Appendix C

Construction ground borne noise and vibration

Appendix C.1 Modelling inputs and parameters

Equipment such as TBM, Roadheaders and rock breakers impart mechanical energy into the ground, and this energy propagates in the form of geometrical spreading and attenuation from soil (material damping).

The following formula provides the industry best practice method of calculating vibration levels at the sensitive receiver locations:

$$PPV = \frac{K}{d} e^{(-\alpha d)}$$

Where *PPV* is the peak particle velocity (mm/s)
d is the distance between TBM tip and receiver
K and α are machine and site specific constants

Predominantly, two parameters are required for the assessment:

- Source levels – The exact model and the associated source vibration levels of the equipment were not available for this assessment. Source vibration levels were therefore estimated based available databases of measured vibration levels of similar equipment – An example database of data from Transport Research Laboratory (TRL Report 429) produced by Hiller and Crabb (2000) is shown in Figure C-0-1.
- Soil attenuation – Exact wave velocities have not been measured on site to determine possible soil attenuations. In this regard, preliminary data provided by Sydney Metro, along with soil profiles have been used to estimate soil attenuation.

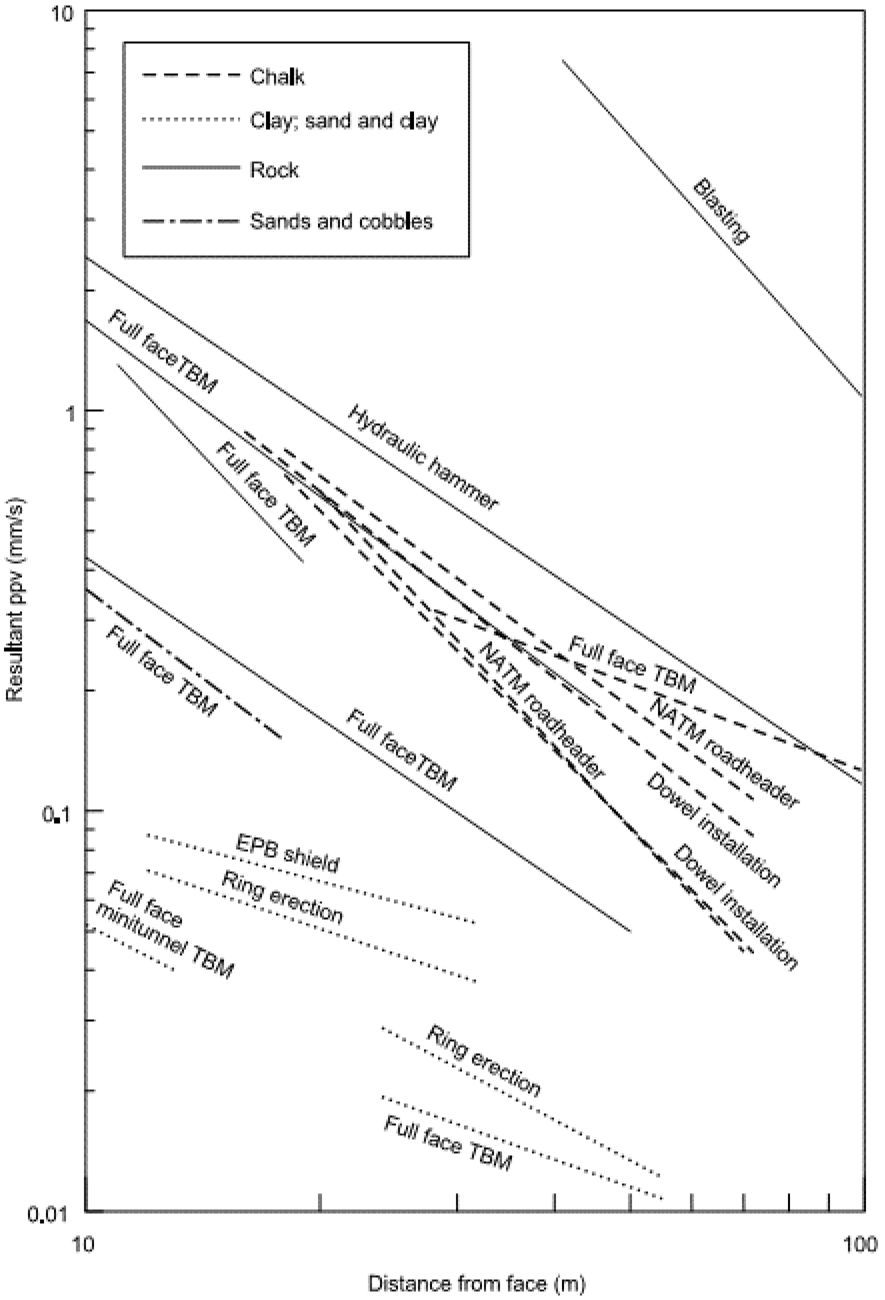


Figure C-0-1 Vibration propagation from various tunnelling works - Hiller and Crabb (2000)

Appendix C.2 Predicted construction ground-borne noise maps

Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

TBM Ground-Borne Noise from tunneling

Appendix C-2a

Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

TBM Ground-Borne Noise from tunneling

Appendix C-2b

Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

TBM Ground-Borne Noise from tunneling

Appendix C-2c

Appendix D

Operational rail airborne noise

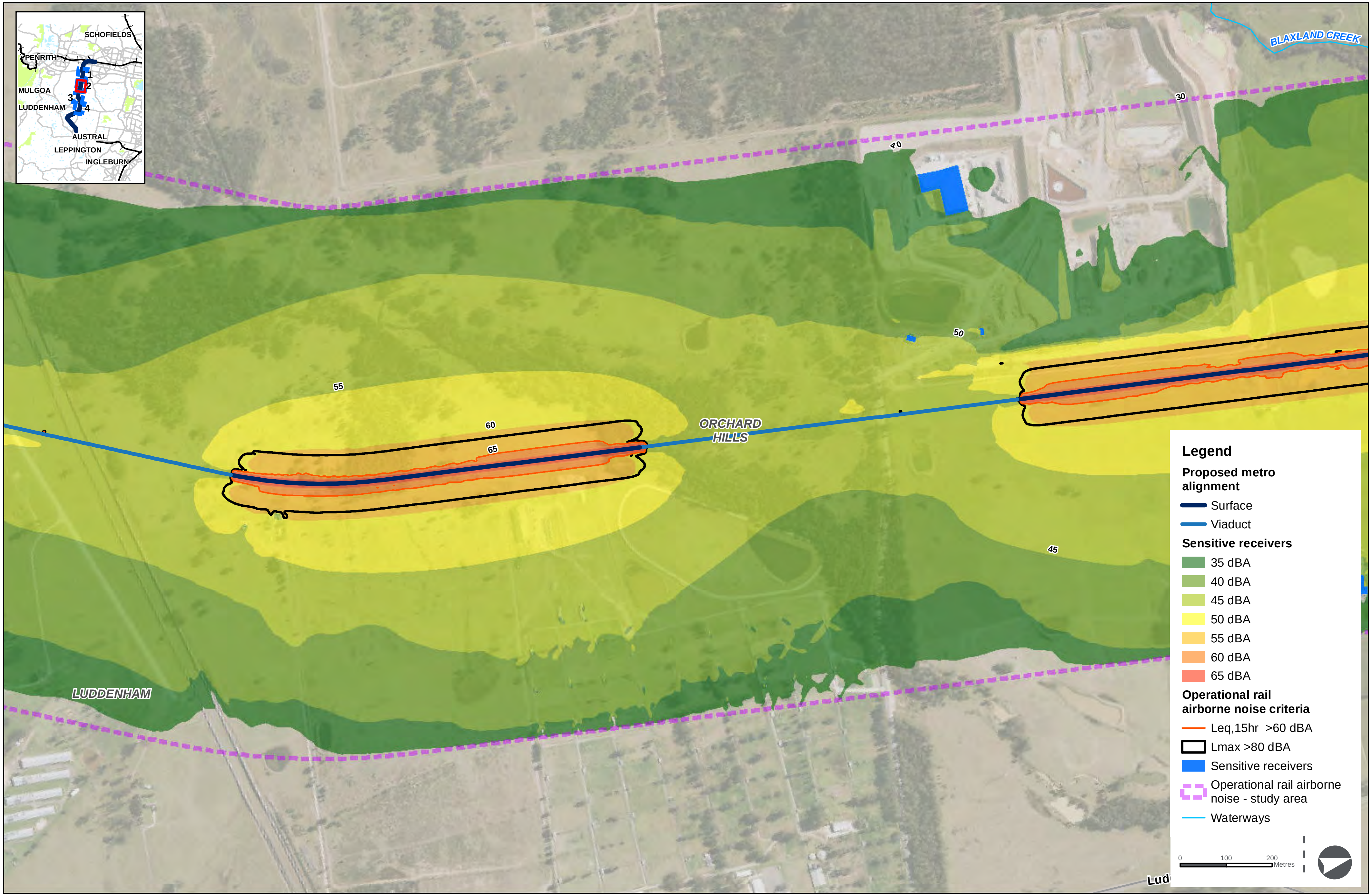
Appendix D.1 Predicted operational rail airborne noise maps

Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Opening Day Operational Rail Noise Impact (dBA)

Appendix D-1a



Sydney Metro – Western Sydney Airport

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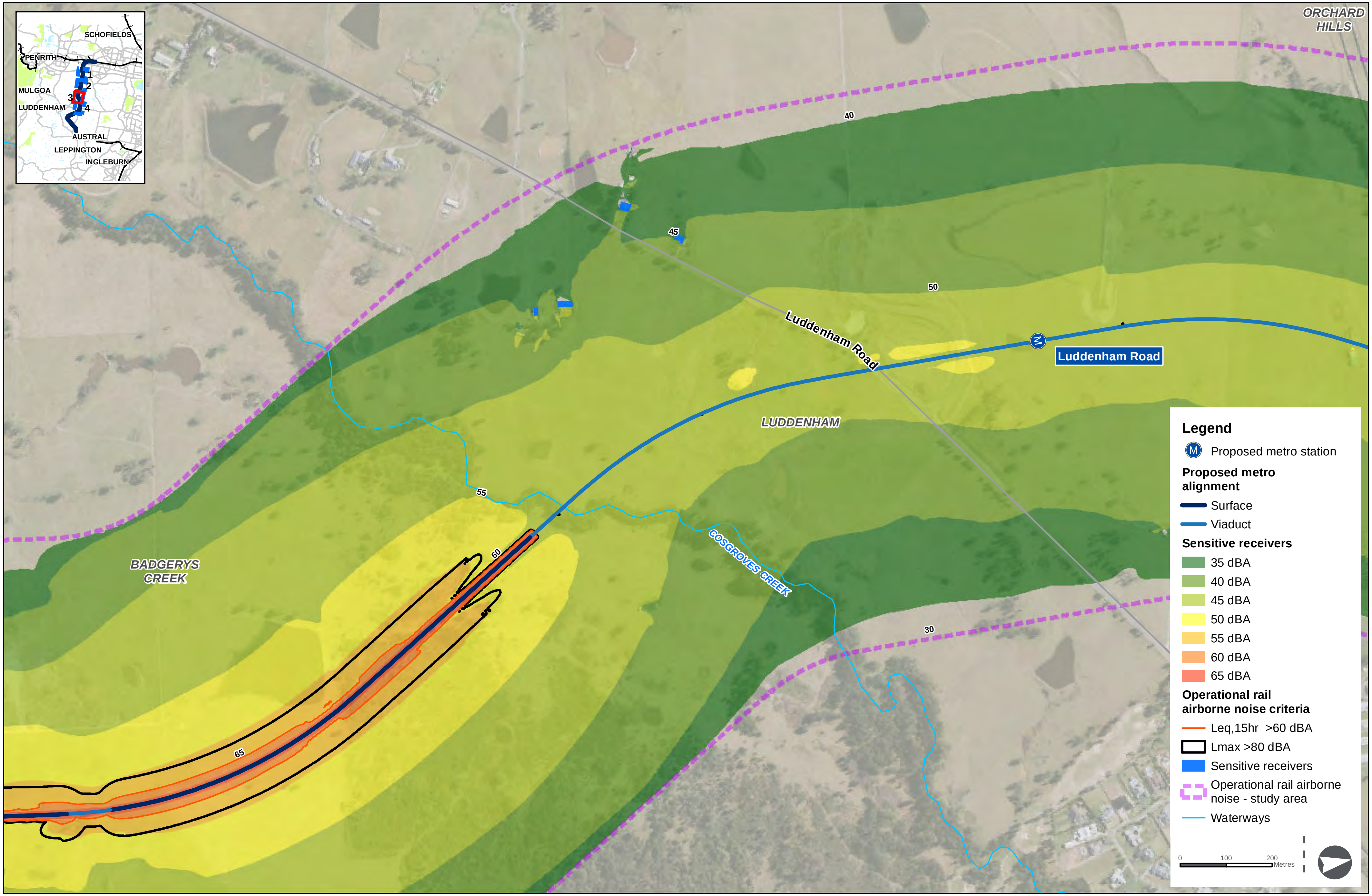
Opening Day Operational Rail Noise Impact (dBA)

Appendix D-1a



Sydney Metro – Western Sydney Airport

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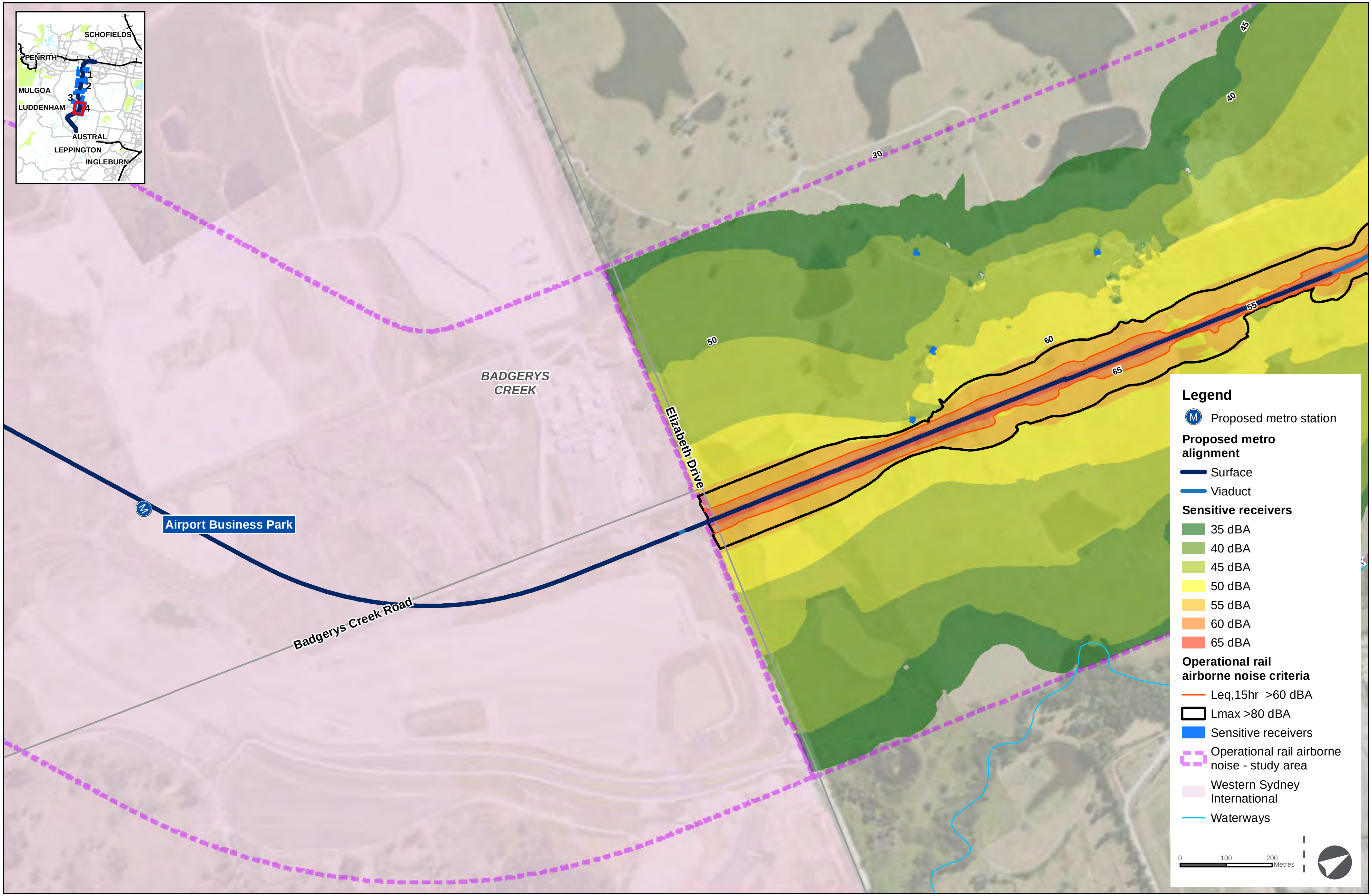
Opening Day Operational Rail Noise Impact (dBA)

Appendix D-1a



Sydney Metro – Western Sydney Airport

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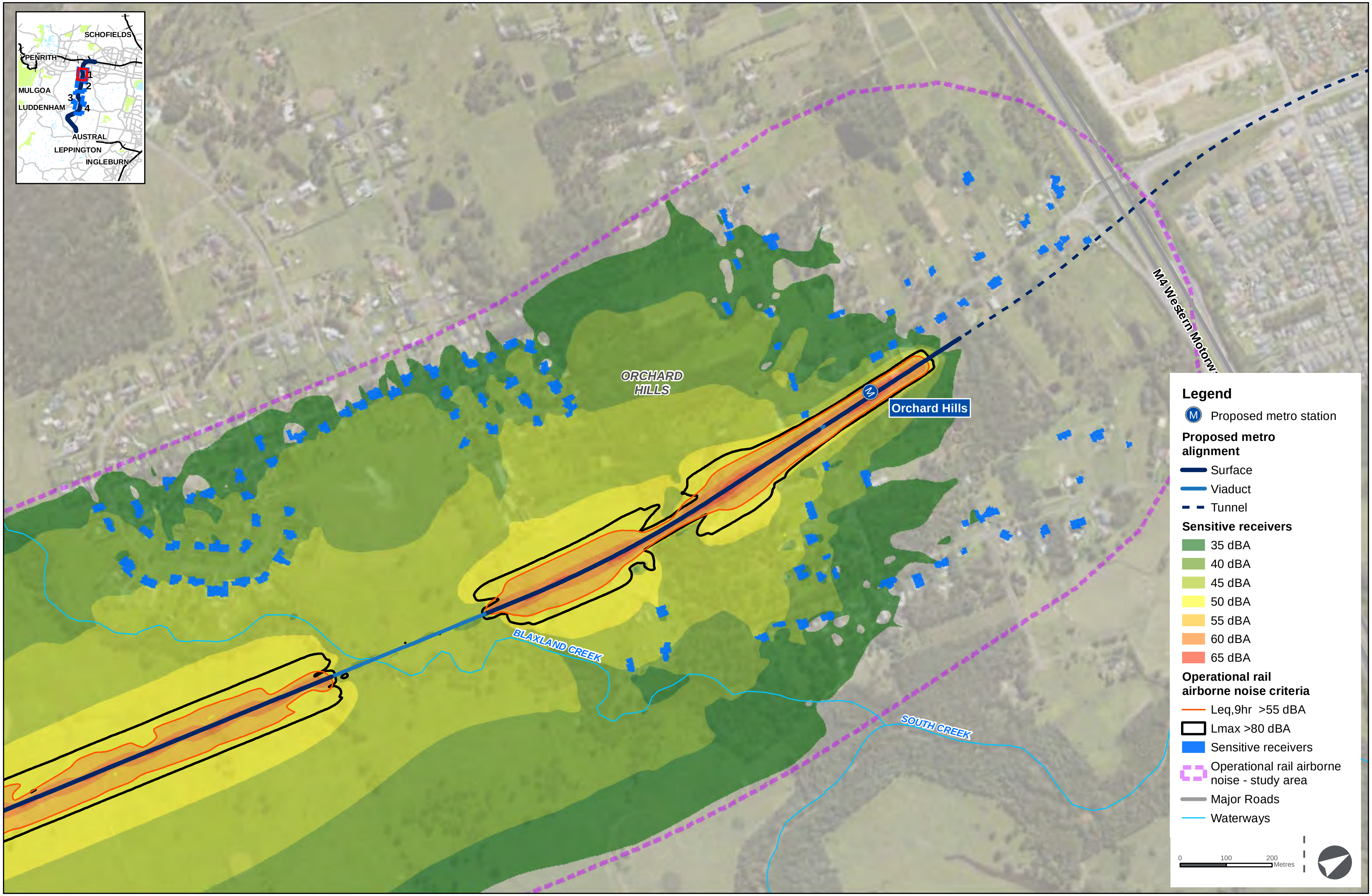
Opening Day Operational Rail Noise Impact (dBA)

Appendix D-1a



Sydney Metro – Western Sydney Airport

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Opening Night Operational Rail Noise Impact (dBA)

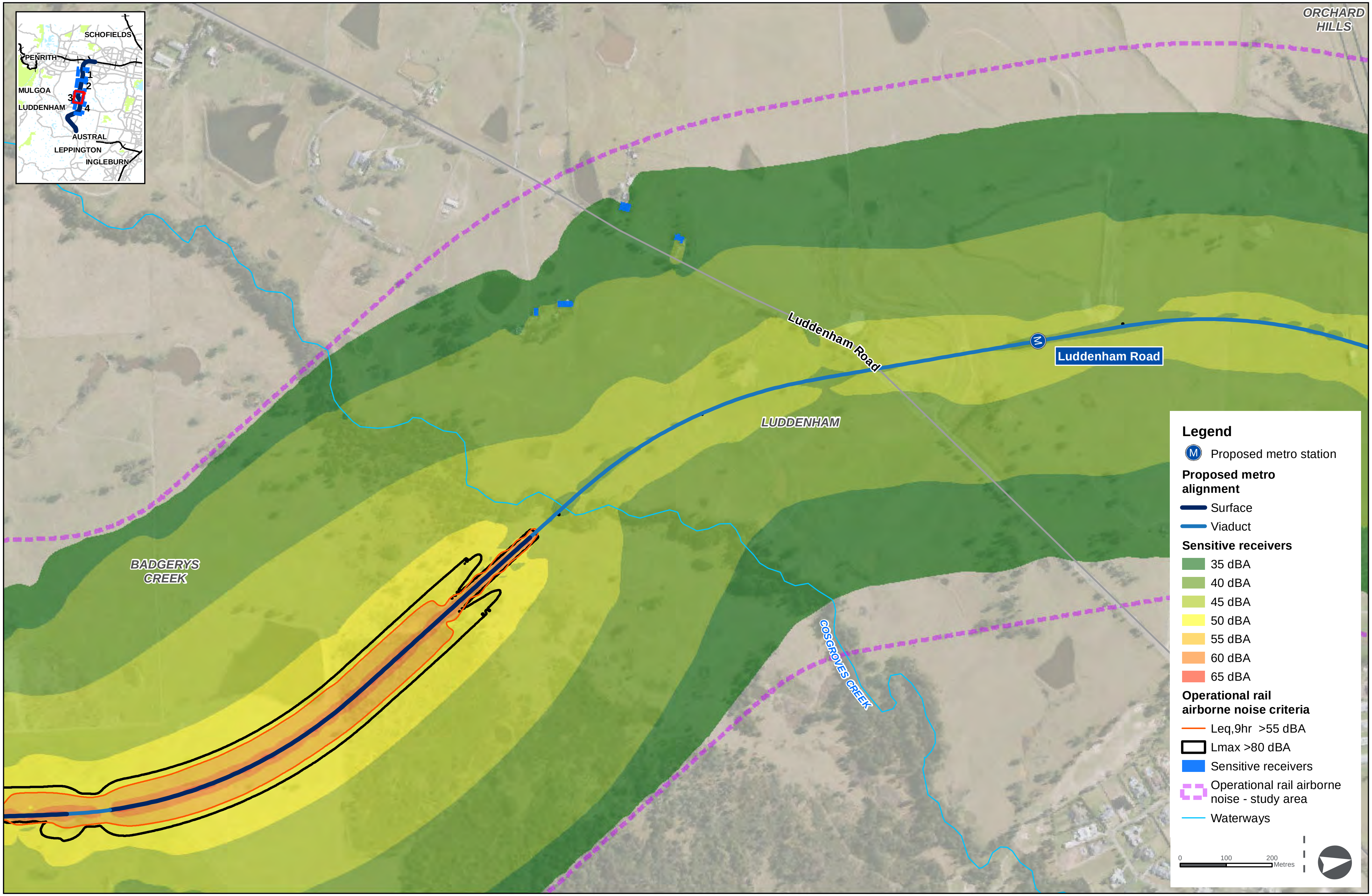
Appendix D-1b

Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Opening Night Operational Rail Noise Impact (dBA)

Appendix D-1b

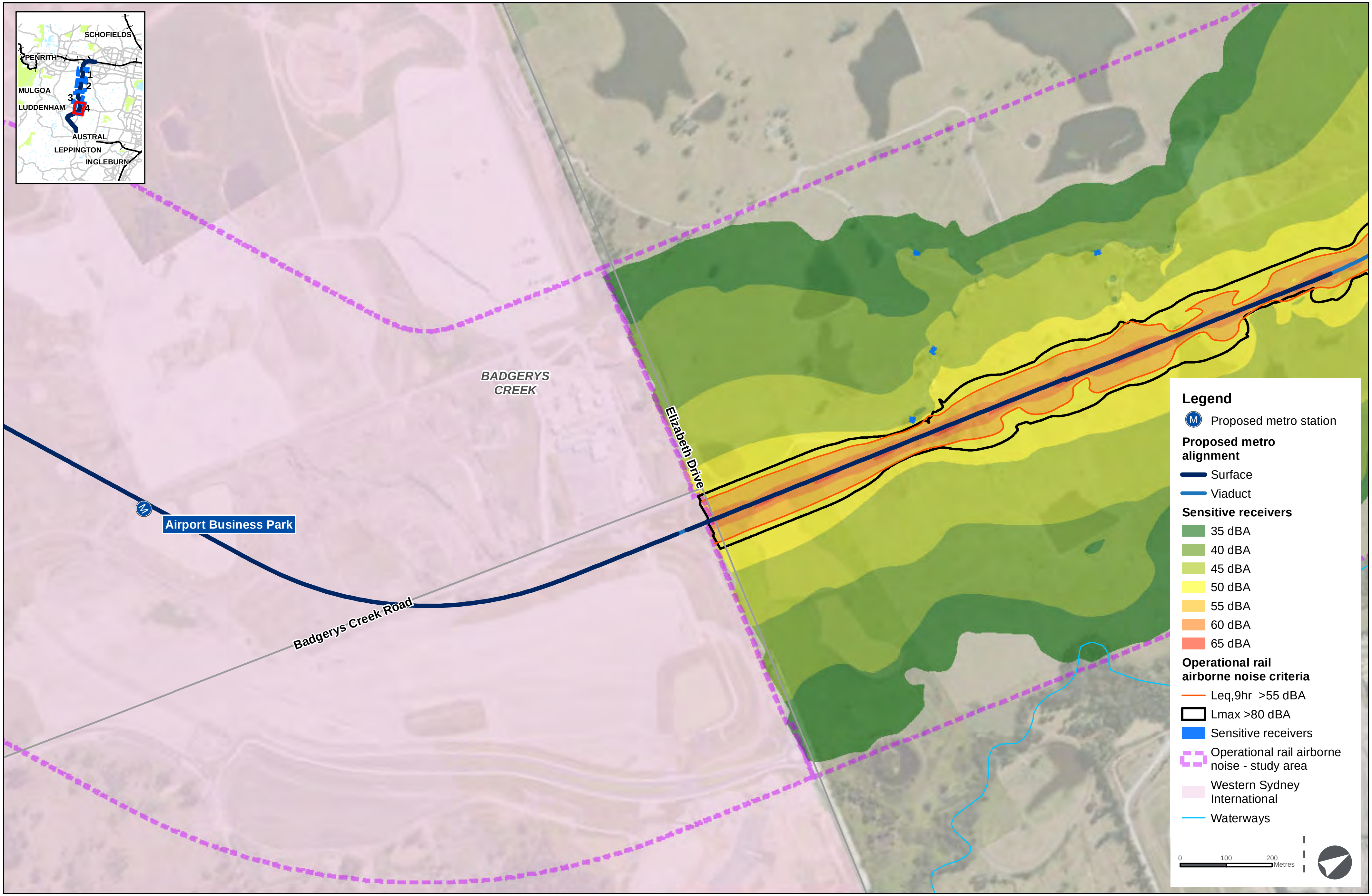


Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Opening Night Operational Rail Noise Impact (dBA)

Appendix D-1b



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Opening Night Operational Rail Noise Impact (dBA)

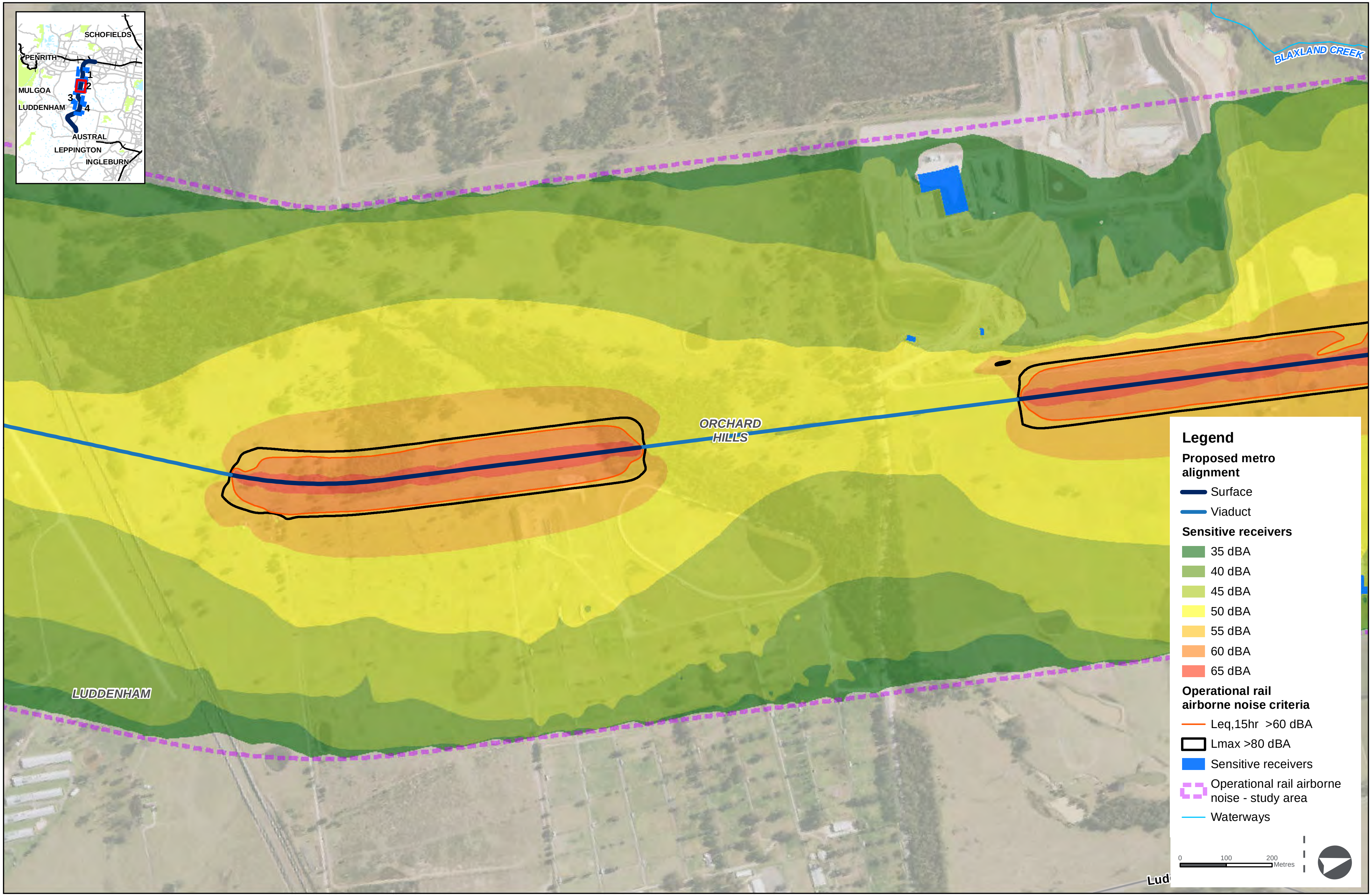
Appendix D-1b

Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Ultimate Day Operational Rail Noise Impact (dBA)

Appendix D-1c



Sydney Metro – Western Sydney Airport

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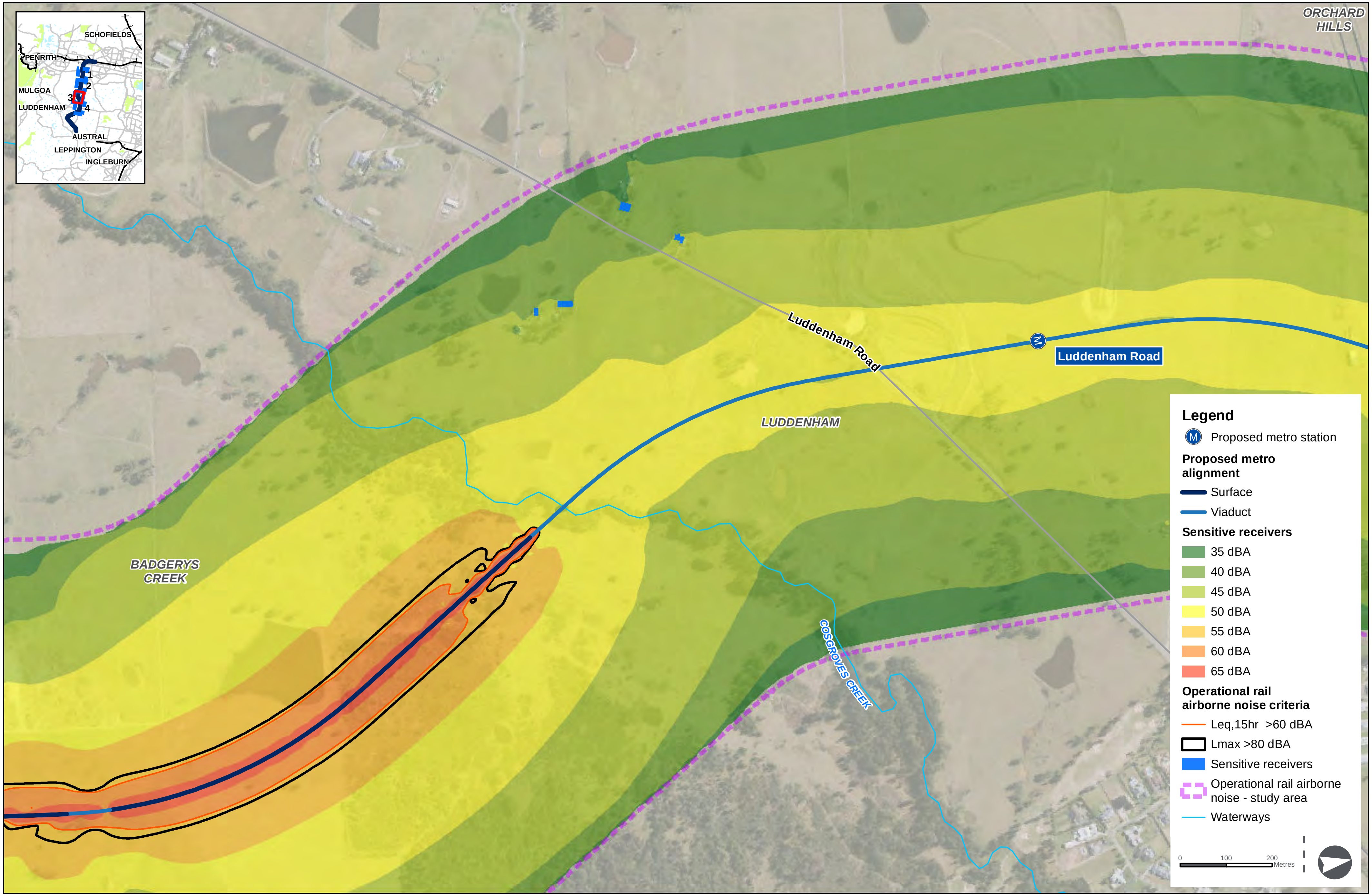
Ultimate Day Operational Rail Noise Impact (dBA)

Appendix D-1c



Sydney Metro – Western Sydney Airport

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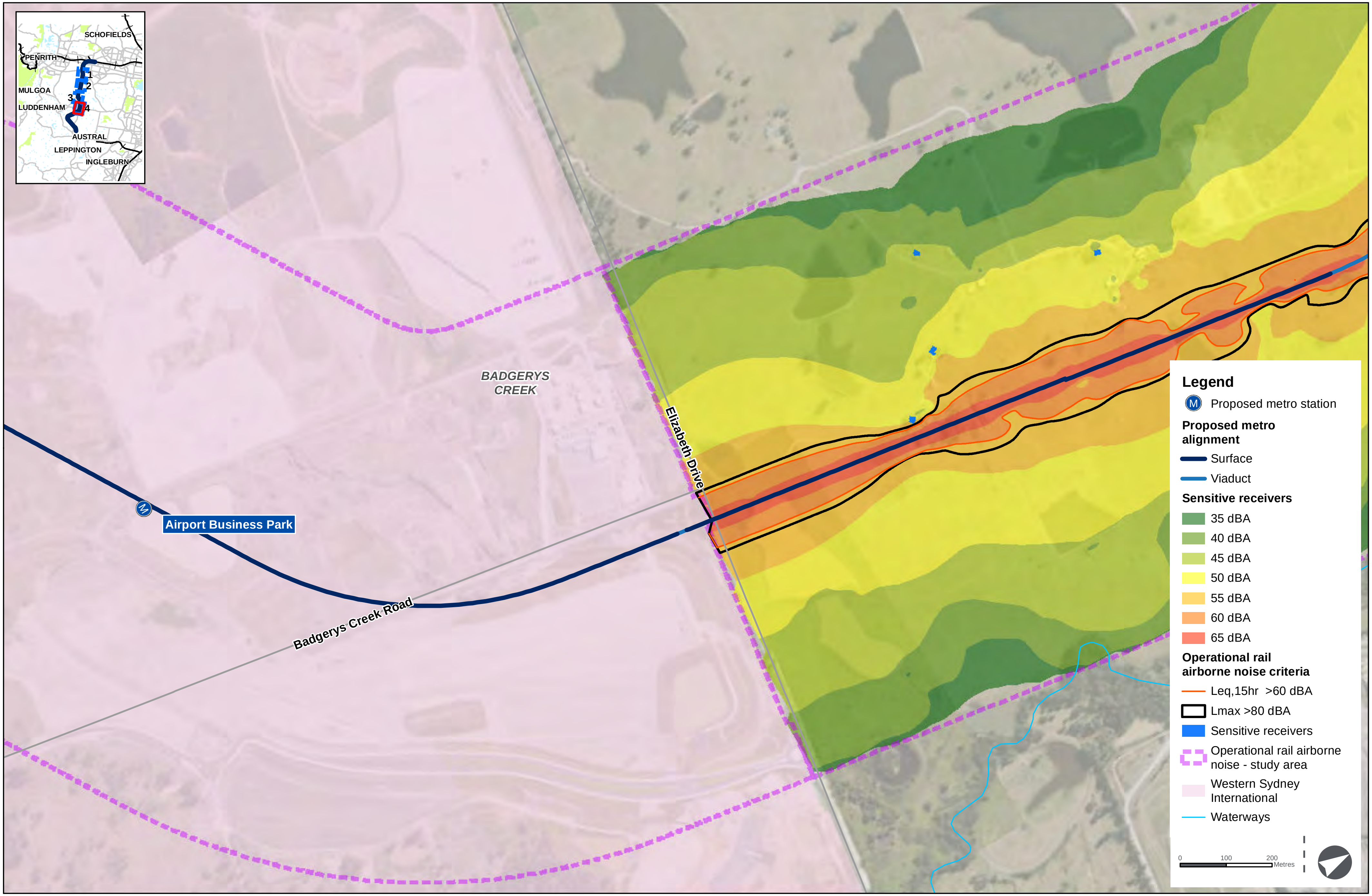
Ultimate Day Operational Rail Noise Impact (dBA)

Appendix D-1c



Sydney Metro – Western Sydney Airport

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Ultimate Day Operational Rail Noise Impact (dBA)

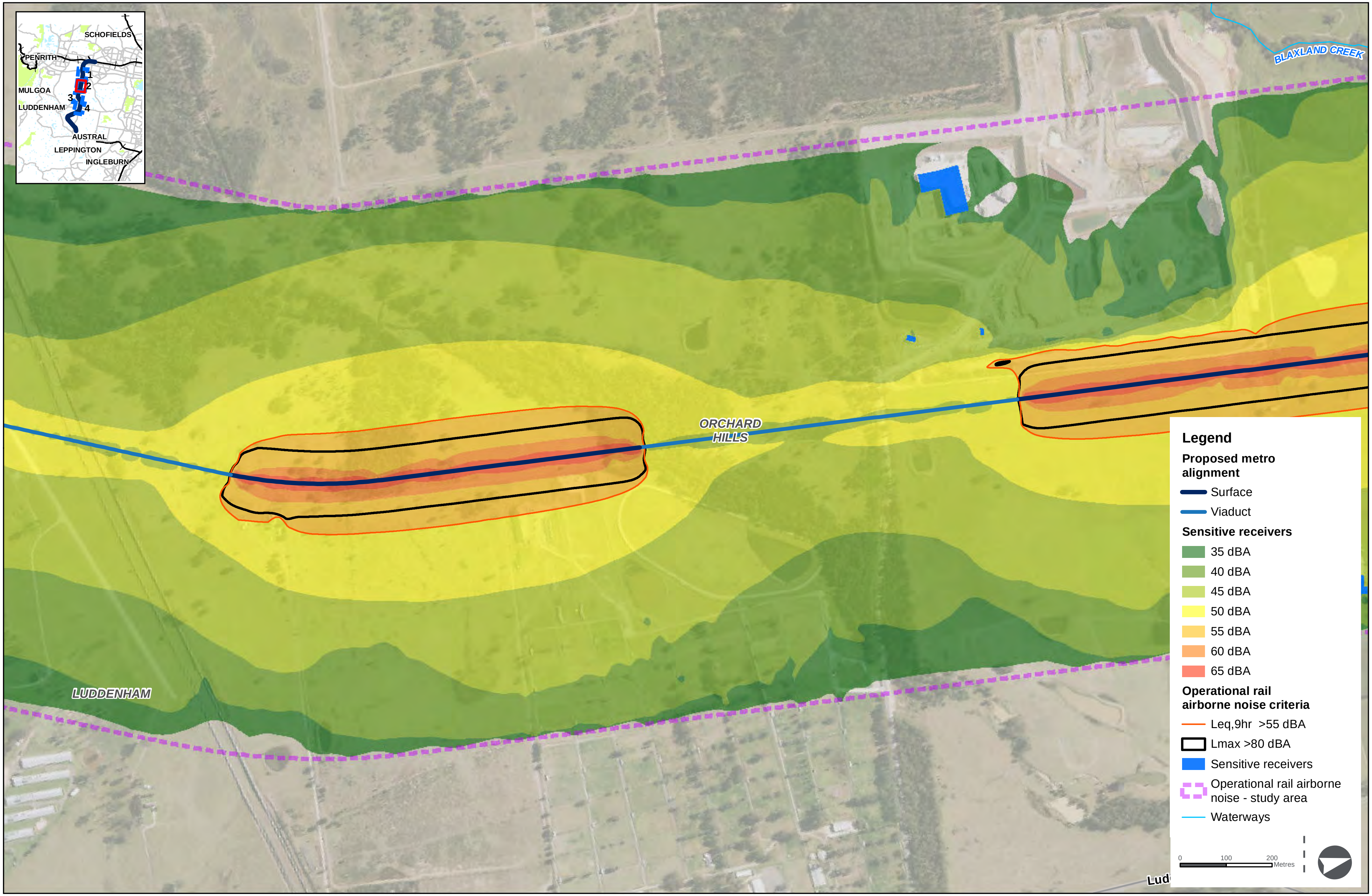
Appendix D-1c

Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Ultimate Night Operational Rail Noise Impact (dBA)

Appendix D-1d

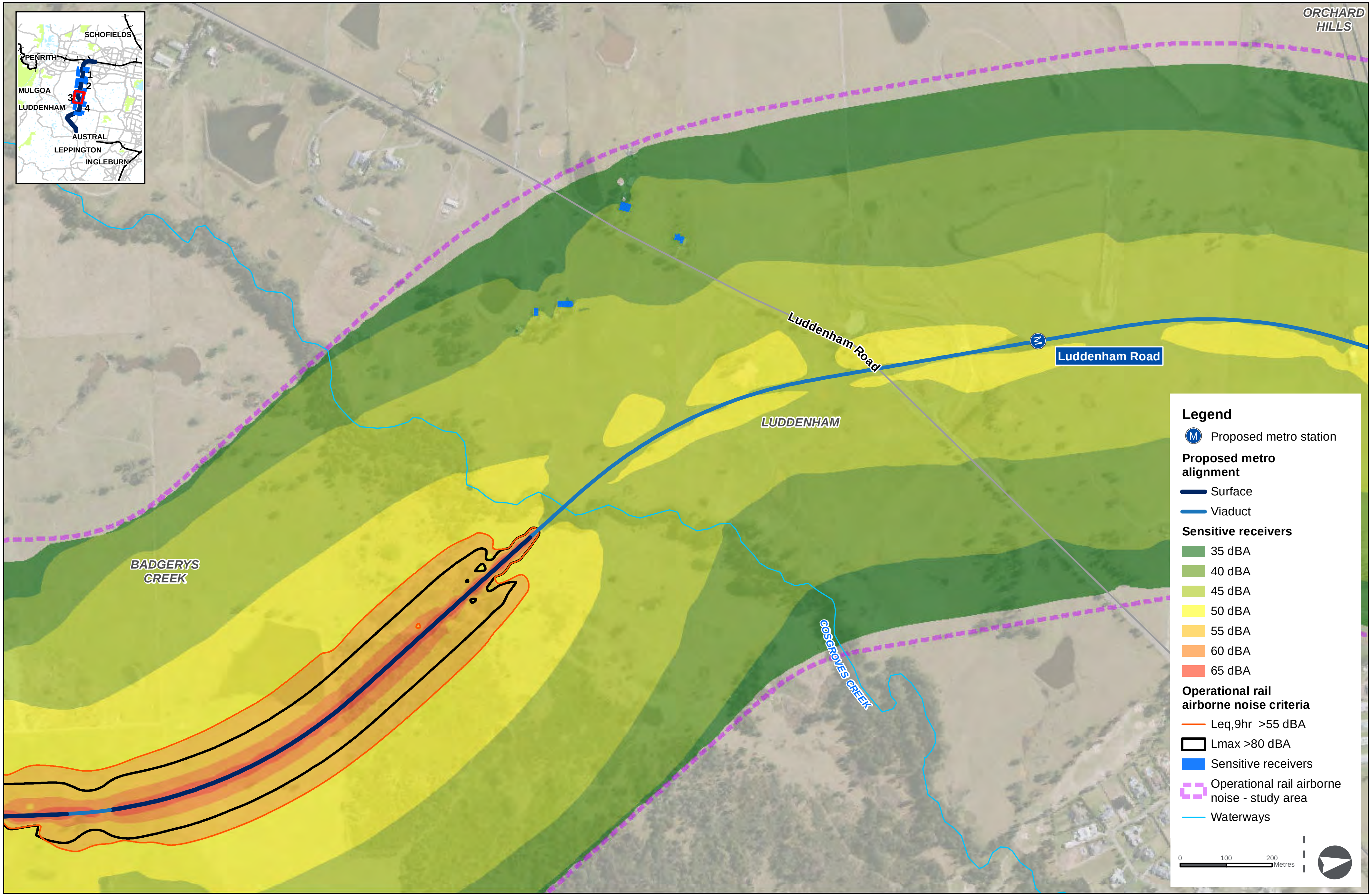


Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Ultimate Night Operational Rail Noise Impact (dBA)

Appendix D-1d

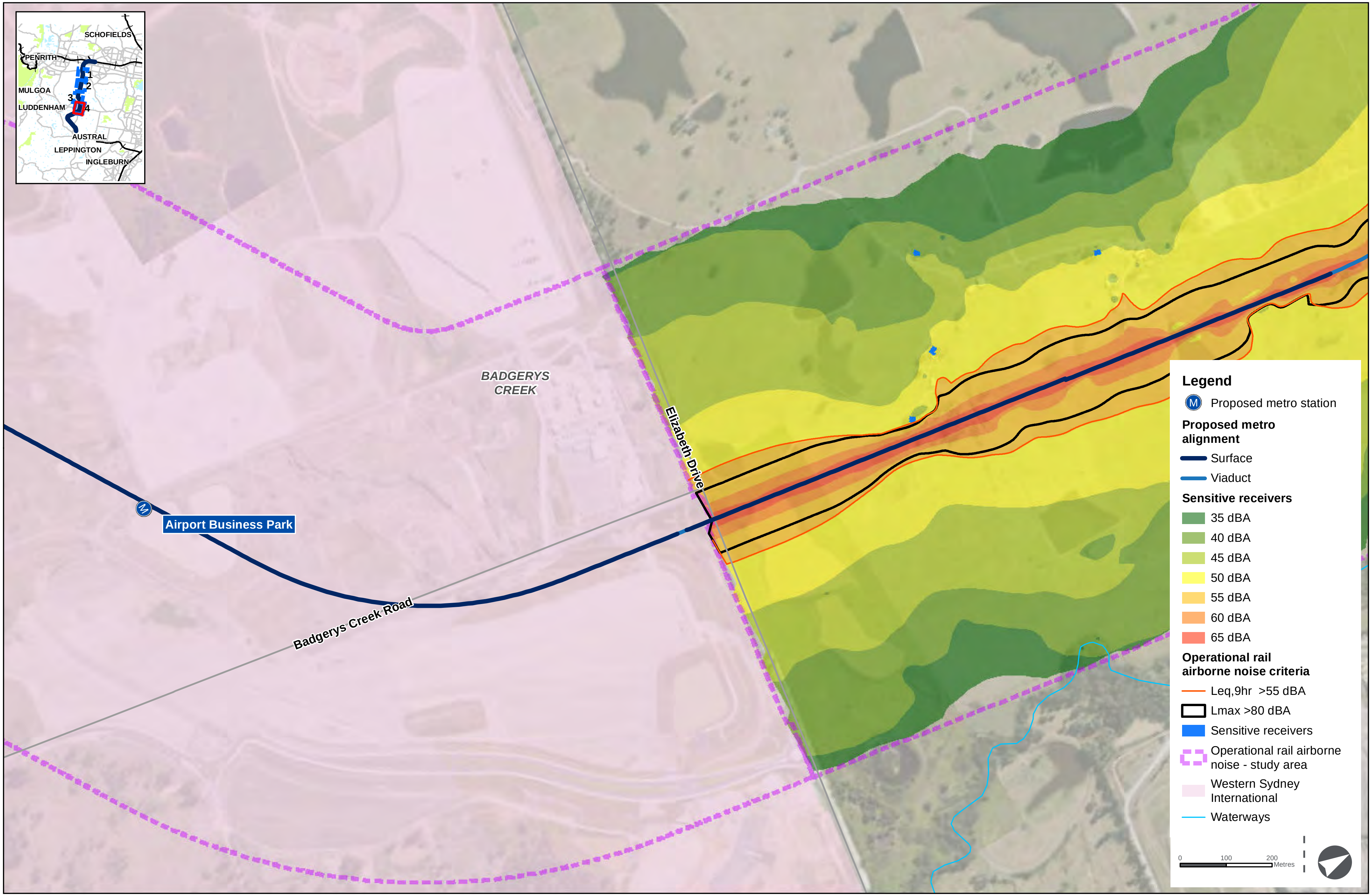


Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Ultimate Night Operational Rail Noise Impact (dBA)

Appendix D-1d



Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Ultimate Night Operational Rail Noise Impact (dBA)

Appendix D-1d

Appendix D.2 Predicted operational rail airborne noise levels

Lot	Plan	NCA	Reciever Type	Criteria			Predicted noise levels					
				Leq, 15hr dBA	Leq, 9hr dBA	Lmax dBA	Opening day (Leq, 15hr dBA)	Opening night (Leq, 9hr dBA)	Opening Max (Lmax dBA)	Design day (Leq, 15hr dBA)	Design night (Leq, 9hr dBA)	Design Max (Lmax dBA)
25	DP831647	NCA08	RES	60	55	80	42	40	62	46	44	62
74	DP29388	NCA08	RES	60	55	80	38	36	60	42	40	61
78	DP29388	NCA08	RES	60	55	80	45	43	65	49	47	66
52	DP846098	NCA08	RES	60	55	80	47	44	66	51	48	67
46	DP846098	NCA08	RES	60	55	80	50	48	71	54	52	72
47	DP846098	NCA08	RES	60	55	80	53	50	71	56	54	72
44	DP846098	NCA08	RES	60	55	80	48	46	67	52	50	67
75	DP29388	NCA08	RES	60	55	80	40	38	63	44	42	64
4	DP588587	NCA08	RES	60	55	80	50	48	69	54	52	70
51	DP29388	NCA08	RES	60	55	80	43	41	64	47	45	65
75	DP29388	NCA08	RES	60	55	80	40	38	61	44	42	62
78	DP846098	NCA08	RES	60	55	80	47	45	66	51	49	67
9	DP831647	NCA08	RES	60	55	80	43	41	62	47	45	63
43	DP846098	NCA08	RES	60	55	80	47	45	65	51	49	66
74	DP846098	NCA08	RES	60	55	80	49	47	66	53	51	67
85	DP29388	NCA08	RES	60	55	80	50	47	72	53	51	73
45	DP846098	NCA08	RES	60	55	80	50	48	69	54	52	70
86	DP29388	NCA08	RES	60	55	80	47	45	67	51	49	67
86	DP29388	NCA08	RES	60	55	80	44	42	67	48	46	67
77	DP29388	NCA08	RES	60	55	80	45	42	65	48	46	66
86	DP29388	NCA08	RES	60	55	80	43	41	65	47	45	65
28	DP831647	NCA08	RES	60	55	80	45	43	63	49	47	63
83	DP29388	NCA08	RES	60	55	80	48	46	71	52	50	72
12	DP831647	NCA08	RES	60	55	80	45	43	64	49	46	65
84	DP29388	NCA08	RES	60	55	80	51	49	73	55	53	74
50	DP846098	NCA08	RES	60	55	80	51	49	69	55	53	70
54	DP846098	NCA08	RES	60	55	80	44	42	64	48	46	65
75	DP846098	NCA08	RES	60	55	80	49	47	67	53	51	68
76	DP846098	NCA08	RES	60	55	80	46	44	65	50	48	65

Lot	Plan	NCA	Reciever Type	Criteria			Predicted noise levels					
				Leq, 15hr dBA	Leq, 9hr dBA	Lmax dBA	Opening day (Leq, 15hr dBA)	Opening night (Leq, 9hr dBA)	Opening Max (Lmax dBA)	Design day (Leq, 15hr dBA)	Design night (Leq, 9hr dBA)	Design Max (Lmax dBA)
73	DP846098	NCA08	RES	60	55	80	45	42	64	48	46	65
51	DP846098	NCA08	RES	60	55	80	50	48	68	54	52	69
2	DP578819	NCA08	RES	60	55	80	49	47	67	53	51	68
49	DP846098	NCA08	RES	60	55	80	51	49	70	55	53	71
30	DP831647	NCA08	RES	60	55	80	47	45	64	51	49	65
8	DP831647	NCA08	RES	60	55	80	46	44	65	50	48	65
81	DP29388	NCA08	RES	60	55	80	53	50	73	56	54	74
26	DP831647	NCA08	RES	60	55	80	44	42	63	48	46	64
101	DP841269	NCA08	RES	60	55	80	52	50	73	56	54	74
32	DP831647	NCA08	RES	60	55	80	43	41	62	47	45	63
70	DP852093	NCA08	RES	60	55	80	43	41	65	47	45	65
90	DP29388	NCA08	RES	60	55	80	46	43	65	49	47	66
31	DP831647	NCA08	RES	60	55	80	45	43	65	49	47	66
48	DP846098	NCA08	RES	60	55	80	51	49	71	55	53	72
72	DP846098	NCA08	RES	60	55	80	42	40	61	46	44	62
77	DP846098	NCA08	RES	60	55	80	48	46	67	52	50	68
55	DP846098	NCA08	RES	60	55	80	43	40	61	46	44	63
86	DP29388	NCA08	RES	60	55	80	43	41	64	47	45	65
86	DP29388	NCA08	RES	60	55	80	49	47	71	53	51	71
73	DP852093	NCA08	RES	60	55	80	49	47	68	53	51	69
62	DP852093	NCA08	RES	60	55	80	45	42	65	48	46	66
69	DP852093	NCA08	RES	60	55	80	44	42	66	48	46	67
65	DP852093	NCA08	RES	60	55	80	49	47	67	53	51	69
11	DP831647	NCA08	RES	60	55	80	45	43	63	49	47	64
74	DP852093	NCA08	RES	60	55	80	45	43	66	49	47	66
61	DP852093	NCA08	RES	60	55	80	43	41	63	47	45	64
75	DP852093	NCA08	RES	60	55	80	47	45	69	51	49	69
66	DP852093	NCA08	RES	60	55	80	46	44	66	50	47	67
13	DP831647	NCA08	RES	60	55	80	45	43	64	49	47	65

Lot	Plan	NCA	Reciever Type	Criteria			Predicted noise levels					
				Leq, 15hr dBA	Leq, 9hr dBA	Lmax dBA	Opening day (Leq, 15hr dBA)	Opening night (Leq, 9hr dBA)	Opening Max (Lmax dBA)	Design day (Leq, 15hr dBA)	Design night (Leq, 9hr dBA)	Design Max (Lmax dBA)
67	DP852093	NCA08	RES	60	55	80	45	43	64	49	47	65
72	DP852093	NCA08	RES	60	55	80	45	43	66	49	47	67
76	DP852093	NCA08	RES	60	55	80	50	48	68	54	52	69
5	DP1013984	NCA08	RES	60	55	80	37	35	58	41	39	59
4	DP1013984	NCA08	RES	60	55	80	39	36	60	42	40	61
59	DP29388	NCA08	RES	60	55	80	32	30	51	36	34	52
59	DP29388	NCA08	RES	60	55	80	27	24	47	30	28	48
11	DP237628	NCA08	RES	60	55	80	37	35	60	41	39	61
11	DP237628	NCA08	RES	60	55	80	37	35	58	41	39	59
7	DP1013984	NCA08	RES	60	55	80	31	28	50	34	32	51
10	DP1195473	NCA08	RES	60	55	80	31	28	52	34	32	53
46	DP29388	NCA08	RES	60	55	80	39	37	58	43	41	59
48	DP29388	NCA08	RES	60	55	80	44	42	63	48	46	64
44	DP29388	NCA08	RES	60	55	80	34	32	52	38	36	53
45	DP29388	NCA08	RES	60	55	80	37	35	55	41	39	56
12	DP237628	NCA08	RES	60	55	80	26	24	46	30	27	47
12	DP237628	NCA08	RES	60	55	80	27	25	50	31	29	50
49	DP29388	NCA08	RES	60	55	80	46	44	66	50	48	67
56	DP29388	NCA08	RES	60	55	80	33	30	54	37	34	55
14	DP237628	NCA08	RES	60	55	80	21	19	44	25	23	45
1	DP120577	NCA08	RES	60	55	80	30	28	50	34	31	50
52	DP29388	NCA08	RES	60	55	80	41	38	63	44	42	63
55	DP29388	NCA08	RES	60	55	80	33	31	52	37	35	53
1	DP120577	NCA08	RES	60	55	80	29	27	51	33	31	52
1	DP576160	NCA08	RES	60	55	80	32	30	51	36	34	52
104	DP128821	NCA08	RES	60	55	80	34	32	55	38	36	56
6	DP1013984	NCA08	RES	60	55	80	36	33	57	39	37	58
1	DP576160	NCA08	RES	60	55	80	26	24	48	30	28	48
58	DP29388	NCA08	RES	60	55	80	29	27	48	33	31	49

Lot	Plan	NCA	Reciever Type	Criteria			Predicted noise levels					
				Leq, 15hr dBA	Leq, 9hr dBA	Lmax dBA	Opening day (Leq, 15hr dBA)	Opening night (Leq, 9hr dBA)	Opening Max (Lmax dBA)	Design day (Leq, 15hr dBA)	Design night (Leq, 9hr dBA)	Design Max (Lmax dBA)
1	DP120624	NCA08	RES	60	55	80	26	24	46	30	28	47
54	DP29388	NCA08	RES	60	55	80	39	37	59	43	41	60
13	DP237628	NCA08	RES	60	55	80	26	24	47	30	28	48
47	DP29388	NCA08	RES	60	55	80	41	39	61	45	42	62
29	DP237628	NCA08	RES	60	55	80	36	34	55	40	38	56
962	DP712220	NCA08	RES	60	55	80	37	35	57	41	39	58
631	DP634838	NCA08	RES	60	55	80	40	37	60	43	41	61
952	DP605491	NCA08	RES	60	55	80	35	33	57	39	37	57
80	DP29388	NCA08	RES	60	55	80	48	46	69	52	50	70
97	DP29388	NCA08	RES	60	55	80	46	44	66	50	48	67
1	DP1013984	NCA08	RES	60	55	80	48	45	67	51	49	68
79	DP29388	NCA08	RES	60	55	80	42	40	66	46	44	67
64	DP852093	NCA08	RES	60	55	80	47	45	66	51	49	67
10	DP831647	NCA08	RES	60	55	80	45	43	64	49	47	65
29	DP831647	NCA08	RES	60	55	80	43	40	60	46	44	61
68	DP852093	NCA08	RES	60	55	80	43	41	62	47	45	63
3	DP1013984	NCA08	RES	60	55	80	39	37	61	43	41	61
71	DP852093	NCA08	RES	60	55	80	46	44	66	50	48	67
2	DP793728	NCA08	RES	60	55	80	51	49	71	55	53	72
10	DP773789	NCA08	RES	60	55	80	52	50	72	56	54	73
7	DP831647	NCA08	RES	60	55	80	45	43	64	49	47	65
63	DP852093	NCA08	RES	60	55	80	46	44	64	50	48	65
42	DP738126	NCA09	RES	60	55	80	46	43	65	49	47	66
101	DP848215	NCA10	RES	60	55	80	51	49	70	55	53	71
1	DP221182	NCA10	RES	60	55	80	40	38	59	44	42	60
1	DP221182	NCA10	RES	60	55	80	43	41	62	47	45	63
63	DP1087838	NCA10	RES	60	55	80	45	43	64	49	47	65
4	DP258439	NCA10	RES	60	55	80	41	39	60	45	43	61
63	DP1087838	NCA10	RES	60	55	80	51	49	74	55	53	74

Lot	Plan	NCA	Reciever Type	Criteria			Predicted noise levels					
				Leq, 15hr dBA	Leq, 9hr dBA	Lmax dBA	Opening day (Leq, 15hr dBA)	Opening night (Leq, 9hr dBA)	Opening Max (Lmax dBA)	Design day (Leq, 15hr dBA)	Design night (Leq, 9hr dBA)	Design Max (Lmax dBA)
A	DP394280	NCA10	RES	60	55	80	45	42	63	48	46	64
63	DP1087838	NCA10	RES	60	55	80	53	50	74	57	54	74
29	DP209399	NCA10	RES	60	55	80	45	43	63	49	47	64

Appendix E

Operational rail ground-borne noise and vibration

Appendix E.1 Source vibration levels

The predominant vibration source results from the wheel-rail interaction of the rolling stock. However, the amount of vibration and associated characteristics depend on a number of factors such as the rolling stock mass and suspension, rail roughness and rail fixing type, slab track design, tunnel wall design and underlying geological conditions.

A number of these parameters are not developed in detail at this stage to accurately predict the source vibration level. Also, no measured relevant vibration data was available during the time of this assessment for the proposed rolling stock. Therefore, vibration data for the Waratah class train set used on previous environmental studies in Sydney have been used for the assessment. The data has been validated through post-construction in-tunnel and surface measurements on other Sydney Metro projects.

The source vibration data are presented in Table E-9-2 and Figure E.9-2. It can been seen that two different trackforms are used for comparison (dynamic stiffness of 28 kN/mm/pad and 12 kN/mm/pad). Predictions have been carried out on the standard attenuation track (28 kN/mm) as a base case. Vibration levels from the high attenuation trackform (12 kN/mm) have been considered for mitigation purposes.

Table E-9-2 Source vibration levels for the assessment

Source level type	Tunnel wall vibration level (dBV re. 1nm/s) at 80 km/hr in One-third octave band centre frequency (Hz)														
	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	Overall
Standard track (28 kN/mm)	77	78	78	77	80	86	86	86	85	84	84	89	86	82	79	96
High attenuation track (12kN/mm)	77	79	80	80	84	88	81	77	77	77	78	84	82	78	75	94

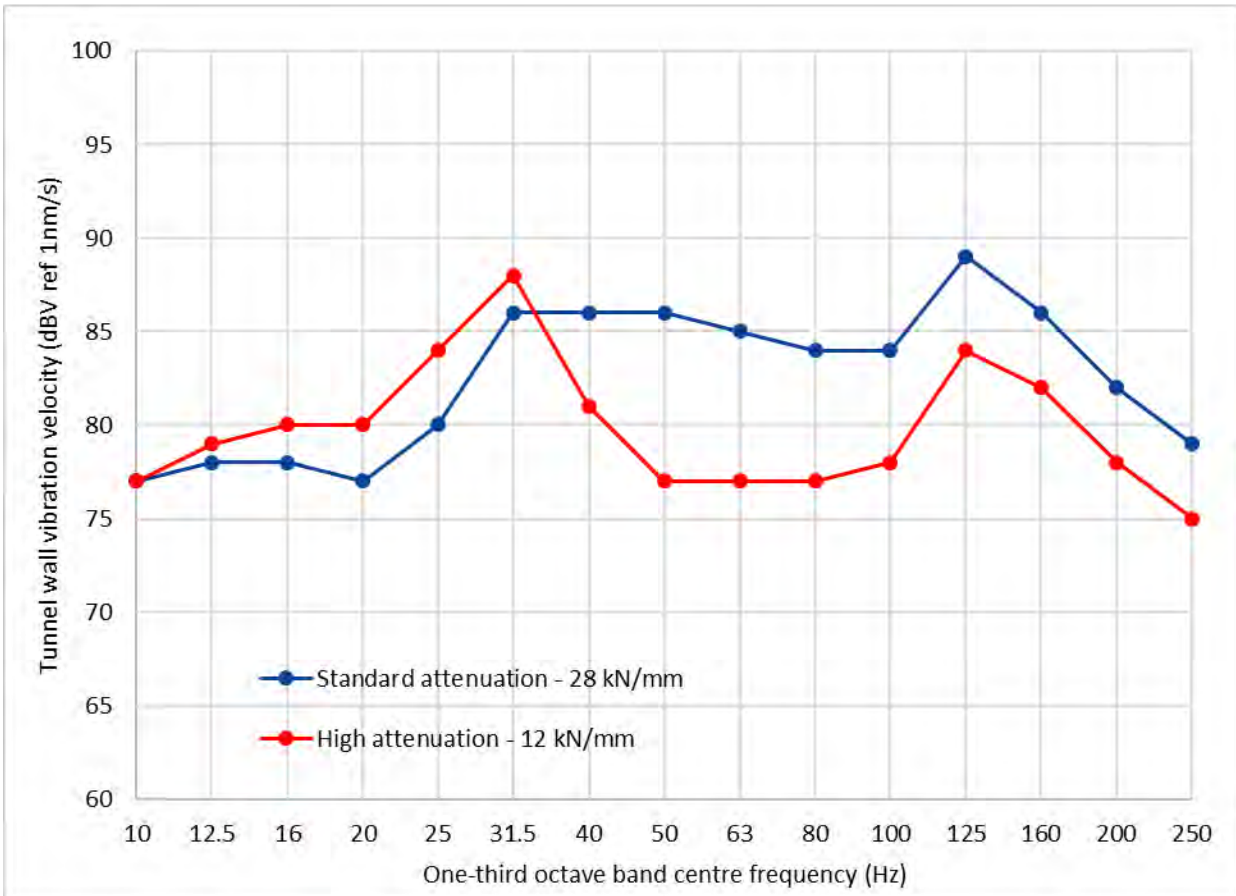


Figure E.9-2 Source vibration levels for the assessment – reference speed of 80 km/hr

Rolling stock

The proposed rolling stock is understood to be a train fleet of modern Electric Multiple Units (EMUs) incorporating dynamic brakes, and friction disc brakes at low speeds. The ultimate stage is understood have a 4-car configuration, to a total train length of approximately 80 metres. Whilst the train length has an impact on the vibration exposure, the ground-borne noise predictions do not change as it is a maximum noise level metric.

Rail alignment

The 3D rail alignment was used to determine the rail tunnel depth relative to the ground and sensitive receivers. All the proposed curve radii in the alignment are greater than 500 metres. As a result, no specific correction has been applied for curves in the predictions. There are no turnouts in the tunnel sections, and hence no corrections have been applied for any turnouts.

Trackform design

Trackform design is a critical consideration in managing ground-borne noise and vibration impacts from underground train movements. For modern underground tunnels, it is common to adopt slab track designs to maximise tunnel space and allow for better maintenance.

The rails are generally fixed to the slab with standard rail foot pads at regular intervals. For higher noise and vibration requirements, the rail fixings may incorporate resilient base plates with varying stiffness. For superior acoustic performance, two levels of vibration isolation can be provided – these can be achieved with rail pads and resilient sleepers and slabs (such as booted sleepers or floating slab tracks).

For this assessment, two types of trackforms are considered (standard and high attenuation, see Table E-9-3). The rail mass is assumed to be 60 kg/m for all scenarios.

Table E-9-3 Trackform considerations for assessment

Trackform type	Dynamic stiffness (kN/mm) per pad assumed for assessment	Product examples - Based on supplier catalogues
Standard resilient baseplate	28 kN/mm	Delkor Alt 1, Pandrol Vipa, Vossloh 300
High attenuation baseplate	12 kN/mm	Delkor Egg, Pandrol Vanguard, Vossloh 336

Tunnel design

The tunnel outer diameter is assumed to be 6.8 metres throughout the tunnel sections, with a concrete wall thickness of 200 mm. Cut and cover sections with rectangular cross sections may alter the vibration propagation characteristics and directivity. However, the exact geometry of the tunnel is not finalised along the entire alignment, especially around the Station boxes. These would be considered in detail during design development.

Operational Speeds

The project has currently not developed the likely speed profiles along the underground sections of the alignment. As a result, a maximum speed of 100 km/hr has been assumed everywhere for the ground-borne noise and vibration calculations. It is acknowledged that this is a conservative approach but is considered reasonable at this stage in order to determine possible worst case impacts.

Source vibration levels have been determined based on a simple logarithmic relationship as per the equation below on a one-third octave basis.

$$V(speed\ corrected) = V(reference) + 20log_{10}\left(\frac{Speed}{Ref.speed}\right)$$

Propagation losses

Train vibrations, once transmitted to the soil, propagate through the ground in the form of vibrational waves. The vibration levels attenuate over distance due to geometric spreading and different ground conditions offering material damping which assist in further attenuating the vibration. The geometric spreading has been estimated in the form a line source for the underground train.

Wave velocities have been estimated based on soil properties provided by Sydney Metro, as listed in Table E-9-4. These are based on bore hole data analysis, and the assessment is predominantly based on Class II or better Shale. The design development would consider more refined data as it becomes available. Based on the velocity estimates, soil damping has been predicted as indicated in Figure E.9-3.

Table E-9-4 Soil properties used for ground-borne noise and vibration assessment

Material classification	sat. weight (kN/m^3)	Elastic modulus (MPa)	Poisson ratio
Class V Shale	24.0	50.0	0.25
Class IV Shale	25.0	150.0	0.25
Class III Shale	25.0	300.0	0.25
Class II or better Shale	25.0	1500.0	0.25

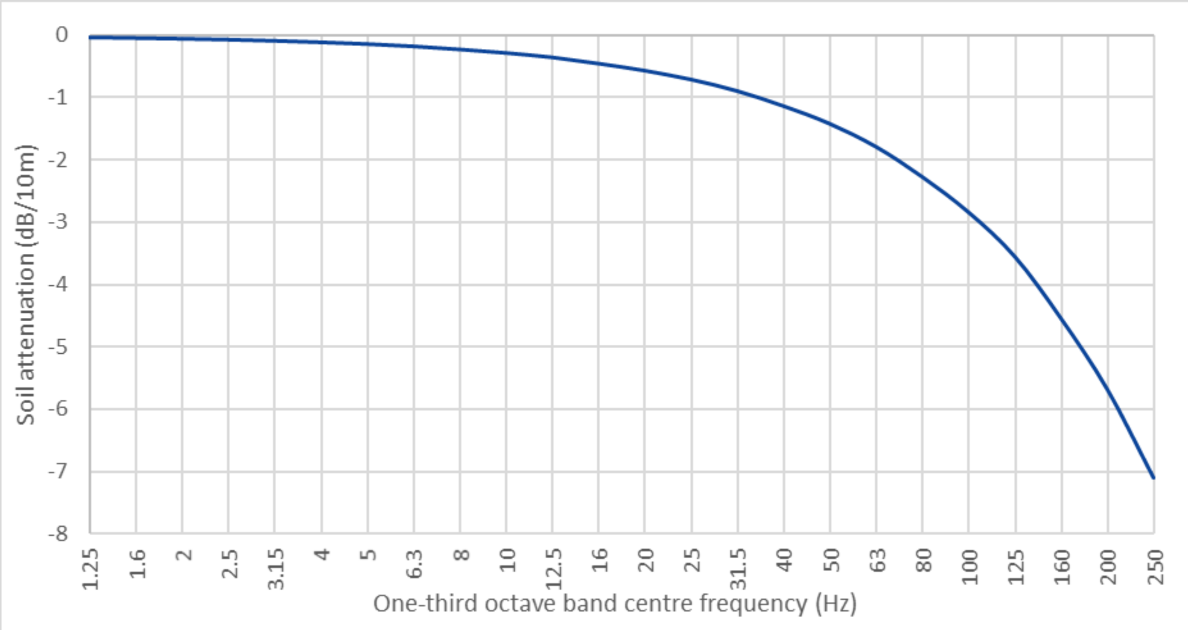


Figure E.9-3 Soil attenuation due to material damping

Building foundations

The sensitive receivers along the underground sections of the alignment are predominantly single or double storey residential buildings with shallow foundations. The other sensitive receivers include a small number of commercial, industrial and educational buildings. As such, the foundation coupling attenuation assumed for this assessment is provided in Table E-9-5. This data has been sourced from available databases such as the RIVAS project in Europe (2013) and Transportation Noise Reference Book, Nelson (1987).

Table E-9-5 Building foundation loss assumption

Building type	Coupling loss (dB) in One-third octave band centre frequency (Hz)															
	<8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250
1-2 storey building with shallow footings on average soil	0	-0.5	-1	-1	-1.5	-2	-2	-3	-3.5	-4	-4.5	-6	-6.5	-8	-11	-13

Floor amplifications

For buildings with two or more storeys, receivers located on the first level above ground are generally expected to experience higher ground-borne noise and vibration. This is attributed to the suspended floor vibration amplifications, and depends on the floor build-up and spans. As there would be subtle differences across each building, it is challenging to capture this with high degree of accuracy. In this regard, a generalised amplification factor is assumed for all sensitive receivers, and these values are presented in Table E-9-6.

Table E-9-6 Floor amplification assumption

Floor type	Slab amplification (dB) in One-third octave band centre frequency (Hz)																	
	5	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250
Timber floor – large span	7.5	7	7.5	11	16	17	13.5	9.5	8	6	6	5	6	3.5	1.5	1	-1	-1

Factor of safety

The assessment inherently has a number of empirical assumptions and data taken from various databases and projects. Since the actual data on site may differ, a + 5 dB factor of safety has been applied to all calculations.

Vibration dose values

The vibration dose values have been calculated for each receiver based on the train length, train speed and number of events (number of trains) for each assessment period (day and night period). These estimated vibration dose values are calculated based on the equation below (as per BS 6472:2008 – Guide to evaluation of human exposure to vibration in buildings):

$$eVDV = 1.4 \times a(t)_{rms} \times t^{0.25}$$

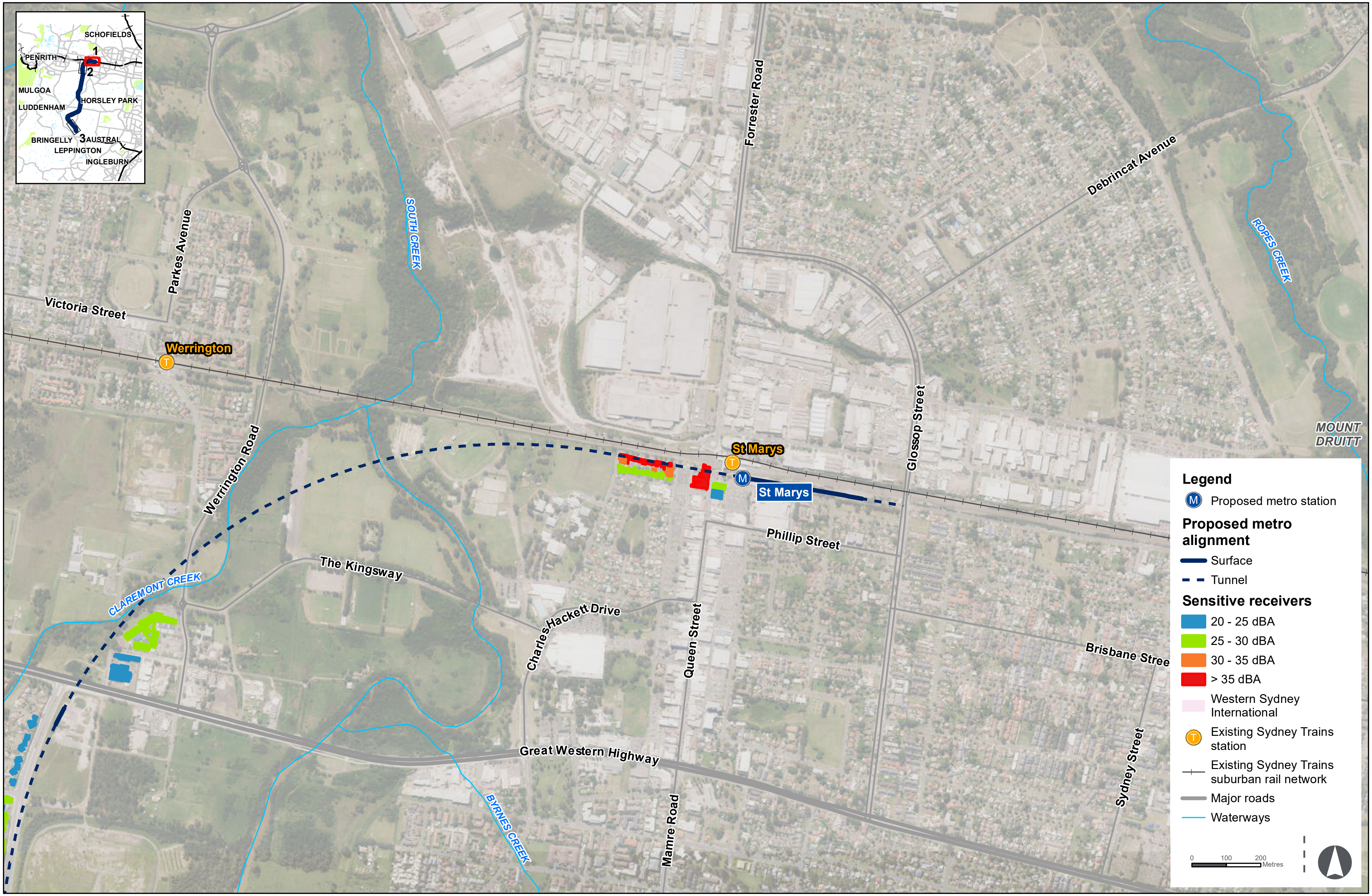
Where a(t) is acceleration as a function of time, and t is time in seconds. The rms overall values from the frequency domain have been determined by using an SRSS (square root of sum of squares) method up to 80 Hz.

Note that the source vibration levels used in this assessment are in the vertical (z) direction which is usually the most dominant direction for rail-borne assessments. Therefore, a W_b weighting curve is applied to predicted levels.

Ground-borne noise

The predicted vibration levels (dBV re 1nm/s) has been converted to noise (dB re 20µPa) by a factor of -27 dB across the spectrum in accordance with Transportation Noise Reference Book, Nelson (1987). These values are then A-weighted and logarithmically summed to arrive at overall $L_{max, slow}$ levels (dBA). Recent research has suggested a conversion factor of -32 dB from vibration to noise – however this factor has not been adopted in order to remain conservative for this preliminary assessment.

Appendix E.2 Predicted operational ground-borne noise



Sydney Metro – Western Sydney Airport

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Predicted operational ground-bourne noise

Appendix E-2a

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Predicted operational ground-bourne noise

Appendix E-2b

Australian Government NSW Government Sydney Metro

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Predicted operational ground-bourne noise

Appendix E-2c

Appendix F

Operational noise – stabling and maintenance facility, stations and services facilities

Appendix F.1 NPfI Methodology

The NPfI provides the framework and process for deriving the noise limits for multiple developments, including industrial or commercial premises and maintenance / repair facilities, under the *Protection of the Environment Operations Act 1997*.

The procedure specifies two aspects of environmental noise that require assessment. The first relates to the intrusiveness of a noise source and allows for the noise under assessment to be a margin above the background, whilst the other procedure relates to the acceptability of the resulting noise, in relation to maintaining the amenity of the surrounding area. The more stringent of the amenity or intrusive criteria would define the appropriate criteria for a project. As the stabling facility will operate 24 hours a day, the night-time criteria are likely to be the controlling time criteria for the project. Further, consideration of sleep disturbance is required in terms of night time operations of noise sources.

Project Intrusiveness Noise Level

A noise source would be deemed to be non-intrusive if the monitored $L_{eq,15min}$ noise level of the development does not exceed the RBL by more than 5 dBA. The RBL is the median of the measured L_{A90} noise level during the day, evening and night during periods when the development is not in operation.

Based on the results of monitoring outlined in Section 3 of the Main Report, Table F-9-7 presents the proposal intrusiveness levels in the vicinity of the stabling facility.

Table F-9-7Proposal Intrusiveness Noise Level

Measurement location	NCA	Time period[1]	RBL (dBA)	Proposal intrusiveness noise level (RBL + 5dB)[2] dBA $L_{eq, 15 min}$
NM08	NCA08	Day	31	36
		Evening	31	36
		Night	30	35
NM09	NCA09	Day	40	45
		Evening	39	44
		Night	34	39
NM16	NCA07	Day	47	52
		Evening	42	47
		Night	30	35

(1) Day: 7am to 6pm Monday to Saturday, 8am to 6pm Sunday; Evening: 6pm to 10pm; Night: 10pm to 7am Monday to Saturday, 10pm to 8am Sunday.

(2) Intrusiveness criteria apply to residential receivers only.

The background noise levels in the vicinity of the three representative locations is currently typical of a semi-rural landscape, with the background noise environments at NCA07 and NCA09 dominated by traffic on nearby roads, and NCA08 by noise from natural sources.

The area of Orchard Hills (NCA08) is currently zoned as rural residential, and its background environment is notably different to that of receivers in NCAs 07 and 09, which would generally be classified as suburban residential in nature.

Project Amenity Noise Levels

To limit continuing increases in noise levels, the amenity noise level within an area from industrial noise sources should not normally exceed the recommended amenity noise levels prescribed in the NPfI.

The recommended amenity noise levels represent the objective for **total** industrial noise at a receiver location, whereas the **proposal amenity noise level** represents the objective for noise from a **single** industrial development at a receiver location, defined as the **recommended noise levels** listed below (Table 2.2 of NPfI) **minus 5 dBA.**

The amenity criteria have been established at the identified receivers near the stabling facility based on the anticipated designation of 'rural residential' land use at receivers in NCA08, and 'suburban residential' land use within NCAs 07 and 09. The amenity criteria applicable to the project are presented in Table F-9-8.

Table F-9-8Project Amenity Noise Levels for Residential Areas

Type of receiver[1]	Period	Existing L_{eq} Noise Level, dBA	Recommended amenity noise level (ANL) dBA $L_{eq, period}$	Project amenity noise level (ANL -5db) dBA $L_{eq, period}$	Project adjusted ANL[2] dBA $L_{eq\ period}$
Residential (Suburban) (NCA07)	Day	59	55	50	50
	Evening	56	45	40	40
	Night	54	40	35	35
Residential (Rural) (NCA08)	Day	52	50	45	45
	Evening	48	45	40	40
	Night	40	40	35	35
Residential (Suburban) (NCA09)	Day	61	55	50	50
	Evening	57	45	40	40
	Night	54	40	35	35

(1) Amenity levels for non-residential receivers apply when the premises are in use.

(2) Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and public holidays; evening: the period from 6 pm to 10 pm; night: the remaining periods.

At all monitoring locations, ambient L_{eq} noise levels for day, evening and night time periods exceed the recommended amenity noise levels outline in the NPfI. Attended measurements indicate these locations are affected by traffic on nearby roads as well as natural (insect) noise. In the absence of other sources, noise levels are expected to be influenced mainly by insect noise.

Modifying Factors

The characteristics of a noise source can increase annoyance for sensitive receivers. Such characteristics include prominent tones, impulsiveness, intermittency and low frequency noise. The NPfI provides guidance on modifying factors which should be applied to predicted or measured noise levels when an annoying noise characteristic is present. To account for this annoyance, the NPfI outlines modifying factors and penalties to be applied in the assessment of intrusiveness and amenity noise levels.

Based on consideration of the annoying characteristics in the NPfI, the noise sources to be assessed as part of the stabling facility are not considered likely to warrant modifying factors.

Shoulder Periods

The NPfI makes allowances for different assessment periods, to account for operations during the morning shoulder period (5 am to 7 am) which would technically fall in the night time assessment period in accordance with the NPfI. This would allow flexibility in terms of assessment for works occurring during these early morning hours where existing background noise levels would generally be steadily rising, and it would be overly strict to assess to a more stringent night time criterion.

Noise logging at the nearest locations in NCA08 (NM08) indicates that the existing background noise environment is lowest before 6 am (refer to Figure F9-4).

With reference to the monitoring data and filtering completed as reported in Section 3 of the Main Report, it is evident that insect noise is a significant factor in the acoustic environment during the night time and early morning period. These increases in the early morning periods are likely to be seasonal and not occur over the whole year (i.e. not occurring in winter). With reference to the trends in noise levels during these periods it is considered that the morning shoulder periods (before 7 am) would be more accurately characterised by the night time period and activities before 7 am will be assessed to the night time criteria.

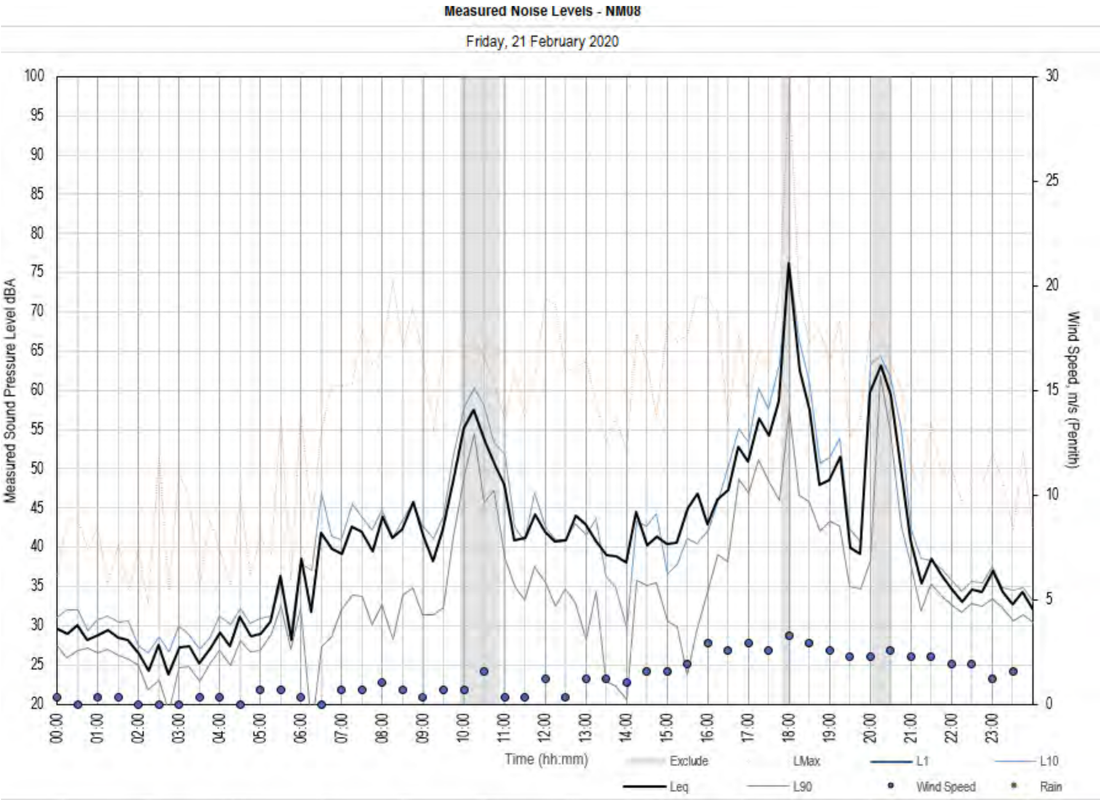


Figure F9-4 Background noise trends at NCA08

As the receivers in NCA08 are in closer proximity than other affected residences, it is assumed that this assumption would be equally applicable to receivers in NCA07 and NCA09, and would result in a more conservative estimate of noise impacts.

Sleep disturbance

Operational noise during night time periods have the potential to disturb people's sleep patterns.

In accordance with the requirements of the NPfI, where the proposal generates night-time noise events at residential locations exceeding the following levels, a detailed maximum noise level event assessment should be undertaken:

- $L_{eq,15min}$ 40 dBA or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{Fmax} 52 dBA or the prevailing RBL plus 15 dB, whichever is the greater.

Based on the background monitoring data for the project, maximum noise levels have been derived as presented in Table F-9-9.

Table F-9-9Sleep disturbance maximum noise level triggers

Receiver type	Noise Measurement Location	Time period[1]	RBL, $L_{eq,15min}$	Screening level, $L_{eq,15min}$[2]	Screening level, L_{Fmax}[3]
Residential (NCA07)	NM16	Night	30	40	52
Residential (NCA08)	NM08	Night	30	40	52

Receiver type	**Noise Measurement Location**	**Time period[1]**	RBL, $L_{eq,15min}$	**Screening level, $L_{eq,15min}$[2]**	**Screening level, L_{Fmax}[3]**
Residential (NCA09)	NM09	Night	34	40	52

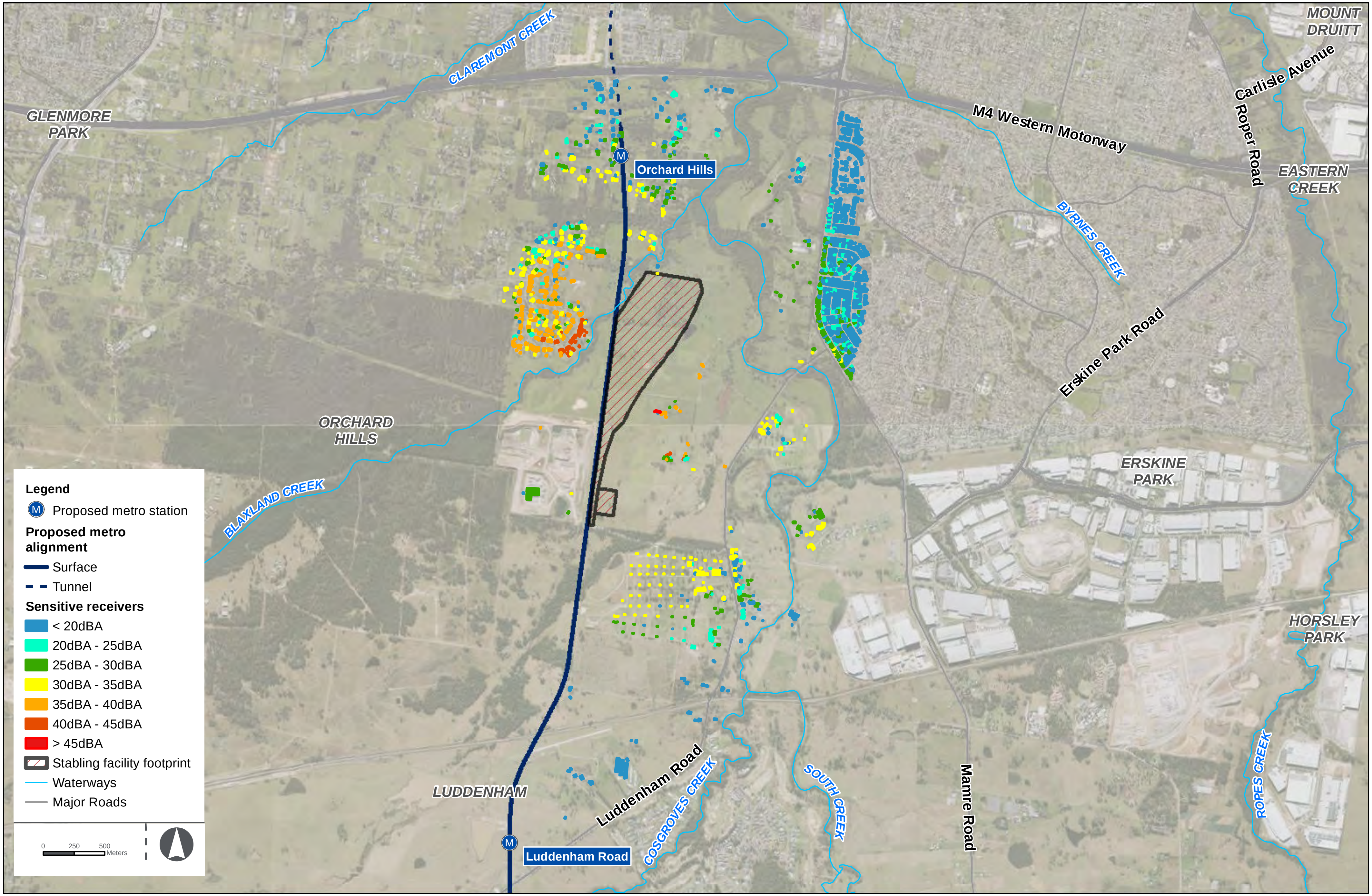
(1) Maximum noise levels assessed for night-time period only

(2) $L_{eq,15min}$ calculated as the greater of 40 dBA or RBL+5 dBA.

(3) L_{Fmax} calculated as the greater of 52 dBA or RBL+15 dBA.

Feasible and reasonable safeguards would be considered where there are night-time predicted exceedances above these levels.

Appendix F.2 Stabling and Maintenance Facility – Operational Noise Contours



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2036 Typical Day Operations (Leq,15 min)

Appendix F-2a