NOISE AND VIBRATION IMPACT ASSESSMENT

TAS-CYP-SDL-ZWD-REP-XLP-NAP-X0001
REV C
24TH APRIL 2018

MELBOURNE METRO RAIL AUTHORITY

Cross Yarra Partnership

VICTORIA State Government

Document Verification

Job title		Metro Tunnel Project - Tunnel and Stations PPP Package			
Document title		Noise and Vibration Impact Assessment			
Document ref		TAS-CYP-SDL-ZWD-REP-XLP-NAP-X0001 REV C NOISE AND VIBRATION ENVIRONMENTAL IMPACT ASSESSMENT			
Revision	**Date**	**Filename**	Noise and Vibration Impact Assessment Rev A		
A	21/12/2017	**Description**	Noise and Vibration Impact Assessment		
			Prepared by	Checked by	Approved by
		Name	Ken-Yi Fong	Kym Burgemeister	Greg Harrison
		Signature			
B	13/03/2018	**Filename**	Noise and Vibration Impact Assessment Rev B		
		Description	Noise and Vibration Impact Assessment		
			Prepared by	Checked by	Approved by
		Name	Nick Wedd	Ken-Yi Fong	Kym Burgemeister
		Signature			
C	24/04/2018	**Filename**	Noise and Vibration Impact Assessment Rev C		
		Description	Noise and Vibration Impact Assessment		
			Prepared by	Checked by	Approved by
		Name	Nick Wedd	Ken-Yi Fong	Kym Burgemeister
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Table of Contents

Executive Summary

Cross Yarra Partnership (CYP) has been contracted by Melbourne Metro Rail Authority (MMRA) to design, build and maintain the tunnels and stations for the Metro Tunnel Project, (the Project). The project includes two nine-kilometre train tunnels and five new underground train stations, linking the north-west Sunbury rail corridor and the south-east Cranbourne/Pakenham rail corridor, unlocking additional capacity in the existing City Loop. The five new underground stations are located at Arden, Parkville, CBD North, CBD South and Domain.
Following the initial risk assessment, this report details a Noise and Vibration Impact Assessment of the additional Project Land proposed by CYP for Melbourne Metro. Effective environmental risk management is a continuous, collaborative and forward-looking process. It aims to anticipate potential impacts so that project related activities can be planned and managed, and were applicable, mitigate adverse impacts. Environmental risk is a function of the likelihood of an adverse event occurring and the consequence of the event. CYP will continue to apply a robust and transparent environmental risk assessment process across all phases and components of the Project including construction and operational phases.
The project has already undergone an extensive and robust planning assessment process. As part of this, MMRA published an Environment Effects Statement (EES) and draft Planning Scheme Amendment that included an integrated assessment of the potential environmental, social, economic and planning impacts of the project, and the approach to managing these impacts.

In developing the EES, MMRA undertook a comprehensive engagement program to seek input from stakeholders and the community. This included stakeholders and the community having the opportunity to provide formal submissions during a public exhibition period, which were then presented to an Inquiry and Advisory Committee. The key focus of the Committee's review, findings and recommendations was the planning and environmental control framework for the Project, which resulted in a report prepared for the Minister for Planning.

In December 2016, the Minister for Planning released his Assessment of the environmental effects of the project. The Assessment was undertaken in line with the *Environment Effects Act 1978* and completed the EES process. The Minister's Assessment concludes that the environmental effects of the Project are acceptable, provided appropriate mitigation and management is implemented. The Minister subsequently approved a Planning Scheme Amendment and Incorporated Document for the project. The Incorporated Document, under Section 4.7 Environmental Management Framework (EMF), required an EMF to be approved. The EMF ensured the inclusion of Environmental Performance Requirements (EPRs), which address sixteen environmental factors. This encompassing process will be referred throughout as the EES and PSA processes.

The EPRs measurements ensure that there is a clear, unambiguous and transparent set of controls in place to guide Project delivery. The EPRs define the project-wide environmental outcomes that must be achieved during design, construction and operation of Melbourne Metro, (regardless of the design solutions adopted). While it will not be possible to avoid all effects and impacts, the recommendations and outcomes of the public submission, Inquiry and Ministerial Assessment; found the EPRs should provide an effective way to manage potential risk.

It is therefore these EPRs that will be used to assess the ability for CYP to appropriately manage and mitigate the proposed changes outside of Project Land. As a consequence of this an updated ERA and EIA has been undertaken for the proposed changes to the Project Land

The CYP changes predominately relate to the provision of underground support structures, additional station connections and temporary road occupations that affect surface land. There are a number of changes related to the change in approved Project Land that have the potential to generate noise and vibration impacts during the construction and operational phases of the project. During the construction phase, the activities with the highest potential for adverse noise or vibration impacts are TBM operation, road headers and rock drilling required to provide additional support to the underground structures. The intended locations of these activities are discussed in Section 4.

Similar to the approach undertaken by MMRA for the initial EES and PSA processes, CYP have completed a robust and transparent environmental risk assessment process for the project, based on the requirements of Risk Management Standards AS/NZS ISO 31000:2009. The outcomes of this process dictated the requirement for this Noise and Vibration impact assessment report.

Following the environmental risk assessment, detailed modelling of the potential noise and vibration impacts was undertaken in locations where potential impacts were identified. This was then followed by an assessment to determine whether the existing EPRs were appropriate to manage the potential noise and vibration impacts associated with the changes to approved Project Land.

The noise and vibration impact assessment process identified medium level residual impacts at all locations. However, the changes to the approved Project Land generally does not introduce any new noise and vibration impacts that can not be managed by the approved EPRs. . Therefore, the existing EPRs are deemed to be appropriate for managing noise and vibration from the construction and operation of Melbourne Metro, and no changes to the EPRs are recommended.

Ultimately, construction and operational noise and vibration within the additional Project Land can be appropriately managed and mitigated via the existing EPRs. Construction noise and potential impacts will also be managed in accordance with the guidance provided in EPA Document 480 and Publication 1254. For operational noise, resilient

track-forms and floating track slab can be adopted to control vibration and ground borne noise emissions from the railway.

1 Introduction

Cross Yarra Partnership (CYP) has been contracted by Melbourne Metro Rail Authority (MMRA) to design, build and maintain the tunnels and stations for the Metro Tunnel Project (the project). The project includes two nine-kilometre train tunnels and five new underground train stations, linking the north-west Sunbury rail corridor and the south-east Cranbourne/Pakenham rail corridor, unlocking additional capacity in the existing City Loop. The five new underground stations are located at Arden, Parkville, CBD North, CBD South and Domain.

The project has undergone an extensive and robust planning and environmental assessment process. In 2016 MMRA exhibited and received public comment on:

- An Environment Effects Statement (EES) that presented an integrated assessment of the potential environmental, social, economic and planning impacts of the project, and the proposed approach to managing these impacts.
- A Draft Planning Scheme Amendment (PSA) to facilitate the use and development of the project, as well as, establishing a mechanism to protect the tunnels, stations and associated infrastructure from potential adverse effects of development in their vicinity.

In December 2016, the Minister for Planning released his assessment of the environmental effects of the project. The Minister subsequently approved a PSA (GC45) for the project which, among other things, inserted the *Melbourne Metro Rail Project Incorporated Document (December 2016)* into the Melbourne, Port Phillip, Stonnington and Maribyrnong Planning Schemes and gave legal effect to the Incorporated Document through clause 52.02 of each of these Schemes. The project's Incorporated Document was subsequently amended by PSA GC67 to facilitate the Park Street, South Melbourne tram stop. The latest Incorporated Document is *Melbourne Metro Rail Project Incorporated Document (May 2017)*.

The EES and PSA processes assessed a Concept Design and indicative construction methodology for that project that was prepared by MMRA. This was described in some detail in Chapter 6 of the EES. The impacts from the construction and operation of Melbourne Metro are subject to the approved Environmental Performance Requirements (EPRs) determined by the Minister for Planning as part of the planning approvals process for the project. The EPRs define the project-wide environmental outcomes that must be achieved during design, construction and operation of Melbourne Metro.

CYP proposes a series of enhancements and changes to the Concept Design as exhibited in the EES and PSA processes that will deliver improvements in accessibility and construction and operational efficiencies.

Some of these CYP enhancements necessitate a need to change the boundary of the approved Project Land, which can only be done by a planning scheme amendment (PSA) to vary the plans appended to the Incorporated Document. The CYP changes predominately relate to the provision of underground support structures, additional station connections and temporary road occupations that affect surface land. These changes are required to be in accordance with the approved environmental performance requirements.

A PSA to amend the Incorporated Document is an appropriate planning response to the project changes, as the alternative would be to seek piecemeal planning permits or planning scheme amendments, as required.

A full noise and vibration assessment for the project was prepared as part of the EES and PSA processes previously submitted to Government. This report provides an assessment of the noise and vibration impacts related to the construction and operation of the project in those areas located on land that is proposed by Amendment GC82 to be added to the approved Project Land. This report focusses on:

- Construction airborne noise
- Construction vibration and ground-borne noise
- Operational airborne noise from trains and fixed infrastructure
- Operational vibration and ground-borne noise from trains.

1.1 Purpose of this Report

The purpose of this report is to assess the potential noise and vibration impacts of the changes to the approved Project Land resulting from CYP design changes from the previously assessed Concept Design.

This noise and vibration impact assessment report assess any new potential impacts arising during construction and operation and includes consideration of both direct and indirect impacts.

This report will support CYP's proposed planning scheme amendment (GC82) which will include the additional project land in the incorporated document.

1.2 Project Description

The infrastructure proposed to be constructed as part of Melbourne Metro, as assessed in the EES and PSA processes, broadly comprises:

- Twin nine-kilometre rail tunnels from Kensington to South Yarra connecting the Sunbury and Cranbourne/ Pakenham railway lines to form the new Sunshine-Dandenong Line (with the tunnels to be used by electric trains)
- Rail tunnel portals (entrances) at Kensington and South Yarra
- New underground stations at Arden, Parkville, CBD North, CBD South and Domain with longer platforms to accommodate longer High Capacity Metro Trains (HCMTs). The stations at CBD North and CBD South would feature direct interchange with the existing Melbourne Central and Flinders Street Stations respectively
- Train/tram interchange at Domain station.

The changes, or project components that require additional Project Land generally relate to the following works at Parkville Station, CBD North Station and CBD South Station:

- Rail alignment: The modified rail alignment represents a change in horizontal or vertical alignment (i.e. change in track geometry).
- Underground support structures are ancillary structures that are used for stabilisation of a primary structure such as a shaft, station box or tunnel:
  - Usually rock bolts are shorter in length and used predominantly along the rail tunnels.
  - Rock anchors are longer in length and can be used to support shafts at the stations. In both instances, each stabiliser can sit 1.5 to 2 metres apart and protrude at an angle.
- Pedestrian adits: A pedestrian adit is a permanent underground passage that connects the tunnel or station to a ground level access point and has a primary purpose of facilitating passenger movements.
- Construction adits: A construction adit is an underground passage that will connect the station to a ground level access point. It is typically used for the movement of equipment, materials and excavated material. It can also be used for storage purposes.
- Flinders Street Station platform works: Additional lifts connecting the station platforms to the Degraves Street Underpass/Campbell Arcade underpass.
- Additional road areas: Additional road areas are road reserves required for construction management, together with temporary and legacy road requirements. TMPs will be prepared and implemented in accordance with the approved EPRs, for each area, setting out specific traffic management activities and legacy roadworks. Generally, temporary traffic management will involve signs, workers and possible signage line marking adjustments. Legacy roadworks will generally involve the re-surfacing of road, kerb and channels, road works, pedestrian/cycle crossings, and hard and soft landscaping.

1.2.1 Parkville Station to CBD North Station

The proposed CYP design and construction changes to the approved Project Land at Parkville Station and in the intervening section between Parkville Station and CBD North Station relate to changes to the rail tunnel alignment and additional underground support structures.

Based on these changes, two properties will also be removed from the approved Project Land. They are 212 Berkeley Street, Carlton and 214 Berkeley Street, Carlton

Table 1 provides a breakdown of the location of changes to the approved Project Land resulting from the above enhancements and changes at Parkville Station and between Parkville Station and CBD North Station.

TABLE 1: PARKVILLE STATION TO CBD NORTH STATION CHANGES TO PROJECT LAND

Element	Location of change to approved Project Land
Rail tunnel alignment	Excursion outside of the approved Project Land is as follows: ▪ south of Grattan Street (near the corner of Bouverie Street), Carlton ▪ south of Church Street, Carlton ▪ Lincoln Street North, Carlton ▪ Swanston Street, Lincoln Square North to Pelham Street, Carlton ▪ Swanston Street, south of Kelvin Place and north of Queensberry Street, Carlton.
Additional underground support structures	Excursion outside of the approved Project Land is as follows: ▪ southern side of Grattan Street, east of Royal Parade and west of Barry Street

1.2.2 CBD North Station

The design and construction changes to the approved Project Land at CBD North Station relate to changes to the rail tunnel alignment and the installation of additional underground support structures.

Table 2 provides a breakdown of the location of changes to approved Project Land resulting from the above enhancements and changes at CBD North Station.

TABLE 2: CBD NORTH STATION CHANGES TO APPROVED PROJECT LAND

Element	Location of change to approved Project Land
Rail tunnel alignment	Excursion outside of the approved Project Land is 3 metres or less as follows: ▪ along Swanston Street, between Franklin Street East and Little Lonsdale Street (east of alignment) ▪ along Swanston Street between Franklin Street West and Little Lonsdale Street (west of alignment)
Additional underground support structures	Excursion outside of the approved Project Land as follows: ▪ north and south Franklin Street West, between Swanston Street and Stewart Street ▪ south of Franklin Street East ▪ along Swanston Street, between Franklin Street West and A'Beckett Street ▪ 391 Swanston Street ▪ north of Literature Lane and between south of Literature Lane and north of Little La Trobe Street ▪ along Swanston Street between La Trobe Street and Little Lonsdale Street (east of alignment) ▪ south Franklin Street East along Swanston Street, between south Franklin Street to Red Cape Lane between La Trobe Street (east side of alignment)

1.2.3 CBD South Station

The design and construction changes to the approved Project Land at CBD South Station relate to changes to the rail tunnel alignment, additional underground support structures, pedestrian and construction adits and works to Flinders Street Station platforms.

Due to CYP's design modifications, the car parking area located at Chapter House Lane, adjoining St.Paul's Cathedral, can be omitted from the Project Land.

Table 3 provides a breakdown of the location of changes to approved Project Land resulting from the above enhancements and changes at CBD South Station.

TABLE 3: CBD SOUTH STATION CHANGES TO APPROVED PROJECT LAND

Element	Location of change to approved Project Land
Rail tunnel alignment	Excursion outside of the approved Project Land are as follows: ▪ between Collins Street and Flinders Lane (west side of alignment) ▪ between the southern side of Collins Street and the northern side of Flinders Lane (west side of alignment) ▪ south Flinders Lane to north Flinders Street (east side of alignment) ▪ a small section of the Federation Square forecourt (east side of alignment).
Additional underground support structures	Excursion outside of the approved Project Land are as follows: ▪ between south Bourke Street and the north Collins Street ▪ between south of Collins Street and the north Flinders Lane (west side of alignment only) ▪ between south Flinders Lane and north Flinders Street (east side of alignment only)
Pedestrian adit	A pedestrian adit will be required to link CBD South Station with Federation Square. This will sit parallel to St.Paul's Cathedral footprint and Swanston Street, between south of Flinders Lane and north of Flinders Street. Another pedestrian adit will be required to provide an emergency egress from the tunnel to City Square. This will sit under Melbourne Town Hall footprint and the footpath at the corner of Collins Street and Swanston Street.
Construction adit	A construction adit extending diagonally south from Flinders Lane towards Swanston Street, under the north western corner of St.Paul's Cathedral.

Flinders Street Station Platform Works	The CYP design changes at Flinders Street Station will require an extension to the approved Project Land to include the middle section of Flinders Street Station Platforms. Some works will occur at Degraves Street Underpass/Campbell Arcade.

1.2.4 Additional road surface works

In addition to the proposed CYP enhancements to tunnel and station design, there is a requirement for additional roads to be incorporated into the approved Project Land. This will be for construction purposes and permanent (legacy) works as follows:

- Construction purposes will result in road management activity such as temporary traffic management measures including signage, line marking and small kerb and channel adjustments.
- Legacy road works including road adjustments and resurfacing, tram works and pedestrian and cycle crossings.

Table 4 overleaf provides a breakdown of the location of changes to approved Project Land resulting from the additional road surface works.

TABLE 4: ADDITIONAL ROAD SURFACE WORKS CHANGES TO APPROVED PROJECT LAND

Element	Location of change to approved Project Land	Temporary road management activity	Legacy road works
Arden Street	Located south of North Melbourne Football Club and north of Laurens Street and west of Fogarty Street and west of Dryburgh Street. Expected use of the road is three months	✓	✗
Royal Parade	Located south of Storey Street to Genetics Lane. The area is required for road management lanes 2, 3, 4 (west to east) and tram tracks. Expected use of the road is three months	✓	✓
Grattan Street	Located east of Bouverie Street and west of Swanston Street. Expected use of the road is three months	✓	✗
Cardigan Street	Located north of Victoria Street and south of Earl Street. Expected use of the road is three months	✓	✗
Flinders Street	Located east of Queen Street and west of Elizabeth Street. Expected use of the road is 3 - 6 months	✓	✓
Flinders Lane	Located west of Elizabeth Street and east of Swanston Street. More specifically, the western half of this area is required for temporary traffic management. Located west of Swanston Street and east of Russell Street. Located west of Elizabeth Street and east of Swanston Street and west of Swanston Street and east of Russell Street. Expected use of the road is 3 - 6 months	✓	✓
Kings Way	Located south of Palmerston Crescent and north of Albert Road. Expected use of the road is 3 - 4 months	✓	✓
Albert Road	Located west of Kings Way and east of Stead Street. Expected use of the road is 3 - 6 months	✓	✓
Toorak Road	Located west of Darling Street and east of Claremont Street. Expected use of the road is 2 - 3 months	✓	✓

1.3 Study Area

The overall study area for the noise and vibration impact assessment includes land within the City of Melbourne, City of Port Phillip and City of Stonnington as shown on Figure 1 through Figure 18.

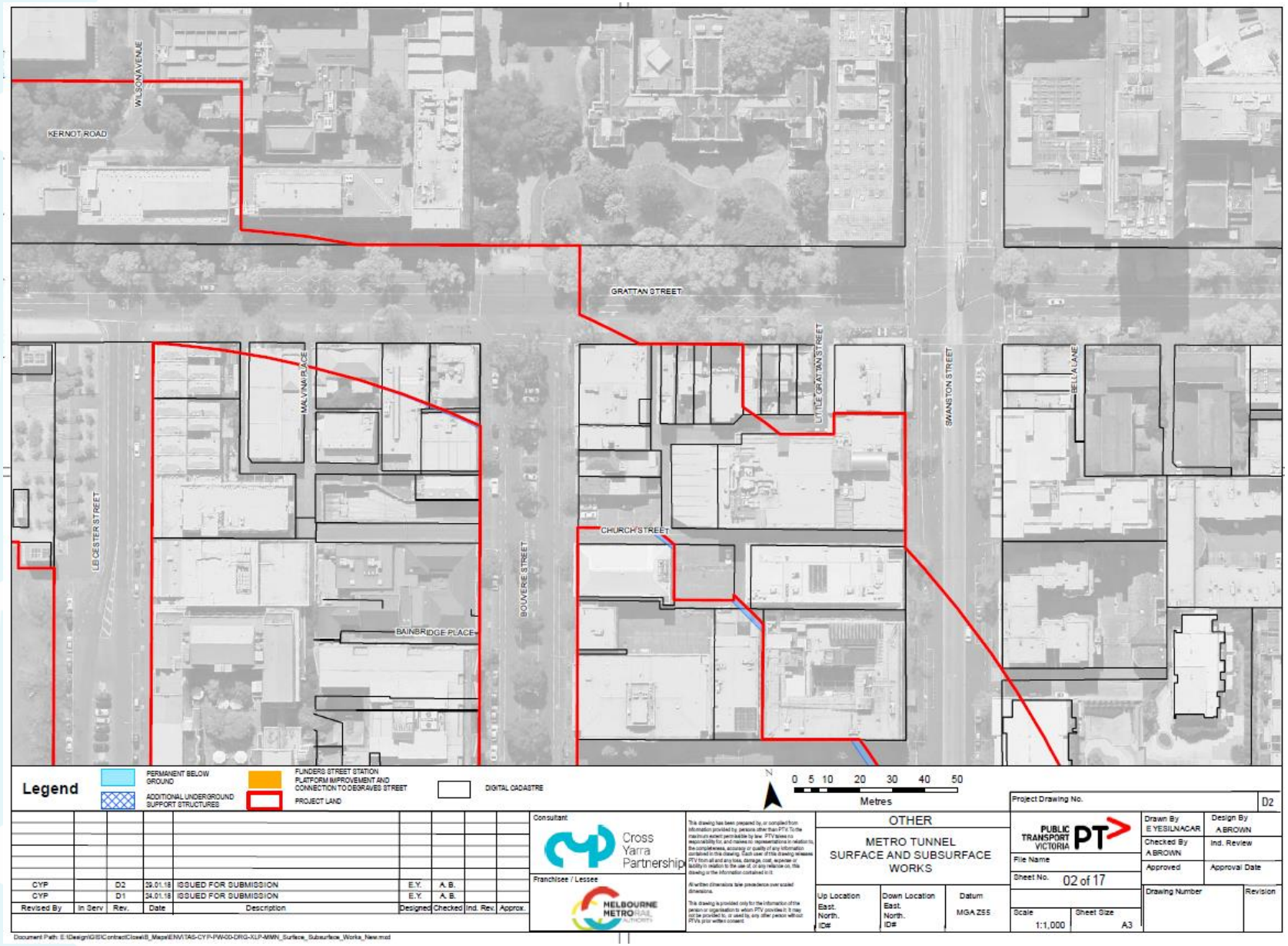

FIGURE 1: ADDITIONAL PROJECT LAND REQUIRED FOR PERMANENT BELOW GROUND BETWEEN PARKVILLE STATION AND CBD NORTH STATION

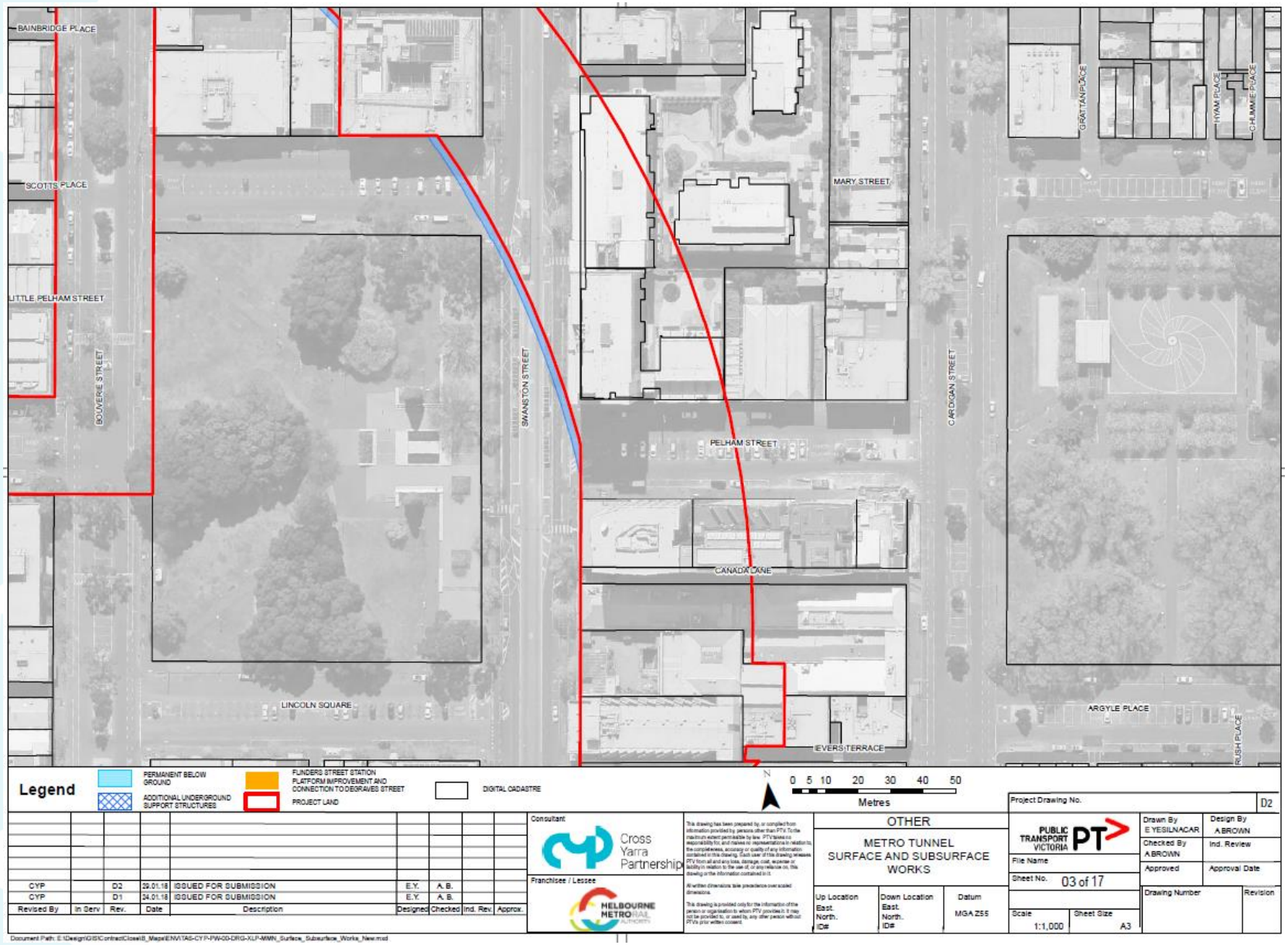

FIGURE 2: ADDITIONAL PROJECT LAND REQUIRED FOR PERMANENT BELOW GROUND BETWEEN PARKVILLE STATION AND CBD NORTH STATION

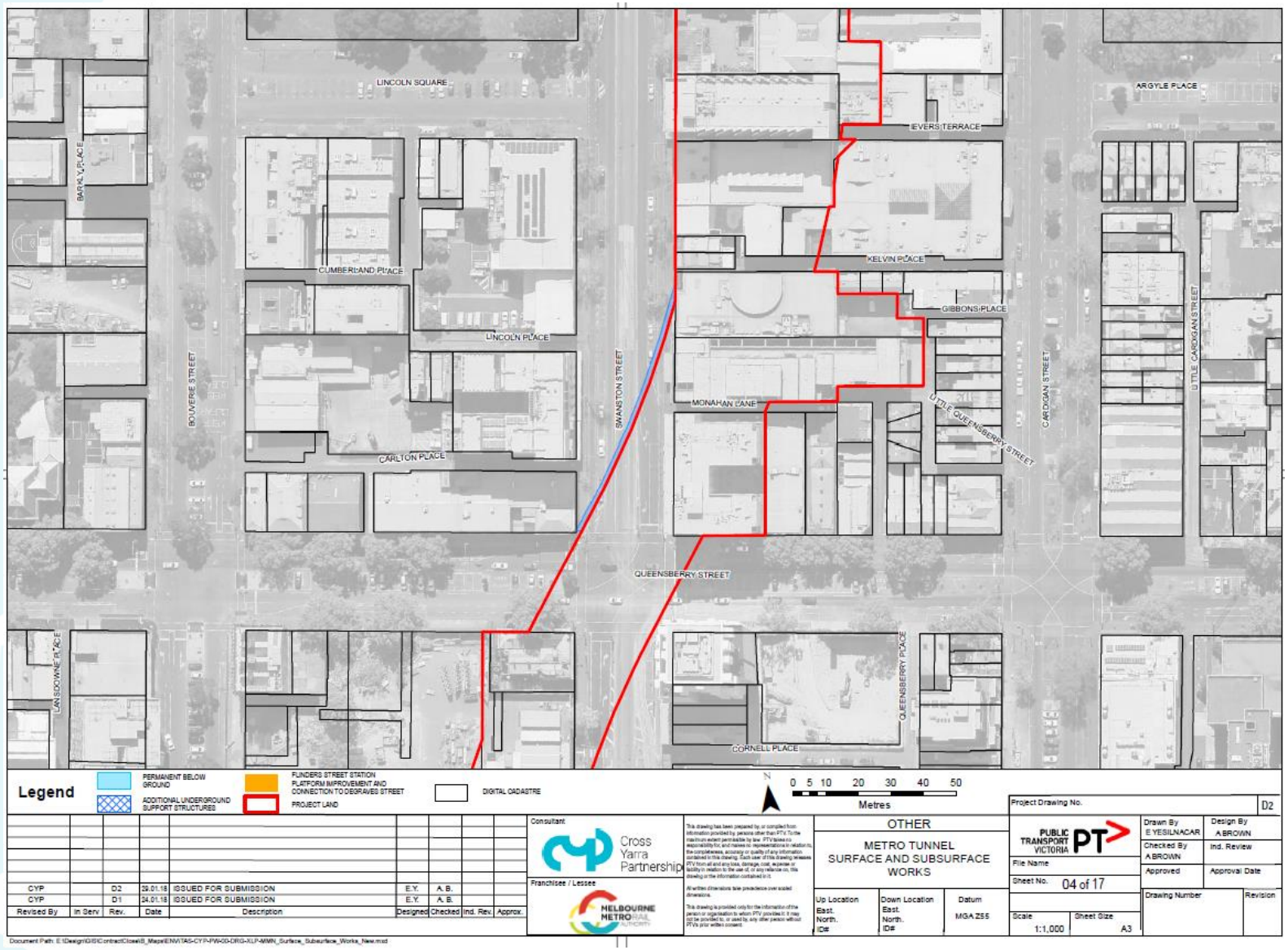

FIGURE 3: ADDITIONAL PROJECT LAND REQUIRED FOR PERMANENT BELOW GROUND BETWEEN PARKVILLE STATION AND CBD NORTH STATION

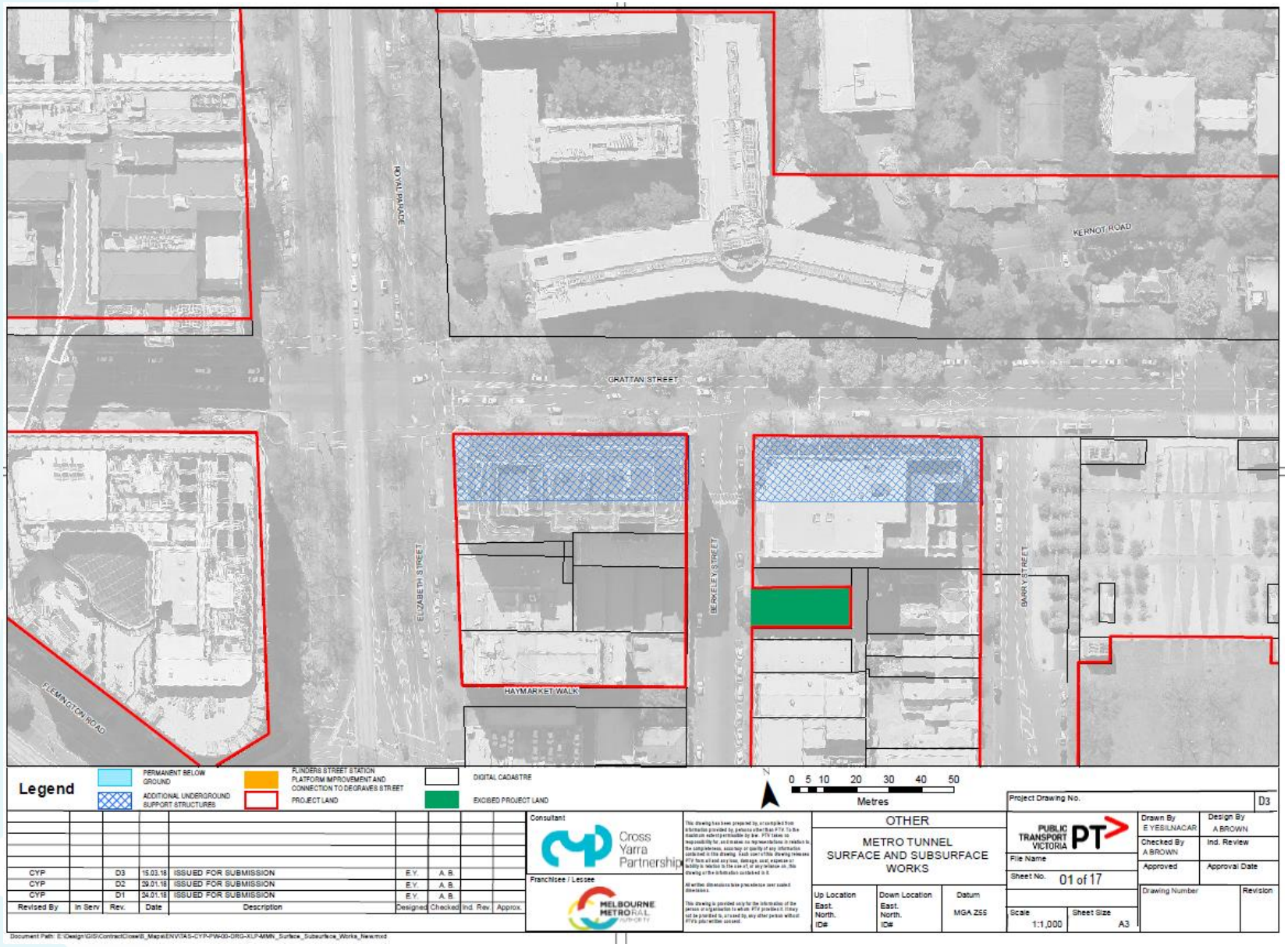

FIGURE 4: ADDITIONAL PROJECT LAND REQUIRED FOR UNDERGROUND SUPPORT STRUCTURES AT PARKVILLE STATION AND EXCISED LAND

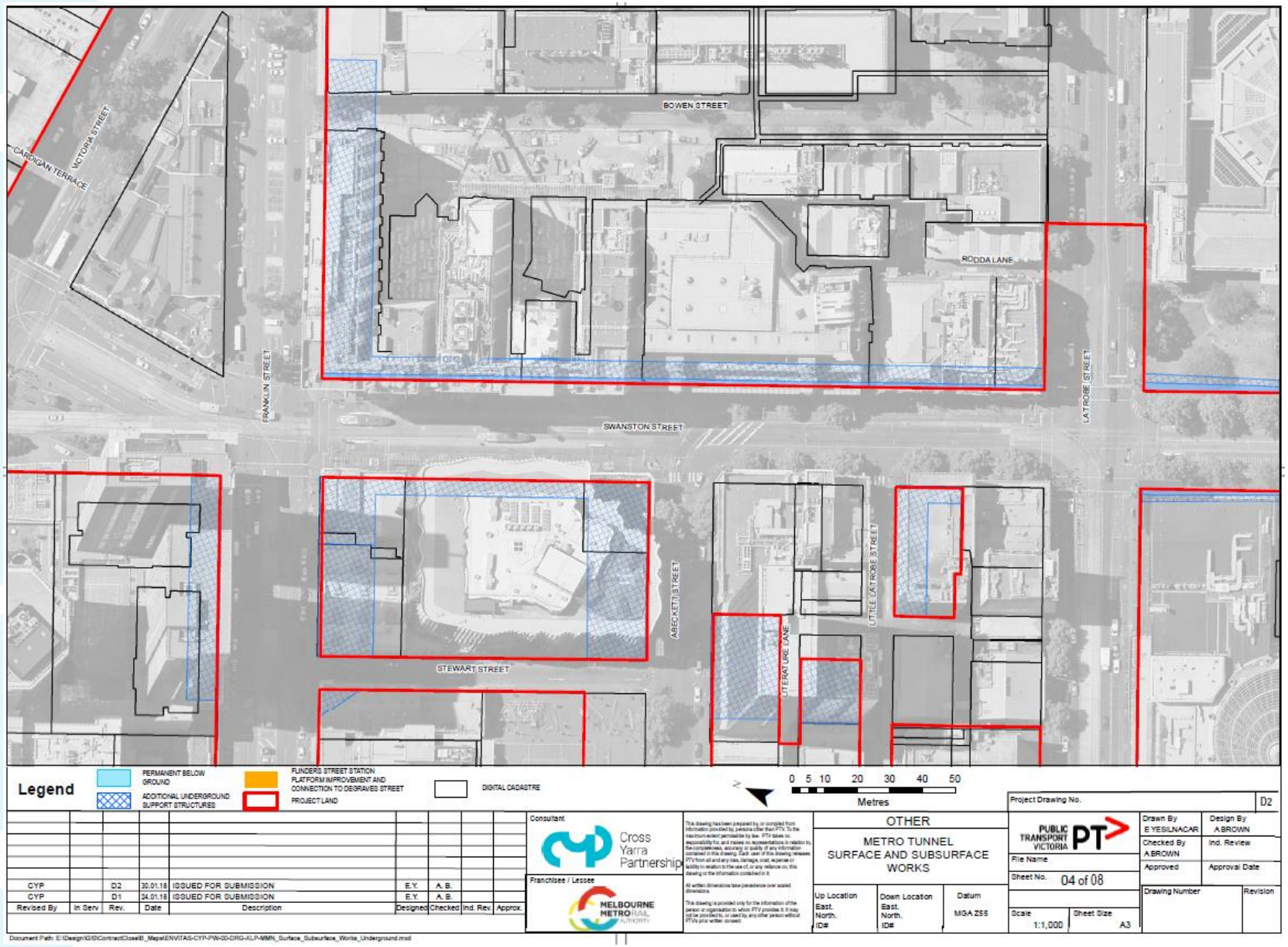

FIGURE 5: ADDITIONAL PROJECT LAND REQUIRED FOR UNDERGROUND SUPPORT STRUCTURES AND PERMANENT BELOW GROUND AT CBD NORTH STATION

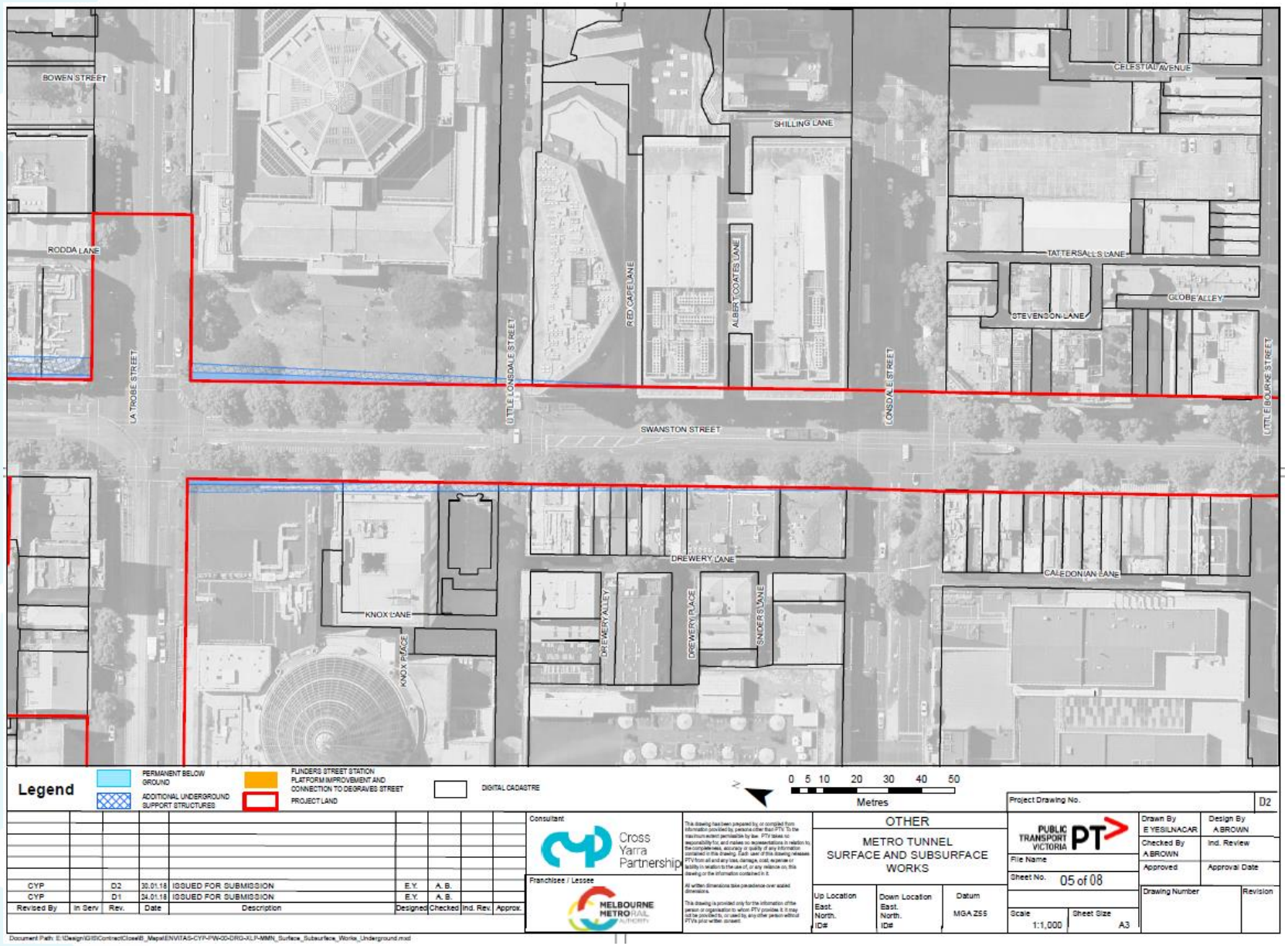

FIGURE 6: ADDITIONAL PROJECT LAND REQUIRED FOR UNDERGROUND SUPPORT STRUCTURES AND TUNNEL ALIGNMENT AT CBD NORTH STATION

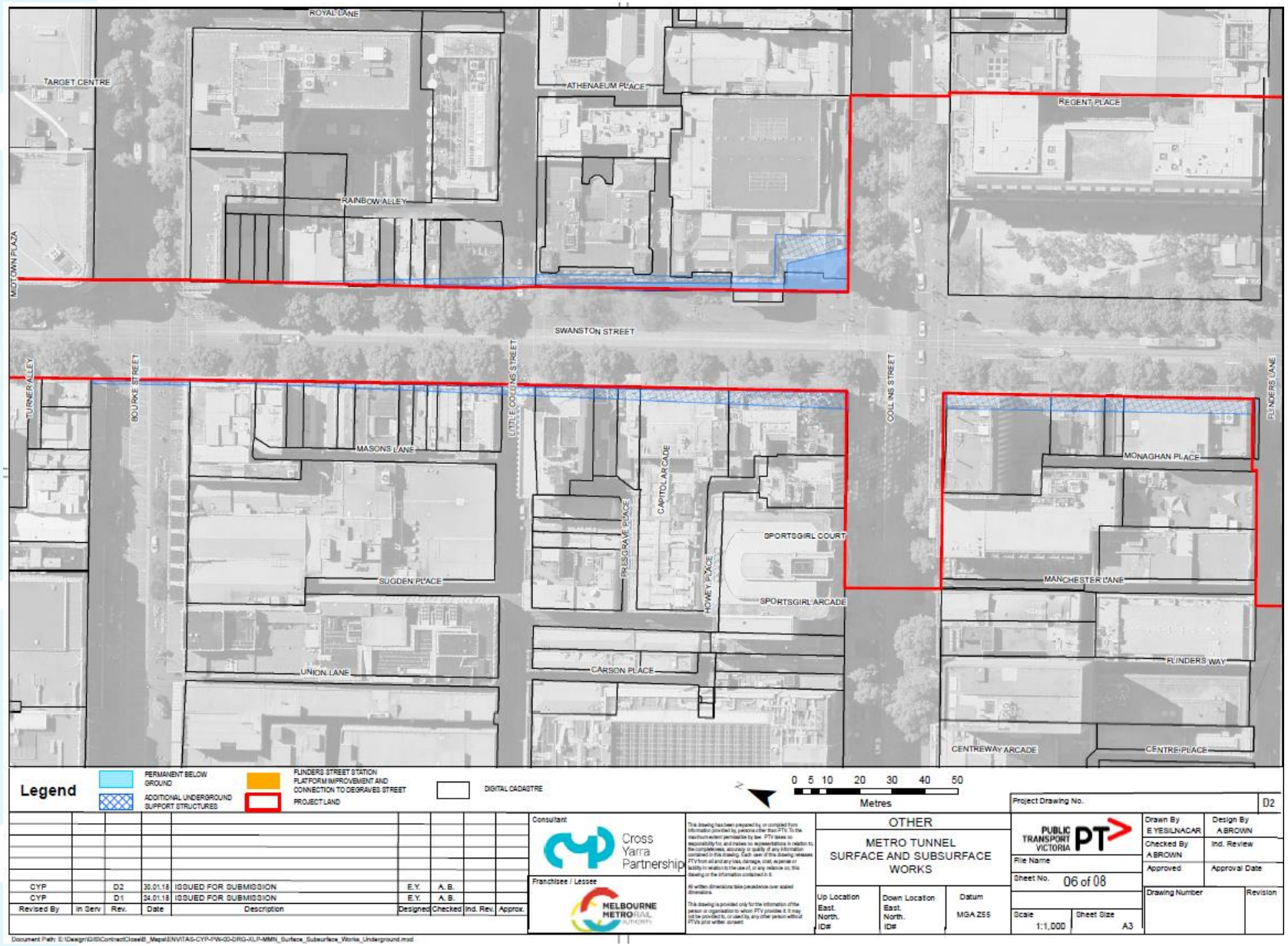

FIGURE 7: ADDITIONAL PROJECT LAND REQUIRED FOR PERMANENT BELOWGROUND AND UNDERGROUND SUPPORT STRUCTURES AT CBD SOUTH STATION

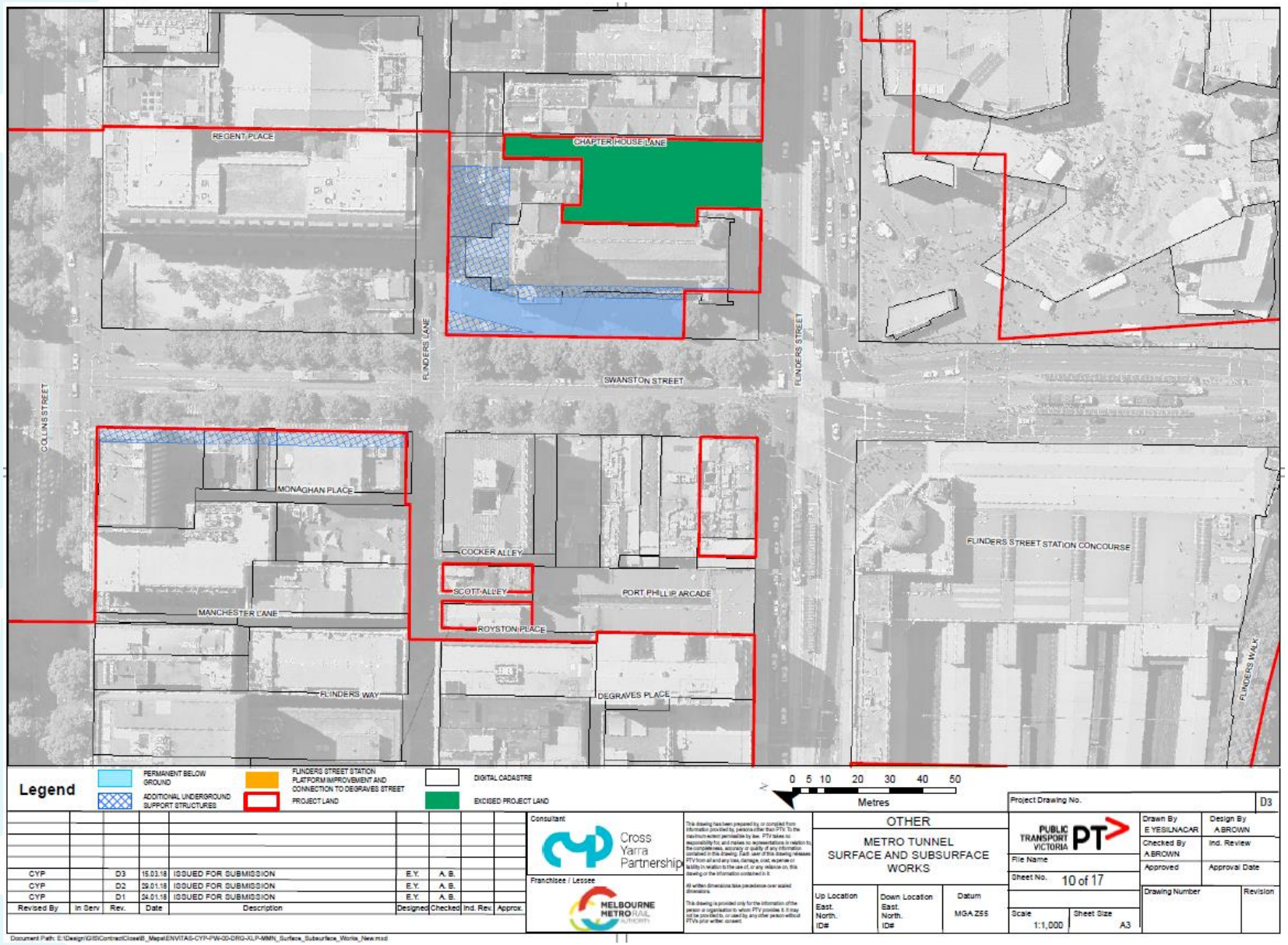

FIGURE 8 ADDITIONAL PROJECT LAND REQUIRED FOR PERMANENT BELOWGROUND, UNDERGROUND SUPPORT STRUCTURES AT CBD SOUTH STATION AND EXCISED LAND

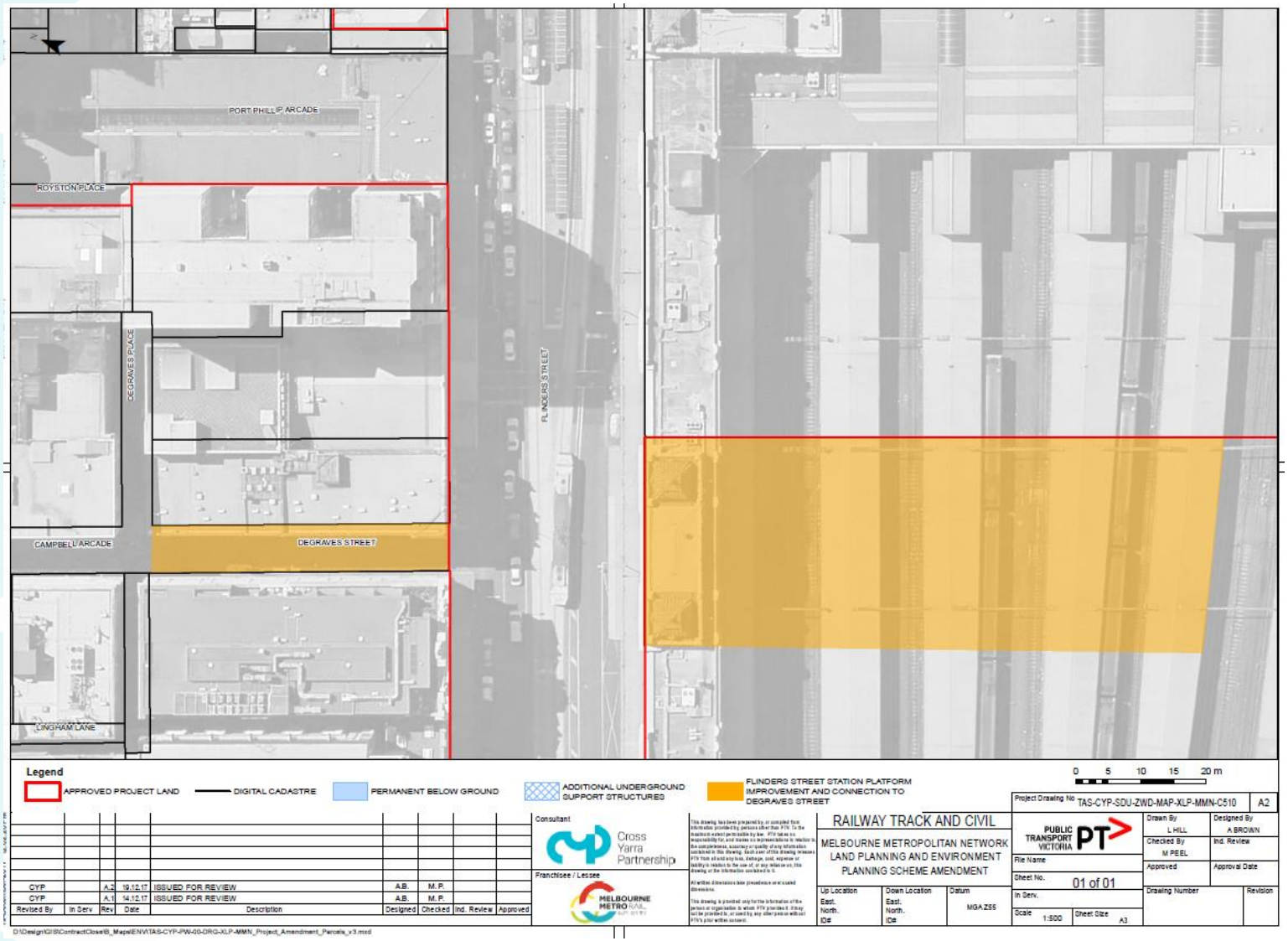

FIGURE 9: ADDITIONAL PROJECT LAND REQUIRED FOR FLINDERS STREET STATION PLATFORM IMPROVEMENTS AND CONNECTION TO DEGRAVES STREET

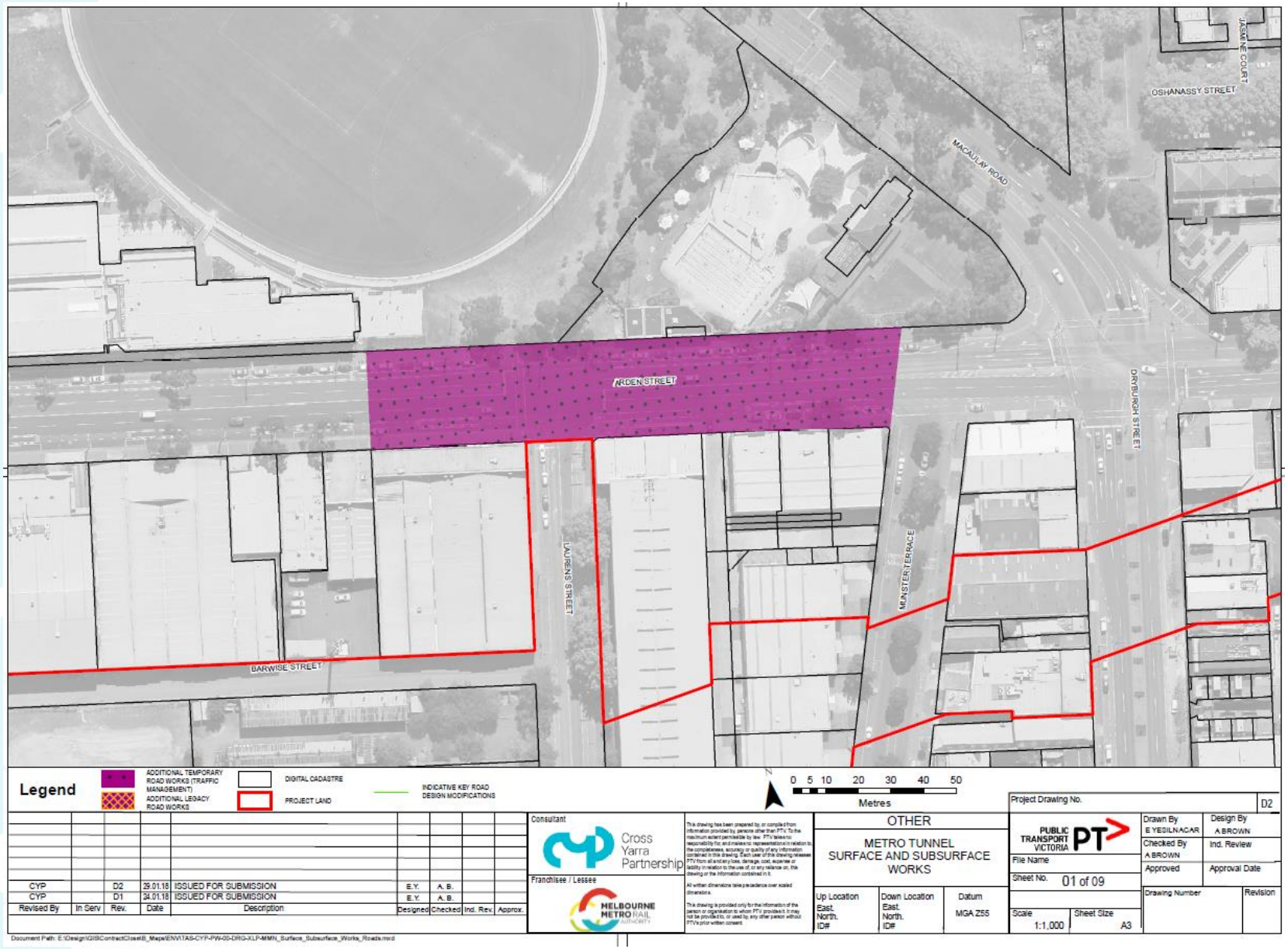

FIGURE 10: ARDEN STREET ADDITIONAL ROAD SURFACE WORKS

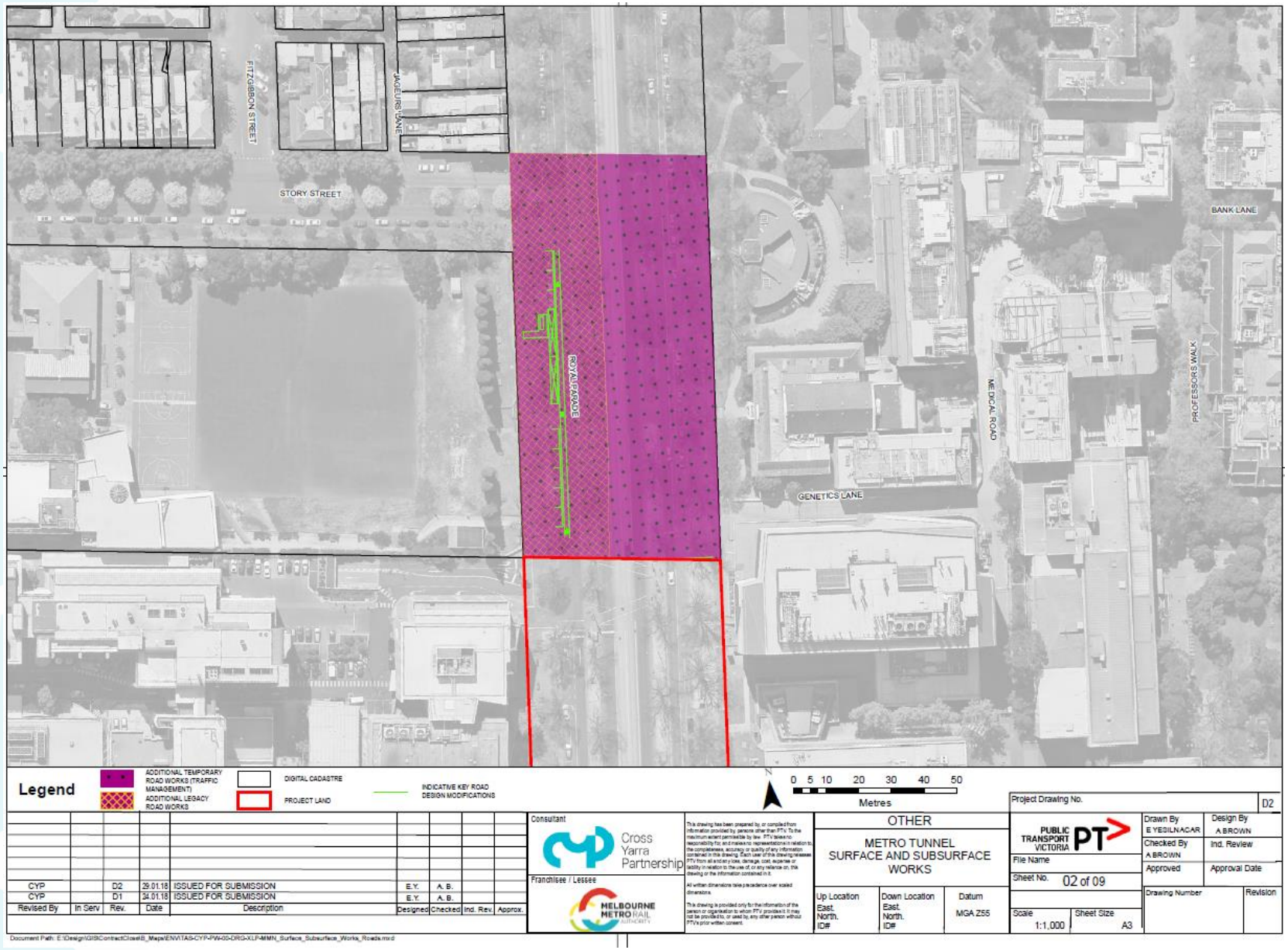

FIGURE 11: ROYAL PARADE ADDITIONAL ROAD SURFACE WORKS

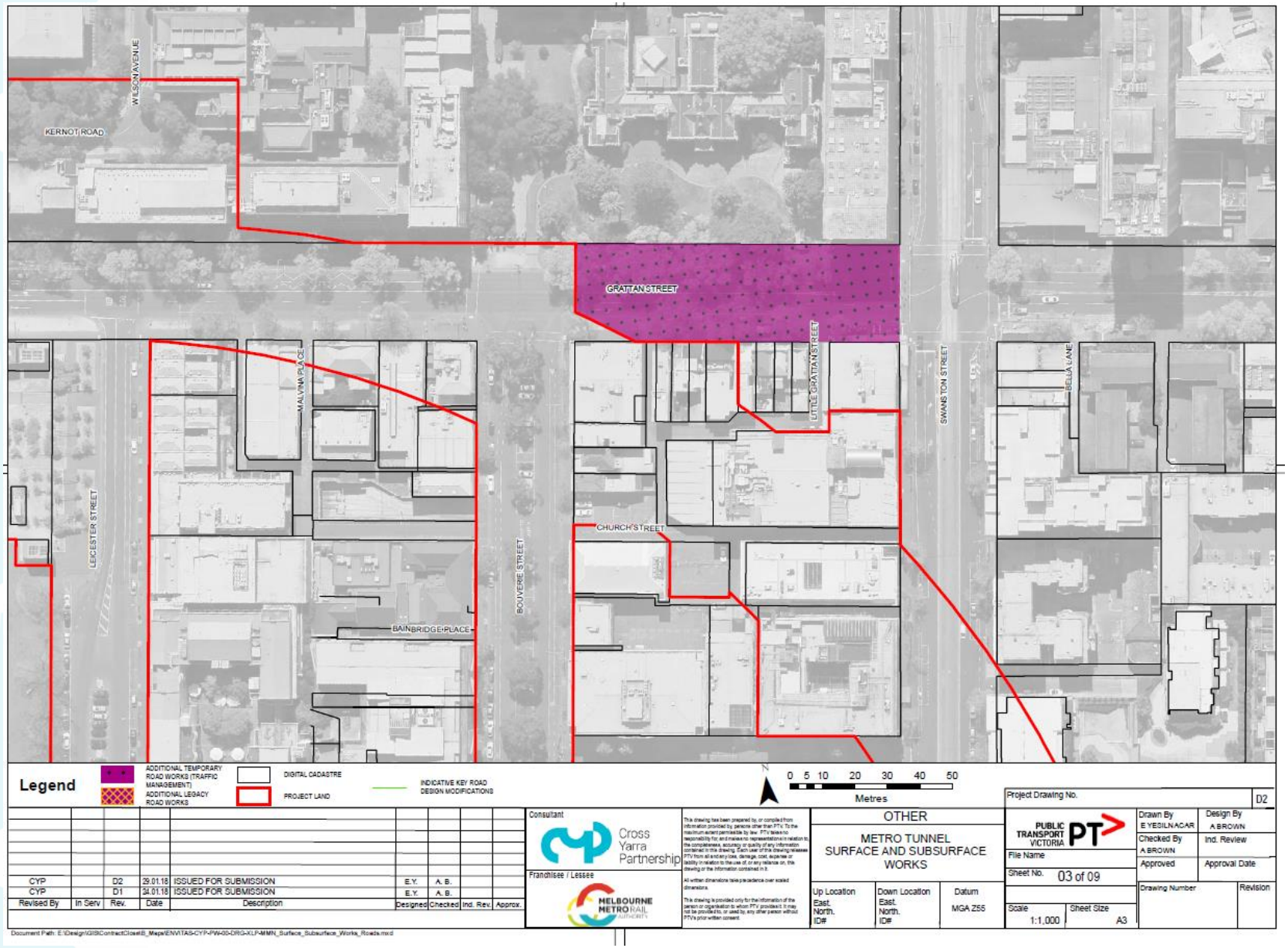

FIGURE 12: GRATTAN STREET ADDITIONAL ROAD SURFACE WORKS

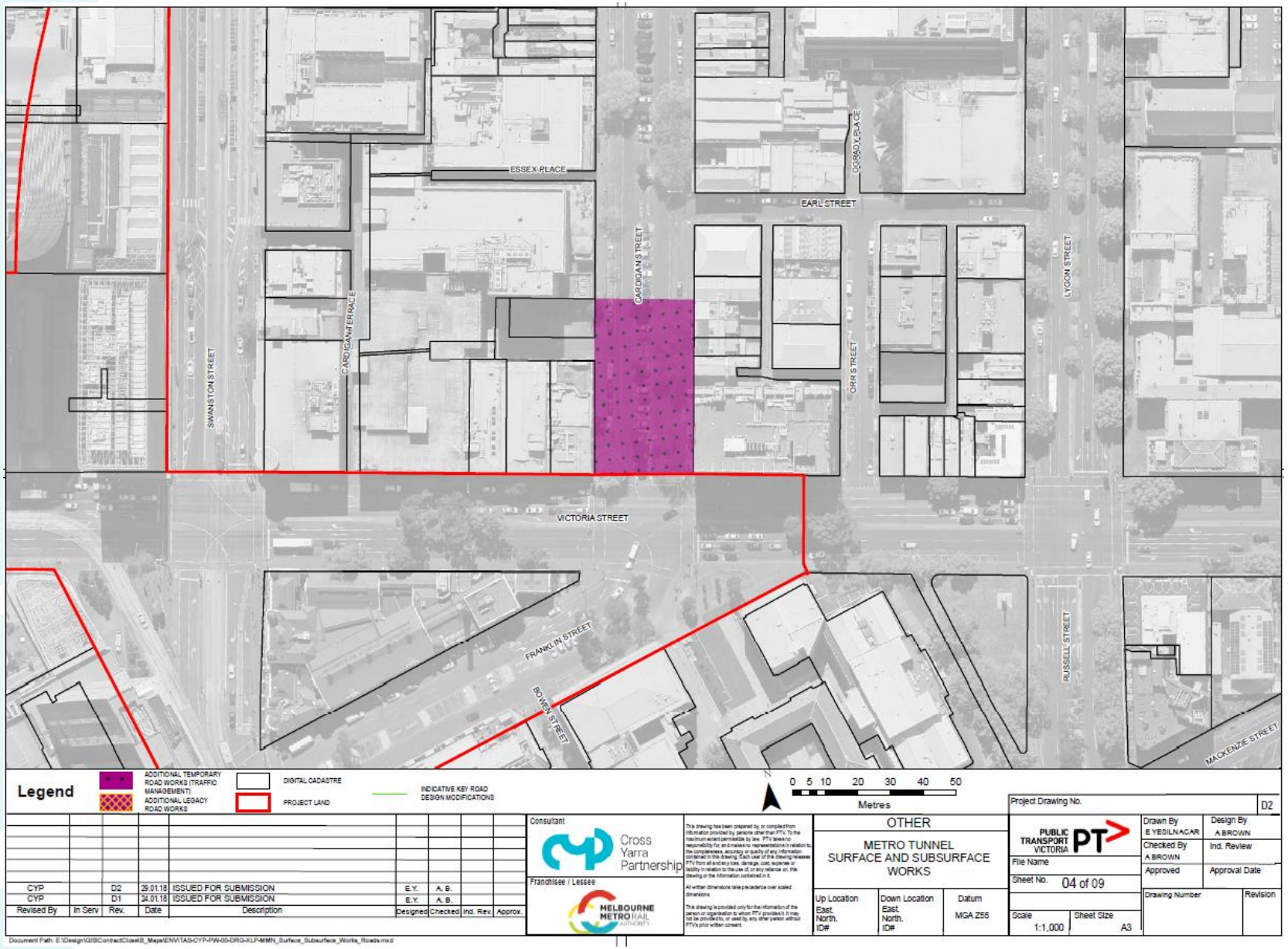

FIGURE 13: CARDIGAN STREET ADDITIONAL ROAD SURFACE WORKS

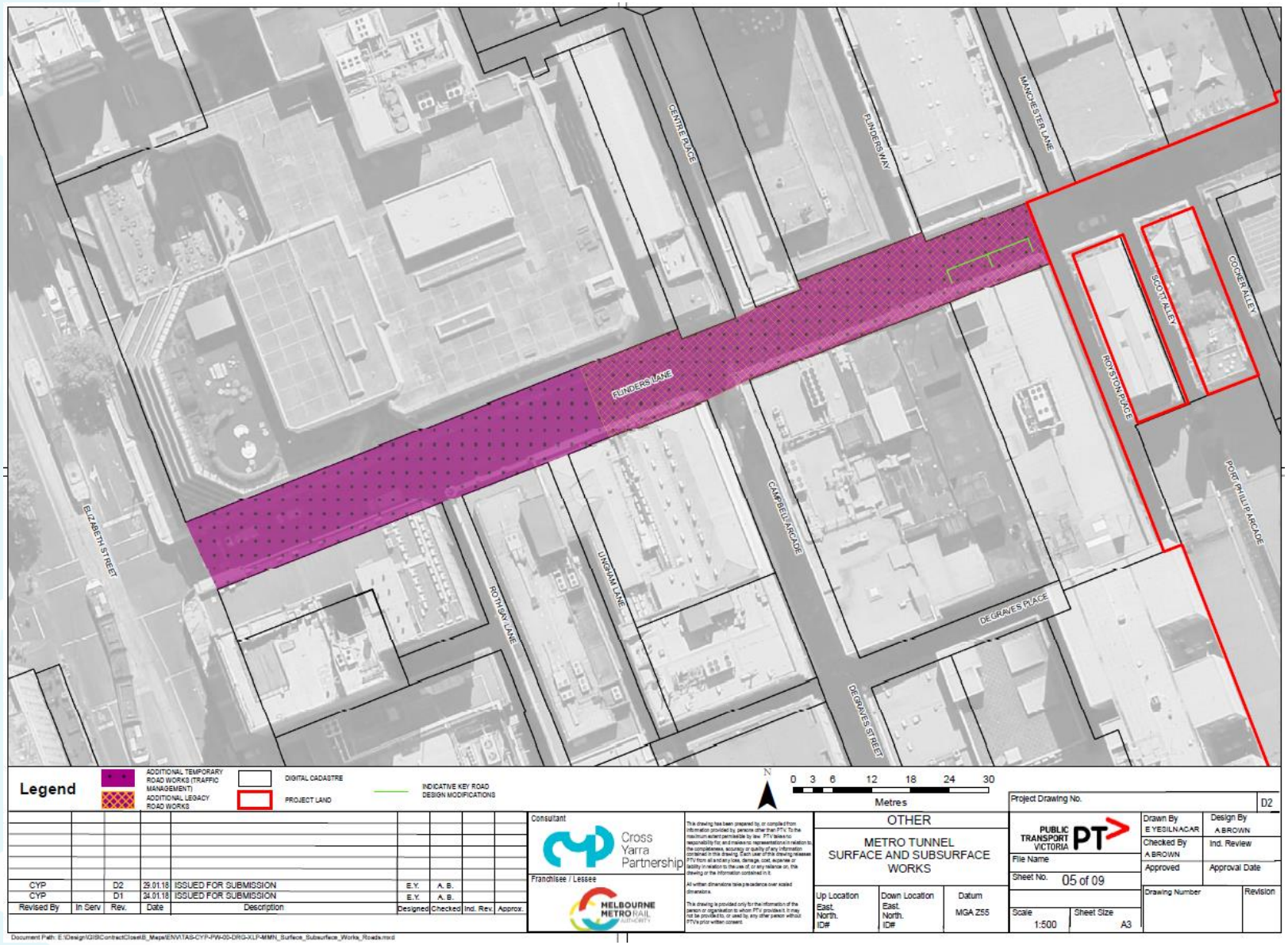

FIGURE 14: FLINDERS LANE ADDITIONAL ROAD SURFACE WORKS

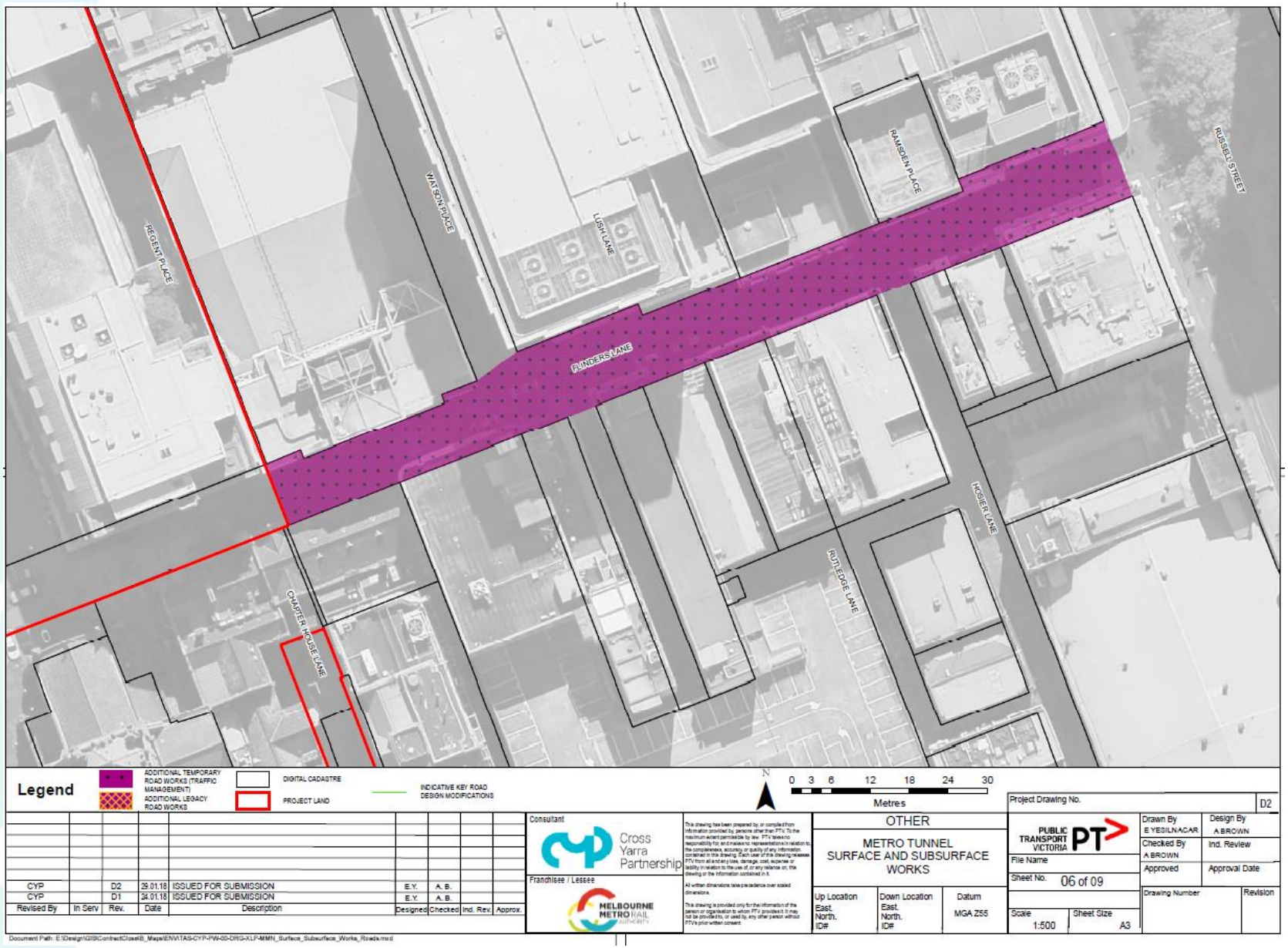

FIGURE 15: FLINDERS LANE ADDITIONAL ROAD SURFACE WORKS

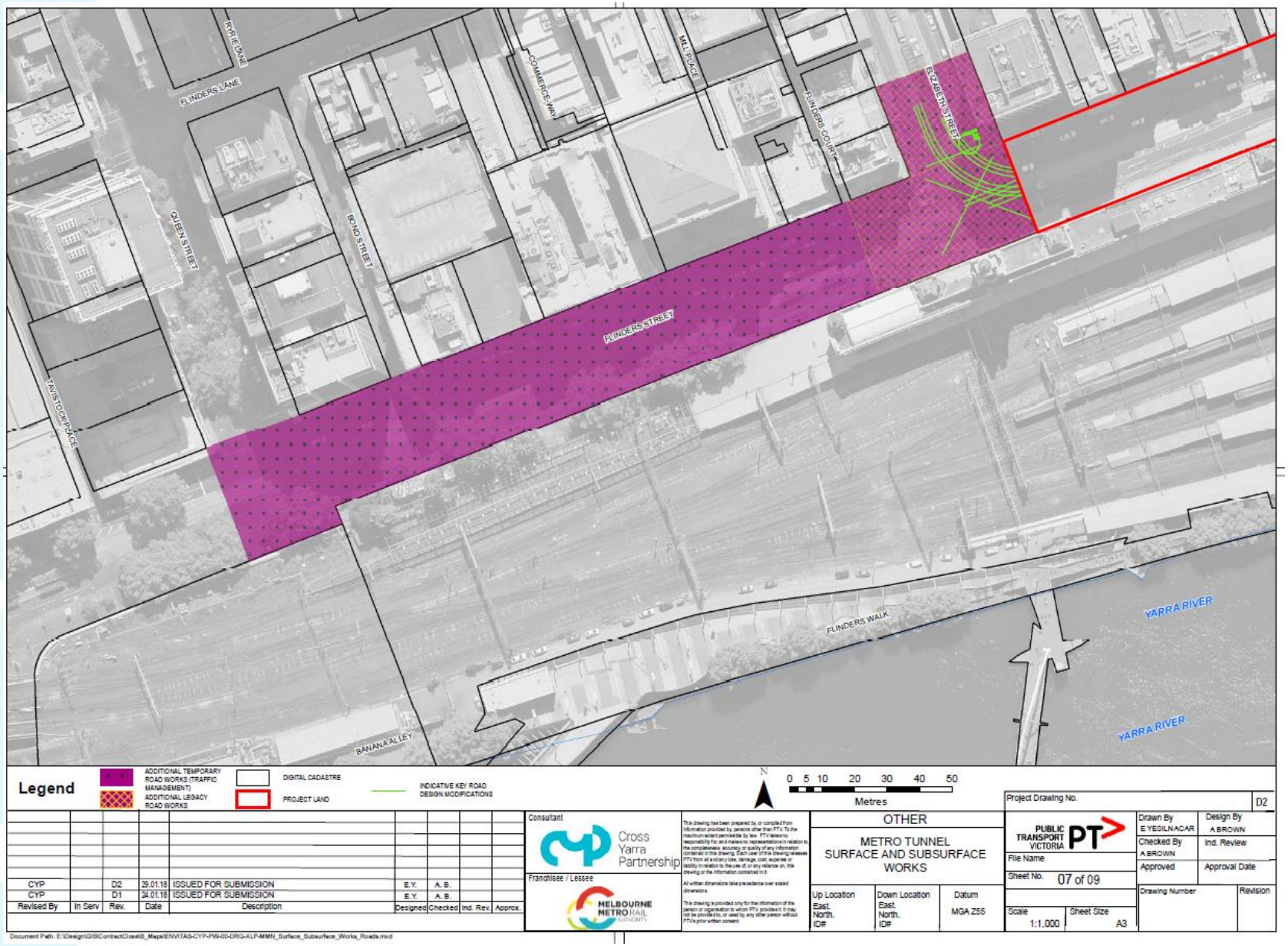

FIGURE 16: FLINDERS STREET ADDITIONAL ROAD SURFACE WORKS

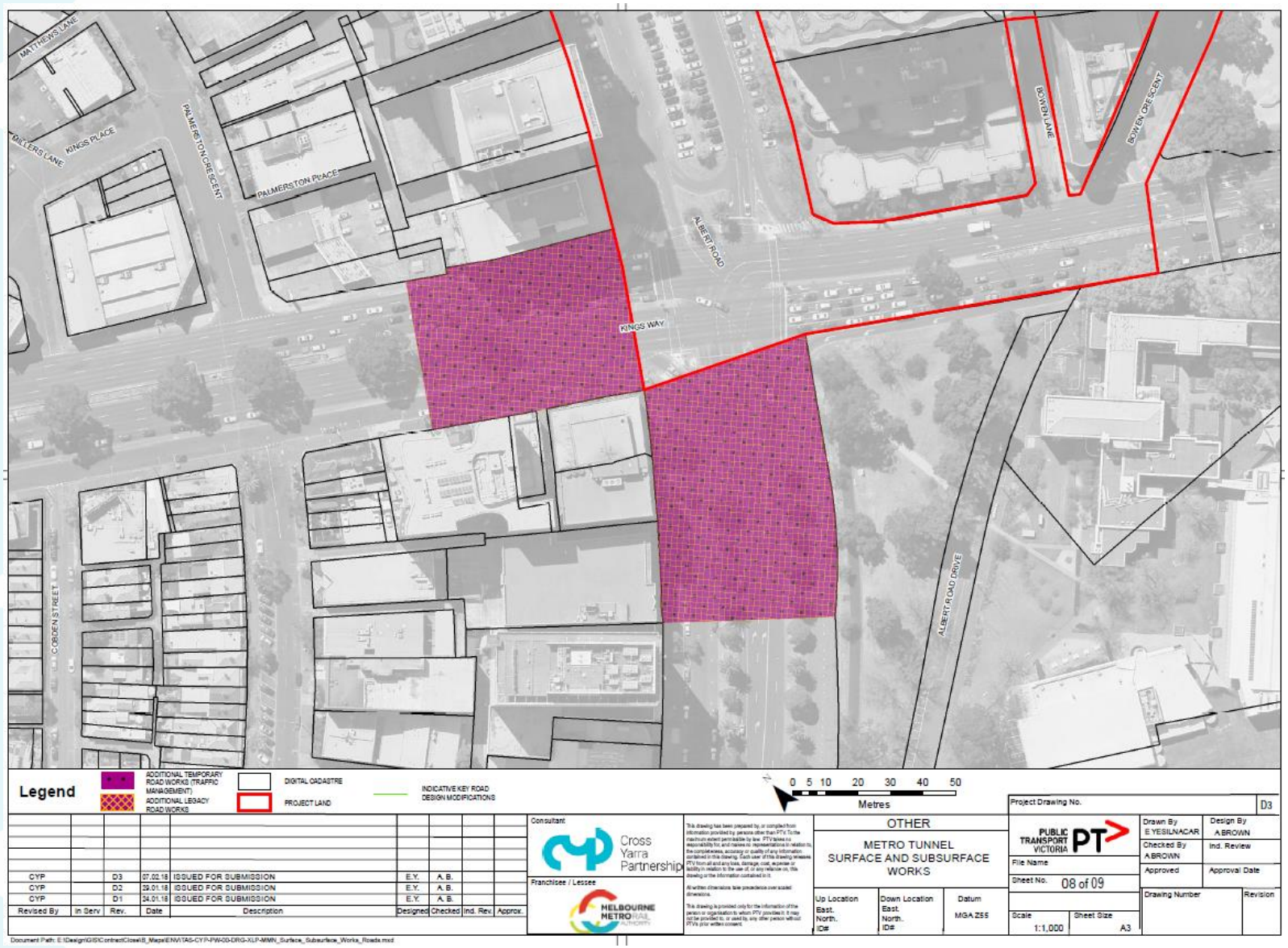

FIGURE 17: KINGS WAY AND ALBERT ROAD ADDITIONAL ROAD SURFACE WORKS

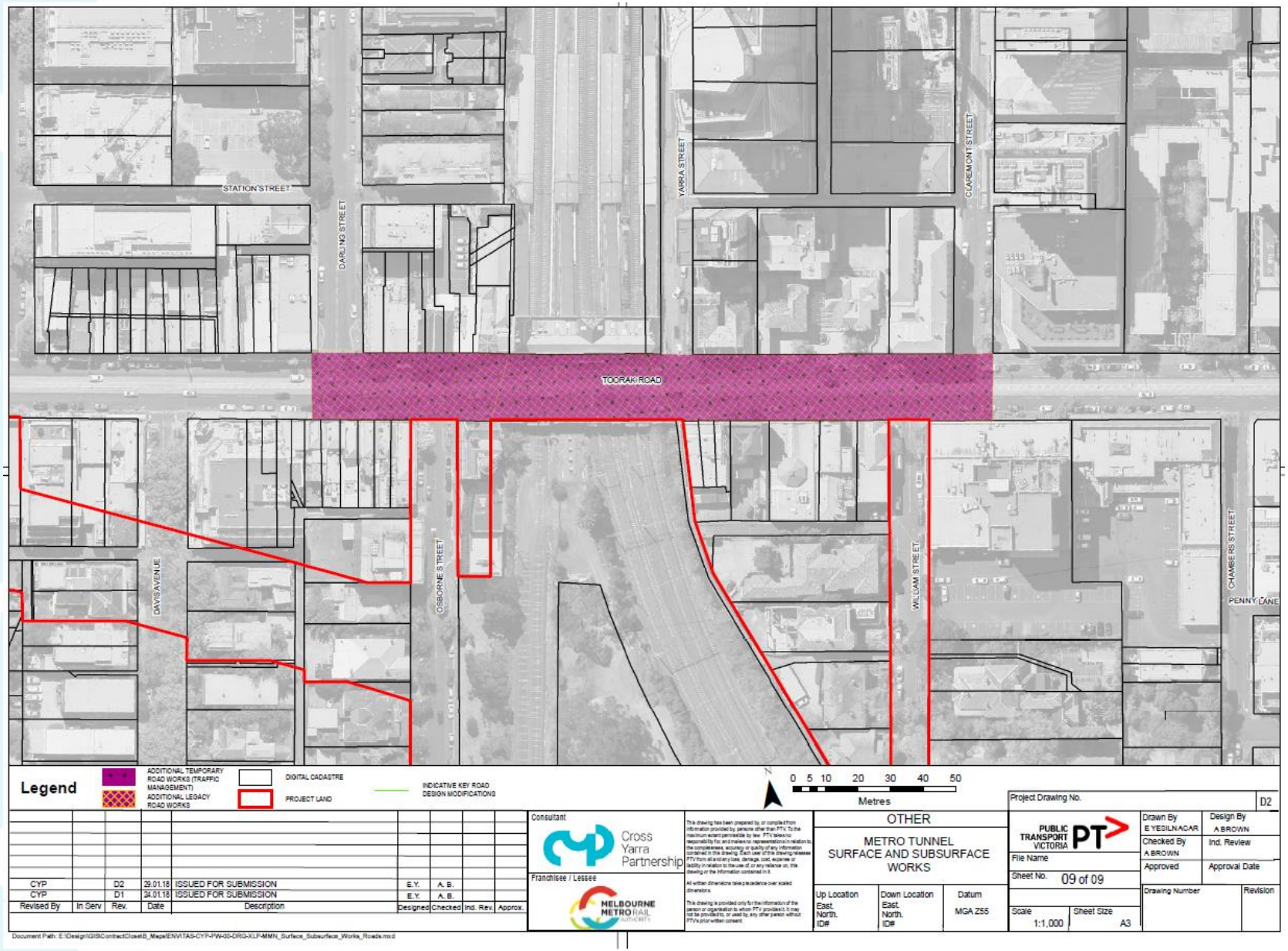

FIGURE 18: TOORAK ROAD ADDITIONAL ROAD SURFACE WORKS

2 Methodology

2.1 Environmental Risk Assessment

As part of the EES and PSA processes undertaken in 2016, MMRA completed a detailed environmental risk assessment (ERA) based on the Concept Design. Through this process an approved set of Environmental Performance Requirements (EPRs) were defined. The EPRs define the project-wide environmental outcomes that must be achieved during design, construction and operation of Melbourne Metro, (regardless of the design solutions adopted). As stated previously, CYP has proposed enhancements and changes to the Concept Design, and as a consequence, have prepared an updated desktop environmental risk assessment to determine the impacts of the proposed changes within the additional Project Land.

CYP have continued to apply a robust and transparent environmental risk assessment process to the project, based on the requirements of Risk Management Standards AS/NZS ISO 31000:2009, as depicted in Figure 19 below. ISO 31000:2009 provides principles and generic guidelines on risk management and represents a standardised risk management approach. It provides a structured approach for the risk assessment and is widely used for EESs and EIAs.

The environmental risk assessment process initially involved the defining the context and scope of the additional Project Land required for the additional works. This entailed the preparation of an updated Project Description for buildings and works located outside of the approved Project Land. Following this, an initial environmental risk screening using the EPRs was undertaken. The approach followed by CYP involved the application of the EPRs as an assessment tool, an approach that accords with the framework established during the EES and PSA processes for the Project.

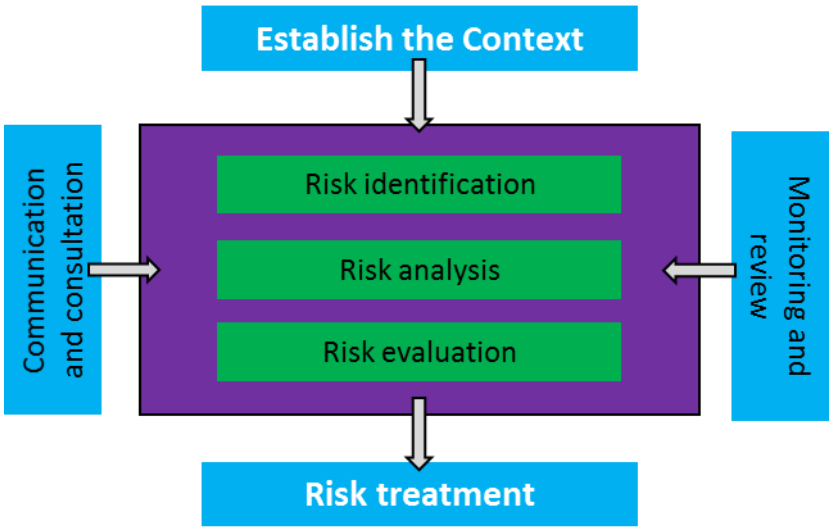

FIGURE 19: RISK ASSESSMENT PROCESS

The initial noise and vibration environmental risk assessment was based on limited design information and construction methodology. This environment risk assessment returned a residual risk rating of very low, low or medium for all project land changes. Given the medium scores returned, it was determined that an impact assessment should be undertaken.

The following aspects of the Scoping Requirements, issued by the Minister for Planning, are applicable to the noise and vibration impacts. The following table represents the process and outcome of that impact assessment.

TABLE 5: SCOPING REQUIREMENTS

Element	Relevant response
Key Issues	▪ Emissions of noise resulting from the Project exceeding relevant statutory, policy or guideline levels, adversely affecting amenity of residences or other sensitive land uses. ▪ Generation of airborne or ground-borne vibrations, which could adversely affect amenity of residential or other sensitive premises.
Priorities for characterizing the existing environment	▪ Existing noise conditions and trends in the neighborhood of the Project alignment and works sites. ▪ Ground conditions, which may influence the transmission of vibrations resulting from construction works or railway operations.

Design and mitigation measures	▪ Design, management and intervention measures, which may be applied to control emissions of construction noise and noise from train operations within relevant SEPP, policy or guideline levels. ▪ Design, management and intervention measures, which may be applied to control vibrations resulting from construction works and from train operations within relevant guideline levels that are appropriate for the project.
Assessment of likely effects	▪ Analysis of potential for noise standards to be exceeded, with respect to timing, durations, localities, degree of potential exceedance and any relevant special noise characteristics (e.g. tonality, impulsiveness). ▪ Analysis of potential for vibration to cause disturbance to occupants of residential buildings or other sensitive land uses.
Approach to manage performance	▪ Describe the principles to be adopted for setting key elements of proposed monitoring programs for, noise and vibration, both during construction works and for project operations, as appropriate. ▪ Describe the principles to be adopted for developing contingency measures to be applied if monitoring demonstrates more significant adverse effects than predicted or permitted.

2.2 Impact Assessment

The Noise and Vibration Impact Assessment has been conducted using the following approach:

- Construct an acoustic model of the station/tunnel area to be assessed.
- Utilise the updated project description rail design and construction methodology, predict noise and vibration levels for the construction and operational phases.
- Compare predicted noise levels with the Melbourne Metro Environmental Performance Requirements (EPRs).
- Test, if necessary, whether acoustic mitigation will allow compliance with the EPRs.
- Where it is predicted that the EPRs cannot be met, provide recommendations for additional controls that will manage noise and vibration impacts in accordance with the Scoping Requirements.

2.2.1 Methodology – Construction noise and vibration

The assessment of the construction noise and vibration impacts broadly follows the approach taken during the original EES and PSA processes. The broad categories of works resulting in noise and vibration impacts associated with the Metro Tunnel, considered include tunnelling and additional construction works.

Broadly, tunnelling activities consist of:

- Tunnel Boring Machines (TBM) for tunnelling along the alignment between the western portal and CBD North station as well as between CBD South station and the Eastern Portal.
- Road headers for mining section of tunnel between CBD North and CBD South stations.
- Road headers for excavating the two cavern stations; CBD North and CBD South

Additional construction activities are defined as all other non-tunnelling activities such as:

- piling
- excavation of entrance shafts to stations
- construction of stations
- installation of underground support structures
    - For the installation of rock anchors, the noise and vibration impacts arise from drilling into the ground substrate. Rock anchors involve drilling up to 30 m into the ground at individual pile locations for the station.
    - Rock drilling are programmed to only occur between the standard working hours of 07:00 hours and 17:00 hours, with operations happening 40% of the time in this period.

Assessment of the construction noise and vibration impacts take into consideration the following potential impacts on receivers outside of the approved Project Land in the vicinity of construction activities:

- Building damage: The potential of ground vibration in causing damage to buildings has been assessed. The relevant criteria are outlined in Section 3.2.1 of this report
- Human comfort: The impact of ground vibration on human comfort has been assessed. The relevant criteria are outlined in Section 3.2.2 of this report
- Ground-borne noise: There is a potential for ground vibration to re-radiate as audible ground-borne noise. This is to be distinguished from air-borne noise relevant to the surface works described in Section 4.5 . The relevant criteria is described in Section 3.1. At locations containing bio-resources are compared against either The Department of Primary Industry Code of Practice guidelines targets of 50 dBL or with existing noise level

measurements. This also considers the frequency range relevant to each type of biological resource. The appropriate criteria will be determined in consultation with the relevant stakeholders as per EPR NV15.

- Impacts on vibration- sensitive equipment: Vibration-sensitive equipment such as MRI machines and high magnification microscopes have an increased level of sensitivity to ground vibration and therefore lower vibration criteria against which they are assessed. EPR NV12 and NV15 identifies different equipment for sensitive research requirements and outlines how monitoring must be undertaken in accordance with equipment specifications to demonstrate compliance, and monitoring locations determined in consultation with operators of sensitive equipment (See EPR NV21). Vibration sensitive equipment have been identified within the Parkville and CBD North precincts and have been assessed. The relevant criteria is described in Section3.3, TABLE 15 . Higher levels may be acceptable if it can be shown that the vibration sensitive equipment under consideration is exposed to higher levels and is not adversely impacted by them.

2.2.2 Prediction Methodology – Vibration and Ground-borne noise

The approach used in this assessment of vibration and ground-borne noise has been adopted from the Melbourne Metro Rail Project Noise and Vibration Impact Assessment, issued C1 released on 20 April 2016 (NVIA) which formed Chapter 13 of the EES. The overall methodology to predict vibration and ground-borne noise impacts are as follows:

- Identification of additional sensitive receivers outside of approved Project Land. Receivers are categorized based on the type of occupancy as they relate to the relevant criteria.
- Create a spreadsheet modelling tool based on the methodology described in the NVIA to predict vibration and ground-borne noise values. The NVIA approach is based on the methodology described in the Federal Transit Administration (FTA) Transit Noise and Vibration Impact Assessment FTA-VA-90-1003-06, FTA 2006 (FTA Guideline). The model was calibrated to produce the same ground-borne vibration attenuation models as described in the NVIA (shown in Figure 20 below).
- Vibration source spectra (one third octave vibration levels) for the TBM and road header as well as the ground vibration attenuation characteristics have been adopted from the NVIA assessment. These have been reviewed and are still relevant to this assessment.
- Use of the model to predict vibration and ground-borne noise levels for receivers. For the Vibration Dose Values (VDV), these are defined as 7:00 am to 10:00pm for day and 10:00pm to 7:00am as per BS6472-1:2008.
- Use the predicted vibration and ground-borne noise levels and compare them against the guideline targets.
- For each receiver, compare the predicted impacts due to works in the scope of this PSA against the impacts identified in the NVIA as part of the overall EES and PSA processes.
- Identify if the impact on individual receivers has been increased due to the additional works proposed in this PSA or if they remain unchanged. In many of the receivers identified, the primary impacts will be due to works assessed as part of the EES and PSA processes which may be outside the scope of the works of this amendment.

Vibration Source Levels and Propagation Functions for Tunnelling Equipment

The ground vibration at the receiver location has been estimated using the formula:

$$PPV = k\frac{d_{ref}}{d}e^{-\propto(d-d_{ref})}$$

Where, *PPV* = resultant peak particle velocity, in mm/s

k = site/machine specific constant

d_{ref} = reference distance for source vibration data (m)

d = slope distance from the receiver location to the closest edge of the tunnel (m)

α = site specific ground attenuation constant (varies with frequency)

The value of *k* was obtained from MMRA Technical Note 042, issued 19 August 2016 where the ground vibration spectrum at a reference distance of 5 m is based on information provided by Heilig & Partners in response to an RFI from the Melbourne Metro Rail Project Environment Effects Statement Inquiry and Advisory Committee. This information was then used to recreate the mathematical model graphically used in the NVIA, shown represented Figure 20 below.

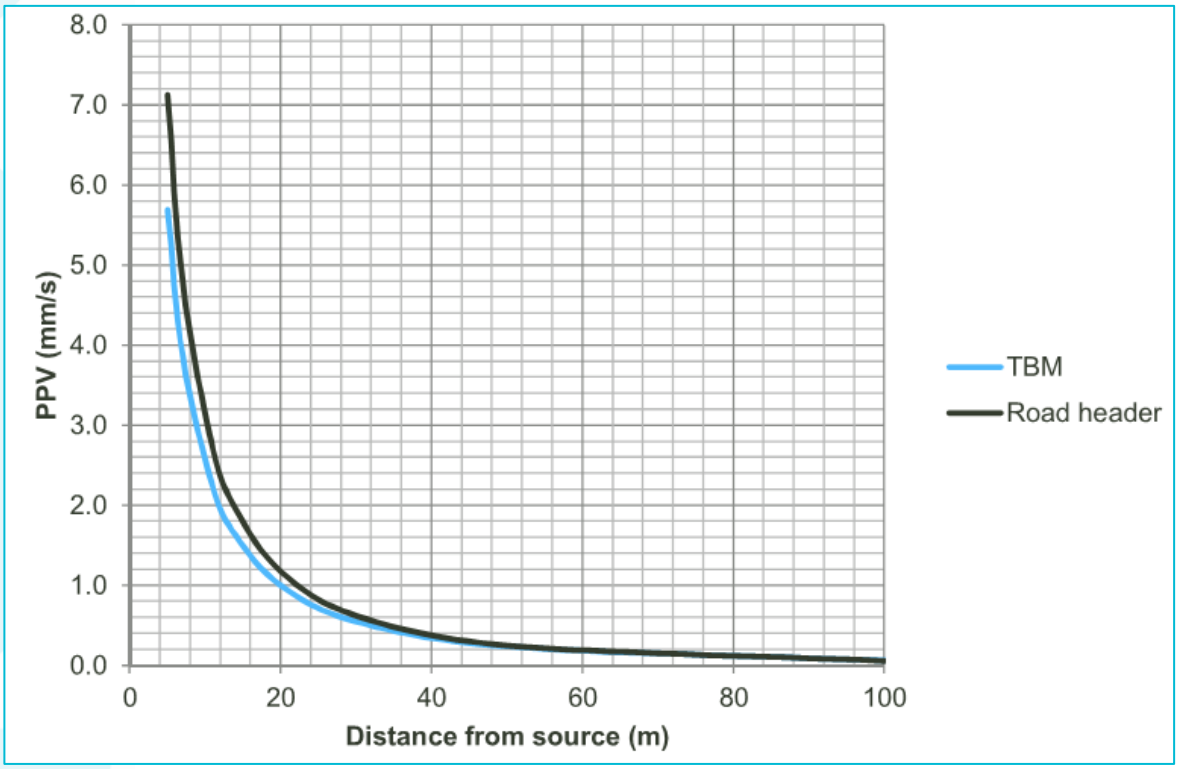

FIGURE 20: GROUND-BORNE VIBRATION ATTENUATION MODELS FOR TBM AND ROAD HEADERS

Vibration Source Levels and Propagation Functions for Additional Construction Works Equipment

As previously discussed, the only Additional Construction Works relevant to this PSA assessment which has not been assessed by the NVIA is for drilling works associated with the rock anchor and rock bolt drilling.

Empirical measurements have been completed and documented in a paper titled "*The prediction of noise and vibration disturbance above tunnels", Hiller, Bowers, Crabb, 2001* (TRL report) which was completed as part of a reinvestment research programme funded by the Transport Research Foundation (associated with the Transport Research Laboratory) in 2001. The objective of the research was to quantify disturbance due to tunnelling construction works for construction methods associated with tunnelling at Ramsgate Harbour Approach Road tunnel. One of the construction methods measured was rock drilling to install additional ground support structures (i.e. rock bolts and rock anchors), similar to the methodology proposed as part of the PSA assessment.

The source vibration level, showing the squared RMS velocity plotted against frequency (Hz) presented in Figure 9 of the TRL report is shown in Figure 21 below. This reports the vibration levels taken at a reference slope distance of 7 m. Although the authors report a distance of 4.5m from the receiver to the crest of the tunnel (ref Section 1.3 of the TRL report) this prediction assumes a more conservative reference slope distance of 7 m as the TRL report may have reported a distance in plan-view only.

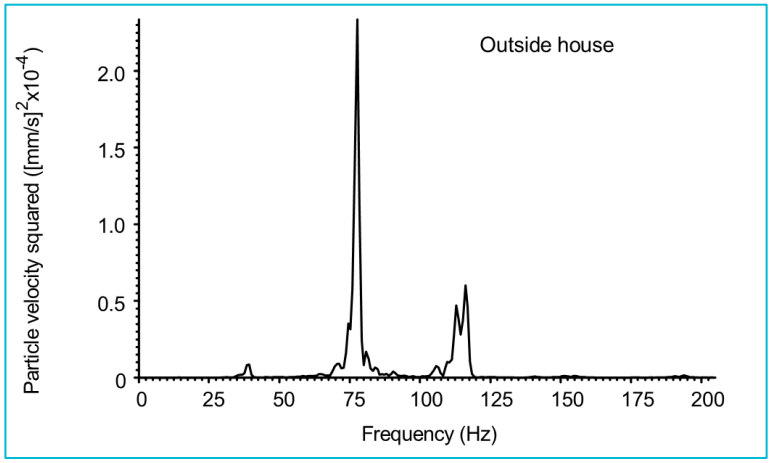

FIGURE 21: FREQUENCY CONTENT OF GROUND VIBRATION OUTSIDE RECEIVER PROPERTY FROM GROUND SUPPORT DRILLING (EXTRACTED FROM FIGURE 9 OF THE TRL REPORT)

To convert the squared RMS to a PPV value, a conservative crest factor of 5 was adopted.

The mathematical formula that represents the PPV of drilling as a function of slope distance is shown in Figure 22. This adopts the same prediction methodology as that used for tunnelling works (road header and TBM).

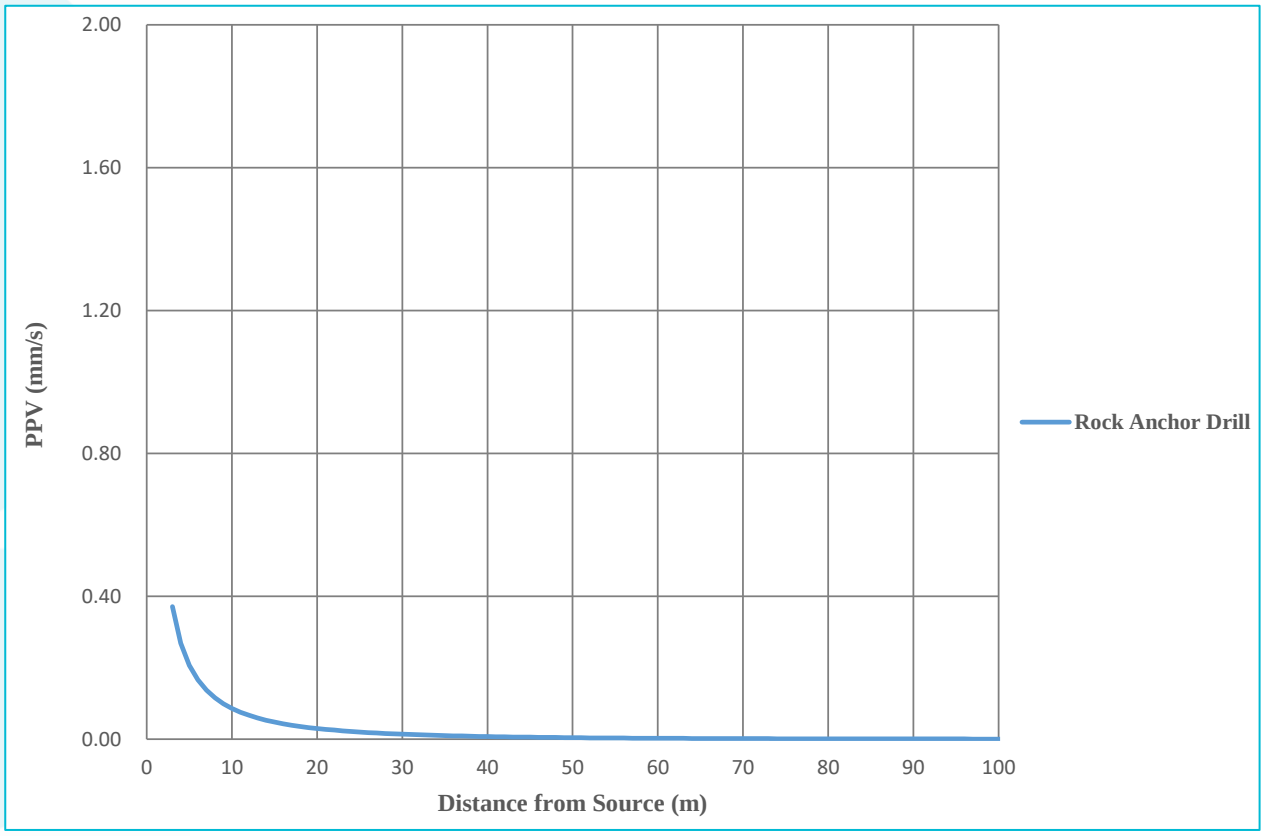

FIGURE 22: GROUND VIBRATION ATTENUATION MODEL FOR ROCK DRILLING

Vibration Level Predictions for Building Damage

The PPV has been predicted at each relevant receiver and compared against the guideline targets for structural damage.

Vibration Level Predictions for Human Comfort

Assessments of ground vibrations for human comfort are done by assessing the VDV against the guideline targets. The VDV is a function of the level of vibration (PPV), spectral content of the vibration and the duration of operation for the time period of assessment.

VDVs for the TBMs and Road Headers have been based on 60% operating time. VDVs for the rock drilling are based on 40% operating time. The method for calculating the VDV is based on the methodology presented in BS 6472-1:2008 using the weighting W_b (for vertical motion). This approach is consistent with the NVIA approach.

Where spectral data for the Additional Construction Equipment is not known, the estimation of the VDV was completed based on the following formula:

$$VDV = 1.4 \times V_{RMS\ Receiver} \times \left(\frac{2 \times \pi \times f_{dom} \times W_b}{1000}\right) \times t^{0.25}$$

Where $V_{RMS\ Receiver}$ = RMS vibration level at the receiver location in mm/s and 't' is the duration of operation in seconds.

This was calculated from the PPV vibration using a crest factor of 4 and other coupling loss factors for building and amplifications due to building resonances as per the FTA guidelines.

Vibration Level Predictions for Sensitive Equipment

Where sensitive receivers are noted, the predicted vibration spectrum is assessed against the relevant VC curve from ASHRAE or baseline measurements where these are reported in the NVIA.

Ground-borne Noise Impact Predictions

The methodology to predict ground-borne noise has been adopted based on the NVIA assessment. This is summarised as below:

- Maximum floor vibration levels have been converted to interior sound pressure levels adopting the correction $L_p = L_v - 27$ dB [*Measurement and assessment of groundborne noise and vibration (Association of Noise Consultants 2012*].
- The crest factor to convert peak levels to Root Mean Square (RMS) values are as follows: 1.4 for TBMs, 2.5 for road headers, 4 for Additional Construction Works. These are deemed to be conservative prediction values.
- 1/3 octave band interior sound pressure levels are then A-weighted, logarithmically summed and converted to overall noise levels for comparison with guideline target levels (occupancy dependant)

Methodology - Operational noise and vibration

Modelling of the transmission of railway operational noise and vibration through the ground has been undertaken using the CTRL/HS1 methods, which was developed in the UK for the Channel Tunnel Rail Link (CTRL, now known as High-Speed 1). The verified CTRL/HS1 methods are empirical and were developed from over 3,000 measurements. The CTRL/HS1 method has been further tested, validated and scrutinised at public inquiry on many urban mass transit systems around the world.

The calculation procedures are consistent with ISO 14837 and take account of all key parameters, including train design, train speed, track design, tunnel design, tunnel depth, ground conditions, receiving building foundations and receiving building type.

The calculation procedures generally consist of three stages as follows:

- source terms;
- propagation; and
- building response.

The source terms have been derived from measurements of vibration undertaken in South Yarra for existing metropolitan rolling stock. Trackform corrections have been undertaken by adjusting for the Insertion Gain (IG) of the various alternative trackforms which have been calculated using dynamic trackform modelling software. The insertion gains are expressed in decibels with reference to a hypothetical 'highly' stiff reference trackform.

Speed correction has been undertaken using the CTRL/HS1 calculation procedure which accounts for differences in the following parameters between the source term train/track system and the proposed system:

- the spacing between sleepers or rail fastening
- the spacing between axles on a train; and
- the change in the dynamic forces generated by the combined surface roughness of the rails and train wheels when the speed is changed

The propagation model for ground-borne sound and vibration bored from tunnelled sections of railway has been derived from a statistical analysis of the results of measurements of ground-borne sound and vibration from a variety of train types in tunnels both in the UK and France. Separate aspects of the transmission path are addressed by three specific terms to account for:

- absorption and geometric dispersion of the bulk waves from tunnel to surface (a function of depth from railhead to surface);
- absorption and dispersion of the surface wave (a function of horizontal distance from tunnel centre); and
- the effect of tunnel width.

Analysis of the available data for ground-borne sound from trains in bored tunnels indicated that differences in lithology do not have a major influence upon the propagation characteristics.

Ground-borne sound levels (Lp_{ASmax}) near the centre of ground floor and basement rooms are calculated from rms third octave band vertical particle velocities (evaluated for the period whilst a train is passing) outside the building of interest. The conversion to internal ground-borne sound levels is based on the equation proposed by Bolt Beranek and Newman (BBN) / Kurzweil, validated and adjusted through an analysis of measurements carried out during a collaborative study between British Rail and London Underground Limited (LUL).

The CTRL/HS1 ground-borne noise and vibration model is the most highly validated available, having been validated against operational measurements of ground-borne noise and vibration at railway projects in the UK, Singapore and Australia.

Source Vibration Spectrum

The source level adopted for the CTRL/HS1 method is based on a ground surface vibration velocity level measured at 10 m from the track centreline. This source level is then adjusted within the model itself to account for differences in

vehicle speed, trackform and vehicle system dynamics between the source measurement reference vehicle, and the study trackform and vehicle.

A composite source spectrum has been used, based on local and overseas railway vibration velocity measurements. To determine local conditions, measurements were conducted at South Yarra, North Melbourne, Kensington and Hawksburn. Due to the higher speeds at the measurement location, the measurements at Hawksburn were determined to be most appropriate for the Melbourne Metro assessment. These measurements were conducted at distances of 8–11 m from the track centreline. To account for potential differences in system roughness, the spectrum has been adjusted upwards based on the source levels measured for the NEL underground rail project in Singapore between 25–80 Hz. Therefore, this source spectrum represents a conservative approach.

The results of the measurements and the source spectrum adopted for the tender assessment are shown Figure 23 below.

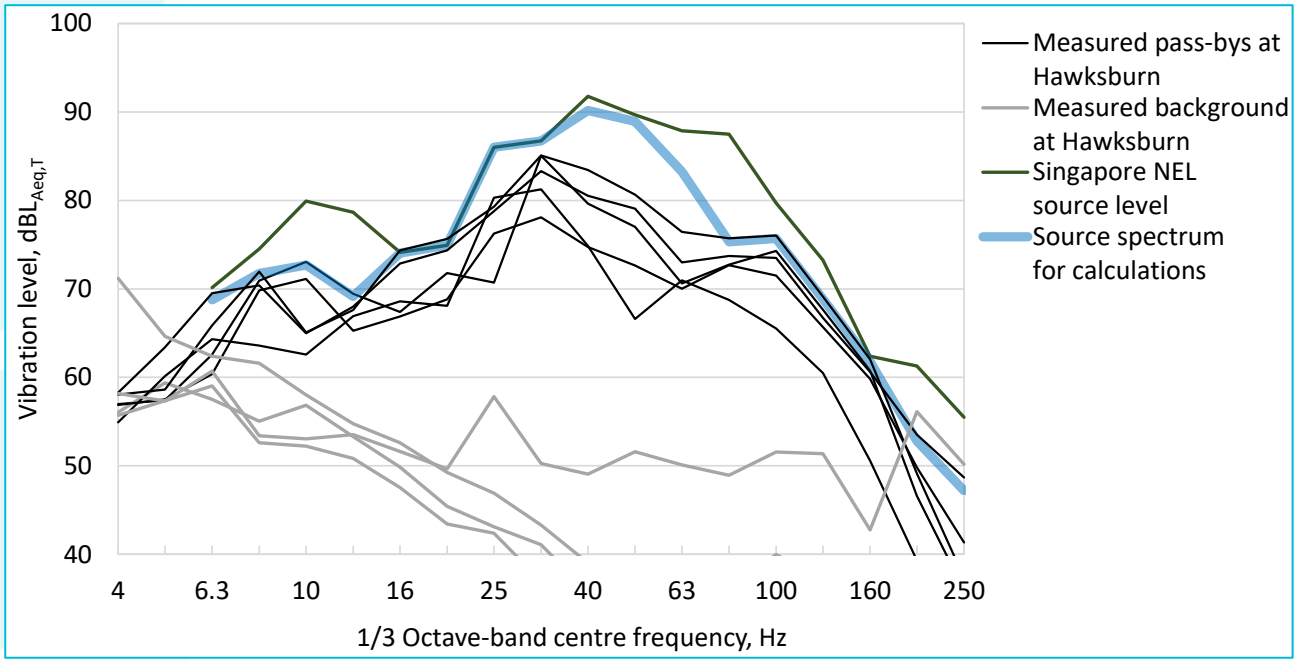

FIGURE 23: SOURCE MEASUREMENT RESULTS AND SOURCE SPECTRUM

Trackform Vibro-Acoustic Performance

Trackform adjustments have been undertaken by adjusting for the Insertion Gain (IG) of the various alternative trackforms which have been calculated using dynamic trackform modelling software. The insertion gains are expressed in decibels with reference to a hypothetical 'highly' stiff reference trackform. The source level is adjusted according to the difference between the insertion gain for the proposed trackform and the insertion gain for the source measurement conditions (ie at-grade ballasted track).

Train/track system insertion gain (ie vibration reduction provided by resilient track system) is dependent on rolling stock physical parameters (eg. Unsprung mass, axle load, axle/bogey spacing). However, final HCMT rolling stock physical parameters have not been provided. Therefore, the train/track system Insertion Gain (vibration reduction provided by resilient track system) is based on system parameters for current Victorian rolling stock, which is not expected to be significantly different to those adopted.

The trackform parameters adopted in the modelling are shown in Table 6.

TABLE 6: TRACKFORM PARAMETERS

System Component/Trackform	Unit	Inertial Reference	Direct fix	Resilient baseplate	Floating slab track
Unsprung mass	kg	1500	1500	1500	1500
Rail					
Bending stiffness	MNm^2	11.85	11.85	11.85	11.85
Mass	kg/m	120	120	120	120
Loss factor	-	0.001	0.001	0.001	0.001
Rail pad					
Stiffness	MN/m^2	40,000	210	210	210
Loss factor	-	0.01	0.2	0.2	0.2
Sleeper					
Stiffness	MN/m^2	-	-	-	-
Mass	kg/m	-	20	20	-
Loss factor	-	-	0.01	0.01	-
Sleeper pad					
Stiffness	MN/m^2	-	28	8.5	-
Loss factor	-	-	0.2	0.2	-
Track slab					
Bending stiffness	MNm^2	-	-	-	1175
Mass	kg/m	-	-	-	3600
Loss factor	-	-	-	-	0.01
Track slab pad					
Stiffness	MN/m^2	-	-	-	20
Loss factor	-	-	-	-	0.2
Tunnel invert					
Stiffness	MN/m^2	7,000	1000	1000	1000
Mass	kg/m	8,000	3668	3668	3668
Loss factor	-	0.01	0.01	0.01	0.01

The resulting Insertion Gains used for this assessment are shown in Figure 24.

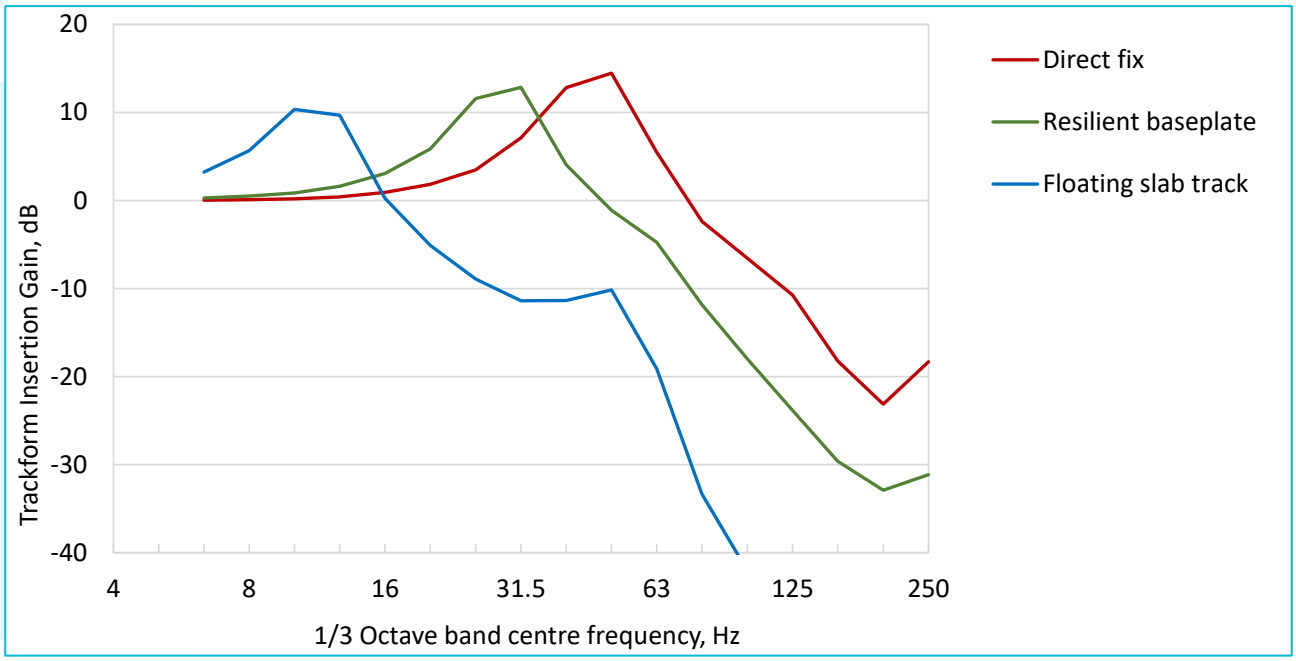

FIGURE 24: INSERTION GAINS FOR TRACKFORMS

Building Response

Ground-borne sound levels (Lp_{ASmax}) near the centre of ground floor and basement rooms are calculated from rms third octave band vertical particle velocities (evaluated for the period whilst a train is passing) outside the building of interest. The conversion to internal ground-borne sound levels is based on the equation proposed by Bolt Beranek and Newman (BBN) / Kurzweil, validated and adjusted through an analysis of measurements carried out during a collaborative study between British Rail and London Underground Limited (LUL).

The CTRL/HS1 ground-borne noise and vibration model is the most highly validated available, having been validated against operational measurements of ground-borne noise and vibration at railway projects in the UK, Singapore and Australia.

To obtain indoor structure-borne noise levels from the predicted outdoor vibration, a conversion factor of -26 dB is used. The floor amplification and per-storey upper floor attenuation used for determining indoor vibration are shown in Table 7.

TABLE 7: INDOOR VIBRATION ADJUSTMENTS USED IN CALCULATIONS.

Adjustment	1/3 Octave-band centre frequency, Hz																
	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250
Floor amplification	1	3	4	5	8	14	14	10	8	6	4	6	-2	-4	-3	0	0
Upper floor (per storey)	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

3 Legislation, Policy and Guidelines

The project environmental requirements as well as the legislation, policy and guidelines which are relevant to the proposed CYP design and construction changes are outlined below.

3.1 Environmental Performance Requirements (EPRs)

As a part of the project approvals, the Minister for Planning developed a series of Environmental Performance Requirements (EPRs) which apply to the project as a whole. A summary of the EPRs applicable to noise and vibration are outlined in Table 8 with corresponding descriptions for each.

The full detail of each EPR and the process that will be required to ensure compliance is required to be presented in a detailed Construction Noise and Vibration Management Plan (CNVMP) for each site. The requirement for the CNVMP is detailed in EPR NV21.

TABLE 8: CONSTRUCTION NOISE AND VIBRATION REQUIREMENTS FROM EPRS

EPR	Overview description
NV1	Requirement to manage construction noise in accordance with EPA Pub. 1254 and as specified in the CNVMP
NV2	Monitor vibration at heritage structures (e.g. Victoria Barracks)
NV3	Predict construction noise and vibration pre-construction, to guide the CNVMP
NV4	Monitor construction noise and vibration
NV5	Prepare and implement a stakeholder communications plan
NV6	External airborne construction noise targets
NV7	Internal airborne construction noise targets
NV8	Construction vibration impacts on structures
NV9	Construction vibration impacts on above ground utilities and infrastructure
NV10	Construction vibration impacts on below-ground infrastructure
NV11	Construction vibration impacts on human comfort
NV12	Construction vibration impacts on sensitive equipment in Parkville and CBD North
NV13	Construction ground-borne noise impacts on human amenity
NV14	Construction ground-borne noise and vibration from blasting
NV15	Construction ground-borne noise impacts on bio-resources
NV16	Operational noise and vibration modelling in compliance with all EPRs
NV17	External airborne operational noise impacts from rail infrastructure (PRINP)
NV18	External airborne operational noise impacts from fixed infrastructure (SEPPN-1)
NV19	Internal ground-borne operational noise impacts from rail infrastructure
NV20	Operational vibration impacts from rail infrastructure
NV21	Preparation of a CNVMP

The EPRs have been written based on guidance from other relevant guidelines, standards and policies both from Australia and internationally. In some EPRs the requirements are adopted directly from these guidance documents. In others, requirements are extracted from guidance documents and modified as relevant to the project. Where requirements differ between the EPRs and the guidance documents, the EPRs take precedence.

A more detailed discussion of how the EPRs relate to specific noise and vibration guidance documents is provided in in Section 3.2 through to Section 3.6.

3.2 Construction noise guidance

The relevant guidelines related to construction noise are the Environmental Guidelines for Major Construction Sites (February 1996) and the Noise Control Guidelines Publication 1254 (October 2008), published by the Victorian EPA. AS/NZS 2107 is also referenced for guidance for spaces with high acoustic sensitivity but not classified as sensitive receivers (as per EPA definitions).

3.2.1 EPA Document 480

The Environmental Guidelines for Major Construction Sites, also known as EPA Document 480, provides measures to control noise emission from construction sites, initiate community consultation, and to restrict construction hours. These measures consist of:

- Fit and maintain appropriate mufflers on earth-moving and other vehicles on the site.
- Enclose noisy equipment.
- Provide noise attenuation screens, where appropriate.
- Where an activity is likely to cause a noise nuisance to nearby residents, restrict operating hours to between 0700 hrs and 1800 hrs weekdays and 0700 hrs to 1300 hrs Saturdays, except where, for practical reasons, the activity is unavoidable.
- Noise should not be above background levels inside any adjacent residence between 2200 hrs and 0700 hrs.
- Advise local residents when unavoidable out-of-hours work will occur.
- Schedule deliveries to the site so that disruption to local amenity and traffic is minimised.
- Conduct a study on the impact of ground vibration from construction activities where these operations occur within 50 m of a building and take appropriate action.
- Minimise air vibrations.

3.2.2 EPA Publication 1254 (Referenced for NV6)

The EPA Noise Control Guidelines, also known as EPA Publication 1254, provide recommendations for protecting nearby residential premises from unreasonable noise. It recommends that commercial and other premises affected by noise should be considered and reasonable measures implemented to reduce impact on these premises. These include;

(i) Community consultation and work scheduling

Community consultation is essential for large-scale projects or high-impact works. Where the community will be significantly impacted, consult on the benefits and drawbacks of different scheduling, planning and remediation options.

(ii) Work requirements

Noise reduction measures should be developed through initial project planning, tenders for equipment and subcontracts. Larger projects should develop a noise management plan (potentially part of a broader environmental management plan) and may require advice from an acoustic specialist, particularly if works are proposed outside of normal working hours.

The following measures apply:

- Where work is conducted in a residential area or other noise-sensitive location, use the lowest-noise work practices and equipment that meet the requirements of the job.
- Site buildings, access roads and plant should be positioned so that the minimum disturbance occurs to the locality. Barriers such as hoardings or temporary enclosures should be used. The site should be planned to minimise the need for reversing of vehicles.
- All mechanical plant is to be silenced by the best practical means with current technology.
- Mechanical plant, including noise-suppression devices, should be maintained to the manufacturer's specifications. Internal combustion engines are to be fitted with a suitable muffler in good repair.
- Fit all pneumatic tools operated near a residential area with an effective silencer on their air exhaust port.
- Install less noisy movement or reversing warning systems for equipment and vehicles that will operate for extended periods, during sensitive times or in close proximity to sensitive sites e.g. broadband sounders in preference to tonal sounders.
- Occupational health and safety requirements for use of warning systems must be followed.
- Turn off plant when not being used.
- All vehicular movements to and from the site are only to occur during the scheduled normal working hours, unless approval has been granted by the relevant authority.
- Where possible, no truck associated with the work should be left standing with its engine operating in a street adjacent to a residential area.
- Special assessment of vibration risks may be needed, such as for pile driving or works structurally connected to sensitive premises.
- Noise from the site needs to comply with the requirements of the schedule, except for unavoidable works and night period low-noise or managed-impact works approved by the local authority.
- Unavoidable works are works that cannot practicably meet the schedule requirements because the work involves continuous work, such as concrete pours, or would otherwise pose an unacceptable risk to life or property, or risk a major traffic hazard. Affected premises should be notified of the intended work, its duration and times of occurrence. The relevant authority must be contacted and any necessary approvals sought.
- Low-noise or managed-impact works are works approved by the local authority that are inherently quiet or unobtrusive (for example, manual painting, internal fit-outs, cabling) or where the noise impacts are mitigated (for example, no impulsive noise and average noise levels over any half hour do not exceed the background) through actions specified in a noise management plan supported by expert acoustic assessment.
- Low-noise or managed-impact works do not feature intrusive characteristics such as impulsive noise or tonal movement alarms.

EPR NV6 provides Airborne Construction Noise Guideline Levels at residential location, as specified within EPA Publication 1254. The following is an extract of the guideline noise levels.

Time Period	Applicable Hours	Guideline Noise Levels, L_{Aeq}	
		Up to 18 months after project commencement	18 months or more after project commencement
Normal Working Hours	7am to 6pm Monday to Friday 7am to 1pm Saturday	No specified Guideline Noise Levels are provided in EPA 1254 – Refer to EPR NV21 for the noise management levels (see note 1)	
Weekend / Evening work	6pm to 10pm Monday to Friday 1pm to 10pm Saturday 7am to 10pm Sunday and Public Holidays	Noise level at any residential premises not to exceed background noise by 10 dB(A) or more.	Noise level at any residential premises not to exceed background noise (L_{A90}) by 5 dB(A) or more.
Night	10pm to 7am Monday to Sunday	Noise is to be inaudible within a habitable room of any residential premises.	

Under EPR NV6, the construction noise and vibration management plan (CNVMP) must address noise levels that exceed the Management Levels specified in Table EPR NV21A for Normal Working Hours. This is an example of where the requirements from guidance documents have been modified by the EPRs.

3.2.3 Highly Sensitive Areas

The above EPA documents do not provide any guidance for highly sensitive areas, such as operating theatres and hospital wards. AS/NZS 2107:2016: *Recommended Design Sound Levels and Reverberation Times for Building Interiors* provides background noise levels to be used as design criteria. In the absence of dedicated construction noise criteria for highly sensitive spaces, the Design Sound Levels for these spaces in AS/NZS 2107 are sometimes used.

EPR NV7 contain requirements for the airborne construction noise guideline targets for internal spaces, based on AS/NZS 2107 requirements. The requirements in NV7 are shown in Table 9.

TABLE 9: NV7 Internal noise levels for sensitive areas (based on AS/NZS 2107).

Type of occupancy/activity	Maximum design sound level, $L_{Aeq,t}$
Intensive care wards	45
Operating theatres	45
Surgeries	45
Wards	40
Classrooms at schools and other educational institutions	45
Places of Worship	45
Other Noise Sensitive Areas (including theatres, concert halls, child care centres, etc)	Depends on intended use. Refer to max levels in AS2107

Underground construction works have the potential to create ground-borne noise impacts. The New South Wales Department of Environment and Climate Change 2009 *Interim Construction Noise Guidelines* provides ground-borne noise levels for residences where “management actions” should be implemented. There levels are referenced in NV13 and Table 10 below.

TABLE 10: EPR NV13 – GROUND-BORNE NOISE LEVELS FOR RESIDENCES, SLEEPING AREAS IN HOSPITAL WARDS, STUDENT ACOOMODATION AND HOTEL ROOMS

Time period	Internal noise level, $L_{Aeq,15min}$
Evening (6pm to 10 pm)	40

Time period	Internal noise level, $L_{Aeq,15min}$
Night (10 pm to 7 am)	35

These levels are only applicable when ground-borne noise levels are higher than airborne noise levels and are assessed at the centre of the most affected habitable room.

3.3 Construction Vibration

For construction projects, various guidelines and standards are often used to assist in the management of construction vibration. These guidelines and standards - for both human comfort and damage to buildings/structures - are outlined below.

DIN 4150-3 (Referenced in NV8)

To assess the potential for building damage, DIN 4150-3 *Structural Vibration Part 3: Effects of vibration on structures* is a German standard which provides vibration targets to avoid damage to building structures from short-term vibration. "Short term" is defined by DIN 4150-3 as "vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated".

NV8 references requirements from DIN 4150-3 for these short term vibration targets. The short-term targets in NV8 (Table NV8-1) referenced from DIN 4150-3 are shown in Table 11.

TABLE 11: EXTRACT OF TABLE NV8-1– SHORT-TERM VIBRATION TARGETS FOR BUILDING STRUCTURES

Structural type	Vibration Velocity, v_i, in mm/s			
	Foundation			Plane of floor of uppermost full storey
	less than 10Hz	10–50Hz	50–100Hz	Frequency mixture
Commercial, Industrial or Similar	20	20 to 40	40 to 50	40
Dwellings or Similar	5	5 to 15	15 to 20	15
Particularly Sensitive Structures, such as heritage buildings	3	3 to 8	8 to 10	8

NV8 references requirements from DIN 4150-3 for vibration targets to avoid damage to building structures for long-term vibration. The long-term vibration targets in NV8 (Table NV8-2) are shown in Table 12.

TABLE 12: EXTRACT OF TABLE NV8-2 – LONG-TERM VIBRATION TARGETS FOR BUILDING STRUCTURES

Type of structure	Vibration velocity, mm/s PPV in horizontal plane at all frequencies
Buildings used for commercial purposes, industrial buildings and similar design	10
Dwellings and buildings of similar design and/or occupancy	5
Structures that have a particular sensitivity to vibration e.g. heritage buildings	2.5

NV10 references requirements from DIN 4150-3 for vibration targets to avoid damage to buried pipework. The below-ground infrastructure targets in NV10 are shown in Table 13.

TABLE 13: DIN 4150-3 – VIBRATION TARGETS FOR BURIED PIPEWORK

Pipe material	Vibration velocity, mm/s PPV
Steel	100
Clay, concrete, reinforced concrete, pre-stressed concrete, metal	80
Masonry, plastic	50

BS 6472-1

To assess impacts on human comfort, BS 6472-1:2008 *Guide to evaluation of human exposure to vibrations in buildings, Part 1: Vibration sources other than blasting* provides a "vibration dose value" (VDV) methodology, which considers both the level of vibration and the duration of the vibration. The VDV approach adopted by BS 6472 is also recommended in the NSW EPA guidelines.

NV11 and NV20 references requirements from BS 6472-1:2008. NV11 relates to VDV targets for construction noise for continuous (TBMs, road headers), intermittent or impulsive vibrations. NV20 relates to VDV targets during the operational phase. The VDV targets for both these EPRs (based on BS 6472-1:2008) are shown in Table 14.

TABLE 14: EXTRACT OF VDV TARGETS IN NV11 AND NV20– VIBRATION DOSE VALUE RANGES

Location	VDV ($ms^{-1.75}$)			
	Day 7:00 am to 10:00 pm		Night 10:00pm to 7:00am	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.2	0.4	0.1	0.2
Offices, schools, educational institutions, places of worship	0.4	0.88	0.4	0.8
Workshops	0.8	1.6	0.8	1.6

ASHRAE VC Curves

To assess vibration impacts on the operation of sensitive equipment (such as microscopes, MRIs and lasers), the American Society of Heating, Refrigerating and Air-Conditioning Engineers 2011 *ASHRAE Handbook – HVAC Applications* provides recommended acceptable vibration criteria for equipment. These criteria for sensitive equipment, often referred to as the VC Curves, are shown in Table 15.

TABLE 15: ASHRAE HANDBOOK – VC CURVES

Equipment	Curve
Bench microscopes up to 100x magnification; laboratory robots	Operating Room
Bench microscopes up to 400x magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators; microelectronics manufacturing equipment; proximity and projection aligners, etc	VC-A
Microsurgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400x; optical equipment on isolation tables; microelectronic manufacturing equipment, such as inspection and lithography equipment (including steppers) to 3 mm line widths	VC-B
Electron microscopes up to 30 000x magnification; microtomes; magnetic resonance imagers; microelectronics manufacturing equipment, such as lithography and inspection equipment to 1 mm detail size	VC-C
Electron microscopes at magnification greater than 30 000x; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment, such as aligners, steppers,	VC-D

Equipment	Curve
and other critical equipment for photolithography with line widths of ½ µm; includes electron beam system	
Unisolated laser and optical research systems; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/4 µm; includes electron beam system	VC-E

3.4 Operational noise

3.4.1 Victorian Passenger Rail Infrastructure Noise Policy

The Victorian Passenger Rail Infrastructure Noise Policy (PRINP) provides targets for airborne noise from train movements. Since the PSA changes affecting rail operations are for underground sections of the railway line, airborne noise impacts are not expected to change.

3.5 Operational vibration

The ASHRAE Handbook provides guidance for operational vibration levels on sensitive equipment, as per for the construction phase. Please see the Construction Vibration section above.

BS 6472-1:2008 provides guidance on human comfort impacts caused by operational vibration, as per for the construction phase. Please see the Construction Vibration section above.

3.6 Residential Impact Mitigation Guidelines

EPR NV21 and SC2 require that a relocation management framework be developed that responds to the Residential Impact Mitigation Guidelines (RIMG). This guideline presents various mitigation measures to be considered based on external predicted noise levels. Table 16 and Table 17 respectively show the mitigation measures to be considered for various levels above background or criteria.

TABLE 16: RIMG GUIDELINE NOISE LEVELS AND MANAGEMENT MEASURES – AIRBORNE NOISE AFFECTING RESIDENCES

Time period	Guideline noise levels	Management measures
Normal working hours		
Mon–Fri: 7:00am–6:00pm **Sat: 7:00am–1:00pm**	External construction $L_{Aeq(15min)}$ > 10dB(A) above pre-existing ambient noise level, L_{Aeq} or 75dB(A) (whichever is higher)	Works Notification Earplugs
Evening / weekend hours and public holidays		
Mon–Fri: 6:00pm–10:00pm **Sat: 1:00pm–10:00pm** **Sun/Pub Hol: 7:00am–10:00pm**	External construction $L_{Aeq(15min)}$ > 5dB(A) above the pre-existing ambient noise level, L_{Aeq}	Works notification Earplugs Individual briefings Phone calls Specific notification Respite offer
Night hours		
Mon-Sun: 10:00pm–7:00am	External construction $L_{Aeq(15min)}$ > 5dB(A) above the pre-existing ambient noise level, L_{Aeq}	Works notification Earplugs Individual briefings Phone calls

		Specific notification Respite offer

TABLE 17: ACOUSTIC TREATMENT GUIDELINE NOISE LEVELS FOR RESIDENCES – AIRBORNE NOISE AFFECTING RESIDENCES.

Day	Relevant time period	Averaging time	Acoustic treatment guideline noise level, dBLAeq(t)
Mon-Fri:	10:00pm–7:00am	1 hour	55
Sat:	10:00pm–7:00am	1 hour	55
Sun / Pub Hol:	10:00pm–7:00am	1 hour	55

Notes:

Predicted at a point 1 m in front of the exposed windows and doors in any façade of a residence.

OR

5dB above the pre-existing ambient noise level, L_{Aeq}, for the corresponding times of day (i.e. the Relevant Time Periods).

Acoustic treatment will only apply where airborne noise levels are predicted to exceed one of the above guideline noise levels on at least 40 days in any six consecutive months.

Alternative accommodation is required to be offered where the total external airborne noise level due to unavoidable works at night (pre-existing ambient, $L_{Aeq(1\ hour)}$, plus airborne noise from Metro Tunnel works), measured or predicted at a point one metre in front of the exposed windows and doors in any façade of a residence, exceeds the higher of:

65dB(A); or

10dB(A) above the pre-existing ambient, L_{Aeq}, noise level.

Between 10:00pm and 7:00am on any day of the week on at least:

10 days in any 15 consecutive days; or

40 days in any six consecutive months.

4 Impact Assessment

4.1 Overview

An environmental risk assessment has been completed by CYP for the proposed Melbourne Metro. The risk-based approach is integral to the Impact Assessment.

4.2 Parkville to CBD North

4.2.1 Project Components

Within this component of the project area, all changes to the proposed design are subterranean. The changes consist of:

- a new tunnel alignment between Parkville Station and CBD North Station and
- relocation of ground support structures encasing shafts at Parkville Station.

Construction activities in this area include operation of the TBM, cross passage excavation and installation of ground support structures. Operational noise and vibration impacts will change due to the new tunnel alignment between Parkville Station and CBD North Station.

The construction-phase and operational-phase noise and vibration impacts of these changes are analysed for this impact assessment.

4.2.2 Existing Conditions

Existing locations potentially affected by the relocation of the Parkville Station ground support structures are the Peter Doherty Institute, the University of Melbourne (UoM) Alan Gilbert building and the UoM medical building.

The noise and vibration sensitive receivers within the Peter Doherty Institute consist of medical equipment, laboratories, teaching spaces and offices. Receivers within the UoM Alan Gilbert building (building 181) consist of teaching spaces, study areas and offices. Receivers within the UoM Medical building consist of medical equipment, laboratories, teaching spaces, study areas, an anatomy museum and offices.

Existing locations potentially affected by the new tunnel alignment between Parkville Station and CBD North Station are UoM Engineering buildings; buildings on the southern side of Grattan Street between Leicester Street and Bouverie Street; buildings in the block bounded by Bouverie Street, Grattan Street, Swanston Street and Lincoln Square; and buildings along Swanston Street between Grattan Street and Queensberry Street.

The noise and vibration receivers within the UoM engineering buildings (buildings 170 and 176) consist of teaching spaces, study areas, laboratories and offices. Receivers along the southern side of Grattan Street consist of student accommodation, offices and the Prince Alfred Hotel. Receivers in the block bounded by Bouverie Street, Grattan Street, Swanston Street and Lincoln Square consist of offices, student accommodation, Trinity College and Ridges on Swanston Hotel. Receivers along Swanston Street consist of mixed-use residential, retail and office buildings.

4.2.3 Risk Assessment

The results of the Risk Assessment are shown in Table 18 overleaf.

TABLE 18: RISK ASSESSMENT FOR PARKVILLE TO CBD NORTH

Impact Pathway	Initial Risk			Relevant Discipline EPRs	Residual Risk		
	Likelihood	Consequence	Inherent Risk Rating		Likelihood	Consequence	Residual Risk Rating
Operation of TBM							
Vibrations from TBM operation exceeding thresholds/limits, impacting on sensitive equipment, property and/or assets	Almost Certain	Moderate	High	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Likely	Moderate	Medium
Noise from TBM operation exceeding thresholds/limits, impacting on sensitive receptors	Almost Certain	Moderate	High	NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Likely	Moderate	Medium
Cross passage excavation							
Vibrations from cross passage excavation exceeding thresholds/limits, impacting on sensitive equipment and receptors	Almost Certain	Moderate	High	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Likely	Minor	Medium
Noise from cross passage excavation exceeding thresholds/limits, impacting on sensitive receptors	Likely	Moderate	Medium	NV1, NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Possible	Minor	Low
Operation							
Vibrations from operation exceeding thresholds/limits, impacting on sensitive receptors and equipment	Likely	Moderate	Medium	NV3, NV12, NV20	Unlikely	Moderate	Low
Noise emissions from operation exceeding thresholds/limits, impacting on sensitive equipment	Likely	Moderate	Medium	NV3, NV19	Unlikely	Moderate	Low

Impact Pathway	Initial Risk			Relevant Discipline EPRs	Residual Risk		
	Likelihood	Consequence	Inherent Risk Rating		Likelihood	Consequence	Residual Risk Rating
Maintenance							
Vibrations from maintenance activities exceeding thresholds/limits, impacting on sensitive equipment and receptors	Possible	Minor	Low	None	Rare/ Remote	Negligible	Very Low
Noise emissions from maintenance activities exceeding thresholds/limits, impacting on sensitive equipment	Possible	Minor	Low	None	Rare/ Remote	Negligible	Very Low

Construction noise and vibration impacts from the TBM operation and cross passage excavation were assigned a residual risk rating of medium, due to the lack of noise and vibration modelling of these activities for the design changes. Modelling of noise and vibration impacts for these construction activities is conducted as part of the Impact Assessment (see Impact Assessment section below), following which the risk ratings are re-evaluated.

Operational noise and vibration impacts from train movements were assigned a residual risk rating of low, due to the lack of ground-borne noise and vibration modelling of train movements on the new alignment. Modelling of operational noise and vibration impacts is conducted as part of the Impact Assessment (see Impact Assessment section below), following which the risk rating as re-evaluated.

Noise and vibration impacts from maintenance activities were assigned a residual risk rating of low, due to typical maintenance activities being low impact and conducted on an occasional basis.

4.2.4 Impact Assessment

Methodology – Construction noise and vibration

The methodological process undertaken for assessing construction noise and vibration impacts for Parkville Station to CBD North Station are discussed in Section 2.2.1. **Results – Construction noise and vibration**

Presented in Table 19 below are the relevant receivers in this project area. It includes addresses, description of these buildings, any heritage considerations and the relevant construction activity impacting them. These have been identified as being relevant to the PSA assessment based on the following criteria:

a. The receivers are currently outside of approved Project Land, and
b. These receivers are impacted due to exposure to vibration impacts from new operations not assessed in the EES and PSA processes, or
c. The distance between the boundary of works (i.e. approved Project Land) and the receivers is reduced due to additional Project Land being sought. This is either as a result of minor changes of the rail alignment, construction of additional station structures and installation of underground support structures

The location of these receivers are also shown in Figure 25 to Figure 27. Each building is identified against a unique Receiver ID.

The summary of prediction results are presented in separate tables for the following scenarios:

a. Table 20: Tunnelling activities- vibration assessments against guideline targets for human comfort (VDV) and ground-borne noise guideline targets.
b. Table 21: Additional construction activities – vibration assessments against guideline targets for human comfort (VDV) and ground-borne noise guideline targets.
c. Table 22: Assessment of vibration for vibration sensitive equipment
d. Table 27: Assessment of Ground-borne noise for bio-resources

TABLE 19 : ASSESSED RECEIVERS PARKVILLE TO CBD NORTH

Receiver ID	Address	Description	Occupancy Type [1]	Affected by Tunnelling Works?	Affected by Additional Construction Works?	Heritage?
1	786 - 798 Elizabeth Street	Peter Doherty Institute Building	Education		Y	N
2	223 Berkeley Street, Carlton	IQ Apartments	Residential		Y	N
3	153- 163 Barry Street, Carlton	Alan Gilbert Building	Education		Y	N
4	220 Berkeley Street/ 225 Grattan St, Carlton	UoM Carpark	Carpark		Y	N
5	214 Berkeley Street, Carlton	UoM building- music practise	Education		Y	N
6	212 Berkeley Street, Carlton	Haymarket Place Eatery	Retail		Y	N
7	143-151 Barry Street, Carlton	Biomedical Research Victoria	Office		Y	N
8	247 - 253 Bouverie Street, Carlton	UoM building	Office	Y		N
9	243 - 245 Bouverie Street, Carlton	UoM building - Trinity College	Education	Y		N
10	205-211 Grattan Street, Carlton	UoM building	Education	Y		N
11	8- 14 Malvina Place Carlton	Grattan Institute	Office	Y		N
12	199 - 203 Grattan Street, Carlton	UoM building	Education	Y		N
13	158 - 164 Bouverie Street, Carlton	UoM building - Services Office	Education	Y		N
14	22 - 40 Lincoln Square, Carlton	Private Car Park - Macquarie Textile Group	Carpark	Y		N
15	18 - 20 Lincoln Square North, Carlton		Education	Y		N
16	623 - 645 Swantston Street, Carlton	UoM - Lincoln House	Education	Y		N
17	609 Swanston Street, Carlton	Tune Hotel	Residential	Y		N
18	599 - 605 Swanston Street, Carlton		Office	Y		N

Notes

1. Many buildings are typically mixed-use. Where multiple occupancy types apply to a building, the worst case type (i.e. lower guideline targets) is listed based on the following orders or priority – 1) residential 2) educational 3) other uses including commercial, retail, etc

FIGURE 25 : MAPS SHOWING ASSESSED RECEIVERS, PARKVILLE TO CBD NORTH (MAP 1 OF 3)

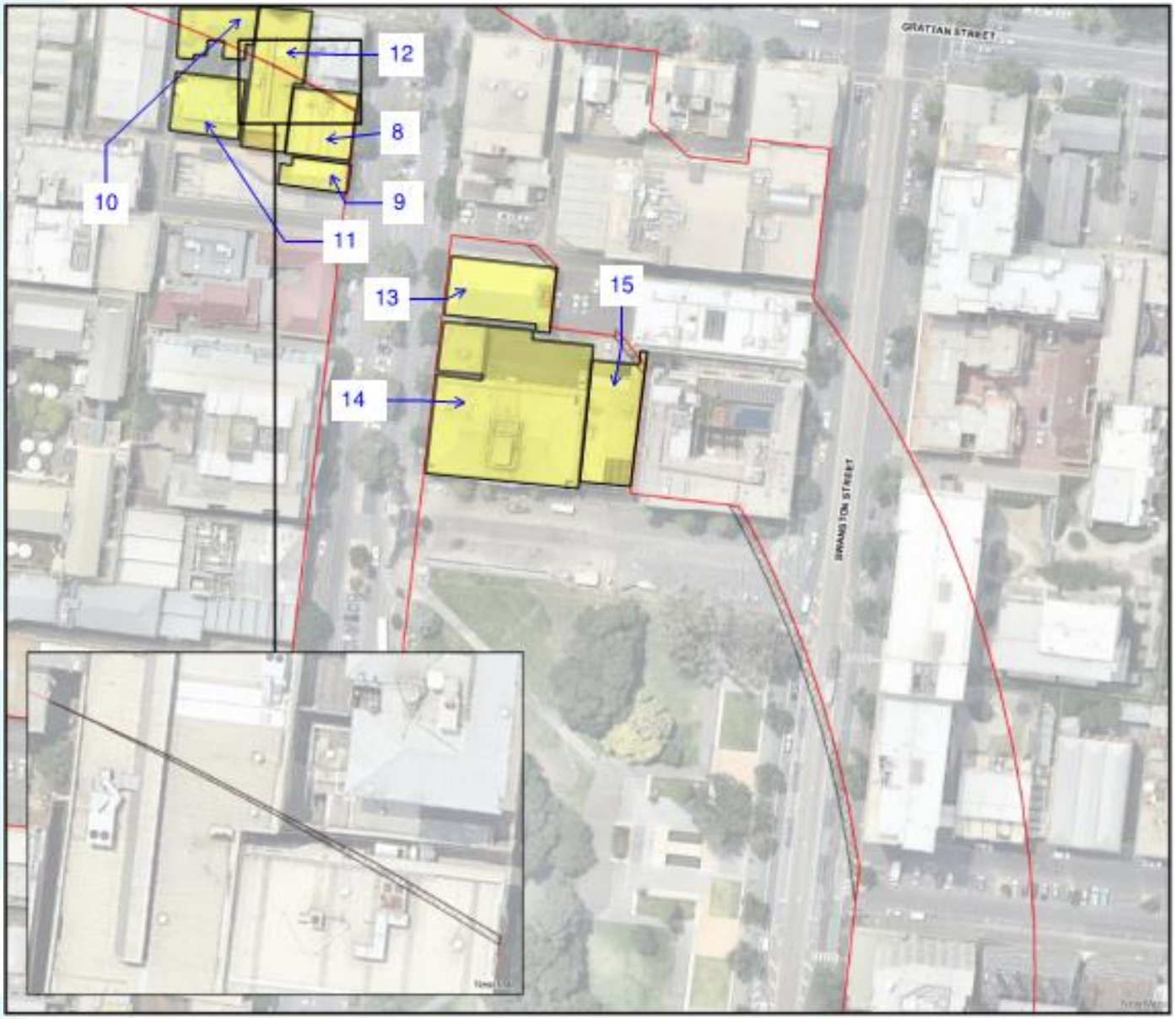

FIGURE 26 : MAPS SHOWING ASSESSED RECEIVERS, PARKVILLE TO CBD NORTH (MAP 1 OF 3)

FIGURE 27: MAPS SHOWING ASSESSED RECEIVERS, PARKVILLE TO CBD NORTH (MAP 3 OF 3)

TABLE 20: PARKVILLE TO CBD NORTH TUNNELLING ACTIVITIES- VIBRATION ASSESSMENT, VDV DAY, VDV NIGHT AND GROUND BORNE NOISE

Receiver ID	Occupancy type	VDV Day			VDV Night			Ground Borne Noise		
		PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome, relative to night guideline target (See Note 2)	NVIA Assessment outcome (See Note 2)	Has PSA works increased impact assessment outcome?
8	Office	below 2x max	below 2x max	N	below max	below 2x max	N	NA	-	N
9	Education	below max	below max	N	below max	below max	N	5-10 dB Note 3	-	N
10	Education	below 2x max	below 2x max	N	below max	below max	N	5-10 dB Note 3	-	N
11	Office	below max	below max	N	below max	below max	N	NA	-	N
12	Education	below 2x max	below 2x max	N	below max	below max	N	5-10 dB Note 3	-	N
13	Education	below max	above 2x max	N	below max	below 2x max	N	5-10 dB Note 3	> 10 dB	N
14	Carpark	below pref	below max	N	below pref	below max	N	NA	-	N
15	Education	below max	below 2x max	N	below max	below 2x max	N	5-10 dB Note 3	> 10 dB	N
16	Education	below pref	below pref	N	below pref	below pref	N	below Note 3	-	N
17	Residential	below 2x max	below pref	Y Note 4	above 2x max	-	Y Note 4	> 10 dB	-	Y Note 4
18	Office	below max	below max	N	below max	below max	N	NA	-	N

Notes

1. For the VDV (Day and Night, whichever is relevant) the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = below maximum guideline target (low probability of adverse comment), 3 = < 2 x maximum guideline target (adverse comment possible), 4 = > 2 x maximum guideline target (adverse comment probable)
2. For the Groundborne noise assessment, the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = 0 – 5 dB above night guideline target/ below evening guideline target, 3 = 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target, 4 = 10 dB above night guideline target/ > 5 dB (A) above evening . As per the EPR requirements, this assessment has been carried out for residences, hospital wards, student accommodation and hotel rooms. It has also been carried out for buildings tagged as educational facilities.
3. As ground-borne noise guideline targets in NV13 of the EPRs specifically relate to residences, hospital wards, student accommodation and hotel rooms, the assessment for educational facilities has been completed by comparing the predicted ground-borne noise levels against the guideline target air-borne noise levels for a classroom at schools and other educational institutions of 45 dB(A) listed in NV7 of the EPRs.
4. It is likely that the increase in assessment impact is due to this receiver previously being assessed in the NVIA as a commercial premise and not a residence. The groundborne noise levels for this receiver were not assessed in the NVIA, therefore no like-for-like comparison is available.

TABLE 21: PARKVILLE TO CBD NORTH ADDITIONAL CONSTRUCTION ACTIVITIES - VIBRATION ASSESSMENT FOR VDV DAY, VDV NIGHT AND GROUND BORNE NOISE

Receiver ID	Occupancy type	VDV (Day) PSA Assessment outcome (See Note 1)	VDV (Day) NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment outcome?	VDV (Night) PSA Assessment outcome (See Note 1)	VDV (Night) NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	Ground Borne Noise PSA Assessment outcome (See Note 2)	Ground Borne Noise NVIA Assessment outcome (See Note 2)	Has PSA works increased impact assessment outcome?
1	Education	below pref	below 2x max	N	-	below 2x max	N	below [Note 3]	-	Note 4
2	Residential	below pref	below 2x max	N	-	below pref	N	below	-	N
3	Education	below pref	below 2x max	N	-	below 2x max	N	0-5 dB [Note 3]	-	Note 4
4	Carpark	below pref	below 2x max	N	-	below 2x max	N	-	-	N
5	Education	below pref	below pref	N	-	below pref	N	below [Note 3]	-	Note 4
6	Retail	below pref	below pref	N	-	below pref	N	-	-	N
7	Office	below pref	below max	N	-	below max	N	-	-	N

Notes

1. For the VDV (Day and Night, whichever is relevant) the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = below maximum guideline target (low probability of adverse comment), 3 = < 2 x maximum guideline target (adverse comment possible), 4 = > 2 x maximum guideline target (adverse comment probable)
2. For the Groundborne noise assessment, the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = 0 – 5 dB above night guideline target/ below evening guideline target, 3 = 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target, 4 = 10 dB above night guideline target/ > 5 dB (A) above evening . As per the EPR requirements, this assessment has been carried out for residences, hospital wards, student accommodation and hotel rooms. It has also been carried out for buildings tagged as educational facilities.
3. As ground-borne noise guideline targets in NV13 of the EPRs specifically relate to residences, hospital wards, student accommodation and hotel rooms, the assessment for educational facilities has been completed by comparing the predicted ground-borne noise levels against the guideline target air-borne noise levels for a classroom at schools and other educational institutions of 45 dB(A), as listed in NV7 of the EPRs.
4. The groundborne noise levels for this receiver were not assessed in the NVIA, therefore no like-for-like comparison is available.

TABLE 22: VIBRATION ASSESSMENT FOR SENSITIVE EQUIPMENT

Location	Vibration Sensitive equipment	Vibration assessment reference	Vibration Assessment due to PSA additional works	NVIA Predicted assessment	Has PSA works increased impact assessment outcome? Comment
Peter Doherty Institute					
Basement	Electron Microscope	VC-A 50 µm/s	32 µm/s	172 µm/s	N
Ground	Auditorium	operating room 100 mm/s	23 µm/s	105 µm/s	N
Level 1	Genomics Room	VC-C 12.5 µm/s	13 µm/s	32 µm/s	N
Level 7	Microscopy	VC-A 50 µm/s	5 µm/s	22 µm/s	N
Level 8	Photon	VC-C 12.5 µm/s	4 µm/s	63 µm/s	N

TABLE 23: GROUND BORNE NOISE ASSESSMENT FOR BIO-RESOURCES

Location	Guideline Targets		Vibration			Groundborne Noise		
	Vibration Guideline Target	Ground Borne Noise Target	Vibration Assessment due to additional PSA works	NVIA Predicted assessment	Has PSA works increased impact assessment outcome?	Groundborne noise due to additional PSA works	NVIA Predicted assessment	Has PSA works increased impact assessment outcome?
Peter Doherty Institute								
Level 8	VC-A 50 µm/s	< 50 dBL	4 µm/s	16 µm/s	N	< 50 dBL	< 50 dBL	N
Level 9		< 50 dBL	4 µm/s	13 µm/s	N	< 50 dBL	< 50 dBL	N
Level 9		< 50 dBL	4 µm/s	13 µm/s	N	< 50 dBL	< 50 dBL	N

Discussion of construction vibration and ground-borne vibration results

The PSA assessment shows that the noise and vibration impacts have not generally increased as a result of the proposed work. In the tables above, the objective assessment shows that the impact has increased for receiver ID # 17. However, this is not due to increased levels of noise and vibration resulting from proposed works, rather because it is likely that the NVIA assessment considered this mixed-use receiver as a commercial property rather than a residential receiver, which has lower guideline targets.

Furthermore, assessments for ground-borne noise assessments have been completed for education institutions, which were not completed in the NVIA. Predicted GBN levels at education facilities exceed 45dBLAeq, 15 minutes, which is the guideline target for classrooms under the EPR NV7.

Results- Operational noise and vibration

As per the EES and PSA processes and assessment, ground-borne noise is the more onerous criteria than vibration dose value (vDv). The predicted ground-borne noise levels, for the trackform mitigation design used in the EES and PSA processes, are shown in Table 24.

TABLE 24: PREDICTED OPERATIONAL GROUND-BORNE NOISE LEVELS WITH MITIGATION.

Address	Trackform	Receiver Type	Predicted ground-borne noise level, $dBL_{As,max}$
Melbourne Uni. Building 175	Floating slab track	Cinema/Public hall	11
Melbourne Uni. Building 354	Floating slab track	Residential	13
Melbourne Uni. Building 368	Floating slab track	Residential	13
Prince Alfred Hotel	Floating slab track	Retail space	13
Melbourne Uni. Building 257	Floating slab track	Office	13
Melbourne Uni. Building 269	Floating slab track	Office	13
Melbourne Uni. Building 384	Resilient baseplate	Office	32
Melbourne Dental Clinic	Resilient baseplate	Education/worship	33
Trinity College	Resilient baseplate	Education/worship	32
Ridges Hotel	Resilient baseplate	Residential	32
640 Swanston Street	Resilient baseplate	Residential	31
604 Swanston Street	Resilient baseplate	Residential	30
127 Pelham Street	Resilient baseplate	Residential	30
586-590 Swanston Street	Resilient baseplate	Residential	31
580 Swanston Street	Resilient baseplate	Residential	31
558 Swanston Street	Resilient baseplate	Residential	30
550 Swanston Street	Resilient baseplate	Office	30
528 Swanston Street	Resilient baseplate	Residential	30
599 Swanston Street	Resilient baseplate	Retail space	30
Queensberry Hotel	Resilient baseplate	Residential	31

The vibration-sensitive equipment and highly sensitive areas in the vicinity of the new alignment are located within the University of Melbourne (UoM) building 261 and building 174. Operational vibration levels have been predicted for these locations, and are shown in Table 25.

TABLE 25: PREDICTED OPERATIONAL VIBRATION LEVELS WITH MITIGATION.

Location	Trackform	Sensitive equip / highly sensitive area	Predicted maximum vibration level
Ground, UoM building 261	Floating slab track	Helium Ion Microscope	45 µg (10 to 90 Hz) 2 µg (> 90 Hz)
Level 1, UoM building 174	Floating slab track	Lasers: continuous	17.1 µm/s

The noise and vibration levels shown in Table 24 and Table 25 above are within the criteria set by the approved EPRs.

Analysis

The construction noise and vibration modelling results above indicate that the impacts are similar to the EES and PSA processes and assessment.

The operational noise and vibration modelling results indicate that operational noise and vibration impacts can comply with the existing Environmental Performance Requirements (EPRs).

Regarding construction noise and vibration impacts from the TBM operation and cross passage excavation, the Impact Assessment indicates that the risks are not significantly changed compared to the EES and PSA processes and assessment. Therefore, the risk ratings are as per the EES and PSA processes.

Regarding operational noise and vibration impacts from train movements, the Impact Assessment indicates that the Environmental Performance Requirements (EPRs) are able to be met with appropriate mitigations. Therefore, the likelihood has been changed to “unlikely”, resulting in a residual risk of low.

The next steps, were modelling identifies the potential for works to impact on buildings, a condition assessment will be undertaken (in line with EPR NV9), the asset owner will be consulted (in line with EPR NV5), and vibration targets will be established (in line with EPRs NV6 – NV15). Furthermore, the Noise and Vibration Management Plan will include a vibration monitoring program, which will aim to demonstrate compliance with the relevant vibration guideline targets, and will include details of remedial action where required.

This modelling is currently being undertaken and will be carried out across the alignment as the design is refined and greater detail of building structure, equipment and ground movement is known (in line with EPR NV3). The findings from these assessments will continue to inform design. Impacted building owners and occupiers are currently, and will continue to be, informed of any potential impacts that may arise (in line with NV5). A Noise and Vibration Management is being prepared for review by the Independent Auditor (in line with EPRs NV21).

4.2.5 Stakeholders

MMRA, with the assistance of CYP, will be undertaking consultation in relation to draft Planning Scheme Amendment GC82. This includes affected Councils and key landowners/occupiers. In recognition that project progress and decisions can be enhanced through dialogue with the community and relevant stakeholders, MMRA has developed core principles and goals for the planning and construction of the project, described in Table 14. CYP shares these principles and goals. Furthermore, the findings from this series of impact assessments will inform refinement of the Communication and Stakeholder Engagement Strategy.

TABLE 26: PRINCIPAL AND GOALS OF THE STAKEHOLDER AND ENGAGEMENT STRATEGY

Principle	Goal
Effective	Engagement is open, consistent, inclusive, accessible and transparent throughout planning and delivery of the project
Timely	Engagement spans all stages of the project, ensuring information is provided to stakeholders as the project develop and feedback is responded to and incorporated in the project’s development
Meaningful	Engagement is clear on the elements of this project that can be influenced by the community and stakeholders, how the feedback will be used and is explicitly on which elements of the project are fixed and the reason for this
No surprises	Engage early to gain understanding of interests, concerns, requirements and preferred outcomes. Close the loop to determine how feedback has been considered

A three phase approach has been developed. Phase 1 – Early Engagement, Phase 2 - Engagement to support public display of draft PSA and Phase 3: Engagement post PSA. The Consultation and Summary Report provides further detail of the process and outcomes and next steps.

Phase 1: Early Engagement

Key stakeholders –government agencies / entities /precinct based

Engagement was focused on briefing key stakeholders particularly government departments and agencies, and Councils on the proposed changes to the Project Land. MMRA and CYP held stakeholder meetings to outline the PSA process and to obtain feedback leading up to submission of the draft PSA to the Minister for Planning. Where possible, MMRA and CYP used existing stakeholder meetings to discuss the PSA. Key messages were high level with the provision of information tailored to the specific needs of the stakeholder.

CYP and MMRA held meetings with each of the following stakeholder stakeholders as part of the ongoing stakeholder engagement strategy:

- City of Maribyrnong
- City of Melbourne
- City of Port Phillip
- City of Stonnington
- DELWP
- EPA
- Heritage Victoria
- Melbourne Water
- Parkville Precinct Reference Group
- Public Transport Victoria (PTV)/TfV
- State Library
- Transport for Victoria (TfV)
- VicRoads.

Landowner/Tenant Engagement

Strata divestment will be required for the proposed CYP design and construction changes to Project Land. Further, temporary occupation may also be required for the Project Land changes at 2 and 2A Chambers Street, South Yarra, for the purposes of the Rail Infrastructure Alliance (RIA), which is yet to be appointed.

MMRA commenced early engagement with the impacted property owners and tenants as part of PSA GC82 and will continue to do so throughout the PSA process.

Letters were sent to landowners and tenants about the proposed changes to Project Land in PSA GC82. The letters outlined the impact to their property, the planning process, how to be involved and how to contact the project for assistance or support.

MMRA and CYP held meetings with each of the following stakeholders as part of the ongoing stakeholder engagement strategy:

- Capitol Theatre
- Federation Square
- MATC
- Melbourne Central
- Manchester Unity
- QV Building
- RMIT University
- University of Melbourne.

Road Surface Works

A number of roads will be included in the draft PSA to enable construction management and some legacy roadworks. Engagement with stakeholders will occur before these permanent changes are undertaken. The nature of the road surface works and the broad timelines (where available) was provided in letters to relevant stakeholders.

Phase 2: Engagement to support public display of draft PSA

The PSA will be on display for 30 calendar days with the following proposed communications tools.

Targeted Letters

Information packs were provided to landowners and tenants, tailored to whether the proposed impact on the property is as follows:

- newly within the Project Land
- newly within the DDO
- an increase in the Project Land
- an increase in the DDO

- adjacent to the road surface works

Strata divestment and DDO-related change information packs included:

- Letters to landowners advising of the proposed changes to the PSA and potential strata divestment/ a potential Design and Development Overlay (DDO) on their property
- Maps relevant to the property
- Invitation to provide feedback online or contact the project team
- The information packs will outline the time frames for the PSA process, opportunity to provide feedback, the strata divestment process (if relevant) and address any immediate questions.

The draft PSA and supporting documents will be published on the Metro Tunnel website for 30 calendar days. An online feedback form will also be made available for the duration of the draft PSA public display period for landowners and tenants to provide feedback on the PSA process and potential impacts on their property. These comments will be responded to, as outlined in Phase 3 of the consultation process. A consultation summary report will be produced to support formal submission of draft Amendment GC82.

Phase 3: Engagement post PSA

CYP will provide a response and update on the issues raised to prescribed stakeholders, key stakeholders, Reference Groups, and the community. Prescribed stakeholders will receive a response on their feedback including through comprehensive briefings.

Key stakeholders will be responded to formally in writing, and in stakeholder meetings. CYP will include presentations on the feedback received to the Parkville Precinct Reference Group and Community Reference Groups. Organisations and members of the community who provide feedback either online through the survey or in writing will be responded to, where email or address details are provided.

In accordance with the existing approved Environmental Performance Requirements and the project's contractual Project Scope & Technical Requirements, further detailed technical assessments are being undertaken including of building and asset condition, ground movement, groundwater, noise and vibration, and Electro Magnetic Interference (EMI). These assessments variously involve stakeholder consultation, and are used to inform design and construction of the project

.

4.2.6 Environmental Performance Requirements

The EPRs that apply to the changes in the Parkville to CBD North component are:

- NV1: Construction Noise Criteria
- NV3: Noise and Vibration Modelling – Design
- NV4: Noise and Vibration Monitoring – Construction
- NV5: Communications Plan
- NV6: Airborne Construction Noise Guideline Targets (External)
- NV7: Airborne Construction Noise Guideline Targets (Internal)
- NV8: Vibration Guideline Targets for Structures
- NV9: Vibration Guideline Targets for Above-ground Utility Assets and Infrastructure
- NV10: Vibration Guideline Targets for Below-ground Utility Assets and Infrastructure
- NV11: Vibration Dose Values (Human Comfort)
- NV12: Sensitive Equipment Guideline Targets
- NV13: Ground-borne (Internal) Noise Guideline Targets for Amenity
- NV15: Bio-resources and Sensitive Research
- NV16: Noise and Vibration Modelling
- NV19: Ground-borne Noise Guideline Targets for Operation
- NV20: Vibration Guideline Targets for Operation
- NV21: Construction Noise and Vibration Management Plan

The proposed Planning Scheme Amendment results in some change to the intensity and location of noise and vibration impacts, however the nature of the impacts is not significantly changed. The Impact Assessment indicates that the EPRs are able to be met if the proposed PSA is approved.

Therefore, the current EPRs remain appropriate for the PSA, and no changes to the EPRs are required or proposed.

4.2.7 Assumption and Limitations

The construction noise and vibration assessment is based on the current construction methodology, which may be revised as the project progresses. EPR NV3 ensures that as the design evolves, so too will the associated modelling. Specifically, NV3 states that *prior to commencement of shaft construction and prior to commencement of main works, each Works Package contractor must appoint a suitably qualified acoustic and vibration consultant to predict construction noise and vibration (through modelling) and update the modelling to reflect current construction*

methodology, site conditions and specific equipment noise and vibration levels (this will require noise and vibration measurements). **The model is to be used to determine appropriate mitigation(s) to achieve the EPRs. Furthermore, the acoustic and vibration consultant must document the modelling and mitigation investigation in a Construction Noise and Vibration Assessment Report for review by the Independent Environmental Auditor. This report must provide the basis for the development of the Construction Noise and Vibration Management Plan required under EPR NV21. Also, the model must consider airborne noise to residential and non-residential receivers, ground-borne noise at residences, blasting vibration and ground-borne vibration. EPR NV4 ensures the model developed during the Design Stage should be updated / calibrated using the results of the noise and vibration monitoring to provide more accurate predictions of the noise and vibration levels associated with ongoing and future construction works.** Source noise and vibration levels of specific construction equipment are likely to vary, however the source levels used for the assessment typically represent worst-case equipment levels. For each scenario, all construction equipment is modelled as operating simultaneously, which is unlikely to occur in practice.

The operational noise and vibration assessment is based on the updated project description rail alignment, which may be revised as the project progresses. Train source levels are based on measurements of existing Victorian rollingstock, therefore differences in vibration source characteristics between existing and HCMT rollingstock are not included. Trains are modelled as travelling at the “line speed” (speed limit) of the track at all times, although it is likely that trains will be travelling at lower speeds in some cases.

Where information is not currently available, conservative assumptions have been used for this assessment. Therefore, it is expected this assessment represents worst-case conditions and in many cases the noise and vibration impact will be lower than predicted.

Conservative assumptions include:

1. For conversion of PPV to RMS for Rock Bolting construction processes, a crest factor of 5 has been assumed, which is deemed to be conservative.
2. Construction equipment is modelled as operating simultaneously, which is unlikely to occur in practice and deemed to be conservative.
3. Operational groundborne noise and vibration has been calculated based on conservative reference source vibration levels and vibration isolating track system insertion gains.

4.3 CBD North Station

4.3.1 4.3.1 Project Components

Within this component of the project area, all changes to the proposed design are subterranean. The changes consist of:

- ground support structures encasing shafts at CBD North Station
- a new tunnel alignment between CBD North Station and Lonsdale Street.

Additional strata (underground) is required for ground support structures to accommodate the change in rail alignment. Swanston Street, in between CBD North Station and the northern side of Lonsdale Street.

Activities in this area include excavation, cross passage excavation and installation of ground support structures. The impacts of these construction-phase and operational-phase changes are analysed for this impact assessment.

The construction-phase noise and vibration impacts of these changes are analysed for this impact assessment.

4.3.2 Existing Conditions

Existing locations potentially affected by the construction of underground support structures are the Verve Apartments mixed-use building, 81 Franklin Street, RMIT buildings 14, 39 and 80, the Oxford Scholar hotel, 19-37 A'Beckett St, 18-20 Little LaTrobe Street, 30 Little LaTrobe Street, 224 LaTrobe Street and 393-397 Swanston Street.

Existing locations potentially affected by the construction of the widened alignment along Swanston Street are 393-397 Swanston Street, RMIT buildings 8, 10, 12, 14, 16, 22 and 80, the State Library forecourt, Melbourne Central shopping centre and 333 Swanston Street.

4.3.3 Risk Assessment

The results of the Risk Assessment are shown in Table 27.

TABLE 27: RISK ASSESSMENT FOR CBD NORTH STATION

Impact Pathway	Initial Risk			Relevant Discipline EPRs	Residual Risk		
	Likelihood	Consequence	Inherent Risk Rating		Likelihood	Consequence	Residual Risk Rating
Excavation							
Vibrations from excavation exceeding thresholds/limits, impacting on sensitive equipment and receptors	Almost Certain	Moderate	High	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12 and NV21	Likely	Minor	Medium
Noise emissions from excavation exceeding thresholds/limits, impacting on sensitive receptors	Likely	Moderate	Medium	NV1, NV3, NV4, NV5, NV6, NV13 and NV21	Possible	Minor	Low
Cross passage excavation							
Vibrations from cross passage excavation exceeding thresholds/limits, impacting on sensitive equipment and receptors	Almost Certain	Moderate	High	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, and NV21	Likely	Minor	Medium
Noise from cross passage excavation exceeding thresholds/limits, impacting on sensitive receptors	Likely	Moderate	Medium	NV1, NV3, NV4, NV5, NV6, NV7, NV13 and NV21	Possible	Minor	Low
Ground support structure							
Vibrations from piling exceeding thresholds/limits, impacting on sensitive equipment and receptors	Almost Certain	Moderate	High	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, and NV21	Likely	Minor	Medium
Noise emissions from piling exceeding thresholds/limits, impacting on sensitive receptors and sensitive equipment	Likely	Moderate	Medium	NV1, NV3, NV4, NV5, NV6, NV7, NV13, and NV21	Possible	Minor	Low
Operation							
Vibrations from operation exceeding thresholds/limits, impacting on sensitive receptors and equipment	Likely	Moderate	Medium	NV3, NV20	Unlikely	Moderate	Low
Noise emissions from operation exceeding thresholds/limits, impacting on sensitive equipment	Likely	Moderate	Medium	NV3, NV19	Unlikely	Moderate	Low
Maintenance							
Vibrations from maintenance activities exceeding thresholds/limits, impacting on sensitive equipment and receptors	Rare/ Remote	Negligible	Very Low	Not applicable	Rare/ Remote	Negligible	Very Low
Noise emissions from maintenance activities exceeding thresholds/limits, impacting on sensitive equipment	Rare/ Remote	Negligible	Very Low	Not applicable	Rare/ Remote	Negligible	Very Low

Construction noise and vibration impacts from cross passage excavation and piling were assigned a residual risk rating of medium, due to the lack of noise and vibration modelling of construction activities with the design changes. Modelling of noise and vibration impacts for these construction activities is conducted as part of the Impact Assessment (see Impact Assessment section below), following which the risk ratings are re-evaluated.

Operational noise and vibration impacts from train movements were assigned a residual risk rating of low, due to the EES and PSA processes and assessment showing that the criteria can be met with appropriate mitigation.

Noise and vibration impacts from maintenance activities were assigned a residual risk rating of low, due to typical maintenance activities being low impact and conducted on an occasional basis.

4.3.4 Impact Assessment

Methodology – Construction noise and vibration

The methodological process undertaken for assessing construction noise and vibration impacts at CBD North Station are discussed in Section 2.2.1.

Results – Construction noise and vibration

Presented in Table 28 below are the relevant receivers in this project area. It includes addresses, description of these buildings, any heritage considerations and the relevant construction activity impacting them. These have been identified as being relevant to the PSA assessment based on the following criteria:

a. The receivers are outside of approved Project Land; and
b. These receivers are impacted due to exposure to vibration impacts from new operations not assessed in the EES and PSA processes, or
c. The distance between the boundary of works (i.e. approved Project Land) and the receivers is reduced due to additional Project Land being sought. This is either as a result of minor changes of the rail alignment, construction of additional station structures and installation of underground support structures

The location of these receivers are also shown in Figure 28 and Figure 29. Each building is identified with a unique Object ID number based on GIS building data provided by MMRA.

The summary of prediction results are presented in separate tables for the following scenarios:

a. Table 29: Assessment of vibration level against long-term vibration likelihood of causing building damage. The assessment has been conducted for all building types but only reported for heritage buildings for simplicity. Vibration levels are significantly lower than guideline targets for all other building types. Additionally long term targets are used for the assessments as these are more onerous compared with the short-term guideline targets.
b. Table 30: Tunnelling activities- vibration assessments against guideline targets for human comfort (VDV) and ground-borne noise guideline targets. (Note: tunnelling activities include TBM and roadheader operations, such as the mining of adits)
c. Table 31: Additional construction activities – vibration assessments against guideline targets for human comfort (VDV) and ground-borne noise guideline targets.

Analysis

The construction noise and vibration modelling results above indicate that the impacts are similar to the EES and PSA processes and assessment.

Regarding construction noise and vibration impacts, the Impact Assessment indicates that the risks are not significantly changed compared to the EES and PSA processes and assessment. Therefore, these risk ratings are as per the EES and PSA processes.

The next steps have been identified in Section 4.2.4, ‘Analysis’.

TABLE 28: ASSESSED RECEIVERS IN CBD NORTH

Receiver ID	Address	Description	Occupancy Type [1]	Affected by Tunnelling Works?	Affected by Additional Construction Works?	Heritage?
19	499 - 511 Swanston Street, Carlton	Brookfield Multiplex, Audi, Maserati, etc	Office	Y	Y	N
20	483 Swanston Street, Melbourne	Verve501 Apartment	Residential	Y	Y	N
21	34 - 38 Franklin Street, Melbourne	Mac's Hotel	Residential	Y	Y	N
22	65 - 77 Franklin Street, Melbourne	RMIT Building 49	Education	Y	Y	Y
23	459 - 469 Swanston Street, Melbourne	RMIT Building 49	Education	Y	Y	Y
24	427 - 457 Swanston Street, Melbourne	RMIT Building 80	Education	Y	Y	N
25	427 Swanston Street, Melbourne	RMIT Building 81- Oxford Scholar Hotel 427	Education	Y	Y	Y
26	414 - 418 Swanston Street, Melbourne	RMIT Building 14	Education	Y	Y	N
27	394 - 412 Swanston Street, Melbourne	RMIT Building 12	Education	Y	Y	N
28	124 La Trobe Street, Melbourne	RMIT Building 9	Education		Y	N
29	392 Swanston Street, Melbourne	RMIT Building 10	Education	Y	Y	N
30	360 Swanston Street, Melbourne	RMIT Building 8	Education	Y	Y	N
31	124 La Trobe Street, Melbourne	RMIT Building 28	Education	Y	Y	N
32	124 La Trobe Street, Melbourne	RMIT Building 6	Education	Y	Y	N
33	124 La Trobe Street, Melbourne	RMIT Building 49	Education	Y	Y	N
34	124 La Trobe Street, Melbourne	RMIT Building 28	Education	Y	Y	N

Receiver ID	Address	Description	Occupancy Type [1]	Affected by Tunnelling Works?	Affected by Additional Construction Works?	Heritage?
35	124 La Trobe Street, Melbourne	RMIT Building 24	Education	Y	Y	N
36	344 Swanston Street, Melbourne	RMIT Building 16 - Storey Hall	Education	Y	Y	Y
37	330 - 334 Swanston Street, Melbourne	RMIT Building 22	Education	Y	Y	N
38	19 - 37 A'Beckett Street, Melbourne	A'Beckett Tower	Residential		Y	N
39	22 - 32 A'Beckett Street, Melbourne	Brady Hotel	Residential		Y	N
40	34 - 36 Little La Trobe Street, Melbourne		Retail		Y	N
41	38 - 40 Little La Trobe Street, Melbourne		Office		Y	N
42	393 - 397 Swanston Street, Melbourne	Deakin House	Education	Y	Y	N
43	224 - 252 La Trobe Street, Melbourne	Aurora Development - office + carpark	Office		Y	N
44	183- 265 Swanston Street, Melbourne	Melbourne Central	Retail		Y	N
45	335 - 347 Swanston Street, Melbourne	Cross Culture Apartments	Residential		Y	Y
46	329 - 333 Swanston Street, Melbourne	Cross Culture Church	Place of Worship		Y	Y
47	304 - 328 Swanston Street, Melbourne	State Library of Victoria	Office	Y	Y	Y
48	300 Swanston Street, Melbourne	QV2 Apartments	Residential		Y	N
49	222 Lonsdale Street, Melbourne	Sensis Building	Residential		Y	N

Receiver ID	Address	Description	Occupancy Type [1]	Affected by Tunnelling Works?	Affected by Additional Construction Works?	Heritage?

Notes

1. **Many buildings are mixed-use. Where multiple occupancy types apply to a building, the worst case type (i.e. lower guideline targets) is listed based on the following orders or priority – 1) residential 2) educational 3) other uses including commercial, retail, etc**

FIGURE 28: ASSESSED RECEIVERS IN CBD NORTH (MAP 1 OF 2)

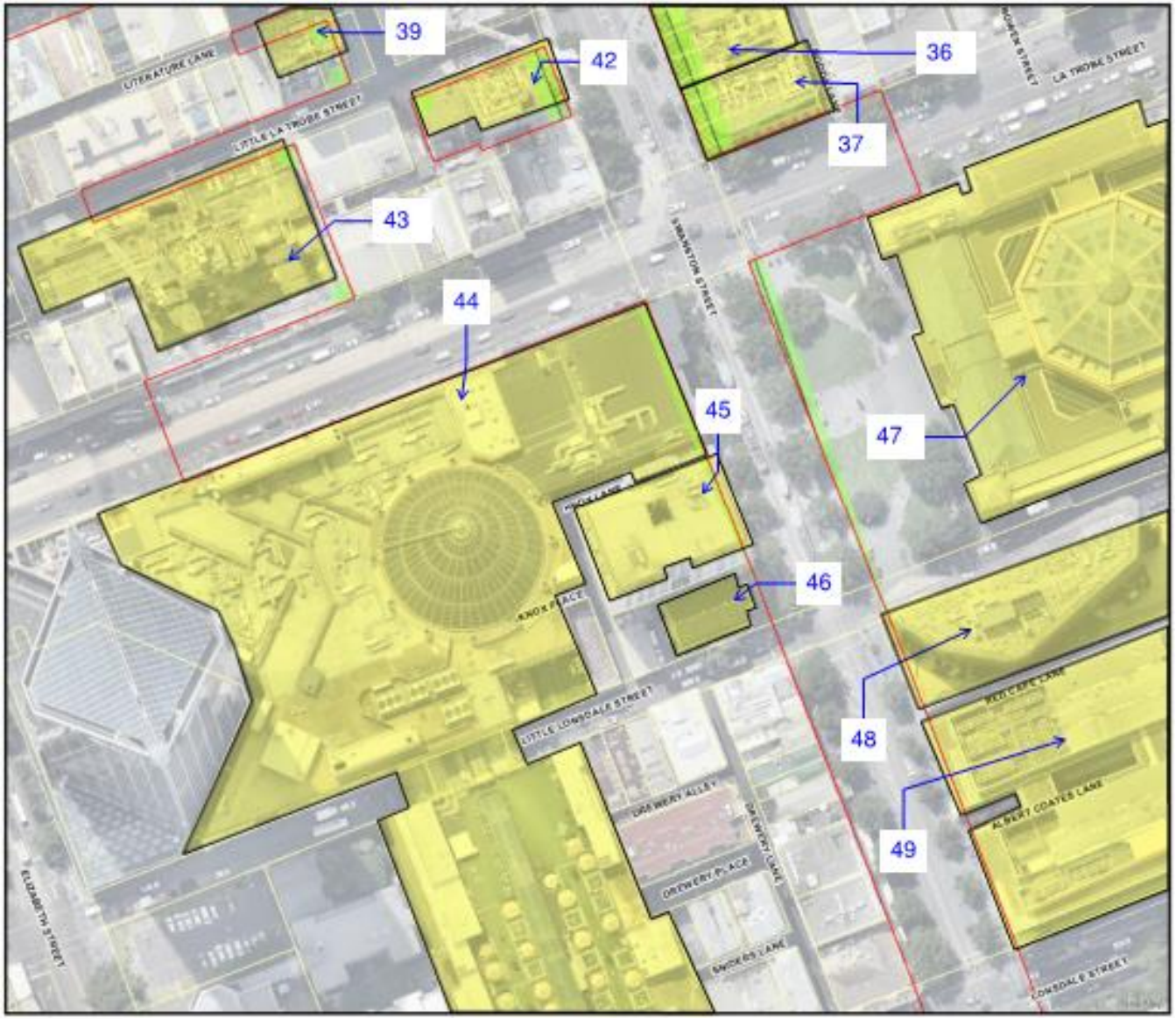

FIGURE 29: ASSESSED RECEIVERS IN CBD NORTH (MAP 2 OF 2)

TABLE 29: CBD NORTH - VIBRATION ASSESSMENT AGAINST LONG-TERM VIBRATION LEVELS LIKELY TO CAUSE BUILDING DAMAGE

Receiver ID	Vibration due to Tunneling works (PPV in m/s)	Vibration due to Additional Construction Works (PPV in m/s)	Exceeds vibration target of 2.5 mm/s?	NVIA assessment outcome – level relative to guideline target for building damage (below/above)	Has PSA works increased impact assessment outcome?[1]
22	0.57	0.01	N	below	N
23	0.78	0.03	N	below	N
25	0.74	0.03	N	below	N
36	0.67	0.03	N	below	N
45	-	0.03	N	below	N
46	-	0.03	N	below	N
47	0.34	0.01	N	below	N

Notes

1. Where the vibration levels due to the PSA construction activities trigger an increase in the assessment outcome, i.e PSA works increase the predicted vibration above PPV guideline targets where NVIA assessment shows that the guideline targets were previously met, a 'Y" response is expected. All other scenarios are to be N.

TABLE 30: CBD NORTH TUNNELLING ACTIVITIES - VIBRATION ASSESSMENT, VDV DAY, VDV NIGHT AND GROUND BORNE NOISE

Receiver ID	Occupancy type	VDV Day			VDV Night			Groundborne Noise		
		PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome, relative to night guideline target (See Note 2)	NVIA Assessment outcome (See Note 2)	Has PSA works increased impact assessment outcome?
19	Office	below pref	below max	N	below pref	below max	N	NA	-	N
20	Residential	below max	below max	N	below 2x max	below 2x max	N	5-10 dB	-	Y Note 5
21	Residential	below pref	below pref	N	below pref	below pref	N	below	below	N
22	Education	below pref	below pref	N	below pref	below pref	N	Below Note 3	-	Note 5
23	Education	below max	below max	N	below pref	below max	N	0 – 5 dB Note 3	-	Note 5
24	Education	below pref	below max	N	below pref	below max	N	0 – 5 dB Note 3	-	Note 5
25	Education	below pref	below 2x max	N	below pref	below 2x max	N	0 – 5 dB Note 3	-	Note 5
26	Education	below pref	below max	N	below pref	below max	N	0 – 5 dB Note 3	-	Note 5
27	Education	below pref	below max	N	below pref	below max	N	0 – 5 dB Note 3	-	Note 5
29	Education	below pref	below max	N	below pref	below max	N	0 – 5 dB Note 3	-	Note 5
30	Education	below pref	below max	N	below pref	below max	N	0 – 5 dB Note 3	-	Note 5
31	Education	below pref	below pref	N	below pref	below pref	N	below Note 3	-	Note 5
32	Education	below pref	below pref	N	below pref	below pref	N	below Note 3	-	Note 5
33	Education	below pref	below pref	N	below pref	below pref	N	below Note 3	-	Note 5
34	Education	below pref	below pref	N	below pref	below pref	N	below Note 3	-	Note 5
35	Education	below pref	below pref	N	below pref	below pref	N	below Note 3	0-5 dB	N

Receiver ID	Occupancy type	VDV Day			VDV Night			Groundborne Noise		
		PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome, relative to night guideline target (See Note 2)	NVIA Assessment outcome (See Note 2)	Has PSA works increased impact assessment outcome?
36	Education	below pref	below max	N	below pref	-	Note 5	0 – 5 dB Note 3	-	Note 5
37	Education	below pref	below max	N	below pref	below max	N	0 – 5 dB Note 3	-	Note 5
42	Education	below pref	below max	N	below pref	below max	N	below Note 3	-	Note 5
47	Office	below pref	below pref	N	below pref	below pref	N	NA	-	N

Notes

1. For the VDV (Day and Night, whichever is relevant) the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = below maximum guideline target (low probability of adverse comment), 3 = < 2 x maximum guideline target (adverse comment possible), 4 = > 2 x maximum guideline target (adverse comment probable)
2. For the Groundborne noise assessment, the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = 0 – 5 dB above night guideline target/ below evening guideline target, 3 = 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target, 4 = 10 dB above night guideline target/ > 5 dB (A) above evening . As per the EPR requirements, this assessment has been carried out for residences, hospital wards, student accommodation and hotel rooms. It has also been carried out for buildings tagged as educational facilities.
3. As ground-borne noise guideline targets in NV13 of the EPRs specifically relate to residences, hospital wards, student accommodation and hotel rooms, the assessment for educational facilities has been completed by comparing the predicted ground-borne noise levels against the guideline target air-borne noise levels for a classroom at schools and other educational institutions of 45 dB(A) listed in NV7 of the EPRs.
4. It is likely that the increase in assessment impact is due to this receiver being assessed as a commercial premise and not a residence in the NVIA.
5. The groundborne noise levels for this receiver were not assessed in the NVIA, therefore no like-for-like comparison is available.

TABLE 31: CBD NORTH ADDITIONAL CONSTRUCTION ACTIVITIES – VIBRATION ASSESSMENT FOR VDV DAY, VDV NIGHT AND GROUND BORNE NOISE

Receiver ID	Occupancy type	VDV (Day)			VDV (Night)			Ground Borne Noise		
		PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment outcome?	PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome (See Note 2)	NVIA Assessment outcome (See Note 2)	Has PSA works increased impact assessment outcome?
19	Office	below pref	below pref	N	below pref	below pref	N	-		N
20	Residential	below pref	below 2x max	N	below pref	below max	N	below	> 10dB	N
21	Residential	below pref	below max	N	below pref	above 2x max	N	below	>10 dB	N
22	Education	below pref	below max	N	below pref	below max	N	below [Note 3]	-	Note 4
23	Education	below pref	below 2x max	N	below pref	below 2x max	N	below [Note 3]	-	Note 4
24	Education	below pref	below max	N	below pref	below pref	N	below [Note 3]	-	Note 4
25	Education	below pref	below max	N	below pref	below max	N	below [Note 3]	-	Note 4
26	Education	below pref	below 2x max	N	below pref	below 2x max	N	below [Note 3]	-	Note 4
27	Education	below pref	below pref	N	below pref	below pref	N	below [Note 3]	-	Note 4
28	Education	below pref	below pref	N	below pref	below pref	N	below [Note 3]	-	Note 4
29	Education	below pref	below pref	N	below pref	below pref	N	below [Note 3]	-	Note 4
30	Education	below pref	below max	N	below pref	below max	N	below [Note 3]	-	Note 4
31	Education	below pref	below pref	N	below pref	below pref	N	below [Note 3]	-	Note 4
32	Education	below pref	below pref	N	below pref	below pref	N	below [Note 3]	-	Note 4
33	Education	below pref	below pref	N	below pref	below pref	N	Below [Note 3]	-	Note 4
34	Education	below pref	below pref	N	below pref	below pref	N	Below [Note 3]	below	N
35	Education	below pref	below pref	N	below pref	below pref	N	below [Note 3]	below	N
36	Education	below pref	below max	N	below pref	below max	N	below [Note 3]	-	Note 4

Receiver ID	Occupancy type	VDV (Day)			VDV (Night)			Ground Borne Noise		
		PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment outcome?	PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome (See Note 2)	NVIA Assessment outcome (See Note 2)	Has PSA works increased impact assessment outcome?
37	Education	below pref	below max	N	below pref	below max	N	below [Note 3]	-	Note 4
38	Residential	below pref	below pref	N	below pref	below max	N	below	-	N
39	Residential	below pref	below max	N	below pref	below max	N	below	-	N
40	Retail	below pref	below max	N	below pref	below max	N	-	-	N
41	Office	below pref	below pref	N	below pref	below max	N	-	-	N
42	Education	below pref	below 2x max	N	below pref	below max	N	below [Note 3]	-	Note 4
43	Office	below pref	above 2x max	N	below pref	above 2x max	N	-	-	N
44	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
45	Residential	below pref	below pref	N	below pref	below pref	N	below	-	N
46	Place of Worship	below pref	below pref	N	below pref	below pref	N	-	-	N
47	Office	below pref	below pref	N	below pref	below pref	N	-	-	N
48	Residential	below pref	below pref	N	below pref	below pref	N	below	-	N
49	Residential	below pref	below pref	N	below pref	below pref	N	below	-	N

Notes

1. **For the VDV (Day and Night, whichever is relevant) the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = below maximum guideline target (low probability of adverse comment), 3 = < 2 x maximum guideline target (adverse comment possible), 4 = > 2 x maximum guideline target (adverse comment probable)**
2. **For the Groundborne noise assessment, the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = 0 – 5 dB above night guideline target/ below evening guideline target, 3 = 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target, 4 = 10 dB above night guideline target/ > 5 dB (A) above evening . As per the EPR requirements, this assessment has been carried out for residences, hospital wards, student accommodation and hotel rooms. It has also been carried out for buildings tagged as educational facilities.**
3. **As ground-borne noise guideline targets in NV13 of the EPRs specifically relate to residences, hospital wards, student accommodation and hotel rooms, the assessment for educational facilities has been completed by comparing the predicted ground-borne noise levels against the guideline target air-borne noise levels for a classroom at schools and other educational institutions of 45 dB(A), as listed in NV7 of the EPRs.**
4. The groundborne noise levels for this receiver were not assessed in the NVIA, therefore no like-for-like comparison is available.

TABLE 32: VIBRATION ASSESSMENT FOR SENSITIVE EQUIPMENT

Location	Vibration Sensitive equipment	Vibration assessment reference	Vibration Assessment due to PSA additional works	NVIA Predicted assessment	Has PSA works increased impact assessment outcome?
RMIT Building 14					
Level 5	Confocal Microscope	VC-B 14 µm/s	< 5 µm/s	10 µm/s	N
Level 7	Electron Microscope	VC-B 18 µm/s	< 5 µm/s	9 µm/s	N

4.3.5 Stakeholders

Refer to Section 4.2.5.

4.3.6 Environmental Performance Requirements

The Environmental Performance Requirements (EPRs) that apply to the changes in the CBD North component are:

- NV1: Construction Noise Criteria
- NV3: Noise and Vibration Modelling – Design
- NV4: Noise and Vibration Monitoring – Construction
- NV5: Communications Plan
- NV6: Airborne Construction Noise Guideline Targets (External)
- NV7: Airborne Construction Noise Guideline Targets (Internal)
- NV8: Vibration Guideline Targets for Structures
- NV9: Vibration Guideline Targets for Above-ground Utility Assets and Infrastructure
- NV10: Vibration Guideline Targets for Below-ground Utility Assets and Infrastructure
- NV11: Vibration Dose Values (Human Comfort)
- NV12: Sensitive Equipment Guideline Targets
- NV13: Ground-borne (Internal) Noise Guideline Targets for Amenity
- NV15: Bio-resources and Sensitive Research
- NV16: Noise and Vibration Modelling
- NV21: Construction Noise and Vibration Management Plan

The proposed Planning Scheme Amendment results in some change to the intensity and location of noise and vibration impacts, however the nature of the impacts is not significantly changed. The Impact Assessment indicates that the EPRs are able to be met for the proposed PSA.

Therefore, the current EPRs remain appropriate for the PSA, and no changes to the EPRs are proposed.

4.3.7 Assumption and Limitations

The construction noise and vibration assessment is based on the current construction methodology, which may be revised as the project progresses. Source noise and vibration levels of specific construction equipment are likely to vary, however the source levels used for the assessment typically represent worst-case equipment levels. For each scenario, all construction equipment is modelled as operating simultaneously, which is deemed to be a conservative approach and is unlikely to occur in practice.

Where information is not currently available, conservative assumptions have been used for this assessment. Therefore, it is expected this assessment represents worst-case conditions and in many cases the noise and vibration impact will be lower than predicted.

Conservative assumptions include:

1. For conversion of PPV to RMS for Rock Bolting construction processes, a crest factor of 5 has been assumed, which is deemed to be conservative.
2. Operational groundborne noise and vibration has been calculated based on conservative reference source vibration levels and vibration isolating track system insertion gains.

4.4 CBD South Station

4.4.1 Project Components

Within this component of the project area, the sub-terrain changes to the proposed design consist of:

- ground support structures to accommodate the inclusion of adits north of CBD South Station
- a new tunnel alignment between Bourke Street Mall and CBD South Station.

The ground support structures to accommodate the change in rail alignment are located:

- between south of Bourke Street Mall and north of Collins Street
- between south of Collins Street and north of Flinders Lane (west side of alignment only)
- between south of Flinders Lane and north of Flinders Street (east side of alignment only)
- north of Flinders Street, between east of Degraves Street and west of Swanston Street

A pedestrian adit will be required to link CBD South Station with Federation Square. This will sit parallel to St.Paul's Cathedral footprint and Swanston Street, between south of Flinders Lane and north of Flinders Street. Another pedestrian adit will be required to provide an emergency egress from the tunnel to City Square. This will sit under Melbourne Town Hall footprint and the footpath at the corner of Collins Street and Swanston Street. In addition, a construction adit will extend diagonally south from Flinders Lane towards Swanston Street, under the north western corner of St.Paul's Cathedral.

Activities in this area include excavation, cross passage excavation, installation of ground support structures, haulage, fit out, reinstatement and the operation and maintenance of the trains. It will therefore be the impacts of these works on future development analysed for this impact assessment.

The construction-phase noise and vibration impacts of these changes are analysed for this impact assessment.

4.4.2 Existing Conditions

Existing locations potentially affected by the construction of underground support structures are the buildings on the western side of Swanston Street between Flinders Lane and Collins Street, the Westin Hotel, St Paul's Cathedral, Campbell Arcade and Degraves Street south of Degraves Place. The buildings on the western side of Swanston Street are the Young & Jackson Hotel and the retail buildings at 9-37 Flinders Street.

The buildings in Degraves Street consist of retail and residential uses.

4.4.3 Risk Assessment

The results of the Risk Assessment are shown in Table 33.

TABLE 33: RISK ASSESSMENT FOR CBD SOUTH STATION

Impact Pathway	Initial Risk			Relevant Discipline EPRs	Residual Risk		
	Likelihood	Consequence	Inherent Risk Rating		Likelihood	Consequence	Residual Risk Rating
Excavation							
Vibrations from excavation exceeding thresholds/limits, impacting on sensitive equipment and receptors	Almost Certain	Moderate	High	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Likely	Minor	Medium
Noise emissions from excavation exceeding thresholds/limits, impacting on sensitive receptors	Likely	Moderate	Medium	NV1, NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Possible	Minor	Low
Cross passage excavation							
Vibrations from cross passage excavation exceeding thresholds/limits, impacting on sensitive equipment and receptors	Almost Certain	Moderate	High	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Likely	Minor	Medium
Noise from cross passage excavation exceeding thresholds/limits, impacting on sensitive receptors	Likely	Moderate	Medium	NV1, NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Possible	Minor	Low
Ground support structure							
Vibrations from piling exceeding thresholds/limits, impacting on sensitive equipment and receptors	Almost Certain	Moderate	High	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Likely	Minor	Medium
Noise emissions from piling exceeding thresholds/limits, impacting on sensitive receptors	Likely	Moderate	Medium	NV1, NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Possible	Minor	Low
Haulage							

Vibrations from haulage trucks exceeding thresholds/limits, impacting on sensitive equipment and receptors	Rare/ Remote	Minor	Very Low	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Rare/ Remote	Minor	Very Low
Noise emissions from haulage trucks exceeding thresholds/limits, impacting on sensitive receptors	Unlikely	Minor	Low	NV1, NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Unlikely	Minor	Low
Fit out							
Noise emissions from fitout activities exceeding thresholds/limits, impacting on sensitive receptors	Possible	Minor	Low	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Unlikely	Negligible	Very Low
Vibration emissions from fitout activities exceeding thresholds/limits, impacting on sensitive equipment and receptors	Possible	Minor	Low	NV1, NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Unlikely	Negligible	Very Low
Reinstatement							
Vibration emissions from reinstatement activities exceeding thresholds/limits, impacting on sensitive equipment and receptors	Possible	Minor	Low	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Unlikely	Negligible	Very Low
Noise emissions from reinstatement activities exceeding thresholds/limits, impacting on sensitive receptors	Possible	Minor	Low	NV1, NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Unlikely	Negligible	Very Low
Operation							
Vibrations from operation exceeding thresholds/limits, impacting on sensitive equipment and receptors	Likely	Moderate	Medium	NV3, NV20	Unlikely	Moderate	Low
Noise emissions from operation exceeding thresholds/limits, impacting on sensitive receptors	Likely	Moderate	Medium	NV3, NV19	Unlikely	Moderate	Low
Maintenance							
Vibrations from maintenance activities exceeding thresholds/limits, impacting on sensitive equipment and receptors	Rare/ Remote	Negligible	Very Low	Not applicable	Rare/ Remote	Negligible	Very Low
Noise emissions from maintenance activities exceeding thresholds/limits, impacting on sensitive receptors	Rare/ Remote	Negligible	Very Low	Not applicable	Rare/ Remote	Negligible	Very Low

Construction noise and vibration impacts from the excavation, cross passage excavation and piling were assigned a residual risk rating of medium, due to the lack of noise and vibration modelling of construction activities with the design changes. Modelling of noise and vibration impacts for these construction activities is conducted as part of the Impact Assessment (see Impact Assessment section below), following which the risk ratings are re-evaluated.

Construction noise and vibration impacts from haulage, fit out and reinstatement were assigned a residual risk rating of low to very low, due to the low impact nature of these works and the relatively high background noise and vibration levels in the area.

Operational noise and vibration impacts from train movements were assigned a residual risk rating of low, due to the EES and PSA processes and assessment showing that the criteria can be met with appropriate mitigation.

Noise and vibration impacts from maintenance activities were assigned a residual risk rating of low, due to typical maintenance activities being low impact and conducted on an occasional basis.

4.4.4 Impact Assessment

Methodology – Construction noise and vibration

The methodological process undertaken for assessing construction noise and vibration impacts at CBD South Station are discussed in Section 2.2.1.

Results- Construction noise and vibration

Presented in Table 34 below are the relevant receivers in this project area. It includes addresses, description of these buildings, any heritage considerations and the relevant construction activity impacting them. These have been identified as being relevant to the PSA assessment based on the following criteria:

d. The receivers are currently outside of approved Project Land; and
e. These receivers are impacted due to exposure to vibration impacts from new operations not assessed in the EES and PSA processes, or
f. The distance between the boundary of works (i.e. approved Project Land) and the receivers is reduced due to additional Project Land being sought. This is either as a result of minor changes of the rail alignment, construction of additional station structures and installation of underground support structures

The location of these receivers are also shown in Figure 30 to Figure 32. Each building is identified with a unique Object ID number.

The summary of prediction results are presented in separate tables for the following scenarios:

d. Table 35: Assessment of vibration level against long-term vibration likelihood of causing building damage. The assessment has been conducted for all building types but only reported for heritage buildings for simplicity. Vibration levels are significantly lower than guideline targets for all other building types. Additionally long term targets are used for the assessments as these are more onerous compared with the short-term guideline targets.
e. Table 36: Tunnelling activities- vibration assessments against guideline targets for human comfort (VDV) and ground-borne noise guideline targets. (Note: tunnelling activities include TBM and roadheader operations, such as the mining of adits)
f. Table 37: Additional construction activities – vibration assessments against guideline targets for human comfort (VDV) and ground-borne noise guideline targets.

Analysis

The construction noise and vibration modelling results above indicate that the impacts are similar to the EES and PSA processes and assessment.

Regarding construction noise and vibration impacts, the Impact Assessment indicates that the risks are not significantly changed compared to the EES and PSA processes and assessment. Therefore, these risk ratings are as per the EES and PSA processes.

The next steps have been identified in Section 4.2.4, ‘Analysis’.

TABLE 34: ASSESSED RECEIVERS IN CBD SOUTH

Object ID	Address	Description	Occupancy Type (Note 1)	Affected by Tunnelling Works?	Affected by Additional Construction Works?	Heritage?
50	149 - 153 Swanston Street, Melbourne		Retail		Y	N
51	147 Swanston Street, Melbourne		Retail		Y	N
52	145 Swanston Street, Melbourne		Retail		Y	N
53	143 Swanston Street, Melbourne		Retail		Y	N
54	139 - 141 Swanston Street, Melbourne		Retail		Y	N
55	135 - 137 Swanston Street, Melbourne	Apartments	Residential		Y	N
56	152 - 156 Swanston Street, Melbourne		Retail		Y	N
57	150 Swanston Street, Melbourne	Shops	Retail		Y	N
58	148 Swanston Street, Melbourne	Shops	Retail		Y	N
59	146 Swanston Street, Melbourne	Shops	Retail		Y	N
60	144 Swanston Street, Melbourne	Shops	Retail		Y	N
61	134 - 142 Swanston Street, Melbourne		Retail		Y	N
62	125-133 Swanston Street, Melbourne	Century Building	Office		Y	Y
63	123 Swanston Street, Melbourne		Office		Y	Y
64	119 - 121 Swanston Street, Melbourne		Office		Y	Y
65	109-117 Swanston Street, Melbourne	Capitol Arcade	Residential	Y	Y	Y
66	220 - 226 Collins Street, Melbourne		Residential	Y	Y	Y
67	228 - 232 Collin Street, Melbourne		Office	Y	Y	Y
68	234 - 250 Collins Street, Melbourne		Office	Y	Y	Y
69	110 - 130 Swanston Street, Melbourne	Melbourne Town Hall - Admin Building	Office		Y	N
70a	90 - 130 Swanston Street, Melbourne	Melbourne Town Hall	Office	Y	Y	Y
70b	90 - 130 Swanston Street, Melbourne	Melbourne Town Hall	Multi-use facility	Y	Y	Y

Object ID	Address	Description	Occupancy Type (Note 1)	Affected by Tunnelling Works?	Affected by Additional Construction Works?	Heritage?
71	221 - 231 Collins Street, Melbourne	Wales Corner Building	Office	Y	Y	Y
72	233 - 239 Collins Street, Melbourne		Residential	Y	Y	Y
73	67 - 73 Swanston Street, Melbourne	EB Games	Residential	Y	Y	Y
74	65 Swanston Street, Melbourne		Retail	Y	Y	Y
75	45 - 63 Swanston Street,, Melbourne		Office	Y	Y	Y
76	202 Flinders Street, Melbourne	St Paul's Cathedral	Place of Worship	Y	Y	Y
77	1 - 7 Swanston Street, Melbourne	Young and Jackson's Hotel	Retail			Y
78	222 - 224 Flinders Street, Melbourne		Retail			Y
79	238 - 242 Flinders Street, Melbourne	Unilodge on Flinders	Residential			Y

Notes

1. Many buildings are typically mixed-use. Where multiple occupancy types apply to a building, the worst case type (i.e. lower guideline targets) is listed based on the following orders or priority – 1) residential 2) educational 3) other uses including commercial, retail, etc

FIGURE 30: ASSESSED RECEIVERS IN CBD SOUTH (MAP 1 OF 3)

FIGURE 31: ASSESSED RECEIVERS IN CBD SOUTH (MAP 2 OF 3)

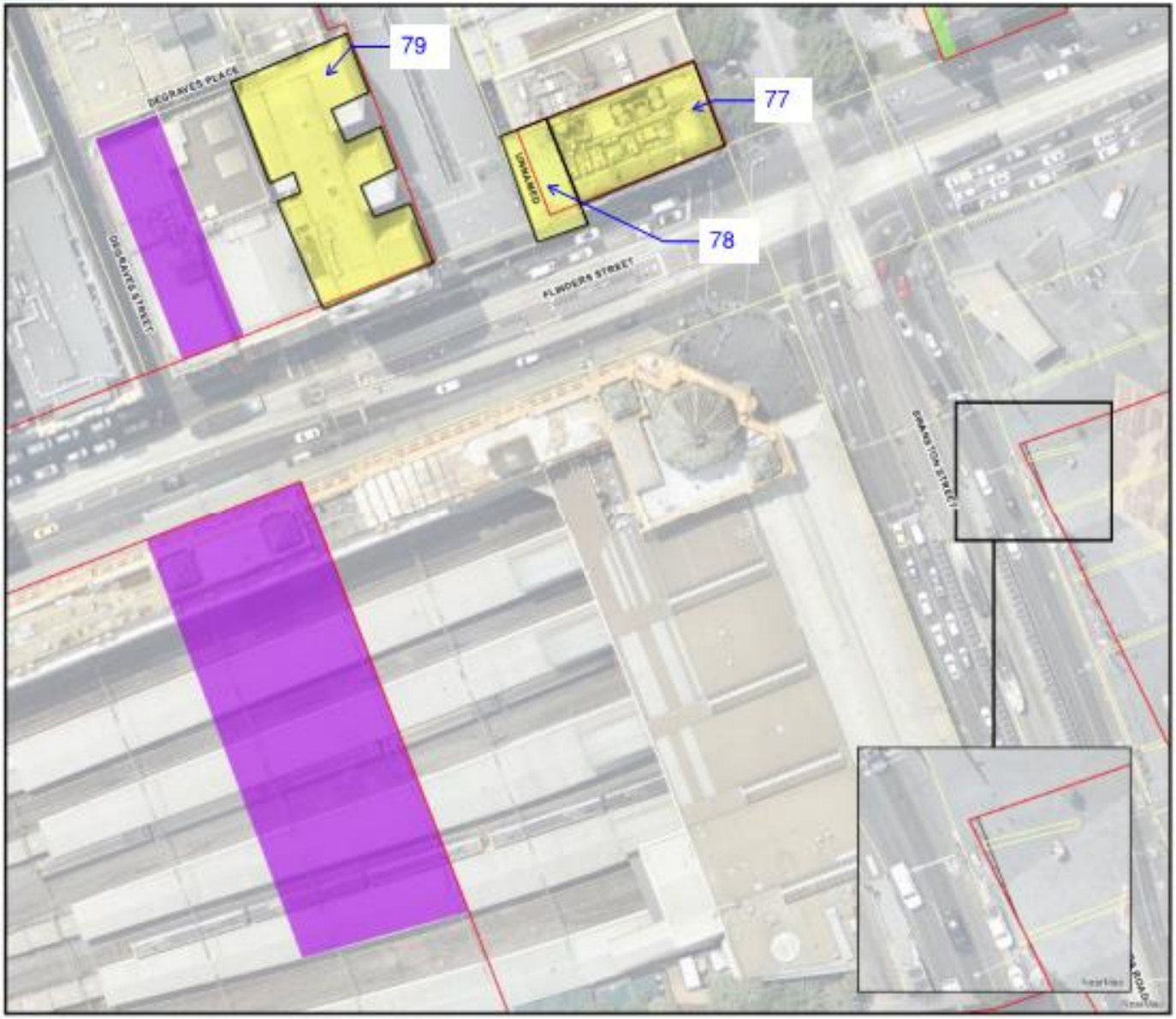

FIGURE 32: ASSESSED RECEIVERS IN CBD SOUTH (MAP 3 OF 3)

TABLE 35: CBD SOUTH – VIBRATION ASSESSMENT AGAINST LONG-TERM VIBRATION LEVELS LIKELY TO CAUSE BUILDING DAMAGE

Reciever ID	Vibration due to Tunneling works (PPV in m/s)	Vibration due to Additional Construction Works (PPV in m/s)	Exceeds vibration target of 2.5 mm/s?	NVIA assessment outcome – level relative to guideline target for building damage (below/above)	Has PSA works increased impact assessment outcome?[1]
62	-	0.04	N	below	N
63	-	0.04	N	below	N
64	-	0.04	N	below	N
65	0.88	0.04	N	below	N
66	1.28	0.04	N	below	N
67	0.83	0.03	N	below	N
68	0.44	0.01	N	below	N
70a	1.36	0.04	N	below	N
70b	1.36	0.04	N	below	N
71	1.17	0.04	N	below	N
72	0.45	0.04	N	below	N
73	1.29	0.04	N	below	N
74	1.35	0.04	N	below	N
75	1.35	0.04	N	below	N
76	2.30	0.10	N	below	N

Notes

1. Where the vibration levels due to the PSA construction activities trigger an increase in the assessment outcome, i.e PSA works increase the predicted vibration above PPV guideline targets where NVIA assessment shows that the guideline targets were previously met, a ‘Y” response is expected. All other scenarios are to be N.

TABLE 36: CBD SOUTH TUNNELLING ACTIVITIES - VIBRATION ASSESSMENT, VDV DAY, VDV NIGHT AND GROUND BORNE NOISE

Object ID	Occupancy type	VDV Day			VDV Night			Ground Borne Noise		
		PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome, relative to night guideline target (See Note 2)	NVIA Assessment outcome (See Note 2)	Has PSA works increased impact assessment outcome?
65	Residential	below 2x max	below 2x max	N	above max	below 2x max	Y Note 4	> 10 dB	-	Y Note 4
66	Residential	below 2x max	below 2x max	N	above 2x max	below 2x max	Y Note 4	> 10 dB	-	Y Note 4
67	Office	below max	below max	N	below max	below max	N	NA	-	N
68	Office	below pref	below pref	N	below pref	below pref	N	NA	-	N
70a	Office	below max	below max	N	below max	below max	N	NA	-	N
70b	Multi-use	below max	below max	N	below max	below max	N	NA	-	Note 5
71	Office	below max	above 2x max	N	below max	below 2x max	N	NA	-	N
72	Residential	below max	below 2x max	N	below 2x max	below 2x max	N	5-10 dB	> 10 dB	N
73	Residential	below 2x max	below 2x max	N	above 2x max	above 2x max	N	> 10 dB	> 10 dB	N
74	Retail	below max	below max	N	below max	below max	N	NA	-	N
75	Office	below max	above 2x max	N	below max	below max	N	NA	-	N
76	Place of Worship	below max	below max	Y	below max	below max	Y	NA	-	N

Notes

1. **For the VDV (Day and Night, whichever is relevant) the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = below maximum guideline target (low probability of adverse comment), 3 = < 2 x maximum guideline target (adverse comment possible), 4 = > 2 x maximum guideline target (adverse comment probable)**
2. **For the Groundborne noise assessment, the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = 0 – 5 dB above night guideline target/ below evening guideline target, 3 = 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target, 4 = 10 dB above night guideline target/ > 5 dB (A) above evening. As per the EPRs, this assessment has been carried out for residences, hospital wards, student accommodation and hotel rooms. It has also been carried out for buildings tagged as educational facilities.**
3. **As ground-borne noise guideline targets in NV13 of the EPRs specifically relate to residences, hospital wards, student accommodation and hotel rooms, the assessment for educational facilities has been completed by comparing the predicted ground-borne noise levels against the guideline target air-borne noise levels for a classroom at schools and other educational institutions of 45 dB(A) listed in NV7 of the EPRs.**
4. **It is likely that the increase in assessment impact is due to this receiver being assessed as a commercial premise and not a residence in the NVIA.**
5. **The EPRs do not prescribe a groundborne noise target for a receiver that is not: residential, sleeping areas in hospital wards, student accommodation and hotel rooms. Consultation with stakeholder should occur to determine appropriate mitigation, if required.**

TABLE 37: CBD SOUTH ADDITIONAL CONSTRUCTION ACTIVITIES – VIBRATION ASSESSMENT FOR VDV DAY, VDV NIGHT AND GROUND BORNE NOISE

		VDV (Day)			VDV (Night)			Ground Borne Noise		
Receiver ID	Occupancy type	PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment outcome?	PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome (See Note 2)	NVIA Assessment outcome (See Note 2)	Has PSA works increased impact assessment outcome?
50	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
51	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
52	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
53	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
54	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
55	Residential	below pref	below pref	N	below pref	below pref	N	below	-	N
56	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
57	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
58	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
59	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
60	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
61	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
62	Office	below pref	below pref	N	below pref	below pref	N	-	-	N
63	Office	below pref	below pref	N	below pref	below pref	N	-	-	N
64	Office	below pref	below pref	N	below pref	below pref	N	-	-	N
65	Residential	below pref	below pref	N	below pref	below pref	N	below	-	N
66	Residential	below pref	below pref	N	below pref	below pref	N	below	-	N

Receiver ID	Occupancy type	VDV (Day)			VDV (Night)			Ground Borne Noise		
		PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment outcome?	PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome (See Note 2)	NVIA Assessment outcome (See Note 2)	Has PSA works increased impact assessment outcome?
67	Office	below pref	below pref	N	below pref	below pref	N	-	-	N
68	Office	below pref	below pref	N	below pref	below pref	N	-	-	N
69	Office	below pref	below pref	N	below pref	below pref	N	-	-	N
70a	Office	below pref	below pref	N	below pref	below pref	N	-	-	N
70b	Multi-use	below pref	below pref	N	below pref	below pref	N	-	-	Note 5
71	Office	below pref	below pref	N	below pref	below pref	N	-	-	N
72	Residential	below pref	below max	N	below pref	above 2x max	N	below	5 – 10 dB	N
73	Residential	below pref	below 2x max	N	below pref	above 2x max	N	below	5 – 10 dB	N
74	Retail	below pref	below pref	N	below pref	below pref	N	-	-	N
75	Office	below pref	below pref	N	below pref	below pref	N	-	-	N
76	Place of Worship	below pref	below pref	N	below pref	below pref	N	-	-	N

Notes

1. For the VDV (Day and Night, whichever is relevant) the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = below maximum guideline target (low probability of adverse comment), 3 = < 2 x maximum guideline target (adverse comment possible), 4 = > 2 x maximum guideline target (adverse comment probable)
2. For the Groundborne noise assessment, the following ratings apply to the assessment, based on the criteria nominated in the EPRs and that used in the NVIA, 1 = below preferred guideline target (adverse comment not expected), 2 = 0 – 5 dB above night guideline target/ below evening guideline target, 3 = 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target, 4 = 10 dB above night guideline target/ > 5 dB (A) above evening . As per the EPR requirements, this assessment has been carried out for residences, hospital wards, student accommodation and hotel rooms. It has also been carried out for buildings tagged as educational facilities.
3. As ground-borne noise guideline targets in NV13 of the EPRs specifically relate to residences, hospital wards, student accommodation and hotel rooms, the assessment for educational facilities has been completed by comparing the predicted ground-borne noise levels against the guideline target air-borne noise levels for a classroom at schools and other educational institutions of 45 dB(A), as listed in NV7 of the EPRs.

Receiver ID	Occupancy type	VDV (Day)			VDV (Night)			Ground Borne Noise		
		PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment outcome?	PSA Assessment outcome (See Note 1)	NVIA Assessment outcome (See Note 1)	Has PSA works increased impact assessment?	PSA Assessment outcome (See Note 2)	NVIA Assessment outcome (See Note 2)	Has PSA works increased impact assessment outcome?

4. The groundborne noise levels for this receiver were not assessed in the NVIA, therefore no like-for-like comparison is available.
5. The EPRs do not prescribe a groundborne noise target for a receiver that is not: residential, sleeping areas in hospital wards, student accommodation and hotel rooms. Consultation with stakeholder should occur to determine appropriate mitigation, if required.

4.4.5 Stakeholders

Refer to Existing Conditions in Section Refer to Section 4.2.5.

4.4.6 Environmental Performance Requirements

As per CBD North Station. Refer to section 4.3.6.

4.4.7 Assumption and Limitations

As per CBD North Station. Refer to section 4.3.7.

4.5 Additional road surface works

4.5.1 Project Components

Additional roads have been identified where temporary road works may be required and/or traffic management will be periodically required during construction.

The additional roads include parts of:

- Arden Street, North Melbourne
- Royal Parade, Grattan Street and Cardigan Street, Carlton
- Flinders Street and Flinders Lane, Melbourne;
- Kings Way, Bowen Lane and Albert Road, South Melbourne
- Toorak Road, South Yarra.

Activities in this area include site establishment, haulage, roadworks, tramworks and reinstatement. Impact of these works on existing properties have been analysed for this impact assessment.

At this stage, road surface works are planned to be carried out only during normal working hours, between the hours of 7am to 6pm Monday to Friday and 7am to 1pm on Saturday. If works are required to be carried out during the evening/night periods, the noise and vibration assessment will be updated and mitigation measures will be employed to meet the relevant guideline targets.

4.5.2 Existing Conditions

Existing locations potentially affected by the additional road surface works on Arden Street are the football ground, North Melbourne Recreation Centre, North Melbourne pool and the industrial/retail buildings on the southern side of Arden Street.

Existing locations potentially affected by the additional road surface works on Royal Parade are the Melbourne Private Hospital, the sports grounds at University High School, the dwellings on Royal Parade between Storey Street and Morrah Street and University of Melbourne buildings 140 (Grainger Museum), 141 (music faculty) and 144 (neuroscience).

Existing locations potentially affected by the additional road surface works on Grattan Street are the buildings between Bouverie Street and Swanston Street. On the northern side of Grattan Street, these buildings are University of Melbourne building 199 (Harold White Theatre and student administration) and building 188 (graduate centre). On the southern side of Grattan Street, the buildings have retail, office and student accommodation uses.

Existing locations potentially affected by the additional road surface works on Victoria Street are RMIT building 51 and Dracula's Theatre Restaurant.

Existing locations potentially affected by the additional road surface works on Flinders Lane are the buildings between Elizabeth Street and Degraves Street, and the buildings between Swanston Street and Russell Street. These buildings have predominantly retail and office uses, with apartments at the upper levels of several buildings, Punthill Apartment Hotel, the Westin Hotel, Adelphi Hotel and Regent Theatre.

Existing locations potentially affected by the additional road surface works on Flinders Street are the buildings on the northern side of Flinders Street between Queen Street and Elizabeth Street. These buildings have predominantly retail and office uses, with apartments at the upper levels of several buildings and the Rendezvous Hotel at 328 Flinders Street.

Existing locations potentially affected by the additional road surface works on Kings Way and Albert Road are the office buildings at 88-144 Albert Road, the apartment building at 346-348 Kings Way, the petrol station at 331 Kings Way and the apartment building at 70 Albert Road.

Existing locations potentially affected by the additional road surface works on Toorak Road South Yarra are the retail and commercial buildings on Toorak Road between Darling Street and Claremont Street. Residential buildings are located behind these retail/commercial buildings, at distances of 30 metres or more from the proposed road surface works.

4.5.3 Risk Assessment

The results of the Risk Assessment are shown in Table 38.

Construction noise and vibration impacts from the tramworks were assigned a residual risk rating of medium, due to the lack of noise and vibration modelling of construction activities with the design changes. Modelling of noise and vibration impacts for these construction activities is conducted as part of the Impact Assessment (see Impact Assessment section below).

Construction noise and vibration impacts from haulage, fit out, site establishment and reinstatement were assigned a residual risk rating of low to very low, due to the low impact nature of these works and the relatively high background noise and vibration levels in the area.

TABLE 38: RISK ASSESSMENT FOR ADDITIONAL ROAD SURFACE WORKS

Impact Pathway	Initial Risk			Relevant Discipline EPRs	Residual Risk		
	Likelihood	Consequence	Inherent Risk Rating		Likelihood	Consequence	Residual Risk Rating
Haulage							
Vibrations from haulage trucks exceeding thresholds/limits, impacting on sensitive equipment and receptor	Rare/ Remote	Minor	Very Low	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Rare/ Remote	Minor	Very Low
Noise emissions from haulage trucks exceeding thresholds/limits, impacting on sensitive receptors	Unlikely	Minor	Low	NV1, NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Unlikely	Minor	Low
Roadworks							
Vibrations from roadworks exceeding thresholds/limits, impacting on sensitive equipment and receptors	Likely	Moderate	Medium	EPR NV3, NV4, NV5, NV8, NV9, NV10, NV11, and NV21	Unlikely	Minor	Low
Noise emissions from roadworks exceeding thresholds/limits, impacting on sensitive receptors	Likely	Moderate	Medium	EPR NV3, NV4, NV5, NV6, NV13, and NV21	Unlikely	Minor	Low
Tramworks							
Vibrations from tram works exceeding thresholds/limits, impacting on sensitive equipment and receptors	Likely	Moderate	Medium	EPR NV3, NV4, NV5, NV8, NV9, NV10, NV11, and NV21	Unlikely	Moderate	Low
Noise emissions from tram worksexceeding thresholds/limits, impacting on sensitive receptors	Likely	Moderate	Medium	EPR NV3, NV4, NV5, NV6, NV13, and NV21	Possible	Moderate	Medium
Reinstatement							

Impact Pathway	Initial Risk			Relevant Discipline EPRs	Residual Risk		
	Likelihood	Consequence	Inherent Risk Rating		Likelihood	Consequence	Residual Risk Rating
Vibration emissions from reinstatement works exceeding thresholds/limits, impacting on sensitive equipment and receptors	Possible	Minor	Low	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Unlikely	Negligible	Very Low
Noise emissions from reinstatement works exceeding thresholds/limits, impacting on sensitive receptors	Possible	Minor	Low	NV1, NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Unlikely	Negligible	Very Low
Site establishment							
Noise emissions during site establishment exceeding thresholds/limits, impacting on sensitive equipment and receptors	Possible	Minor	Low	NV3, NV4, NV5, NV8, NV9, NV10, NV11, NV12, NV15, NV16 and NV21	Unlikely	Negligible	Very Low
Vibration impacts during site establishment exceeding thresholds/limits, impacting on sensitive receptors	Possible	Minor	Low	NV1, NV3, NV4, NV5, NV6, NV7, NV13, NV15, NV16 and NV21	Unlikely	Negligible	Very Low

4.5.4 Impact Assessment

Methodology – Construction noise and vibration

The impacts arising from the additional road surface works relate primarily to airborne noise. The impacts from vibration are predicted to be negligible as vibration generating equipment (excavator with hydraulic hammer) will only be required for specific minor portions of works and used only sparingly. Therefore, the assessment of these works focus primarily on airborne construction noise which is the primary impact.

In order to predict the airborne construction noise, a 3D acoustic model was constructed using the environmental noise modelling software package SoundPLAN v7.4. The acoustic model includes inputs such as topography, buildings, noise sources, receiver locations, ground absorption and other environmental factors such as air absorption and meteorology. The propagation model based on *ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation (ISO 9613-2)* was used.

The following assumptions were made for the 3D model

- All plant in the scenarios modelled were operating concurrently. This is deemed to be a conservative approach and is unlikely to occur in practice.
- All works that are not Unavoidable Works are planned only during normal working hours period, i.e. day period (7am to 6pm weekdays, 7am to 1pm weeknight)
- Noise sensitive receivers are based upon the land use survey prepared for Melbourne Metro
- Construction vehicles on public roads are not included in the assessment. This includes all the road management activities which include things such as traffic lane access control, traffic management to allow entries and exits cater for traffic volumes and ensures that traffic flows comply with safety guidelines and regulations.
- All sources were modelled at a height of 1.5 m
- Ground absorption was assumed to be 0.3 for urban coverage, 1.0 for areas with natural ground cover (i.e. soft ground) and 0 for bodies of water.

Construction Scenarios and Source Noise Levels

Legacy road surface works proposed at each of the sites within the additional Project Land are all of a similar nature with minor variations. The types of work proposed involve:

- Re-surfacing of road, kerb and channels
- Landscaping works to improve the public realm
- Footpath resurfacing
- Upgrading utilities
- Upgrading drainage paths
- Installing new pedestrian/cycle crossings
- Installation of new traffic signals

Each scenario has been modelled with the same set of noise sources which is considered to also be a conservative approach. In each scenario, the following noise sources were included within the model:

- 35 T Excavator
- 2 x Trucks
- Road profiler
- Asphalt Paver
- 25 T Wheeled Mobile Crane
- Concrete/Asphalt Truck
- 15T Vibratory Roller
- Small excavator with hammer
- Handheld circular saw

The sound power levels used in the acoustic modelling are provided in Table 39 below.

TABLE 39: SOUND POWER LEVELS OF CONSTRUCTION EQUIPMENT

Equipment	Sound Power Level, PWL (dB) Octave Band Frequency (Hz)								PWL, dB(A)	Source of data
	63	125	250	500	1k	2k	4k	8k		
35T Excavator	104	107	103	103	104	101	98	93	108	DEFRA Noise Database 2009
Trucks	100	97	94	92	88	87	86	84	95	Adopted from NVIA
Road Profiler	109	115	107	105	105	102	98	95	110	DEFRA Noise Database 2009
Asphalt Paver	100	105	102	100	99	98	95	88	105	DEFRA Noise Database 2009
25T Wheeled Mobile Crane	113	101	95	99	100	97	91	84	104	DEFRA Noise Database 2009
Concrete/Asphalt Truck	111	102	94	97	98	106	88	83	108	Adopted from NVIA
15T Vibratory Roller	118	110	101	100	98	93	87	82	103	DEFRA Noise Database 2009
Small excavator with Hammer	109	108	108	111	110	107	104	101	114	Adopted from NVIA
Handheld circular saw	112	114	106	106	105	106	110	108	115	DEFRA Noise Database 2009

Results- Construction noise and vibration

The results of the noise assessments are presented below. These prediction maps show noise contours at a height of 1.5 m above ground level.

a) Legacy Road works at Royal Parade – Figure 33
b) Legacy Road works and tramworks at Elizabeth Street- Figure 34
c) Legacy Road works at Flinders Lane – Figure 35
d) Legacy Road works at Kings Ways – Figure 36
e) Legacy Road works at Albert Road – Figure 37
f) Ground utility works at Toorak Road – Figure 38

Analysis

The construction noise and vibration modelling results above indicate that the impacts are similar to the EES and PSA processes and assessment.

At this stage, it is assumed that evening and night-works are not necessary to undertake road surface works as these are not classified as Unavoidable Works. If the modelled construction activities are completed during evening and night periods, the noise levels are likely to exceed the guideline target noise limits, and are therefore not recommended. If these works are required, they shall comply with all the EPR requirements (e.g. NV1 requirements for inaudibility within habitable room during night period) and the MMRA Residential Impact Mitigation Guidelines (RIMG).

Where Unavoidable Works are to be carried out outside of normal working hours, mitigation measures shall be incorporated as per the RIMG where the noise levels exceed the noise limits specified.

Regarding construction noise and vibration impacts, the Impact Assessment indicates that the risks are not significantly changed compared to the EES and PSA processes and assessment. Therefore, these risk ratings are as per the EES and PSA processes.

The next steps have been identified in Section 4.2.4, ‘Analysis’.

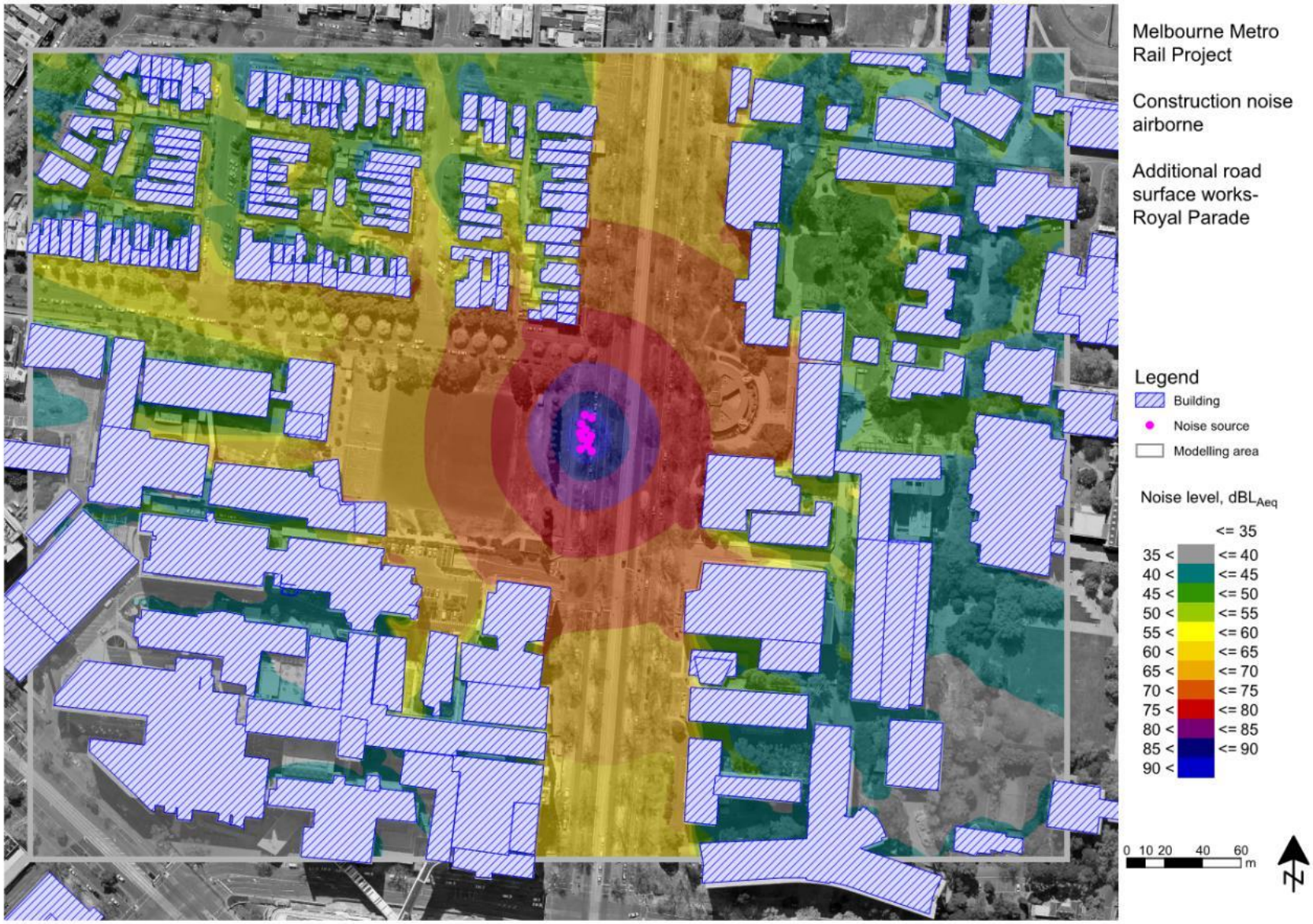

FIGURE 33: NOISE LEVEL PREDICTIONS FOR ROAD SURFACE WORKS AT ROYAL PARADE – DAY PERIOD

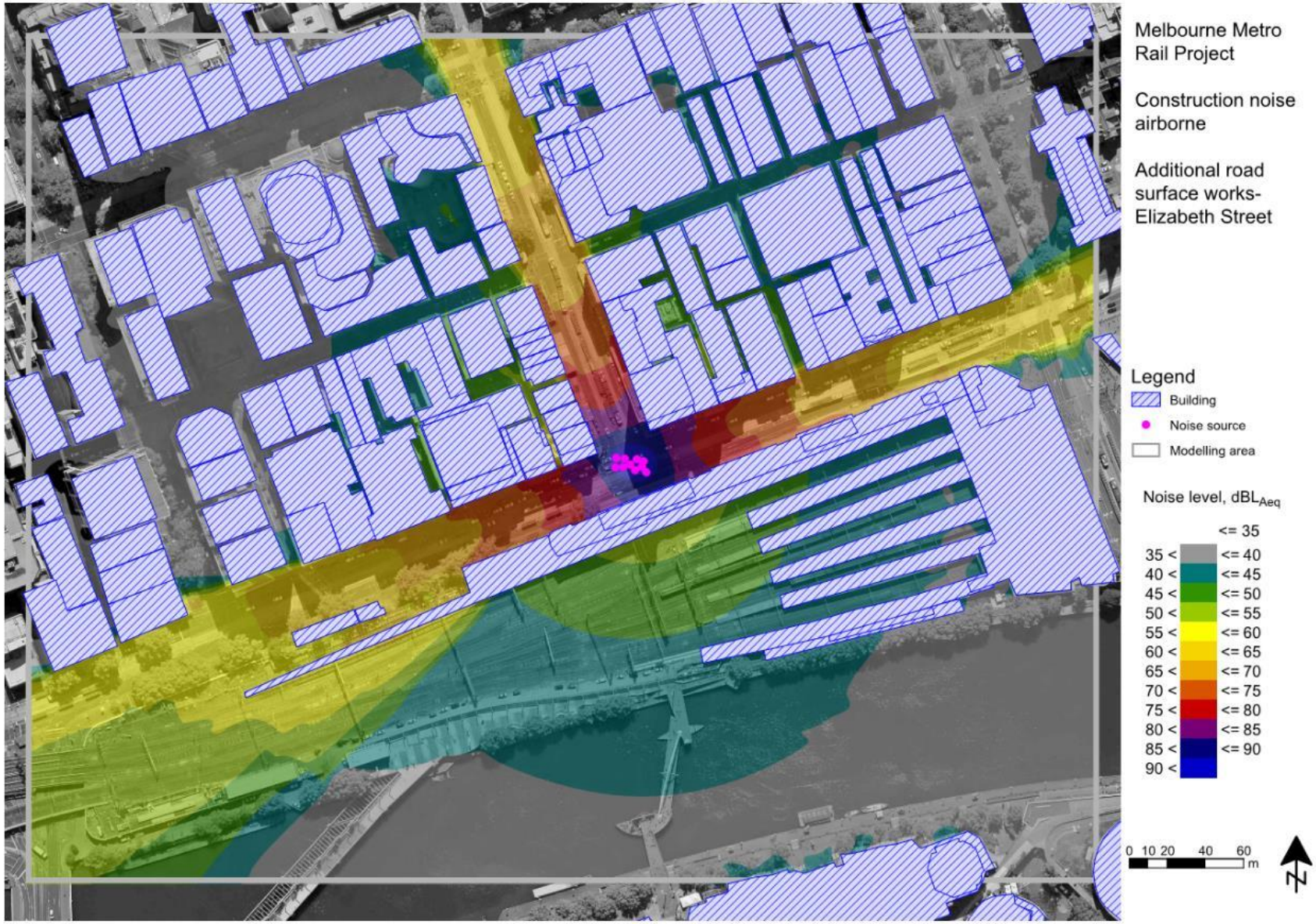

FIGURE 34: NOISE LEVEL PREDICTIONS FOR ROAD SURFACE WORKS AT ELIZABETH STREET – DAY PERIOD

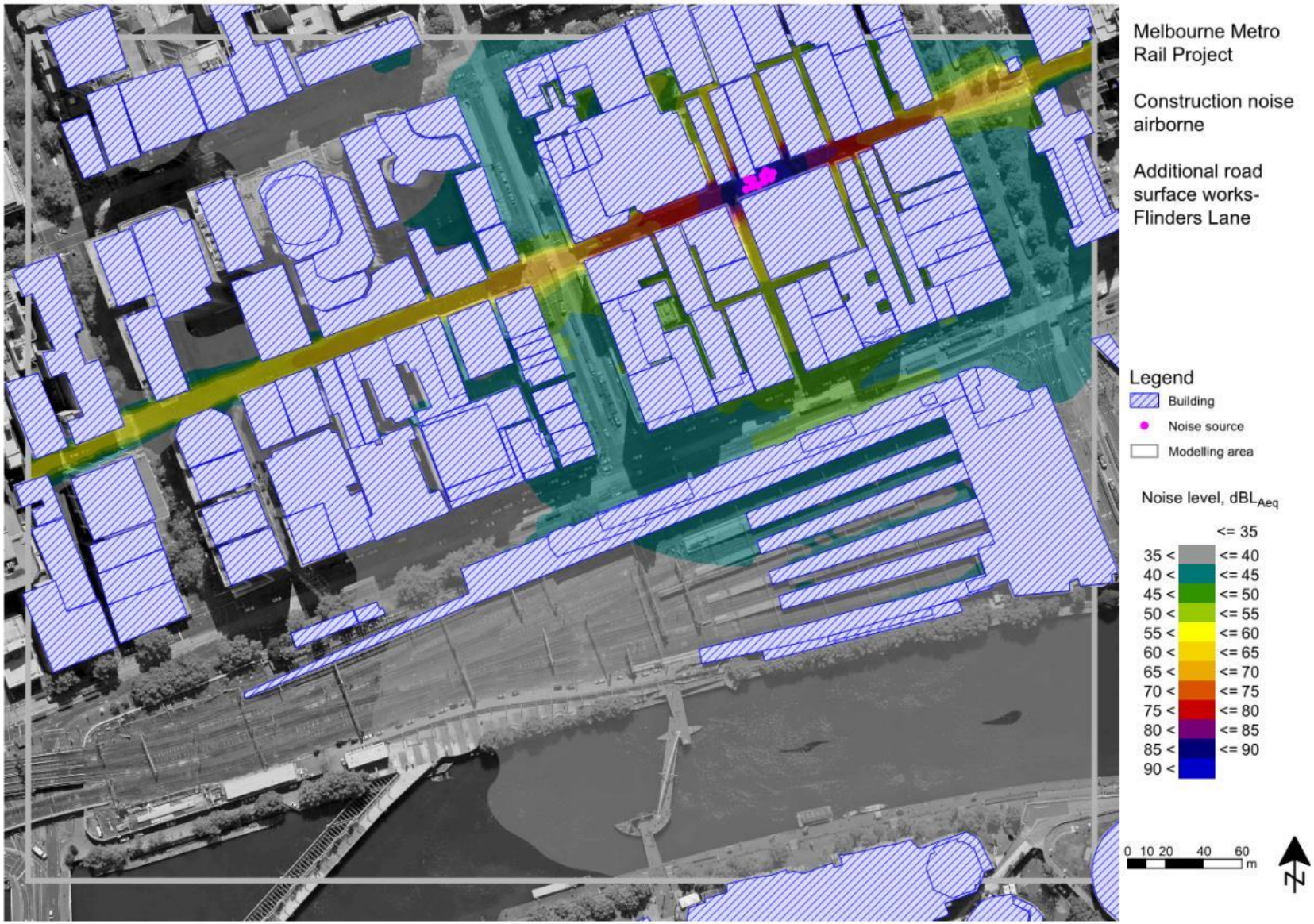

FIGURE 35: NOISE LEVEL PREDICTIONS FOR ROAD SURFACE WORKS AT FLINDERS LANE – DAY PERIOD

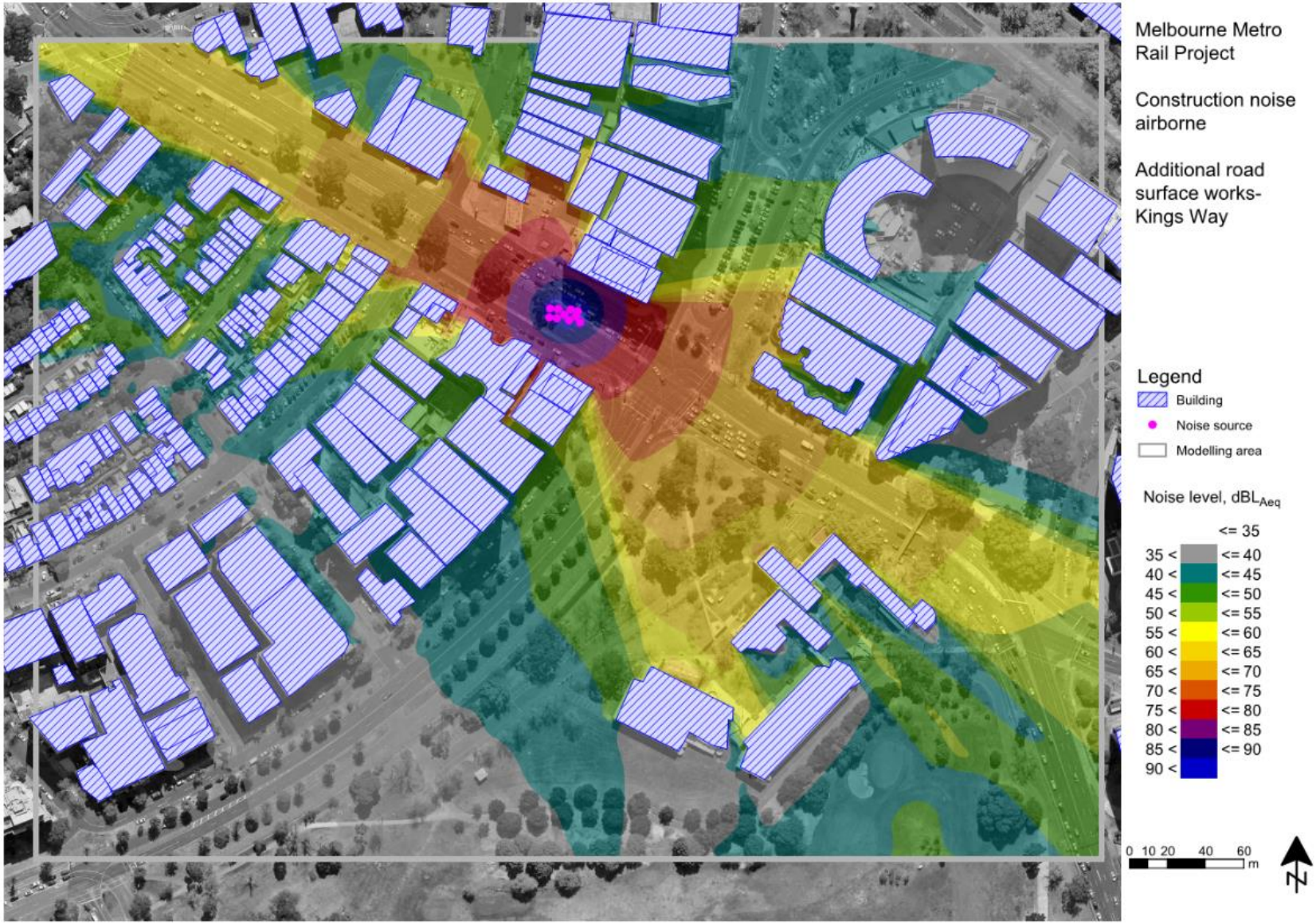

FIGURE 36: NOISE LEVEL PREDICTIONS FOR ROAD SURFACE WORKS AT KINGS WAY – DAY PERIOD

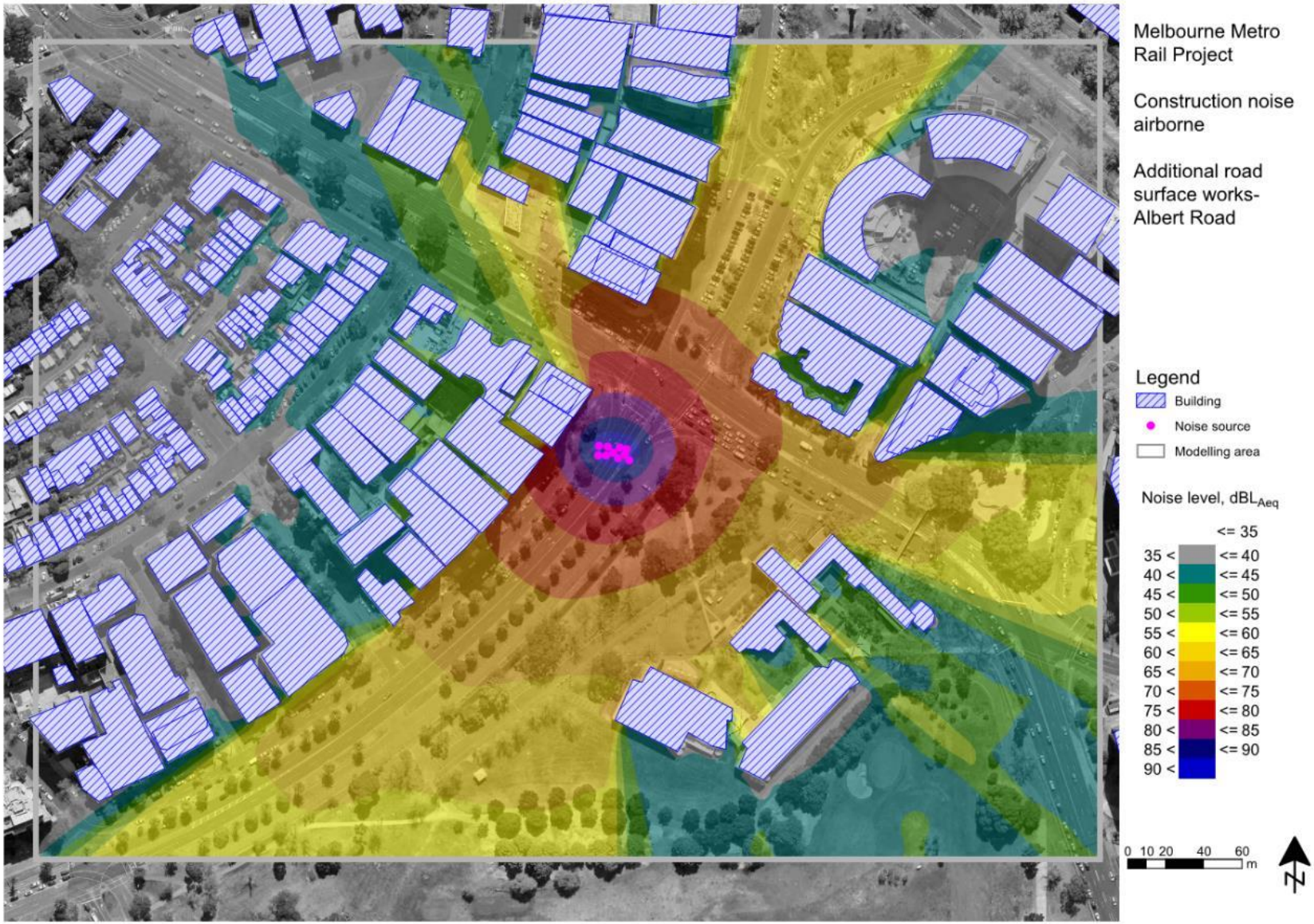

FIGURE 37: NOISE LEVEL PREDICTIONS FOR ROAD SURFACE WORKS AT ALBERT ROAD – DAY PERIOD

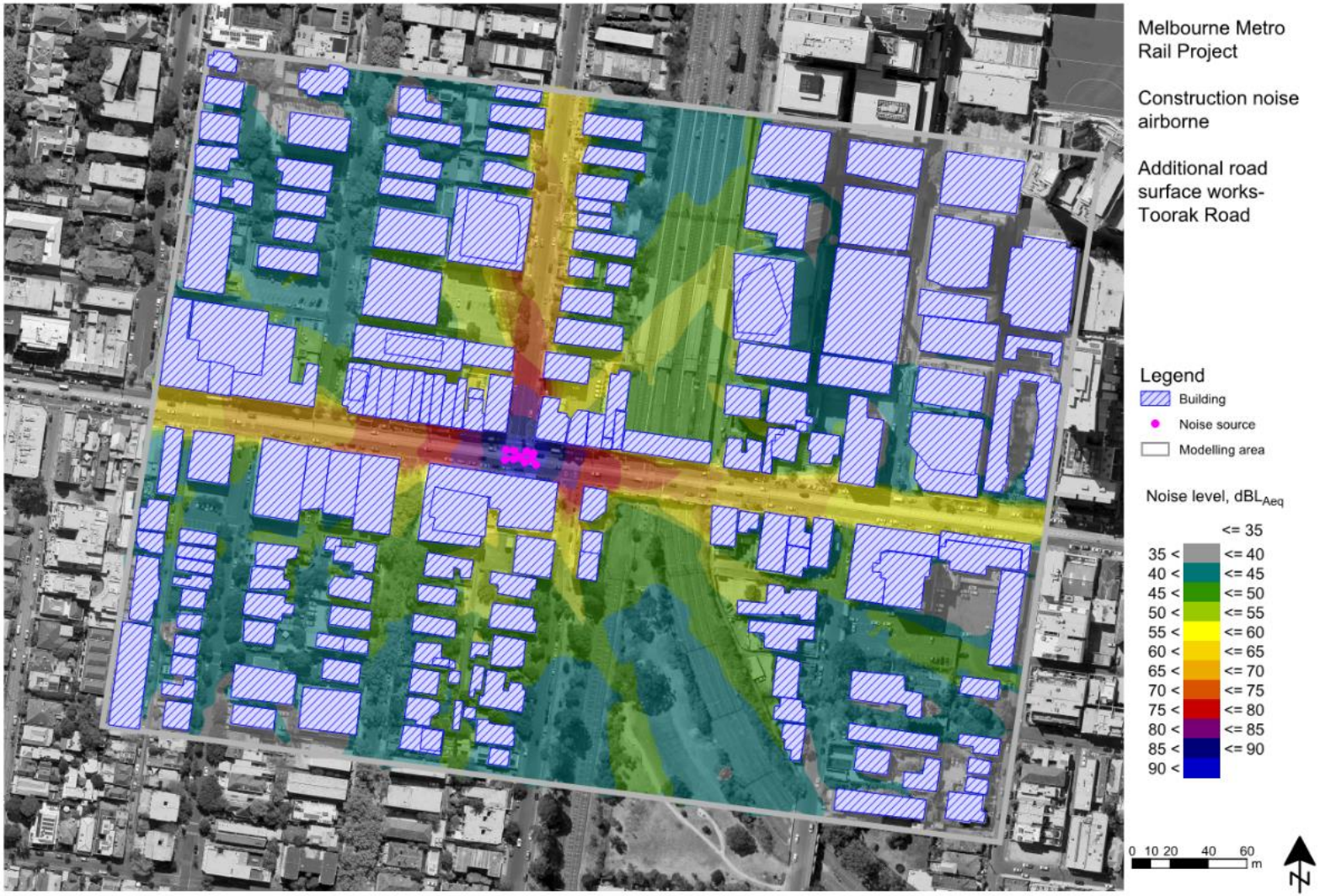

FIGURE 38: NOISE LEVEL PREDICTIONS FOR ROAD SURFACE WORKS AT TOORAK ROAD – DAY PERIOD

4.5.5 Stakeholders

Refer to Section 4.2.5.

4.5.6 Environmental Performance Requirements

As per CBD North Station. Please refer to section 4.3.6.

4.5.7 Assumption and Limitations

As per CBD North Station. Please refer to section 4.3.7.

5 Conclusion

The noise and vibration impacts from the construction and operation of the Melbourne Metro have been assessed in relation to the proposed CYP changes to the approved Project Land.

The impact assessment process identified residual medium impacts at all locations. However, the changes to the approved Project Land generally does not introduce any new noise and vibration impacts that can not be managed by the approved EPRs. Therefore, the existing EPRs are deemed to be appropriate for managing noise and vibration from the construction and operation of Melbourne Metro, and no changes to the EPRs are recommended.

Ultimately, noise and vibration from the construction works and operation of the railway within the additional Project Land can be managed and mitigated to achieve the requirements of the project EPRs. For construction noise, potential impacts are capable of being managed in accordance with the requirements of the environmental performance requirements, including following the guidance provided in EPA Document 480 and Publication 1254.For operational noise, resilient trackforms and floating track slab can be adopted to control vibration and ground borne noise emissions from the railway.

The next steps, were modelling identifies the potential for works to impact on buildings, a condition assessment will be undertaken (in line with EPR NV9), the asset owner will be consulted (in line with EPR NV5), and vibration targets will be established (in line with EPRs NV6 – NV15). Furthermore, the Noise and Vibration Management Plan will include a vibration monitoring program, which will aim to demonstrate compliance with the relevant vibration guideline targets, and will include details of remedial action where required.

This modelling is currently being undertaken and will be carried out across the alignment as the design is refined and greater detail of building structure, equipment and ground movement is known (in line with EPR NV3). The findings from these assessments will continue to inform design. Impacted building owners and occupiers are currently, and will continue to be, informed of any potential impacts that may arise (in line with NV5). A Noise and Vibration Management is being prepared for review by the Independent Auditor (in line with EPRs NV21).