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Transportation Noise & Vibration Assessment

METRONET -Yanchep Rail Extension

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8/01/2018	-	Issued to Client as Final	Daniel Lloyd	Terry George

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1 INTRODUCTION

This assessment has been prepared to quantify the noise and vibration emissions resulting from the 13.8 km extension of the passenger railway from Butler Station to Yanchep – refer *Figure 1-1*. The results of the assessment are compared against relevant transportation noise and vibration criteria and recommendations on mitigation measures provided to ensure compliance with the criteria and minimise impacts to all existing and planned sensitive premises.

A glossary of the acoustic terminology used throughout this report is provided in *Appendix D*.

Figure 1-1 Rail Project Extent

2 CRITERIA

2.1 Noise Criteria

The criteria relevant to this assessment is the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (hereafter referred to as the Policy) produced by the Western Australian Planning Commission (WAPC). The objectives in the Policy are to:

- Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;
- Protect major transport corridors and freight operations from incompatible urban encroachment;
- Encourage best practice design and construction standards for new development proposals and new or redevelopment transport infrastructure proposals;
- Facilitate the development and operation of an efficient freight network; and
- Facilitate the strategic co-location of freight handling facilities.

The Policy's outdoor noise criteria are shown below in *Table 2-1*. These criteria apply at ground floor level of a noise sensitive premises, 1-metre from a habitable facade.

Table 2-1 Outdoor Noise Criteria

Period	Target	Limit
Day (6am to 10pm)	55 dB $L_{Aeq(Day)}$	60 dB $L_{Aeq(Day)}$
Night (10pm to 6am)	50 dB $L_{Aeq(Night)}$	55 dB $L_{Aeq(Night)}$

Note: The 5 dB difference between the target and limit is referred to as the margin.

In the application of these outdoor noise criteria to new major transport projects, the objectives of this Policy is that the new infrastructure be designed and constructed so that noise emissions are at a level that -

- provides an acceptable level of acoustic amenity for existing noise-sensitive land uses and for the planning of noise-sensitive developments;
- is consistent with other planning policies and community expectations; and
- is practicably achievable.

If a transport infrastructure project will emit transport noise levels that meet the noise *target*, no further measures are required under this Policy. Otherwise, transport infrastructure providers should design mitigation measures to achieve the noise *limit* of 60 dB $L_{Aeq(Day)}$ and 55 dB $L_{Aeq(Night)}$, when assessed at one metre from the facade at ground floor level.

Transport infrastructure providers are also required to consider design measures to meet the noise *target* of 55 dB $L_{Aeq(Day)}$ and 50 dB $L_{Aeq(Night)}$, and to implement these measures where reasonable and practicable.

In addition to the policy criteria stated above and in line with the criteria used in the noise management plan for the Clarkson Station to Romeo Road section of railway (July 2010), the maximum pass-by noise level is also considered in this assessment. The maximum noise level criteria used are:

- Criterion 1: Noise mitigation will be provided to ensure that noise levels caused by rail operations do not exceed a level of L_{Amax} of 80 dB at a distance of 1 metre from a building with a noise sensitive use on a noise sensitive premises;

- Criterion 2: Noise mitigation will be considered where the noise level is at or above L_{Amax} of 75 dB at, at a distance of 1 metre from a building with a noise sensitive use on noise sensitive premises.

It should be noted that a draft update to the Policy has recently been released for public comment. The key changes proposed in the draft policy that would affect this assessment is summarised below:

- For new railways a criteria of $L_{Aeq\ (Day)}$ 55 dB and $L_{Aeq\ (Night)}$ 50 dB at the facade of noise sensitive premises;

- The noise is to be assessed at the first two floors (or more if practicable); and

- The target level of $L_{Aeq\ (Day)}$ 55 dB and $L_{Aeq\ (Night)}$ 50 dB is to be achieved in at least one outdoor entertaining area.

While this assessment does assume criteria of $L_{Aeq\ (Day)}$ 55 dB and $L_{Aeq\ (Night)}$ 50 dB, it was considered premature to assess the noise to upper floors of residences, particularly as the vast majority of houses built along the proposed railway alignment would be single storey, or to design noise mitigation to achieve the target in an outdoor area.

If a new infrastructure project is to be constructed in the vicinity of a future noise-sensitive land use, mitigation measures should be implemented in accordance with the Policy. For this purpose, a proposed noise-sensitive land use is any noise sensitive development that is subject to an approved detailed area plan, subdivision approval or development approval, such that the transport infrastructure provider is able to adequately design noise mitigation measures to protect that development. In these instances, the infrastructure provider and developer are both responsible for ensuring that the objectives of this policy are achieved, and a mutually beneficial noise management plan, including individual responsibilities, should be negotiated between the parties.

2.2 Vibration Criteria

For the existing railway south of Butler Station, the ground-borne vibration criteria resulting from the train pass-bys was given in the *Ministerial Statement 623.* The Ministerial Conditions required that the proponent meet specific vibration criteria with reference to the *Australian Standard AS 2670.2-1990: Evaluation of human exposure to whole body vibration - Part 2: Continuous and shock induced vibration in buildings (1 to 80 Hz)*. This Standard characterises sources (of vibration) which operate intermittently, but which would produce continuous vibration if operated continuously, such as railway trains. The preferred method of assessing the influence of continuous vibrations is to determine the root mean square (RMS) value of the weighted particle acceleration. In terms of vibrational energy, both particle acceleration and velocity are identical.

The criteria in the *Ministerial Statement 623* were as follows:

- **Criterion 1**: vibration isolation measures will be provided where the predicted or actual vibration is Curve 2 (106 dB) or greater, as defined in AS 2670.2;
- **Criterion 2**: the proposal will be designed to meet Curve 1.4 (103 dB), as defined in AS 2670.2;
- **Criterion 3**: Vibration will be managed to be as low as reasonably practicable.

3 METHODOLOGY

3.1 Noise Assessment

The computer programme *SoundPLAN 8.0* was utilised incorporating the Nordic Rail Prediction Method (Kilde Rep. 130) algorithm. The algorithm has been modified to reflect local conditions as follows:

- The Nordic Rail Prediction Method (Kilde Rep. 130) algorithm is for generic train types in Europe and requires modification to align with measured noise levels of passenger trains operating in the Perth region. Measured noise levels used are shown in *Table 3-1.*

Table 3-1 Sound Pressure Levels Used in the Noise Model

Description	dB(A) at One-Third Octave Frequencies (Hz)									Overall dB(A)
	31.5	63	125	250	500	1K	2K	4K	8K	
Train speed of 130 km/hr at a distance of 15m	30	51	59	62	73	79	79	77	69	87
	35	54	61	65	73	79	80	74	64	
	42	53	61	69	78	80	78	72	58	

3.1.1 Ground Topography, Road Design & Cadastral Data

Topographical data was based on that provided by PTA with the contours being in 0.01 metre intervals. The railway design and groundworks have been incorporated into the existing ground levels to develop a 3-dimensional model. It should be noted that the railway has been designed to be in a cutting, between 4-7m below road level, for the majority of the alignment and that the modelling has taken this into account.

Existing buildings have been included in the noise model as these can provide barrier attenuation when located between a source and receiver, in much the same way as a hill or wall provides noise shielding. In addition to this, future subdivisions and station layouts have also been included together with the expected location of future buildings and future noise-sensitive premises. It must be, however, acknowledged that the design of these subdivision are in the preliminary stages and ground levels may change as more detailed design work is undertaken.

For the purposes of the modelling, all buildings are assumed to be single storey and have a height of 4.0 metres

3.1.2 Train Data

The train configuration and numbers of movements used in the noise prediction modelling are presented below in *Tables 3-2 and 3-3.*

Table 3-2 Variables Used in the Noise Prediction Model

Description of Variable	Value
Type of noise source	Line source
6 Car Set	150 metres
Height of noise source above railhead	0.8 metres

Table 3-3 Daily Rail Movements Assumed in the Noise Model

Train Description	Train Movements	
	Day	Night
Northbound		
6 Car Sets	75	22
Southbound		
6 Car Sets	75	22

3.1.3 Train Speeds

The calculated train speeds, based on simulation plots determined by Australis Rail Consulting, are shown in *Figure 3-1 and 3-2*. The black dotted line shows the maximum speed limit (km/h), the red line shows the actual calculated train speed attained (km/h), and the brown line shows the vertical track profile (m). Note that the train does not always reach the maximum speed limit due the requirement to stop at stations and the effect of track gradients and alignment. For the purposes of the noise modelling, the speeds have been divided into sections as shown in *Table 3-4*.

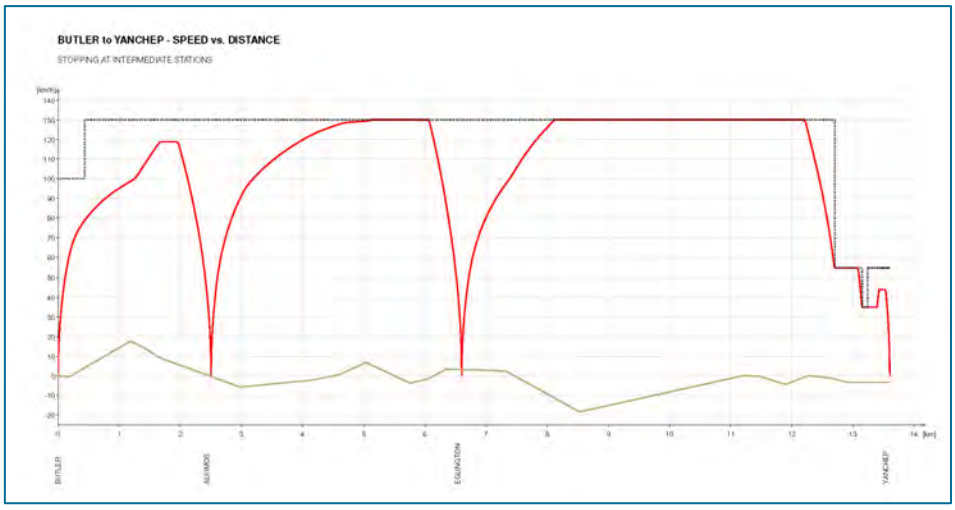

Figure 3-1 Train Speeds vs Distance Butler to Yanchep

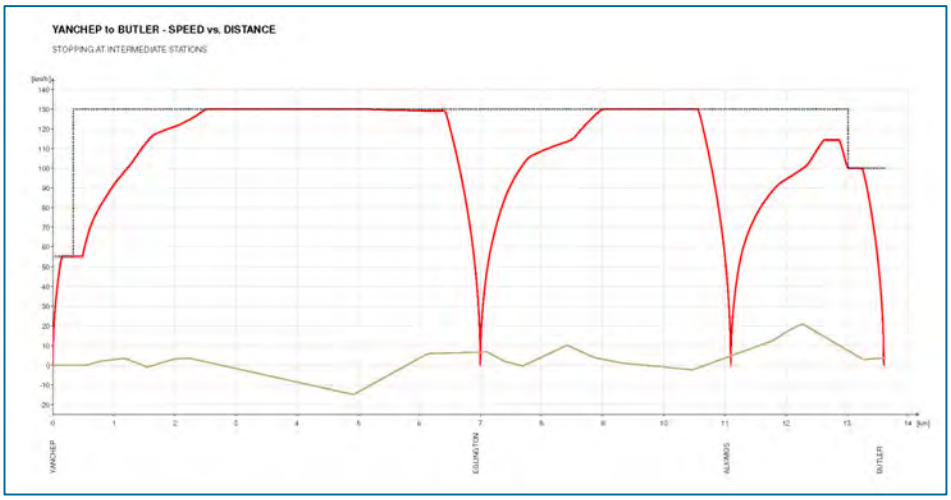

Figure 3-2 Train Speeds vs Distance Yanchep to Butler

Table 3-4 Train Speeds Assumed in the Noise Model

Butler to Yanchep		Yanchep to Butler	
Chainage	Speed	Chainage	Speed
0	70	0	55
350	90	500	75
800	100	750	90
1300	120	1000	110
2400	60	2000	120
2700	90	2500	130
3000	110	6900	60
3500	130	7100	90
6450	70	7500	110
6750	90	8000	120
7200	110	8500	130
7500	130	11000	60
12700	55	11400	80
		11500	95
		12200	115
		13000	100
		13300	60

3.2 Vibration Assessment

The propagation of vibration through the ground is a complex phenomenon. Even for a simple source, the received vibration at any point includes the arrival of several different wave types, including reflections and other effects caused by changes in ground conditions along the propagation path (including reflected paths).

The three principal wave types are compression waves (or surface waves), rayleigh waves and shear waves. The various wave types propagate at different speeds through the ground, with the compression wave propagating fastest (eg 500 m/s to 1000 m/s for sandy soil), the shear wave propagating significantly slower (eg 150 m/s to 200 m/s for sandy soil) and the rayleigh wave propagating marginally slower than the shear wave. A fourth wave type, known as the "head wave", can be produced in the surface layer as a result of the compression wave propagating at higher speed through a subsurface layer or water table.

Attenuation with distance occurs due to the geometric spreading of the wave front and due to other losses within the ground material, known as "damping". The attenuation due to geometric spreading occurs equally for all frequencies, whereas the damping is frequency dependent, with greater loss per metre occurring at high frequencies than at low frequencies. As a conservative approach and considering the high possibility of limestone between the railway and receivers, the dampening component will be ignored for the vibration level predictions.

There have been a number of vibration studies to assess the vibration levels resulting from the passenger railway operating the northern suburbs. Herring Storer Acoustics undertook the most recent assessment: *Northern Rail Extension Romeo Road to Yanchep - Ground Vibration Assessment; November 2012; Ref 15438-12160*, which produced the following distances from the railway to achieve the target criteria of Curve 1.4 in Australian Standard 2670.2-1990 "*Evaluation of human exposure to whole-body vibration; Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)"* :

- Near Station - 50 metres
- Inside bend - 55 metres
- Outside bend - 40 metres
- Straight Track - 40 metres

The predicted vibration level to sensitive receivers will be determined assuming the above distance calculations and assuming the energy from the train produces a line source. It is also assumed that the trains will be travelling at high speed.

4 RESULTS

4.1 Noise Assessment

The results of the $L_{Aeq(Day)}$ noise predictions to the ground floor of representative receiver locations, together with a comparison against the Policy target criterion is provided below in *Table 4-1* and shown graphically in *Figures 4-1 to 4-9.* The receiver locations have been chosen to represent the changing conditions along the railway alignment. The receiver locations are detailed in *Appendix A.*

The predictions assume the proposed railway design, expected train speed and configuration and existing noise barriers constructed as part of recent housing developments.

It should be noted that from noise measurements of the existing railway south of Butler Station, it is the daytime noise levels ($L_{Aeq(Day)}$) that will dictate compliance or otherwise with the Policy criteria. Therefore for this assessment, the night period noise levels ($L_{Aeq(Night)}$) have not been provided.

The results of the post-construction noise monitoring are provided in *Appendix B* for information purposes.

Table 4-1 Predicted Noise Levels to Ground Floor

Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB	Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB
1	63	81	31	55	73
2	61	79	32	54	71
3	61	80	33	55	72
4	62	81	34	53	69
5	60	78	35	55	71
6	61	80	36	54	71
7	62	81	37	53	70
8	62	81	38	54	71
9	61	80	39	54	70
10	58	74	40	54	71
11	57	74	41	55	72
12	56	73	42	67	86
13	47	65	43	64	83
14	50	68	44	61	80
15	54	72	45	60	78
16	52	70	46	57	75
17	57	73	47	59	75
18	56	73	48	59	76
19	57	73	49	59	75
20	57	74	50	58	74
21	57	74	51	57	74
22	56	73	52	55	72
23	56	73	53	54	69
24	55	72	54	54	67
25	54	70	55	54	67
26	56	73	56	51	66
27	56	74	57	54	70
28	53	71	58	55	71
29	52	68	59	55	71
30	52	68	60	55	71
xx	Indicates limit criterion is exceeded				
xx	Indicates target criterion is exceeded				

Table 4-2 Predicted Noise Levels to Ground Floor with Noise Barriers

Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB	Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB
61	55	71	91	62	81
62	55	71	92	57	75
63	56	73	93	62	81
64	56	73	94	60	78
65	56	71	95	61	79
66	55	71	96	63	81
67	54	68	97	63	82
68	58	75	98	63	82
69	55	72	99	60	77
70	58	75	100	61	78
71	59	76	101	62	80
72	60	76	102	66	83
73	60	78	103	65	83
74	60	78	104	63	81
75	61	78	105	61	78
76	55	71	106	63	80
77	56	72	107	61	78
78	57	72	108	65	82
79	58	74	109	63	80
80	59	76	110	62	80
81	59	76	111	64	81
82	59	76	112	56	75
83	62	79	113	57	75
84	60	78	114	57	75
85	59	75	115	57	75
86	58	74	116	57	75
87	57	75	117	58	76
88	58	75	118	58	76
89	60	79	119	57	75
90	62	81	120	58	75
xx	Indicates limit criterion is exceeded				
xx	Indicates target criterion is exceeded				

Table 4-3 Predicted Noise Levels to Ground Floor with Noise Barriers

Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB	Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB
121	64	83	152	58	75
122	68	87	153	58	75
123	67	85	154	51	66
124	67	86	155	57	74
125	67	86	156	56	73
126	67	86	157	64	81
127	66	84	158	52	68
128	64	83	159	54	71
129	65	84	160	65	84
130	67	86	161	64	83
131	68	86	162	63	82
132	66	84	163	60	79
133	55	74	164	56	72
134	54	71	165	51	68
135	53	69	166	51	68
136	55	72	167	51	69
137	58	76	168	58	76
138	60	78	169	60	78
139	62	80	170	65	84
140	62	79	171	65	84
141	66	85	172	68	86
142	60	77	173	65	84
143	61	79	174	62	82
144	61	78	175	60	79
145	61	79	176	60	78
146	62	81	177	58	77
147	57	74	178	58	76
148	59	76	179	57	76
149	59	77	180	56	74
150	58	75	181	55	70
151	58	76	182	54	70
xx	Indicates limit criterion is exceeded				
xx	Indicates target criterion is exceeded				

METRONET - Yanchep Rail Extension - Butler
Predicted $L_{Aeq,day}$ Noise Levels - Existing Noise Barriers

Figure 4-1

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METRONET - Yanchep Rail Extension - Alkimos
Predicted $L_{Aeq,day}$ Noise Levels - Existing Noise Barriers

Figure 4-2

Scale
0 30 60 120 180 240 300 360 m

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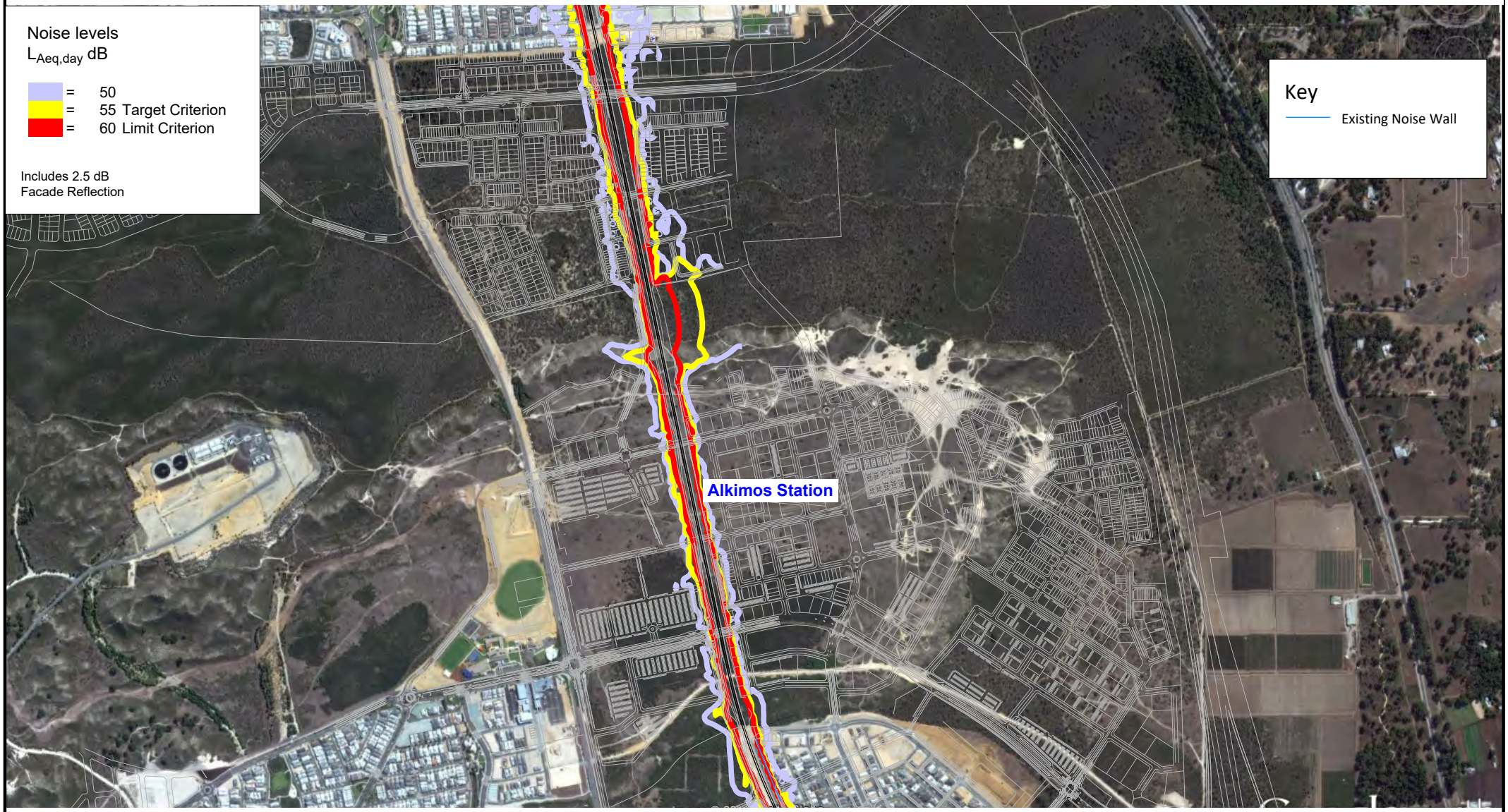
METRONET - Yanchep Rail Extension - North of Alkimos
Predicted $L_{Aeq,day}$ Noise Levels - Existing Noise Barriers

Figure 4-3



Scale
0 50 100 200 300 400 500 600 m

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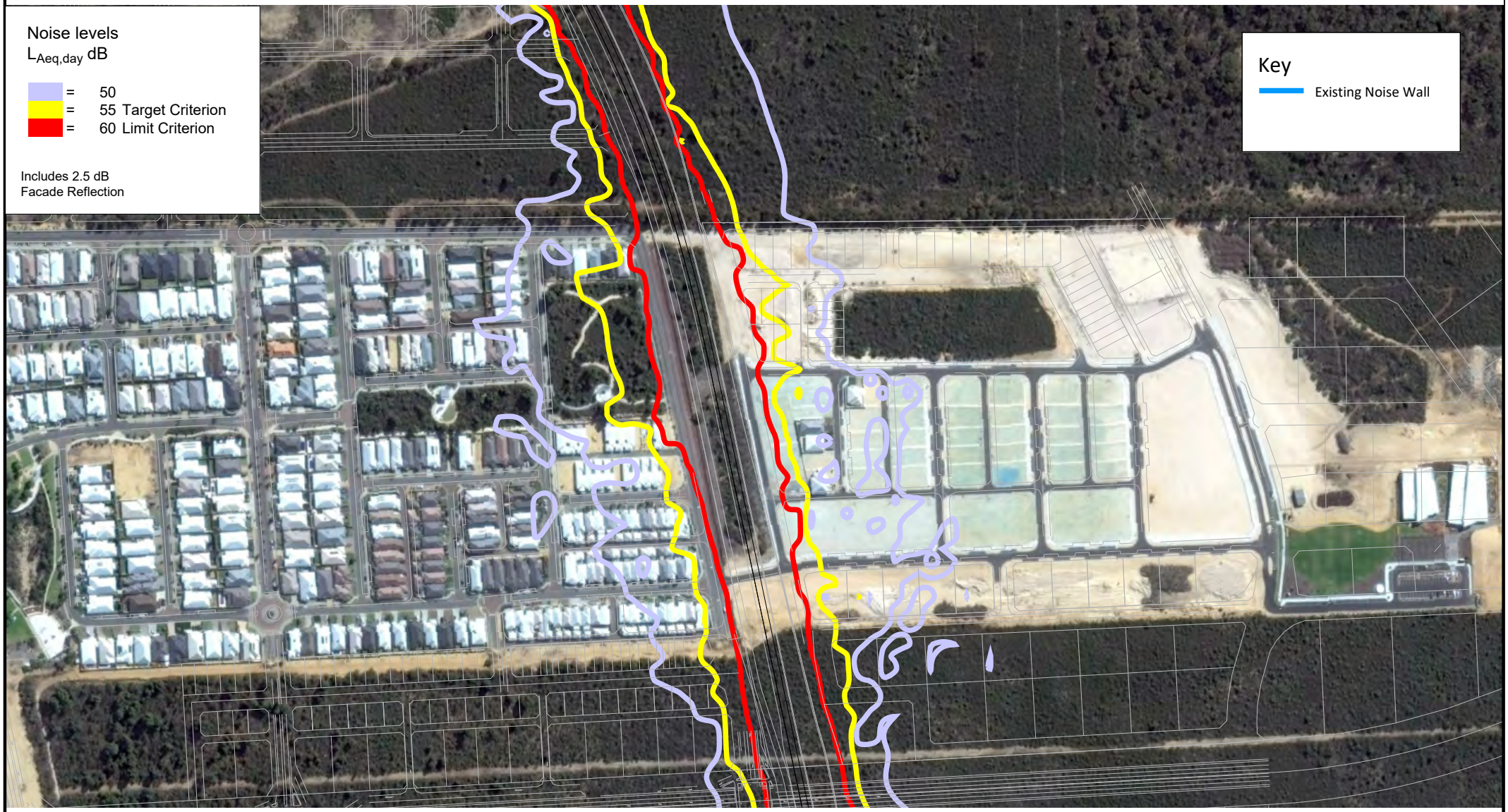
METRONET - Yanchep Rail Extension - Shorehaven
Predicted $L_{Aeq,day}$ Noise Levels - Existing Noise Barriers

Figure 4-4



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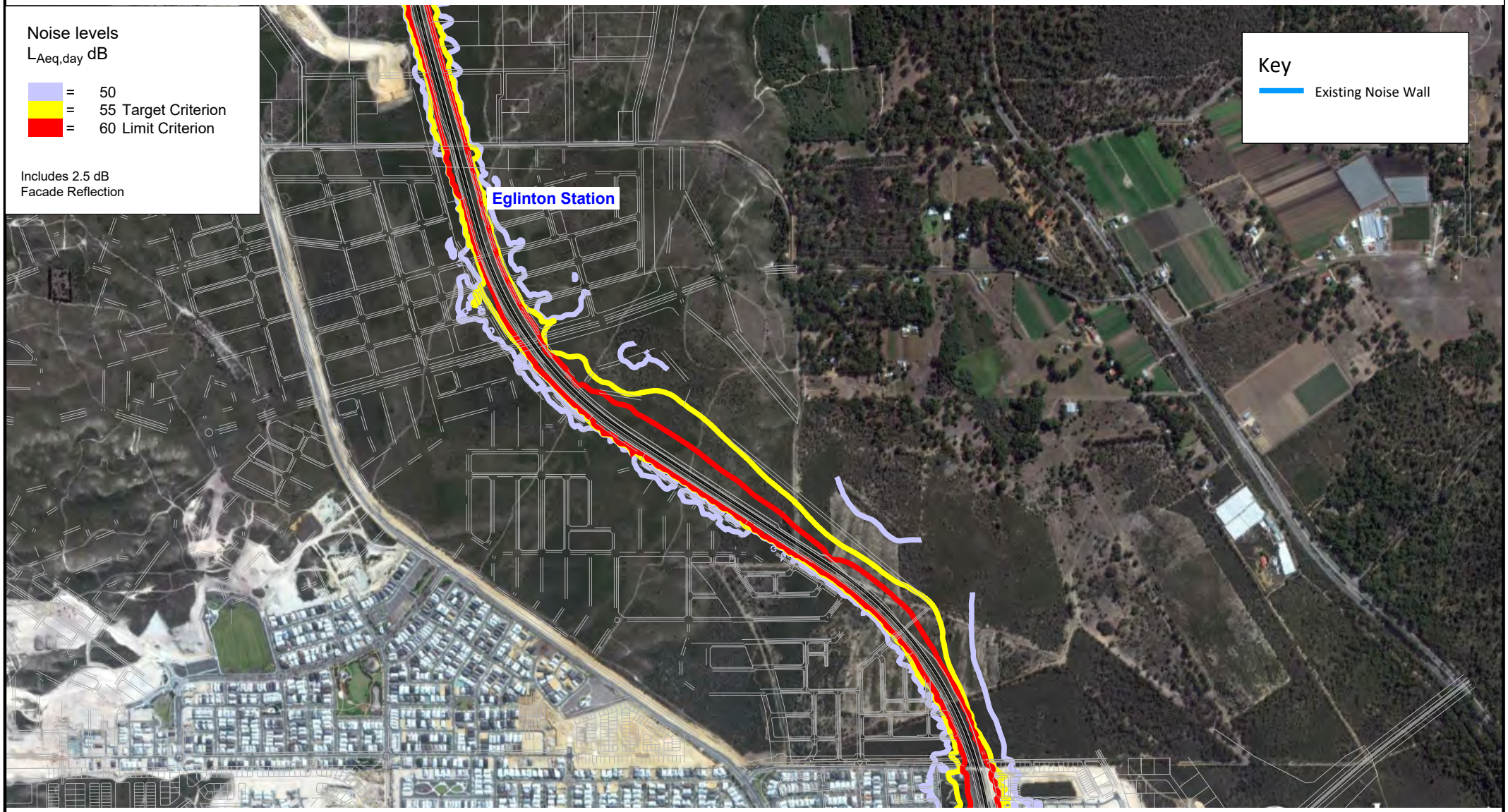
METRONET - Yanchep Rail Extension - North of Shorehaven
Predicted $L_{Aeq,day}$ Noise Levels - Existing Noise Barriers

Figure 4-5



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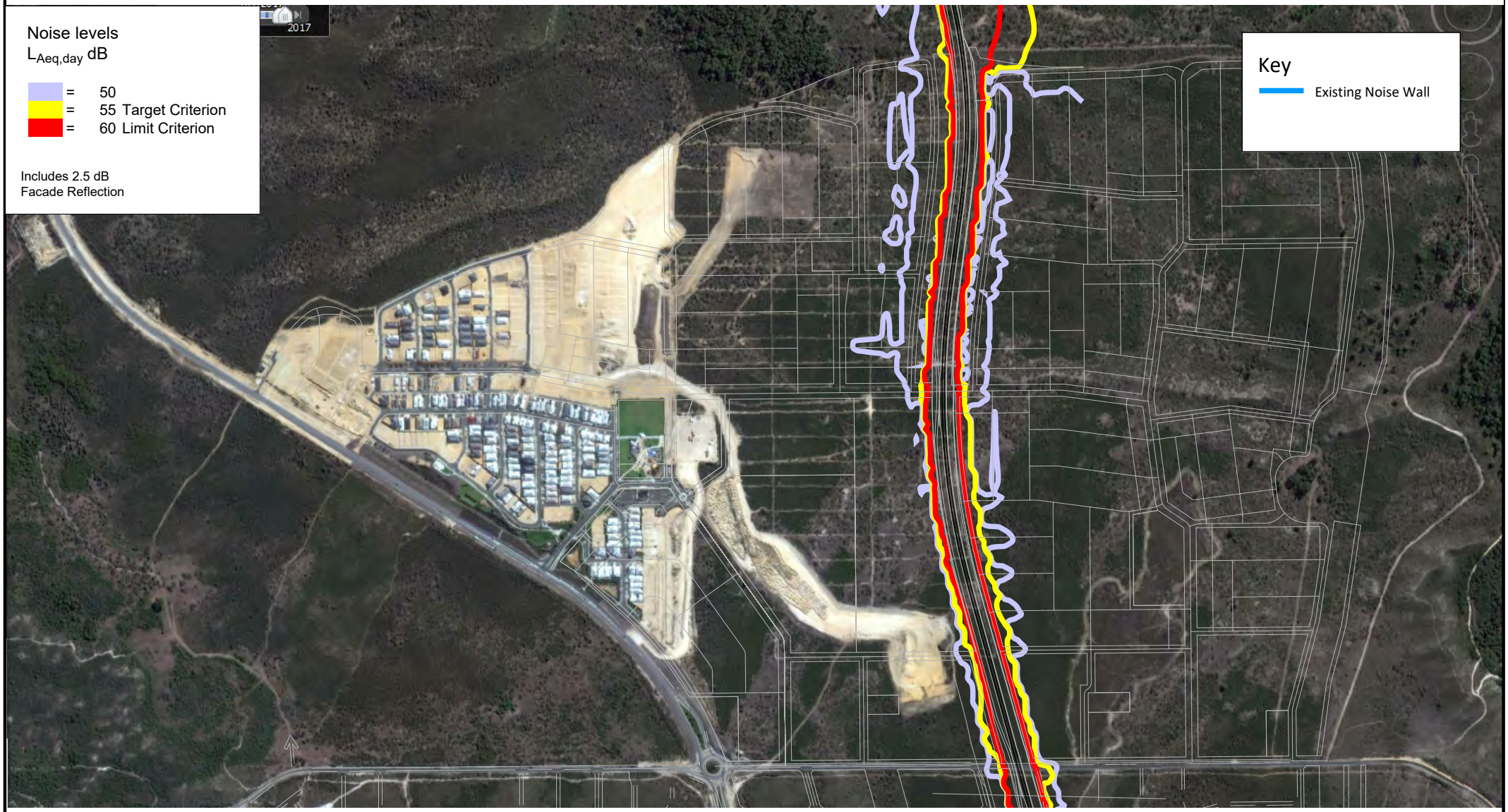
METRONET - Yanchep Rail Extension - Eglinton
Predicted $L_{Aeq,day}$ Noise Levels - Existing Noise Barriers

Figure 4-6



Scale

0 50 100 200 300 400 500 600 m

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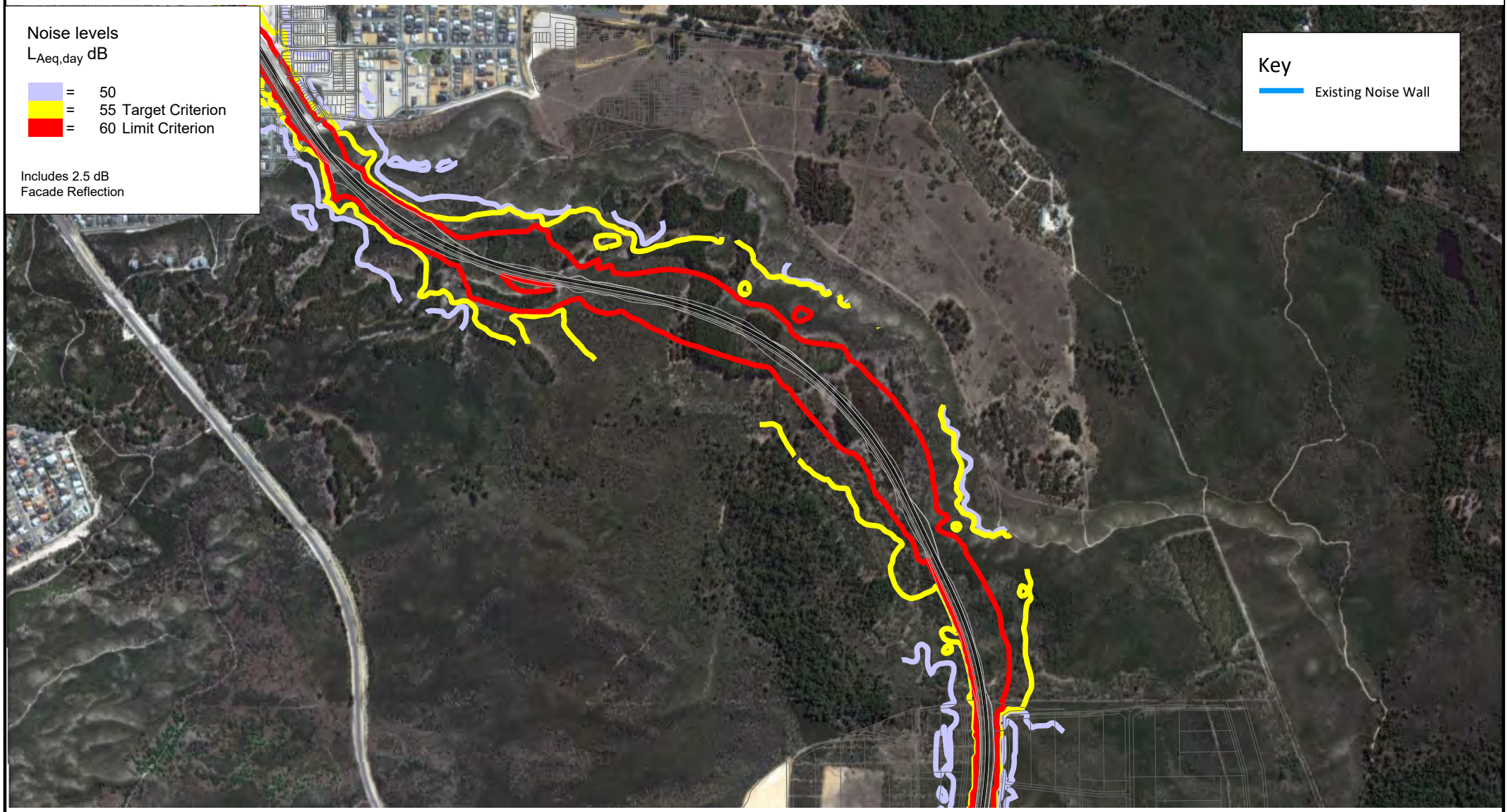
METRONET - Yanchep Rail Extension - North of Eglinton
Predicted $L_{Aeq,day}$ Noise Levels - Existing Noise Barriers

Figure 4-7



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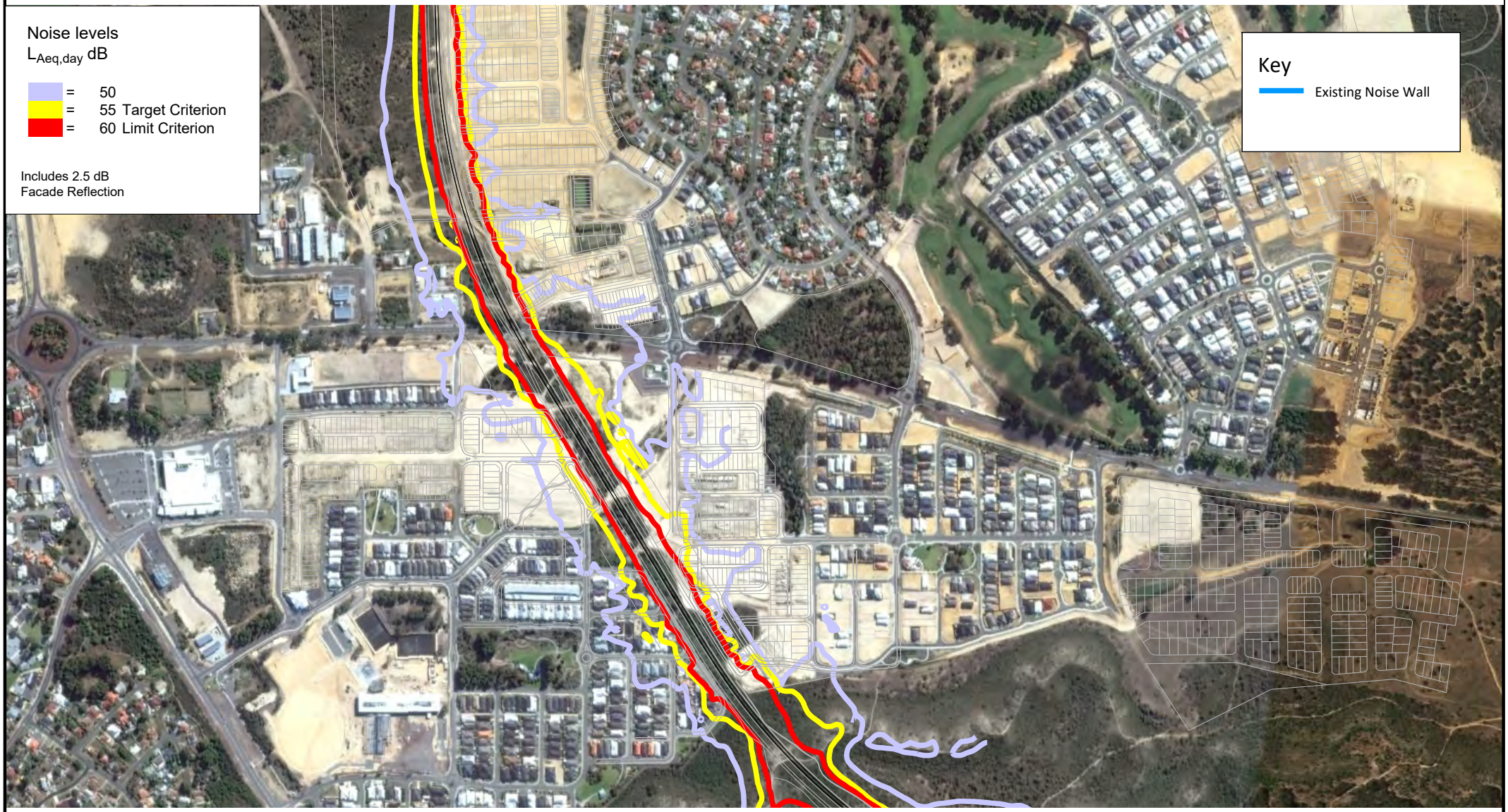
METRONET - Yanchep Rail Extension - South Yanchep
Predicted $L_{Aeq,day}$ Noise Levels - Existing Noise Barriers

Figure 4-8



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METRONET - Yanchep Rail Extension - North Yanchep
Predicted $L_{Aeq,day}$ Noise Levels - Existing Noise Barriers

Figure 4-9

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4.2 Vibration Assessment

The results of the vibration predictions to representative receiver locations, together with a comparison against the target criterion of Curve 1.4 (103 dB_V (re 1E-6 mm/s)) of AS2670.2-1990 are provided below in *Table 4-2*. This criterion applies to both continuous and intermittent vibration. Only existing buildings or those where the development is completed or under construction have been included. The receiver locations and numbers are detailed in *Appendix A*.

Table 4-4 Predicted Vibration to Sensitive Receivers

Receiver ID	Predicted Vibration Level dB_V (re 1E-6 mm/s)	Receiver ID	Predicted Vibration Level dB_V (re 1E-6 mm/s)
1	106	112-120	103
2 - 4	104	121-132	104
3-12	103	133-135	103
13	98	136-147	104
14	99	148-151	104
15	100	152-153	103
16	102	154	100
17-41	104	155-156	103
42-45	105	157	105
46	105	158	101
47-50	103	159	102
51-54	102	160-162	105
55-56	100	163	103
57-67	103	164	101
68-75	103	165	98
76-83	103	166	97
85-91	106	168-169	103
92	103	170-183	104
93-111	105		
xx	Shaded cell indicates target criterion is exceeded		

5 RECOMMENDATIONS

5.1 Noise Control

From the results presented in *Section 4*, it can be seen that the noise *target* will be exceeded at a number of the assessed sensitive premises and as such it is recommended that noise walls be incorporated into the design of the railway in order to achieve the *target*, where practicable, at all existing noise sensitive premises. In terms of practicability, the noise walls have been limited to a height of 4 metres above ground level. The predicted noise levels assuming the existing noise walls and proposed wall design is provided in *Table 5-1* and shown graphically in *Figures 5-1 to 5-9*. It should be noted that receivers predicted to marginally exceed the criterion are a result of the constraint on the wall height.

Details of the proposed noise walls, which are based on the expected ground levels of existing and future residential developments at the time of this assessment, are provided in *Appendix C*.

It should be acknowledged that the design of these barriers might change when the detailed design (i.e. design levels or building façade noise control packages) of residential subdivisions are further developed. In addition the responsibility for construction of barriers will also need to be confirmed at this time.

Table 5-1 Predicted Noise Levels to Ground Floor with Noise Barriers

Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB	Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB
1	54	71	23	54	70
2	54	71	24	54	71
3	54	72	25	54	70
4	55	73	26	54	69
5	54	71	27	53	71
6	55	72	28	53	70
7	55	73	29	51	68
8	55	73	30	52	68
9	55	74	31	53	70
10	55	71	32	55	72
11	54	70	33	55	73
12	53	69	34	54	70
13	50	67	35	55	72
14	52	70	36	55	72
15	54	72	37	53	71
16	54	72	38	55	71
17	53	71	39	54	70
18	53	69	40	55	72
19	53	70	42	54	71
20	54	70	43	53	70
21	55	71	44	53	70
22	54	71	45	52	68
xx	Shaded cell indicates target criterion is exceeded				

Table 5-2 Predicted Noise Levels to Ground Floor with Noise Barriers

Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB	Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB
46	55	71	83	56	73
47	55	69	84	56	72
48	55	69	85	57	74
49	55	69	86	55	70
50	55	71	87	53	70
51	55	72	88	54	71
52	53	68	89	55	73
53	53	68	90	55	75
54	54	67	91	55	76
55	54	67	92	53	70
56	51	66	93	55	73
57	54	71	94	55	73
58	55	71	95	55	72
59	55	71	96	55	73
60	55	71	97	55	73
61	55	71	98	55	73
62	55	71	99	54	71
63	55	71	100	55	72
64	55	70	101	55	73
65	55	71	102	55	73
66	55	71	103	55	73
67	54	68	104	55	73
68	56	71	105	55	72
69	55	72	106	55	73
70	55	70	107	55	72
71	54	70	108	55	73
72	55	70	109	55	74
73	55	71	110	55	73
74	55	71	111	55	73
75	56	71	112	53	72
76	55	71	113	53	71
77	56	72	114	53	70
78	55	70	115	53	71
79	56	71	116	54	71
80	55	71	117	54	72
81	55	71	118	54	72
82	55	71	119	54	71
xx	Shaded cell indicates target criterion is exceeded				

Table 5-3 Predicted Noise Levels to Ground Floor with Noise Barriers

Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB	Receiver ID	Predicted Noise Level $L_{Aeq(Day)}$ dB	Predicted Max Level dB
120	55	71	152	55	72
121	54	71	153	55	72
122	55	71	154	51	66
123	55	72	155	55	72
124	55	72	156	54	70
125	55	72	157	55	72
126	55	72	158	52	68
127	55	72	159	54	71
128	55	72	160	56	73
129	55	71	161	55	72
130	54	71	162	55	72
131	55	71	163	55	72
132	55	72	164	56	71
133	54	72	165	51	68
134	54	71	166	51	68
135	54	71	167	51	69
136	54	72	168	55	72
137	55	71	169	55	72
138	55	72	170	55	72
139	54	71	171	54	70
140	56	72	172	54	70
141	56	71	173	54	71
142	55	71	174	54	71
143	55	72	175	55	72
144	55	72	176	54	72
145	55	71	177	53	71
146	55	71	178	54	72
147	55	71	179	52	71
148	55	72	180	51	68
149	55	72	181	50	64
150	54	71	182	50	64
151	54	72			
xx	Shaded cell indicates target criterion is exceeded				

METRONET - Yanchep Rail Extension - Butler
Predicted $L_{Aeq,day}$ Noise Levels - Existing & Proposed Noise Barriers

Figure 5-1

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METRONET - Yanchep Rail Extension - Alkimos
Predicted $L_{Aeq,day}$ Noise Levels - Existing & Proposed Noise Barriers

Figure 5-2

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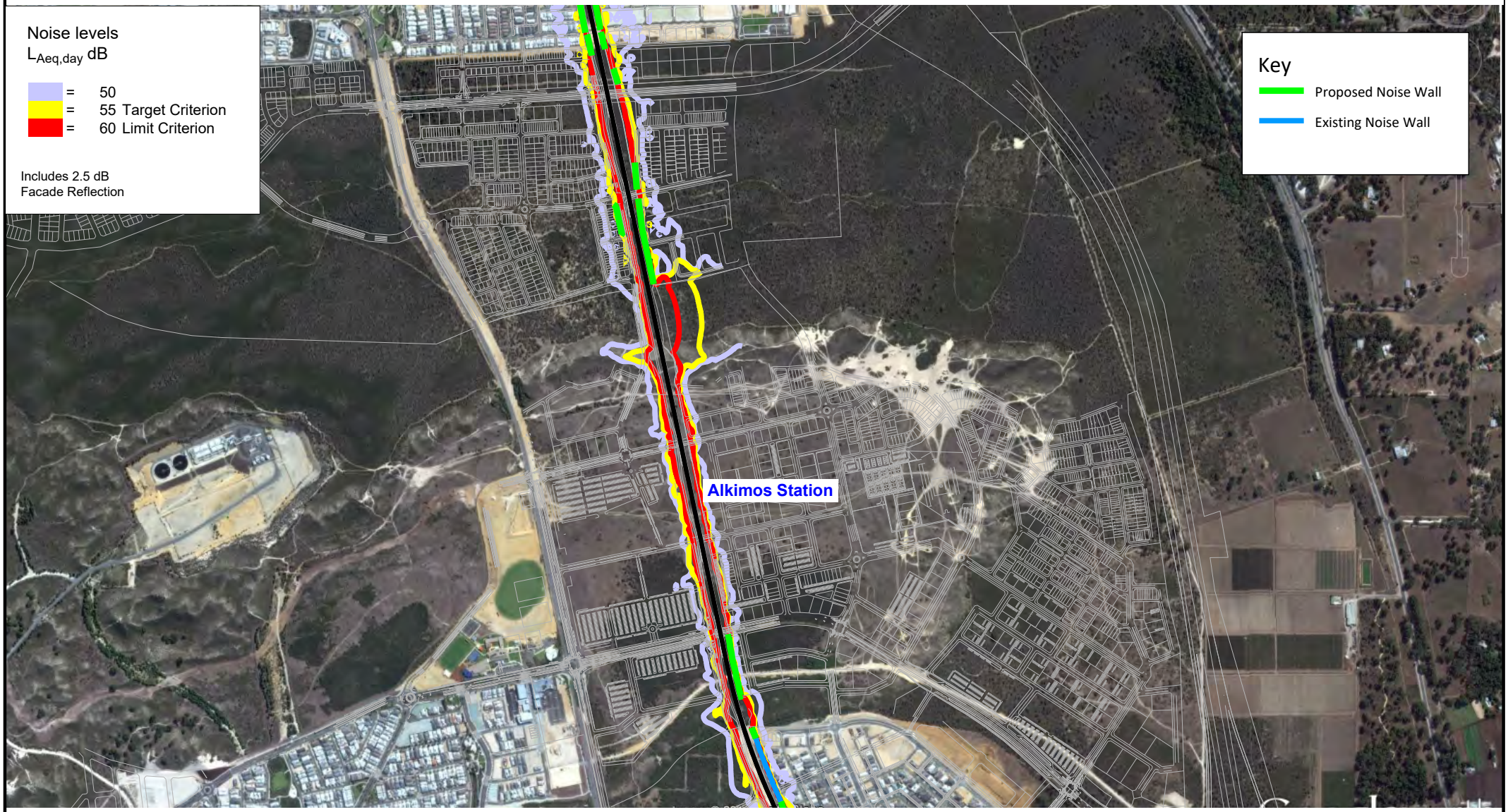
METRONET - Yanchep Rail Extension - North of Alkimos
Predicted $L_{Aeq,day}$ Noise Levels - Existing & Proposed Noise Barriers

Figure 5-3



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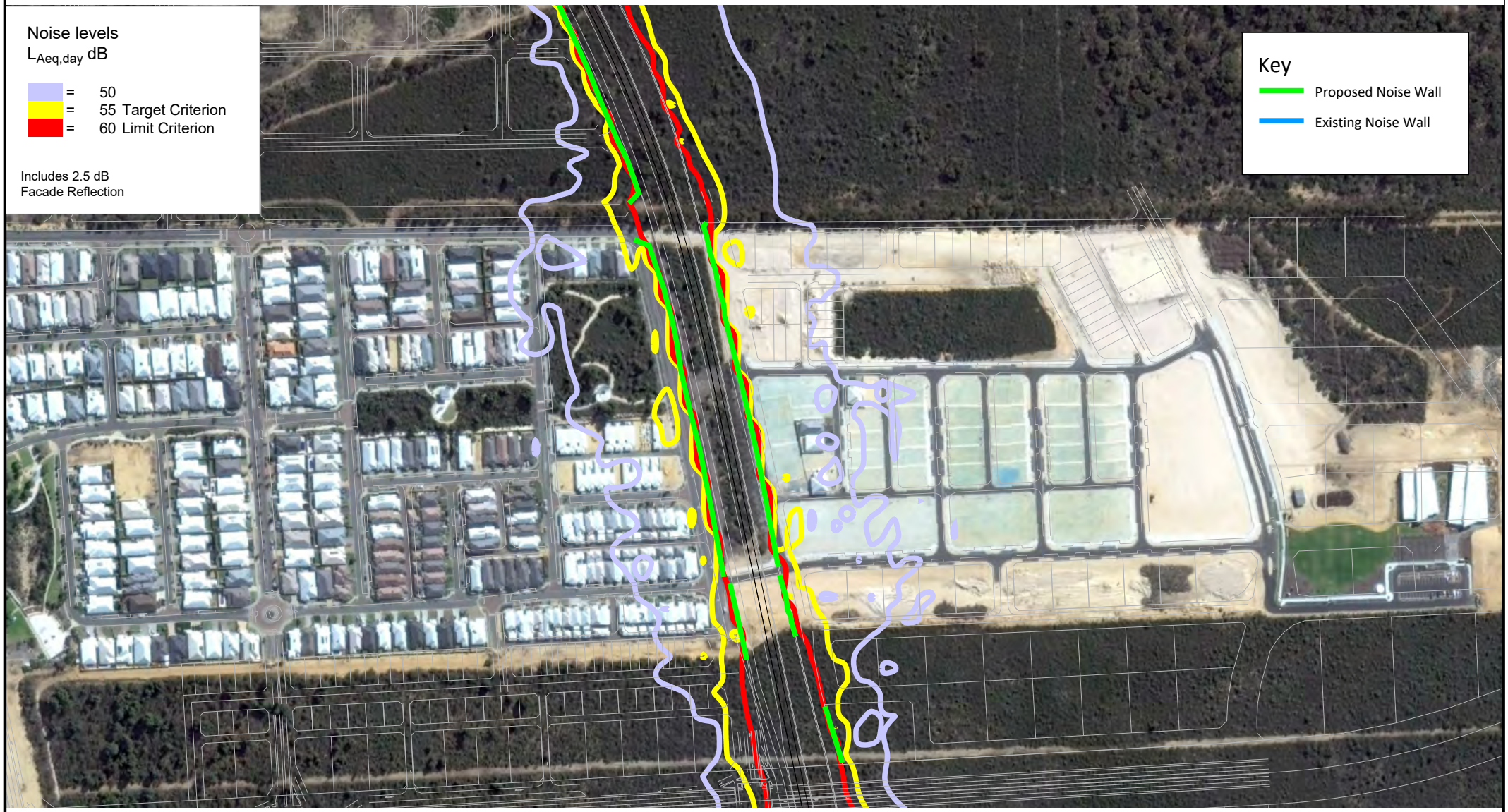
METRONET - Yanchep Rail Extension - Shorehaven
Predicted $L_{Aeq,day}$ Noise Levels - Existing & Proposed Noise Barriers

Figure 5-4



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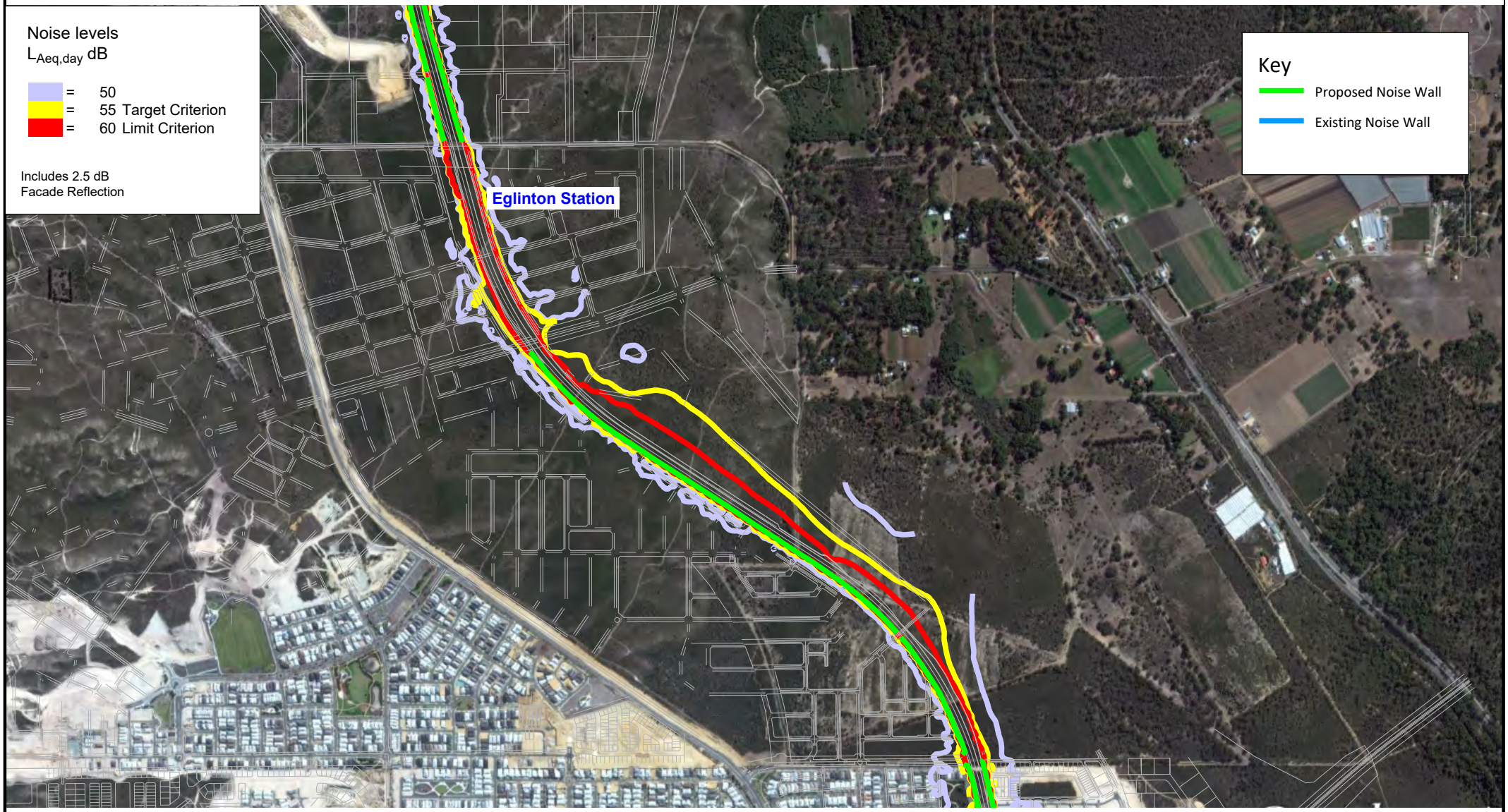
METRONET - Yanchep Rail Extension - North of Shorehaven
Predicted $L_{Aeq,day}$ Noise Levels - Existing & Proposed Noise Barriers

Figure 5-5



Scale
0 50100 200 300 400 500 600
m

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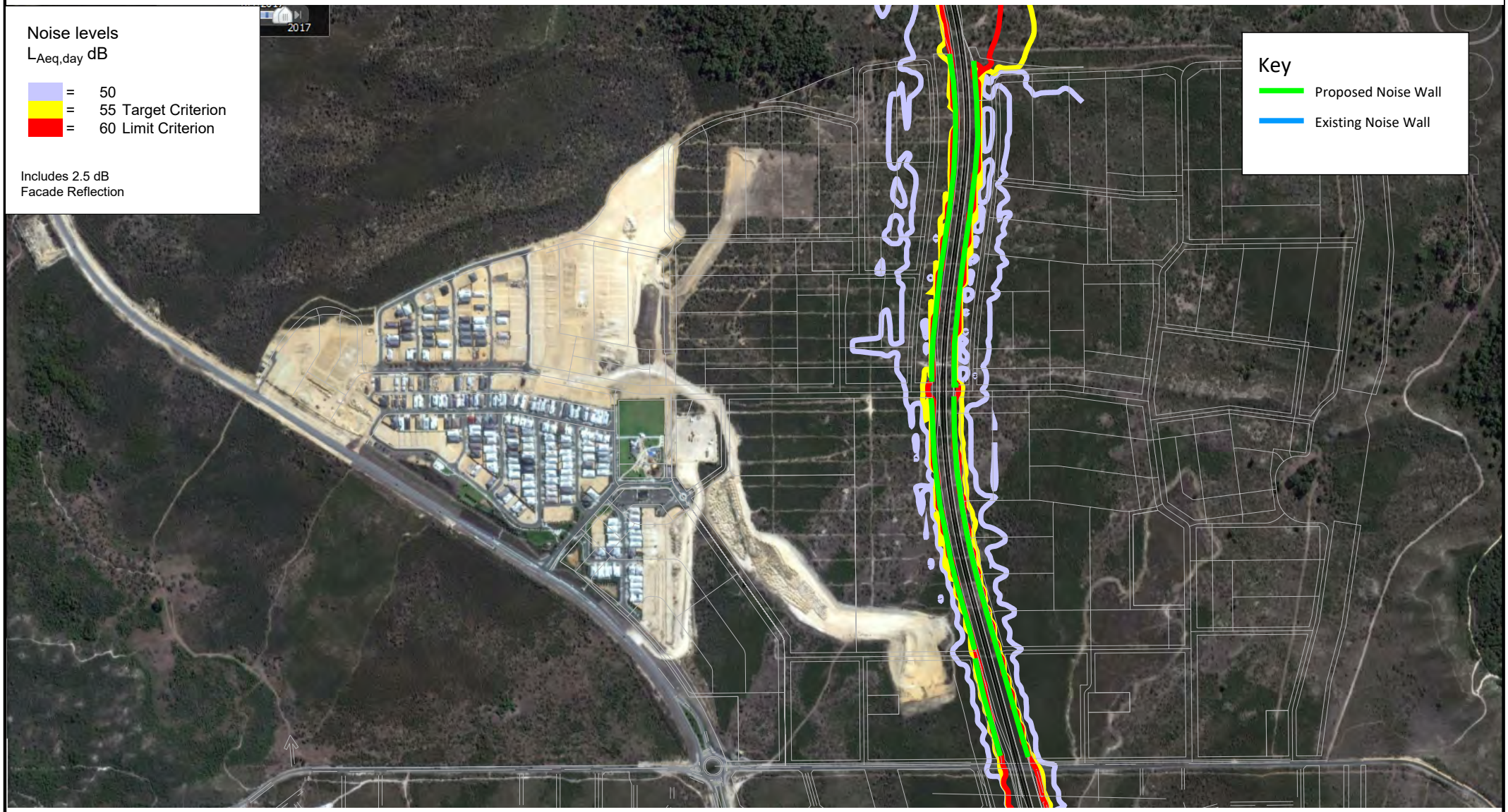
METRONET - Yanchep Rail Extension - Eglinton
Predicted $L_{Aeq,day}$ Noise Levels - Existing & Proposed Noise Barriers

Figure 5-6



Scale
0 50 100 200 300 400 500 600 m

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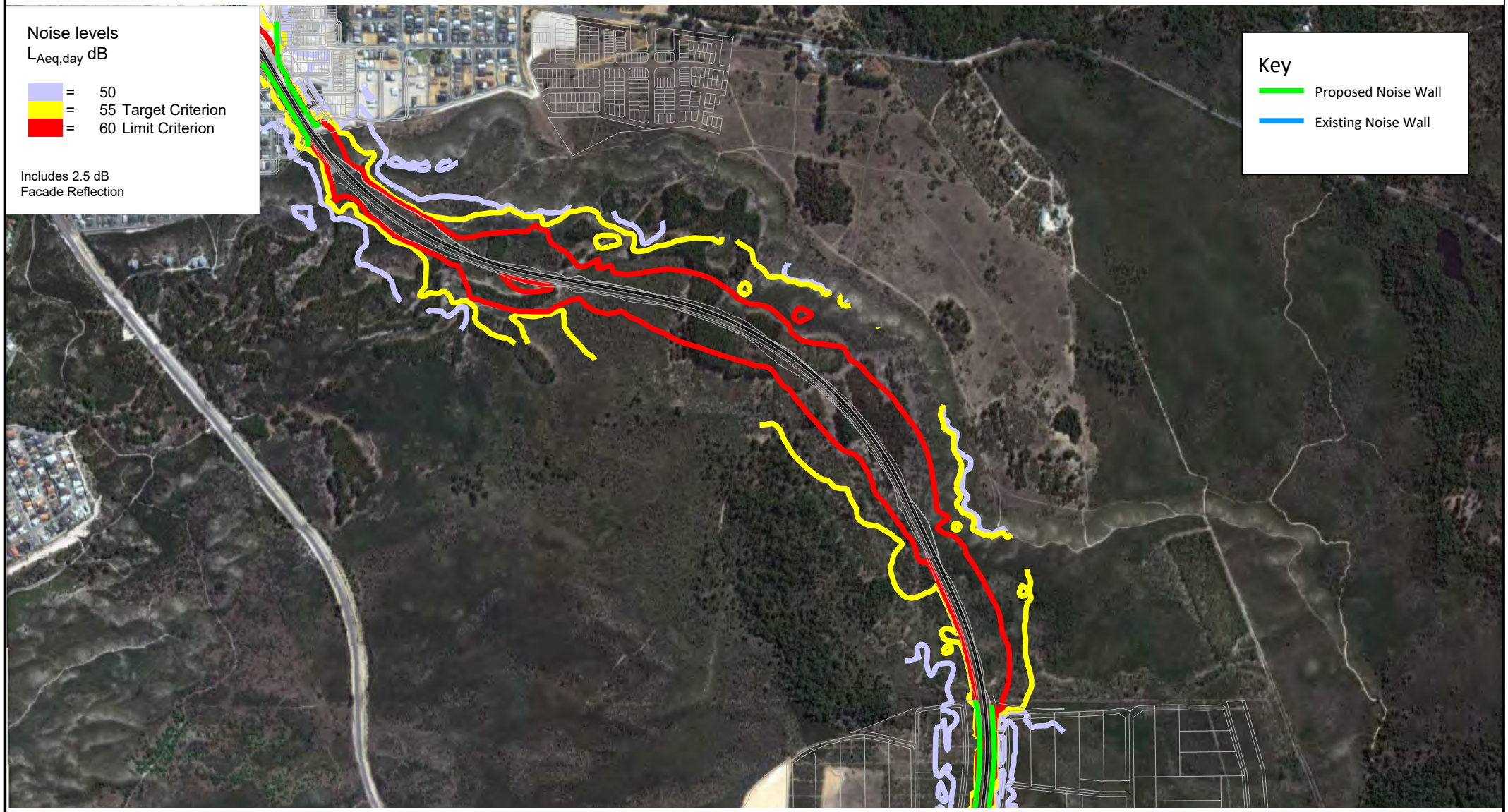
METRONET - Yanchep Rail Extension - North of Eglinton
Predicted $L_{Aeq,day}$ Noise Levels - Existing & Proposed Noise Barriers

Figure 5-7



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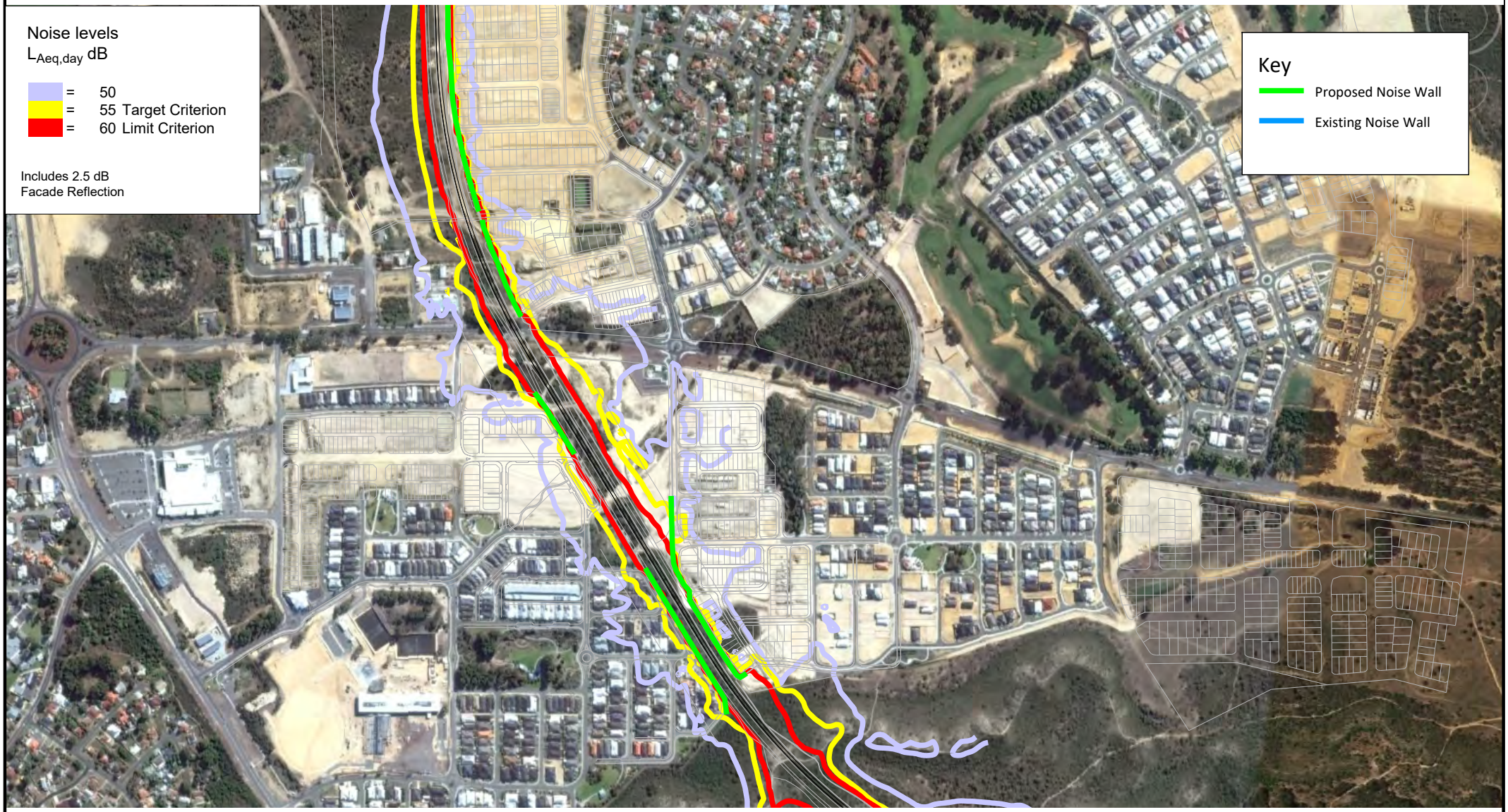
METRONET - Yanchep Rail Extension - South Yanchep
Predicted $L_{Aeq,day}$ Noise Levels - Existing & Proposed Noise Barriers

Figure 5-8



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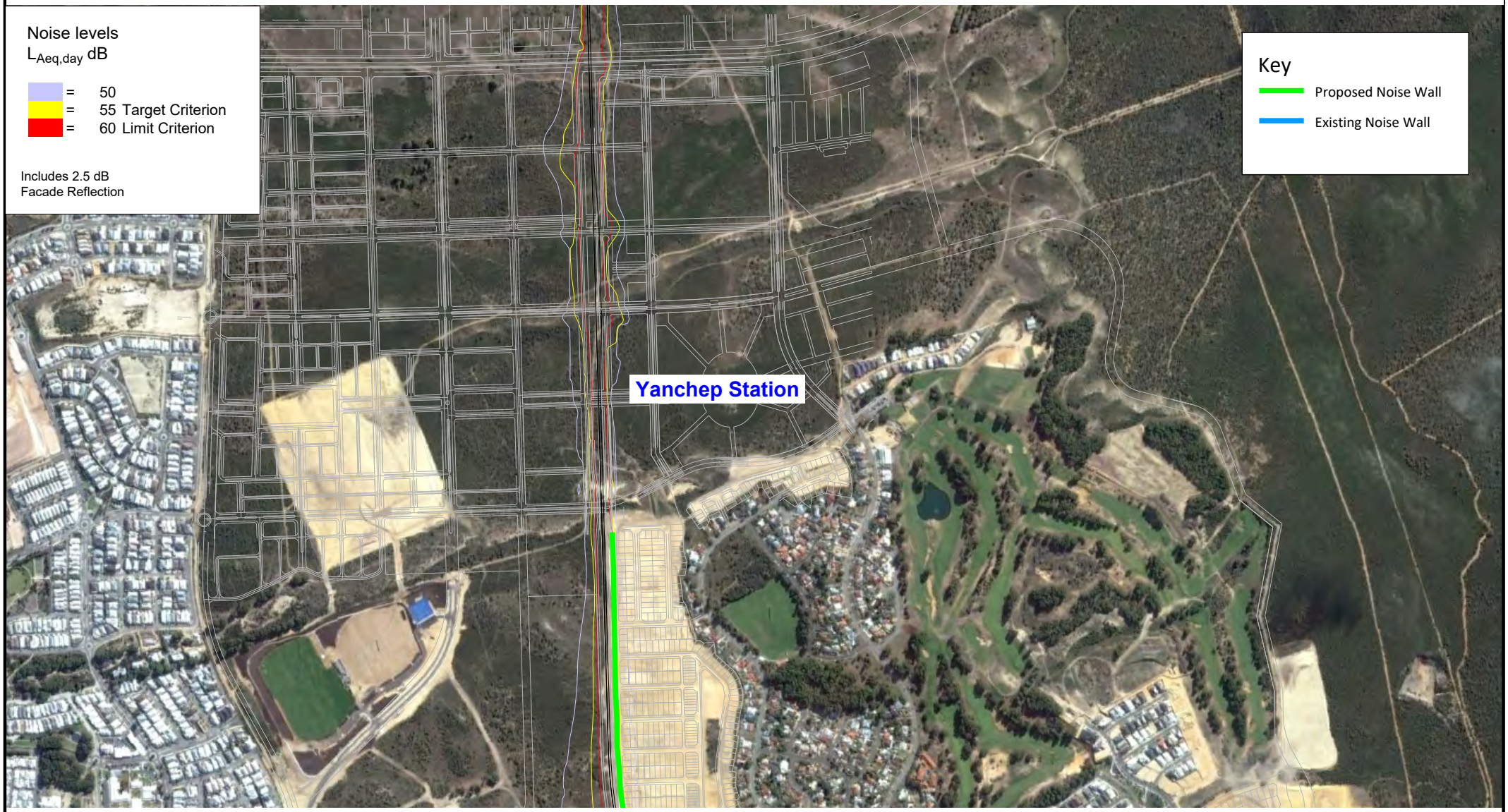
METRONET - Yanchep Rail Extension - North Yanchep
Predicted $L_{Aeq,day}$ Noise Levels - Existing & Proposed Noise Barriers

Figure 5-9



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5.2 Vibration Control

The results of the vibration assessment show the criterion of 103 dB_V is predicted to be marginally exceeded at a number of locations along the railway alignment. While vibration criteria for aboveground railways are generally set to address annoyance (i.e. Curve 1.4 AS2670.2-1990), the ground conditions south of Butler Station resulted in a number of properties experiencing structure-borne regenerated noise issues (rumbling) as trains passed by. As a result of this, PTA have committed to installing ballast matting adjacent to all existing and approved future residential developments. A reduction of between 10 to 15 dB_V can be expected which would significantly reduce vibration levels to well below the vibration criterion.

6 CONCLUSION

This assessment has shown that to ensure that noise levels are below the Policy *target* criteria at ground floor level of all existing and future noise sensitive receivers adjacent to the proposed Butler to Yanchep railway, noise walls will need to be constructed. The proposed noise wall design is provided in *Appendix C*. It should be acknowledged that the design of these barriers might change when the detailed design (i.e. design levels or building façade noise control packages) of residential subdivisions are further developed. In addition the responsibility for construction of barriers will also need to be confirmed at this time.

In respect to ground-borne vibration levels, the installation of ballast matting adjacent to all existing and approved future residential developments is expected to reduce vibration levels by 10 to 15 dB_V, which would result in levels being well below the vibration criterion.

Appendix A

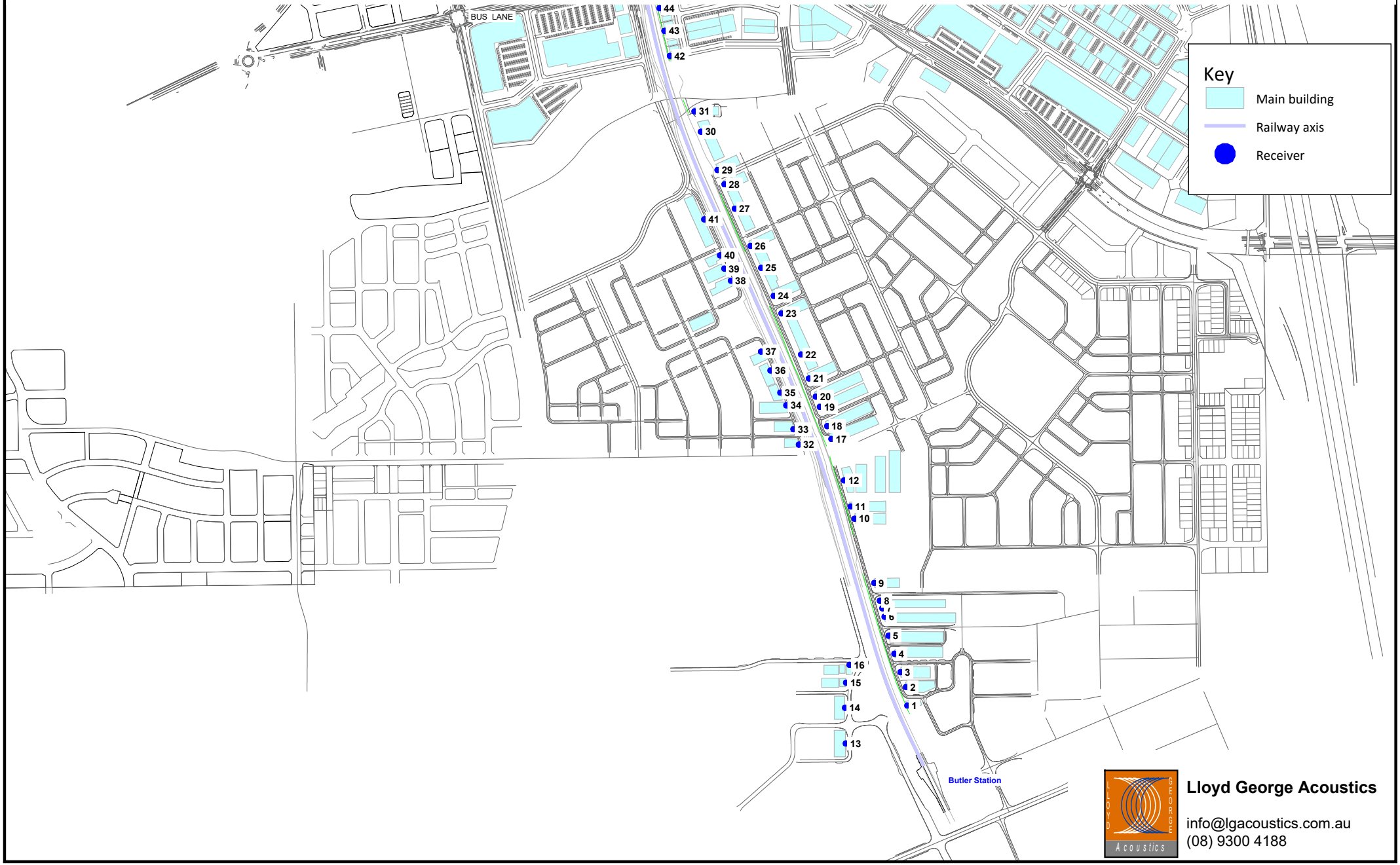
Noise Sensitive Receiver Locations

METRONET - Yanchep Rail Extension
Receiver Locations

Scale
0 50 100 200 300 400 m

N

Figure A1



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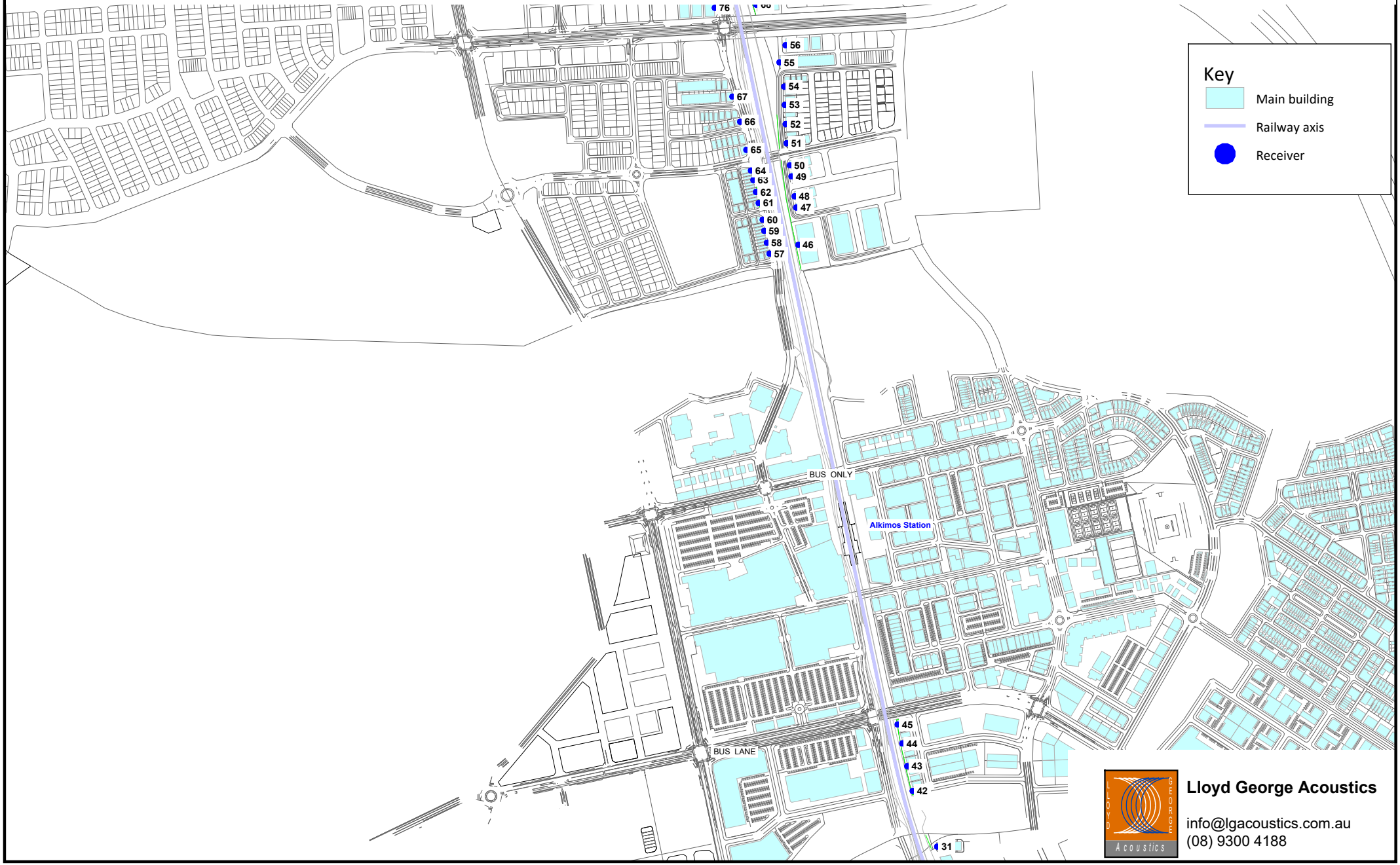
METRONET - Yanchep Rail Extension
Receiver Locations

Scale
0 50 100 200 300 400 m

N

Figure A2



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METRONET - Yanchep Rail Extension
Receiver Locations

Scale
0 50 100 200 300 400 m

N

Figure A3

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METRONET - Yanchep Rail Extension
Receiver Locations

Scale
0 50 100 200 300 400 m

N

Figure A4

Key
- Main building
- Railway axis
- Receiver

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METRONET - Yanchep Rail Extension
Receiver Locations

Scale
0 50 100 200 300 400 m

N

Figure A5

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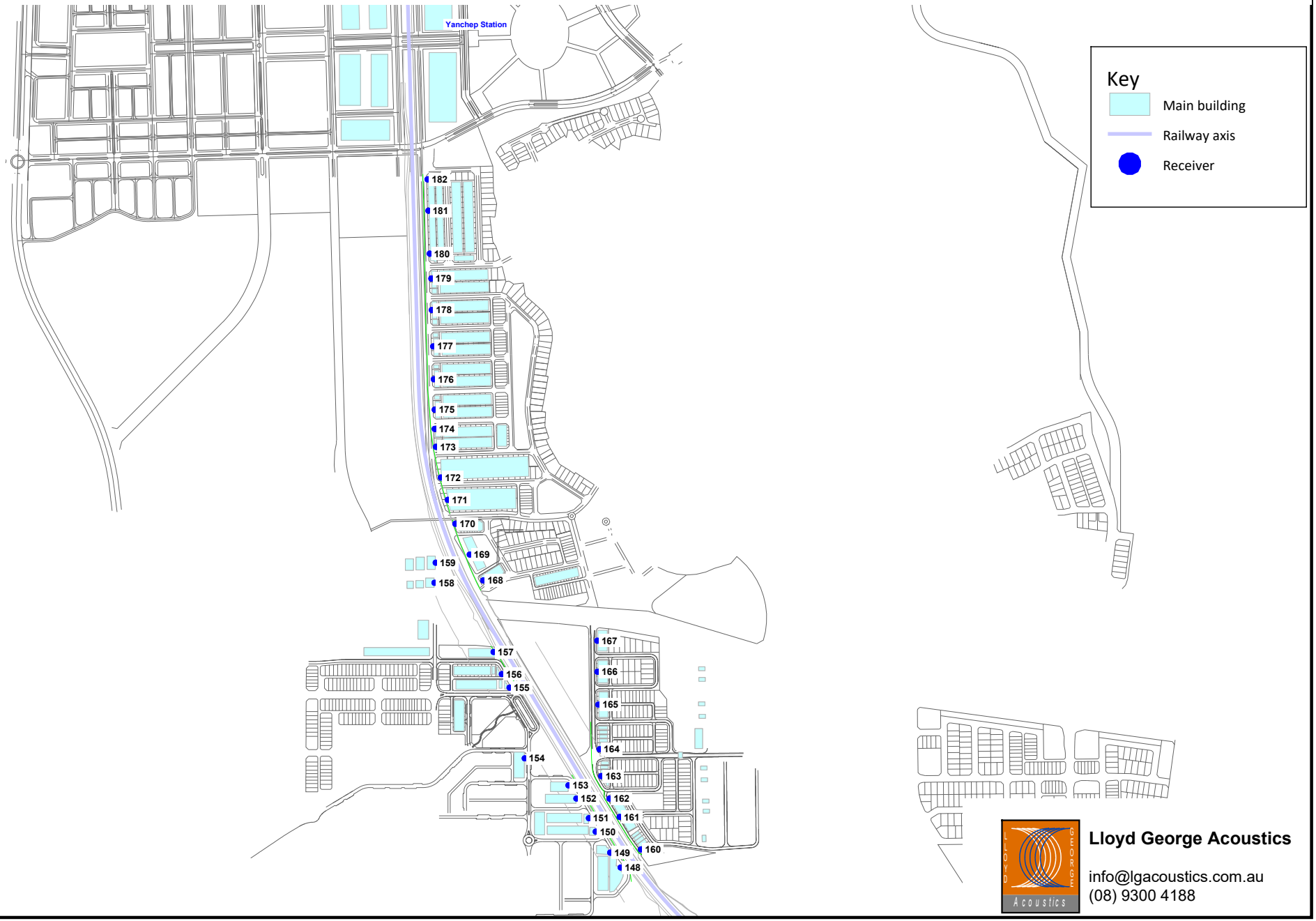
METRONET - Yanchep Rail Extension
Receiver Locations

Scale
0 50 100 200 300 400 m

N

Figure A6



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Appendix B

Results of External Noise Monitoring South of Butler Station

Table B-1 Results of External Noise Monitoring South of Butler Station

Address	$L_{Aeq\ (Day)}$ dB	$L_{Aeq\ (Night)}$ dB	L_{Amax} dB
U4/19 Capitol Turn, Clarkson	43	39	62
99 Liberty Drive, Clarkson	47	37	50
48 Balin Lane, Clarkson	43	40	58
42 Corinda Way, Ridgewood*	47	42	63
44 Kilkee Street, Ridgewood	55	51	80
33 Manasota Approach, Butler*	48	40	54
41 Claremorris Parkway, Butler	47	41	69
27 Rosegreen Avenue, Butler	48	40	69
30 Cape Meares Crescent, Butler	51	41	69
7 Boncath Road	46	38	41
29 Thurleigh Approach	48	43	47
15 Dirleton Loop, Butler	51	41	61
42 Vanderlin Crescent, Ridgewood	46	39	61
15 Blackrock Avenue, Butler	46	40	63

Note: * Indicates that the L_{Aeq} levels were highly influenced by barking dogs. In these instances, the L_{A25} level was used as this correlated well with the L_{Aeq} level but generally excluded short-term high noise events such as dogs barking.

Appendix C

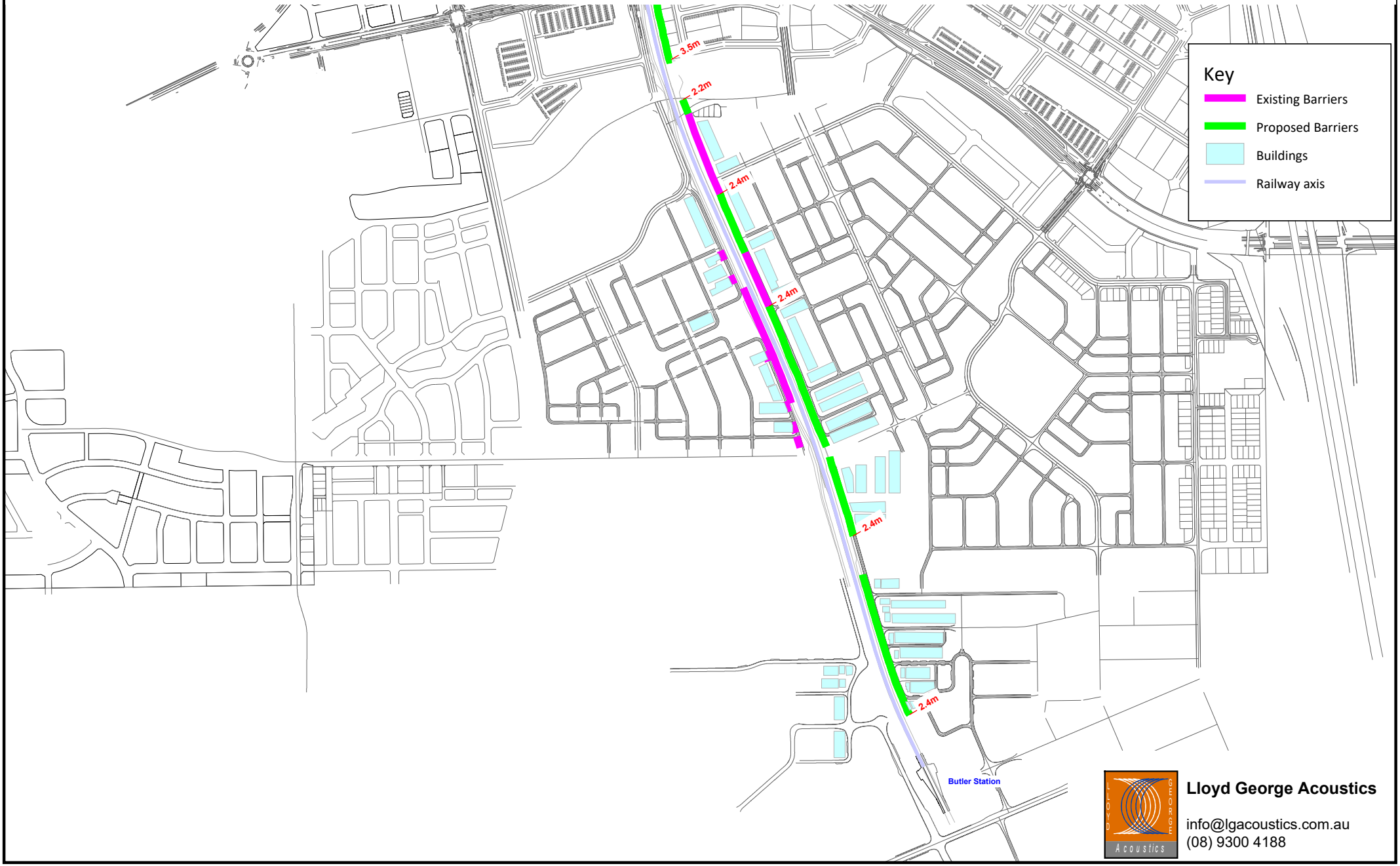
Noise Wall Details

METRONET - Yanchep Rail Extension
Proposed Noise Barriers

Scale
0 50 100 200 300 400 m

N

Figure C1



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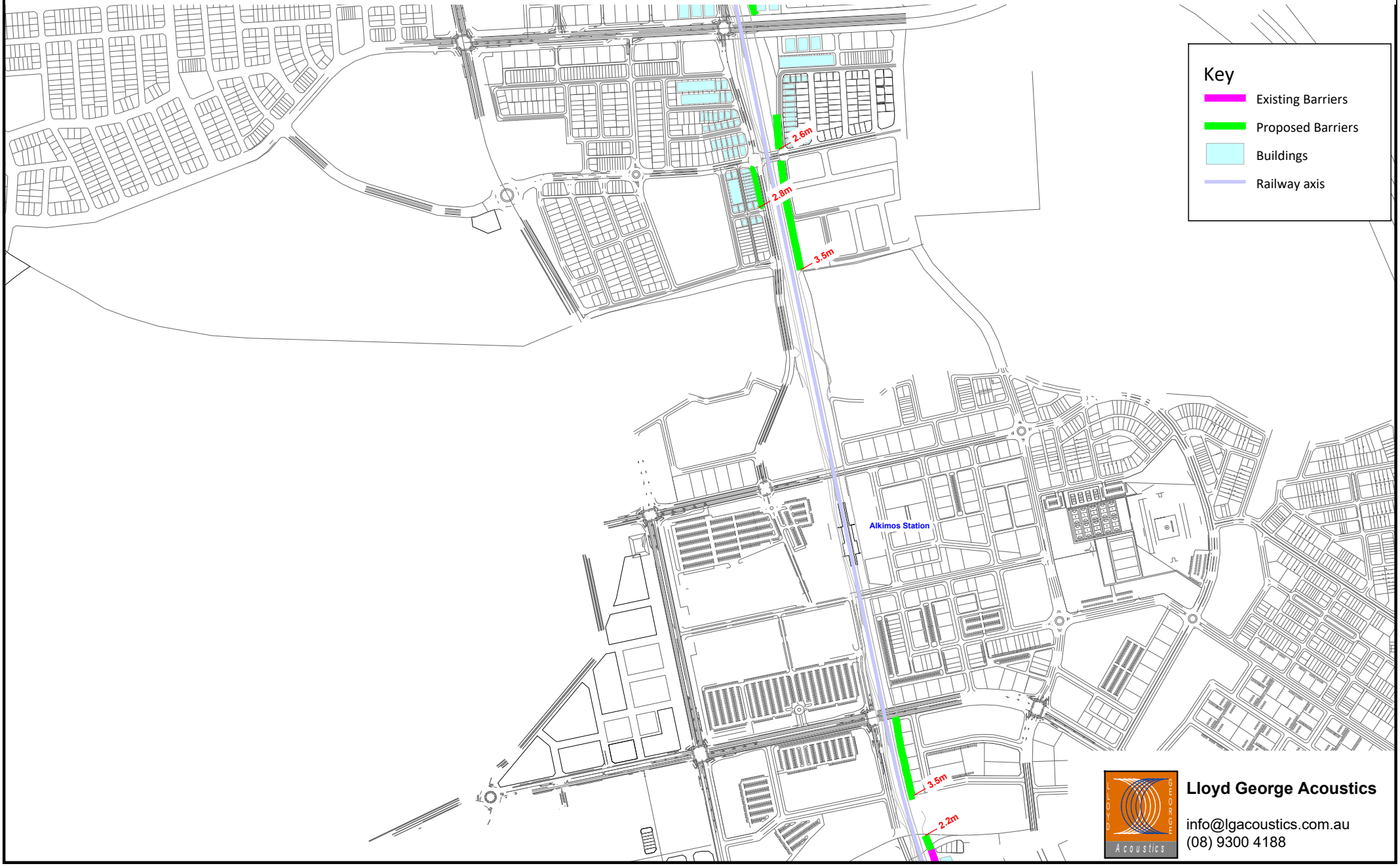
METRONET - Yanchep Rail Extension
Proposed Noise Barriers

Scale
0 50 100 200 300 400 m

N

Figure C2



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METRONET - Yanchep Rail Extension
Proposed Noise Barriers

Scale
0 50 100 200 300 400 m

N

Figure C3

Key
- Existing Barriers
- Proposed Barriers
- Buildings
- Railway axis

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METRONET - Yanchep Rail Extension
Proposed Noise Barriers

Scale
0 50 100 200 300 400 m

N

Figure C4

Key
- Existing Barriers
- Proposed Barriers
- Buildings
- Railway axis

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METRONET - Yanchep Rail Extension
Proposed Noise Barriers

Scale
0 50 100 200 300 400 m

N

Figure C5

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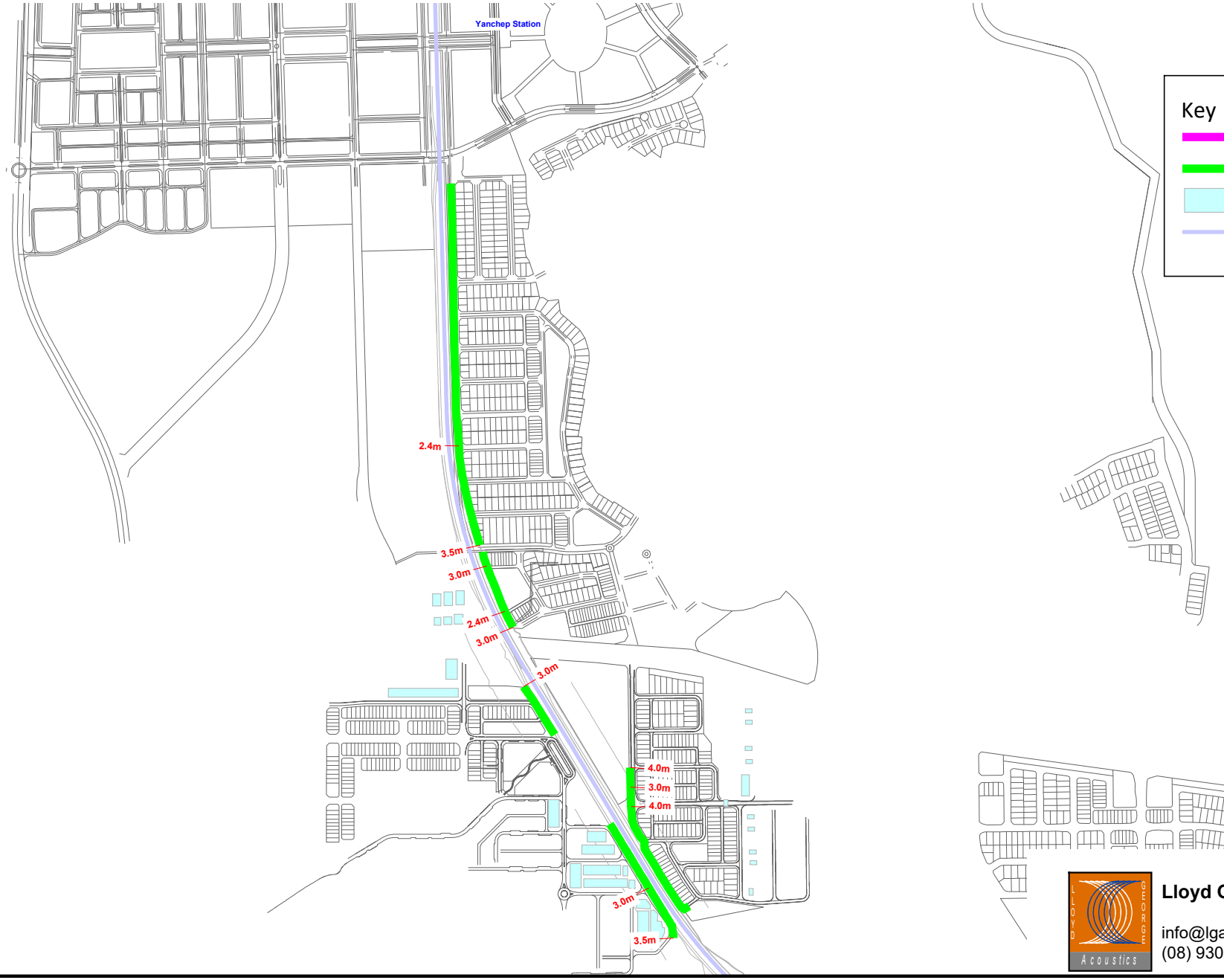
METRONET - Yanchep Rail Extension
Proposed Noise Barriers

Scale
0 50 100 200 300 400 m

N

Figure C6



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Appendix D

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)
The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting
An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

L_1
An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{10}
An L_{10} level is the noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{90}
An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}
The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$
The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$
The $L_{Aeq,24\ hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

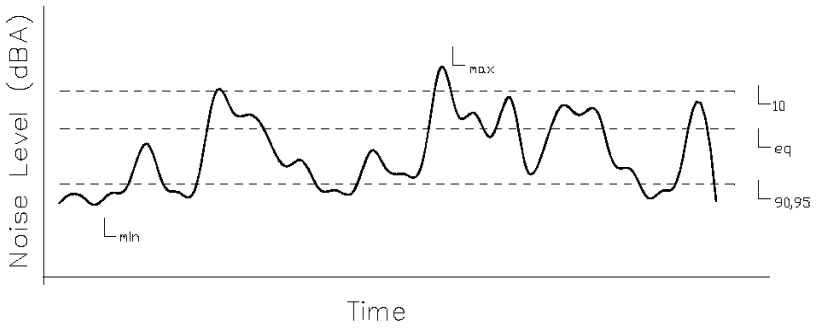
$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$
The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
The $L_{Aeq\ (Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

Satisfactory Design Sound Level
The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.

Maximum Design Sound Level
The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.

Chart of Noise Level Descriptors



Typical Noise Levels