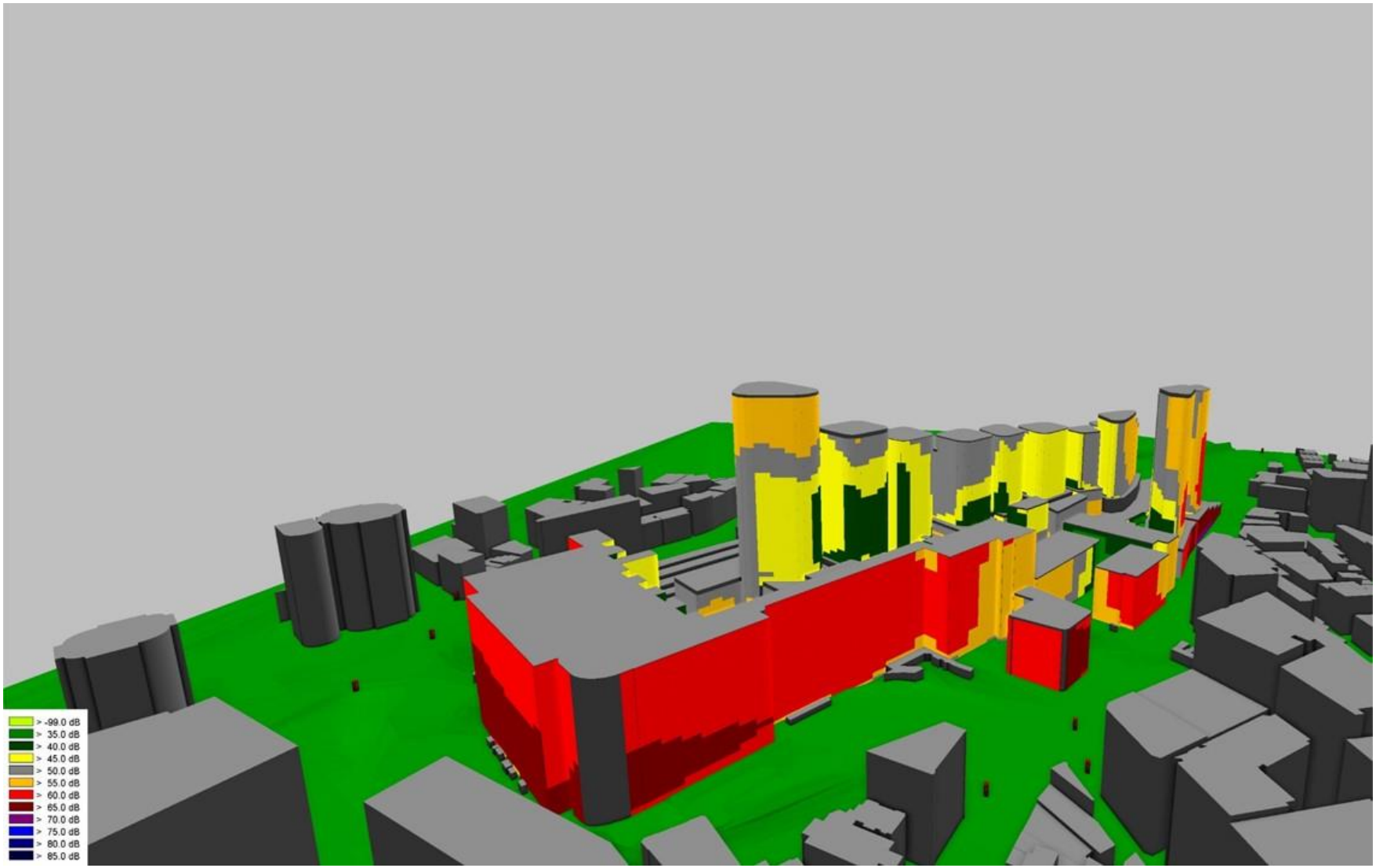


Figure 11: 3D Facade map A to D – south-east side

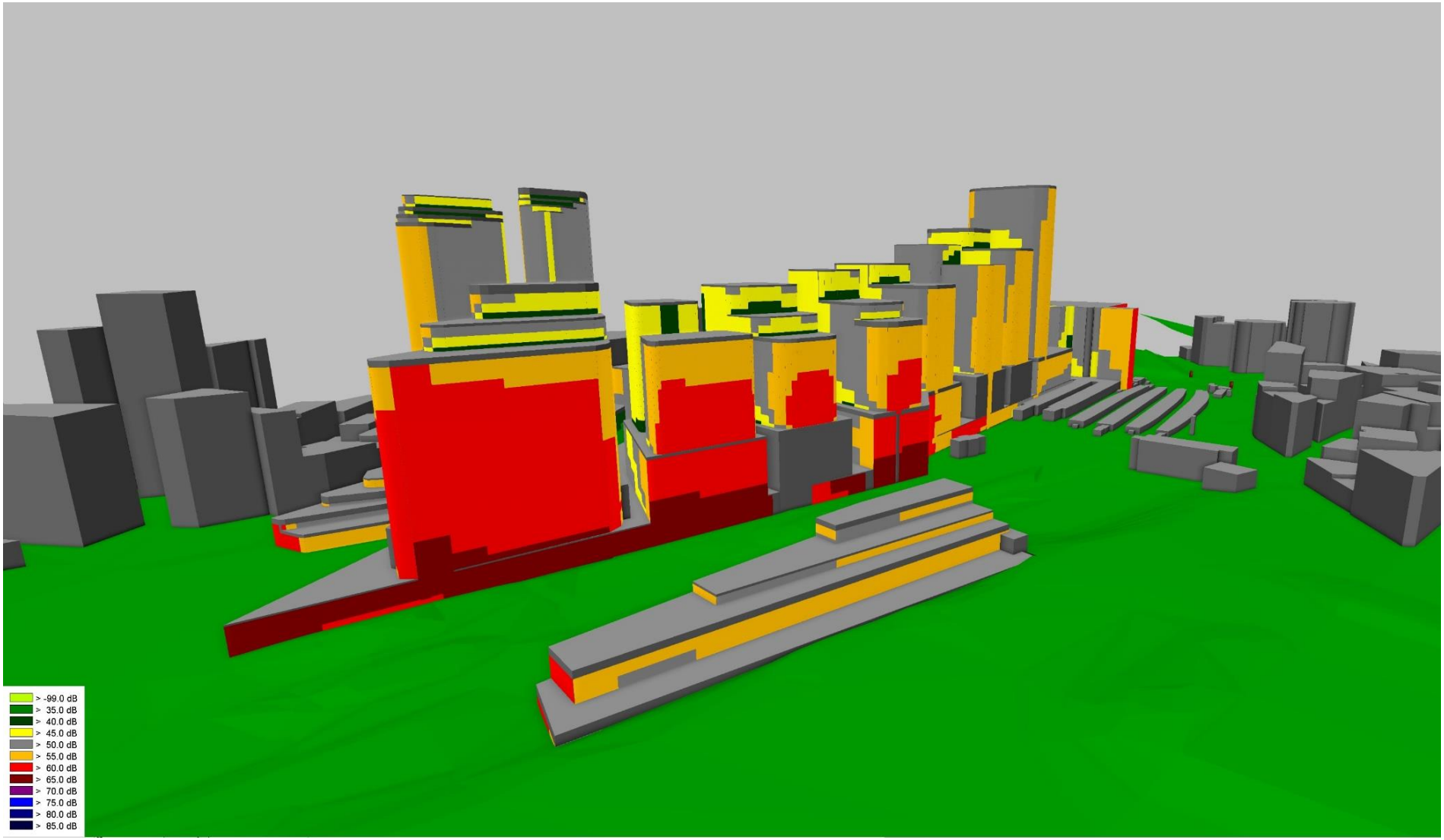
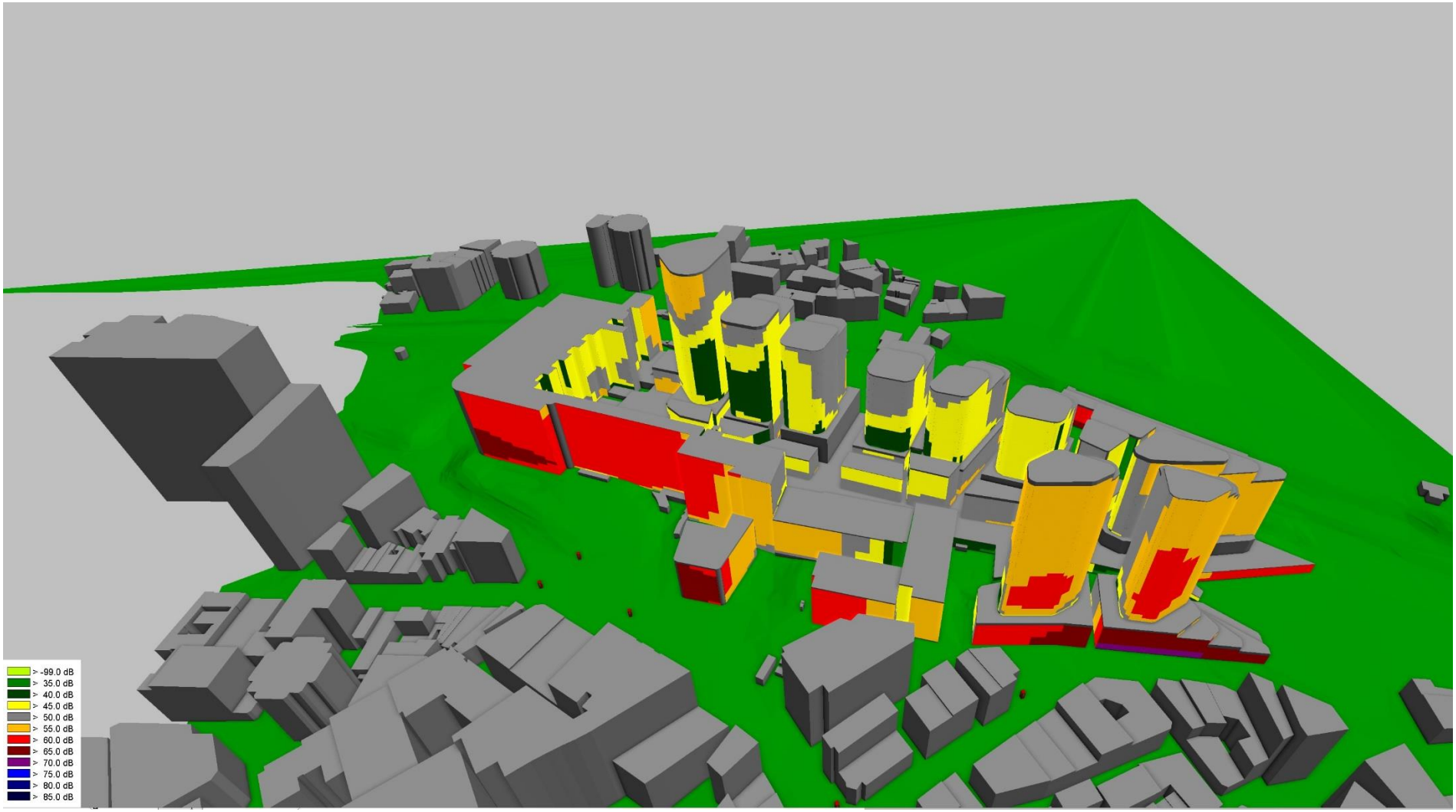


Figure 12: 3D Facade map A to D - west side



6. Mechanical plant noise

No details of specific mechanical plant have been determined at this stage of the Central Precinct Renewal Project (CPRP). Likely sources of noise from the proposed development will be the mechanical plant associated with individual building air-conditioning and ventilation.

A detailed review of noise from mechanical plant servicing the development should be conducted once specific mechanical system details are designed and selected.

6.1 Noise emission criteria

Noise criteria are dependent on existing background noise levels which have been previously measured at surrounding noise sensitive receivers. Acoustic requirements from City of Sydney Council and *NSW Noise Policy for Industry (NPfI)* have been considered for this assessment.

6.1.1 Noise Policy for Industry

The NSW NPfI provides a framework and process for deriving noise criteria for consents and licences that enable the Environmental Planning and Assessment (EPA) and others to regulate premises that are scheduled under the Protection of the Environment Operations Act 1997 [13]. Whilst specifically aimed at assessment and control of noise from industrial premises regulated by the EPA, the policy is also appropriate for use by the NSW Department of Planning, Industry and Environment (DPI&E) when assessing major development proposals.

Having been designed for large industrial and agricultural sources, the monitoring and assessment procedures may not be applicable to the smaller developments and noise sources regulated by local government. It is recognised however, that councils may find the policy to be of assistance in noise assessment and land-use planning.

The NPfI documents a procedure for assessment and management of industrial noise which involves the following steps:

- Determining the project noise trigger levels for a development. The project noise trigger level is a benchmark level above which noise management measured are required to be considered. They are derived by considering short-term intrusiveness due to changes in the existing noise environment (applicable to residential receivers only) and maintaining noise level amenity for particular land uses for residents and other sensitive receivers
- Predicting or measuring noise produced by the development (having regard to any associated annoying characteristics and prevailing meteorological effects)
- Comparing the predicted or measured noise level with the project noise trigger level and assessing impacts and the need for noise mitigation and management measures
- Considering any residual noise impacts following the application of feasible and reasonable noise mitigation measures
- Setting statutory compliance levels that reflect the best achievable and agreed noise limits for development
- Monitoring and reporting environmental noise levels from the development.

The project noise trigger level represents the level that, if exceeded, may indicate a potential noise impact upon a community. It is a benchmark or objective and is not intended for use as a mandatory requirement.

6.1.1.1 Intrusiveness noise level

For assessing intrusiveness, the background noise level (L_{A90}) is measured, and the Rating Background Level (RBL) determined. The intrusiveness of an industrial noise source may generally be considered acceptable if the equivalent continuous noise level (L_{Aeq}) of the source (measured over a 15-minute period) does not exceed the RBL by more than 5dBA.

6.1.1.2 Amenity noise level

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise and do not include transportation noise (when on public transport corridors), noise from motor sport, construction noise, community noise, blasting, shooting ranges, occupational workplace noise, wind farms, amplified music/patron noise.

The amenity noise level aims to limit continuing increases in noise levels which may occur if the intrusiveness level alone is applied to successive development within an area.

The recommended amenity noise level represents the objective for total industrial noise at a receiver location. The project amenity noise level represents the objective for noise from a single industrial development at a receiver location.

To prevent increases in industrial noise due to the cumulative effect of several developments, the project amenity noise level for each new source of industrial noise is set at 5dBA below the recommended amenity nose level.

The following exceptions apply to determining the project amenity noise level:

- For high-traffic areas the amenity criterion for industrial noise becomes the $L_{Aeq,period(traffic)}$ minus 15dBA
- In proposed developments in major industrial clusters
- If the resulting project amenity noise level is 10dB or lower than the existing industrial noise level, the project amenity noise level can be set at 10dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time
- Where cumulative industrial noise is not a consideration because no other industries are present in, or likely to be introduced into the area, the relevant amenity noise level is assigned as the project amenity noise level for the development.

Amenity noise levels are not used directly as regulatory limits. They are used in combination with the project intrusiveness noise level to assess the potential impact of noise, assess mitigation options and determine achievable noise requirements.

An extract from the NSW NPfI that relates to the amenity noise levels for surrounding receivers is given in **Table 16**.

Table 16: Amenity noise levels

Receiver	Noise Amenity Area	Time of Day	Recommended Amenity Noise Level
Residence	Urban	Day	60
		Evening	50
		Night	45

***Note**: Daytime 7.00am–6.00pm; Evening 6.00pm–10.00pm; Night 10.00pm-7.00am.*

6.1.2 Council noise requirements

The typical noise requirements from the City of Sydney have been reproduced below:

(1) NOISE – GENERAL

(a) The emission of noise associated with the use of the premises including the cumulative operation of any mechanical plant and equipment, and air conditioning shall comply with the following:

(i) The $L_{Aeq,15minute}$ noise level emitted from the use must not exceed the project specific noise level for that receiver as determined in accordance with the NSW EPA Industrial Noise Policy [14]. Noise must be measured in accordance with the Industrial Noise Policy and relevant requirements of Australian Standard AS 1055-1997 Acoustics – Description and measurement of environmental noise.

(ii) Project specific noise levels shall be determined by establishing the existing environmental noise levels, in complete accordance with the assessment $L_{A90,15minute}$ / rating $L_{A90,15minute}$ process to be in accordance with the requirements for noise monitoring listed in the NSW EPA Industrial Noise Policy and relevant requirements of Australian Standard AS1055-1997 Standard AS 1055-1997 Acoustics – Description and measurement of environmental noise.

(iii) Modifying factors in Table 4.1 of the NSW EPA Industrial Noise Policy are applicable.

(b) An $L_{Aeq,15minute}$ noise level emitted from the use must not exceed the $L_{A90,15minute}$ noise level by more than 3dB in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) when assessed inside any habitable room of any affected residence or noise sensitive commercial premises provided that;

(i) Where the $L_{A90,\ 15\ minute}$ noise level is below the threshold of hearing, Tf at any Octave Band Centre Frequency as defined in Table 1 of International Standard ISO 226 : 2003-Normal Equal-Loudness-Level Contours then the value of Tf corresponding to that Octave Band Centre Frequency shall be used instead.

(ii) The $L_{Aeq,15minute}$ noise level and the $L_{A90,15minute}$ noise level shall both be measured with all external doors and windows of the affected residence closed;

(iii) The relevant background noise level ($L_{A90,\ 15\ minute}$) is taken to mean the day, evening or night rating background noise level determined in complete accordance with the methodology outlined in the NSW EPA Industrial Noise Policy and Australian Standard AS1055.1997 Acoustics – Description and measurement of environmental noise[15].

(iv) Background noise shall be established in the absence of all noise emitted from the use but with the ventilation equipment normally servicing the affected residence operating. Background noise measurements are to be representative of the environmental noise levels at the affected location.

(v) Modifying factors in Table 4.1 of the NSW EPA Industrial Noise Policy are applicable. Internal Noise measurements are not to be corrected for duration.

6.2 Criteria adopted for this assessment

For the purposes of this assessment, we have conservatively focussed on the more stringent night time period. Based on the historical ambient noise data presented in **Section 2.1.2**, night time intrusiveness criterion (RBL plus 5) for residential receivers are expected to be significantly higher than the amenity criterion as defined in the NPfI (50dBA vs 43dBA). This is also in line with the superseded Industrial Noise Policy (INP) as referred to by the City of Sydney. On this basis, the night time amenity criterion was adopted for this assessment.

Criteria for other spaces (commercial receivers, recreation areas, etc) have been adopted from the NPfI.

6.3 Noise emission preliminary assessment

6.3.1 Assumptions

Preliminary discussions with the design team and experience on similar projects indicate that mechanical plant items may be selected on roof tops as follows.

- On the rooftop of existing Central Station building:
    - Three 400kW chillers have been proposed on the roof of the existing Central Station Building. Using data collected recently on similar projects, chillers have been assumed to generate the following octave band sound power levels (**Table 17**). Plant room roof (applicable to new buildings roofs and mid-rise plant rooms) and fan outlets/inlets (applicable to new buildings roofs) have also been estimated as outlined in **Table 18** and **Table 19**.

Table 17: Assumed chiller sound power levels

Plant	Octave band levels								dBA
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
1x 400kW Chiller	95	95	95	96	88	83	77	69	95

Table 18: Assumed plant room roof sound power levels

Plant	Octave band levels								dBA
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
Assumed plant room roof	81	83	85	81	78	74	71	57	83

Table 19: Assumed fan outlet/inlet sound power levels

Plant	Octave band levels Assumed sound power levels, dB								dBA
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
Assumed supply air fan	87	85	80	77	71	72	72	68	80
Assumed kitchen exhaust fan	85	83	79	79	76	70	64	58	81
Assumed exhaust air fan	74	71	63	55	56	57	55	49	64
Assumed fan outlets/inlets SAF+KEF+EAF (total sound power level)	94	91	86	85	81	78	77	73	87

6.4 Modelling of mechanical plant noise

A CadnaA noise model was prepared in order to investigate noise from mechanical plant with the study area. Impacts to the CPRP and surrounding receivers have been predicted based on the following:

- Three 400kW chillers are assumed to be installed on the roof of the existing Central Station building.
- Plant items are expected to be installed on each building roof within the CPRP
- Noise emissions through louvres around the perimeter of plant rooms have been modelled on the CPRP buildings, in accordance with 3D concept drawings provided by Ethos Urban dated 19 November 2021.
- Plant items sound power levels presented in **Section 6.3** have been incorporated in the model.

Predicted noise levels at surrounding sensitive receivers are presented in **Table 20**.

Table 20: Predicted mechanical plant noise levels at external receivers

Rec ID	Location	Receiver Type	Predicted noise levels $L_{Aeq,15min}$	Criteria[1]	Comply
R01	138 Hay Street	Commercial	30	65	**Yes**
R02	323 Castlereagh Street	Commercial	31	65	**Yes**
R03	467 Pitt Street	Commercial	30	65	**Yes**
R04	228 Elizabeth Street	Commercial	35	65	**Yes**
R05	477 Pitt Street	Commercial	29	65	**Yes**
R06	24 Rawson Place	Commercial	28	65	**Yes**
R07	242 Elizabeth Street	Commercial	33	65	**Yes**
R08	YHA Hostel - 11 Rawson Place	Hotel	30	65	**Yes**
R09	812 George Street	Place of Worship	32	40 (internally) 65 (externally)	**Yes**
R10	Belmore Park	Park	32	55	**Yes**
R11	250 Elizabeth Street	Commercial	31	65	**Yes**
R12	509 Pitt Street	Hotel	32	65	**Yes**
R13	280 Elizabeth Street	Commercial	31	65	**Yes**
R14	300 Elizabeth Street	Commercial	34	65	**Yes**
R15	302 Elizabeth Street	Commercial	35	65	**Yes**
R16	Western Gateway Precinct (Block C)	Hotel	32	65	**Yes**
R26	Western Gateway Precinct (Block A) - 8-10 Lee Street	Commercial	30	65	**Yes**
R17	Dental Hospital A (north) - 2 Chalmers Street	Commercial	37	65	**Yes**
R18	18 Lee Street	Commercial	29	65	**Yes**
R19	14 Lee Street	Commercial	39	65	**Yes**
R20	Dental Hospital B (south) - 2 Chalmers Street	Commercial	39	65	**Yes**
R21	1 Randle Street	Residential	21	43 (night)	**Yes**
R22	7 Randle Street	Commercial	21	65	**Yes**
R23	30 Chalmers Street	Residential	39	43 (night)	**Yes**
R24	34 Regent Street	Residential	35	43 (night)	**Yes**
R25	11 Randle Street	Commercial	22	65	**Yes**
R27	Western Gateway Precinct (Block B - East tower) - 26 Lee Street	Commercial	30	65	**Yes**

Rec ID	Location	Receiver Type	Predicted noise levels $L_{Aeq,15min}$	Criteria[1]	Comply
R28	38 Chalmers Street	Residential	39	43 (night)	**Yes**
R29	15 Randle Street	Commercial	21	65	**Yes**
R30	46 Chalmers Street	Residential	39	43 (night)	**Yes**
R31	419 Elizabeth Street	Commercial	31	65	**Yes**
R32	101 Chalmers Street	Commercial	40	65	**Yes**
R33	52 Devonshire Street	Commercial	38	65	**Yes**
R34	53 Regent Street	Residential	37	43 (night)	**Yes**
R35	88 Chalmers Street	Commercial	38	65	**Yes**
R36	Chalmers Street	Industrial	41	70	**Yes**
R37	65 Regent Street	Residential	35	43 (night)	**Yes**
R38	73 Regent Street	Residential	35	43 (night)	**Yes**
R39	Sydney Trains, Chalmers Street	Industrial	48	70	**Yes**
R40	52 Regent Street	Residential	33	43 (night)	**Yes**
R41	105 Regent Street	Residential	32	43 (night)	**Yes**
R42	54 Regent Street	Residential	33	43 (night)	**Yes**
R43	88 Meagher Street	Commercial	32	65	**Yes**
R44	Sydney Trains, Chalmers Street	Commercial	36	65	**Yes**
R45	115 Regent Street	Commercial	31	65	**Yes**
R46	70 Regent Street	Commercial	32	65	**Yes**
R47	Prince Alfred Park	Active recreation area	33	55	**Yes**
R47	Prince Alfred Park (Train Measurement point)	Active recreation area	34	55	**Yes**
P1	Podium 1	Active recreation area	45	55	**Yes**
P5	Podium 5	Active recreation area	41	55	**Yes**
P6	Podium 6	Active recreation area	44	55	**Yes**
P7	Podium 7	Active recreation area	44	55	**Yes**
P9	Podium 9	Active recreation area	46	55	**Yes**
P2	Podium 2	Active recreation area	42	55	**Yes**
P4	Podium 4	Active recreation area	51	55	**Yes**
P3	Podium 3	Active recreation area	50	55	**Yes**
P8	Podium 8	Active recreation area	46	55	**Yes**

Notes: *(1) intrusiveness criteria for each receiver have not been determined at this stage.*

Mechanical plant noise levels generated by new plant items have also been predicted for the buildings, podiums and open spaces of Central Precinct. These are presented in **Table 21**.

Table 21: Predicted noise levels

Façade / Land use	Predicted noise levels, dBA L_{Aeq}	Comment
Towers Lower half	43-52	Predicted noise levels are likely to be below the 65dBA[1] external criterion nominated for commercial receivers. Standard mitigation measures such as noise barriers, enclosures may be used to reduce noise levels in case of exceedances. For building façades, standard mitigation techniques including single glazing will be satisfactory.
Towers Upper half	48-60	
Podiums / open spaces	41-51	Predicted noise levels are expected to remain below the 55dBA[1] external criterion adopted at ground level, where open spaces / podiums will be considered. Standard mitigation measures such as silencers, absorption and acoustic louvres may be considered in case of exceedances.

Notes: *(1) as adopted from the NSW Noise Policy for Industry (EPA, 2017)*

7. Construction noise and vibration impacts

Construction activities have the potential to create high noise and vibration levels for receivers such as:

- passengers within Central Station but beyond the boundary of the development;
- receivers within the development; and
- external residential and, to a lesser extent, commercial receivers.

Sufficient information to conduct a detailed Construction Noise and Vibration Impact Assessment (CNVIA) does not currently exist, nor is it a study requirement. This is normally performed once construction staging, construction methodology, equipment selection, construction program has been finalised. A detailed CNVIA should be conducted in consultation with design/construction staff and contractors.

To provide some guidance, particularly around high vibration produced by some construction equipment, we have identified the key risks and how these may be mitigated.

7.1 Criteria

7.1.1 Noise Goals

Construction noise goals will be determined in accordance with the NSW EPA Interim Construction Noise Guideline [16]. This guideline sets Noise Management Levels (NMLs) above which all reasonable and feasible noise mitigation should be implemented. It should be noted these are not mandatory hard limits, but rather goals used to guide where mitigation efforts should be focused. Construction sites regularly exceed the NMLs with suitable mitigation in place.

NMLs for construction activities will be determined in future studies once the relevant information becomes available (refer **Section 9.4**).

7.1.2 Building Damage Vibration Goals

Vibration due to construction has the potential to cause damage, both cosmetic and structural, to surrounding buildings. The German Standard *DIN 4150-3: Structural Vibration in Buildings* [17] is to be applied when assessing the potential for building damage.

The vibration guide values for building damage for typical buildings as outline in DIN 4150-3-2016 are provided in **Table 22**.

Table 22: Vibration Guide Values for Building Damage – DIN 4150-3

Guideline values for velocity – mm/s (peak)				
Structure	At foundation at a frequency of			Top storey (horizontal)
	1 to 10 Hz	10 to 50 Hz	50 to 100 Hz	All frequencies
Residential	5	5 to 15	15 to 20	15
Commercial/Industrial	20	20 to 40	40 to 50	40
Vibration Sensitive Structures such as Heritage Structures	3	3 to 8	8 to 10	8

These values are generally considered very conservative for Australian buildings. Alternative values for vibration goals are found in the British Standard *BS 7385-2:1993*. The building damage vibration goals from this standard are summarised in **Table 23**.

Table 23 : Vibration Guide Values for Building Damage – BS 7385-2

Type of building	Peak Particle Velocity (PPV in mm/s) in the frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz & above
Reinforced or framed structures Industrial and heavy commercial buildings	50mm/s at 4 Hz and above	
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4 Hz increasing to 20mm/s at 15 Hz	20mm/s at 15 Hz increasing to 50mm/s at 40 Hz and above

The British Standard states that "A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."

We recommend adopting screening criteria for construction activities that have the potential to cause building damage. These criteria, based on a conservative 50% of the British Standard *BS 7385-2:1993* levels, measured as Peak Component Particle Velocity (PCPV), are:

- Reinforced or framed structures: 25.0mm/s
- Unreinforced or light framed structures: 7.5mm/s

The British Standard suggests that heritage structures should not be assumed to be more sensitive to vibration sources and should be assessed by the same screening criteria, unless they are found to be structurally unsound after inspection. If a heritage structure is found to be structurally unsound, screening criteria of 2.5mm/s PCPV will apply.

Attended vibration monitoring of each specific item of vibration intensive plant should be conducted before beginning construction works to establish a more accurate minimum working distance. A heritage specialist should be consulted when installing equipment used for vibration, movement and noise monitoring around heritage listed structures.

No specific criteria have been issued for Sydney Trains infrastructure within the rail corridor. However, these are likely to be higher than normal building damage criteria. Using the screening criteria discussed will likely result in a conservative outcome.

Continuous vibration monitoring with audible and visual alarms should be implemented at the nearest sensitive receiver when activities are to occur inside the safe working distances.

7.1.3 Human Comfort Vibration Goals

In accordance with *Assessing Vibration: A Technical Guide (DEC, 2006)*, human comfort levels relating to vibration from continuous, impulsive and intermittent sources are measured as a Vibration Dose Value (VDV).

In the context of impact to human comfort continuous, impulsive and intermittent sources are defined within Assessing Vibration: A Technical Guide (DEC NSW 2006) as:

- **Continuous vibration** continues uninterrupted for a defined period (usually throughout daytime and/or night time).
- **Impulsive vibration** is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds. Impulsive vibration will be experienced on no more than three occurrences in an assessment period.

Intermittent vibration can be defined as interrupted periods of continuous (e.g., a drill) or repeated periods of impulsive vibration (e.g., a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g., pile drivers and forging presses) or repetitive sources (e.g., pavement breakers), or sources which operate intermittently, but which would produce continuous vibration if operated continuously (for example, intermittent machinery, railway trains and traffic passing by).

Table 24 indicates the preferred and maximum Vibration Dose Value for intermittent vibration.

Table 24: Vibration Dose Value goals for human comfort

Place	Time	Vibration Dose ($m/s^{1.75}$)	
Residences	Daytime	0.20	0.40
	Night time	0.13	0.26
Offices	Day or night time	0.40	0.80
Workshops	Day or night time	0.80	1.60

7.2 Identification of Key Risks

To provide some guidance, particularly around vibration produced by construction equipment, **Table 25** identifies some of the key construction activities that may give rise to high level of noise and vibration. Based on the information discussed in **Table 25**, it is unlikely that the stability of existing rail infrastructure will be affected from vibration levels assuming the nominated setback distances can be achieved. It should be noted that there are other geotechnical factors that affect stability. This assessment only addresses vibration.

The impacts of site wide construction noise and vibration should be considered in a future stage of the project once more information becomes available. Each individual building should be subject to its own construction noise and vibration impact assessment and construction noise and vibration management plan, both to be completed prior to issue of construction certificate for each development.

Table 25: Key activities identified during construction

Source/Activity	Risk	Likely Outcome	Mitigation Strategy
Bored Piling Rig/foundation piling	High noise levels during construction activities	Receivers beyond the site boundary and passengers on platforms may be above noise management levels. As a result, all reasonable and feasible mitigation should be applied as per the *ICNG*.	Selection of quietest possible equipment, site barriers, respite periods.
	High vibration levels during construction activities leading to building damage	Unlikely to exceed building damage criteria within 5m of piling activities.	Appropriate setbacks between construction activities and active rail infrastructure and buildings. Dilapidation surveys prior to, during, and after completion of construction.
	High vibration levels during construction activities leading to exceedance of comfort criteria	Unlikely to exceed human comfort criteria within 20m of piling activities.	Appropriate setbacks between construction activities and publicly accessible areas. Some areas may need to be temporarily closed.
Large excavators/rock hammering	High noise levels during construction activities	Receivers beyond the site boundary and passengers on platforms may be above noise management levels. As a result, all reasonable and feasible mitigation should be applied as per the ICNG.	Selection of quietest possible equipment, site barriers, respite periods.
	High vibration levels during construction activities leading to building damage	Unlikely to exceed building damage criteria within 8m of excavation/hammering activities.	Appropriate setbacks between construction activities and active rail infrastructure and buildings. Dilapidation surveys prior to, during, and after completion of construction.
	High vibration levels during construction activities leading to exceedance of comfort criteria	Unlikely to exceed human comfort criteria within 20m of piling activities.	Appropriate setbacks between construction activities and publicly accessible areas. Some areas may need to be temporarily closed.

8. Consultation

Consultation is a core requirement of the State Significant Precinct (SSP) study commissioned by the NSW Department of Planning and Environment (the Department). As part of the Pollution Assessment, consultation with relevant stakeholders has been undertaken as outlined in the following sections. Stakeholder consultation records are provided as **Appendix B**.

8.1 Department of Planning and Environment

A meeting with the Department of Planning and Environment (the Department) occurred on 14 February 2022, which included consultation on the Pollution Assessment. The main item of concern raised by the Department was in relation to noise and vibration impacts to and from Central Precinct.

8.2 City of Sydney

A meeting was held with the City of Sydney on 4 April 2022, which included consultation on the Pollution Assessment. The main area of discussion was in relation to noise and vibration impacts including noise from licensed premises. The issues discussed have been included in **Section 9.4** of this report.

8.3 Environment Protection Authority

A meeting was held with the Environment Protection Authority (Strategic Planning Section) on 6 April 2022, which included consultation on the Pollution Assessment. The Environment Protection Authority indicated that as well as future activities that are likely to be subject to Environment Protection Licences, the agency would also have an ongoing interest in the urban design of the precinct as it relates to amenity. Relevant standards and guidelines have been adopted in this report.

9. Recommendations

9.1 Building controls and mitigation measures

Internal noise levels will primarily be as a result of cumulative noise transfer through façade elements, such as glazing and doors, as these are relatively light building elements that offer less resistance to the transmission of sound.

The predicted noise levels are based on the measured level and spectral characteristics of the cumulative external noise, the area of building elements exposed to the sources, the absorption characteristics of the rooms and the noise reduction performance of the building elements.

In all cases, the recommended mitigations (refer below) reduce internal noise levels to within the nominated criteria for the various space types.

9.1.1 Recommended glazing

Table 26 lists the recommended glazing assemblies for the Central Precinct Renewal Project (CPRP), which are required to achieve the internal traffic noise requirements. External windows are assumed to be closed or fixed glazing. Internal noise criteria adopted are detailed in **Section 4.1.4**.

The glazing thicknesses recommendations have been identified to satisfy external acoustic requirements and do not take into account other factors such as thermal, structural, safety or other considerations. These additional considerations may require the glazing thickness to be increased beyond the acoustic requirement. In such cases, thicker window glazing will be acoustically acceptable.

Table 26: Glazing construction minimum requirements (indicative)

Type	Glazing thickness	R_w
Facing Railway and/or busy roads(s)		
Residential/Student Accommodation/Hotel	Minimum 10.38mm laminated/12.38mm laminated for residences directly facing busy roads (i.e., Regent Street)	35/37
Commercial	Minimum 10.38mm laminated	35
Education	Minimum 10.38mm laminated	35
Retail	Minimum 6.38mm laminated	31
Not facing Railway or busy roads(s)		
Residential/Student Accommodation/Hotel	Minimum 10.38mm laminated	35
Commercial	Minimum 6.38mm laminated	31
Education	Minimum 10.38mm laminated	35
Retail	Minimum 6mm FLOAT	29

***Note**: (1) Glazing requirements will require to be revised when floor plans and architectural drawings are available.*

In addition to complying with the minimum scheduled glazing thickness, the R_w rating of glazing fitted into operable frames and fixed into the building openings should not be lower than the values listed in **Table 27**. Where nominated, this will require the use of acoustic seals around the full perimeter of operable frames and the frame will need to be sealed into the building opening using a flexible sealant.

Table 27: Minimum STC/R_w of glazing requirements

Glazing assembly	Acoustic seals	Minimum R_w of installed window
6mm float	Yes	29
6.38mm Laminated	Yes	31
10.38mm Laminated	Yes	35
12.38mm Laminated	Yes	35

9.1.2 External roof/ceiling construction

Proposed external roof structures should be constructed from concrete elements. If any penetration is required through the slab, appropriate details and acoustic sealant should be used to ensure sufficient acoustic requirements.

9.1.3 External walls

All proposed external walls will be composed from concrete construction. Proposed systems will not require acoustic upgrading to satisfy the acoustic objectives.

Variations to any concrete or masonry constructions to light weight wall in-fills or light weight roof constructions should be assessed to determine compliance during the detailed design phase of the CPRP.

Any ventilation openings or penetrations in the façade need to be acoustically treated to maintain the acoustic integrity of the façade construction.

9.2 Management of mechanical plant noise

No details of specific mechanical plant have been determined at this stage of the CPRP. Likely sources of noise from proposed developments will be the mechanical plant associated with building air-conditioning and ventilation.

Noise levels generated by mechanical plant items have been predicted based on likely plant items for these types of development. These indicate that compliance can be achieved for receivers within and external to the CPRP.

In case of non-compliance, all plant can be satisfactorily attenuated to levels complying with noise emission criteria through appropriate location and (if necessary) standard acoustic treatments such as noise screens, enclosures, in-duct treatments (silencers/lined ducting) or similar.

It has been noted that we have not been able to conduct suitable background noise monitoring for this study due to COVID. For residential receivers, a criterion of 40dBA (amenity level minus 5 to allow for other industrial noise in the area) has been adopted as a worst case/ night time limit. Based on historical data, night time intrusiveness criteria for residential receivers are expected to be significantly higher than this and the amenity level would always be more stringent. We would not expect ambient noise surrounding the project to reduce

significantly over time. Therefore, we conclude that even if we had updated data, the outcome of our assessment would not change.

A detailed review of noise from mechanical plant servicing the development should be conducted at a later stage once specific mechanical system details are selected by the mechanical contractor.

9.3 Evaluation of vibration impacts

The most prevalent vibration impacts will be from train movements in the new intercity yard, below the deck. This issue has been documented in a previous report CPRP025-ADAP-CEN-NV-RPT-000001 - *Central Station Force Density Measurements and Analysis*, 27 October 2020 (provided as **Appendix C**). The findings of that report are still valid in summary:

- Detailed information on the vibration emissions (force density level) of current rollingstock was obtained. This was found to be consistent with previous measurements once accounting for speed differences.
- Predictions of structureborne noise and vibration levels were made using the limited information available at the time.
- It is unlikely that a highly resilient baseplate system (such as Delkor Cologne Egg) will be suitable to achieve the nominated criteria.
- Suitable trackform options included Pandrol Vanguard, Sonneville HALVT, Isolated Slab Track (IST), and Floating Slab Track (FST). Any of these systems, when designed correctly, would ensure that structureborne noise and vibration criteria would be achieved.

This assessment should be reviewed in future stages of the CPRP to ensure the assumptions align with the project design parameters.

9.3.1 Vibration impacts associated with development above the Goulburn Street carpark

The Goulburn Street site/sub-precinct is a site that is already included in the B8 Metropolitan Centre Zone and which has an established height and FSR controls under the SLEP 2012. These existing planning controls already determined indicate that the site is appropriate for redevelopment in the future. The SSP Study will result in some amendments to the height and FSR provision relating to the site, but does not seek to change anything with regards to its land use permissibility. This part of the SSP precinct is therefore different to the rest of the precinct, which is currently zoned SP2 Infrastructure. On this basis it is considered unnecessary to have a noise and vibration analysis for this part of the precinct in order to inform a rezoning proposal. The SSP study does not seek to amend land use permissibility rights that already exist on the site. As with all sites within the Precinct, a detailed Noise and Vibration impact assessment will be required to support any future development application.

9.4 Future Work

We recommend that the following work be conducted in future stages of the project.

1. **Update ambient noise study** – this should be conducted once traffic noise levels return to normal (pre-COVID-19 levels) and construction noise impacts from Sydney Metro works have subsided.
2. **Update road and rail noise impacts** – this should be conducted if traffic volumes are revised and amended. Future traffic volumes have been considered for the year 2036, however these volumes may require to be updated as the project progresses.
3. **Prepare a site wide Construction Noise and Vibration Assessment** – this should be conducted once further information staging, structural specifics, and buildability become available. Outcomes of this will inform assessments of individual buildings when progressing through future approval stages.
4. **Update vibration assessment** – this should be done as the structural design for the precinct progresses. A full dynamic FEA model demonstrating compliance with the previously identified criteria should be considered.
5. **Update assessment of mechanical noise emissions** – as discussed in this report, there was limited information available to conduct our assessment. This should be updated as the design progresses.
6. **Prepare a site wide precinct plan to address noise produced by retail and licensed premises** – this plan should be prepared to guide the application and approval of licensed premises and retail venues within the precinct to ensure all uses can co-exist. This should be done once tenancy uses have been confirmed and enough architectural detail exists.
7. **Prepare an assessment of the proposed childcare centre** – this should be done once design details such as capacity, architectural layouts, etc become available.
8. **Site wide monitoring program** – prior to any work commencing on site, a site wide noise and vibration monitoring program should be considered. The purpose of this is to continuously monitor noise and vibration levels during the construction period. A similar system is currently in place for the Sydney Metro works.

It may be prudent to consolidate two or more of these recommendations in an acoustic design guide, to be used by future developers and design staff.

The standards identified in **Section 4** and **Section 6.1** should continue to be used in combination with the ambient noise levels identified in **Section 2.1** for future assessments.

10. Conclusions

This report provides a high-level summary of key acoustic issues that may potentially impact the development.

The results and recommendations for each issue is discussed in the following sections.

10.1 Road and rail Noise Intrusion

A detailed acoustic model of the surrounding road and rail systems has been developed. This has been based on road and rail traffic volumes and operational statistics supplied by the project team. The model was used to predict noise levels at the façade of each proposed building. Based on internal noise criteria developed from relevant guidelines and standards, indicative acoustic performance of façade elements was determined for each building.

Our study concluded that the required performance can be achieved using standard construction techniques and relevant internal noise criteria will be achieved.

Road and rail noise ingress should be considered during the detail design phase of each building.

10.2 Vibration impacts from Sydney Yard and adjacent suburban network

A detailed assessment of vibration impacts associated with the proposed Sydney Yard upgrade works has been conducted during a previous stage of the project. This study concluded that a high attenuation trackform will be required to mitigate vibration impacts on the buildings above.

We have confirmed that the assumptions and modelling conducted during that previous assessment are still aligned with the current design. No further mitigation beyond the previous recommendations is required.

10.3 Noise emission to surrounding receivers

The primary source of noise emissions will be mechanical services associated with the development. A high-level assessment based on indicated plant layout, typical selections, and typical sound power levels has been conducted. Noise levels at the most impacted receivers surrounding the site have been predicted and shown to comply with relevant noise guidelines.

Based on the assessment performed, there are no specific mitigation measures identified at this stage of the project. However, typical noise control techniques such as lined ductwork, attenuators, barriers, etc (all part of standard mechanical services design practice) may be required as the design progresses.

Further assessment of mechanical noise emission should be conducted during the detail design phase of each building.

References

- City of Sydney Development Control Plan 2012, City of Sydney, 2012
- NSW Noise Policy for Industry (NPfI), NSW EPA, 2017
- AS/NZS 2107:2016 Recommended Design Sound Levels and Reverberation Times for Building Interiors
- Development Near Rail Corridors and Busy Roads - Interim Guideline (iSEPP), NSW Department of Planning and Environment, 2008
- British Standard BS 7385 Part 2, 1993
- Australian Standard AS 2670.2 1990, Evaluation of human exposure to whole-body vibration - Continuous and shock-induced vibration in buildings (1 to 80 Hz)
- Assessing Vibration - A technical guideline, DEC, 2006
- British Standard BS 6472:1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)"
- The Guidelines for Councils - Consideration of Rail Noise and Vibration in the Planning Process, Rail Corporation New South Wales, 2003
- Calculation of Road Traffic Noise, UK Department of Transport, 1988
- Road Traffic Noise - Interim Traffic Noise Policy, Roads and Traffic Authority, 1992
- Model Validation Guideline, Roads and Maritime Services, 2018
- Protection of the Environment Operations Act 1997, NSW Legislation
- NSW EPA Industrial Noise Policy, NSW EPA, 2017
- Australian Standard AS1055.1997 Acoustics – Description and measurement of environmental noise, 1997
- Interim Construction Noise Guideline, DECC, 2009
- DIN 4150-3:2016-12: Vibration in Buildings - Part 3: Effects On Structures, 1999

Appendix A – Line of sight

The line of sight table below presents a high level review of acoustic issues including the aspirational goals and solutions recommended for each issue.

Table A1: High level review of acoustic issues

Issue	Aspirations	Solutions
Potential Noise impacts from road, rail, and other sources on the development.	That internal noise levels and criteria for other spaces meet relevant guidelines and standards.	Glazing and other relevant building elements should be specified to ensure appropriate criteria are achieved. The performance required is achievable with conventional materials and components. This should be addressed during the detailed design of each building.
Potential rail vibration impacts on the development from active intercity terminal below and nearby suburban lines.	That groundborne/structureborne noise and vibration criteria meet relevant guidelines.	Trackform has been designed to incorporate required vibration attenuation.
Mechanical services noise emissions to external receivers.	That mechanical noise levels meet the criteria determined in accordance with the Noise Policy for Industry and other planning requirements.	Noise from mechanical services will be able to meet the required criteria utilising conventional noise mitigation measures such as attenuators, barriers, acoustic louvres, etc. Noise from Mechanical Services should be reviewed during the detailed design of each building.

Appendix B – Evidence of consultation

Stakeholder	Department of Planning and Environment (NSW)
Title	TfNSW consultation with DPIE on Safety and security, noise and vibration, pollution and Daylight, sky view and solar access at Central Station
Participants	Andrew McWhinney (IR), Ben Waldner (IR), Hugh Thornton (TfNSW), Peter Rand (Arcadis), Tim Carr (Arup), Rebecca Cadorin (Arup), Ben Lawrence (RWDI), Jemma Basso (Architectus), Greg Burgon (Architectus), David Atwood (Ethos Urban) DPE invitees: Elizabeth Bowra, Caroline Butler-Bowdon, Fiona Morrison, Daniel Stace, Drew Pinazza
Date / Time	Monday, 14 February 2022 9:30 AM-11:00 AM
Summary	Key issues addressed in this report were discussed, including scope for future work. No major concerns were raised with regard to noise and vibration aspects.

Stakeholder	City of Sydney Council
Title	Central Station SSP - Technical study consultation - Pollution & noise and vibration
Participants	James Dirickx-Jones (CoS), Paul Stokes (CoS), Andrew McMillan (CoS), Niamh Hynes (CoS), Hugh Thornton (TfNSW), Peter Rand (Arcadis) Melanie Gostelow (Arcadis), Ben Lawrence (RWDI), Matthew Di Maggio (Ethos Urban), Kimberly Bautista (Ethos Urban), Tim Carr (Arup), Rebecca Cadorin (Arup)
Date / Time	Monday, 4 April 2022 1:00 PM-2:00 PM
Summary	City of Sydney suggested further discussions about technical details. Construction noise and vibration to be addressed in the report, at a high level as discussed in Section 8.2 of this report Future noise from licensed premises was discussed along with other topics discussed in Section 9.4.

Stakeholder	NSW Environment Protection Authority
Title	Central State Significant Precinct introductory call
Participants	Lauren Musgrave (EPA), Jacqueline Pulkkinen (EPA), Anthony Knox (EPA), Peter Rand (Arcadis), Melanie Gostelow (Arcadis), Ben Lawrence (RWDI), Paul Stoller (Atelier Ten), Matthew di Maggio (EU), Colin Sargent (TfNSW), Rebecca Cadorin (ARUP), Hugh Thornton (TfNSW), Tim Carr (ARUP)
Date / Time	Wednesday, 6 April 2022 11:30 AM-12:00 PM
Summary	High-level meeting describing the key noise issues discussed in this report. EPA generally supportive of RWDI's approach, but wanted to explore more details about physical and functional aspect of the project before commenting further.

Appendix C – Central Station Force Density Measurements and Analysis

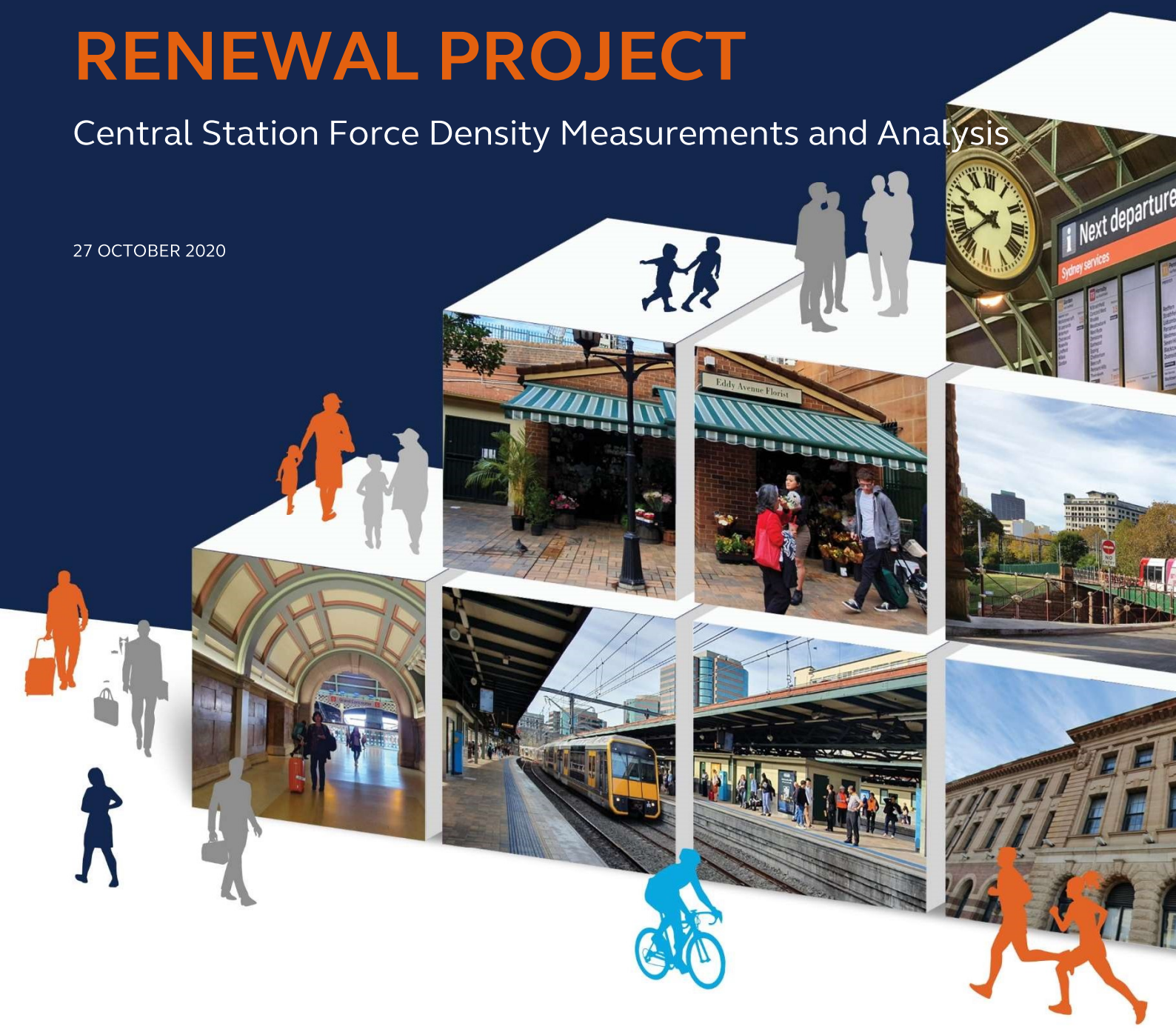
NSW GOVERNMENT | Transport for NSW

ARCADIS | Design & Consultancy for natural and built assets

CENTRAL PRECINCT RENEWAL PROJECT

Central Station Force Density Measurements and Analysis

27 OCTOBER 2020



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TRANSPORT FOR NSW
CENTRAL PRECINCTS RENEWAL PROJECT

Central Station Force Density Measurements and Analysis

Report

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Approver	Jonathan Davies	

Report No	CPRP025-ADAP-CEN-NV-RPT-000001
Date	27/10/2020
Revision Text	A

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REVISIONS

Revision	Date	Description	Prepared by	Approved by
A	27 Oct 2020	Draft for initial comment	Ben Lawrence	John Merrick

CONTENTS

APPENDICES

1 INTRODUCTION

The Central Precinct Renewal Project (CPRP) represents the revitalisation of one of the cornerstones of Sydney's transport infrastructure. As part of this project, a deck is proposed over Sydney yard. This will support over station development and activation of this space.

To ensure noise and vibration of passing trains do not interfere with the use of this space, a detailed structureborne noise and vibration assessment will be conducted. As an input to this assessment, it is necessary to determine the vibration output from intercity trains passing underneath the deck. This will enable us to refine our predicted structureborne noise levels in the proposed development above deck.

This report details those measurements and provides updated predicted structureborne noise levels at receivers above deck.

2 SITE DESCRIPTION

Activation of the space above Sydney yard will be achieved through construction of a deck structure above. This will enable Sydney yard to operate at increase capacity whilst supporting various medium and high-rise development above.

The approximate extent of the proposed deck is shown below in Figure 2-1.

Figure 2-1 Proposed Deck Extents

A three-dimensional view looking north showing the proposed development above the deck is presented in Figure 2-2 below.

Figure 2-2 Example of Proposed Medium and High Rise Development above Deck

Given that trains will typically run at speeds up to 60 km/h below the deck structure, up to 75km/h at the southern-most end. The purpose of this assessment is to ensure structureborne noise levels do not exceed appropriate criteria.

3 CRITERIA

Given the early stage of this project, no formal criteria for this development have been set. Land uses within development will be mainly commercial office space and two hotels. The following table details recommended criteria for similar projects and relevant guidelines.

Table 3-1 Review of Appropriate Criteria

Guideline/Project	Criteria	Applies to
NSW EPA Rail Infrastructure Noise Guideline (2013)	40 to 45dBA, $L_{AMax,slow,}$95%	Schools, educational institutions, places of worship. **NO CRITERIA FOR OFFICES/COMMERCIAL DEVLELOPMENTS**
	Daytime: 40dBA, $L_{AMax,slow,95\%}$ Night time: 35dBA, $L_{AMax,slow,95\%}$	Residential developments
Crossrail, UK	40dBA, $L_{AMax,slow}$	Residential buildings, Offices, Hotels, Schools, Colleges, Hospitals, Laboratories, Libraries
Sydney Metro (Northwest and CBD)	40dBA, $L_{AMax,slow,95\%}$	Commercial receivers with private offices or conference rooms

For this project, and on the basis of the above precedents, we have adopted a criteria of 40dBA, $L_{AMax,slow,95\%}$ for this project.

4 MEASUREMENT PROCEDURE

4.1 General Procedure

This report details the measurement of force density levels (FDL) for each train pass by. This is an objective measurement of vibration output from a given train, independent of the response from the surrounding ground or structure. This measurement is transferable to the proposed structural scenario for this project and used the prediction of structureborne noise levels within development above deck.

This approach is consistent with the USA Department of Transport “Transit Noise & Vibration Impact Assessment Handbook” (published by the Federal Transit Administration which forms part of the Department of Transport). The handbook is commonly referred to as the FTA Report.

Measurements were conducted at the southern end of Platforms 2 and 3 and 8 and 9 during the following times:

- Platforms 8 & 9: 12am to 10am, Wednesday 26 August 2020
- Platforms 2 & 3: 12am to 11am, Thursday 27 August 2020

The measurement of force density involved two distinct operations:

1. measurement of transfer mobility; and
2. measurement of vibration levels from passing trains.

These are discussed in the following sections. From these two operations, results are numerically combined to determine the force density for each train movement.

4.2 Measurement of Transfer Mobility

Transfer mobility is the ratio of output vibration velocity at the measurement point on the platform to the input force applied at track level. This is measured by using an instrumented hammer to apply the force and measuring the output vibration impulse using accelerometers. This measurement accounts for the acoustic response of the ground and platform structure. All instruments are connected to the same analyser allowing the direct measurement of point source transfer mobility. The measurement arrangement is shown in the following two figures.

Figure 4-1 Section showing Transducer Locations

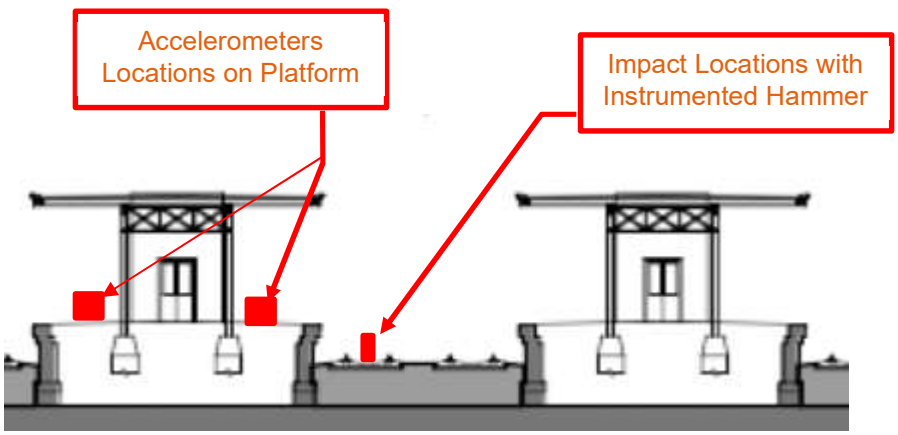
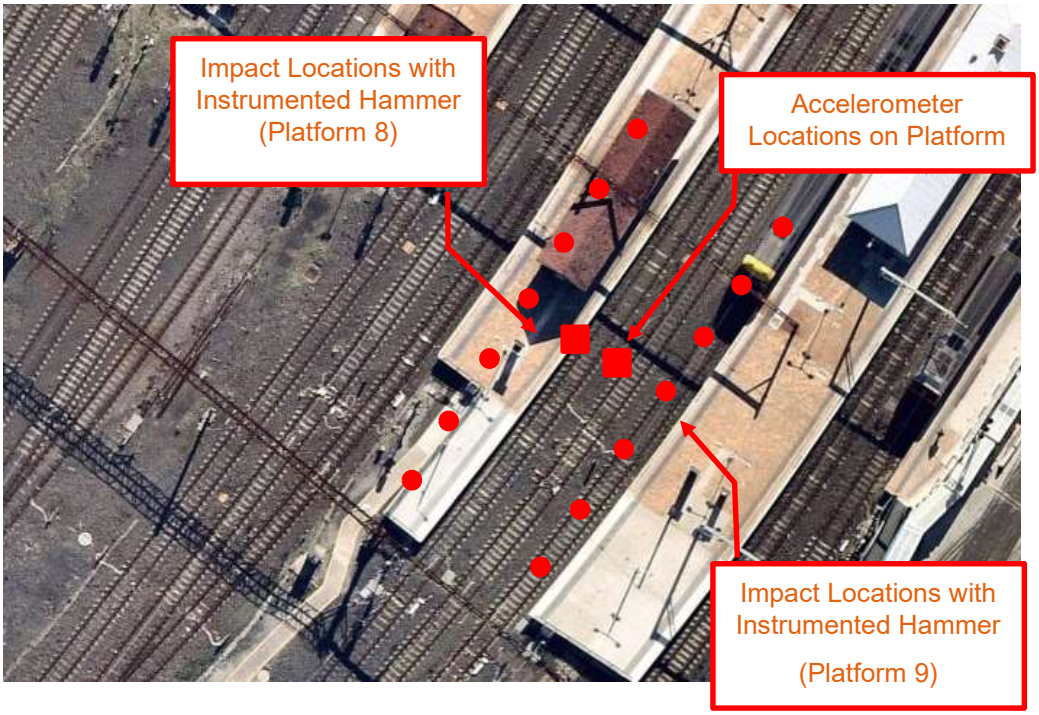


Figure 4-2 *Plan showing Hammer Impact Locations and Accelerometer Locations (Platforms 8 and 9)*



All measurements were conducted during a nightly shutdown. A series of impacts are made using the instrumented hammer midspan on sleepers. The hammer is rubber tipped and will not damage the sleeper. At each position, 10 impacts are measured (both force and resulting vibration) and averaged. Impacts are measured at positions perpendicular to and 5m, 10m, 15m, 20m, 30m, 40m, and 50m offset in either direction on each track.

All transfer mobility measurements are conducted during a nightly shutdown to have a minimal impact on station and rail operations. Ambient vibration levels will be at their lowest during this time. Once all impacts are complete, no further work is required on track or in the danger zone.

4.3 Measurement of Vibration Levels

Once transfer mobility measurements were complete, the hammer and associated cabling was no longer required. The accelerometers and analyser were left in place to measure vibration levels for the following days running.

As the train approaches or departs, the measurement captured vibration levels during the entire train pass by. Once these measurements concluded, all equipment was removed.

4.4 Instrumentation

There were four main instruments used for these measurements:

1. Endevco 2304 instrumented hammer;
2. Wilcoxon 731-207 accelerometer (2); and
3. Brüel & Kjær PULSE 3560C signal recorder/analyser.

The instrumented hammer is shown in use in the following figure. The hammer is rubber tipped and did not damage the sleeper in any way.

Figure 4-3 Instrumented Hammer

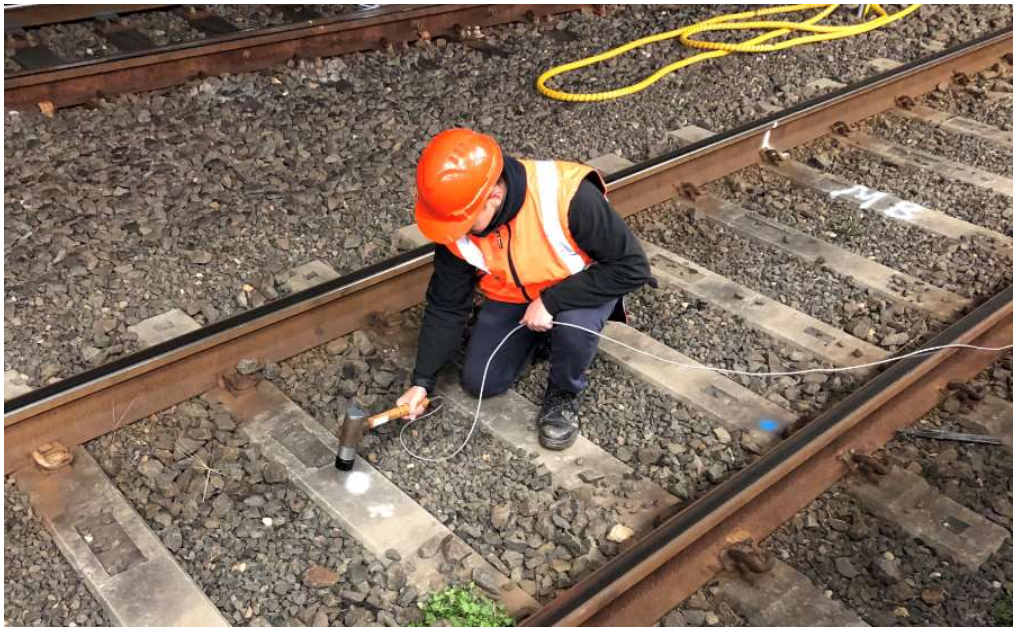
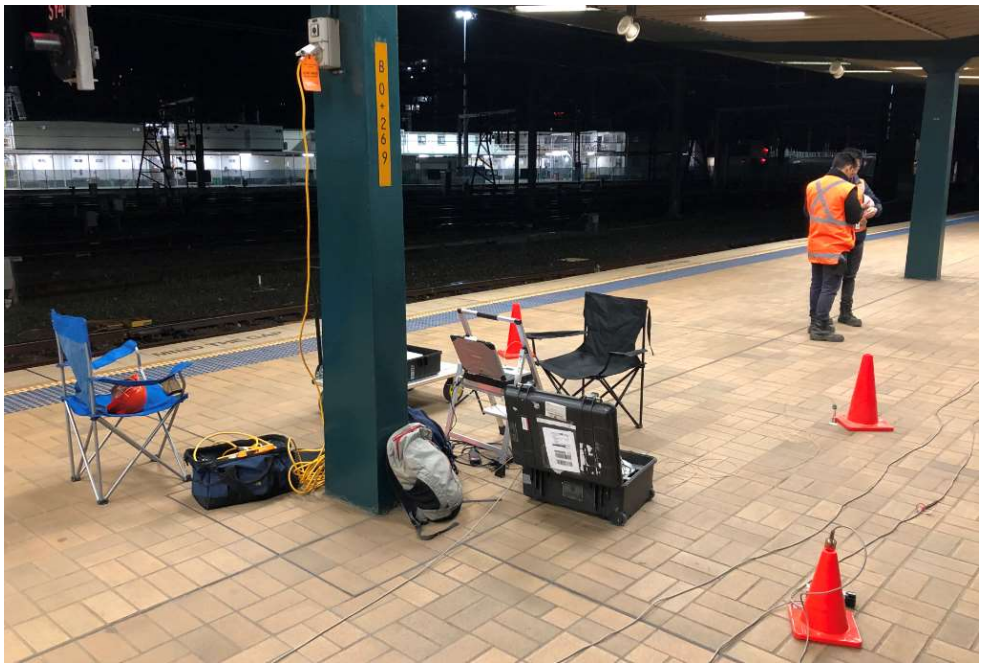


Figure 4-4 below shows a typical accelerometer mounting arrangement. A small cement stud Mount is temporarily glued to the platform surface. This couples the accelerometer firmly to the platform for the duration of our measurements. Once the measurements are concluded, the accelerometer and mount are removed leaving no damage to the surface.

Figure 4-4 Typical Accelerometer Mounting Arrangement

The overall measurement setup is shown in Figure 4-5 below.

Figure 4-5 Pelican Case containing Analyser (Platforms 2 and 3)

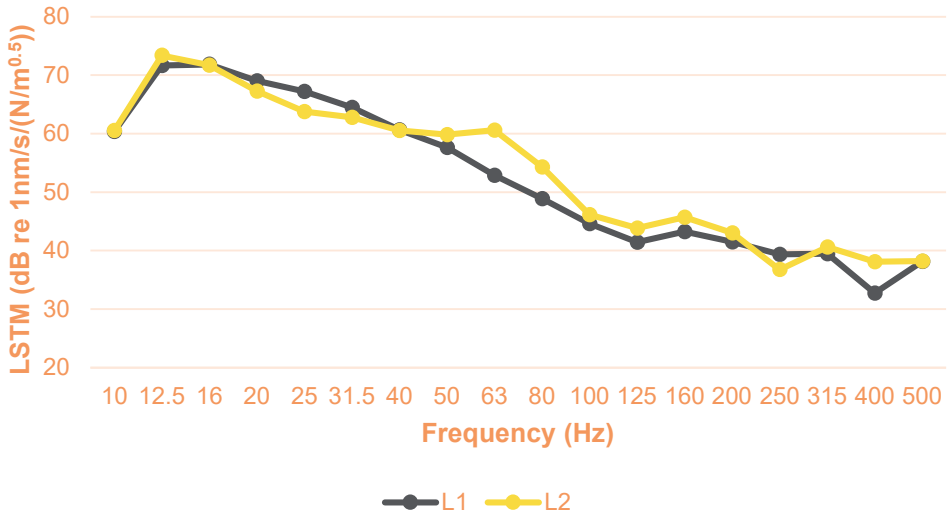


5 MEASUREMENT RESULTS

5.1 Transfer Mobility Measurements

Point Source Transfer Mobility (PSTM) measurements were combined to determine the Line Source Transfer Mobility (LSTM) as defined in the FTA report. Typical line source transfer mobility spectra between the rail line and each accelerometer position are shown in the following figures.

Figure 5-1 LSTM (Platform Road 8 to Accelerometers L2 and L1)



5.2 Force Density Levels

Octave band force density levels measured for each train pass by are presented in Appendix A. The levels presented are consistent with those measured elsewhere across the Sydney trains network when accounting for variations in speed. This exercise has been very useful, confirming the FDLs across a range of speeds and rollingstock.

It is useful to note that the first train measured on Platform 2 was one of the new intercity fleet currently under trials across the network. This train type will be in service and will eventually replace older train types for intercity duties. Although only two pass bys were measured, these were consistent with FDLs for other modern rolling stock types. There was no evidence to suggest that these sets created more or less vibration than the other trains measured.

5.3 Updated Structureborne Noise Level Predictions

Wilkinson Murray have previously conducted a preliminary analysis of structureborne noise levels affecting commercial development above deck. Modelling at this point of the project is a series of spreadsheet calculations that follow the procedure set out in the FTA Report. The information gathered from this study was used to update source input information in our model. Structural losses have been assumed based on previous measurements of elevated structures.

The following two tables present the calculated noise levels in typical buildings on the deck above assuming a high attenuation baseplate (such as Delkor Cologne Egg) is used in the design. These have been separated into the two measurement locations (platforms 8 and 9 and platforms 2 and 3).

A speed correction of $20\log(V/V_{ref})$ was applied to the measured data to provide predicted structureborne noise levels at the design speed of 60km/h. Results are presented for the indicated speed and the normalised 60km/h design speed.

Table 5-1 Predicted Structureborne Noise Levels – Platforms 8 and 9

Train No.	Platform	Type	Direction	Speed	Predicted Noise Level (high attenuation baseplate)	
					Indicated Speed	60 km/h
1	8	V set	Departing	25.9	30.3	36.2
2	9	Oscar	Arriving	13.8	23.9	31.9
3	9	Oscar	Departing	30.0	38.2	42.1
4	9	V set	Arriving	14.4	28.4	34.9
5	9	V set	Departing	15.8	28.5	35.0
6	9	Oscar	Arriving	14.0	25.7	33.1
7	8	Tangara	Arriving	12.0	22.4	31.0
8	8	Tangara	Departing	27.6	31.4	37.0
9	9	Oscar	Departing	22.5	34.9	39.6
10	9	Oscar	Arriving	25.5	35.2	39.8
11	9	Oscar	Departing	18.0	26.7	33.7
12	8	Tangara	Arriving	32.0	31.9	37.4
13	9	V set	Arriving	13.9	28.7	35.1
14	8	Tangara	Departing	24.7	29.0	35.3
15	8	Waratah	Arriving	32.9	35.2	39.8
16	9	V set	Departing	22.5	34.4	39.2
17	8	Waratah	Departing	21.9	25.4	32.9
18	8	Tangara	Arriving	30.9	30.8	36.6
19	8	Tangara	Departing	33.9	31.5	37.1
				Max:	**38.2**	**42.1**
				95th percentile:	**35.5**	**40.0**
				Min:	**22.4**	**31.0**

Table 5-2 Predicted Structureborne Noise Levels – Platforms 2 and 3

Train No.	Platform	Type	Direction	Speed	Predicted Noise Level (high attenuation baseplate)	
					Indicated Speed	60 km/h
1	2	NIF	Arriving	15.4	27.4	39.2
2	2	NIF	Departing	16.1	27.6	39.0
3	2	2001	Arriving	20.7	31.4	40.6
4	2	2006	Departing	17.6	33.0	43.7
5	2	Tangara	Arriving	22.1	26.4	35.1
6	2	Tangara	Departing	22.2	26.4	35.1
7	3	2527	Arriving	19.5	29.7	39.4
8	2	V set	Arriving	17.0	29.1	40.0
9	2	V set	Departing	19.3	30.2	40.0
10	2	V set	Arriving	25.0	34.4	42.0
11	2	V set	Departing	15.0	30.8	42.8
12	2	2814	Arriving	13.8	27.3	40.1
13	3	2503	Departing	16.5	28.2	39.4
				Max:	**34.4**	**43.7**
				95th percentile:	**33.6**	**43.2**
				Min:	**26.4**	**35.1**

A safety factor of 3dB is included in the predicted structureborne noise levels presented in the tables above.

Based on the measurements performed and the information available to date, a high attenuation baseplate is unlikely to meet the nominated 40dBA structureborne noise goal for trains operating at the design track speed of 60 km/h.

5.4 Alternative Attenuation Options

Four alternative options for groundborne noise and vibration mitigation have been considered. These are:

- Pandrol Vanguard;
- Sonneville HALVT;
- Isolated Slab Track (IST); and
- Floating Slab Track (FST).

These are discussed further below.

5.4.1 Pandrol Vanguard

This is a different type of fastener that grips the rail by the web rather than the foot as shown in the following figure. This fastener typically offers better performance than a high attenuation baseplate.

Figure 5-2 Pandrol Vanguard

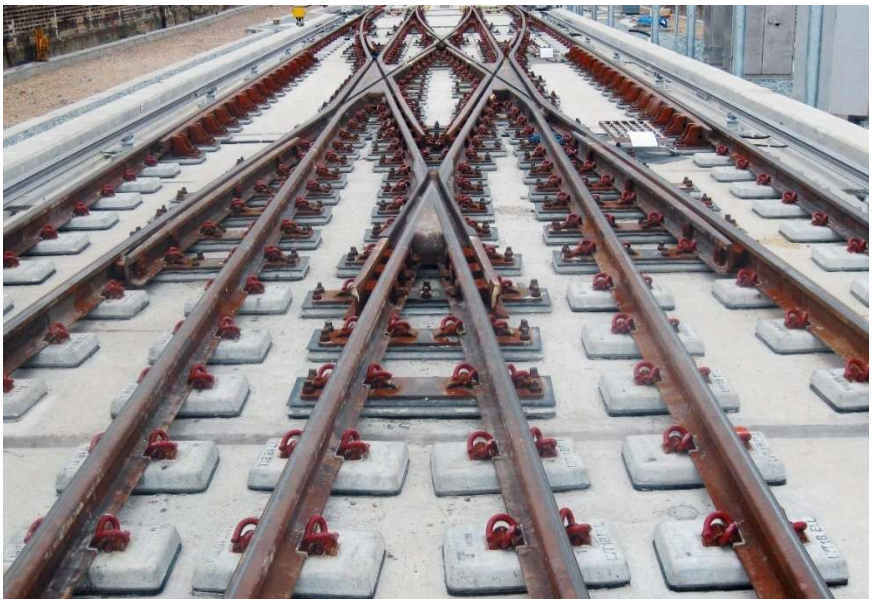
One potential downside is that we are not aware of a variant for turnouts, of which there will be some for this project. This means that an alternative is required in these areas.

These fasteners were used successfully on the Perth Urban Rail Development and New MetroRail (Perth) projects. There have been many installations of this system overseas in the last 20 years. These include the London Underground, Rome Metro, and MTR (Hong Kong).

5.4.2 Sonneville HALVT

This a high attenuation version of the standard Sonneville booted block system. Blocks are physically larger and incorporate a softer boot.

Figure 5-3 Sonneville HALVT



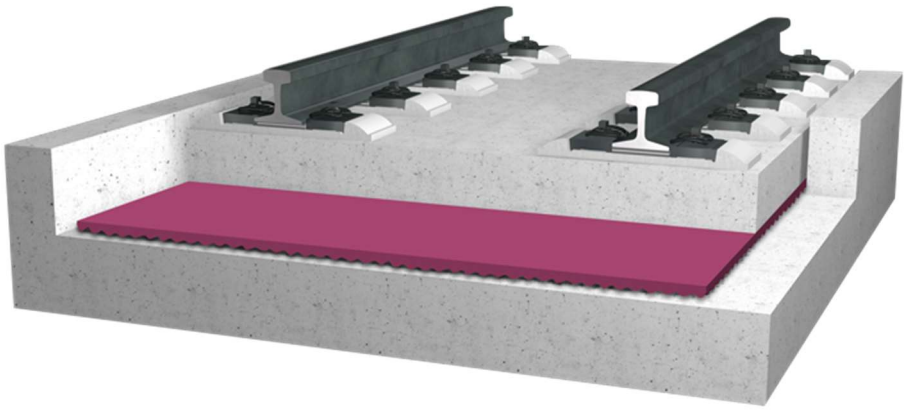
It should be noted that we have limited test data on this system dating back to 2002. We understand that this system has been used in many installations since that time and the design has likely been further refined. Better test data may result in lower predicted noise levels than those shown in this report.

This system has been successfully used in the Cross City Link (Zurich), Canal Tunnel (London), and CityTunnel Malmo (Sweden).

5.4.3 Isolated Slab Track

This term is given to track constructions that are suspended on a continuous layer of resilient under ballast mat.

Figure 5-4 Isolated Slab Track



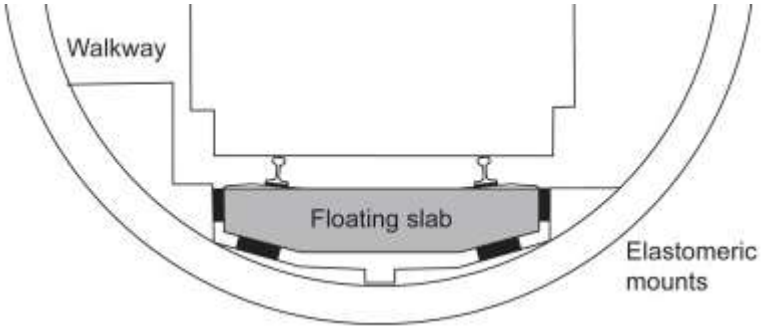
This system has been used in numerous projects around the world, including the Sydney Light Rail below the Casino. Whilst it offers good acoustic performance, this can be tricky to build correctly. Any concrete leak when pouring the isolated invert slab can 'bridge' the isolation and negate the benefit of the system. Drainage is an important issue as this can have the same affect in the ballast mat becomes waterlogged. If something goes wrong with this system, it's hard to rectify without major construction work.

The acoustic performance can be 'tuned' by varying the mass of the isolated invert slab and stiffness of the mat.

5.4.4 Floating Slab Track

Similar to IST above, Floating Slab Track suspends a concrete invert slab on discrete rubber bearings. This has better performance than IST and can be tuned according to the required insertion loss. Very high attenuation versions of this design can incorporate steel springs.

Figure 5-5 Floating Slab Track



It is possible to design this system so that pads can be easily inspected or exchanged if necessary. Drainage is more easily accomplished and maintained. Floating sections can be either cast in-situ or take advantage of a precast design. The downside to these systems is they are usually the most expensive.

5.4.5 Acoustic Performance

A similar analysis to that discussed in Section 5.3 above has been conducted for each of these options. The results of this is presented in the table below (compared to the high attenuation baseplate option) for comparison. Note that insertion losses assumed for all systems are indicative only. Insertion losses for IST and FST can be 'tuned' up or down depending on final requirements.

Table 5-3 Predicted Noise Levels, 60km/h

Option	Platforms 8 & 9	Platforms 2 & 3
High Attenuation Baseplate (Delkor Cologne Egg)	40.0	43.2
Pandrol Vanguard	36.9	39.0
Sonneville HALVT (10kN/mm)	39.3	43.8
Isolated Slab Track	32.6	32.7
Floating Slab Track	31.0	29.5

Based on this information, it's possible that Pandrol Vanguard could be made to work with further refinement. IST and FST are likely to achieve the required acoustic performance.

IST should be a feasible solution over the Metro Box within the constraints discussed in this report. In other areas, Pandrol Vanguard, IST, and FST should be appropriate.

5.5 Further Consideration

There are pros and cons associated with any option selected. These should be carefully considered as the design progresses. These include:

- Reaction of braking and other forces;
- Increased wheel/rail wear;
- Increased noise levels on the platforms; and
- Cost.

Current assumptions that may require further consideration include:

- The analysis is based upon existing rollingstock that will eventually be phased out. Newer rollingstock may require further consideration.
- We have assumed an equivalent rail head condition. No allowance has been made for any undue rail corrugation or additional roughness associated with higher braking forces and speeds.
- Structural transmission losses have been assumed based on measurements of similar structures. As the structural design is developed and details become available, we recommend moving to a dynamic Finite Element Model to determine this more accurately.
- We have assumed a speed of 60km/h in line with the current design.
- IST and FST systems are yet to undergo full detailed design. Typical insertion losses have been assumed for these trackforms.

We recommend that these predictions are reviewed and updated as the design is refined in future stages.

6 CONCLUSION

Wilkinson Murray have conducted a detailed noise and vibration survey to determine the Force Density Levels (FDLs) produced by existing intercity and regional fleets arriving at Central Station. The detailed series of point source transfer mobility and pass by measurements were conducted to calculate these.

We were able to confirm that measured FDLs were consistent with other similar measurements across the Sydney network once train speed was accounted for. Further useful information of the speed relationship was obtained from speeds as low as 15 km/h.

Structureborne noise predictions to commercial development above deck were updated based on the information obtained. Based on these calculations, it is unlikely that a highly resilient baseplate (such as a Delkor Cologne Egg) will be suitable to achieve the nominated 40dBA limit for structureborne noise.

To meet with the structureborne noise limits, the options are:

1. For the area directly above the new Sydney Metro Central Station box, the isolated slab track (IST) system is a feasible option noting this system has specific construction and maintenance requirement discussed in this report
2. For the remainder of the track, the feasible options include:
    - Pandrol Vanguard
    - IST (isolated slab track) and
    - FFST (floating slab track)

To develop these options, further engineering design is required based upon such key inputs as:

- Design information of the future rolling stock i.e. braking curves
- Rail head condition assessments i.e. griding
- Design interface with the slab track structure using finite element modelling to increase the level of accuracy of the structureborne noise
- Capital cost assessments
- Operational maintenance requirements

APPENDIX A – GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise and vibration which continuously varies. To describe the overall environment, a number of noise and vibration descriptors have been developed and these involve statistical and other analysis of the varying noise. These noise and vibration descriptors are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast or slow response, during the sample period.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

Vibration Velocity – The amplitude of the vibration, expressed as a velocity. This is often determined by integrating an acceleration signal. Units are usually expressed in decibels relative to a reference level of 1nm/s (10-9m/s).

Frequency Response Function - The quantitative measure of the output spectrum of a system or device in response to a stimulus and is used to characterize the dynamics of the system.

Point Source Transfer Mobility (PSTM) – A mathematical relationship describing the ratio of point source input (usually force) to vibration output.

Line Source Transfer Mobility (LSTM) – A mathematical relationship describing the ratio of an incoherent line source input (usually force density) to vibration output.

APPENDIX B – FORCE DENSITY LEVEL RESULTS

Force Density Levels - Platforms 2 and 3

Speed as Indicated

Train Number	Platform	Type	Direction	Speed	Force Density Level (dB re 1N/m$^{0.5}$)																	
					10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500
1	8	V set	Departing	25.9	15.7	16.2	21.7	24.8	25.1	25.3	27.2	34.5	35.4	35.1	38.6	31.6	43.1	32.0	34.0	30.4	24.8	22.4
2	9	Oscar	Arriving	13.8	13.5	10.6	19.8	14.6	17.7	22.4	19.1	23.9	25.8	29.8	37.1	25.3	31.1	24.7	19.5	18.3	11.7	11.4
3	9	Oscar	Departing	30.0	18.9	17.4	19.6	20.7	22.7	25.6	28.7	32.5	36.7	50.0	50.6	38.4	43.5	41.4	32.7	30.0	24.3	24.0
4	9	V set	Arriving	14.4	15.4	16.2	20.6	18.7	21.9	28.6	23.3	25.8	26.0	33.9	42.7	28.2	30.0	27.0	20.3	17.6	13.8	14.4
5	9	V set	Departing	15.8	13.6	16.3	24.1	25.1	26.5	29.7	31.4	35.5	34.7	39.7	38.7	32.5	35.5	30.2	26.8	23.2	14.9	14.4
6	9	Oscar	Arriving	14.0	22.3	15.4	18.2	18.4	21.2	24.9	25.6	27.2	32.4	35.0	39.2	25.7	27.5	21.7	16.2	14.9	10.8	10.8
7	8	Tangara	Arriving	12.0	18.9	11.1	12.1	22.3	26.7	25.9	30.1	34.6	31.7	29.1	28.1	28.3	27.9	22.9	29.8	22.2	21.8	13.8
8	8	Tangara	Departing	27.6	20.2	14.4	16.8	19.5	27.1	27.3	37.4	45.0	39.2	37.8	39.5	34.0	32.3	26.6	32.6	24.1	23.0	17.9
9	9	Oscar	Departing	22.5	18.9	16.9	22.1	21.3	23.9	27.1	25.0	34.8	32.5	44.8	48.4	33.2	38.8	34.5	27.5	24.8	17.5	17.7
10	9	Oscar	Arriving	25.5	19.7	20.9	16.3	19.9	28.0	28.1	24.5	35.5	38.5	43.6	48.8	33.7	38.4	35.5	31.5	30.4	22.4	21.1
11	9	Oscar	Departing	18.0	16.4	18.5	21.5	19.6	20.4	22.6	19.1	24.2	28.2	35.8	40.2	28.4	27.8	27.5	25.8	20.1	13.9	13.3
12	8	Tangara	Arriving	32.0	24.3	20.2	19.4	20.9	24.9	24.7	30.4	38.2	39.5	36.8	40.3	39.0	42.0	35.9	39.0	35.3	31.3	24.1
13	9	V set	Arriving	13.9	14.2	17.7	21.5	23.9	22.8	28.4	27.2	26.6	28.9	38.4	41.5	32.6	32.6	33.5	28.9	28.9	22.7	28.2
14	8	Tangara	Departing	24.7	17.6	14.3	15.9	24.1	25.6	30.6	35.7	42.3	38.0	37.3	35.6	31.7	30.5	28.3	31.5	24.7	25.2	19.0
15	8	Waratah	Arriving	32.9	28.5	22.6	21.4	26.9	33.1	34.4	37.9	42.0	41.0	34.8	40.3	44.6	44.2	41.3	46.2	38.0	38.9	30.3
16	9	V set	Departing	22.5	17.2	16.7	24.3	25.4	28.0	27.1	29.2	30.4	35.4	41.2	47.5	40.8	37.2	37.2	33.3	29.1	22.3	24.4
17	8	Waratah	Departing	21.9	18.3	18.2	19.3	20.6	23.2	23.7	32.5	38.8	39.2	29.6	30.6	27.2	24.9	21.7	20.3	13.3	15.7	10.6
18	8	Tangara	Arriving	30.9	25.6	20.4	21.1	26.3	29.1	30.5	37.7	42.7	41.3	40.4	38.9	34.9	31.0	29.1	30.4	27.6	28.8	23.8
19	8	Tangara	Departing	33.9	23.4	22.9	25.8	28.7	28.8	38.1	40.0	45.3	42.8	36.3	37.3	33.1	30.6	29.4	33.5	30.4	31.0	23.8

Speed Corrected to 60km/h

Train Number	Platform	Type	Direction	Speed	Force Density Level (dB re 1N/m$^{0.5}$)																	
					10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500
1	8	V set	Departing	25.9	23.0	23.5	29.0	32.1	32.4	32.6	34.5	41.8	42.7	42.4	46.0	38.9	50.4	39.3	41.3	37.7	32.1	29.7
2	9	Oscar	Arriving	13.8	26.3	23.4	32.6	27.4	30.5	35.2	31.9	36.7	38.5	42.5	49.9	38.1	43.9	37.4	32.2	31.1	24.4	24.2
3	9	Oscar	Departing	30.0	24.9	23.4	25.6	26.7	28.7	31.6	34.7	38.5	42.7	56.0	56.7	44.4	49.5	47.4	38.7	36.1	30.3	30.1
4	9	V set	Arriving	14.4	27.7	28.6	33.0	31.1	34.2	40.9	35.6	38.2	38.4	46.3	55.0	40.6	42.4	39.3	32.7	30.0	26.1	26.8
5	9	V set	Departing	15.8	25.2	27.9	35.7	36.7	38.1	41.3	43.0	47.1	46.2	51.3	50.3	44.1	47.1	41.8	38.4	34.8	26.5	26.0
6	9	Oscar	Arriving	14.0	34.9	28.0	30.8	31.0	33.8	37.5	38.2	39.8	45.1	47.6	51.8	38.3	40.1	34.3	28.8	27.5	23.5	23.4
7	8	Tangara	Arriving	12.0	32.9	25.1	26.0	36.3	40.7	39.9	44.0	48.5	45.7	43.1	42.0	42.2	41.9	36.8	43.8	36.1	35.7	27.8
8	8	Tangara	Departing	27.6	26.9	21.2	23.5	26.2	33.9	34.0	44.2	51.7	45.9	44.5	46.2	40.8	39.0	33.4	39.3	30.8	29.8	24.7
9	9	Oscar	Departing	22.5	27.4	25.5	30.6	29.8	32.4	35.6	33.5	43.3	41.1	53.4	56.9	41.7	47.3	43.0	36.0	33.3	26.0	26.2
10	9	Oscar	Arriving	25.5	27.1	28.4	23.7	27.3	35.4	35.6	31.9	42.9	46.0	51.0	56.3	41.2	45.9	42.9	39.0	37.9	29.9	28.6
11	9	Oscar	Departing	18.0	26.9	29.0	31.9	30.0	30.8	33.0	29.6	34.7	38.6	46.2	50.7	38.8	38.3	38.0	36.2	30.5	24.4	23.8
12	8	Tangara	Arriving	32.0	29.7	25.6	24.8	26.3	30.3	30.1	35.9	43.7	45.0	42.2	45.8	44.5	47.4	41.4	44.4	40.8	36.7	29.5
13	9	V set	Arriving	13.9	26.9	30.4	34.2	36.6	35.5	41.1	39.9	39.3	41.6	51.1	54.2	45.3	45.3	46.2	41.6	41.6	35.4	40.9
14	8	Tangara	Departing	24.7	25.3	22.0	23.6	31.8	33.3	38.3	43.4	50.0	45.7	45.0	43.4	39.5	38.2	36.1	39.3	32.4	32.9	26.7
15	8	Waratah	Arriving	32.9	33.7	27.9	26.6	32.1	38.3	39.6	43.1	47.2	46.2	40.1	45.5	49.8	49.4	46.5	51.4	43.2	44.1	35.6
16	9	V set	Departing	22.5	25.7	25.2	32.9	33.9	36.5	35.6	37.8	38.9	43.9	49.7	56.0	49.3	45.8	45.7	41.9	37.6	30.8	33.0
17	8	Waratah	Departing	21.9	27.0	26.9	28.0	29.3	32.0	32.5	41.2	47.5	47.9	38.4	39.3	35.9	33.6	30.4	29.1	22.1	24.5	19.4
18	8	Tangara	Arriving	30.9	31.4	26.2	26.9	32.0	34.9	36.3	43.4	48.5	47.0	46.2	44.7	40.7	36.8	34.8	36.2	33.3	34.5	29.6
19	8	Tangara	Departing	33.9	28.4	27.9	30.8	33.7	33.7	43.0	44.9	50.3	47.8	41.2	42.2	38.0	35.5	34.3	38.5	35.3	36.0	28.8

Force Density Levels - Platforms 2 and 3

Train Number	Platform	Type	Direction	Speed (km/h)	Force Density Level (dB re 1N/m$^{0.5}$)																	
					10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500
1	2	NIF	Arriving	15.4	19.0	18.1	21.0	16.6	20.8	17.8	22.8	26.7	30.0	36.0	38.2	34.0	30.9	37.7	34.7	27.6	23.4	22.4
2	2	NIF	Departing	16.1	9.2	12.2	15.7	17.9	22.4	16.0	22.0	24.4	29.9	35.1	39.9	33.0	30.9	36.1	32.5	29.1	27.2	25.1
3	2	2001	Arriving	20.7	19.4	12.5	18.5	25.0	21.7	22.4	24.5	33.3	37.5	40.9	43.5	35.8	33.3	36.0	38.6	35.9	33.8	37.4
4	2	2006	Departing	17.6	22.6	13.7	13.3	23.4	20.7	18.2	20.0	29.0	35.9	41.7	45.6	39.1	34.5	37.1	39.0	35.9	35.4	36.3
5	2	Tangara	Arriving	22.1	24.2	17.6	18.2	21.5	23.0	24.0	20.7	28.4	34.3	36.2	37.3	32.7	30.7	32.1	33.9	30.8	25.6	23.5
6	2	Tangara	Departing	22.2	15.8	14.3	17.4	21.7	24.7	22.7	19.1	25.7	31.6	36.5	36.3	32.3	31.6	35.6	36.8	31.7	31.5	27.9
7	3	2527	Arriving	19.5	14.2	22.9	21.4	23.3	28.6	20.6	23.7	28.6	30.3	36.4	40.0	38.1	34.6	39.0	37.4	33.3	28.0	25.1
8	2	V set	Arriving	17.0	17.6	16.6	23.7	22.0	24.4	18.6	19.6	27.0	27.5	32.1	41.4	35.5	32.4	39.0	35.6	30.1	27.9	26.1
9	2	V set	Departing	19.3	16.1	17.2	22.3	25.2	28.6	27.1	24.5	25.0	30.3	34.0	37.9	38.6	38.0	42.1	38.0	36.0	32.5	29.4
10	2	V set	Arriving	25.0	20.0	27.6	28.1	25.5	26.1	23.6	25.7	28.4	32.2	37.1	42.6	42.4	41.5	46.9	42.9	41.0	38.4	33.3
11	2	V set	Departing	15.0	13.6	23.1	21.9	20.5	26.5	23.1	24.9	29.8	29.7	34.9	33.8	42.4	39.1	36.4	38.1	34.8	32.0	29.6
12	2	2814	Arriving	13.8	14.3	10.9	18.4	16.5	22.2	19.2	22.4	27.4	30.4	34.2	37.7	36.0	31.9	36.0	34.6	31.6	28.7	28.5
13	3	2503	Departing	16.5	15.9	16.8	15.8	18.9	23.6	22.8	22.7	26.5	29.8	37.7	37.7	35.9	33.8	37.0	37.2	35.3	31.1	30.8

Speed Corrected to 60km/h

Train Number	Platform	Type	Direction	Speed (km/h)	Force Density Level (dB re 1N/m$^{0.5}$)																	
					10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500
1	2	NIF	Arriving	60.0	30.8	29.9	32.8	28.4	32.6	29.6	34.6	38.5	41.8	47.8	50.0	45.8	42.7	49.5	46.5	39.4	35.2	34.2
2	2	NIF	Departing	60.0	20.6	23.7	27.1	29.3	33.8	27.5	33.5	35.8	41.3	46.5	51.4	44.4	42.4	47.5	43.9	40.5	38.6	36.6
3	2	2001	Arriving	60.0	28.7	21.8	27.7	34.3	30.9	31.7	33.8	42.5	46.7	50.2	52.8	45.1	42.6	45.2	47.9	45.1	43.1	46.6
4	2	2006	Departing	60.0	33.2	24.4	24.0	34.0	31.3	28.9	30.7	39.6	46.6	52.3	56.3	49.7	45.1	47.7	49.7	46.6	46.1	46.9
5	2	Tangara	Arriving	60.0	32.8	26.2	26.9	30.2	31.7	32.6	29.4	37.1	43.0	44.9	46.0	41.4	39.4	40.8	42.6	39.5	34.2	32.1
6	2	Tangara	Departing	60.0	24.4	22.9	26.0	30.3	33.4	31.3	27.8	34.3	40.2	45.1	44.9	40.9	40.3	44.2	45.5	40.4	40.1	36.5
7	3	2527	Arriving	60.0	24.0	32.6	31.2	33.0	38.3	30.4	33.4	38.4	40.0	46.2	49.8	47.9	44.4	48.7	47.1	43.1	37.8	34.9
8	2	V set	Arriving	60.0	28.5	27.5	34.6	32.9	35.4	29.5	30.6	37.9	38.4	43.0	52.3	46.4	43.3	49.9	46.5	41.0	38.9	37.0
9	2	V set	Departing	60.0	25.9	27.0	32.1	35.1	38.4	37.0	34.4	34.9	40.2	43.8	47.8	48.5	47.8	52.0	47.8	45.9	42.3	39.3
10	2	V set	Arriving	60.0	27.6	35.2	35.7	33.1	33.7	31.2	33.3	36.0	39.8	44.7	50.2	50.0	49.1	54.5	50.5	48.6	46.0	40.9
11	2	V set	Departing	60.0	25.7	35.1	33.9	32.5	38.6	35.2	36.9	41.8	41.8	46.9	45.8	54.5	51.1	48.4	50.1	46.8	44.0	41.6
12	2	2814	Arriving	60.0	27.0	23.7	31.1	29.2	34.9	31.9	35.1	40.1	43.1	46.9	50.4	48.7	44.6	48.7	47.3	44.3	41.4	41.2
13	3	2503	Departing	60.0	27.1	28.0	27.0	30.1	34.8	34.0	33.9	37.7	41.0	48.9	48.9	47.1	45.0	48.2	48.4	46.5	42.3	42.0

APPENDIX C – TECHNICAL ADVICE NOTE

Technical Advice Notification

Technical Advice No.: (refer Naming Convention)	**PROJ.**	**ORIGINATOR**	**LOCATION**	**DICIP.**	**DOC. TYPE**	**NO.**	**Rev.**	B
	CPRP	**ADAP**	**CEN**	**NV**	**NTS**	**000020**		
Advice Title:	Noise & Vibration Advice						**Date:**	08/11/19
Advice Description:	This TAN advises trackwork types suitable for allowing Central Precinct development to occur into the future							
Prepared By:	Barry Murray						**Company**	ADAP
Issued to:	Transport for New South Wales						**Company**	TFNSW
Associated TAN Numbers:								
List of Attachment(s):	• Preliminary Prediction of Groundborne Noise Levels							

Purpose Of This Advice: (Refer to CRCP PMP QA Process)		
☐	**Category A**	For Reliance/advice for 3rd parties, contractual or cost decisions
☐	**Category B**	For decision making
☒	**Category C**	For information and initial decision making
☐	**Category D**	For information only

Phase Of This Advice

☒ Interim Advice

☐ Urban Structure Plan

☐ Central North Transformation Feasibility/Scoping

Status Of This Advice

☐ Initial Draft

☒ Intermediate Draft

☐ FINAL ISSUE

Authorised Approver Signoff

(Refer to CRCP PMP QA Process)

☐ **Engineering Manager** (Category A)

☒ **Design Manager** (Category B)

☐ **Discipline Lead** (Category C)

☐ **Discipline Lead** (Category D)

Approver Details

Date: 08/11/2019

Approver: John Merrick

Type ☒ Spot Check

☐ Comprehensive

Technical Advice Notification

Details of Advice / Discussion

This TAN provides the submission of the noise and vibration issues relevant to the Central Precinct development.

Rail Engineering & Design Report

A Rail Engineering & Design Report (R1) was prepared by Mott Macdonald in November 2018. This report has been reviewed and, in particular, Appendix C which addresses noise and vibration.

The Rail Engineering & Design Report discusses noise and vibration issues and mitigation in a general sense without providing specific mitigation recommendations. The information provided in this current TAN is consistent with the Rail Engineering & Design Report.

Airborne Noise

All trains entering and leaving Central Station will generate airborne noise which can affect residential, commercial and other development nearby. However, the proposed deck over Platforms 1-14 will provide substantial noise attenuation to above the deck and to the surrounding area. Where required, control of airborne noise can be incorporated into nearby developments. This may take the form of suitable glazing or other architectural elements.

Apart from control of noise transmission into developments in the vicinity of the station, it will also be necessary to control noise levels and acoustic conditions under the deck. This could be achieved by lining some sections of walls and the soffit with acoustically absorbent material.

Vibration and Groundborne Noise

When trains enter and leave Central Station, they will generate vibration within the ground which can transmit up to the deck and to developments supported on the deck, as well as to developments in the surrounding area. Whilst the vibration may possibly be perceptible, it is the groundborne noise generated by this vibration which will have the greatest effect. The best method of controlling groundborne noise is by designing the trackwork to reduce the vibration transmitted to the surrounding area. Whilst it is possible to vibration isolate whole building structures, this approach is more expensive and has greater risk than controlling the vibration at the track.

Since groundborne noise is difficult to control in practice, groundborne noise levels will drive early decisions in relation to noise and vibration.

Preliminary groundborne noise predictions have been made to establish what type of track will provide satisfactory acoustic conditions for buildings on the deck and in the surrounding area. Details of these predictions are attached.

It is concluded that:

- The use of ballasted track will not provide sufficient vibration attenuation, even with ballast mat under the ballast, to allow unimpeded development over the deck and nearby;
- Concrete slab track is the best trackform to allow flexibility of vibration mitigation; and
- Isolated slab track or floating slab track is likely to be required under the deck to provide sufficient vibration control, even if only commercial development occurs over the deck.

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Since isolated slab track is difficult to maintain, floating slab track is the best form of track under the deck. At this stage, it is suggested that costing be based on floating slab track under the deck and low stiffness fastener in the yard.

Deck Construction

The prediction of groundborne noise levels discussed in the attachment and the conclusions regarding trackwork are based on the assumption of a concrete deck construction. If the deck is constructed using steel composite construction involving steel beams with a concrete slab over, vibration and groundborne noise levels expected in buildings on the deck will be slightly higher than discussed above. However, the conclusions regarding trackwork will remain the same.

Noise and Vibration Integration Strategy

Given that a number of contracts are currently being implemented at Central Station, particularly regarding Sydney Metro construction, there will need to be coordination between noise levels generated by those contracts and Central Precinct Renewal Project. This could best be carried out by the preparation of a Noise and Vibration Integration Strategy.

Other Noise and Vibration Issues

New developments to form part of Central Precinct Renewal Project will need to take account of other noise and vibration issues unrelated to Central train operations, such as mechanical noise control. Noise emanating from the developments will need to comply with State Government requirements and the building designs will need to take into account other noise types affecting the area, such as road traffic noise and aircraft noise.

Construction Noise and Vibration

During construction of new trackwork, the deck and other building developments, it will be necessary to manage construction noise and vibration. Procedures are available in NSW for this process and these procedures will need to be adhered to.

References

R1 *Central Precinct Renewal Project – Rail Engineering & Design*, Mott Macdonald, 30 November 2018.

R2 *Transit Noise and Vibration Impact Assessment*, Federal Transit Administration, FTA-VA-90-1003-06, May 2006

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Limitations / Assumption

The advice in this TAN is based on preliminary groundborne noise predictions and future measurements will be required to confirm these predictions.

Risks / Opportunities to be further assessed

A vibration survey across the relevant area is required to establish existing vibration levels and to predict future vibration levels. This will allow a detailed assessment of groundborne noise levels and allow confirmation of the type of track required for the development.

Actions to be undertaken at the next design stage

A more detailed noise and vibration analysis will be required to provide relatively detailed guidelines for future development. The following steps will be required:

- Measurement of vibration levels across the relevant area;
- Prediction of groundborne noise level within future developments and confirmation of the required vibration controls;
- Measurement of airborne noise levels in the area; and
- Determination of likely airborne noise controls to be incorporated into future developments.

Description of changes from previous TAN revision (where relevant)

Not relevant; no previous TAN issued.

Prepared By:	Barry Murray	**Signed:**	
Reviewed By:	Ben Lawrence	**Signed:**	

Technical Advice Notification

Preliminary Prediction of Groundborne Noise Levels

Given the importance of controlling groundborne noise levels in future developments and given the difficulty of this control, preliminary predictions of groundborne noise levels have been carried out at likely future development locations. The predictions are based on the following factors and steps:

- Force density level of rolling stock. Previous measurement in the Sydney area has determined the force density level of various local rolling stock used. It is possible that other trains to use Platforms 1-14 will generate higher force density levels than those used in the predictions.
- Adjustment of the measured force density level to an assumed maximum speed of 50km/h under the deck.
- Estimate of the vibration transfer mobility from the track to the closest assumed deck footing at 3.5m (3.5m from centre of track to centre of footing). The transfer mobility has been taken from transfer mobility measurements across the ground at other locations.
- An allowance has been made for coupling loss and building amplification, based on concrete deck construction. However, this is approximate and should be more rigorously assessed at a later design stage.
- Attenuation of vibration up the structure onto the deck. In accordance with the FTA method (R2) of vibration prediction, a 2dB attenuation has been assumed up the structure.
- Conversion from vibration to groundborne noise. A factor of 27 has been deducted from the vibration levels at all frequency to determine noise levels in typical residential and commercial spaces. The noise level was then expressed as an A-weighted level.

The results of the prediction are summarised in Table 1, noting that the predictions are preliminary and by nature are approximate.

Table 1 Preliminary groundborne noise prediction in developments on deck

Track Type	Vibration Control	Predicted Groundborne Noise Level
Ballasted track	Nil (current trackform)	48dBA
	Ballast mat	46dBA
Slab track	Standard fasteners (static stiffness 25kN/mm)	42dBA
	Low stiffness fastener (static stiffness 8kN/mm)	41dBA
	Isolated slab track (continuous mat)	35dBA
	Floating slab track (discrete bearings)	27dBA

The predicted groundborne noise levels have been assessed by reference to the *Rail Infrastructure Noise Guideline* (RING), Environment Protection Authority, May 2013. This document recommends a maximum level of 35dBA for residences at nighttime. It is reasonable to adopt 40dBA as the maximum noise level for high level commercial premises.

The predicted levels in Table 1 indicate that ballasted track will not achieve the 40dBA criterion for commercial premises, nor the 35dBA criterion for residential premises.

Concrete slab track is expected to result in groundborne noise levels which comply with the commercial and residential criteria above the deck, but only with isolated slab track or floating slab track.

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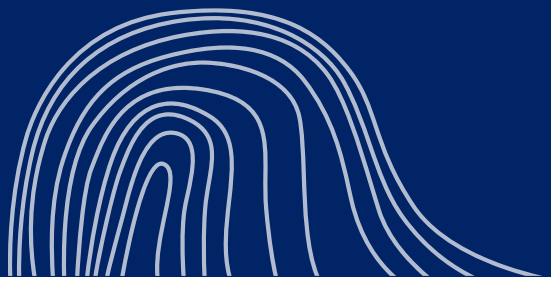

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