An abstract graphic featuring overlapping geometric shapes in various shades of blue and green, creating a layered, mountain-like effect against a light blue background.

## Appendix B. Construction: Vibration and Ground-borne Noise





B.1 Introduction

B.1.1 Description of the Construction Works that are Relevant to Vibration

Construction activities on the Melbourne Metro Rail Project (Melbourne Metro) have been divided into two broad categories: 1) Tunnelling, and 2) Additional Construction Works.

The Tunnelling and Additional Construction Works are described below.

B.1.1.1 Tunnelling Works

Underground tunnelling activities are proposed to occur along the Melbourne Metro alignment and consist of:

- Tunnel Boring Machines (TBM) for tunnelling along the alignment between the western portal and CBD North station as well between CBD South station and the Eastern Portal. The TBMs are large cylindrical machines with a rotating cutting wheel at the head of the machine. TBMs typically produce less vibration and fewer disturbances than traditional drilling and blasting techniques
- Road headers for mining the section of tunnel between CBD North and CBD South stations. Road headers consist of a cutting head which is mounted on a boom
- Road headers for excavating the two cavern stations; CBD North and CBD South.

When viewing the results of the vibration assessment, it is important to note that the “Tunnelling works” include the road header excavation of the CBD North and South station caverns. Results contained under the heading of “Tunnelling works” do not relate to excavation works that are to be completed using piling rigs, excavators, rippers and rock breakers.

The alignment of the Melbourne Metro tunnel is shown in Figure B.1 in blue. The red dots show buildings that are above or near to the tunnel alignment.

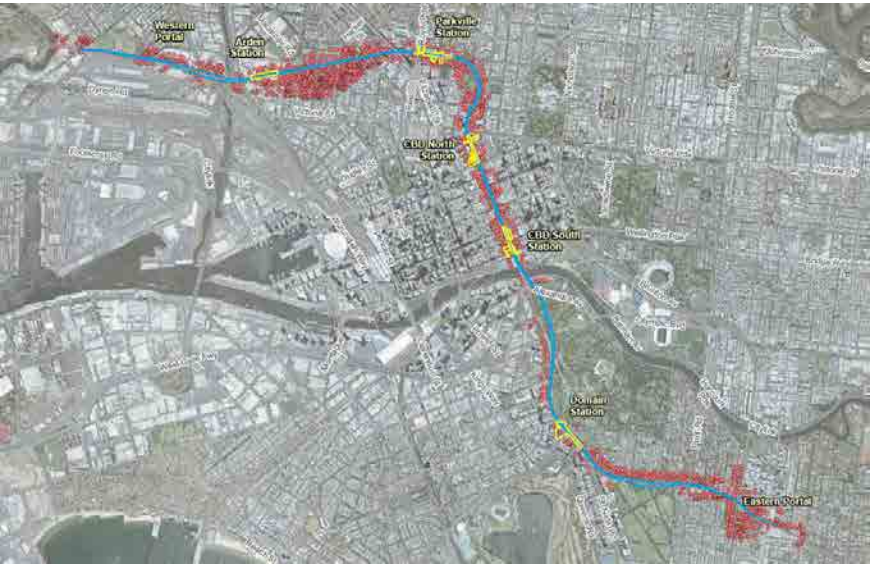


Figure B.1: Melbourne Metro Tunnel Alignment. The Tunnel alignment is shown in blue. The receiver sites are represented by red dots.

B.1.1.2 Additional Construction Works

The Additional Construction Works include all non-tunnelling construction activities (for example they include construction of the stations and construction of TBM launch / recovery sites). The locations where the Additional Construction Works are to take place are shown in Figure B.2.

The equipment that is relevant to vibration as part of the Additional Construction Works is listed in Table B.1

Most of the above ground equipment (e.g. piling rigs, hydromills) would be operated during Normal Working Hours of 7 am to 6 pm week days and 8 am to 1 pm Saturdays. At many of the construction sites it is expected that underground works (including excavation and rockbreaking) would occur 24 hours a day and 7 days a week once the station roofs have been constructed. Exceptions to this are the Western Portal, Fawkner Park and Eastern Portal construction sites where works are anticipated to occur during Normal Working Hours.

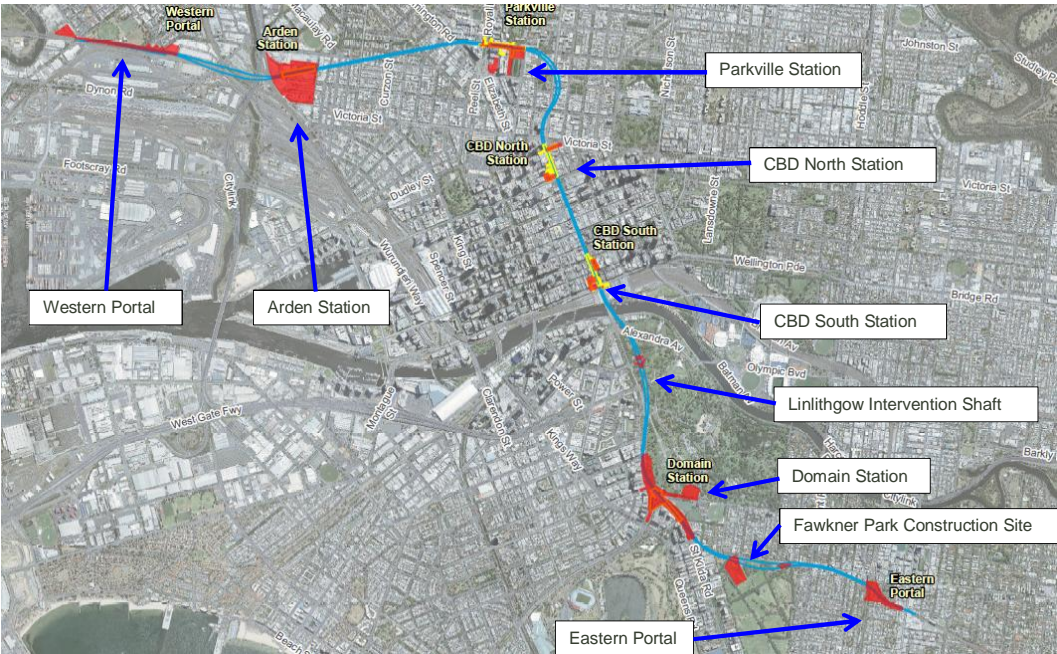


Figure B.2: Melbourne Metro Additional Construction Work sites. Construction sites are marked in red. The tunnel alignment is shown in blue.



Table B.1: Construction equipment that is relevant to vibration.

Location / Precinct	Key vibration generating equipment						
	Excavator with hydraulic rock breaker	Piling Rig (bored)	Clam shovel (diaphragm walls)	Hydromill (diaphragm walls)	Excavator with ripper attachment	Excavator	Fixed plant (eg water treatment, concrete batching, de-sanding plant)
Western Portal	o	o				o	o
Arden Station		o				o	o
Parkville Station	o	o			o	o	o
CBD North	o	o			o	o	o
CBD South	o	o	o	o	o	o	o
Linlithgow Avenue Emergency Access Shaft	o	o				o	o
Domain	o	o	o	o		o	o
Fawkner Park construction site	o	o				o	o
Eastern Portal	o	o				o	o

## B.1.2 Overview of the Potential Impacts of Vibration Caused by the Construction Works

The construction equipment used for tunnelling and station excavation is predicted to cause ground vibration. Some construction activities are predicted to cause vibration which at times would be perceptible to receivers that are located near to the construction activities and tunnels. At other times the vibration may not be perceptible.

Ground vibration during construction may have a number of potential impacts on receiver locations that are situated near to the construction activities. Potential impacts of ground vibration are:

- **Building damage:** Major structural damage is rarely a concern from construction activities. Damage to building structures only occurs when buildings are exposed to intense shock loads from blasting or driven piling from within a few meters. Some of the equipment that would be used on the Melbourne Metro has the potential to cause minor cosmetic damage such as cracking of plaster and rattling of windows and other fragile objects. Predictions have been undertaken to estimate ground vibration levels in buildings and structures that are located near to construction activities to identify locations where there is potential for minor cosmetic damage to buildings. In those instances where there is a potential for minor cosmetic damage to buildings, lower vibration construction techniques have been recommended. In the assessment of building damage, particular emphasis has been placed on heritage listed sites.

- **Human comfort:** There is potential for ground vibration to have an impact on the comfort of people living or working near to construction activities. When ground vibrations exceed the threshold of perception people may experience some level of annoyance. The potential for impact on human comfort from construction vibration has been assessed. Mitigation steps have been identified where construction activities are predicted to impact on human comfort.

- **Ground-borne noise:** Ground-borne noise can also have an impact upon human comfort. Ground-borne noise is noise caused by ground vibration and is typically characterised as low frequency “rumbling” noise. Potential sources of ground-borne noise include trains, buses on rough roads, and vibration intensive construction activities. There is a distinction between ground-borne noise and airborne noise. Ground-borne noise is caused by ground vibration and is typically characterised as low frequency “rumbling” noise (as mentioned above). Airborne noise on the other hand describes noise transmitted through the air. This section of the report deals with ground-borne noise only. An airborne noise impact assessment has been completed for the Melbourne Metro and details of that assessment may be found in the main body of this report and in Appendix A.

The potential for human discomfort due to ground-borne noise during the Melbourne Metro construction works has been assessed and additional mitigation has been recommended where ground-borne noise is predicted to impact upon the comfort of receivers in the vicinity of the construction sites.

- **Impacts on vibration-sensitive equipment:** There is potential for ground vibration to impact upon vibration-sensitive equipment. Vibration-sensitive equipment includes medical equipment such as MRI machines and research laboratory equipment such as high power microscopes. The functionality of vibration-sensitive equipment may be degraded if ground vibration and building vibrations exceed certain levels. The vibration levels specified for these items of equipment can be many times lower than the level of human perception. This means that vibration-sensitive equipment can be affected by low levels of vibration that people cannot detect.

There are a number of research laboratories and medical facilities in the Parkville and CBD North station precincts that house vibration-sensitive equipment. The potential exists for sensitive equipment to be affected by vibration from the construction works that are to be undertaken in Parkville and CBD North (RMIT) and this has been assessed.

## B.1.3 Overview of the Vibration and Ground-borne Noise Assessment Methodology

Details of a desktop study that has been undertaken to predict the vibration and ground-borne noise levels at buildings in the vicinity of the tunnel alignment and station construction sites are provided. Management actions have been recommended where receivers are predicted to be impacted.

An overview of the desktop assessment methodology is given as follows:

1. Guideline targets for vibration and ground-borne noise were established using Australian and international standards and guidelines
2. Vibration source levels were determined for the most vibration intensive equipment that is proposed to be used during construction
3. Predictions were undertaken to determine the reduction of vibration with distance. Predictions were also undertaken to determine how much vibration is transmitted from the ground into buildings. The vibration predictions were completed at approximately 3000 buildings that are located in the vicinity of the rail alignment and construction sites
4. Detailed vibration assessments were completed at receiver locations where the predicted vibration and/or ground-borne noise levels were higher than the guideline targets. The detailed assessments considered additional factors such as existing vibration and ground-borne noise levels and the anticipated duration of the construction works. The detailed assessments aided in determining appropriate management actions for these receivers.





The predictions are based upon the “worst case” vibration levels that are expected to occur during the period of construction. Therefore vibration levels are expected to be lower than the predicted levels for the majority of construction works. The vibration levels that are predicted relate to the point in time at which the most vibration intensive equipment is operating at the minimum distance from each receiver. It is important to note that equipment would not always be operating at that minimum distance. For example, the distance from the tunnelling equipment to a receiver would vary as the tunnelling machines move along the alignment. There would also be changes in the types of construction equipment that are used throughout the construction. For example, rockbreakers would only be required for a portion of the station excavation works (rather than throughout the entire period of construction).

Further details on the guideline targets and the vibration prediction methodology are provided in Sections B.2 and B.3.

## B.2 Guideline Targets used to Assess the Potential Impact of Construction Vibration on Structures, Human Comfort and Sensitive Equipment

The guideline targets provided below. These guideline targets were used as a trigger for detailed assessment and development of management actions.

### B.2.1 Vibration

Guideline targets for vibration are provided below for:

- (i) Damage to Buildings
- (ii) Damage to Utilities (eg. sewers, drains)
- (iii) Human Comfort
- (iv) Vibration-sensitive Equipment.

#### (i) Damage to Buildings

There are no Victorian or national Australian documents that provide guidance with respect to potential vibration damage to buildings.

DIN 4150-3 Structural Vibration Part 3: Effects of vibration on structures, February 1999, (DIN 4150) has been chosen for the assessment of construction vibration.

DIN 4150 sets vibration levels which *when complied with would not result in damage that would have an adverse effect of the structures serviceability*. If the levels from DIN 4150 are exceeded it does not follow that damage would occur. Therefore, if exceedances are predicted then further site specific assessment would be required and if the risk of damage is determined to be low then higher levels of vibration may be approved. The DIN 4150 values are provided in Table B.2 and Table B.3 for short term and long term vibration respectively.

Table B.2: Guideline values for vibration velocity for evaluating short-term vibration on structures

Type of Structure	Vibration at the foundation, mm/s (Peak Component Particle Velocity)			Vibration at horizontal plane of highest floor at all frequencies  mm/s (Peak Component Particle Velocity)
	1 to 10 Hz	10 to 50 Hz	50 to 100 Hz <sup>Note 1</sup>	
<b>Type 1: Buildings used for commercial purposes, industrial buildings and buildings of similar design</b>	20	20 to 40	40 to 50	40
<b>Type 2: Dwellings and buildings of similar design and/or occupancy</b>	5	5 to 15	15 to 20	15
<b>Type 3: Structures that have a particular sensitivity to vibration e.g. heritage buildings</b>	3	3 to 8	8 to 10	8

Notes:

- At frequencies above 100 Hz, the values given in this column may be used as minimum values.
- Vibration levels slightly exceeding those vibration levels in the table would not necessarily mean that damage would occur.
- For civil engineering structures ( e.g. with reinforced concrete constructions used as abutments or foundation pads) the values for Type 1 buildings may be increased by a factor of 2.
- For buildings short term vibration is defined as *Vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated.*

Table B.3: Guideline values for vibration velocity to be used when evaluating the effects of long-term vibration on structures

Type of Structure	Vibration Velocity, mm/s (Peak Component Particle Velocity) in horizontal plane at all frequencies
<b>Buildings used for commercial purposes, industrial buildings and similar design</b>	10
<b>Dwellings and buildings of similar design and/or occupancy</b>	5
<b>Structures that have a particular sensitivity to vibration e.g. heritage buildings</b>	2.5

Notes:

- Vibration levels slightly exceeding those in the table would not necessarily mean that damage would occur.
- In this context 'long-term' means vibration events that may result in resonant structural response.

#### (ii) Damage to Utilities

Table B.4: Guideline values for vibration velocity to be used when evaluating the effects of long-term vibration on structures

Utility / Service	Vibration Velocity, mm/s (Peak Component Particle Velocity) at all frequencies
<b>All utilities (unless specified below)</b>	20
<b>Melbourne Water unreinforced structures and pipework</b>	10
<b>South Yarra sewer main</b>	2

#### (iii) Human Comfort

There is no Victorian or current national Australian document that provides guidance with respect to human comfort from construction vibration.



For past projects, including large infrastructure projects, Australian Standard AS2670.2 – 1990 *Evaluation of human exposure to whole body vibration* has been used to provide *satisfactory magnitudes of building vibration with respect to human response*. This standard is now withdrawn. SAI Global has advised that it has been replaced with ISO 2631-2:2003 *Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 2: Vibration in buildings (1 Hz to 80 Hz)*. This document does not include magnitudes of vibration for human comfort.

The following guideline which addresses human response to vibration has been developed in NSW:

- Assessing Vibration: A Technical Guideline, February 2006, NSW Department of Environment and Conservation (*NSW Vibration*).

In developing this document *Australian and International standards, current scientific research and the practices of other regulating authorities were reviewed*.

*NSW Vibration* is based on British Standard BS6472-1:1992. *Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)* (BS6472-1:1992) which is now superseded. Therefore, in assessing the impact of vibration on human comfort for the Melbourne Metro, the approach described in the *NSW Vibration* (Sections 2.3 and 2.4) has been used, together with the updated vibration targets from the later version of the British Standard, being: British Standard BS6472-1:2008. *Guide to Evaluation of Human Exposure to Vibration in Buildings. Part 1: Vibration sources other than blasting* (BS6472-1:2008).

The vibration guideline targets (trigger levels for management actions) for continuous (as for TBMs and road headers), intermittent, or impulsive (other than blasting) vibration are provided in Table B.5 and are proposed to be applied for the Melbourne Metro project within the Victorian assessment framework for addressing construction impacts.

**Table B.5: Guideline targets for Human Comfort (trigger levels for management actions)**

Location	Vibration Dose Value, VDV ( $\text{m/s}^{1.75}$ )			
	Day 7:00 am to 10:00 pm		Night 10:00 pm to 7:00 am	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.10	0.20
Offices, schools, educational institutions, places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:

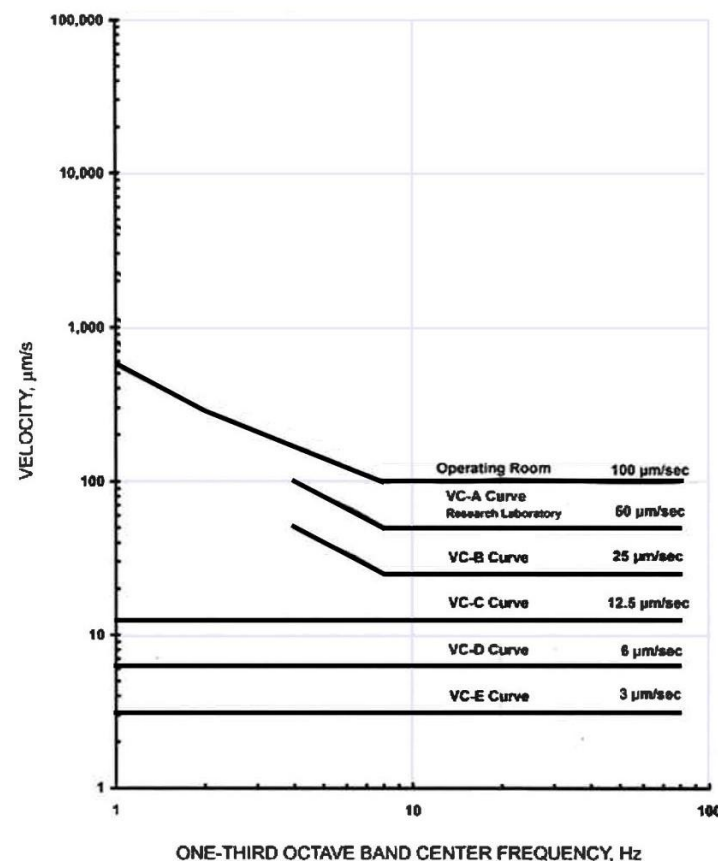
- The VDV's are based on Table 1 in BS6472-1:2008
- BS6472-1:2008 states that:
  - adverse comments are not expected at VDV's less than the Preferred Value
  - there is a low probability of adverse comments at VDV's between the Preferred and Maximum Values
  - adverse comments are possible at VDV's in the range [Maximum Value to 2 x the Maximum Value]
  - adverse comment is probable at VDV's in the range [2 x Maximum Value to 4 x Maximum Value]
  - adverse comment is very likely at VDV's greater than 4 x Maximum Value
- Activities should be designed to meet the Preferred Values where an area is not already exposed to vibration. Where all feasible and reasonable measures have been applied, values up to the Maximum Value may be used if they can be justified. For values beyond the Maximum Value, the operator should negotiate directly with the affected community.
- The guideline targets are non-mandatory; they are goals that should be sought to be achieved through the application of feasible and reasonable mitigation measures.
- Guideline vibration targets for Highly Sensitive areas such as hospital operating theatres or precision laboratories are provided below.

#### (iv) Sensitive Equipment

Hospitals, laboratories and research institutions may utilise sensitive imaging equipment such as MRI machines and microscopes that are highly sensitive to vibration. Vibration guideline targets for sensitive equipment are defined either by referencing equipment supplier data or if this is not available the vibration criteria (VC) curves provided by American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE), Chapter 48, Noise and Vibration Control, 2011 can be used. Ambient vibration levels where sensitive equipment is successfully operating may also be used to set targets on the basis of precedent. The VC curves are presented in Figure B.3 and provide the 1/3 octave RMS vibration tolerances of different classes of sensitive equipment. The VC curve that applies to a specific site is dependent on the type of equipment and activities being conducted. The equipment requirements from ASHRAE are provided in Table B.6.

The location and type of vibration-sensitive equipment have been identified for the project and site-specific vibration targets derived.

Where targets cannot be achieved, management approaches would need to be implemented so that construction activities do not interfere with the use of vibration-sensitive equipment.



**Figure B.3: VC Curves from ASHRAE**



Table B.6: Equipment Vibration Guideline Targets - ASHRAE

Equipment Requirements	VC Curve
Bench microscopes up to 100x magnification ; laboratory robots	Operating Room
Bench microscopes up to 400x magnification; optical and other precision balances; co-ordinate measuring machines; metrology laboratories; optical comparators; micro electronics manufacturing equipment; proximity and projection aligners, etc.	VC-A
Microsurgery, eye surgery, neurosurgery; bench microscope at magnification greater than 400x; optical equipment on isolation tables; microelectronic manufacturing equipment such as inspection and lithography equipment (including steppers) to 3mm line widths	VC-B
Electron microscopes up to 30,000x magnification; microtomes; magnetic resonance images; 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 and other critical equipment for photo-lithography with line widths of ½ micro m; includes electron beam systems	VC-D
Un-isolated laser and optical research systems; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for photolithography with line widths of ¼ micro m; includes electron beam systems	VC-E

## B.2.2 Ground-borne Noise

There is no Victorian or national Australian document that provides guidance with respect to construction ground-borne noise. The following guideline which addresses ground-borne noise has been developed in NSW:

- NSW Interim Construction Noise Guideline, Department of Environment and Climate Change, July 2009 (*the Guideline*).

This document has been successfully applied on recent projects in NSW which are similar to the Melbourne Metro. It has been developed by the Department of Environment and Climate Change NSW, the NSW Department of Planning, Roads and Traffic Authority NSW, Work Cover NSW, Health NSW and the Local Government and Shires Associations of NSW. Preparation of the document included extensive public consultation and the view of industry stakeholders were considered along with the Standards Australia committee.

The relevant section of *The Guideline* is Section 4.2. It presents the ground-borne noise trigger levels which indicate when management actions should be implemented. These levels recognise the temporary nature of construction and are to protect the amenity and sleep of people when they are home. It is also proposed that for the Melbourne Metro they be applied to sleeping areas in hospital wards, student accommodation and hotel rooms. The levels are reproduced in Table B.7. It is proposed that the values in Table B.7 (from Section 4.2 of the Guideline) apply for the Melbourne Metro. These are to be applied within the Victorian assessment framework for addressing construction impacts.

Table B.7: Guideline targets for ground-borne noise (trigger levels for management actions)

Time Period	Internal $L_{Aeq,15min}$ , dB
Evening, 6pm to 10pm	40
Night, 10 pm to 7am	35

Note:

1. Levels are only applicable when ground-borne noise levels are higher than airborne noise levels
2. The noise levels are assessed at the centre of the most affected habitable room
3. Management Actions include extensive community consultation to determine acceptable level of disruption and provision of respite accommodation in some circumstances.

The Department of Primary Industry Code of Practice for the Housing and Care of Laboratory Mice, Rats, Guinea Pigs and Rabbits provides noise recommends that background noise levels are kept below 50 dBL. Ground-borne noise at locations where biological resources are housed has been compared with either a guideline target of 50 dBL or with existing noise level measurements. In making these assessments, the frequency range relevant to each type of biological resource has been considered.

## B.3 Method used to predict vibration and ground-borne noise

### B.3.1 Approach

The following approach has been used for the assessment of vibration and ground-borne noise from tunnelling construction:

- The type of occupancy (residential, commercial, other sensitive use) has been identified for each of the receivers
- A sophisticated spreadsheet modelling tool has been developed based on the Federal Transit Administration (FTA) predictive methodology (the US Department of Transportation FTA document, *Transit Noise and Vibration Impact Assessment* FTA-VA-90-1003-06, FTA 2006) (FTA Guideline)
- Vibration source spectra (one third octave vibration levels) for the TBM and road header have been estimated using a combination of literature-based data along with AJM JV's library of test data
- The ground vibration attenuation characteristics for the alignment have been derived from a combination of literature-based data and interpretation of geotechnical measurements at borehole locations
- The model has been used to predict vibration and ground-borne noise levels for receivers in the vicinity of the rail alignment For the purpose of calculation of Vibration Dose Values (VDV) day has been defined as 7:00 am to 10:00 pm and night has been defined as 10:00 pm to 7:00 am as per BS6472-1:2008
- The predicted vibration and ground-borne noise levels have been compared to the guideline targets for each occupancy type
- Where guideline targets are exceeded, a further analysis has been carried out at one or more of the worst affected receivers to quantify the duration of the exceedance for tunnelling activities.

### B.3.2 Vibration Source Levels and Propagation Functions

#### Tunnelling equipment

Vibration source levels and spectral characteristics are dependent on machine type and size and the ground conditions through which tunnelling is proposed to occur. TBM and road header vibration source levels and spectral characteristics have been determined based on literature and test results for similar size and type machines in comparable soil/rock conditions.

The frequency spectra defined for the TBM and road header are based on the assumption that the majority of vibration is in the 16 to 80 Hz frequency bands.



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

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

Where *PPV* = peak particle velocity, in mm/s  
*k* = site/machine specific constant  
*d<sub>ref</sub>* = 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 site/machine specific constants have been selected based on international literature and AJM JV's library of test data, taking into account the expected ground conditions in the Melbourne Metropolitan Area along with machine types and sizes. The mathematical models used are represented graphically in Figure B.4.

These equations are a best fit vibration estimate and vibration measurements should be undertaken at the commencement of work to confirm the mathematical prediction model.

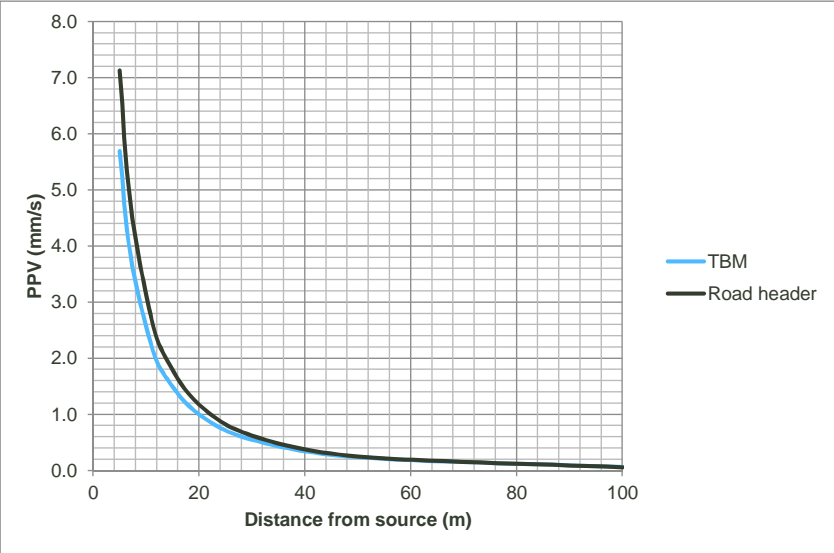


Figure B.4: Ground-borne Vibration Attenuation Models for TBM and Road headers

The vibration adjacent to the receiver location has been estimated by calculating the minimum slope distance from each receiver to the top of the tunnel alignment, as shown in

Figure B.5.

In the minimum slope distances calculations the tunnel diameter has been taken as 5.7 m and the station cavern roof height as 13.5 m above rail height.

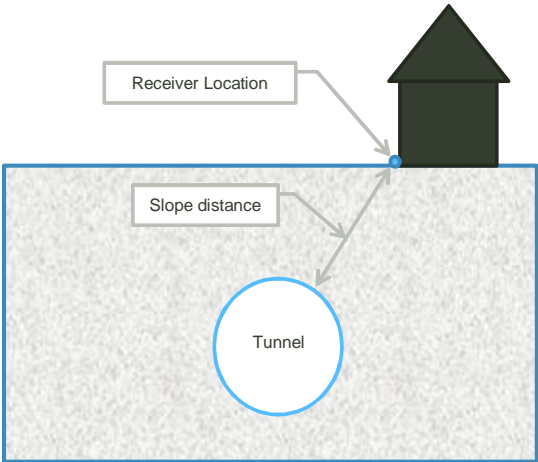


Figure B.5: Slope Distance between Tunnel and Receiver

Additional Construction Works Equipment

Source vibration levels used to model the Additional Construction Works equipment are presented in Table B.8.

Table B.8: Source vibration levels for equipment for Additional Construction Works

Description of vibration source	PPV at 7.6 m (mm/s)	Reference/Comment
32 tonne excavator with hydraulic rockbreaker	6.9	Based on representative data
20 tonne excavator with hydraulic rockbreaker	4.7	Based on representative data
12-15 tonne excavator with hydraulic rockbreaker	3.3	Based on representative data
7 tonne excavator with hydraulic rockbreaker	2.4	Based on representative data
Excavator with ripper	1.3	Based on representative data
Hydromill in rock (diaphragm wall construction)	0.4	FTA Guideline
Piling rig (bored)	1.0	British Standard BS5228.
Heavy vehicle traffic	1.9	FTA Guideline
Fixed plant	1.9	Expected to be better than or equal to heavy vehicle traffic





For the rockbreakers, the ground vibration at each receiver (adjacent to the building foundation) has been estimated using a relationship similar to that which was used for the tunnelling equipment. Equipment other than rockbreakers has been using the formula from the FTA Guideline:

$$PPV_{Receiver} = PPV_{Ref} \times \left( \frac{d_{ref}}{d} \right)^{1.5}$$

Where  $PPV_{Receiver}$  = peak particle velocity at the receiver in mm/s

$PPV_{Equipment Ref}$  = peak particle velocity of the source, measured at the reference distance (7.6 m)

$d_{ref}$  = reference distance for the vibration source (7.6 m)

$d$  = horizontal distance from the source to the receiver (m)

The vibration attenuation models are presented graphically in Figure B.6:

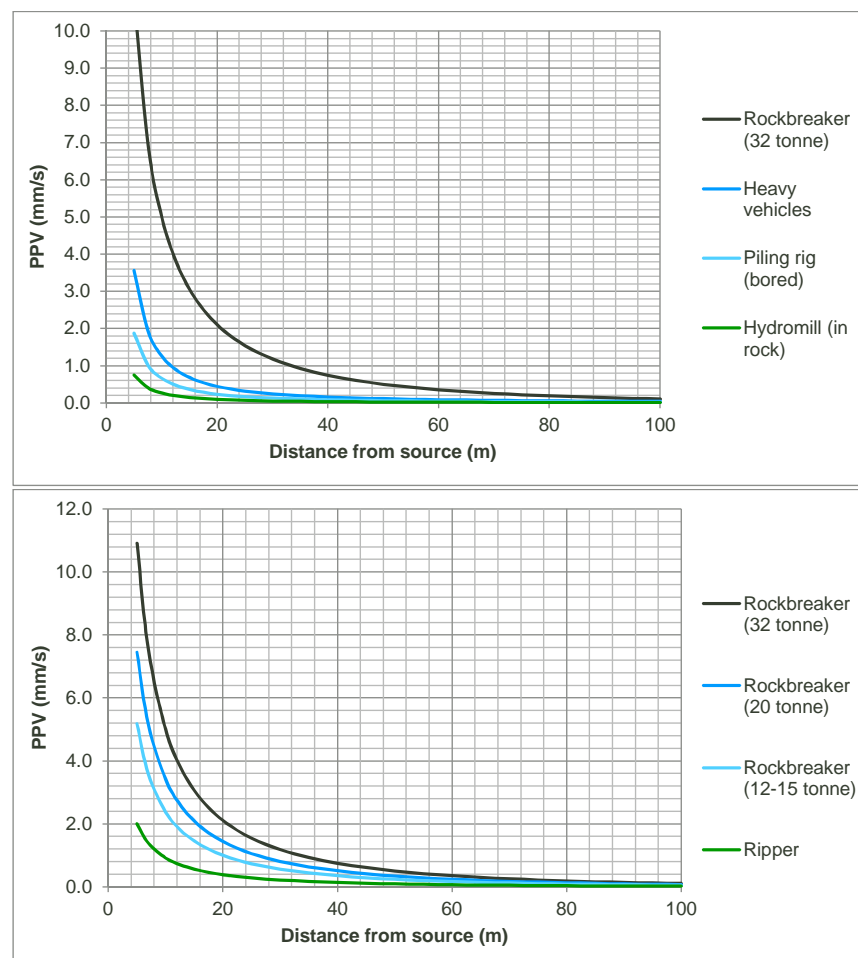


Figure B.6: Vibration attenuation models for equipment associated with Additional Construction Works

At each construction site, vibration has been assessed for the “worst case” (highest vibration) machine. For each receiver, vibration has been assessed with the equipment operating in the “worst case” position (i.e. with the machine positioned as closely as possible to the receiver). In other words, the distance “d” has been predicted as the distance from the location of the receiver to the nearest boundary of the nominated work area.

For most machines, the horizontal distance was used in the prediction. However, the slope distance was used for rockbreakers in order to reflect reductions in vibration that occur when rockbreakers are working deeper underground. The assumed depths of operation for rockbreakers are summarised in Table B.9.

It is important to note that the vibration prediction results are less accurate when machines are extremely close to receiver locations (e.g. less than 5 m). Therefore the Proponent would need to undertake vibration measurements to ensure that the guideline targets are met when vibration critical construction machinery is less than 5 m from the nearest building.

Table B.9: Rockbreaker sizes and depths of operation

Precinct	Assumed geology	Rockbreaker excavator size (tonnes)	Depth (m)
Western Portal	Older Volcanics	12	-
Arden	Coode Island Silt	Not required	-
Parkville	Melbourne Formation (MF4-3)	20	>25
CBD North (Franklin St Excavation)	Melbourne Formation (MF2)	20	10 – 25
CBD North (A'Beckett and Southern Entrance Excavations)	Melbourne Formation (MF2)	20	15 – 25
	Melbourne Formation (MF1)	32	>25
CBD South (City Square and Flinders/Swanston Excavations)	Melbourne Formation (MF2)	20	>20
CBD South (Federation Square Excavation)	Melbourne Formation (MF4-2)	12	>15
Fawcner Park	Melbourne Formation (HW)	Not required	0 – 20
	Melbourne Formation (MW)	20	> 20
Domain	Brighton Group	Not required	0 – 10
	Melbourne Formation (HW)	20	> 10
Eastern portal	Brighton Group	Not required	0 – 10
	Melbourne Formation (HW)	7	> 10

### B.3.3 Model

Construction vibration and ground-borne noise levels for the tunnelling have been predicted using the modelling and assessment methodology described in the FTA Guideline (as referenced above), with modifications to allow for the use of point sources such as are typical for the TBM cutting face, road headers, piling equipment etc. The general and detailed FTA Guideline approaches have been used to create a model for the entire alignment.



The overall modelling process has been summarized in the flowchart shown in Figure B.7.

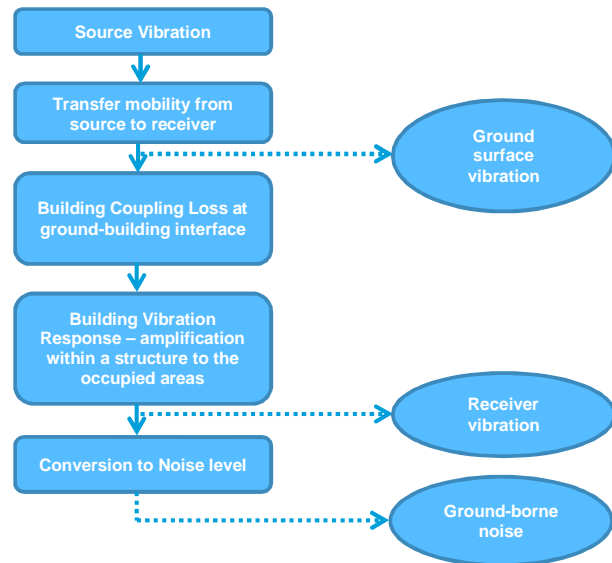


Figure B.7: Construction vibration and ground-borne noise modelling process (based on FTA guideline with modifications)

### B.3.4 Vibration Predictions

Predicted levels of vibration at each sensitive receiver have been based on relevant vibration source spectra and vibration propagation functions as presented above, and adjusted for building coupling loss factors and vibration response.

#### Building Damage

At each receiver point the overall Peak Particle Vibration (PPV) has been calculated for comparison with the guideline targets for structural damage.

#### Human Comfort

The VDV is dependent on three key parameters:

- Level of vibration
- Spectral content of the vibration
- Duration of operation

VDVs for the TBM have been calculated based on continual operation and VDV for road headers have been based on 60% operating time. Vibration spectra for these machines is based on data from the literature. The VDV for tunnelling works has been calculated based on the methodology presented in BS6472-1:2008 using weighting Wb (for vertical motion) and the predictions compared to the human comfort vibration trigger for management action.

Where spectral data for the Additional Construction Equipment is not known, the VDV was estimated using the following formula:

$$VDV = 1.4 \times V_{RMS \text{ Receiver}} \times \left( \frac{2 \times \pi \times 31.5 \times 0.49}{1000} \right) \times t^{0.25}$$

Where  $V_{RMS \text{ Receiver}}$  = 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 (consistent with the crest factor used in the FTA guideline). The calculation also included coupling loss factors for the building and amplifications due to building resonance.

This equation assumes that the dominant vibration is at 31.5 Hz (where the BS6472 Wb frequency weighting is 0.49). It is noted that this calculation can lead to conservative VDV estimates.

#### Sensitive Equipment

For sensitive receivers, the receiver vibration frequency spectrum has been inspected and compared with the relevant VC curve from ASHRAE (and baseline measurements where applicable).

### B.3.5 Ground-borne Noise Impact Predictions

For the tunnelling works, the ground-borne noise model is based on the method outlined above for vibration prediction, with the addition of a conversion factor between maximum floor vibration level and maximum interior sound pressure level using the method described in the publication – *Measurement and assessment of ground-borne noise and vibration* (Association of Noise Consultants 2012).

Vibration levels for this methodology are RMS (Root Mean Square) values. The relationship between the peak value calculated in the vibration prediction and the RMS level required for the ground-borne noise prediction is a function of the shape of the vibration pulse. For a true sinusoidal vibration the peak vibration must be divided by a factor of 1.4 to obtain RMS units, however for vibration which contains elevated peaks (higher crest factors) this factor may increase to more than 5.

TBM and road header vibration is considered to be continuous in nature, but is not necessarily sinusoidal. A factor of 2.5 has been used for the conversion of peak to RMS vibration levels for the road header, while a factor of 1.4 has been used in the case of the TBM. These factors are considered conservative and therefore likely to produce conservative RMS values as well as conservative results for ground-borne noise.

The calculated 1/3 octave band interior sound pressure levels have been A-weighted, logarithmically summed and converted to overall noise levels for comparison with the guideline ground-borne noise targets for the different occupancy types.

A simplification of this method has been used to predict ground-borne noise for the Additional Construction Works (where estimates of the vibration spectra were not available). The formula used to compute ground-borne noise is (FTA Guideline, Table 10.1):

$$L_{Aeq \ 15min} = 20 \times LOG_{10} \left( \frac{L_V}{2.54^{-5}} \right) - 35$$

Where  $L_{Aeq \ 15min}$  = the equivalent noise level over a 15 minute period in dB

$L_V$  = the RMS vibration level in the occupied area (mm/s). The RMS vibration level was calculated from the PPV using a crest factor of 4 (FTA guideline).

Note: This  $L_{Aeq \ 15min}$  calculation assumes that that equipment (including heavy vehicle traffic) operates continually. It is expected that actual  $L_{Aeq \ 15min}$  values would be lower at construction sites where equipment operates intermittently and vehicular traffic is light.



## B.4 Results of Initial Vibration and Ground-borne Noise Assessment for Tunnelling works

Vibration and ground-borne noise has been predicted across the Melbourne Metro alignment. The predictions relate to the highest vibration levels that are predicted to occur at any point in time during the construction. For multiple story buildings, the predictions relate to the vibration levels on the ground floor where vibration levels are expected to be highest. Vibration levels would be lower on higher floors of the multi-story buildings.

The results of the predictions are plotted against tunnel chainage as follows:

- Figure B.8: Predicted vibration levels due to tunnelling at commercial receivers
- Figure B.9: Predicted vibration levels due to tunnelling at residential receivers
- Figure B.10: Predicted VDV – Day levels for Human Comfort due to tunnelling at residential receivers
- Figure B.11: Predicted VDV – Night levels for Human Comfort due to tunnelling at residential receivers
- Figure B.12: Predicted VDV – Day levels for Human Comfort due to tunnelling at commercial & educational receivers
- Figure B.13: Predicted VDV – Night levels for Human Comfort due to tunnelling at commercial & educational receivers
- Figure B.14: Predicted VDV – Day levels for Human Comfort due to tunnelling at workshop receivers
- Figure B.15: Predicted VDV – Night levels for Human Comfort due to tunnelling at workshop receivers
- Figure B.16: Predicted ground-borne noise levels for Human Comfort due to tunnelling at residential receivers

VDV levels and ground-borne noise levels due to the TBM and road header tunnelling are presented as colour coded levels on the Melbourne Metro precinct maps as follows:

- Figure B.17: Colour coded tunnelling VDV (day) levels for Human Comfort for Western Portal Precinct
- Figure B.18: Colour coded tunnelling VDV (day) levels for Human Comfort for Western Portal to Arden Tunnel Precinct
- Figure B.19: Colour coded tunnelling VDV (day) levels for Human Comfort for Arden Station Precinct
- Figure B.20: Colour coded tunnelling VDV (day) levels for Human Comfort for Arden to Parkville Precinct
- Figure B.21: Colour coded tunnelling VDV (day) levels for Human Comfort for Parkville Station Precinct
- Figure B.22: Colour coded tunnelling VDV (day) levels for Human Comfort for Parkville to CBD North Tunnel Precinct
- Figure B.23: Colour coded tunnelling VDV (day) levels for Human Comfort for CBD North Station Precinct
- Figure B.24: Colour coded tunnelling VDV (day) levels for Human Comfort for CBD North and CBD South Tunnel Precinct
- Figure B.25: Colour coded tunnelling VDV (day) levels for Human Comfort for CBD South Station Precinct
- Figure B.26: Colour coded tunnelling VDV (day) levels for Human Comfort for CBD South to Domain Tunnel Precinct
- Figure B.27: Colour coded tunnelling VDV (day) levels for Human Comfort for Domain Station Precinct
- Figure B.28: Colour coded tunnelling VDV (day) levels for Human Comfort for Domain to Eastern Tunnel Precinct
- Figure B.29: Colour coded tunnelling VDV (day) levels for Human Comfort for Eastern Portal Precinct
- Figure B.30: Colour coded tunnelling VDV (night) levels for Human Comfort for Western Portal Precinct
- Figure B.31: Colour coded tunnelling VDV (night) levels for Human Comfort for Western Portal to Arden Tunnel Precinct
- Figure B.32: Colour coded tunnelling VDV (night) levels for Human Comfort for Arden Station Precinct

- Figure B.33: Colour coded tunnelling VDV (night) levels for Human Comfort for Arden to Parkville Tunnel Precinct
- Figure B.34: Colour coded tunnelling VDV (night) levels for Human Comfort for Parkville Station Precinct
- Figure B.35: Colour coded tunnelling VDV (night) levels for Human Comfort for Parkville to CBD North Tunnel Precinct
- Figure B.36: Colour coded tunnelling VDV (night) levels for Human Comfort for CBD North Station Precinct
- Figure B.37: Colour coded tunnelling VDV (night) levels for Human Comfort CBD North and CBD South Tunnel Precinct
- Figure B.38: Colour coded tunnelling VDV (night) levels for Human Comfort for CBD South Station Precinct
- Figure B.39: Colour coded tunnelling VDV (night) levels for Human Comfort for CBD South to Domain Tunnel Precinct
- Figure B.40: Colour coded tunnelling VDV (night) levels for Human Comfort for Domain Station Precinct
- Figure B.41: Colour coded tunnelling VDV (night) levels for Human Comfort for Domain to Eastern Tunnel Precinct
- Figure B.42: Colour coded tunnelling VDV (night) levels for Human Comfort for Eastern Portal Precinct
- Figure B.43: Colour coded tunnelling ground-borne noise levels for Western Portal Precinct
- Figure B.44: Colour coded tunnelling ground-borne noise levels for Western Portal to Arden Tunnel Precinct
- Figure B.45: Colour coded tunnelling ground-borne noise levels for Arden Station Precinct
- Figure B.46: Colour coded tunnelling ground-borne noise levels for Western Portal to Parkville Tunnel Precinct
- Figure B.47: Colour coded tunnelling ground-borne noise levels for Parkville Station Precinct
- Figure B.48: Colour coded tunnelling ground-borne noise levels for Parkville to CBD North Tunnel Precinct
- Figure B.49: Colour coded tunnelling ground-borne noise levels for CBD North Station Precinct
- Figure B.50: Colour coded tunnelling ground-borne noise levels for CBD North and CBD South Tunnel Precinct
- Figure B.51: Colour coded tunnelling ground-borne noise levels for CBD South Station Precinct
- Figure B.52: Colour coded tunnelling ground-borne noise levels for CBD South to Domain Tunnel Precinct
- Figure B.53: Colour coded tunnelling ground-borne noise levels for Domain Station Precinct
- Figure B.54: Colour coded tunnelling ground-borne noise levels for Domain to Eastern Tunnel Precinct
- Figure B.55: Colour coded tunnelling ground-borne noise levels for Western Portal Precinct

VDV levels and ground-borne noise levels due to the road header mining of the CBD North and CBD South station caverns are presented as colour coded levels on the Melbourne Metro precinct maps as follows:

- Figure B.56: Colour coded station cavern mining VDV (day) levels for Human Comfort for CBD North Station Precinct
- Figure B.57: Colour coded station cavern mining VDV (day) levels for Human Comfort for CBD South Station Precinct
- Figure B.58: Colour coded station cavern mining VDV (night) levels for Human Comfort for CBD North Station Precinct
- Figure B.59: Colour coded station cavern mining VDV (night) levels for Human Comfort for CBD South Station Precinct
- Figure B.60: Colour coded station cavern mining ground-borne noise levels for CBD North Station Precinct
- Figure B.61: Colour coded station cavern mining ground-borne noise levels for CBD South Station Precinct

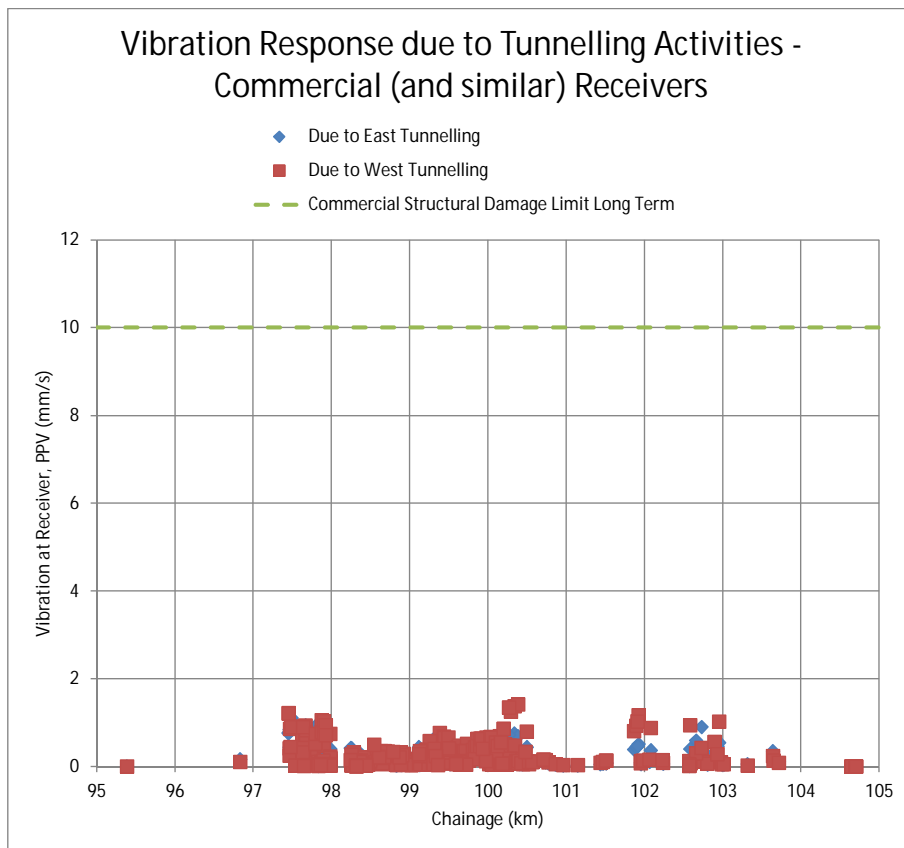


Figure B.8: Predicted vibration levels due to tunnelling at commercial receivers

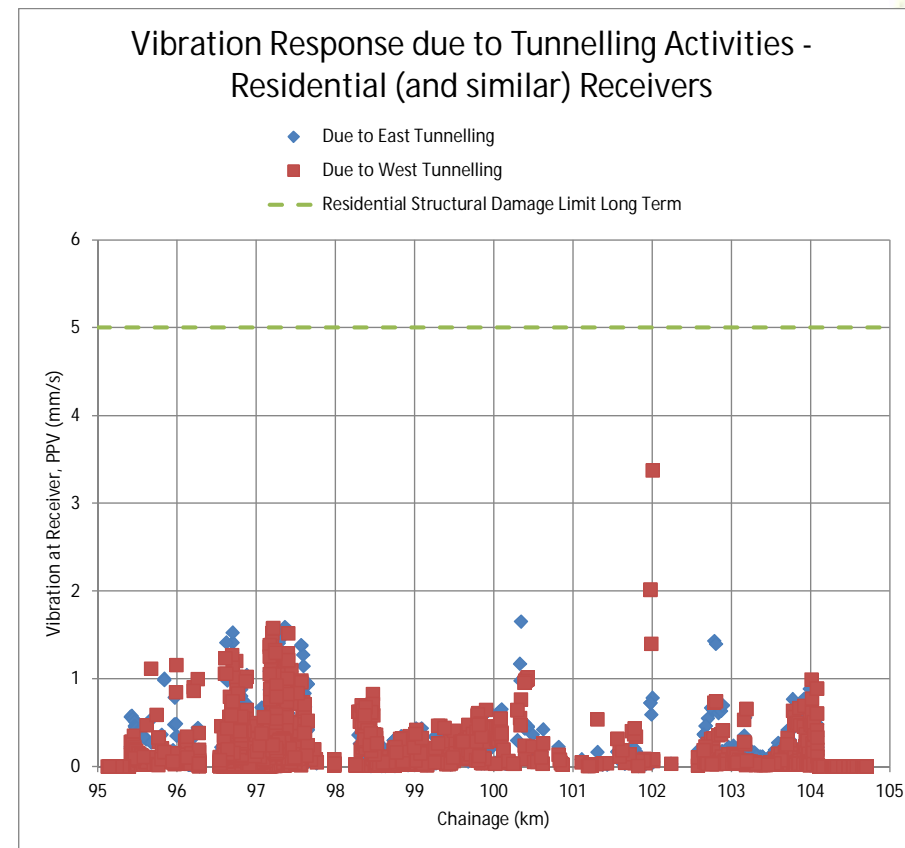


Figure B.9: Predicted vibration levels due to tunnelling at residential receivers



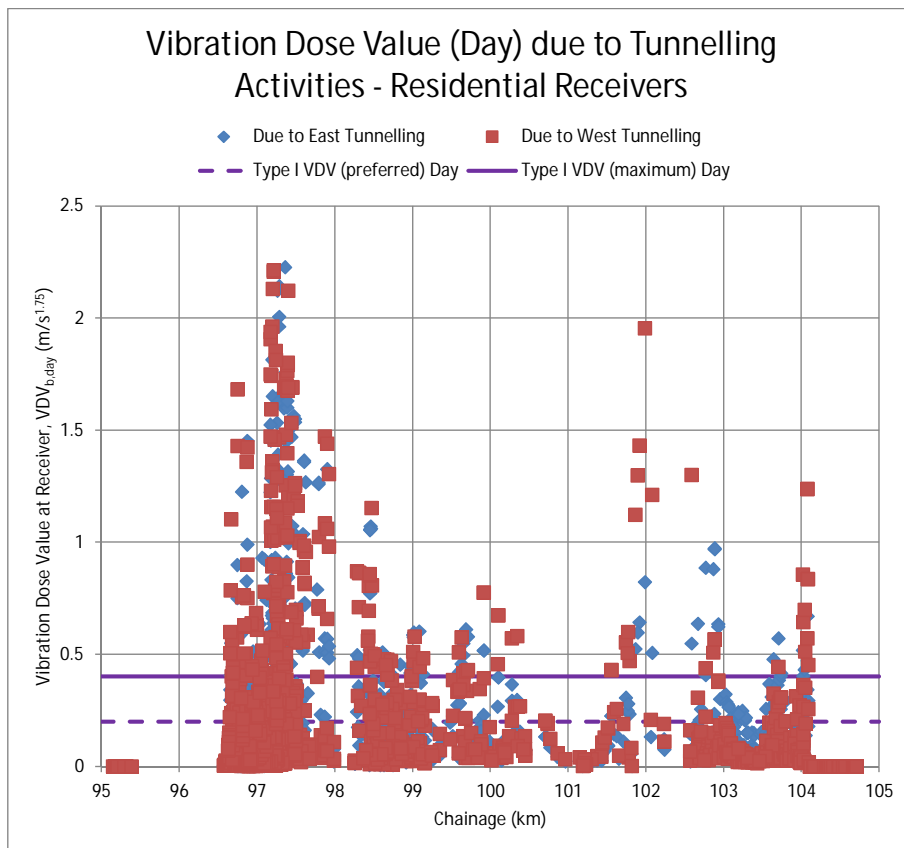


Figure B.10: Predicted VDV – Day levels for Human Comfort due to tunnelling at residential receivers

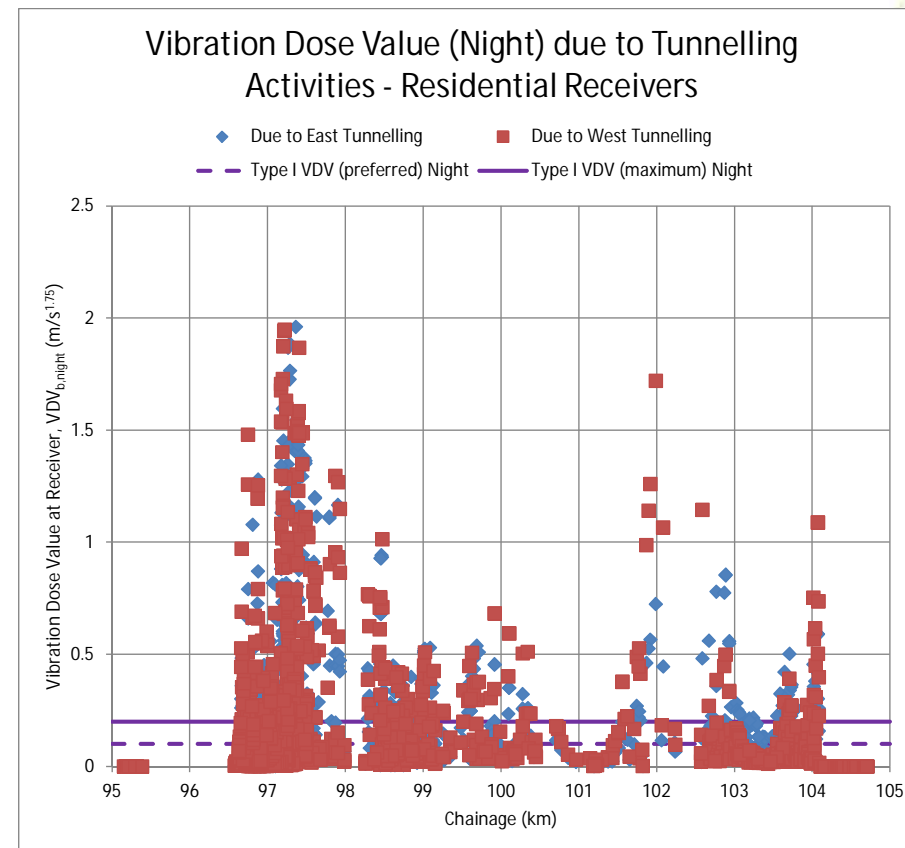


Figure B.11: Predicted VDV – Night levels for Human Comfort due to tunnelling at residential receivers

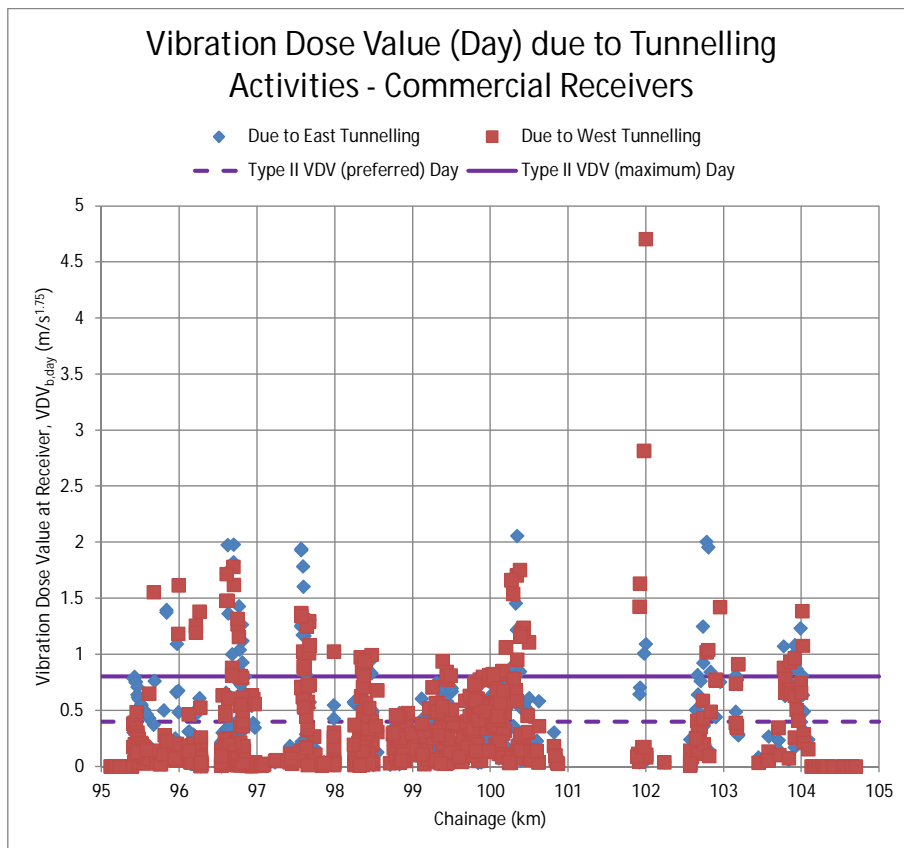


Figure B.12: Predicted VDV – Day levels for Human Comfort due to tunnelling at commercial & educational receivers

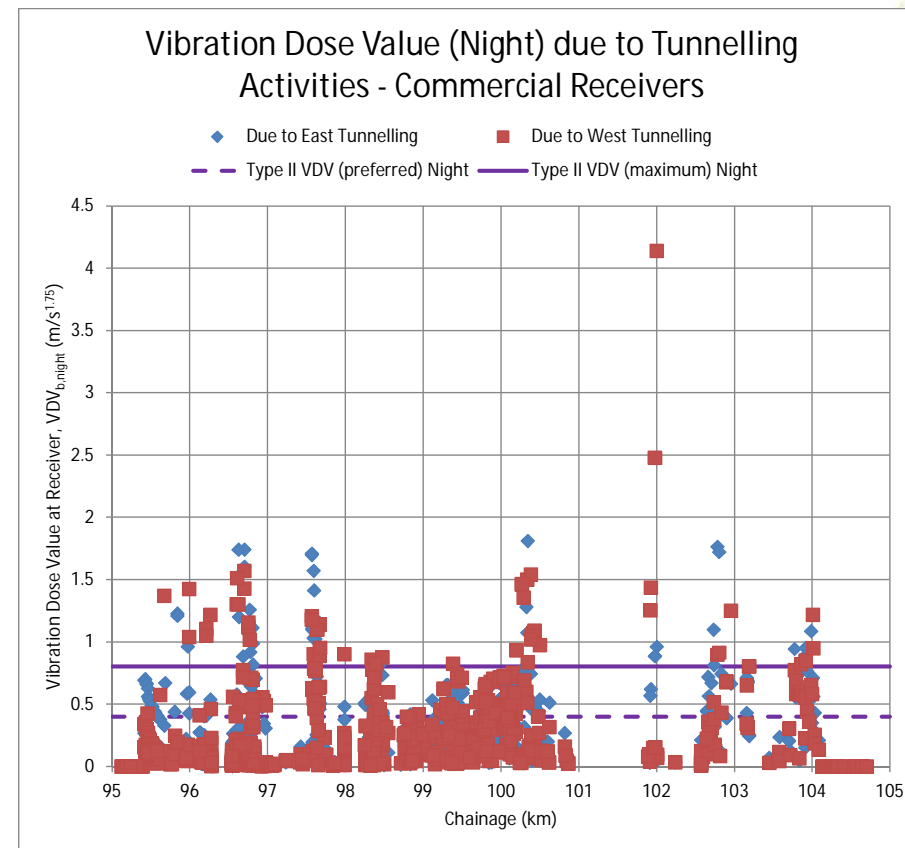


Figure B.13: Predicted VDV – Night levels for Human Comfort due to tunnelling at commercial & educational receivers

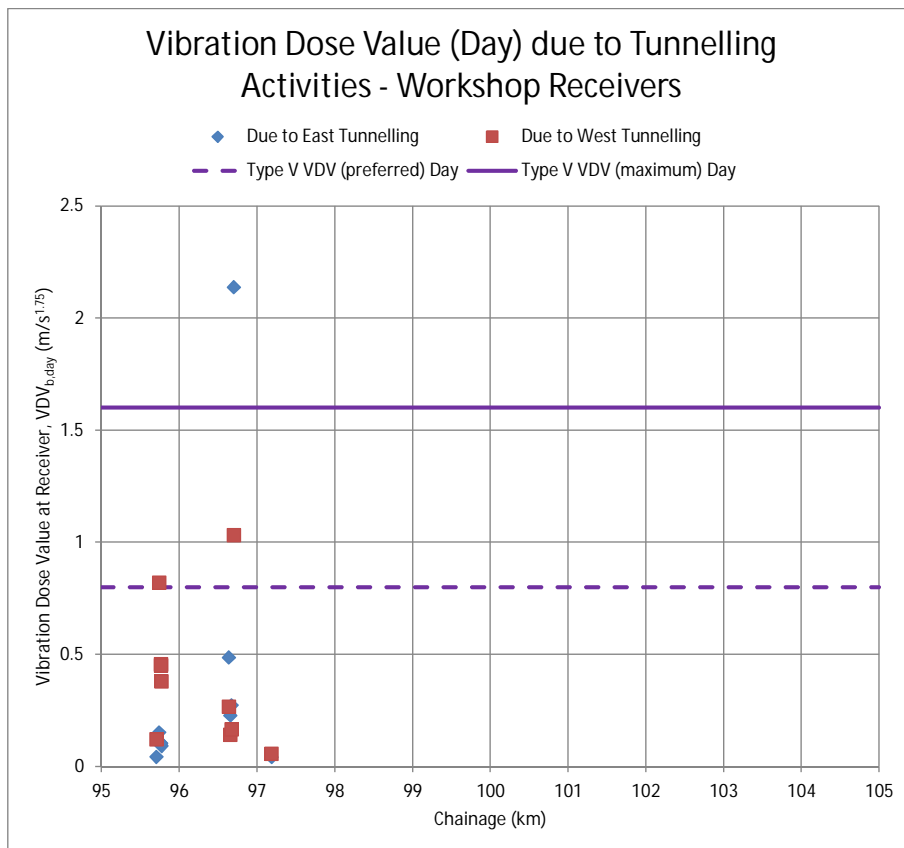


Figure B.14: Predicted VDV – Day levels for Human Comfort due to tunnelling at workshop receivers

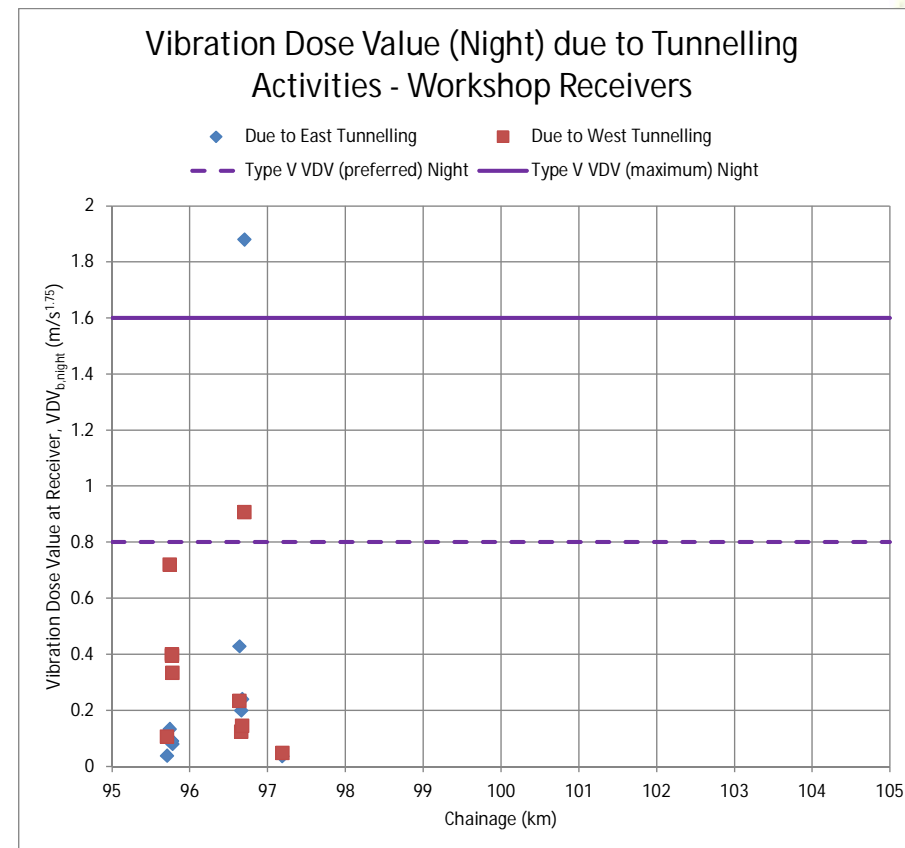


Figure B.15: Predicted VDV – Night levels for Human Comfort due to tunnelling at workshop receivers

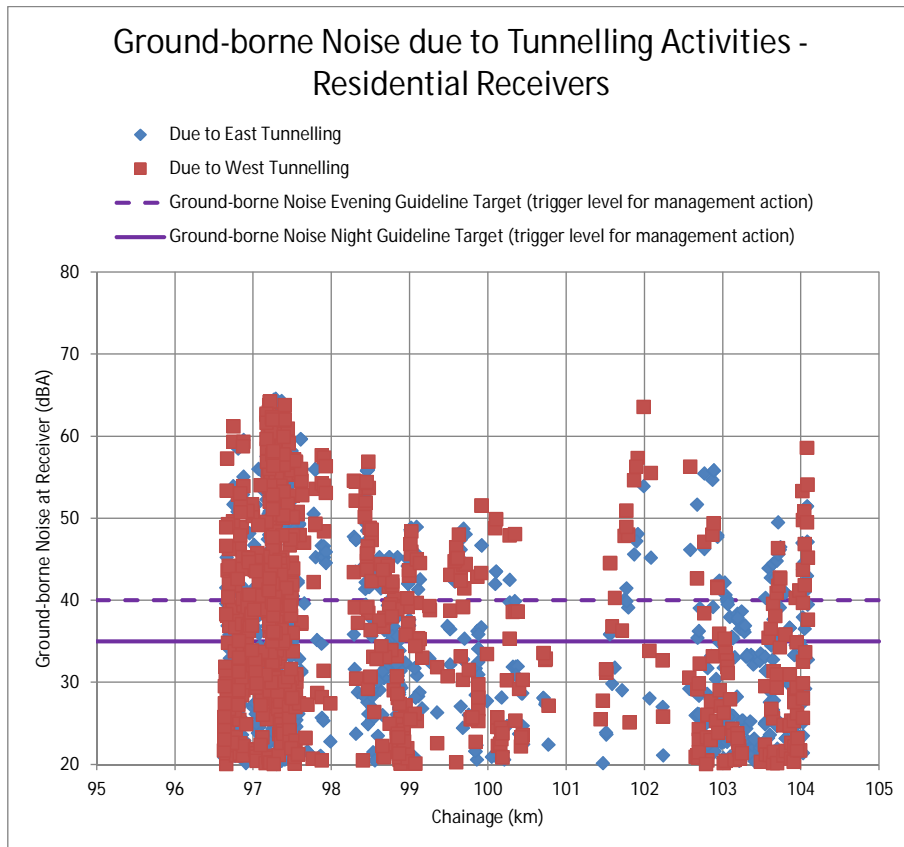


Figure B.16: Predicted ground-borne noise levels for Human Comfort due to tunnelling at residential receivers





## Legend

### Result Set 1

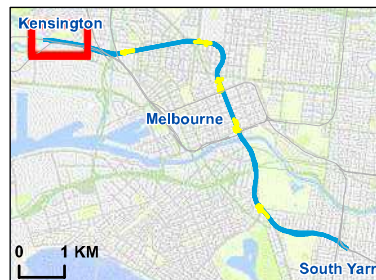
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 1 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - Western Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

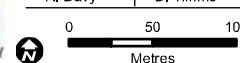
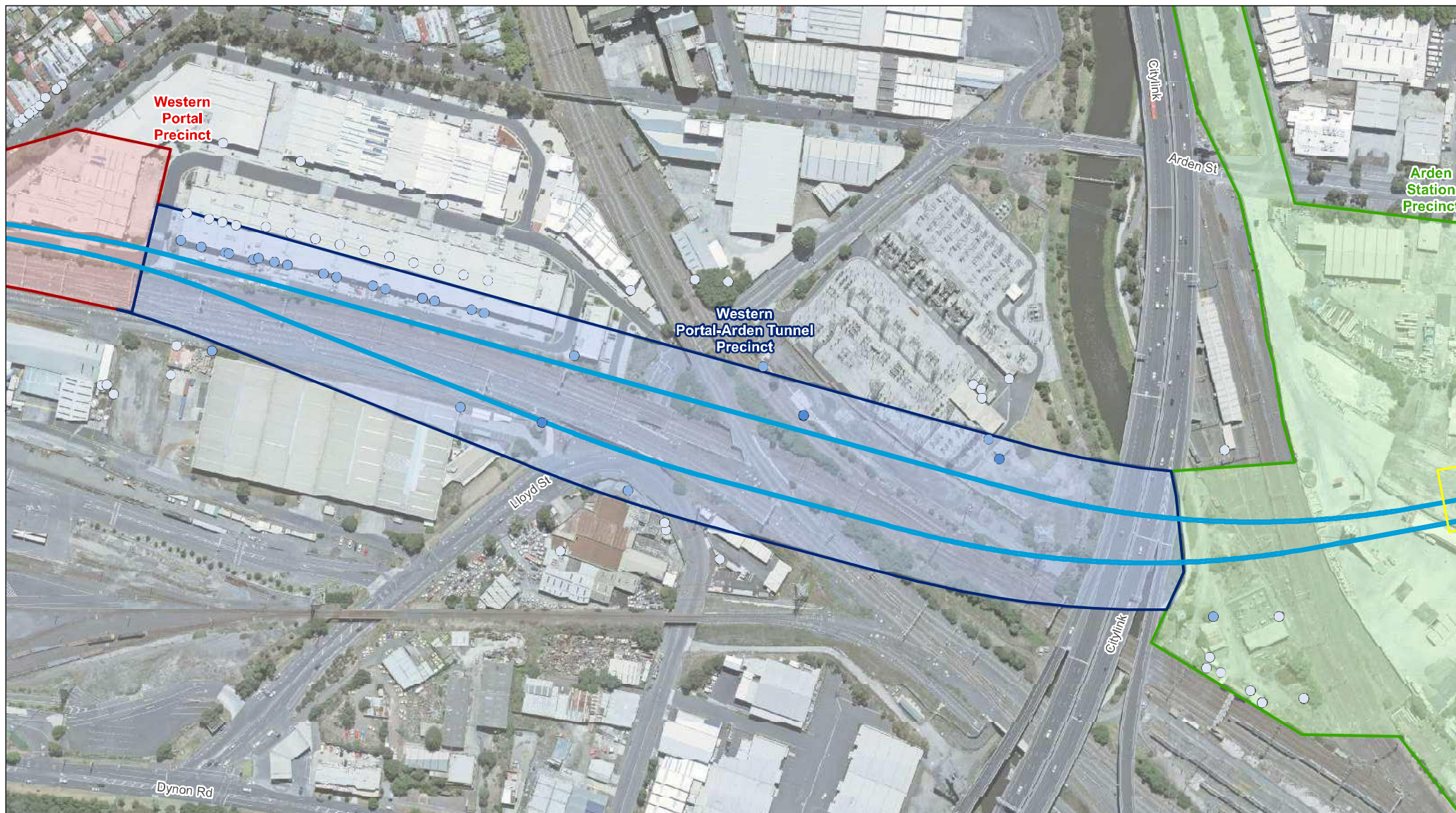


Figure B.17: Colour coded tunnelling VDV (day) levels for Human Comfort for Western Portal Precinct

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## Legend

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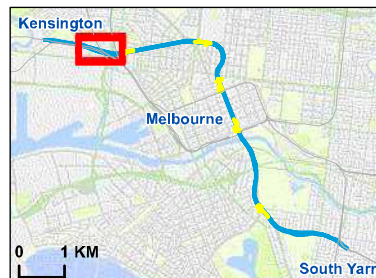
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 2 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - Western Portal to Arden

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

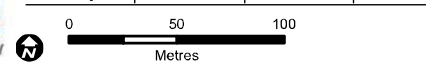


Figure B.18: Colour coded tunnelling VDV (day) levels for Human Comfort for Western Portal to Arden Tunnel Precinct





## Legend

### Result Set 1

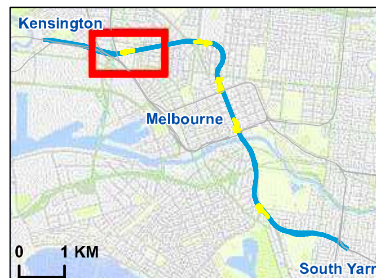
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 3 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - Arden Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

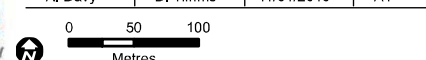
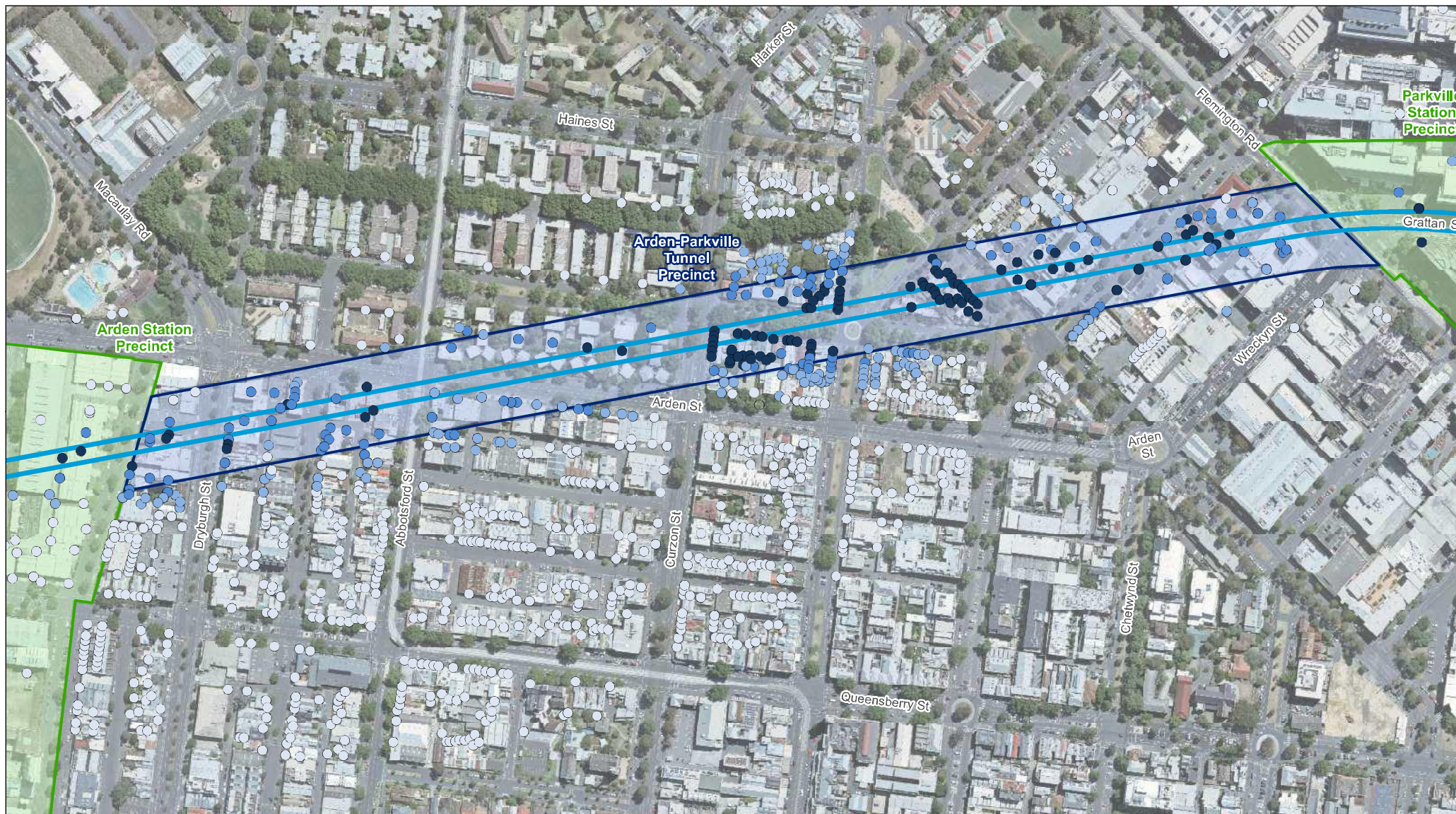


Figure B.19: Colour coded tunnelling VDV (day) levels for Human Comfort for Arden Station Precinct

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## Legend

### Result Set 1

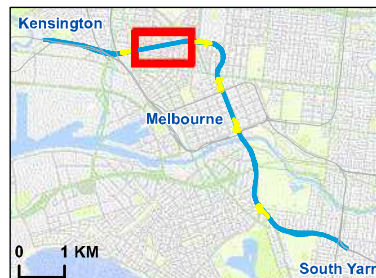
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 4 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - Arden to Parkville

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

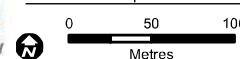
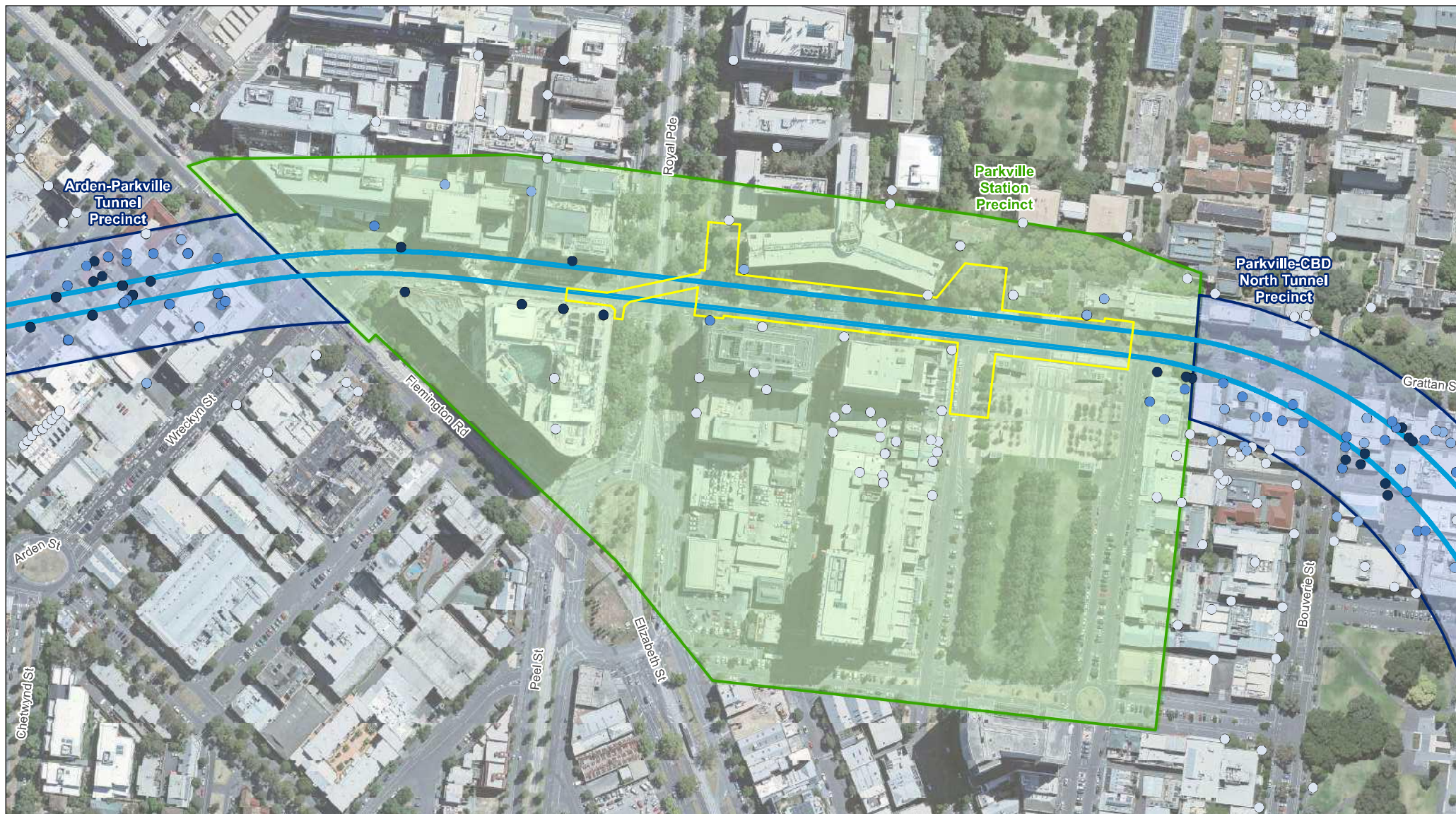


Figure B.20: Colour coded tunnelling VDV (day) levels for Human Comfort for Arden to Parkville Precinct





## Legend

### Result Set 1

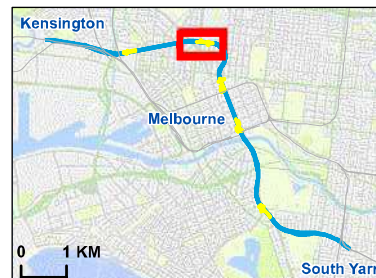
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - Parkville Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500203  
Revision: P1

Drawn By: A. Davy  
Approved By: D. Timms  
Date: 11/04/2016  
Map Size: A4

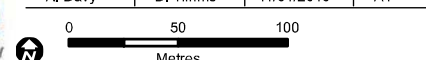


Figure B.21: Colour coded tunnelling VDV (day) levels for Human Comfort for Parkville Station Precinct





## Legend

### Result Set 1

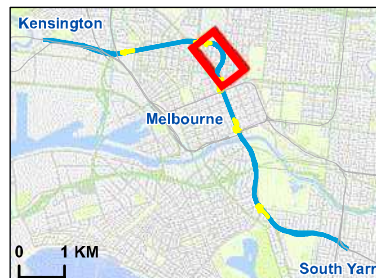
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - Parkville to CBD North

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

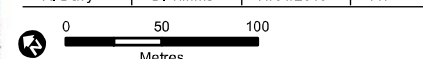
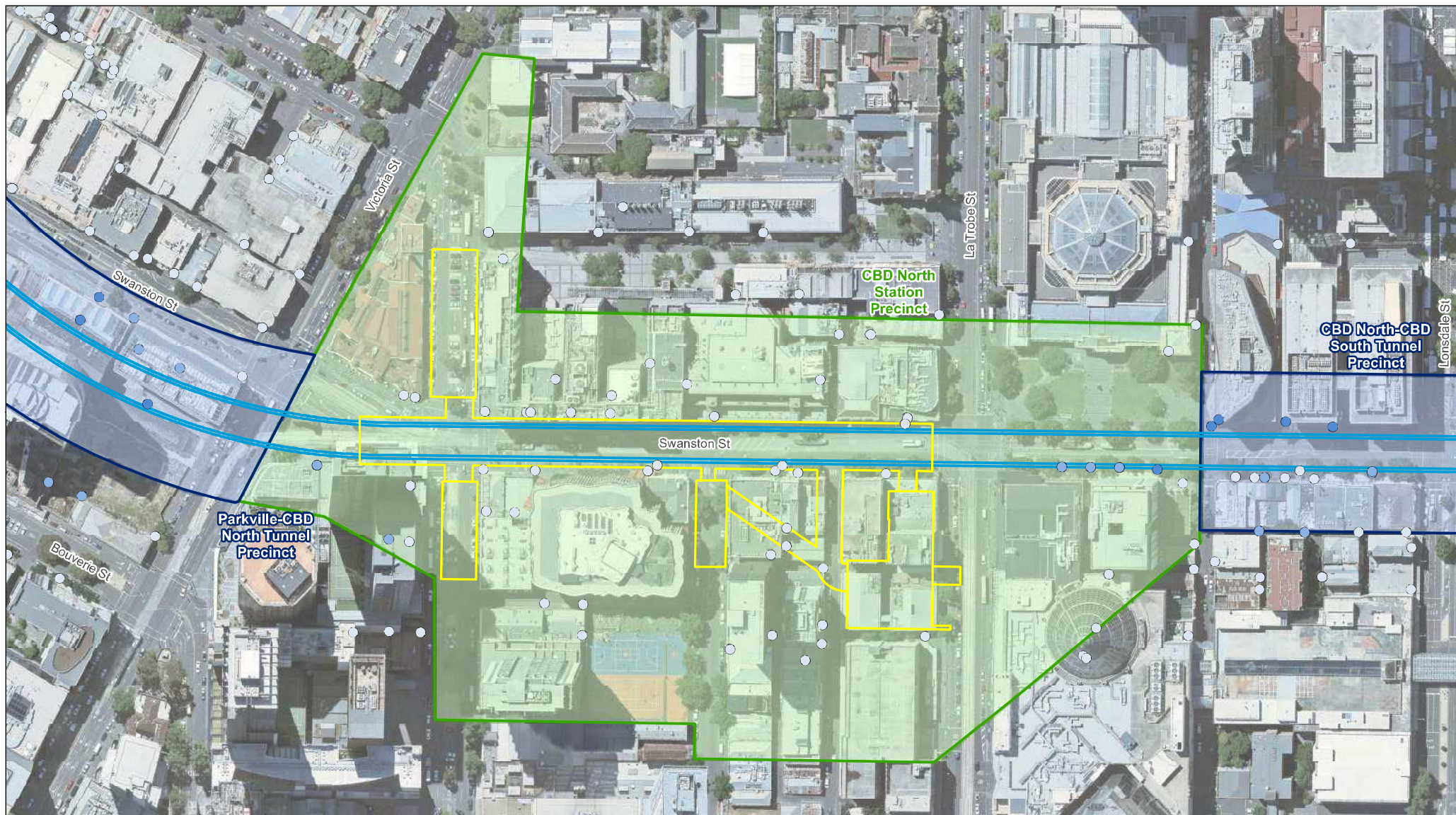


Figure B.22: Colour coded tunnelling VDV (day) levels for Human Comfort for Parkville to CBD North Tunnel Precinct

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## Legend

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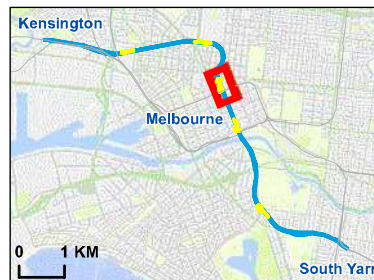
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - CBD North Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

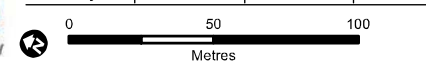


Figure B.23: Colour coded tunnelling VDV (day) levels for Human Comfort for CBD North Station Precinct

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## Legend

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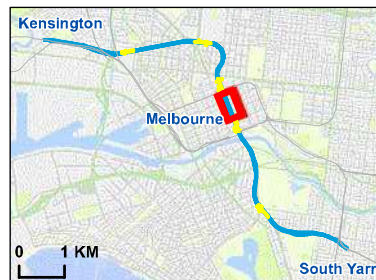
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - CBD North to CBD South

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

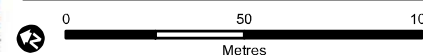


Figure B.24: Colour coded tunnelling VDV (day) levels for Human Comfort for CBD North and CBD South Tunnel Precinct

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## Legend

### Result Set 1

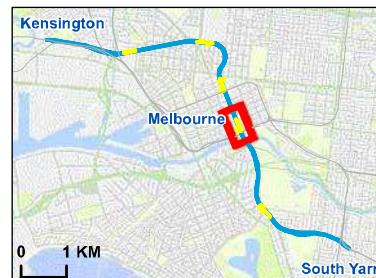
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 9 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - CBD South Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

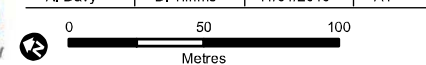
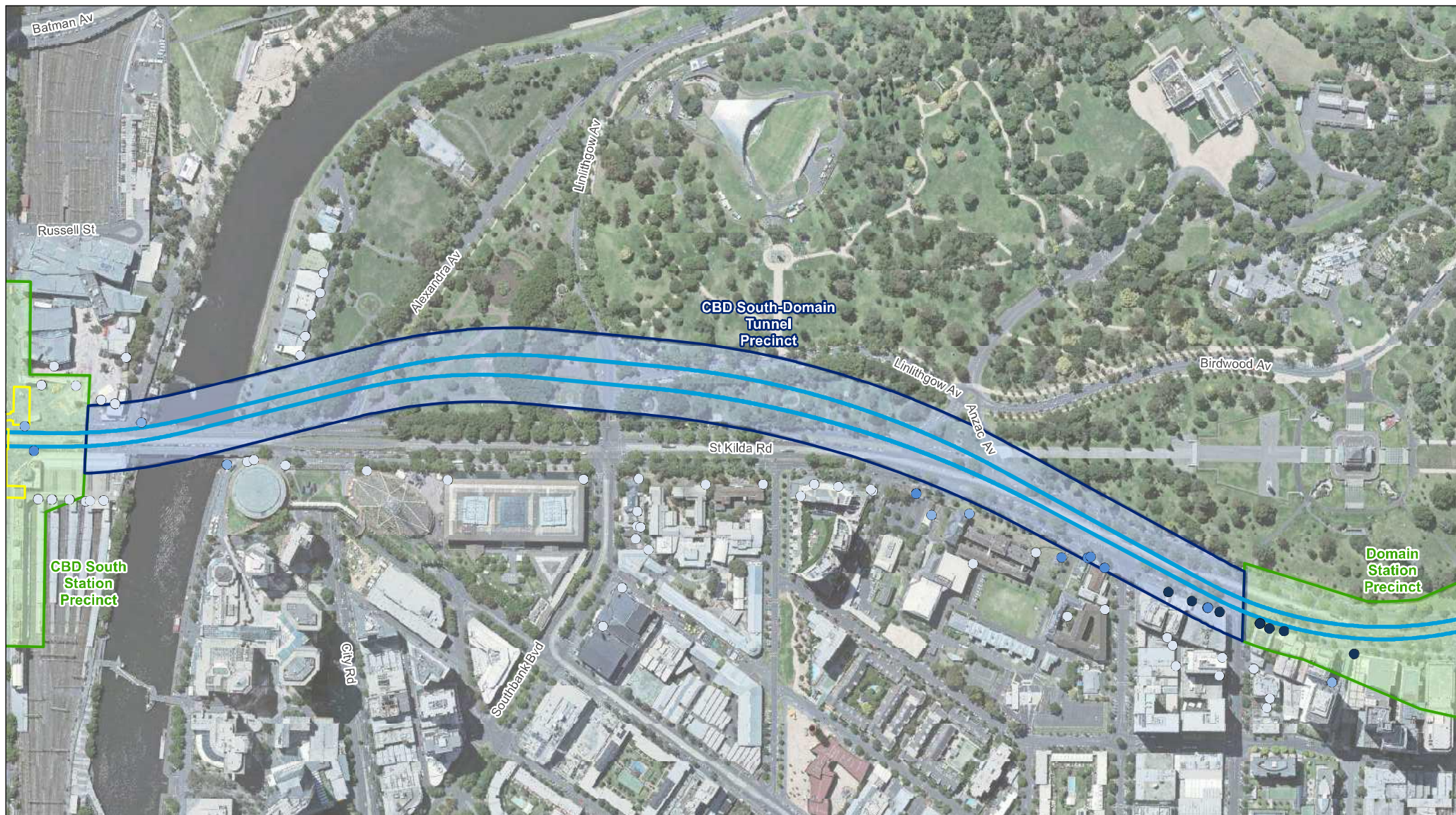


Figure B.25: Colour coded tunnelling VDV (day) levels for Human Comfort for CBD South Station Precinct

G:\MMR-AJM01\_WIP\FW-1-AA-KG\_GIS640\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Result\_Set\_1.mxd





## Legend

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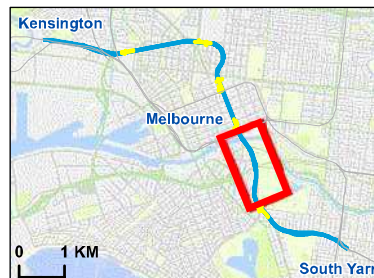
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - CBD South to Domain

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

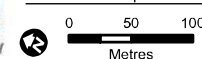


Figure B.26: Colour coded tunnelling VDV (day) levels for Human Comfort for CBD South to Domain Tunnel Precinct





Map 11 of 13

## Legend

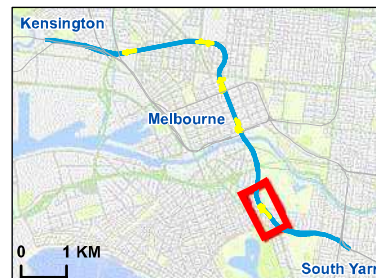
### Result Set 1

#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - Domain Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4



Figure B.27: Colour coded tunnelling VDV (day) levels for Human Comfort for Domain Station Precinct

G:\MMR-AJM01\_WIP\PW-1-AA-KG\_GSI640\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Result\_Set\_1.mxd





Map 12 of 13

## Legend

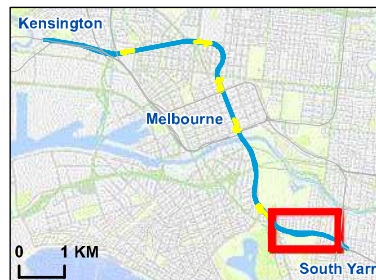
### Result Set 1

#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - Domain to Eastern Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

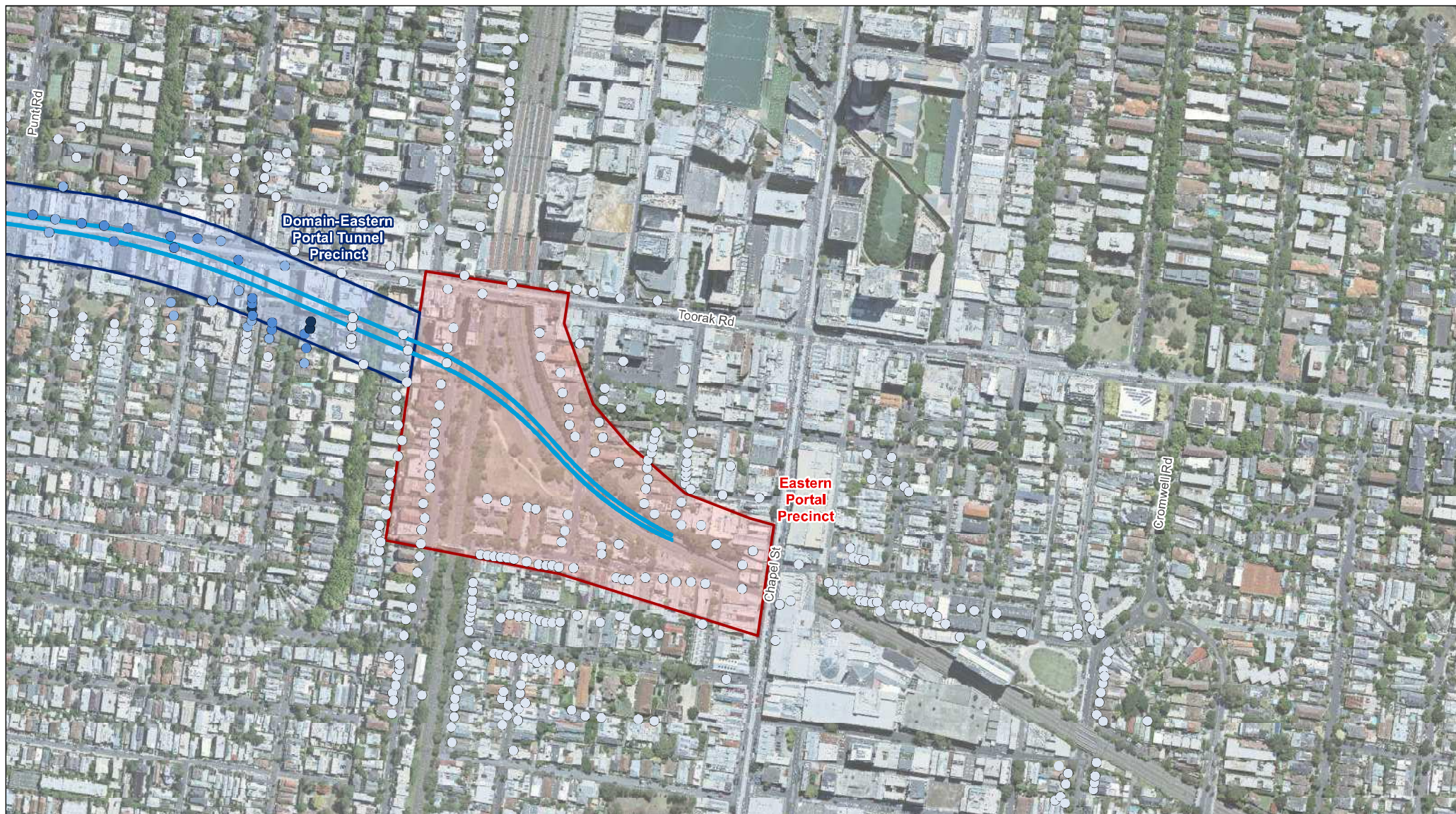
Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4



Figure B.28: Colour coded tunnelling VDV (day) levels for Human Comfort for Domain to Eastern Tunnel Precinct

G:\MMR-AJM01\_WIP\FW-1-AA-KG\_GIS\640\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Result\_Set\_1.mxd





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## Legend

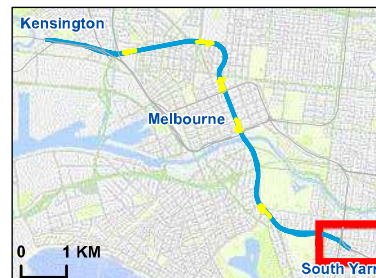
### Result Set 1

#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Day  
Target - Eastern Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500203 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

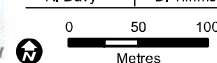


Figure B.29: Colour coded tunnelling VDV (day) levels for Human Comfort for Eastern Portal Precinct





## Legend

### Result Set 2

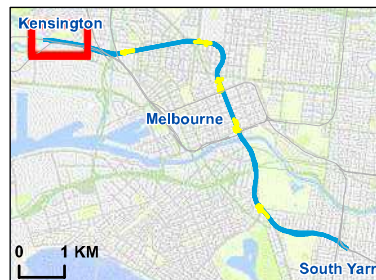
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 1 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - Western Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

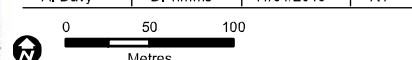


Figure B.30: Colour coded tunnelling VDV (night) levels for Human Comfort for Western Portal Precinct





## Legend

### Result Set 2

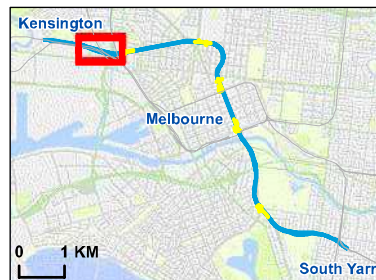
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 2 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - Western Portal to Arden

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

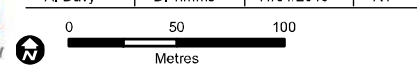
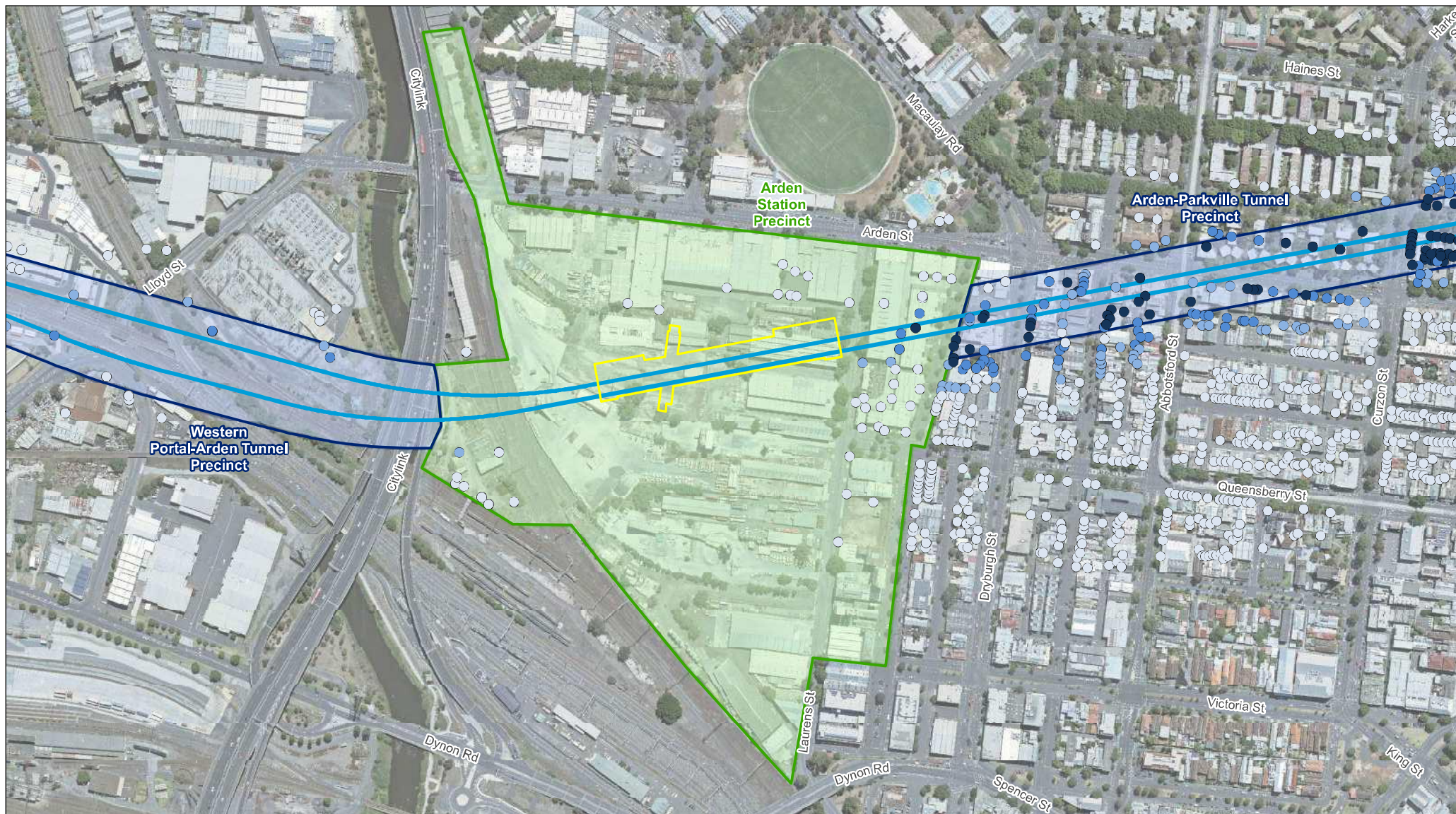


Figure B.31: Colour coded tunnelling VDV (night) levels for Human Comfort for Western Portal to Arden Tunnel Precinct

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## Legend

### Result Set 2

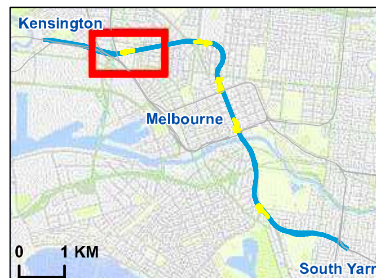
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 3 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - Arden Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

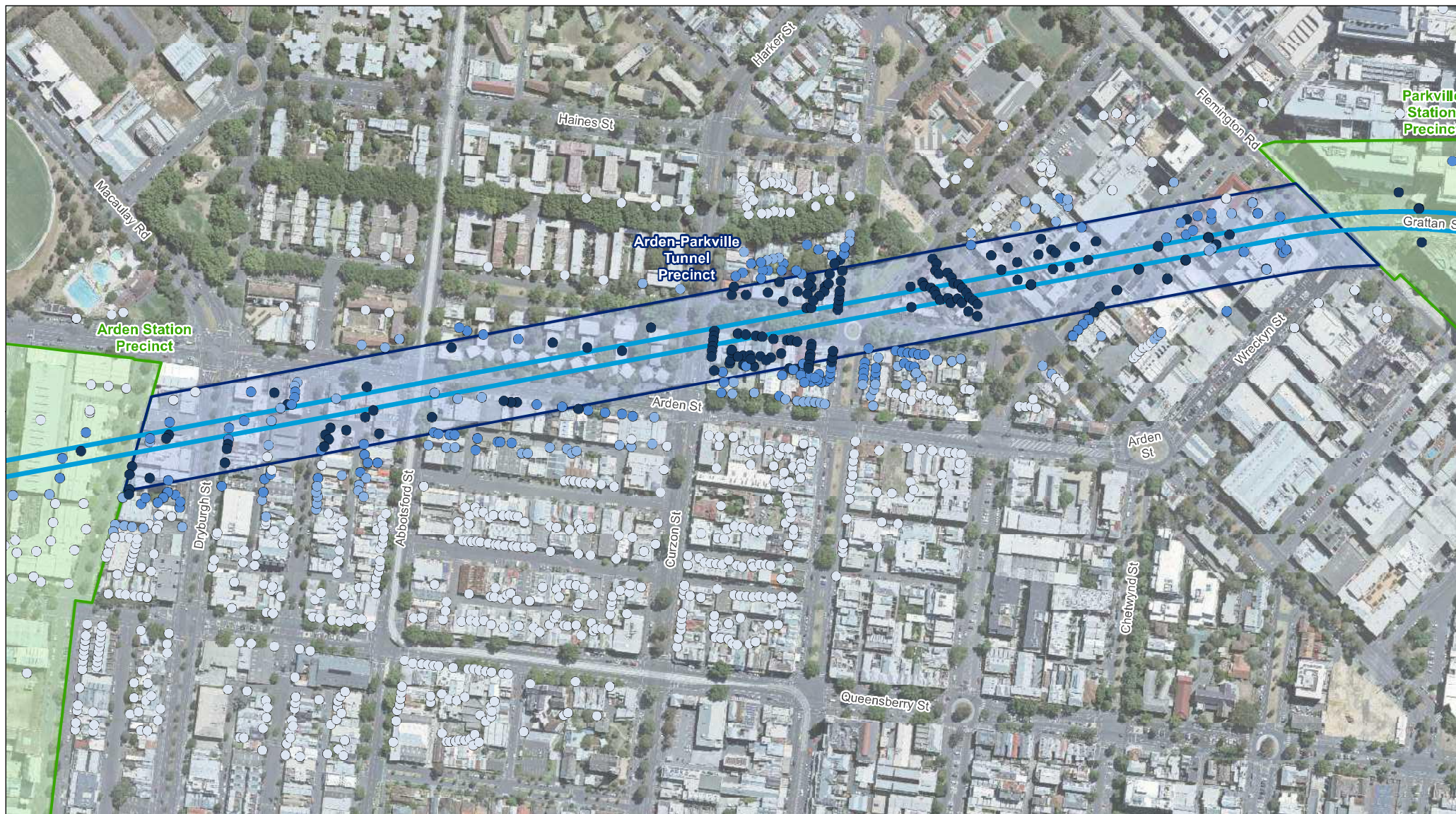
Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

0 50 100 Metres

Figure B.32: Colour coded tunnelling VDV (night) levels for Human Comfort for Arden Station Precinct

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## Legend

### Result Set 2

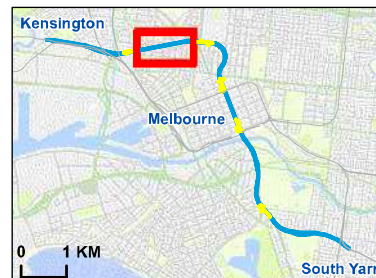
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 4 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - Arden to Parkville

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

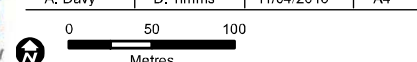


Figure B.33: Colour coded tunnelling VDV (night) levels for Human Comfort for Arden to Parkville Tunnel Precinct





## Legend

### Result Set 2

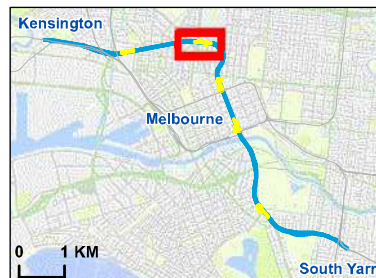
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - Parkville Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500204  
Revision: P1

Drawn By: A. Davy  
Approved By: D. Timms  
Date: 11/04/2016  
Map Size: A4

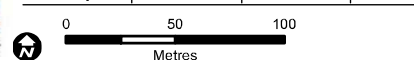


Figure B.34: Colour coded tunnelling VDV (night) levels for Human Comfort for Parkville Station Precinct





## Legend

### Result Set 2

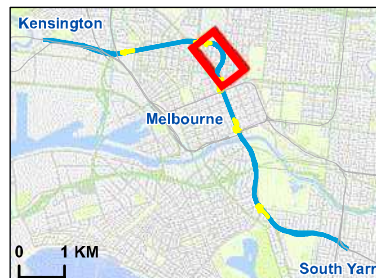
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
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Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - Parkville to CBD North

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

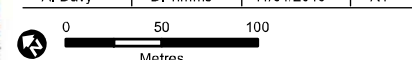
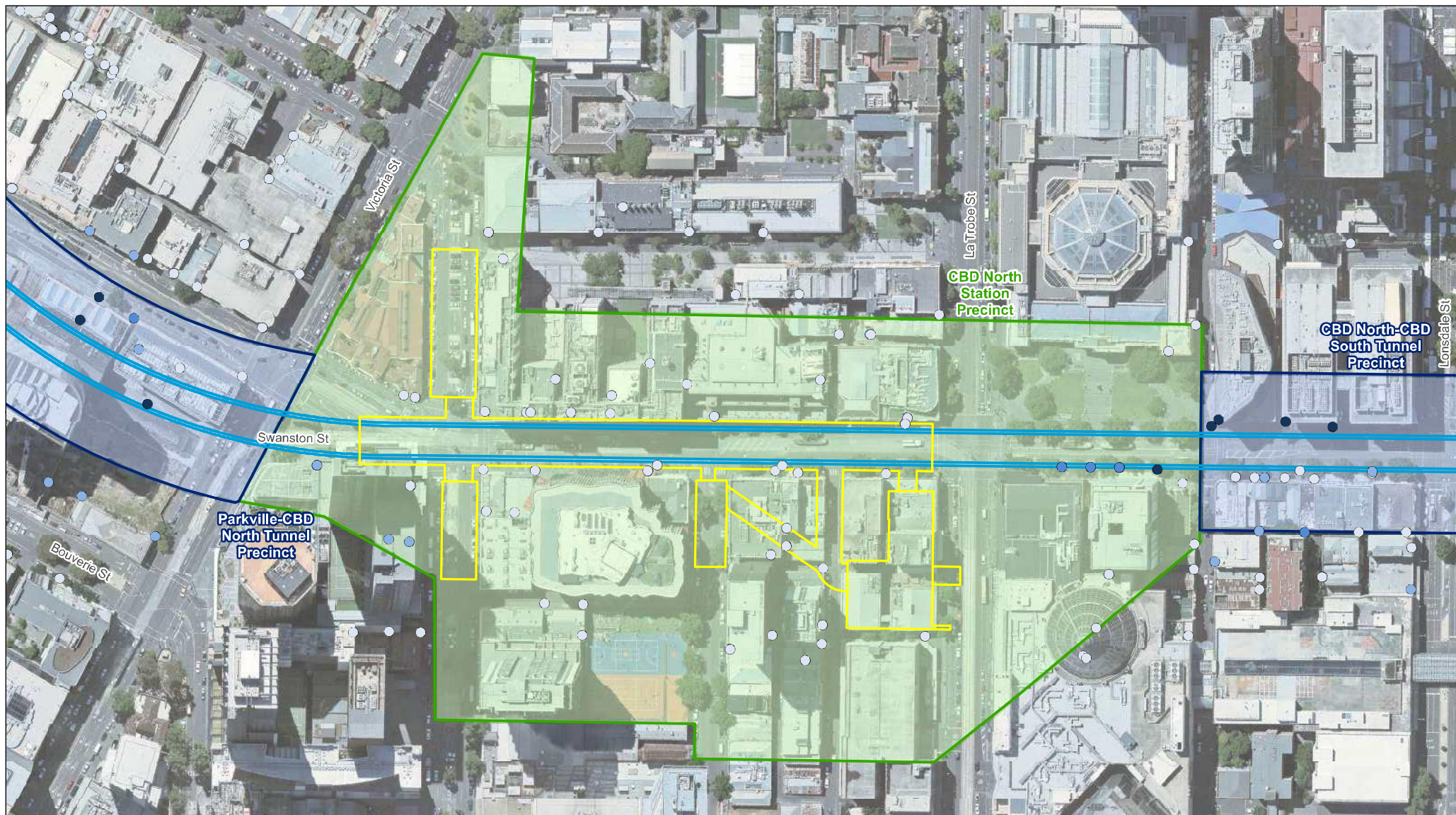


Figure B.35: Colour coded tunnelling VDV (night) levels for Human Comfort for Parkville to CBD North Tunnel Precinct

G:\MMR-AJM01\_WIP\PW-1-AA-KG\_GIS\640\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Result\_Set\_2.mxd





## Legend

### Result Set 2

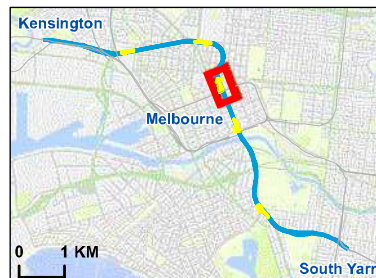
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - CBD North Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

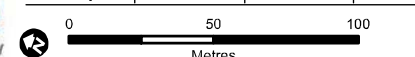
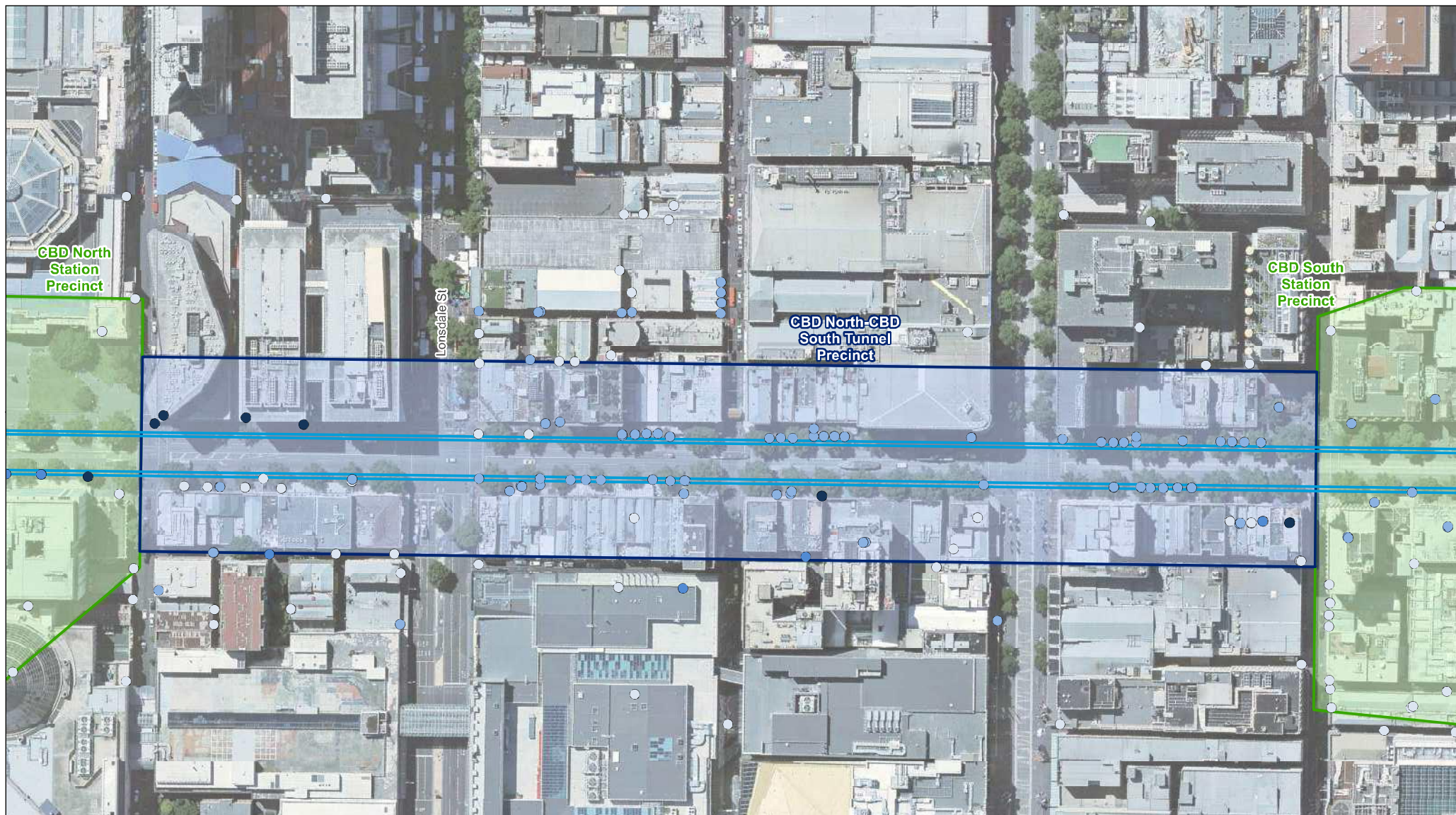


Figure B.36: Colour coded tunnelling VDV (night) levels for Human Comfort for CBD North Station Precinct

G:\MMR-AJM01\_WIP\FW-1-AA-KG\_GIS\640\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Result\_Set\_2.mxd





## Legend

### Result Set 2

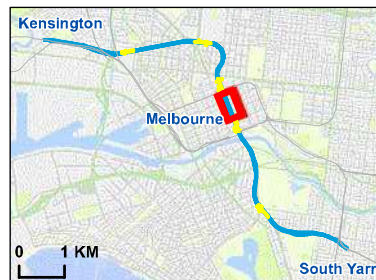
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - CBD North to CBD South

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

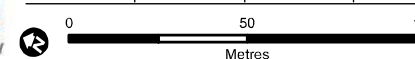


Figure B.37: Colour coded tunnelling VDV (night) levels for Human Comfort CBD North and CBD South Tunnel Precinct

G:\MMR-AJM01\_WIP\PW-1-AA-KG\_GSI640\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Result\_Set\_2.mxd





## Legend

### Result Set 2

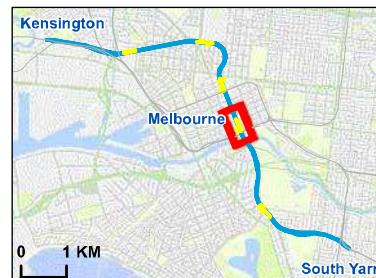
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - CBD South Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

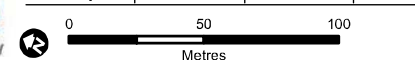
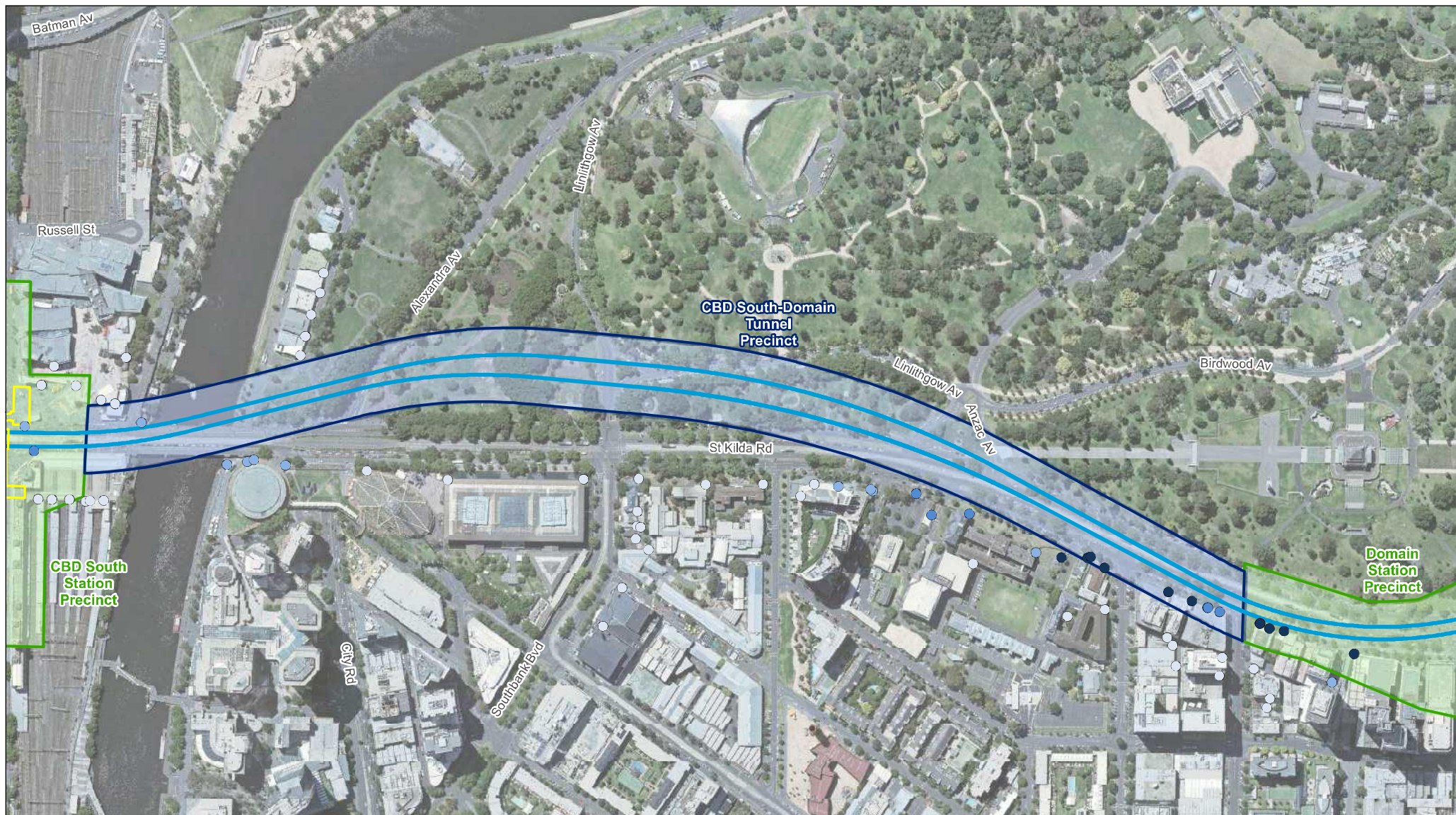


Figure B.38: Colour coded tunnelling VDV (night) levels for Human Comfort for CBD South Station Precinct





Map 10 of 13

## Legend

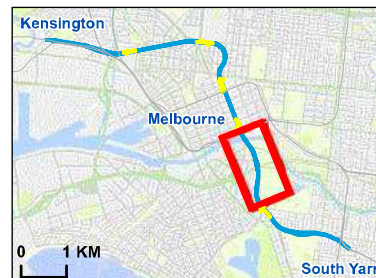
### Result Set 2

#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - CBD South to Domain

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

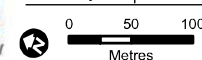


Figure B.39: Colour coded tunnelling VDV (night) levels for Human Comfort for CBD South to Domain Tunnel Precinct

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Map 11 of 13

## Legend

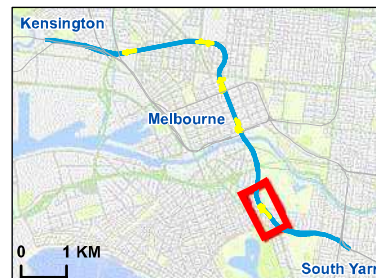
### Result Set 2

#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - Domain Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500204  
Revision: P1

Drawn By: A. Davy	Approved By: D. Timms	Date: 11/04/2016	Map Size: A4
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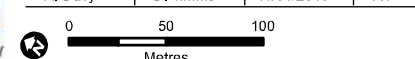


Figure B.40: Colour coded tunnelling VDV (night) levels for Human Comfort for Domain Station Precinct

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Map 12 of 13

## Legend

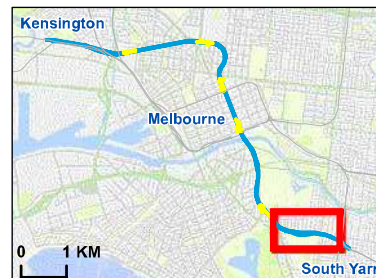
### Result Set 2

#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - Domain to Eastern Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

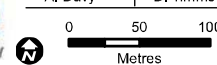
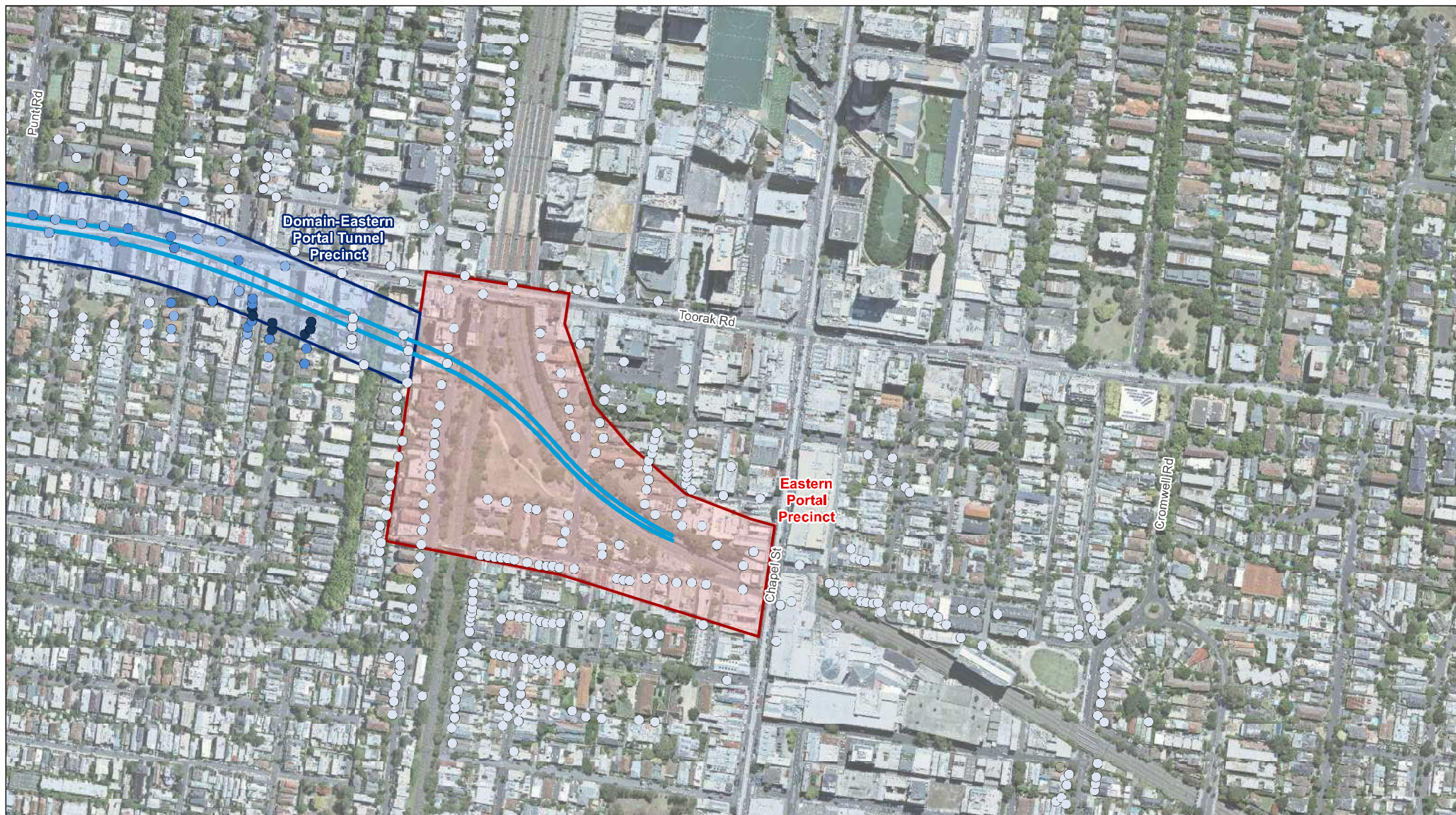


Figure B.41: Colour coded tunnelling VDV (night) levels for Human Comfort for Domain to Eastern Tunnel Precinct

G:\MMR-AJM01\_WIP\FW-1-AA-KG\_GIS\640\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Result\_Set\_2.mxd





Map 13 of 13

## Legend

### Result Set 2

#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Tunnelling Vibration Dosage Value (VdV) - Night  
Target - Eastern Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500204 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

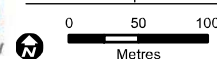


Figure B.42: Colour coded tunnelling VDV (night) levels for Human Comfort for Eastern Portal Precinct

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## Legend

### Result Set 3

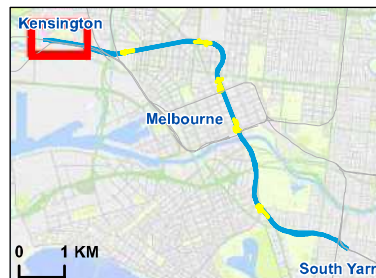
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 1 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Groundborne Noise (GBN)-Evening and Night Targets - Western Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

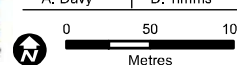


Figure B.43: Colour coded tunnelling ground-borne noise levels for Western Portal Precinct





## Legend

### Result Set 3

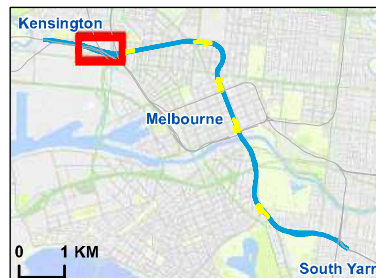
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 2 of 13



## Melbourne Metro Rail Project

Title: Tunnelling Groundborne Noise (GBN)-Evening and Night Targets - Western Portal to Arden

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

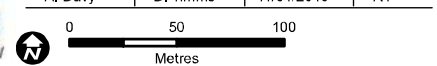
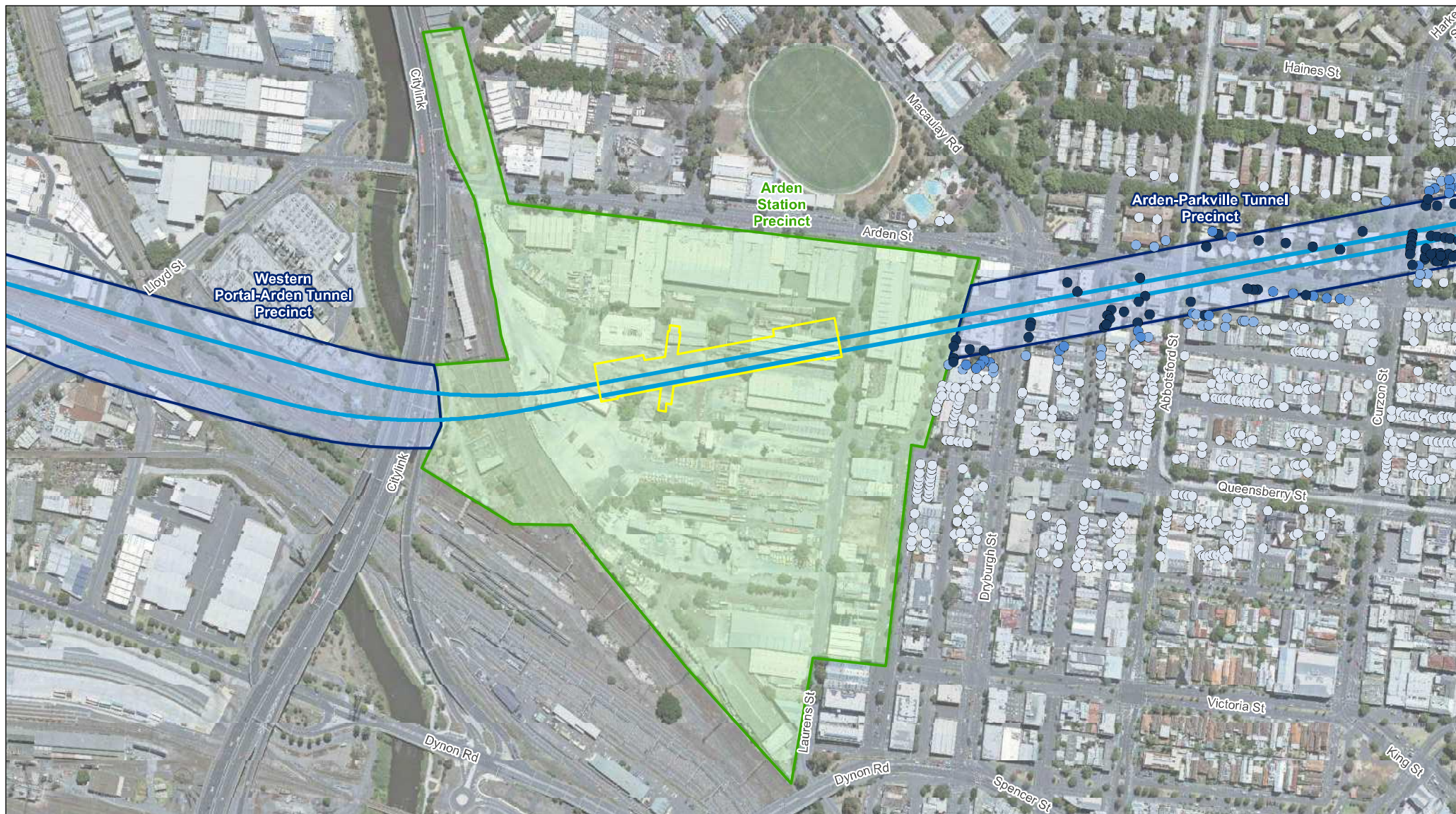


Figure B.44: Colour coded tunnelling ground-borne noise levels for Western Portal to Arden Tunnel Precinct





## Legend

### Result Set 3

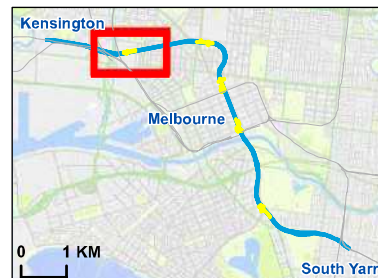
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 3 of 13



## Melbourne Metro Rail Project

Title: Tunnelling Groundborne Noise (GBN)-Evening and Night Targets - Arden Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

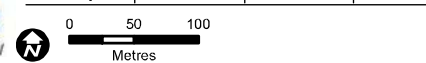
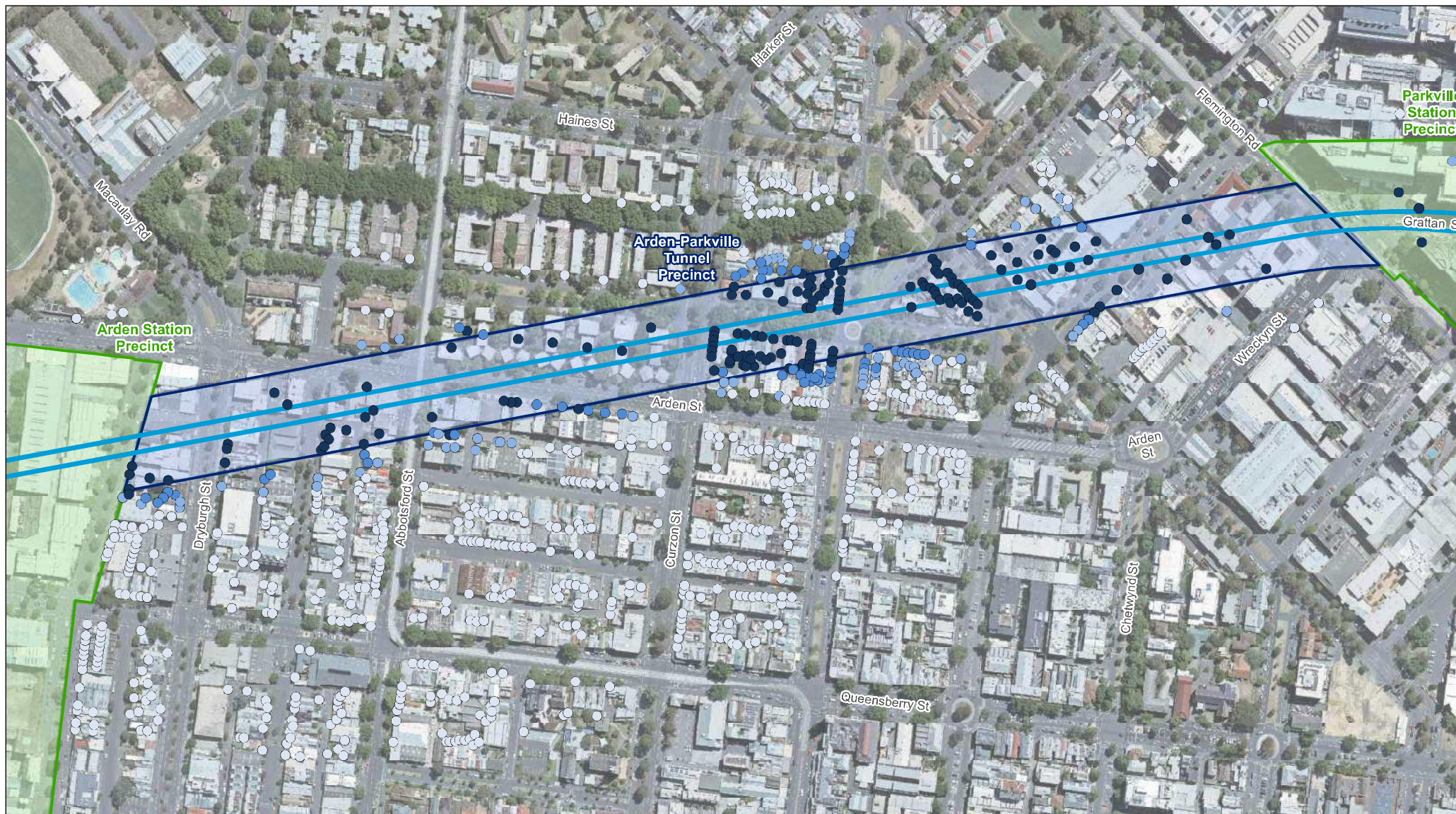


Figure B.45: Colour coded tunnelling ground-borne noise levels for Arden Station Precinct

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## Legend

### Result Set 3

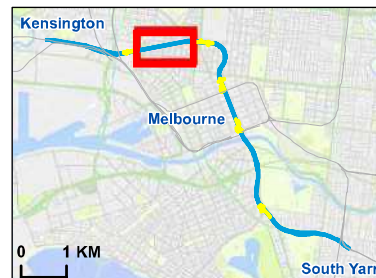
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 4 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Groundborne Noise (GBN)-Evening and  
Night Targets - Arden to Parkville

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

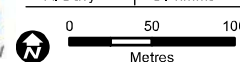
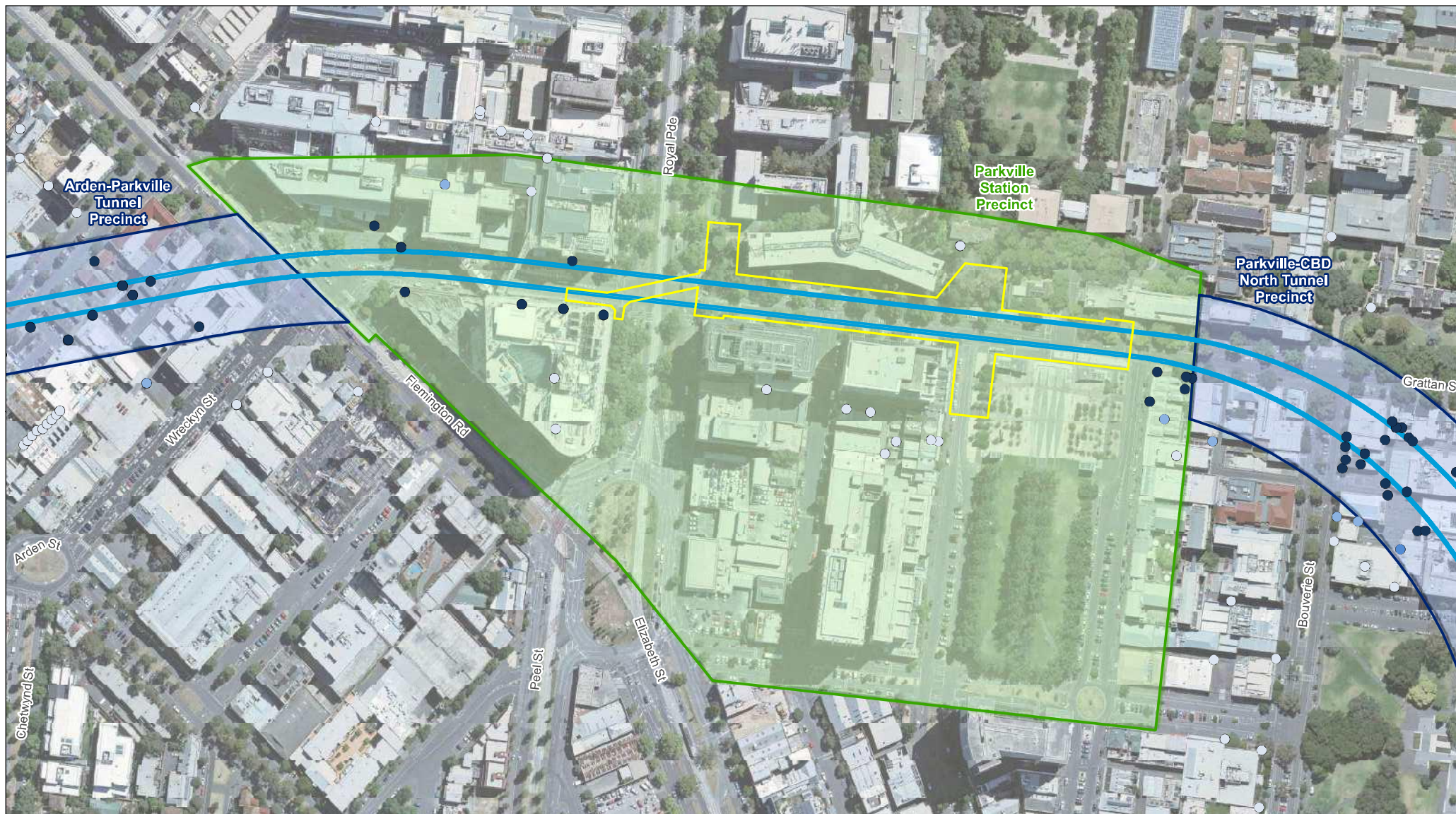


Figure B.46: Colour coded tunnelling ground-borne noise levels for Western Portal to Parkville Tunnel Precinct





## Legend

### Result Set 3

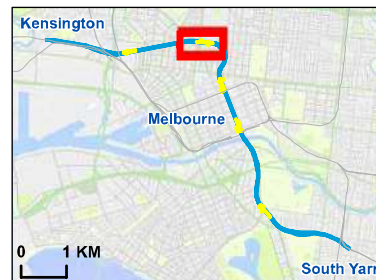
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 5 of 13



## Melbourne Metro Rail Project

Title:  
Tunnelling Groundborne Noise (GBN)-Evening and  
Night Targets - Parkville Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

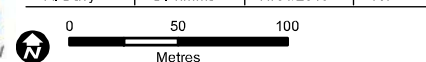


Figure B.47: Colour coded tunnelling ground-borne noise levels for Parkville Station Precinct





## Legend

### Result Set 3

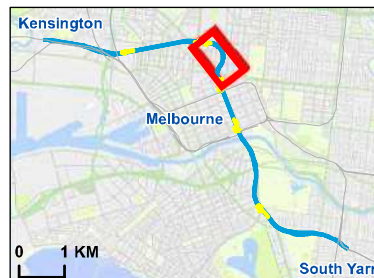
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
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## Melbourne Metro Rail Project

Title: Tunnelling Groundborne Noise (GBN)-Evening and Night Targets - Parkville to CBD North

Drawing Number:

MMR-AJM-UGAA-MP-NO-500205

Revision:

P1

Drawn By:  
A. Davy

Approved By:  
D. Timms

Date:  
11/04/2016

Map Size:  
A4

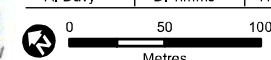
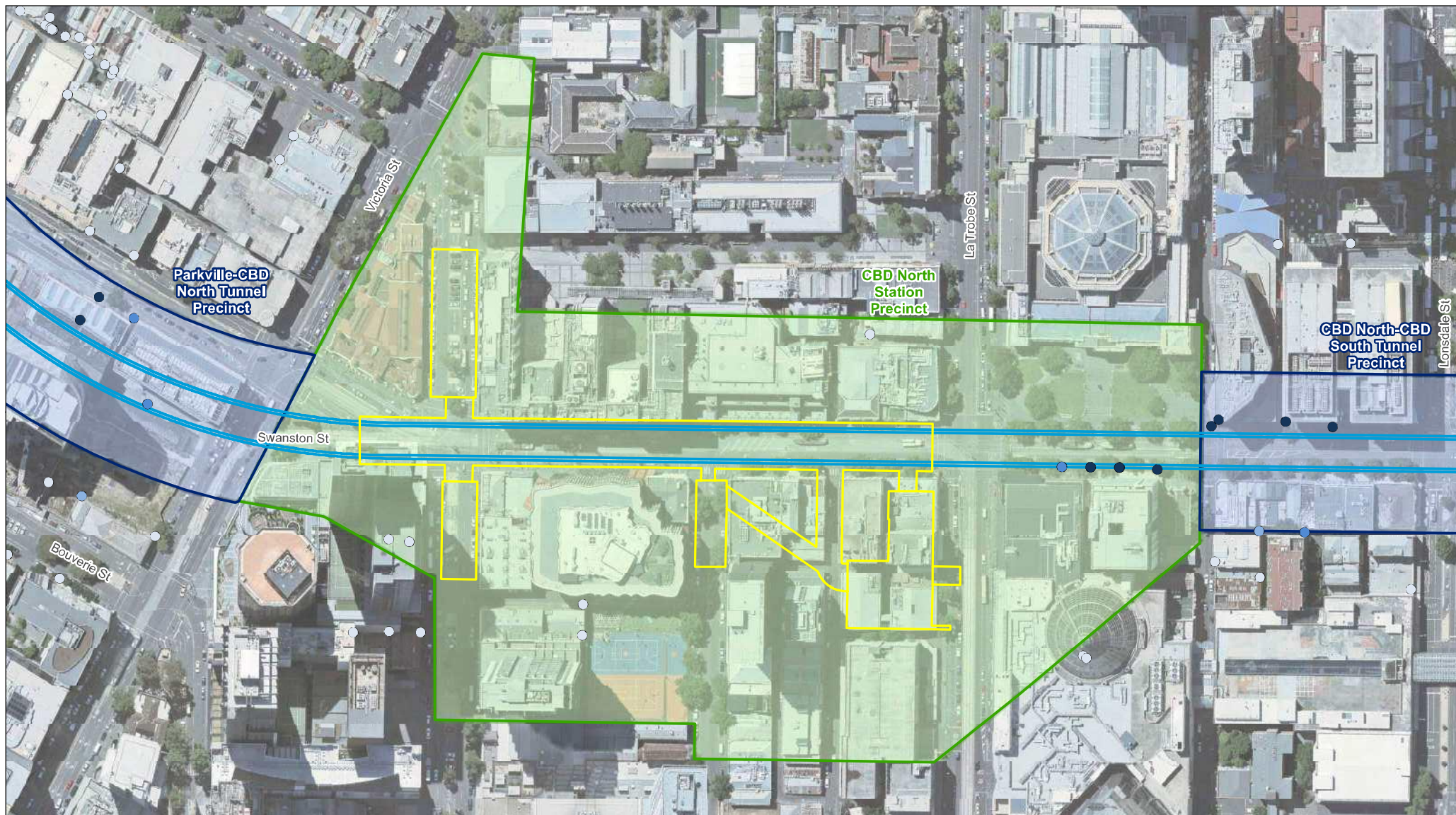


Figure B.48: Colour coded tunnelling ground-borne noise levels for Parkville to CBD North Tunnel Precinct





## Legend

### Result Set 3

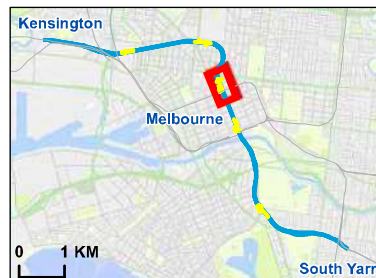
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title: Tunnelling Groundborne Noise (GBN)-Evening and Night Targets - CBD North Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

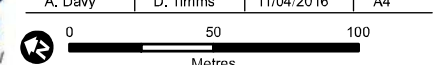
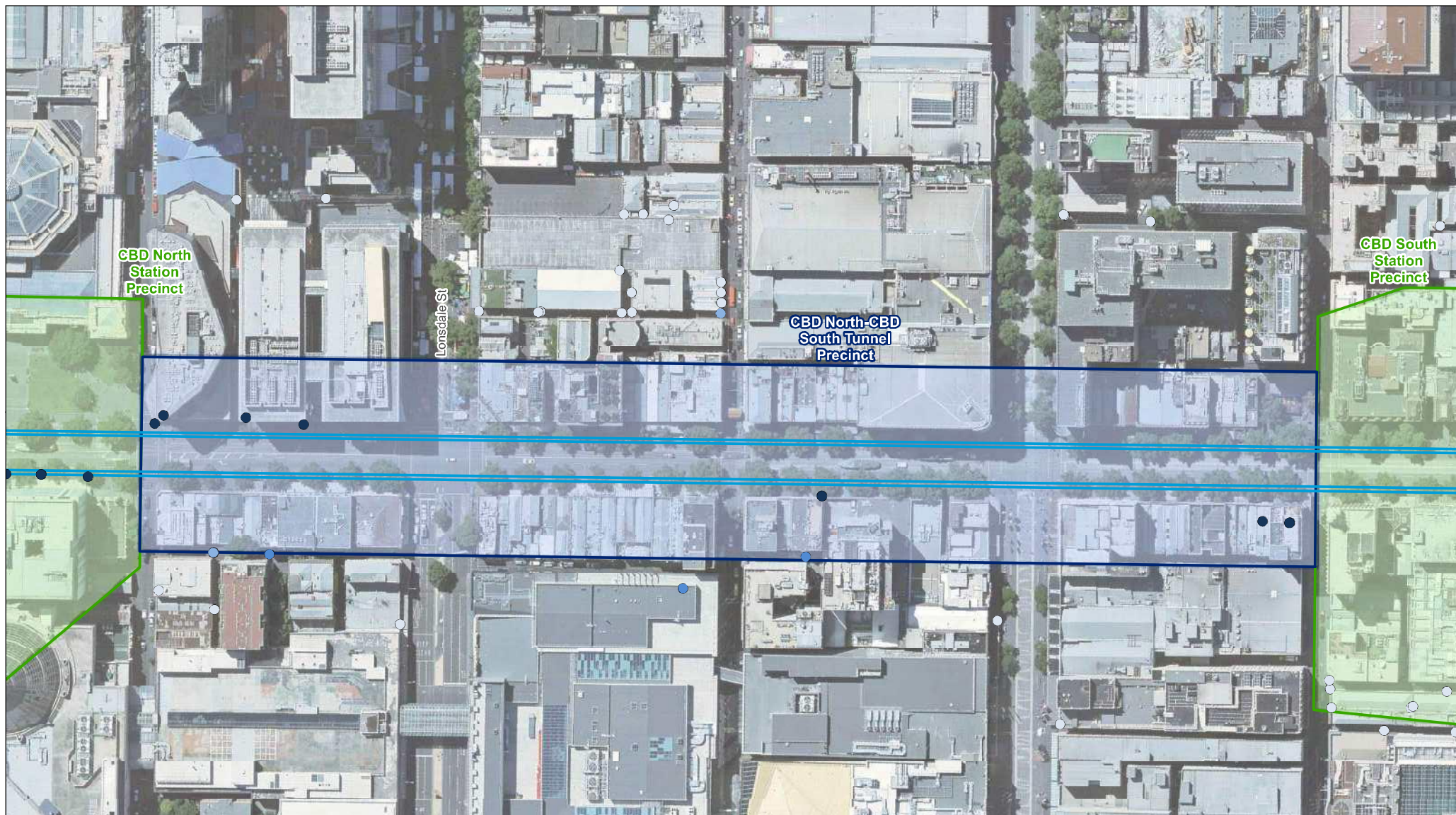


Figure B.49: Colour coded tunnelling ground-borne noise levels for CBD North Station Precinct





## Legend

### Result Set 3

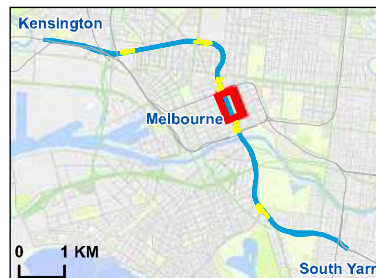
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Groundborne Noise (GBN)-Evening and  
Night Targets - CBD North to CBD South

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

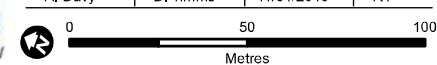


Figure B.50: Colour coded tunnelling ground-borne noise levels for CBD North and CBD South Tunnel Precinct





## Legend

### Result Set 3

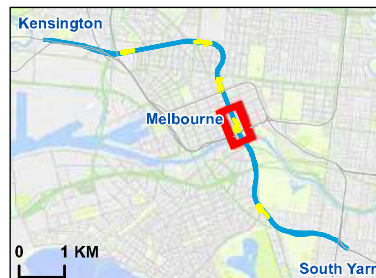
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Groundborne Noise (GBN)-Evening and Night Targets - CBD South Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

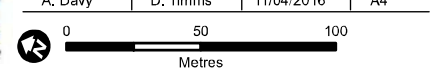
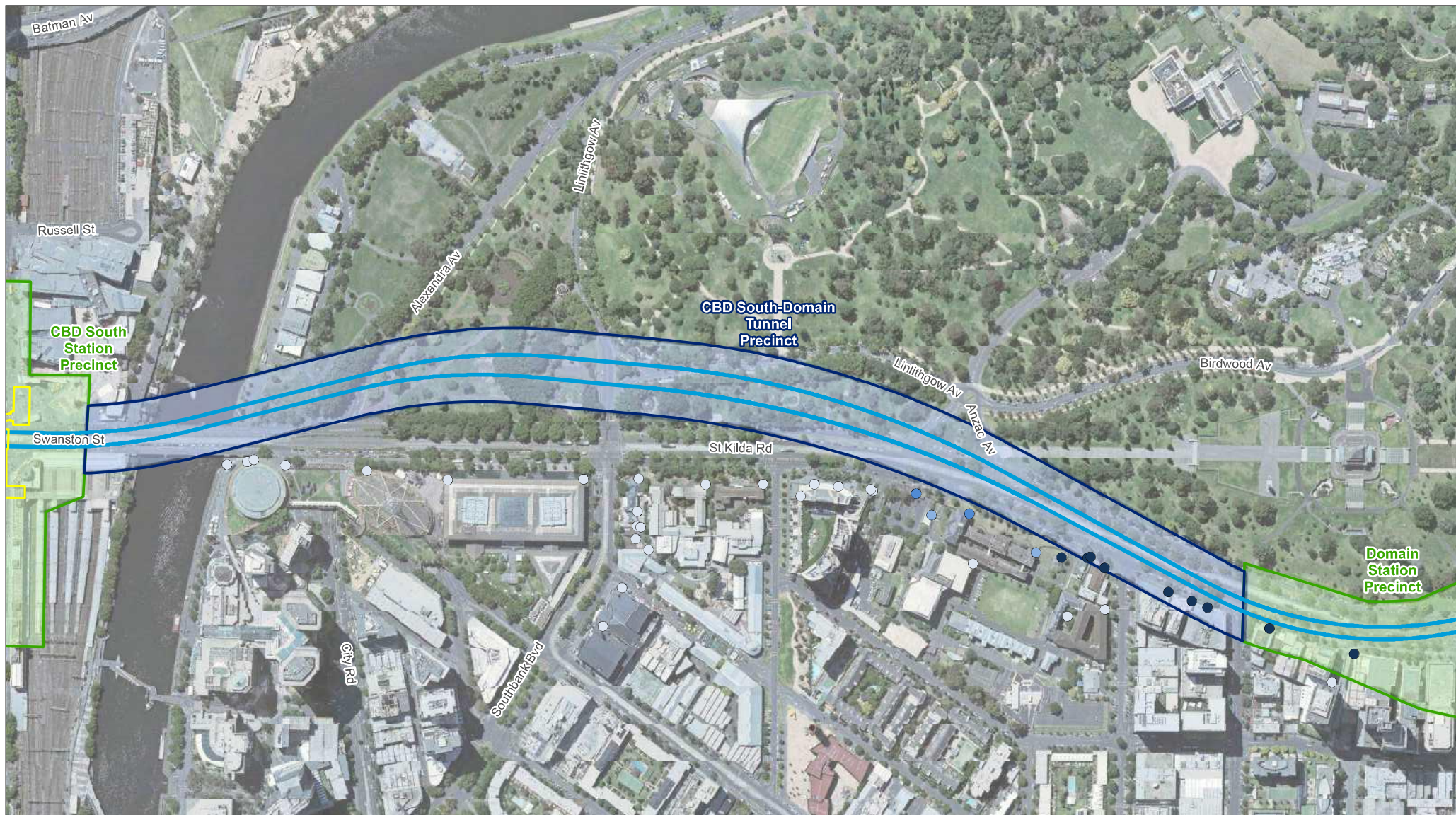


Figure B.51: Colour coded tunnelling ground-borne noise levels for CBD South Station Precinct

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## Legend

### Result Set 3

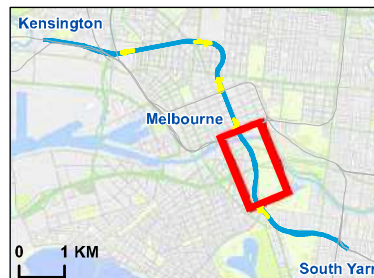
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title: Tunnelling Groundborne Noise (GBN)-Evening and Night Targets - CBD South to Domain

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

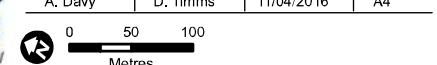


Figure B.52: Colour coded tunnelling ground-borne noise levels for CBD South to Domain Tunnel Precinct





## Legend

### Result Set 3

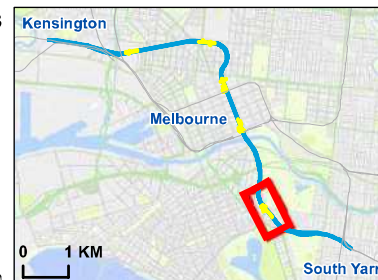
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 11 of 13



## Melbourne Metro Rail Project

Title: Tunnelling Groundborne Noise (GBN)-Evening and Night Targets - Domain Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4



Figure B.53: Colour coded tunnelling ground-borne noise levels for Domain Station Precinct





## Legend

### Result Set 3

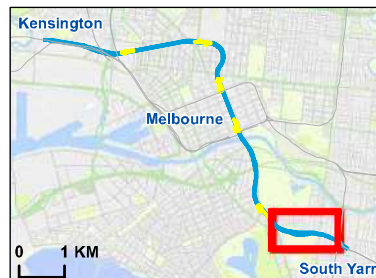
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

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## Melbourne Metro Rail Project

Title:  
Tunnelling Groundborne Noise (GBN)-Evening and Night Targets - Domain to Eastern Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

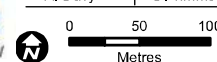
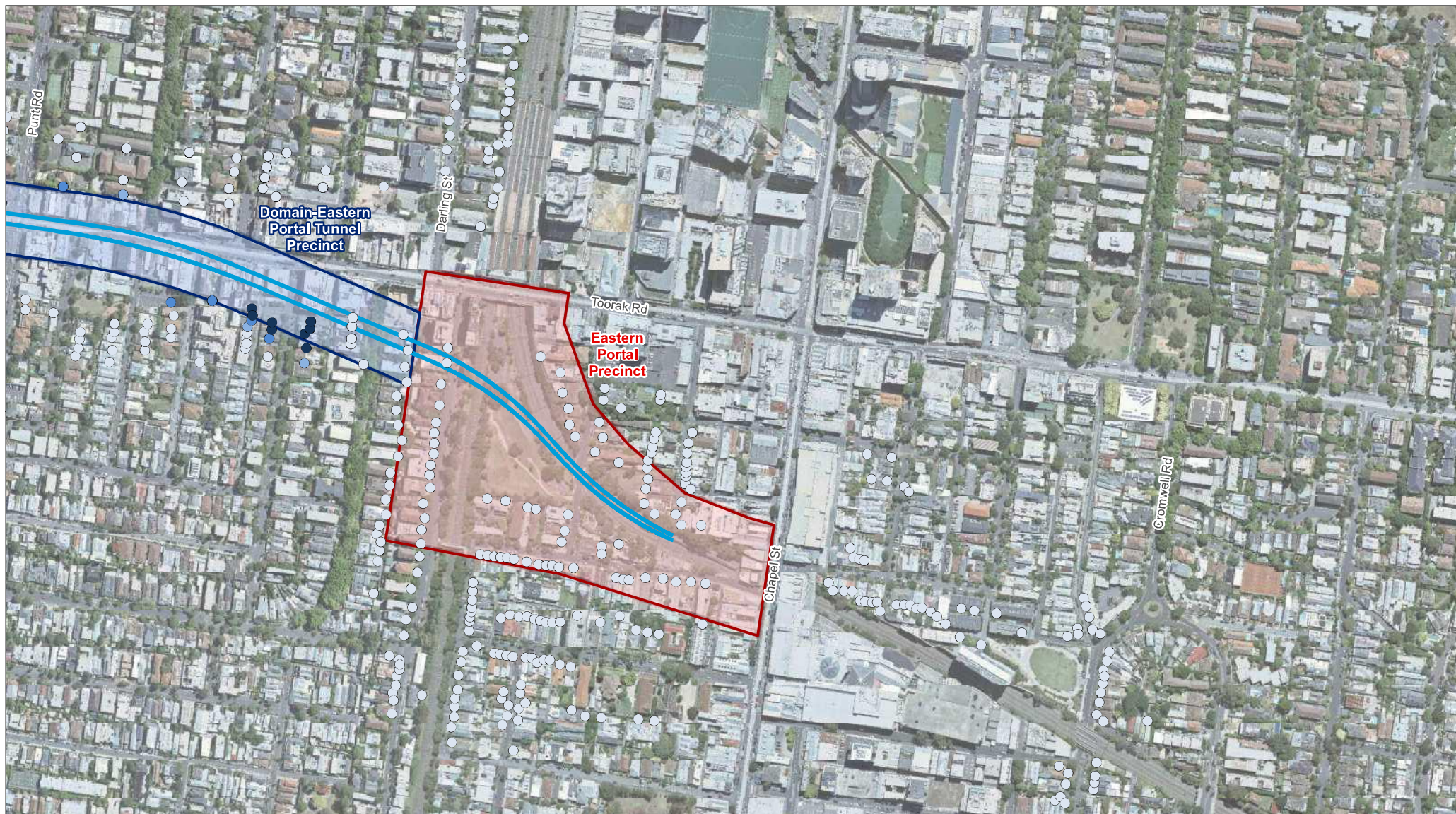


Figure B.54: Colour coded tunnelling ground-borne noise levels for Domain to Eastern Tunnel Precinct





Map 13 of 13

## Legend

### Result Set 3

#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Tunnelling Groundborne Noise (GBN)-Evening and  
Night Targets - Eastern Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500205 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

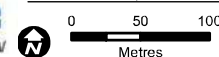
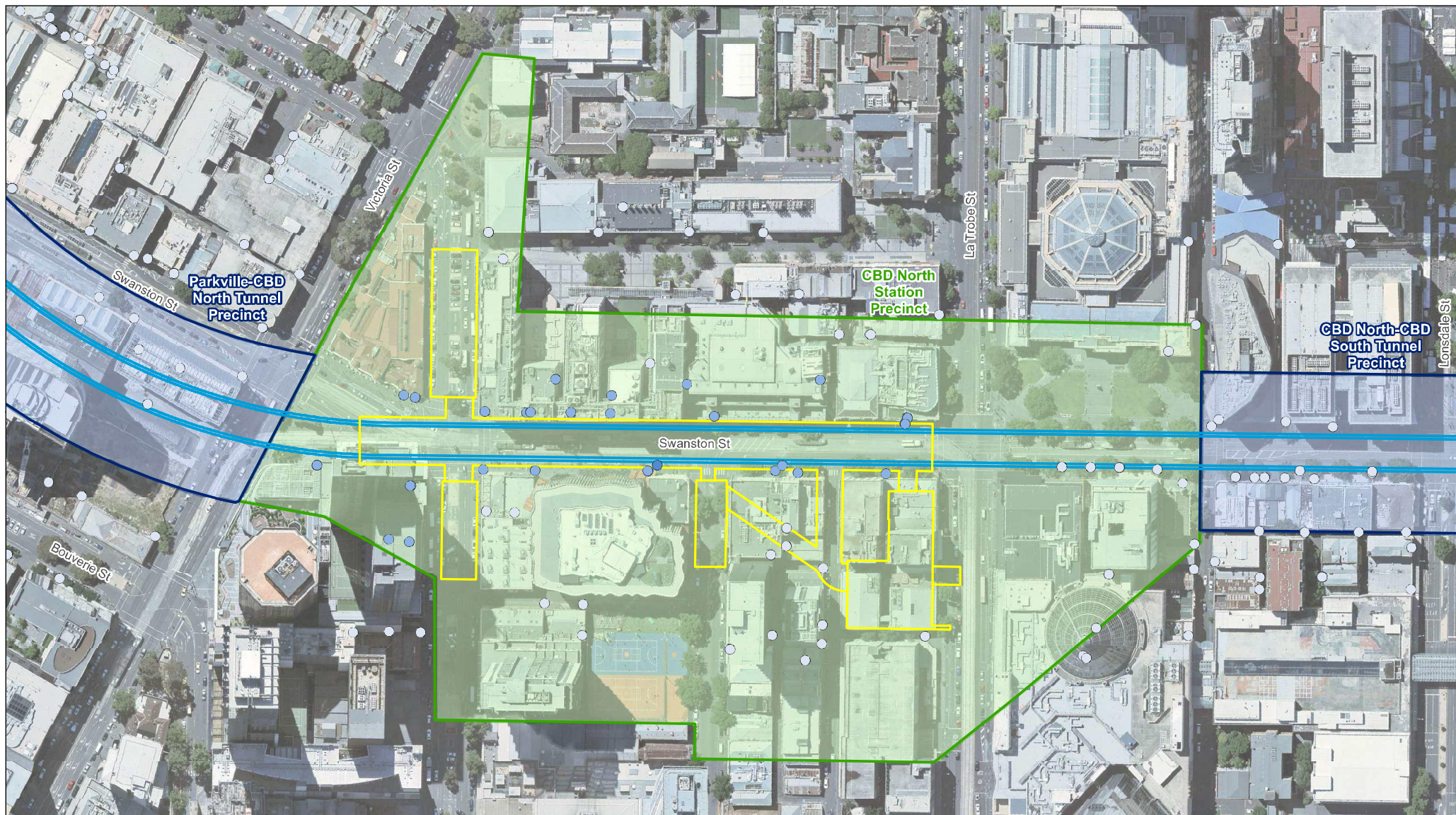


Figure B.55: Colour coded tunnelling ground-borne noise levels for Eastern Portal Precinct





## Legend

### VdV Day Target

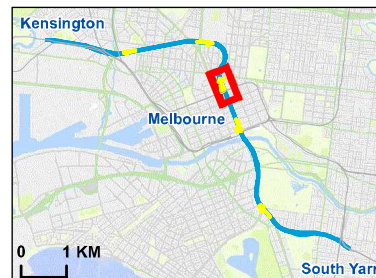
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 1 of 2



## Melbourne Metro Rail Project

Title:  
Station Cavern Mining Vibration Dosage Value (VdV) -  
Guideline Day Target - CBD North Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500446 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

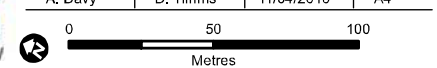
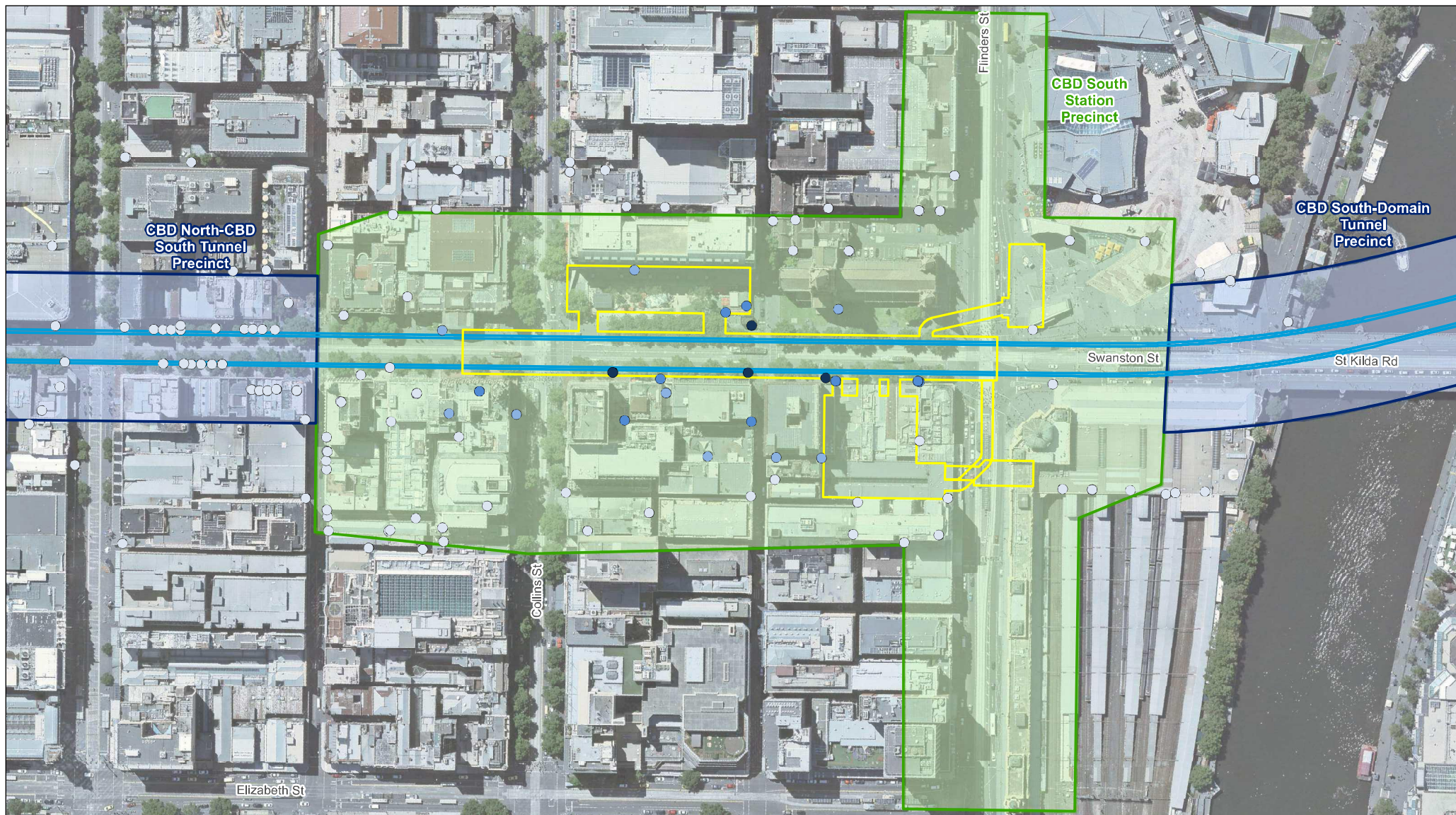


Figure B.56: Colour coded station cavern mining VDV (day) levels for Human Comfort for CBD North Station Precinct

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## Legend

### VdV Day Target

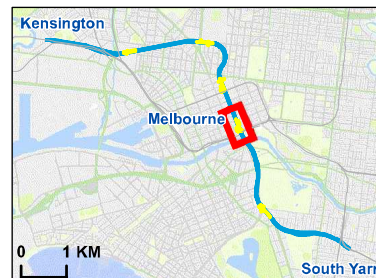
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

## Map 2 of 2



## Melbourne Metro Rail Project

Title:  
Station Cavern Mining Vibration Dosage Value (VdV) -  
Guideline Day Target - CBD South Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500446 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

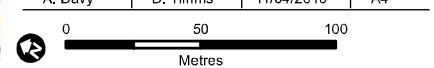
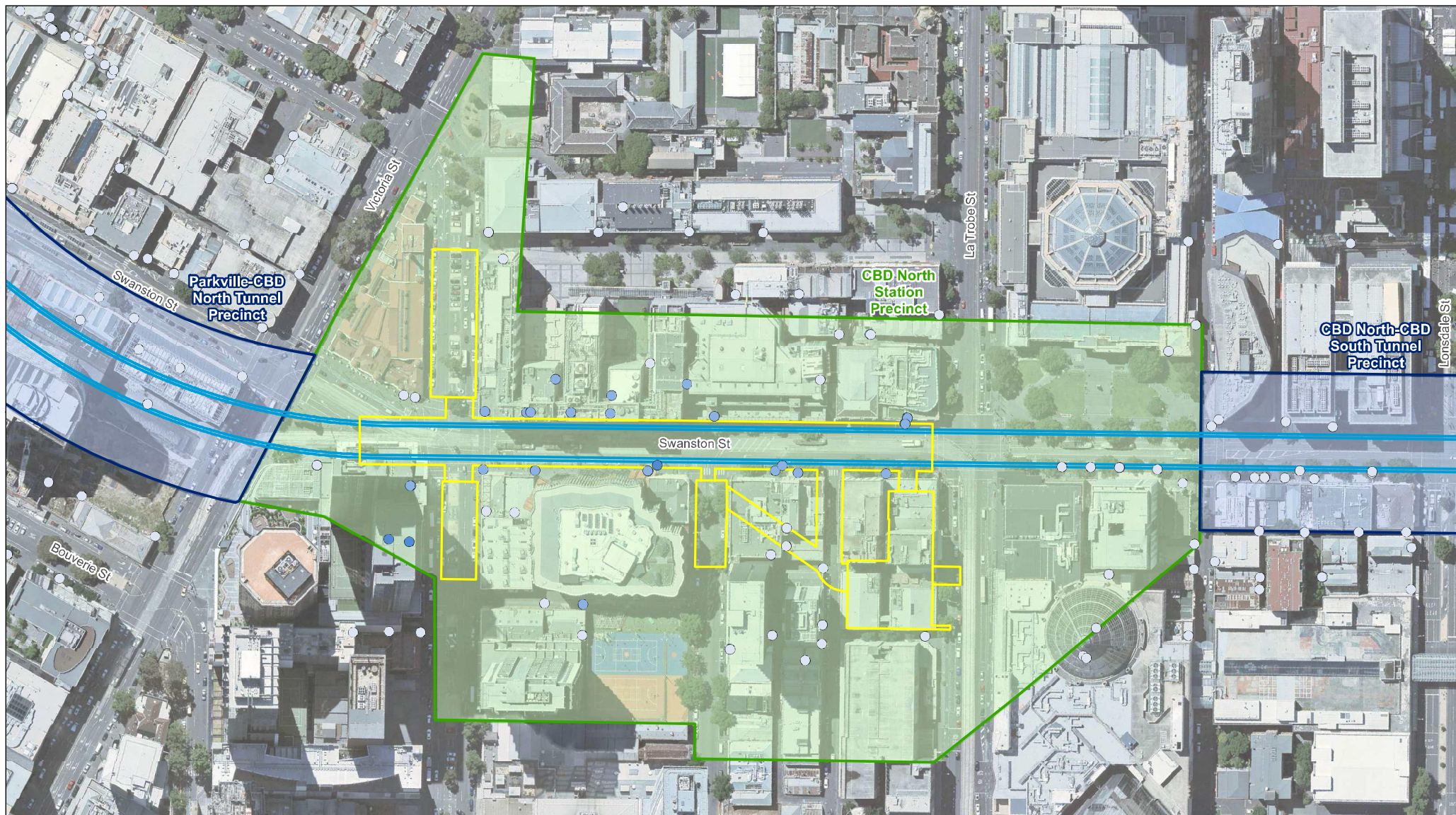


Figure B.57: Colour coded station cavern mining VDV (day) levels for Human Comfort for CBD South Station Precinct

G:\MMR-AJM01\_WIP\IPW-1-AA-KG\_GIS\640\_SitePlans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Station\_Cavern\_Mining\_VdV\_Day.mxd





## Legend

### VdV Night Target

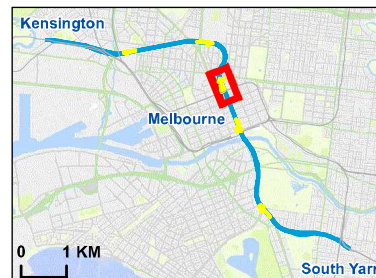
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

## Map 1 of 2



## Melbourne Metro Rail Project

Title:  
Station Cavern Mining Vibration Dosage Value (VdV) -  
Guideline Night Target - CBD North Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500447 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

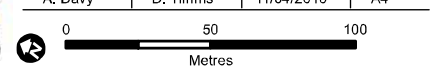
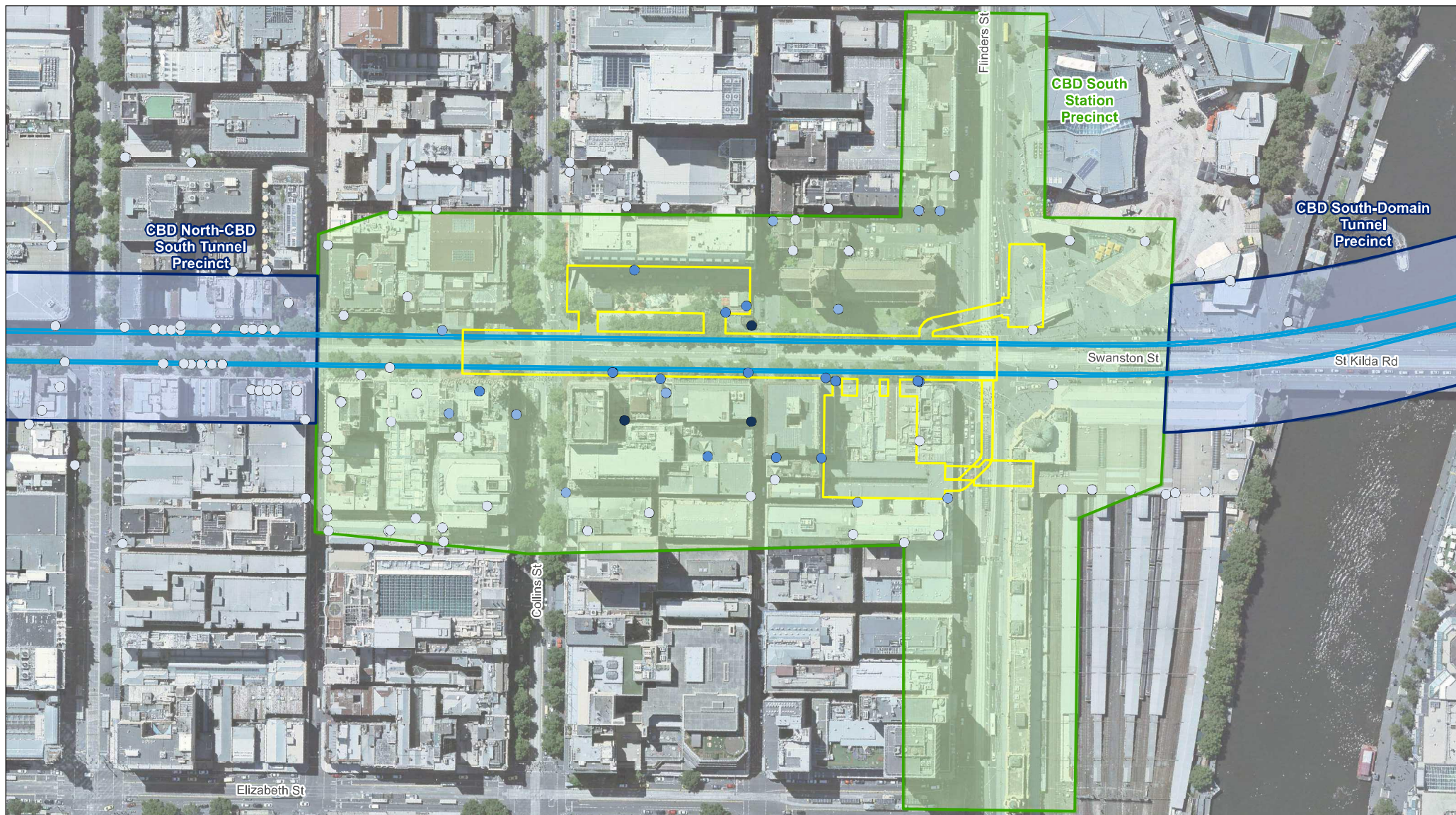


Figure B.58: Colour coded station cavern mining VdV (night) levels for Human Comfort for CBD North Station Precinct

G:\MMR-AJM01\_VIP\PW-1-AA-KG\_GIS\640\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Station\_Cavern\_Mining\_VdV\_Night.mxd





## Legend

### VdV Night Target

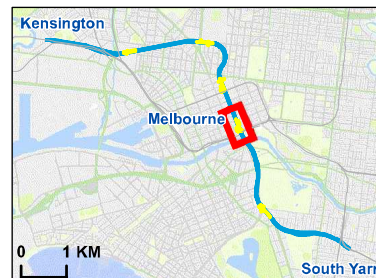
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

## Map 2 of 2



## Melbourne Metro Rail Project

Title:  
Station Cavern Mining Vibration Dosage Value (VdV) -  
Guideline Night Target - CBD South Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500447 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

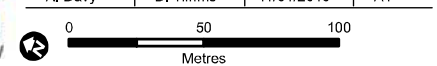
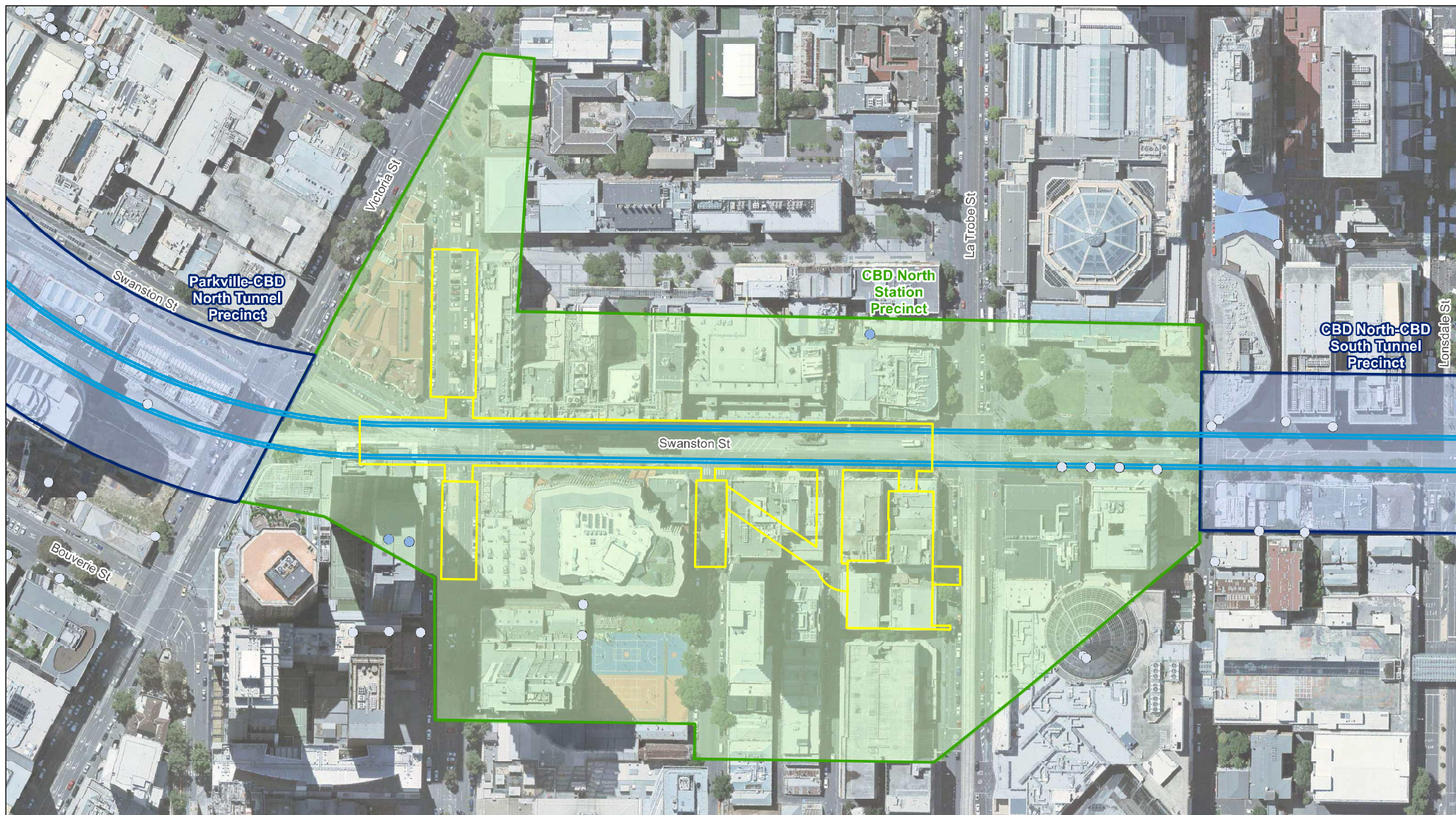


Figure B.59: Colour coded station cavern mining VdV (night) levels for Human Comfort for CBD South Station Precinct

G:\MMR-AJM01\_WIP\PW-1-AA-KG\_GIS\640\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Station\_Cavern\_Mining\_VdV\_Night.mxd





## Legend

### Ground-borne Noise

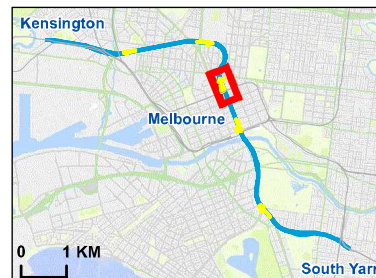
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

Map 1 of 2



## Melbourne Metro Rail Project

Title:  
Station Cavern Mining Ground-borne Noise -  
CBD North Station

Drawing Number:

MMR-AJM-UGAA-MP-NO-500448

Revision:

P1

Drawn By:

A. Davy

Approved By:

D. Timms

Date:

11/04/2016

Map Size:

A4

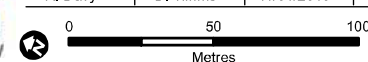
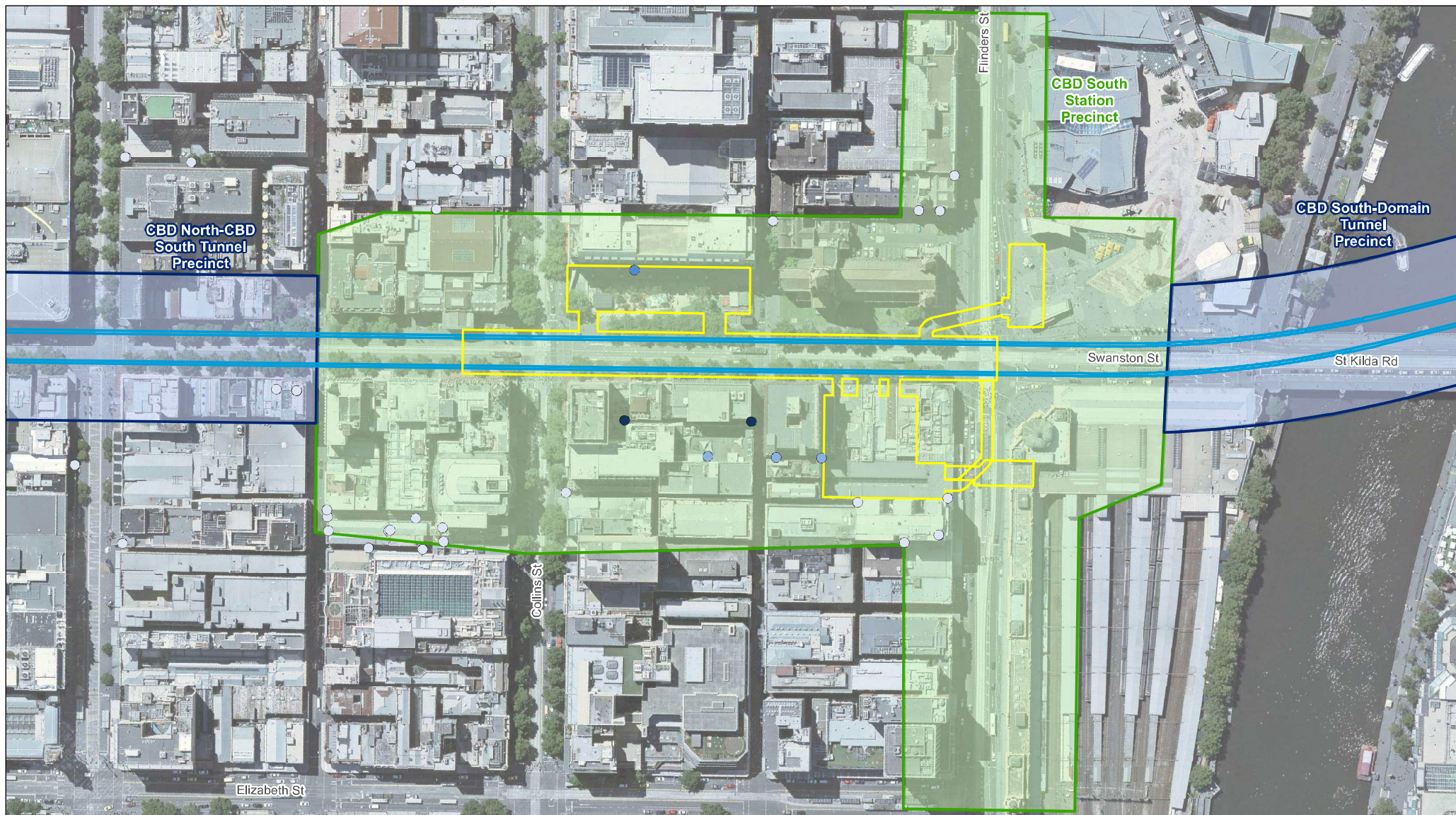


Figure B.60: Colour coded station cavern mining ground-borne noise levels for CBD North Station Precinct

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## Legend

### Ground-borne Noise

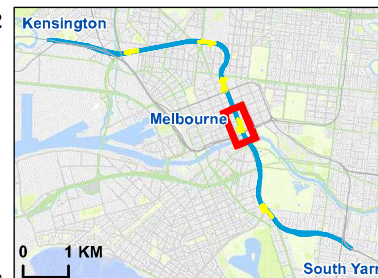
#### Rating

- Below preferred guideline target (adverse comment not expected)
- 0 – 5 dB above night guideline target / below evening guideline target
- 5 – 10 dB above night guideline target / 0 – 5 dB above evening guideline target
- > 10 dB above night guideline target / > 5 dBA above evening guideline target

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015;  
Aerial photo (DELWP, February 2015)

## Map 2 of 2



## Melbourne Metro Rail Project

Title:  
Station Cavern Mining Ground-borne Noise -  
CBD South Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500448 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

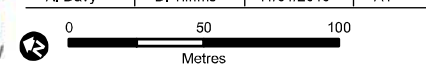


Figure B.61: Colour coded station cavern mining ground-borne noise levels for CBD South Station Precinct





## B.5 Results of Initial Vibration and Ground-borne Noise Assessment for Additional Construction Works

Vibration and ground-borne noise has been predicted at each of the Melbourne Metro construction sites. The predictions relate to the highest vibration levels that are predicted to occur at any point in time during the construction. For multiple story buildings, the predictions relate to the vibration levels on the ground floor where vibration levels are expected to be highest. Vibration levels would be lower on higher floors of the multi-story buildings.

Vibration levels have been predicted and compared against the guideline target PPV for building damage (from DIN 4150) and are presented as follows:

- Figure B.62: Colour coded building damage assessment due to Additional Construction Works – Western Portal Precinct
- Figure B.63: Colour coded building damage assessment due to Additional Construction Works – Arden Station Precinct
- Figure B.64: Colour coded building damage assessment due to Additional Construction Works – Parkville Station Precinct
- Figure B.65: Colour coded building damage assessment due to Additional Construction Works – CBD North Station Precinct
- Figure B.66: Colour coded building damage assessment due to Additional Construction Works – CBD South Station Precinct
- Figure B.67: Colour coded building damage assessment due to Additional Construction Works – CBD South to Domain Tunnel Precinct
- Figure B.68: Colour coded building damage assessment due to Additional Construction Works – Domain Station Precinct
- Figure B.69: Colour coded building damage assessment due to Additional Construction Works – Domain to Eastern Tunnel Precinct
- Figure B.70: Colour coded building damage assessment due to Additional Construction Works – Eastern Portal Precinct

VDV day levels have been predicted and compared with the guideline targets and are presented as follows:

- Figure B.71: Colour coded VDV day assessment for Additional Construction Works – Western Portal Precinct
- Figure B.72: Colour coded VDV day assessment for Additional Construction Works – Arden Station Precinct
- Figure B.73: Colour coded VDV day assessment for Additional Construction Works – Parkville Station Precinct
- Figure B.74: Colour coded VDV day assessment for Additional Construction Works – CBD North Station Precinct
- Figure B.75: Colour coded VDV day assessment for Additional Construction Works – CBD South Station Precinct
- Figure B.76: Colour coded VDV day assessment for Additional Construction Works – Domain Station Precinct
- Figure B.77: Colour coded VDV day assessment for Additional Construction Works – Domain to Eastern Portal Tunnels Precinct
- Figure B.78: Colour coded VDV day assessment for Additional Construction Works – Eastern Portal Precinct

VDV night levels have been predicted and compared with the guideline targets and are presented as follows:

- Figure B.79: Colour coded VDV night assessment for Additional Construction Works – Western Portal Precinct
- Figure B.80: Colour coded VDV night assessment for Additional Construction Works – Arden Station Precinct
- Figure B.81: Colour coded VDV night assessment for Additional Construction Works – Parkville Station Precinct
- Figure B.82: Colour coded VDV night assessment for Additional Construction Works – CBD North Station Precinct
- Figure B.83: Colour coded VDV night assessment for Additional Construction Works – CBD South Station Precinct
- Figure B.84: Colour coded VDV night assessment for Additional Construction Works – Domain Station Precinct
- Figure B.85: Colour coded VDV night assessment for Additional Construction Works – Domain to Eastern Portal Tunnels Precinct
- Figure B.86: Colour coded VDV night assessment for Additional Construction Works – Eastern Portal Precinct

Ground-borne noise levels have been predicted and compared against the guideline ground-borne noise targets and are presented as follows:

- Figure B.87: Colour coded ground-borne noise assessment for Additional Construction Works – Western Portal Precinct
- Figure B.88: Colour coded ground-borne noise assessment for Additional Construction Works – Arden Station Precinct
- Figure B.89: Colour coded ground-borne noise assessment for Additional Construction Works – Parkville Station Precinct
- Figure B.90: Colour coded ground-borne noise assessment for Additional Construction Works – CBD North Station Precinct
- Figure B.91: Colour coded ground-borne noise assessment for Additional Construction Works – CBD South Station Precinct
- Figure B.92: Colour coded ground-borne noise assessment for Additional Construction Works – CBD South to Domain Tunnel Precinct
- Figure B.93: Colour coded ground-borne noise assessment for Additional Construction Works – Domain Station Precinct
- Figure B.94: Colour coded ground-borne noise assessment for Additional Construction Works – Domain to Eastern Tunnel Precinct
- Figure B.95: Colour coded ground-borne noise assessment for Additional Construction Works – Eastern Portal Precinct





## Legend

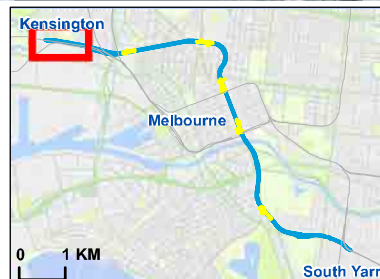
### Result Set 4

#### Rating

- Below PPV guideline target (cosmetic damage is not expected)
- Above PPV guideline target (trigger level for further investigation)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct
- Proposed Construction Site
- Proposed Excavation Area

Map 1 of 9



Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Building Damage (PPV) - Western Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500206 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 14/04/2016 Map Size: A4

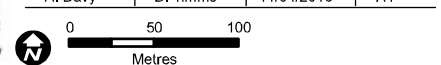
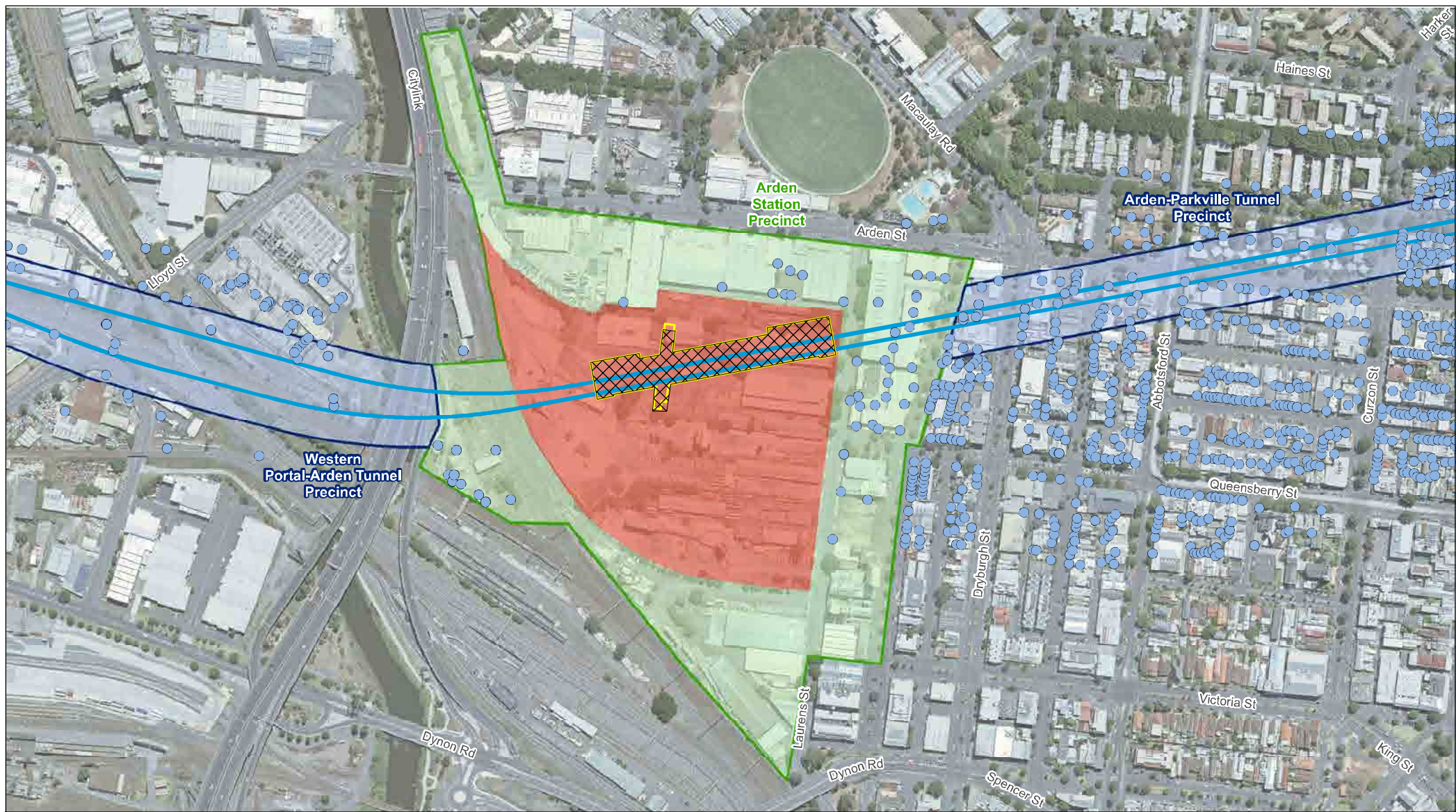


Figure B.62: Colour coded building damage assessment due to Additional Construction Works – Western Portal Precinct

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## Legend

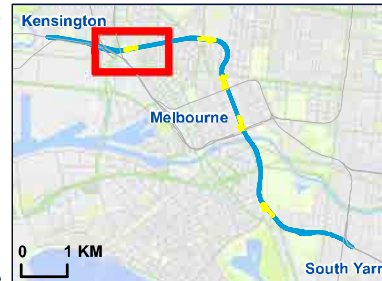
### Result Set 4

#### Rating

- Below PPV guideline target (cosmetic damage is not expected)
- Above PPV guideline target (trigger level for further investigation)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct
- Proposed Construction Site
- Proposed Excavation Area

### Map 2 of 9



Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Building Damage (PPV) - Arden Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500206 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 14/04/2016 Map Size: A4

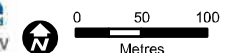


Figure B.63: Colour coded building damage assessment due to Additional Construction Works – Arden Station Precinct





## Legend

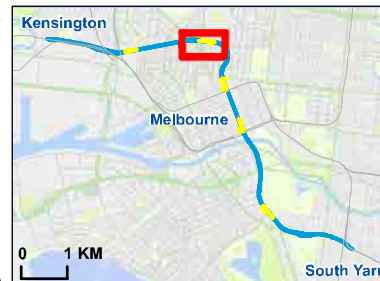
### Result Set 4

#### Rating

- Below PPV guideline target (cosmetic damage is not expected)
- Above PPV guideline target (trigger level for further investigation)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct
- Proposed Construction Site
- Proposed Excavation Area

### Map 3 of 9



Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Building Damage  
(PPV) - Parkville Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500206  
Revision: P1

Drawn By: A. Davy	Approved By: D. Timms	Date: 14/04/2016	Map Size: A4
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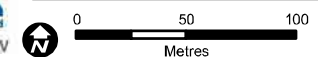
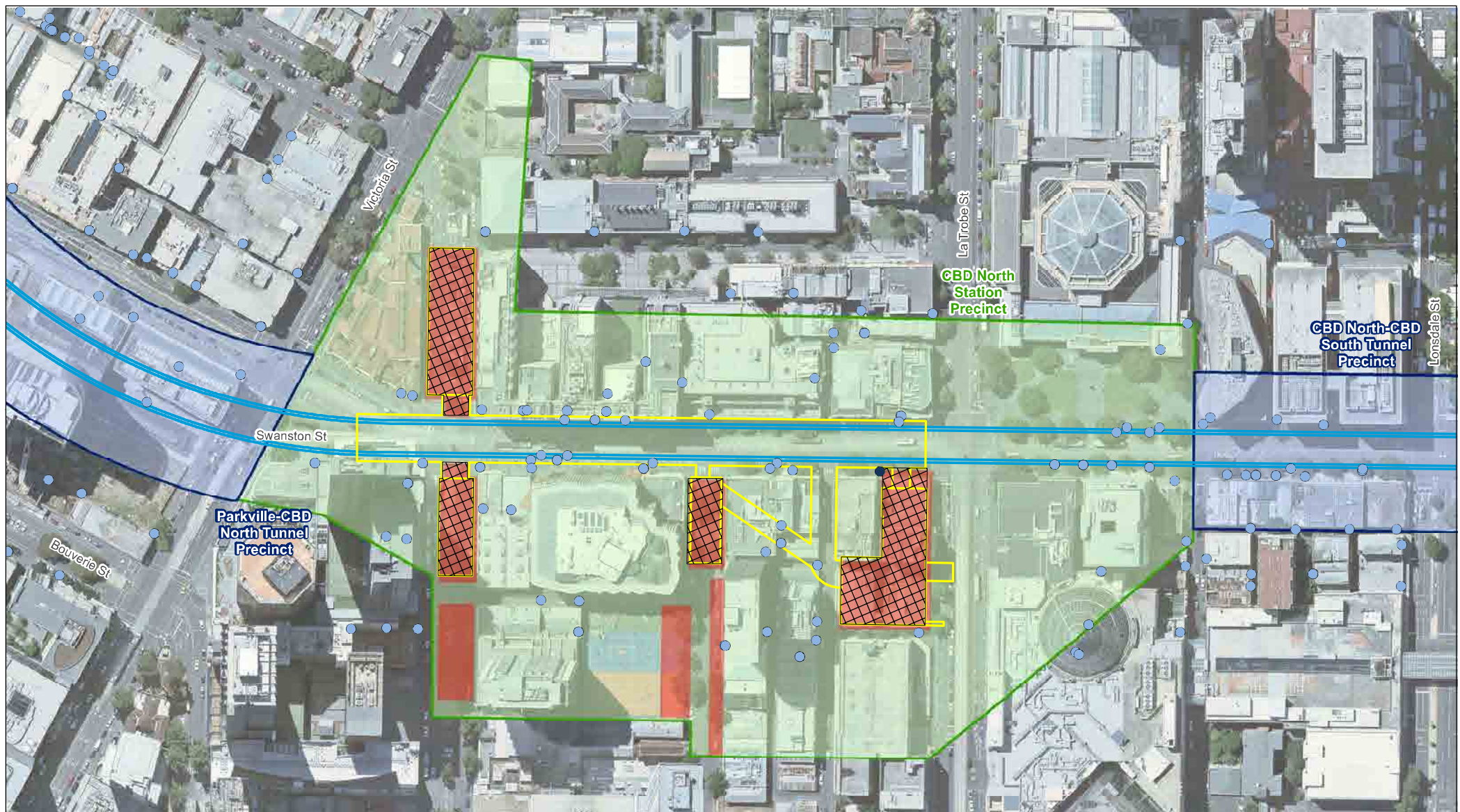


Figure B.64: Colour coded building damage assessment due to Additional Construction Works – Parkville Station Precinct





## Legend

### Result Set 4

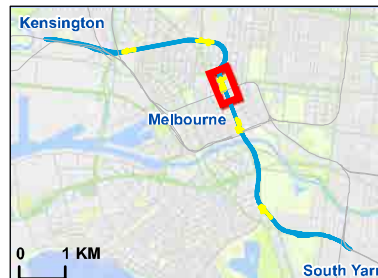
#### Rating

- Below PPV guideline target (cosmetic damage is not expected)
- Above PPV guideline target (trigger level for further investigation)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct
- Proposed Construction Site
- Proposed Excavation Area

Map 4 of 9

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015.  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Building Damage (PPV) - CBD North Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500206 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 14/04/2016 Map Size: A4

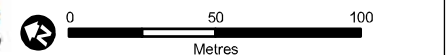


Figure B.65: Colour coded building damage assessment due to Additional Construction Works – CBD North Station Precinct

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## Legend

### Result Set 4

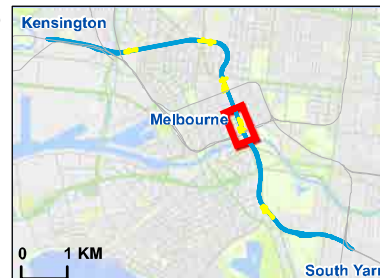
### Rating

- Below PPV guideline target (cosmetic damage is not expected)
- Above PPV guideline target (trigger level for further investigation)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct
- Proposed Construction Site
- Proposed Excavation Area

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015.  
Aerial photo (DELWP, February 2015)

Map 5 of 9



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Building Damage (PPV) - CBD South Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500206 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 14/04/2016 Map Size: A4

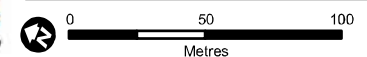
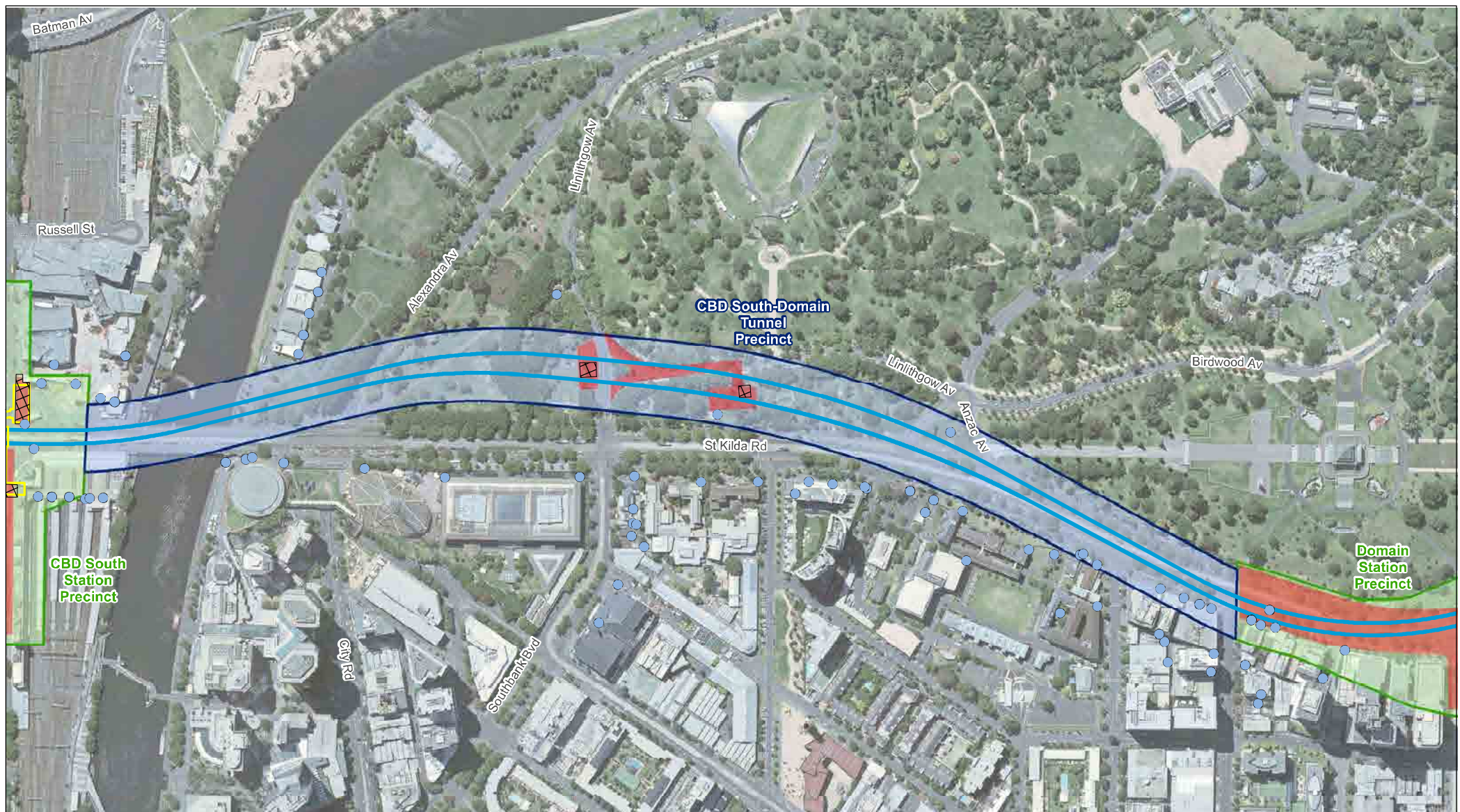


Figure B.66: Colour coded building damage assessment due to Additional Construction Works – CBD South Station Precinct

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## Legend

### Result Set 4

#### Rating

- Below PPV guideline target (cosmetic damage is not expected)
- Above PPV guideline target (trigger level for further investigation)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct
- Proposed Construction Site
- Proposed Excavation Area

Map 6 of 9

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Building Damage (PPV) - CBD South to Domain

Drawing Number: MMR-AJM-UGAA-MP-NO-500206  
Revision: P1

Drawn By: A. Davy	Approved By: D. Timms	Date: 14/04/2016	Map Size: A4
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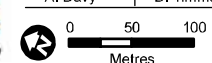


Figure B.67: Colour coded building damage assessment due to Additional Construction Works – CBD South to Domain Tunnel Precinct





## Legend

### Result Set 4

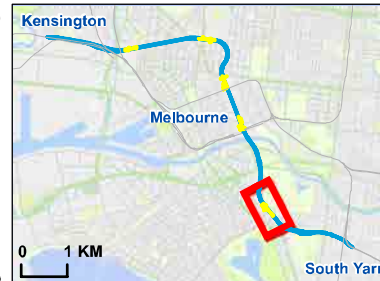
#### Rating

- Below PPV guideline target (cosmetic damage is not expected)
- Above PPV guideline target (trigger level for further investigation)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct
- Proposed Construction Site
- Proposed Excavation Area

Map 7 of 9

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015.  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Building Damage (PPV) - Domain Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500206 Revision: P1

Drawn By: A. Davy	Approved By: D. Timms	Date: 14/04/2016	Map Size: A4
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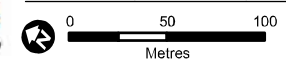


Figure B.68: Colour coded building damage assessment due to Additional Construction Works – Domain Station Precinct

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## Legend

### Result Set 4

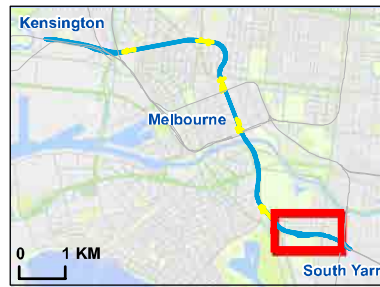
### Rating

- Below PPV guideline target (cosmetic damage is not expected)
- Above PPV guideline target (trigger level for further investigation)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct
- Proposed Construction Site
- Proposed Excavation Area

Map 8 of 9

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Building Damage (PPV) - Domain to Eastern Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500206  
Revision: P1

Drawn By: A. Davy	Approved By: D. Timms	Date: 14/04/2016	Map Size: A4
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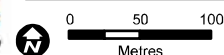


Figure B.69: Colour coded building damage assessment due to Additional Construction Works – Domain to Eastern Tunnel Precinct

G:\MMR-AJM\01\_WIP\IPW-1-AA-<G\_GIS\040\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Result\_Set\_4.mxd





## Legend

### Result Set 4

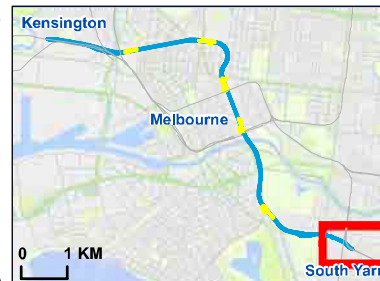
#### Rating

- Below PPV guideline target (cosmetic damage is not expected)
- Above PPV guideline target (trigger level for further investigation)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct
- Portal Precinct
- Proposed Construction Site
- Proposed Excavation Area

Map 9 of 9

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2015  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Building Damage (PPV) - Eastern Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500206 Revision: P1

Drawn By: A. Davy	Approved By: D. Timms	Date: 14/04/2016	Map Size: A4
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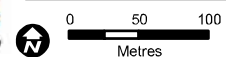


Figure B.70: Colour coded building damage assessment due to Additional Construction Works – Eastern Portal Precinct





## Legend

### Result Set 6

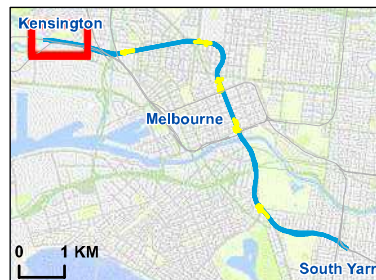
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Portal Precinct

Map 1 of 13

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2016;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Vibration Dosage Value (VdV) - Guideline Day Target - Western Portal

Drawing Number: MMR-AJM-UGAA-MP-NO-500293 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

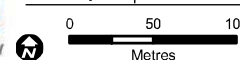


Figure B.71: Colour coded VdV day assessment for Additional Construction Works – Western Portal Precinct

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## Legend

### Result Set 6

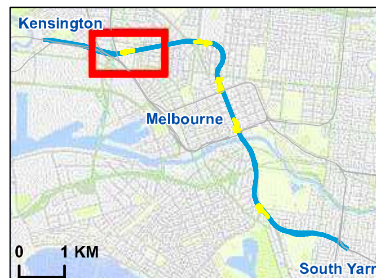
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2016;  
Aerial photo (DELWP, February 2015)

Map 3 of 13



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Vibration Dosage Value (VdV) - Guideline Day Target - Arden Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500293 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

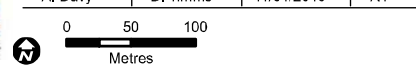
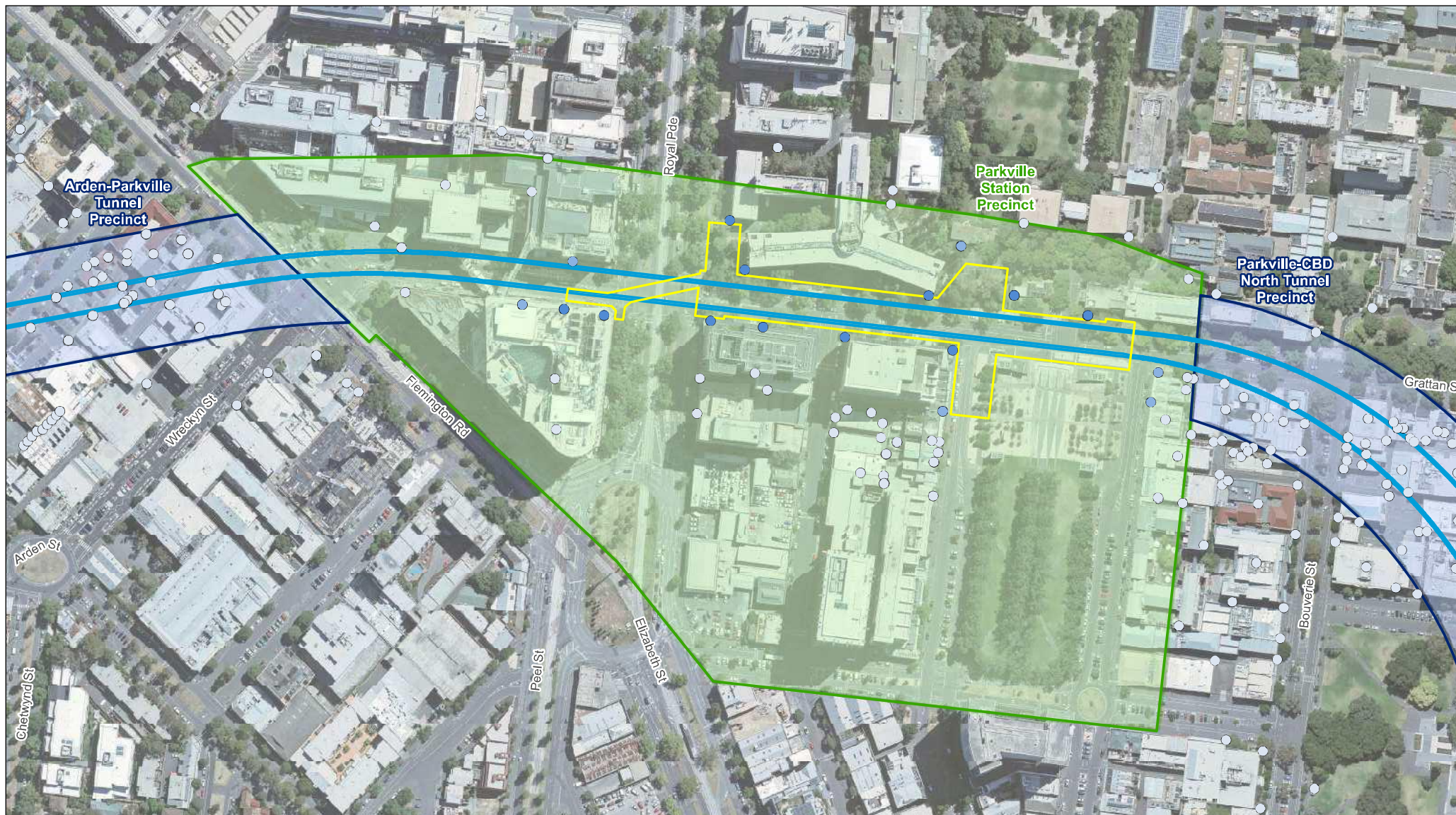


Figure B.72: Colour coded VdV day assessment for Additional Construction Works – Arden Station Precinct

G:\MMR-AJM01\_WIP\FW-1-AA-KG\_GSI640\_Site\_plans\MMR\_0322\_NoiseVibration\_EES\MMR\_0322\_Result\_Set\_6.mxd





## Legend

### Result Set 6

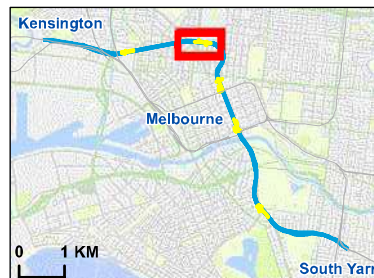
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct

Map 5 of 13

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2016;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Vibration Dosage Value (VdV) - Guideline Day Target - Parkville Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500293 Revision: P1

Drawn By: A. Davy	Approved By: D. Timms	Date: 11/04/2016	Map Size: A4
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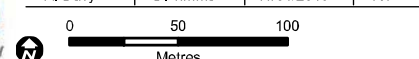
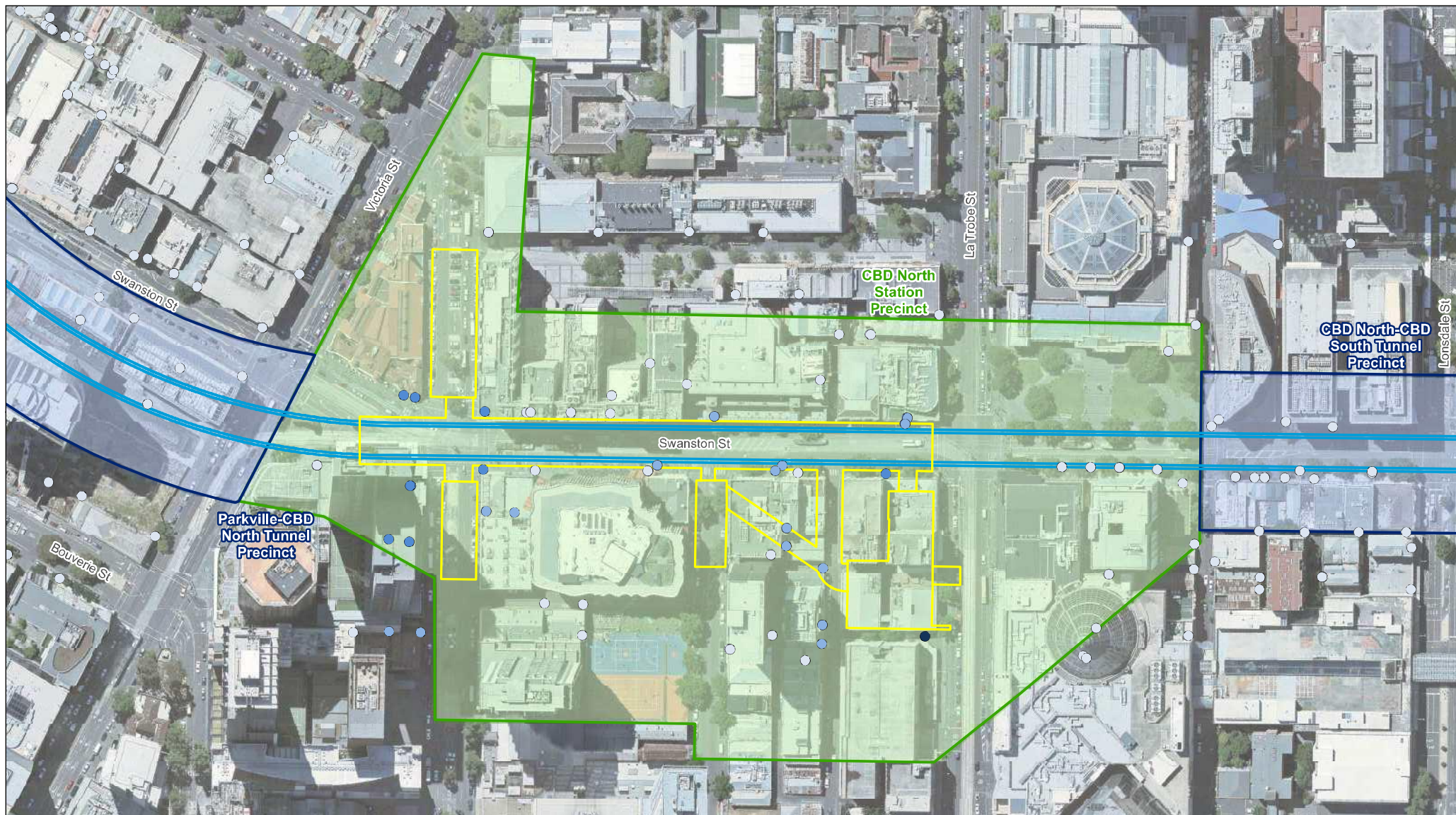


Figure B.73: Colour coded VDV day assessment for Additional Construction Works – Parkville Station Precinct





## Legend

### Result Set 6

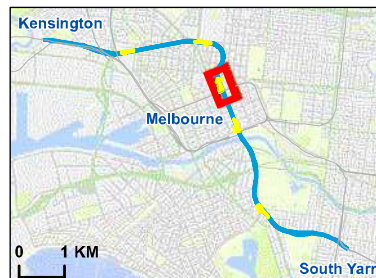
#### Rating

- Below preferred guideline target (adverse comment not expected)
- Below maximum guideline target (low probability of adverse comment)
- < 2 x maximum guideline target (adverse comment possible)
- > 2 x maximum guideline target (adverse comment probable)

- Proposed Station Footprint
- Proposed Alignment
- Tunnel Precinct
- Station Precinct

Map 7 of 13

Data Sources:  
Proposed Infrastructure: AJM 2016  
Contains Vicmap Information  
© State of Victoria 2016;  
Aerial photo (DELWP, February 2015)



## Melbourne Metro Rail Project

Title:  
Additional Construction Works Vibration Dosage Value (VdV) - Guideline Day Target - CBD North Station

Drawing Number: MMR-AJM-UGAA-MP-NO-500293 Revision: P1

Drawn By: A. Davy Approved By: D. Timms Date: 11/04/2016 Map Size: A4

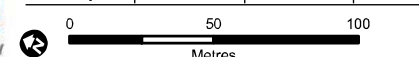


Figure B.74: Colour coded VDV day assessment for Additional Construction Works – CBD North Station Precinct