14 Appendices

Appendix A Acoustic terminology

Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest.
The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, while a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.
The table below lists examples of typical noise levels.

Table A-1 Typical Noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (such as B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(Lin) or dB.

Sound Power Level

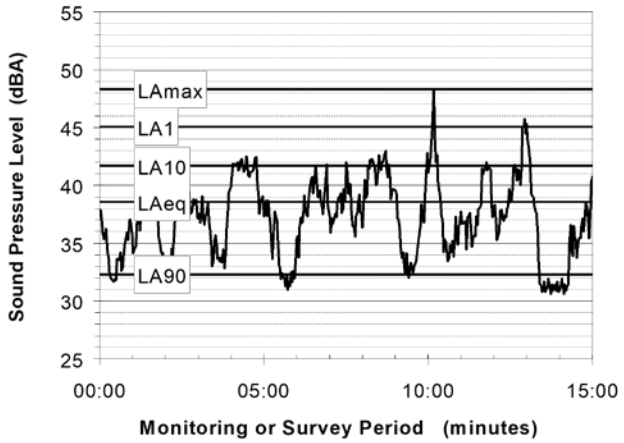
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dBA or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

The following figure presents an example of a 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} The A-weighted equivalent noise level (basically, the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the 'repeatable minimum' L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition, the method produces mean or 'average' levels representative of the other descriptors (L_{Aeq}, L_{A10}, etcetera).

Tonality

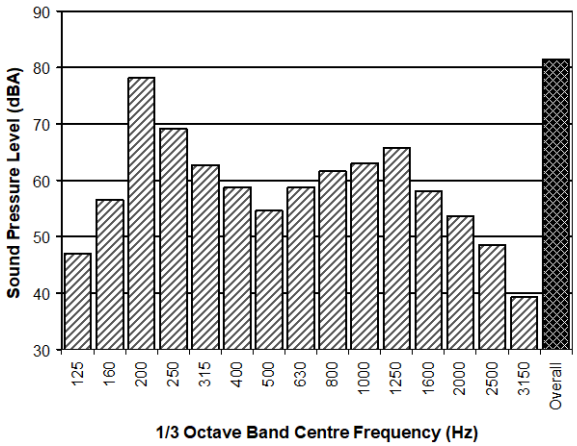
Tonal noise contains one or more prominent tones (distinct frequency components) and is normally regarded as more offensive than 'broad band' noise.

Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

Frequency Analysis

Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters but is now normally carried out using Fast Fourier Transform (FFT) analysers.



The units for frequency are Hertz (Hz), which represent the number of cycles per second. Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width).

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.

Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula $20 \log (V/V_o)$, where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organisations.

Human Perception of Vibration

People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

Over-Pressure

The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (unweighted), at frequencies both in and below the audible range.

Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (such as rockbreakers), and building services plant (fans, compressors and generators).

The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.

Appendix B Building classifications

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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B1

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LEGEND

Building Type

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Building Classifications

FIGURE B2

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LEGEND

Building Type

- Hospital
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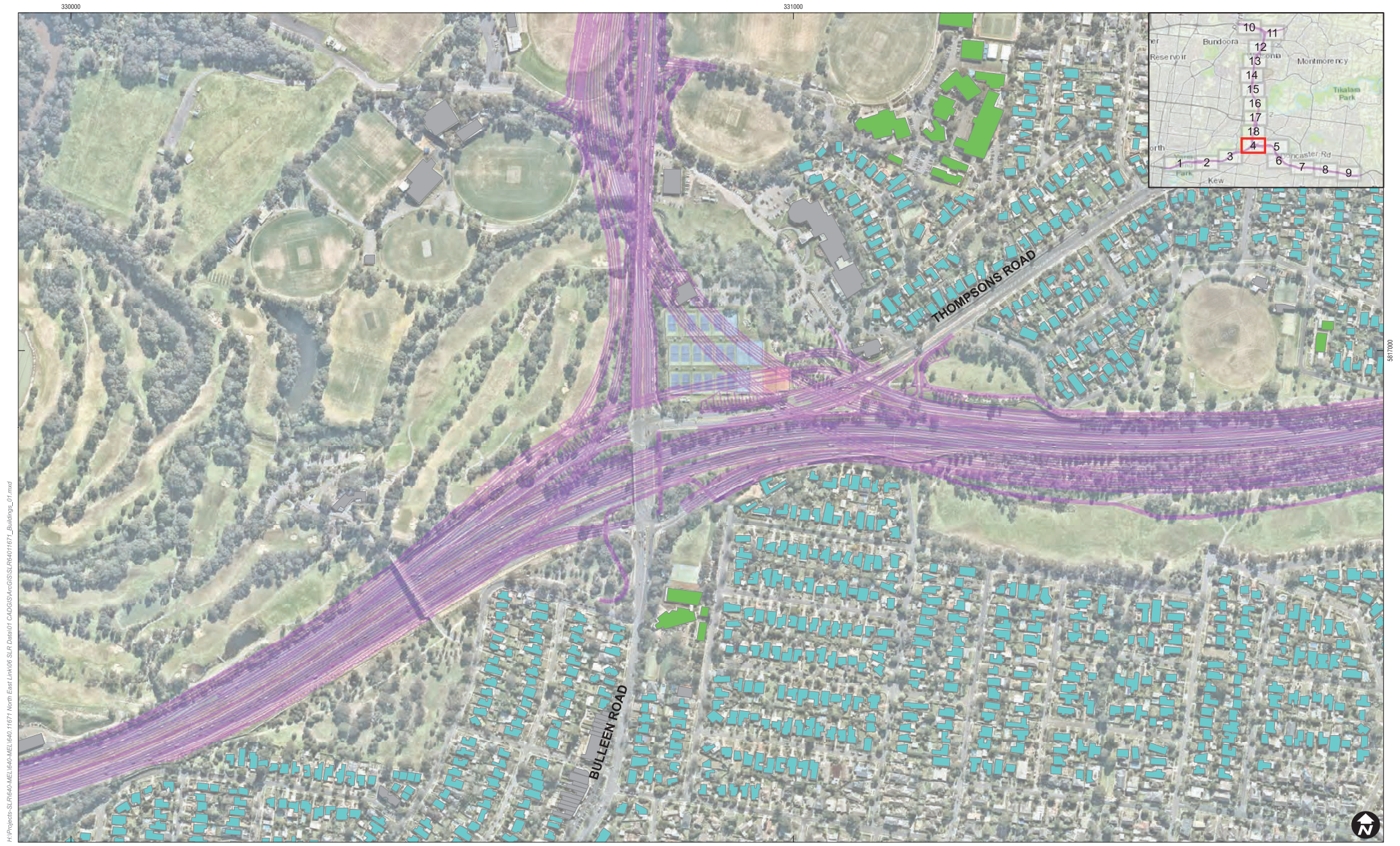
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B3



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LEGEND

Building Type

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- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B4

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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
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- Non Assessable Buildings

Building Classifications

FIGURE B5

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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B6

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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B7

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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
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- Non Assessable Buildings

Building Classifications

FIGURE B8

Sheet Size : A3

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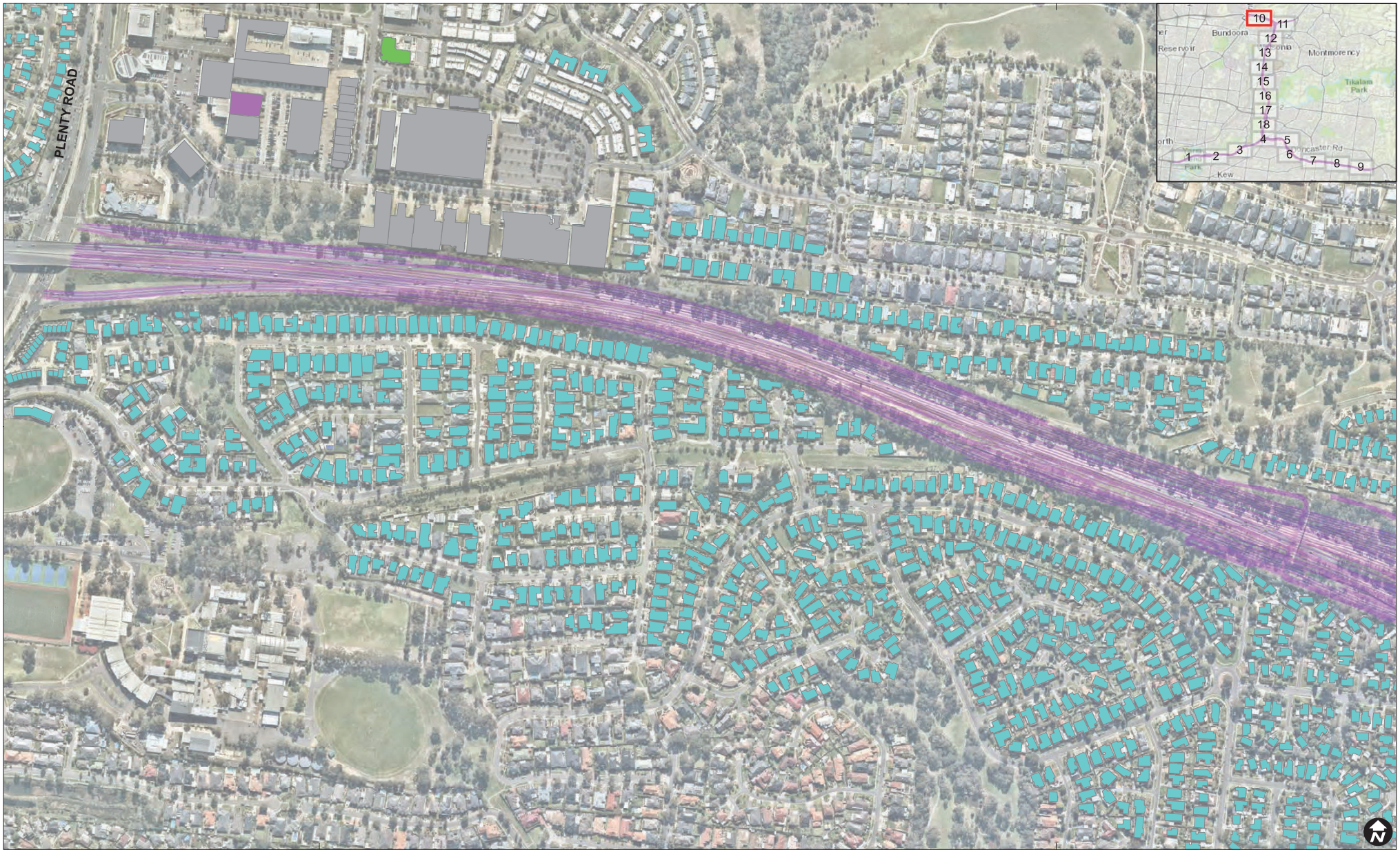
LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B9



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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B10

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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B11

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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B12

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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B13

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LEGEND

Building Type

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- Non Assessable Buildings

Building Classifications

FIGURE B14

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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
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- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B15

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LEGEND

Building Type

- Hospital
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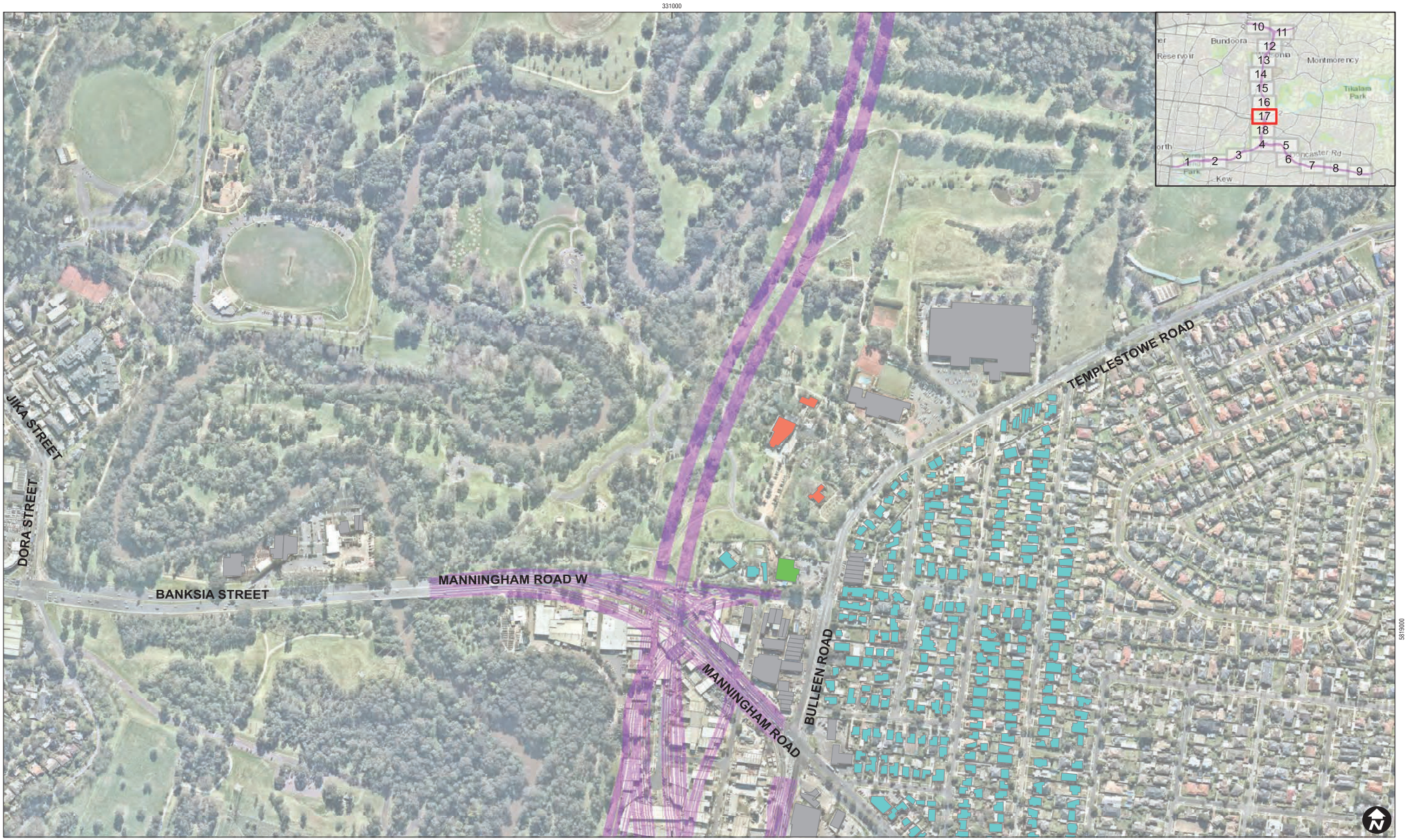
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B16



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Scale: 1:5,000
GDA94 MGA zone 55

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Sheet Size : A3

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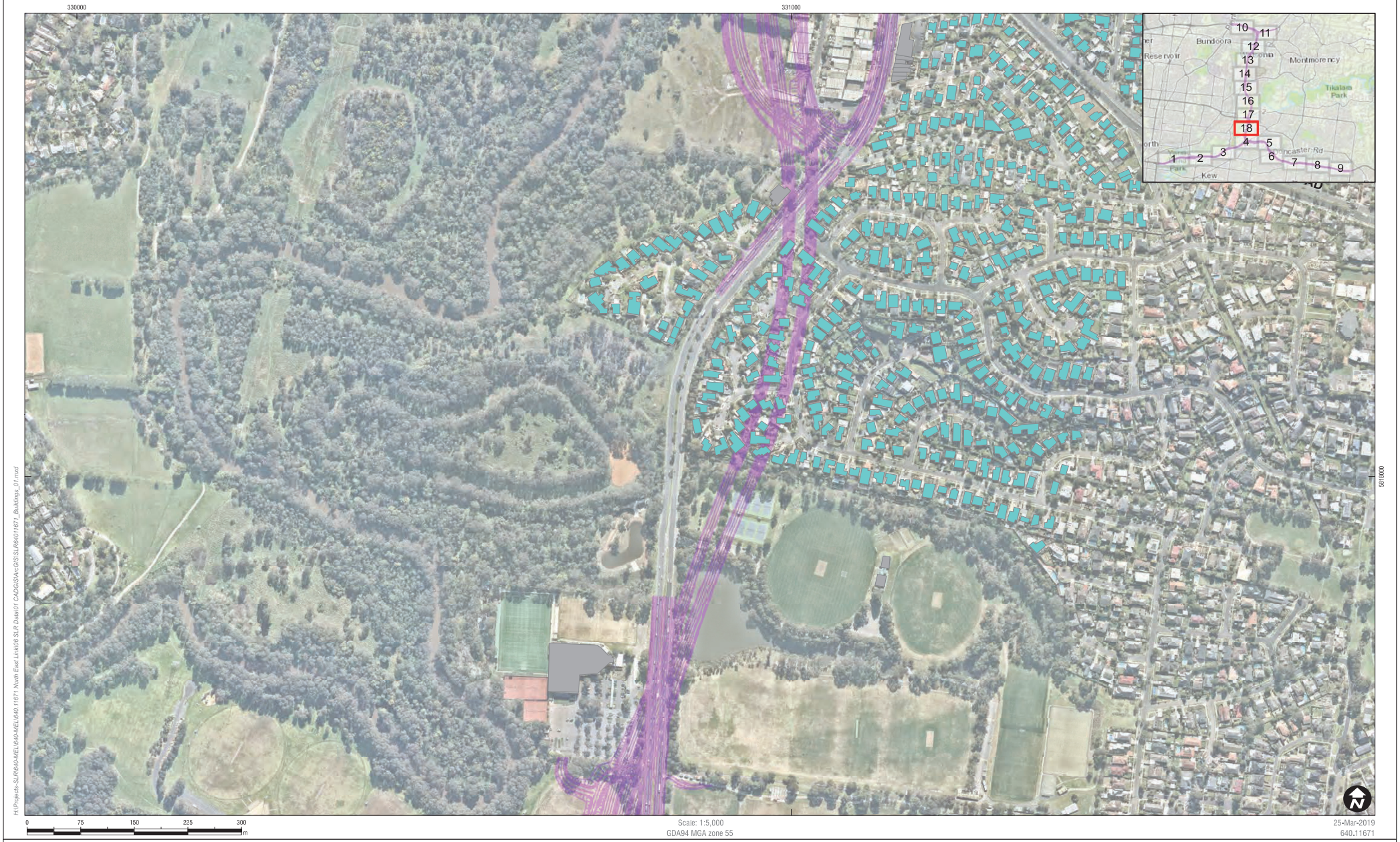
LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B17



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LEGEND

Building Type

- Hospital
- School / University / Preschool
- Religious Building
- Library / Museum / Advisory Centre
- Residential Building
- Aged Care
- Non Assessable Buildings

Building Classifications

FIGURE B18

Appendix C Risk assessment

Risk Assessment

Table C-2 Risk assessment

Risk ID	Potential threat and effect on the environment	INITIAL RISK							RESIDUAL RISK							
		Initial EPR	Characterisation of consequence			Overall consequence	Likelihood of impact	Risk level	Final EPR	Magnitude of effect			Overall consequence	Likelihood of impact	Risk level
			Extent	Severity	Duration					Extent	Severity	Duration			
Construction															
Risk SNV01	Noise generated by surface works during construction (including transport of spoil) causes an increase in noise or vibration affecting amenity at sensitive receivers	NV10, NV3	Corridor	High	3 months to 2 years	Major	Likely	High.	NV10, NV3	Corridor	Medium	3 months to 2 years	Minor	Possible	Medium
Risk SNV02	Mitigation measures required to mitigate surface works during construction are not feasible, reasonable or practical	NV4	Corridor	Medium	3 months to 2 years	Moderate	Possible	Medium	NV4	Local	Medium	3 months to 2 years	Minor	Unlikely	Low
Risk SNV03	Human impact vibration (VDV) resulting by surface works during construction (including transport of spoil) causes loss of amenity at sensitive receivers	NV4, NV8	Municipality	Medium	3 months to 2 years	Moderate	Likely	Medium	NV4, NV8	Local	Medium	3 months to 2 years	Minor	Possible	Low
Risk SNV04	Structural damage to buildings resulting by surface works during construction (including transport of spoil) causes damage to structures	NV4, Nv9	Local	Very High	3 months to 2 years	Major	Unlikely	Medium	NV4, NV9	Local	High	3 months to 2 years	Moderate	Rare	Low
Risk SNV05	Vibration to sensitive scientific equipment from construction works	NV4, NV13	Local	High	3 months to 2 years	Moderate	Rare	Low	NV4, NV13	Local	Medium	3 months to 2 years	Moderate	Rare	Low
Risk SNV06	Vibration damage to underground services from construction vibration works	NV4, NV5	Corridor	High	3 months to 2 years	Major	Unlikely	Medium	NV4, NV5	Local	Medium	3 months to 2 years	Moderate	Rare	Low

Risk ID	Potential threat and effect on the environment	INITIAL RISK							RESIDUAL RISK							
		Initial EPR	Characterisation of consequence			Overall consequence	Likelihood of impact	Risk level	Final EPR	Magnitude of effect			Overall consequence	Likelihood of impact	Risk level
			Extent	Severity	Duration					Extent	Severity	Duration			
Operation															
Risk SNV08	Traffic noise generated by the redistribution of traffic on the wider road network causes an increase in noise affecting amenity at sensitive receivers	NV1, NV2	Corridor	Medium	7+ years	Moderate	Possible	Medium	NV1, NV2	Corridor	Low	7+ years	Moderate	Possible	Low
Risk SNV09	Traffic noise mitigation measures required to reduce road traffic noise levels are not feasible, reasonable or practical	NV1, NV2	Local	Medium	7+ years	Moderate	Possible	Medium	NV1, NV2	Local	Low	7+ years	Minor	Possible	Low
Risk SNV10	Additional post-opening mitigation required	NV1, NV2	Corridor Local	High	7+ years	Major	Possible	High.	NV1, NV2	Local	Medium	7+ years	Major	Unlikely	Low
Risk SNV11	The traffic noise along North East Link causes an increase in noise affecting amenity at sensitive receivers	NV1, NV2	Municipality	Medium	7+ years	Moderate	Possible	Medium	NV1, NV2	Municipality	Medium	7+ years	Moderate	Unlikely	Low
Risk SNV12	Human impact vibration (VDV) at sensitive receivers generated by the redistribution of traffic due to operation causes an increase in noise	NV8	Municipality	Medium	7+ years	Moderate	Unlikely	Low	NV8	Municipality	Medium	7+ years	Moderate	Unlikely	Low
Risk SNV13	Structural damage at sensitive receivers, resulting from traffic on North east Link	NV9	Local	High	7+ years	Major	Rare	Medium	NV9	Local	Low	7+ years	Minor	Unlikely	Low
Risk SNV14	Noise emissions from fixed plant exceed criteria and affects amenity at sensitive receivers	NV6, NV7	Local	High	7+ years	Major	Unlikely	Low	NV6, NV7	Local	Low	7+ years	Minor	Unlikely	Low
Risk SN15	Increase in engine bake noise in community along North East Link	NV13	Local	High	7+ years	Major	Possible	High	NV13, NV14	Local	Medium	7+ years	Minor	Possible	Medium

Appendix D Noise and vibration (surface) monitoring methodology

Existing conditions noise monitoring

The purpose of the noise measurements is to provide an understanding of the existing noise conditions at various locations along the project boundary. The existing noise environment is established to aid in determining appropriate noise limits for the project in accordance with the guidelines established in **Section 4**. Specifically, this data has been used to validate the operational noise traffic model, establish construction noise management levels, operational road traffic noise objectives and for SEPP-N1 criteria for fixed facilities.

Methodology

The locations for the noise monitoring were chosen through examination of aerial photography and site inspections. They were also informed by the engagement with stakeholders and the community. Attended noise measurements were also undertaken to determine the nature of the local noise environment and confirm the road traffic noise was the dominant noise source at each given location (for the validation of the operational noise model).

Background noise monitoring locations were selected on the basis that they were generally representative of the noise sensitive receivers likely to be most affected by the works. These locations and the noise monitoring results are presented in tabular form later in this appendix.

A noise monitor measures the noise level over the sample period and then determines L_{A10}, L_{A90}, L_{Amax} and L_{Aeq} levels of the noise environment. The L_{A10} and L_{A90} levels are the levels exceeded for 10 per cent and 90 per cent of the sample period respectively. The L_{Amax} is the maximum noise level occurring at the measurement location during the measurement interval. The L_{A90} is taken as the background noise level. The L_{Aeq} is the energy averaged noise level over a defined sample period.

The existing noise levels were measured in general accordance with the VicRoads document *Traffic Noise Measurement Requirements for Acoustic Consultants,* September 2011. This document outlines the standard of noise measuring devices, measurement period, microphone position, measurement location (siting), weather conditions, traffic conditions, reporting requirements, adjustments of data and rejection of data.

The VicRoads measurement guidelines are specifically intended to provide procedures for performing compliance noise measurements. Consequently, the measurements undertaken in accordance with the Policy are normally undertaken adjacent to a road or freeway with the aim of determining compliance with the requirements detailed in the VicRoads Traffic Noise Reduction Policy (2005). When compliance is being assessed there is a need for the measured noise levels to be scrutinised so that the measurements are consistent with the guidelines.

The existing conditions noise measurement data captured was subject to conditions that may not comply with policy guidelines. For example, adverse weather is included in the measurements unless there is significant interference (wind speeds above 5 m/s or prolonged periods of rainfall). Measurement data for locations determined to be suitable for the validation of the operational noise model was reviewed more closely to eliminate data that was potentially adverse meteorological conditions and noise from extraneous sources.

A summary of the methodology used to conduct noise measurements is provided below:

- Unattended Noise Monitoring (Residential and Community Noise Sensitive Receivers):
  - At least seven consecutive days of unattended noise logging (the deployment of sound measurement equipment in a suitable location that logs noise levels continuously throughout the logging period).
  - All noise monitoring equipment had current laboratory calibration status at the time of the measurements. Each noise monitor was checked in the field for calibration with a hand-held calibrator at the start of the monitoring, and at the completion of monitoring at each location. No significant drifts in calibration had occurred between the pre- and post-monitoring field checks.
  - Noise monitoring was undertaken with the microphone either one metre from the façade of each dwelling, approximately at the centre of the ground or first floor window at the most exposed façade; or at least 3.5 metres from all reflecting surfaces (in the free-field) and at the height representative of the centre of the ground or first floor window. Reflecting surfaces includes building walls, sheds, solid fences etcetera. Positioning the microphone at least 3.5 metres from such surfaces removes the impact of reflected noise such that it does not significantly affect (increase) the measured noise levels.
  - Set up in in locations to minimise the impacts from extraneous noise sources, for example, insects, air conditioners, pool pumps and so forth.
  - Noise measurements should be conducted during normal traffic flow conditions (on weekdays and outside school holiday periods and public holidays).
- Short-term attended noise monitoring (recreation and public open spaces and selected community buildings):
  - An operator visits the recreation and public open spaces and selected community buildings for a period of approximately 30 minutes.
  - These measurements allow the operator to gather an indication of the noise environment at each of these spaces and observe any specific noise events.

Locations

The existing ambient noise environment was surveyed at 59 locations along the project boundary, comprising predominantly of Category A noise sensitive residential buildings, and including seven Category B community buildings. The sites ranged from the northern extent of the project around the M80 Ring Road and Greensborough Road (Watsonia North, Watsonia, Greensborough, Macleod, Yallambie) through to the Eastern Freeway on Bulleen Road and along the Eastern Freeway component of the project between Hoddle Street and Springvale Road (Kew, Kew East, Balwyn North, Bulleen, Doncaster, Doncaster East, Donvale, Month Albert North, Box Hill North, Blackburn North). The measurement sites were selected to represent locations where there would potentially be changes in the traffic flows and matrix (cars and heavy vehicles) and therefore changes in baseline noise levels.

Prior to its commencement, approval to conduct noise monitoring was granted by the resident, or property manager, at each of the sites spanning the extent of the project alignment. The locations, dates and monitor serial of all unattended monitoring locations are presented in the table below.

Table D-3 Baseline monitoring locations – unattended monitoring

Site ID	Address	GPS coordinates		Noise monitoring		
		Latitude	Longitude	Serial	Start	End
Residential						
N01	34 Edmund Rice Pde, Watsonia North	37°41'24.17"S	145° 4'59.90"E	164396	13/04/18	24/04/18
N02	12 Eastgate Dr, Greensborough	37°41'23.06"S	145° 5'14.19"E	409174	5/02/18	13/02/18
N03	43 Gillingham St, Watsonia North	37°41'36.81"S	145° 5'26.29"E	164394	5/02/18	13/02/18
N04	4 Yonde Ct, Greensborough	37°41'28.89"S	145° 5'51.41"E	175537	5/02/18	13/02/18
N05	77 Pinehills Dr, Greensborough	37°41'35.04"S	145° 5'54.67"E	354110	8/02/18	16/02/18
N06	15 Banfield Tce, Greensborough	37°41'37.94"S	145° 5'41.10"E	87815E	5/02/18	22/02/18
N07	4 Vincent Ct, Greensborough	37°41'45.18"S	145° 5'35.28"E	164393	13/04/18	24/04/18
N08	90 Sellars St, Watsonia North	37°41'45.97"S	145° 5'27.40"E	164393	5/02/18	13/02/18
N09	22 Sellars St, Watsonia North	37°42'3.83"S	145° 5'24.17"E	164396	5/02/18	22/02/18
N10	21 Boyd St, Greensborough	37°41'55.56"S	145° 5'32.04"E	465445	8/02/18	16/02/18
N11	1 Saxon Ct, Greensborough	37°42'5.97"S	145° 5'28.28"E	8780CA	8/02/18	16/02/18
N12	1/470 Greensborough Road, Greensborough	37°42'27.76"S	145° 5'17.77"E	878037	8/02/18	16/02/18
N13	34 Ibbottson St, Watsonia	37°42'32.78"S	145° 5'7.60"E	409174	14/02/18	22/02/18
N14	462 Greensborough Road, Watsonia	37°42'31.72"S	145° 5'14.44"E	465445	16/02/18	22/02/18
N15	319 Greensborough Road, Watsonia	37°42'54.13"S	145° 4'54.23"E	354110	23/02/18	6/03/18
N16	384 Service Road, Watsonia	37°42'49.40"S	145° 5'1.91"E	175537	14/02/18	22/02/18
N17	17 Watson St, Macleod	37°43'5.00"S	145° 4'56.94"E	175537	13/04/18	26/04/18
N18	179 Greensborough Road, Macleod	37°43'23.66"S	145° 4'49.26"E	164394	14/02/18	22/02/18
N19	115 Greensborough Road, Macleod	37°43'39.66"S	145° 4'46.53"E	164393	14/02/18	22/02/18
N20	10 Borlase St, Yallambie	37°43'59.21"S	145° 4'49.30"E	856769	14/02/18	22/02/18
N21	218 Bulleen Road, Bulleen	37°45'41.94"S	145° 5'1.50"E	354110	16/02/18	22/02/18
N22	2 Golden Way, Bulleen	37°45'59.94"S	145° 4'52.40"E	8780CA	23/02/18	6/03/18
N23	3 Ilma Ct, Bulleen	37°46'1.60"S	145° 4'47.80"E	164394	23/02/18	6/03/18
N24	8 Ben Nevis Gr, Bulleen	37°46'36.30"S	145° 4'54.12"E	175537	8/03/18	22/03/18
N25	10 Vaughan Cr, Kew	37°47'32.89"S	145° 1'27.61"E	1273093	20/04/18	1/05/18
N27	32 Kilby Road, Kew East	37°47'29.47"S	145° 2'42.75"E	865769	17/04/18	26/04/18
N28	20 Willow Gr, Kew East	37°47'24.31"S	145° 2'45.80"E	465445	17/04/18	26/04/18
N29	7 Fairway Dr, Kew East	37°47'28.12"S	145° 3'6.08"E	354110	4/05/18	16/05/18
N30	1549B Old Burke Road, Kew East	37°47'8.90"S	145° 3'41.53"E	15299453	20/04/18	1/05/18
N31	21 Orion St, Balwyn North	37°47'1.85"S	145° 4'21.77"E	164394	24/04/18	28/04/18
N32	52 Columba St, Balwyn North	37°46'55.19"S	145° 4'34.30"E	164393	24/04/18	4/05/18
N33	150 Mountain View Road, Balwyn North	37°46'49.52"S	145° 4'56.70"E	164396	24/04/18	4/05/18
N34	7 Kampman St, Bulleen	37°46'44.85"S	145° 5'9.58"E	164393	22/03/18	3/04/18
N35	4 Carron St, Balwyn North	37°46'54.07"S	145° 5'21.63"E	465445	1/05/18	9/05/18

Site ID	Address	GPS coordinates		Noise monitoring		
		Latitude	Longitude	Serial	Start	End
N36	33 Estelle St, Bulleen	37°46'44.62"S	145° 5'31.09"E	865769	1/05/18	9/05/18
N37	117 Willow Bend, Bulleen	37°46'55.71"S	145° 6'0.23"E	865769	22/03/18	3/04/18
N38	49 Gardenia Road, Balwyn North	37°47'5.31"S	145° 5'55.77"E	175537	1/05/18	9/05/18
N39	3/69 Sweyn St, Balwyn North	37°47'32.38"S	145° 6'21.10"E	354110	20/04/18	1/05/18
N40	39 Stanton St, Doncaster	37°47'39.97"S	145° 6'44.26"E	175537	23/02/18	6/03/18
N41	15 Valda Ave, Mont Albert North	37°47'46.24"S	145° 6'43.99"E	164396	23/02/18	6/03/18
N42	17 Sargent St, Doncaster	37°47'47.56"S	145° 7'16.34"E	465445	23/02/18	6/03/18
N43	9/19 Paul Ave, Box Hill North	37°47'54.08"S	145° 7'19.01"E	1273093	9/03/18	22/03/18
N44	24 Grange Park Ave, Doncaster	37°47'43.83"S	145° 7'48.29"E	465445	8/03/18	22/03/18
N45	48 Eram Road, Box Hill North	37°47'54.98"S	145° 8'15.08"E	409174	28/02/18	9/03/18
N46	2/46 Gedye St, Doncaster	37°47'57.52"S	145° 8'55.07"E	164396	9/03/18	22/03/18
N47	21 Middlefield Dr, Blackburn North	37°48'5.04"S	145° 9'5.65"E	164394	13/04/18	24/04/18
N48	3/22 Boronia Gr, Doncaster East	37°48'0.12"S	145° 9'24.26"E	865769	28/02/18	9/03/18
N49	4/52 Bowen Road, Doncaster East	37°48'6.43"S	145° 9'54.87"E	164393	28/02/18	9/03/18
N50	61 Kett St, Blackburn North	37°48'13.78"S	145°10'8.42"E	87815E	28/02/18	9/03/18
N51	60 Darvall St, Donvale	37°48'11.21"S	145°10'27.36"E	15299453	28/02/18	9/03/18
N20A	3 Kay Ct, Yallambie	37°43'46.52"S	145° 4'49.99"E	164394	22/03/18	3/04/18
Schools						
NS01	St Mary's Parish Primary School, Greensborough	37°42'11.5"S	145°05'28.6"E	175537	11/12/17	21/12/17
NS02	Watsonia Primary School	37°42'24.51"S	145° 5'16.20"E	878101	13/12/17	21/12/17
NS03	St Martin of Tours, Rosanna	37°44'05.2"S	145°04'42.1"E	164394	11/12/17	21/12/17
NS04	Belle Vue Primary School, Balwyn North	37°46'51.99"S	145° 4'43.92"E	865769	11/12/17	21/12/17
NS05	Kalker Montessori Centre, Bulleen	37°46'44.73"S	145° 5'21.38"E	865769	9/05/18	22/05/18
NS06	Marcellin College, Bulleen	37°46'31.17"S	145° 4'44.90"E	465445	9/05/18	22/05/18
NS07	Trinity Marles Playing Fields, Bulleen	37°46'12.74"S	145° 4'47.09"E	12773093	9/05/18	22/05/18

Existing conditions surface vibration monitoring

Unattended vibration measurements at 21 locations across the project boundary have been undertaken to determine existing vibration levels to inform both the surface vibration and underground tunnelling noise and vibration reports.

Vibration measurement locations have been selected to be representative of the vibration environment in a number of different conditions, that is; buildings and structures within the project boundary that are currently exposed to vibration from various sources.

A summary of the methodology used to conduct vibration measurements is provided below:

- Monitoring equipment capable of measuring Peak Particle Velocity (PPV) in three directions at one-minute intervals
- Units to be set up to monitor and a sampling frequency of 1 kHz, covering the range 1 Hz to 80 Hz, as appropriate for assessment of vibrations in buildings
- Where possible, the vibration sensors to be placed at the foundation of the structure being measured at ground level
- Geophone sensor coupled to the surface/soil using an embedded Mount, adhesive or ground spikes
- Monitoring at each location for a minimum of three days to provide a representation of the background vibration levels

A summary of the vibration monitoring locations at each site is presented below.

Table D-4 Baseline monitoring locations – vibration

Site ID	Address	GPS coordinates		Noise monitoring		
		Latitude	Longitude	Monitor Serial	Start	End
V1	27 Greensborough Road, Rosanna	37°44'0.76"S	145° 4'42.69"E	BE14839	26/04/18	4/05/18
V2	11 Greensborough Road, Rosanna	37°44'4.47"S	145° 4'42.09"E	BE14514	16/04/18	20/04/18
V3	314 Lower Plenty Road, Rosanna	37°44'6.02"S	145° 4'45.27"E	BE14839	16/04/18	20/04/18
V4	31 Leura Ave, Rosanna	37°44'11.39"S	145° 4'43.76"E	BE12586	16/04/18	20/04/18
V5	50 McCrae Road, Rosanna	37°44'17.03"S	145° 4'46.21"E	BE14840	29/03/18	6/04/18
V6	9 Homewood Ct, Rosanna	37°44'25.36"S	145° 4'47.41"E	BE14510	29/03/18	6/04/18
V7	9/87 Banyule Road, Rosanna	37°44'30.66"S	145° 4'54.09"E	BE14839	29/03/18	6/04/18
V8	57 Halifax Ave, Heidelberg	37°44'38.11"S	145° 4'58.75"E	BE14514	29/03/18	6/04/18
V9	5 Sevenoaks Ave, Heidelberg	37°44'46.37"S	145° 5'1.46"E	BE14510	10/04/18	13/04/18
V10	58 Buckingham Dr, Heidelberg	37°44'55.96"S	145° 5'1.08"E	BE14514	10/04/18	13/04/18
V11	3 St Andrews Cr, Bulleen	37°45'58.39"S	145° 4'54.38"E	BE14839	10/04/18	13/04/18
V12	3 Ilma Ct, Bulleen	37°46'1.51"S	145° 4'48.00"E	BE14840	17/04/18	24/04/18
V13	4 Belmain Ct, Bulleen	37°46'4.35"S	145° 4'48.55"E	BE12586	10/04/18	13/04/18
V14	8 Claremont Ln, Bulleen	37°46'9.60"S	145° 4'47.13"E	BE14069	10/04/18	13/04/18
V15	5 Derwent Sq, Bulleen	37°46'2.07"S	145° 4'51.04"E	BE14840	10/04/18	13/04/18
V18	1/326 Lower Plenty Road, Rosanna	37°44'4.17"S	145° 4'48.38"E	BE14510	16/04/18	20/04/18
V19	47 Greensborough Road, Macleod	37°43'56.24"S	145° 4'43.80"E	BE14069	16/04/18	20/04/18
V00A	Heide Park (South), Bulleen	37°45'29.36"S	145° 4'58.71"E	BE12586	29/03/18	6/04/18
V00B	Heide Park (North), Bulleen	37°45'27.75"S	145° 4'59.86"E	BE14069	29/03/18	6/04/18

Weather conditions

The meteorological data captured by the Viewbank weather station, operated by the Bureau of Meteorology, and by the Heidelberg rain gauge, operated by Melbourne Water, have been used to identify periods where measured noise levels should be adjusted and removed due to extraneous weather.

These weather stations are located 10 metres above the ground. As such, the wind speed was corrected to present the equivalent wind speed at the ground floor receiver height. All of the wind data was adjusted as per the paper *Converting Bureau of Meteorology Wind Speed Data to Local Wind Speeds at 1.5 m Above Ground Level,* placing all weather stations in Category 2 (for >10 m) and all measurement locations in Category 3 (for <3 m). As a result, the magnitude of all wind speed data was reduced to 63.3% of the value measured at the weather stations.

Noise monitoring sites north of Lower Plenty Road have been assessed with weather conditions based on Viewbank weather station. Sites south of Lower Plenty Road have assessed with weather conditions from Viewbank weather station with rainfall data from Melbourne Water's Heidelberg Rain Gauge. This was to provide more accurate rainfall data to these areas.

Noise monitoring results were adjusted to remove extraneous weather in accordance with the VicRoads Road Design Note (RDN) 06-01, SEPP N-1 and the NSW ICNG.

Data captured during adverse weather periods were also removed from the overall dataset when calculating the construction noise criteria and the SEPP N-1 noise limits.

The weather data for each measurement location was assigned from the nearest weather station.

Quality Control and Instrumentation

All road traffic noise monitoring was undertaken by technical officers from AECOM with experience and training in conducting traffic noise measurements.

Unattended noise logging was provided through the use of the following environmental noise loggers:

- Rion NL-21
- Rion NL-31
- Rion NL-52
- ARL EL315
- ARL NGARA.

These noise loggers are, at minimum, Class 2 sound level metres. Class 2 sound level metres are typically considered for measuring ambient noise levels.

All noise loggers and sound level metres recorded noise data for the L_{A1}, L_{A10}, L_{A90}, L_{Aeq} and L_{Amax} descriptors at hourly intervals and were field-calibrated using Class 1 acoustic calibrators both before and after noise measurements, to monitor drifts in calibration. Measurements where drifts in calibration were in excess of 0.5 dBA were disregarded.

All sound level loggers, metres and calibrators were in current National Association of Testing Authorities (NATA) calibration at the time of use. NATA is Australia's national laboratory accreditation authority.

Unattended ambient noise monitoring results

The average ambient noise levels (L_{A90}) are required for determining the relevant SEPP-N1 noise limits applicable to noise from industrial plant, including tunnel ventilation systems.

The average L_{A90} noise levels at each noise measurement site have been determined and are shown in **Table 6-6**.

The measured noise levels can be used to determine the applicable SEPP N-1 noise limits for receivers potentially impacted by noise from the proposed tunnel ventilation systems.

Note that the noise levels in **Table 6-6**. have not been adjusted to account for sound where the noise monitor microphone was located at one metre from the building façade.

Short-term attended noise monitoring results

Attended measurements were completed with a hand-held sound level meter in tandem with site observations over a 30-minute period at selected outdoor community, recreation and public open spaces during May 2018. The personnel in attendance noted location, date and time, atmospheric conditions, and the level of noise from various noise sources, including the frequency of occurrence of impulsive, continuous or tonal noise. The attended measurements were also used to categorise the noise sources that contribute to the overall measured levels in the areas where noise monitoring was being conducted.

The table on the next page contains the noise measurement site summary showing the $L_{A90(30\ min)}$, $L_{Aeq(30\ min)}$ and $L_{A10(30\ min)}$ noise levels from the short-term monitoring at each location.

The short-term traffic noise levels were undertaken during the following conditions:

- Constant traffic flow on the roads where traffic was the dominant noise at the measurement location
- Weather was generally overcast with winds up to 5 m/s blowing in a north westerly direction. No rainfall was noted. Measurements taken on 18/05/2018 may have been affected by wet conditions following overnight rain.

These are indicative short-term measurements conducted to support site observations, since these measurements may create confusion with modelling results.

It is considered that the noise sources and levels observed during these short-term measurements are indicative of the typical daytime noise sources and levels at each of the above locations.

Table D-5 Baseline monitoring locations – short-term measurements

Attended short-term measurements								
Site ID	Name of open space	Start time of measurement	Measured Noise Level, dBA				Observation of noise sources	
			L_{Aeq}	L_{A90}	L_{A10}	L_{max}	Local environment	Traffic noise source (road)
P01	Winsor Reserve	10/03/2016 9:38	63	57	65	78	Dominant road traffic noise.	Greensborough Road
P02	Borlase Reserve	10/03/2016 10:26	65	59	67	84	Dominant road traffic noise.	Greensborough Road
P03	Bulleen Park	10/03/2016 11:35	63	55	66	81	Dominant road traffic noise.	Bulleen Road
P04	Yarra Flats Park (Bulleen Road)	10/03/2016 0:18	65	56	68	83	Dominant road traffic noise.	Bulleen Road
P05	Yarra Flats Park (north end)	17/05/2018 8:14	58	55	59	67	Wind through trees, birds.	Banksia Road
P06	Yarra Flats Park (south end)	17/05/2018 9:07	51	47	52	66	Veneto Club activity – occasional construction noise.	Bulleen Road

Attended short-term measurements								
Site ID	Name of open space	Start time of measurement	Measured Noise Level, dBA				Observation of noise sources	
			L_{Aeq}	L_{A90}	L_{A10}	L_{max}	Local environment	Traffic noise source (road)
P07	Manningham Park Reserve	17/05/2018 10:00	63	61	64	79	Dominant road traffic noise.	Eastern Freeway
P08	Katrina Street Reserve	17/05/2018 10:44	59	57	60	71	Dominant road traffic noise.	Eastern Freeway
P09	Elgar Park	17/05/2018 11:57	62	59	63	71	Dominant road traffic noise.	Eastern Freeway
P10	Tram Road Reserve	18/05/2018 7:47	55	54	56	69	Dominant road traffic noise, planes, birds.	Eastern Freeway
P11	Koonung Creek Linear Park	18/05/2018 8:30	57	52	56	88	Dominant bird noise (loud magpies and crows) and road traffic noise. Occasional dog barking at nearby residence.	Eastern Freeway
P12	Boronia Grove Reserve	18/05/2018 9:18	61	57	61	83	Dominant road traffic noise and birds. Many path users – cyclists, walkers and dog walkers. Police helicopter passes at 10 min.	Eastern Freeway
P13	Slater Reserve	18/05/2018 10:04	57	55	58	74	Dominant birds and road traffic noise. Flock of cockatoos at 25min. Occasional passing car in nearby carpark.	Eastern Freeway
P14	Eastern Freeway Linear Reserve	18/05/2018 10:47	56	54	58	68	Dominant road traffic noise. Occasional birdsong.	Eastern Freeway
P15	Jack O'Toole Reserve	22/05/2018 15:08	61	59	62	72	Dominant road traffic noise and birds. Passing cars in carpark.	Eastern Freeway
P16	Hays Paddock	22/05/2018 14:21	60	58	62	66	Dominant road traffic noise and birds. Light, steady wind.	Eastern Freeway
P17	Musca Street Reserve	22/05/2018 13:27	58	56	60	68	Dominant road traffic noise and birds. Some wind through the trees.	Eastern Freeway
P18	Koonung Creek Reserve (west end)	22/05/2018 12:39	59	57	61	71	Dominant road traffic noise, birds.	Eastern Freeway
P19	Koonung Creek Reserve near playground	18/05/2018 12:36	57	55	58	75	Dominant road traffic noise, birds, and wind through the trees.	Eastern Freeway
P20	Winfield Road Reserve	18/05/2018 11:48	55	53	56	75	Dominant road traffic noise, birds, and wind through the trees.	Eastern Freeway
P21	Greythorn Bowling Club	22/05/2018 11:51	61	59	62	69	Dominant road traffic noise, birds, and wind through the trees.	Eastern Freeway
P22	Simpson Barracks between Blamey Road and Simpson Ave	6/06/2018 9:15	54	52	56	69	Dominant road traffic noise, birds. Occasional passing cars on main road.	Greensborough Road

Attended short-term measurements								
Site ID	Name of open space	Start time of measurement	Measured Noise Level, dBA				Observation of noise sources	
			L_{Aeq}	L_{A90}	L_{A10}	L_{max}	Local environment	Traffic noise source (road)
P23	Simpson Barracks on grass area cnr Blamey Road and Stevens Road	6/06/2018 7:37	58	56	60	67	Ambient road traffic noise. Bird noise and passing aircraft. Site is south of the base entrance, so experiences stationary and slow passing car noise at peak hour.	Greensborough Road
P24	Simpson Barracks on sports field off Mackay Road	6/06/2018 8:20	52	49	54	67	Ambient road traffic noise, birds. Occasional passing aircraft and cars on main road.	Greensborough Road

Road traffic noise measurements

Measurements were not conducted at every dwelling near the existing freeways and highways. Rather, the selection of noise monitoring sites was designed to provide a representation of sensitive receivers within the study area that offer a range of topographical influences (eg houses positioned higher than the road, adjacent and below) and conditions.

The VicRoads document *Traffic Noise Measurement Requirements for Acoustic Consultants,* September 2011 provides the following guidance in regard to the selection of noise monitoring locations:

- Noise monitoring shall be conducted in locations that are typical of areas where the predominant source of noise is the freeway in question (avoid locations near intersections with busy arterial roads etcetera).
- Typically, noise measurements at each location lasted for seven days to ensure sufficient data was captured.
- Noise monitoring was generally undertaken with the microphone either:
    - One metre from the façade of a noise sensitive building, approximately at the centre of the ground or first floor window at the most exposed façade; or
    - At least 3.5 metres from all reflecting surfaces (in the free-field) and at the height representative of the centre of the ground or first floor window.

Reflecting surfaces include building walls, sheds, solid fences etcetera. Positioning the microphone at least 3.5 metres away from reflecting surfaces removes the influence of reflected noise to a point where it does not significantly affect (increase) the measured noise levels.

It is commonly accepted that a microphone placed one metre in front of a reflective building façade will provide a noise level approximately 2.5 dBA louder than a microphone placed in the free field. As a result, throughout the remainder of this report the noise levels presented will be façade corrected, where a 2.5 dBA correction (increase) has been applied to all free field measurements.

Weather

As part of the noise monitoring exercise, the weather was recorded through the Bureau of Meteorology to ensure negligible wind or rain influence was evident for each noise measurement. These locations have been discussed previously in this appendix.

Wind speeds (hourly averaged) greater than 3 m/s, or rainfall greater than 0.3 mm/h were both defined as 'adverse weather' conditions for the purposes of this assessment.

Road noise monitoring results

The $L_{A10(18h)}$ noise level is the descriptor used to assess road traffic noise in Victoria for residential dwellings. The L_{A10} noise level is representative of the level of noise exceeded for 10% of the measurement any period (usually one hour). The $L_{A10(18h)}$ within this report is an arithmetic average of the $L_{A10(1h)}$ noise levels for each hour over the 18 consecutive hours between 6 am and midnight on a weekday.

Table 6-6 presents the summary of the baseline unattended noise measurements.

Review of Measurement Data (to determine acceptability)

The noise data for each measurement was filtered against the following adverse measurement conditions:

- Wind for the hourly measurement that exceeded 3 m/s
- Rain for the hourly measurement that exceeded 0.3 mm.

In addition, a visual review of the measured noise levels was undertaken, and data was excluded where it was apparent that it was influenced by local events. This part of the analysis does not correspond to a published procedure, but rather based on professional judgement.

From the noise measurement data available for traffic noise assessment, the analysis was based on:

- The time period, 6 am to 12 midnight (on the same day), when calculating the $L_{A10(18hour)}$ noise metric and 10 pm to 6 am when calculating the $L_{Aeq(8hour)}$ metric
- Weekdays only.

Any measurement site for which two or more useable days remained was reviewed to ensure data was road dominated and thus used in the analysis.