Airport Link
Phase 2 – Detailed Feasibility

CHAPTER 10

NOISE AND VIBRATION

- October 2006

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10. Noise and Vibration

This Chapter addresses Section 5.5 of the Terms of Reference. Results of technical studies undertaken as part of the project are summarised from Technical Report No 6–Noise and Vibration in Volume 3 of the EIS. The existing noise environment is described for areas with potential to be affected by construction and/or operation of the proposed tunnels and roadways. Baseline monitoring at selected sites, adjacent to potentially sensitive locations in the study corridor has been undertaken to determine the existing noise environment. The only earlier ambient noise monitoring results pertinent to this project are those from the most northerly monitoring sites of the NSBT Project.

Construction noise and vibration impacts from tunnelling, road works, worksite operations and spoil haulage routes are identified and assessed against relevant criteria. Operational noise and vibration impacts are also identified and assessed against relevant criteria. A 3-D noise contour model is used to model air-borne noise transmission, including predicted traffic noise, around critical portal areas which include potential ventilation outlet sites and new surface roadways.

Predicted noise levels are compared with planning levels stated in the Environmental Protection (Noise) Policy 1997 and Department of Main Roads 'Road Traffic Noise Management: Code of Practice 2000'. Where predicted noise and vibration levels are found to exceed criteria or guidelines, appropriate mitigation measures are suggested to manage these impacts.

10.1 Description of Existing Environment

Chapter 10 – Noise and Vibration is based on a comprehensive investigation and analysis of the existing acoustic environment and the likely impacts of the construction and operation of the Airport Link Project. The findings of this comprehensive study are presented in a report prepared by Heggies Australia Pty Ltd, dated July 2006, and contained in Technical Report 6 – Noise and Vibration in Volume 3 of the EIS

10.1.1 Noise

Data from which the existing noise environment is deduced have been obtained from:

- Site inspections during peak traffic periods and during quiet periods late at night;
- Unattended continuous measurement of sound pressure levels at selected locations over a 7 day period.

Noise monitoring sites have been selected to be representative of residential development that may be potentially affected by the Airport Link project. Site selection has focused on residential development as it is generally the most noise-sensitive type of development in areas that may be affected by the tunnel. One monitoring site was established on a sensitive community facility being the Royal Brisbane Hospital facing Bowen Bridge Road. The details of the selected noise monitoring sites, and their relevance to potential tunnel noise issues is summarised in **Table 10-1**.

The noise environment in the study corridor area is typical of many inner urban areas, in that it is largely determined by road traffic noise. However at some locations rail noise and/or mechanical plant noise are other significant sources. Elevated night time background noise levels at two sites adjacent to Kalinga Park are attributed to nocturnal insect activity.

Monitoring sites were inspected during morning or afternoon peak traffic times and also during the late night/early morning period when background noise is typically quietest. The dominant audible sounds at each

location are summarised in **Table 10-2**. As can be seen in **Table 10-2**, traffic noise from nearby major roadways was a dominant source of noise at all times of the day.

Maps detailing the noise monitoring locations and photographs showing the noise logger position at each monitoring site are presented in Technical Report No. 6 – Noise and Vibration in Volume 3 of the EIS

Table 10-1 Noise Monitoring Locations

Address	Relevance to Tunnel Noise Issues	Location in Appendix A
30 Wongara Street, Clayfield	Construction and operational (surface traffic and/or ventilation outlet) impacts at north-eastern portal	Location 1
86 Alma Road, Clayfield	Construction and operational (surface traffic and/or ventilation outlet) impacts at north-eastern portal	Location 2
27 Parkland Street, Nundah	Construction and operational (surface traffic and/or ventilation outlet) impacts at north-eastern portal	Location 3
72 Kalinga Street, Clayfield	Construction impacts associated with north-eastern portal	Location 4
34 Park Road, Kedron (Kedron State High School)	Construction impacts associated with East to West Link	Location 5
20 Perry Street, Lutwyche	Construction and operational (surface traffic and/or ventilation outlet) impacts at north-western portal	Location 6
30 Colton Avenue, Lutwyche	Construction and operational (surface traffic and/or ventilation outlet) impacts at north-western portal	Location 7
12 Park Terrace, Kedron	Construction and operational (surface traffic and/or ventilation outlet) impacts at north-western Portal	Location 8
46 Gallway Street, Windsor	Construction and operational (surface traffic and/or ventilation outlet) impacts at southern Portal	Location 9
49 Earle Street, Windsor	Construction and operational (surface traffic and/or ventilation outlet) impacts at southern Portal	Location 10
Royal Womens Hospital	Construction and operational (surface traffic and/or ventilation outlet) impacts at southern Portal	Location 11
62 Victoria Street, Windsor	Construction impacts associated with tunnel	Location 12

Table 10-2 Dominant (Observed) Noise Sources

Location	Description	Dominant Daytime Noise Sources	Dominant Noise Sources Late at Night
1	Rear landing; logger on upper storey, with a facade reflection, facing E-W Arterial (behind noise barriers)	East West Arterial Road Traffic	East West Arterial Road Traffic
2	Rear yard, detached dwelling at 86 Alma Road, Clayfield	Sandgate Road traffic, Northern and Air Train railway	Sandgate Road traffic, Northern Line and Air Train rail traffic, insects
3	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	Sandgate Road traffic, Northern Line and Air Train rail traffic, Construction Work	Sandgate Road Traffic, North Coast Line and Air Train rail traffic
4	Rear yard, eastern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	Sandgate Road Traffic, North Coast Line and Air Train rail traffic	Sandgate Road Traffic, North Coast Line and Air Train rail traffic, insects
5	On top of awning adjacent to canteen block, facing Kedron Brook and Gympie Road, at Kedron State High	Lutwyche Road/Gympie Road Traffic	Lutwyche Road/Gympie Road Traffic, Mechanical Plant from Dept of Emergency Services
6	Front yard, with a facade reflection, 2m above ground, facing Gympie Road, detached dwelling	Lutwyche Road/Gympie Road Traffic	Lutwyche Road/Gympie Road Traffic
7	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	Lutwyche Road/Gympie Road Traffic, Pool Filter	Lutwyche Road/Gympie Road Traffic
8	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	Gympie Road traffic, commercial activities (car yard), mechanical Plant	Gympie Road Traffic, distant mechanical plant
9	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	Ferny Grove Line and Mayne Yards rail noise, barking dogs, local road traffic	Rail noise from Mayne Yards, dogs barking
10	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	Lutwyche Road/ICB traffic, local (Earle Street) traffic, rail noise from Mayne yards	Lutwyche Road/ICB Traffic, Rail noise from Mayne Yards, distant mechanical plant
11	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	Bowen Bridge Road, Campbell Street traffic, mechanical plant, Helicopter on Hospital	Bowen Bridge Road and Campbell Street Traffic, mechanical plant
12	Front yard, detached dwelling at 62 Victoria Street, Windsor	Lutwyche Road and local (Victoria St) traffic, commercial activities across road	Lutwyche Road Traffic, Localised (Victoria Street) Traffic

Noise logger measurements were undertaken between Thursday 24 November and Thursday 15 December 2005. Weather conditions during this period were typically fine and warm to hot however, there were some periods of significant rainfall. Winds were generally light to moderate with typically calm conditions, or light winds, occurring at night.

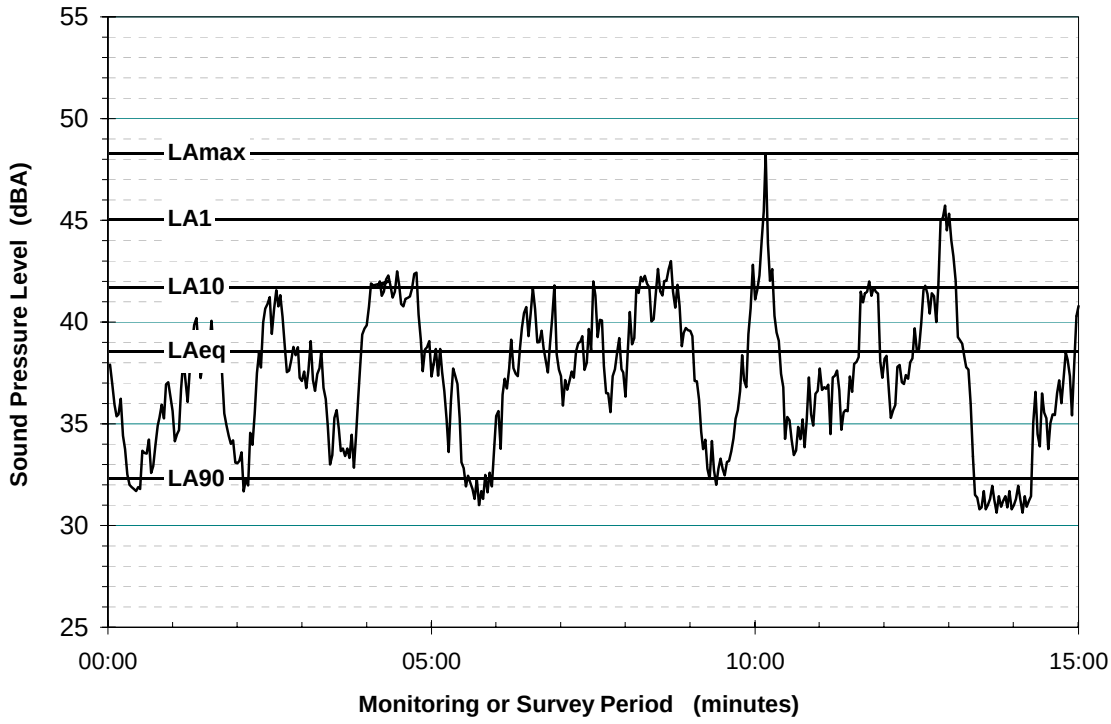
Results of the noise logger measurements are summarised in **Tables 10-5** to **10-7** and provided in full detail (including the prevailing weather conditions) in Appendix B of Technical Report No. 6 – Noise and Vibration in Volume 3 of this EIS. These tables of results (**Tables 10-5** to **10-7**) exclude noise monitoring results obtained during periods of rain (greater than 0.5 mm per 15 minute interval) or high wind speeds (greater than 5 m/s) as recommended in AS 1055.1. Operator-attended noise measurements are summarised in **Table 10-7**.

Noise level descriptors used in the EIS and the supporting Technical Reports are tabulated in **Table 10-3** and graphically illustrated in **Table 10-4**.

Table 10-3 Noise Level Descriptors

LAmax	The maximum A-weighted noise level associated with a noise sampling period.
LA1	The noise level exceeded for 1% of a given measurement period. This parameter is often used to represent the typical maximum noise level in a given period.
LA10	The A-weighted sound pressure level exceeded 10% of a given measurement period and is utilised normally to characterise average maximum noise levels.
LAeq	The average sound level is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound over the same period.
LA90	The A-weighted sound pressure level exceeded 90% of a given measurement period and is representative of the average minimum background sound level (in the absence of the source under consideration), or simply the "background" level.

Table 10-4 Graphical Representation of Noise Level Descriptors



- **Table 10-5 Existing Noise Levels – Background and L_{Aeq} Parameter**

Locations		Traffic Noise $L_{A10(18hr)}$ (dBA) Planning Level 68dBA	Minimum Average Background Levels+ (standard deviation) L_{A90} (dBA)			Maximum night $L_{aeq(1hr)}$ dBA Planning Level 60 dBA	LAeq Levels + (standard deviation)		
			Day 6am – 6pm	Ev'ing 6pm – 10pm	Night 10pm – 6am		Day 6am – 6pm	Evening 6pm – 10pm	Night 10pm – 6am
1	30 Wongara St, Clayfield	58	49(2.2)	50(4.0)	40(2.8)	52	59 (2.7)	61 (59.8)	48 (3.3)
2	86 Alma Rd, Clayfield	61	47 (4.5)	55 (2.4)	55 (3.2)	58	59 (2.9)	60 (60.4)	58 (1.6)
3	27 Parkland St, Nundah	62	53 (3.1)	50 (4.8)	42 (3.0)	57	62 (2.3)	62 (62.1)	52 (5.9)
4	72 Kalinga St, Clayfield	54	45 (2.5)	48 (5.0)	41 (2.3)	49	54 (2.5)	59 (5.6)	49 (3.8)
5	34 Park Rd, Kedron	52	45 (2.5)	43 (4.7)	34 (1.4)	40	56 (3.8)	51 (4.8)	38 (2.7)
6	20 Perry St, Lutwyche	67	58 (1.5)	55 (3.0)	47 (4.1)	63	65 (1.1)	64 (1.3)	61 (3.0)
7	30 Colton Ave, Lutwyche	53	48 (1.8)	45 (2.2)	39 (3.1)	48	53 (2.2)	51 (3.3)	45 (3.6)
8	12 Park Tce, Kedron	58	50 (2.4)	48 (2.7)	40 (3.8)	52	60 (3.5)	57 (4.8)	51 (3.3)
9	46 Gallway St, Windsor	54	47 (2.0)	48 (3.0)	41 (1.6)	49	54 (2.5)	54 (2.9)	47 (3.2)
10	49 Earle St, Windsor	54	47 (1.4)	46 (2.7)	42 (1.9)	49	54 (2.1)	52 (2.8)	47 (2.1)
11	Royal Women's Hospital	69	62 (0.5)	61 (0.6)	60 (0.5)	65	67 (0.7)	66 (0.9)	64 (1.6)
12	62 Victoria St, Windsor	56	48 (1.8)	45 (2.6)	39 (2.6)	51	56 (2.1)	52 (2.8)	48 (4.4)

Table 10-6 Existing Noise Levels - LAmax Parameter

Locations		Description	LAmax Levels + (standard deviation)		
			Day6am – 6pm	Evening 6pm – 10pm	Night10pm – 6am
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling, logger on upper (2nd) storey, includes a facade reflection, facing East-West Arterial Road (behind noise barriers)	76 (5.3)	71 (5.0)	64 (6.1)
2	86 Alma Rd, Clayfield	Rear yard, detached dwelling	70 (3.4)	69 (3.2)	66 (4.5)
3	27 Parkland St, Nundah	Southern property boundary facing parkland, detached dwelling	79 (3.8)	81 (4.2)	65 (9.5)
4	72 Kalinga St, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga St, Clayfield	72 (3.9)	70 (4.7)	62 (7.7)
5	34 Park Rd, Kedron	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School	74 (5.1)	63 (7.8)	52 (8.6)
6	20 Perry St, Lutwyche	Front yard, with a facade reflection, 2 m above ground, facing Gympie Rd, detached dwelling	81 (4.3)	80 (4.3)	76 (3.5)
7	30 Colton Ave, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	68 (4.9)	62 (5.5)	58 (6.0)
8	12 Park Tce, Kedron	Rear yard western property boundary, detached dwelling	70 (4.2)	67 (4.8)	62 (5.0)
9	46 Gallway St, Windsor	Rear verandah northwest corner, detached dwelling	75 (5.6)	72 (6.6)	63 (7.2)
10	49 Earle St, Windsor	Front yard near southern boundary, detached dwelling	72 (4.2)	68 (5.0)	62 (5.5)
11	Royal Women's Hospital	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	78 (4.4)	77 (3.6)	75 (4.2)
12	62 Victoria St, Windsor	Front yard, detached dwelling	75 (4.9)	70 (4.5)	64 (7.2)

Table 10-7 Summary of Operator-Attended (Short-term) Noise Measurements

Measurement Location	Date - Time	Period	L10 (dBA)	Leq (dBA)	L90 (dBA)	Discernible Sources
49 Earle St, Windsor	12/12/05 - 13:05	Day	52	52	45	Traffic on Lutwyche Road, Birds, Mayne Rail Yard.
	06/12/05-00:15	Night	45	43	41	Traffic on Lutwyche Road, Mayne Rail Yard, distant mechanical plant.
72 Kalinga St, Clayfield	12/12/05 - 12:19	Day	58	55	44	Traffic on Sandgate Road, Train Passby, Birds and Insects
	12/12/05 - 01:32	Night	43	41	38	Traffic on Sandgate Road, Train Passby, Insects
20 Perry St, Lutwyche	09/12/05 - 17:35	Day	65	64	58	Traffic on Gympie Road, Birds and Insects
	09/12/05 - 23:00	Night	65	62	51	Traffic on Gympie Rd, Birds and Insects

10.1.2 Vibration

Vibration measures were carried out at fours locations (**Table 10-8**) to determine existing vibration levels prior to the start of construction. These measurements show that existing vibration levels are at or below the floor of the measurement equipment (~0.08 mm/s) and therefore below the threshold of human perception (~ 0.15 mm/s)

- **Table 10-8 Summarised Vibration Measurements**

Location	Date – Time	Dominant Frequency	Max PPV mm/s
49 Earle Street, Windsor	16/12/05 – 15:04	>100 Hz	0.08 mm/s
72 Kalinga Street, Clayfield	16/12/05 – 14:17	>100 Hz	0.08 mm/s
20 Perry Street, Lutwyche	16/12/05 – 14:33	>100 Hz	0.08 mm/s

10.2 Potential Construction Impacts and Mitigation Measures

10.2.1 Community Values

For both construction and operational phases of the Airport Link Project, the Queensland Environmental Protection (Noise) Policy 1997 defines the values to be protected as the qualities of the acoustic environment that are conducive to:

- The wellbeing of the community or a part of the community, including its social and economic amenity; or
- The wellbeing of an individual, including the individual's opportunity to have sleep, relaxation and conversation without unreasonable interference from intrusive noise.

Sleep

A person's ability to sleep is perhaps the most important value that can be impacted by noise and/or vibration. Noise and vibration effects on sleep are generally referred to as sleep disturbance.

Recreation

Recreation is an important aspect of a healthy lifestyle. Recreation may include time spent both indoors and outdoors. In terms of acoustic function, recreation may involve communication with others in conversation or simple enjoyment of an outdoor or indoor setting.

Education and Work

The needs for education and work in relation to the acoustic environment relate to the need to be able to communicate effectively either face-to-face or by telephone, and the ability to think or focus on auditory information without undue intrusion from other sources of noise.

Evaluating Impacts

The impact of a project on community values relating to noise and vibration and is normally evaluated using statutory regulations and policies that describe acceptable levels of noise and vibration from various sources.

For types of noise for which specific levels are not listed in statutory regulations or policies, it is common to refer to relevant Australian or internationally recognised standards that define acceptable levels of noise and vibration in various human and structural contexts. Such standards can serve an advisory function to regulatory organisations and may be adopted by statutory authorities for the purpose of defining regulatory levels.

10.2.2 Environmental Objectives

To achieve an acceptable outcome during both the construction and operational phases of the Airport Link Project, in terms of noise and vibration, environmental objectives are required as the foundation to a performance-based approach to management and mitigation of environmental effects.

Environmental Objectives – Construction Noise and Vibration

Environmental objectives for noise and vibration are taken from the Coordinator-General's Report on the Environmental Impact Statement for the proposed North-South Bypass Tunnel Project. Appendix 1, Schedule 6:

- Maintain a reasonable acoustic environment for living and use of properties along the corridor of construction influence during construction works.
- Mitigate and manage the vibration impacts along the corridor of construction influence.
- Establish early and effective consultation with concerned property owners and occupants in the corridor of the construction influence.

Performance Criteria

- Adopt suitable construction techniques to achieve a 'reasonable' noise and vibration environment within the corridor of construction influence, having regard to the scale and duration of construction works, the nature of the terrain through which the construction works are to pass and the character of land use activities.
- If required, identify and implement other reasonable and practicable mitigation measures to achieve noise and vibration objectives for construction works, and maintain the 'status quo' with regards road traffic noise for newly-exposed, noise-sensitive properties along major roads adjacent to construction sites.
- Undertake continual monitoring to ensure reasonable environmental conditions are being maintained within the corridor of construction influence.
- Report regularly on the performance of construction works with regards environmental goals for noise and vibration.

Environmental Objectives – Operational Noise

- Minimise the impact of noise from the operation of ventilation and other plant and equipment, and mitigate road traffic noise for newly exposed properties.

Performance Criteria – Operational Noise

- Manage the ventilation outlets and operation of plant and equipment in the ventilation station to achieve acoustic goals.
- Mitigate road traffic noise impacts upon noise-sensitive properties newly exposed as a consequence of the Airport Link Project.

10.2.3 Assessment Criteria

The sources of potential noise and vibration to be assessed with regards the construction phase of the Airport Link Project include, but are not limited to:

- Tunnelling – operation of tunnelling machinery such as roadheaders and tunnel-boring machines, earth-moving equipment, conveyors and other associated plant and equipment;

- Surface roadworks – operation of earth-moving equipment, compaction equipment (rollers including vibratory rollers), elevated equipment (e.g. cranes, pile-boring machinery), drilling equipment and other associated plant and equipment;
- General construction works – including drilling and blasting, operation of plant and equipment (eg concrete batching, asphalt batching, operation of spoil handling and loading equipment, and spoil haulage vehicles, and the operation of ventilation systems.

The operation of some equipment, such as tunnelling equipment, would include 24 hr, 7 day per week work, whereas above-ground works, would mostly be limited to 6.30am to 6.30pm Mondays to Saturdays. There would be some circumstances where out of hours work on the surface would be required to avoid or minimise disruption to surface traffic flows or daily patterns of activity. Spoil haulage is likely to be limited to 6.30am Monday to 6.30 pm Saturday.

The assessment criteria adopted for the assessment of noise and vibration effects of the construction of the Airport Link Project are those imposed as conditions by the Coordinator-General's Report on the Environmental Impact Statement for the proposed North-South Bypass Tunnel Project. Appendix 1, Schedule 6 (August 2005) for the North-South Bypass Tunnel Project. These conditions have been adopted as the most appropriate suite of measures relating to long-term construction undertakings such as the Airport Link Project. An explanation of the development of the assessment criteria is provided in Technical Report No 6 – Noise and Vibration in Volume 3 of the EIS.

Construction Noise Criteria

To achieve the objective of preserving community values for noise during construction, where reasonable and practicable, construction activity above ground and outside an acoustically-lined work enclosure, should be limited to the hours of 6.30 am to 6.30 pm Monday to Saturday, excluding public holidays. The Airport Link Project would involve some instances where construction activity would be required to be undertaken on a 24 hour basis, mostly underground, and that would likely be audible outside of the regulated construction hours.

As with the goals established in the Coordinator-General's conditions for NSBT, the construction noise goals for the Airport Link Project relate to goals for the avoidance of sleep disturbance for night time construction and internal noise for day time construction. The goals for night time construction are set out in **Table 10-9**.

Table 10-9 Internal Noise Goals – Night Time Construction

Activity	Environmental objective	Hours	Internal Noise Goal
Intermittent construction	Avoid sleep disturbance	18.30 – 06.30	45dBA (L_{Amax}) for residences in R1 – R3 categories 50dBA ($L_{A\ max}$) for residences in R4 – R6 categories[1]
Steady construction	Avoid sleep disturbance	18.30 – 06.30	For residences R4 – R6 categories: 40 dBA $L_{Aeq,adj\ (15\ minutes)}$ for temporary noise[2] 35 dBA $L_{Aeq,adj\ (15\ minutes)}$ for long-term noise[3]
			For residences within R1 – R3: 35 dBA $L_{Aeq,adj\ (15\ minutes)}$ for temporary noise 30 dBA $L_{Aeq,adj\ (15\ minutes)}$ for long-term noise

Source: Evaluation Report of the Coordinator-General, Environmental Impact Statement for the NSBT Project, August 2005, condition 7, Schedule 3. Categories R1 to R6 as referred to in AS1055 are somewhat subjective. R3 is described as "Areas with medium density transportation or some commerce or industry" and is tabulated with an average night-time (10pm-7am) background noise level of 40 dBA (LA90). R4 is described as "Areas with dense transportation or with some commerce or industry" with an average night-time background level of 45dBA (LA90).

For day-time construction works, the noise goals for internal construction noise levels at affected adjacent premises, are derived from levels in AS/NZS 2107:2000. Day time construction noise must be assessed by a LAeq(15minute) parameter for steady noise sources and a LA10(15minute) parameter for non-steady noise sources. The goals for day time construction internal noise are set out in **Table 10-10**.

Table 10-10 Internal Noise Goals – Day Time Construction

Type of Building Occupancy	Maximum Construction Internal Noise Targets	
	Steady construction noise $L_{Aeq(15minute)}$ (dBA)	Non-steady construction noise $L_{A10(15minute)}$
Residential buildings (living areas)	45 (near major roads) 40 (near minor roads)	55 (near major roads) 50 (near minor roads)
Place of Worship	40 (with speech amplification)	50 (with speech amplification)
School music rooms	45	55
School teaching area	45	55
School library	50	60
School Gymnasium	55	65
Commercial buildings – office space	45	55
Commercial Buildings – retail space	50	60

Source: AS/NZS 2107:2000

Note: Additional "Building Occupancies" to those documented in Table 2 may apply throughout the construction period. The "maximum" levels provided in AS/NZS2107:2000 should be utilised in these instances for steady noises, with the non-steady levels set 10 dBA higher.

Because the AS/NZS 2107 design levels are expressed in terms of the LAeq parameter, some variability in a noise source is implicitly included when the average level meets the design level noise goal. For residential receptors, the implicit variability permitted by the LAeq parameter can be problematic at night. For this reason,

[1] Areas with dense to extremely dense transportation or commercial and industrial activities

[2] NIAPSP, section 6.2.2 – Application of AS2107

night-time noise sources need to be assessed against sleep disturbance criteria for the LAmax parameter in addition to the AS/NZS 2107 LAeq levels.

Construction Vibration Criteria

The environmental objectives for the management and mitigation of construction vibration relate to:

- The maintenance of reasonable conditions for living, including sleeping, and the use of properties,
- Minimisation of disturbance of building contents, and in particular, vibration-sensitive building contents such as precision balances, some optical microscopes, and some electronic equipment and computer hard-drives; and
- Minimisation or avoidance of cosmetic or structural building damage.

The goals for construction-related vibration, established by the Coordinator-General's Report on the Environmental Impact Statement for the North-South Bypass Tunnel Project. Appendix 1, Schedule 6 (August 2005), are set out in **Table 10-11**.

- **Table 10-11 Construction Vibration Goals**

Objective	Vibration Type	Peak Particle Velocity (mm/sec)		
Avoid sleep disturbance (on a low probability of reaction)	Continuous	0.5		
		Heritage buildings	Residential	Sensitive commercial
Minimal risk of cosmetic damage	Transient	2	10	10
	Continuous	2	5	5

With advanced consultation, cooperation and liaison with the occupants of potentially affected properties, significantly higher levels of short-term vibration could be tolerated by many people during construction projects. In some instances there may be a trade-off between the magnitude and duration of construction related vibration (e.g. rockbreaking versus blasting).

The impacts of transient blast noise and vibration must be assessed, monitored, and if necessary, mitigated and managed in accordance with the Environmental Protection Regulation 1998 and Brisbane City Council's Local Law 5. This includes, for maintaining human comfort, limiting transient airblast over-pressure to 115 dBLin peak hold for 4 out of 5 blasts and not exceeding 120dB (linear) peak for any blast.

10.2.4 Construction Impacts and Mitigation Measures

The objective for management of construction noise and vibration is to maintain a 'reasonable' noise and vibration environment within sensitive properties for the duration of the project. The recommended definition of 'reasonable' construction noise for detailed development of mitigation strategies is as follows:

- For the daytime, "maximum" internal design levels in AS/NZS 2107:2000 as non-binding noise targets for steady and quasi-steady sources of construction noise assessed by a $L_{Aeq(15minute)}$ parameter (e.g. rock-drill, excavator, bulldozer), with a tolerance of 10 dB above these levels for the $L_{A10(15minute)}$ parameter to control non-steady sources of construction noise (e.g. rock-hammer, pile-driver);
- For long-term evening and night-time noise sources (e.g. ventilation plant, and 24 hour spoil handling systems):

  - For transient noises, internal sleep disturbance criteria for L_{Amax} levels of 45dBA/50dBA (BCC Noise Iimpact Assessment Planning Scheme Policy (NIAPSP)); and
  - For steady noises, "satisfactory"3 internal design levels in AS/NZS 2107:2000, or imission levels not greater than the external background noise level (L_{A90}), whichever is lower, with imission assessed using an $L_{Aeq,adj}$[4] $_{(15minute)}$ parameter.
- For temporary evening and night-time noise sources (e.g. regenerated noise):
  - For transient noises, internal sleep disturbance criteria for L_{Amax} levels of 45dBA/50dBA (NIAPSP); and
  - For steady noises, "maximum" internal design levels in AS/NZS 2107:2000 assessed by an $L_{Aeq(15minute)}$ parameter.

'The definition of 'reasonable' construction vibration for the purpose of detailed development of vibration mitigation strategies for this project is as follows:

- For the daytime, statutory vibration limits for blasting, and the recommended vibration guide values for other construction methods as summarised in **Table 10-11**, and a blasting limit of 4 mm/s vertical peak particle velocity at Amarina Nursing Home and Rosemount Hospital based on daytime transient vibration criteria for "low probability of reaction" derived from AS2670:1990.
- For night-time human comfort, recommended 'reasonable' continuous vibration levels would be up to 0.5mm/s (peak).

Preparation and Operation of Worksites

Southern Worksite

Construction activities at the southern worksite will include site preparation works involving surface earthworks, day-time tunnelling for the cut and cover construction, and night-time tunnelling for the drive tunnel. Construction works will be conducted within a high performance acoustic enclosure as soon as it can be established on the worksite.

Impact assessment has considered potentially sensitive receptors in two scenarios, one for residential properties south of Federation Street and the other for residential properties to the north of Federation Street. It is likely that most if not all residential properties to the south of Federation Street will be acquired to establish the worksite, but the assessment is presented as a sensitivity for a possible 'worst case'.

The highest impacts are expected at the residences south of Federation Street, where, without mitigation, maximum levels of noise could interfere with normal indoor living (e.g. interference with passive listening, resting, and conversation) over several months. For properties to the north of Federation Street and not likely to be acquired for establishment of the construction worksite, the potential noise impacts are much lower and, for tunnel construction, are generally below the external noise goals adopted for the assessment. The noise levels for these properties during the initial site preparation works are likely to exceed the noise goals, leading to potentially noticeable impacts. A summary of the construction noise impacts is presented in **Table 10-12**.

[3] "satisfactory" noise level recommendations in AS2107 are generally 10 dBA lower, or more stringent, than "maximum" recommendations.

[4] Adjusted for intrusive tonal or impulsive characteristics in accordance with AS1055 Part 1.

Table 10-12 Southern Worksite – Construction Noise Impacts

Factors		Representative Receptors			
		Residences south of Federation Street		Residences north of Federation Street	
Min. separation from works		15m		80m	
AS/NZS2107 max. internal noise goal (L_{Aeq} – dBA)		45 (living area, near minor roads, day) 40 (sleeping areas, major roads, night)		45 (living area, near minor roads, day) 40 (sleeping areas, major roads, night)	
Nominal façade reduction (dBA)		10		10	
External noise goal (L_{Aeq} dBA)		**55**		**55**	
External noise goal (L_{Amax} dBA)		**60**		**60**	
Average $L_{Aeq, 15\ min.}$ dBA		54		54	
Average $L_{Amax, 15\ min.}$ dBA		72		75	
Highest Noise Source		**Indicative external plant noise level @ Receptor (L_{Aeq} dBA)**			
	Plant Sound Power Levels ($L_{Amax, 15\ min.}$ dBA)				
Site preparation works					
Hydraulic rock-breaker	120	80		66	
Bulldozer	118	78		64	
Grader (200 kW)	116	76		62	
Excavator (200 kW, 35 t)	114	74		60	
Daytime Tunnelling		**Indicative external plant noise level @ Receptor[2] (L_{Aeq} dBA)**			
Front-end loader (200 kW, 25 t)	92[1]	52 – 57		38 – 43	
Semi-trailer	90[1]	50 – 55		36 – 41	
Concrete pump	83[1]	43 – 48		29 – 34	
Night-time Tunnelling		**L_{Aeq}**	**L_{Amax}**	**L_{Aeq}**	**L_{Amax}**
Front-end loader (200 kW, 25 t)	93	52	60	38	46
Concrete pump	83	43	51	29	37
Electric conveyor drive (600 kW)	78	38	46	24	32

1 Indicates the effective sound power level adjusted for a high performance acoustic enclosure

2 Lower value indicates noise levels when acoustic shed closed; higher value for open shed at nominal entry and exit doors, allowing for nominal 5 dBA reduction for performance of shed.

Noise mitigation should be further considered to maintain a reasonable noise environment at the residences identified in **Table 10-12**. Tunnelling works are likely to be undertaken within an enclosure designed and constructed to meet the environmental objectives for noise mitigation (as set out in Technical Report No. 6 Noise and Vibration in Volume 3 of the EIS), air quality and dust nuisance. Surface works are likely to be undertaken with the aid of temporary noise screens between the works and existing residential properties. During night-time tunnelling, all surface noise sources would be enclosed within the enclosure extending over the tunnel portals. Spoil handling and loading would also be undertaken within enclosures designed and constructed to achieve an acceptable acoustic performance for sensitive noise receptors.

Due to the significant separation distances between the site preparation works and the residential areas to the north of Federation Street, vibration impacts are not anticipated. This also is the case for the residential areas to the south of Federation Street should some residential properties not be acquired for the establishment of the worksite.

North-western Worksite – east of Gympie Road

Whilst noise from site preparation may exceed goals, the prevailing level of traffic noise will provide a mask to the construction noise, minimising any impacts. Detailed construction planning should take into account the activities and needs at Kedron State High School for acoustic screening from construction activities. Consultation with the school's administration in preparation of the Construction EMP and as construction progresses will assist in meeting the operational needs of the school. A performance-based approach will enable the construction to address the school's needs while maintaining steady and efficient construction progress.

A summary of some of the key findings of the construction noise impacts for the north-western construction activities is presented in **Table 10-13**.

Table 10-13 North-western Worksite (East Side) – Construction Noise Impacts

Factors		Representative Receptors		
		Park Tce Residences	Kedron High School	Gorman St Residences
Min. separation from works		100m	160m	150m
AS/NZS2107 max. internal noise goal (L_{Aeq} – dBA)		45 (day-time, living areas, major roads) 40 (night-time, sleeping areas, major roads)	45 (day-time, school, teaching area)	40 (day-time, living areas, minor roads) 35 (night-time, sleeping areas, minor roads)
Nominal façade reduction (dBA)		10	10	10
External noise goal (L_{Aeq} dBA)		**55** (50 night-time)	**55**	**50** (45 night-time)
External noise goal (L_{Amax} dBA)		**60** (night-time)	N/A	**55** (night-time)
Average $L_{Aeq, 15\ min.}$ dBA		60	56	56
Average $L_{Amax, 15\ min.}$ dBA		70	74	74
Highest Noise Source		**Indicative external plant noise level @ Receptor (L_{Aeq} dBA)**		
	Plant Sound Power Levels ($L_{Amax, 15\ min.}$ dBA)			
Site preparation works				
Hydraulic rock-breaker	120	64	60	60
Bulldozer	118	62	58	58
Grader (200 kW)	116	60	56	56
Excavator (200 kW, 35 t)	114	58	54	54
Daytime Tunnelling		**Indicative external plant noise level @ Receptor[2] (L_{Aeq} dBA)**		
CAT 966 Loader	104[1]	46-51	44-49	44-49
Semi-trailer	102[1]	44-49	42-47	42-47
Concrete pump	95[1]	37-42	35-40	35-40
Night-time Tunnelling		**L_{Aeq}** **L_{Amax}**		**L_{Aeq}** **L_{Amax}**
Front-end loader (200 kW, 25 t)	104	46 54		44 52
Concrete pump	95	37 45		35 43
Electric conveyor drive (600 kW)	90	32 40		30 38

1 Indicates the effective sound power level adjusted for a medium performance acoustic enclosure

2 Lower value indicates noise levels when acoustic shed closed; higher value for open shed at nominal entry and exit doors, allowing for nominal 5 dBA reduction for performance of shed.

Noise from the tunnelling operations is expected to be below the design objectives and therefore not result in any significant impact upon the Kedron State High School or residential areas as shown in **Table 10-13**. Apart from the provision of noise mitigation for surface works, the tunnelling works in this location would be

undertaken within a ventilated, acoustically-lined enclosure or shed designed and constructed to achieve the goals. Similarly, this will include the storage, handling and loading of construction spoil.

A similar assessment has been undertaken for the west side of the north-western worksite. The findings of that assessment are presented in **Table 10-14**.

Table 10-14 North-western Worksite (West Side) – Construction Noise Impacts

Factors		Representative Receptors		
		Adjacent Residences	Adjacent Offices	Wooloowin Primary School
Min. separation from works		15m	25m	50m
AS/NZS2107 max. internal noise goal (L_{Aeq} – dBA)		40 (day-time, living areas, major roads) 40 (night-time, sleeping areas, minor roads)	45 (day-time, offices)	45 (day-time, school teaching area)
Nominal façade reduction (dBA)		10	20	20
External noise goal (L_{Aeq} dBA)		**55**	**65**	**65**
External noise goal (L_{Amax} dBA)		**55** (night-time)	N/A	N/A
Average $L_{Aeq, 15\ min.}$ dBA		45	66	66
Average $L_{Amax, 15\ min.}$ dBA		58	81	81
Highest Noise Source		**Indicative external plant noise level @ Receptor (L_{Aeq} dBA)**		
	Plant Sound Power Levels ($L_{Amax, 15\ min.}$ dBA)			
Site preparation works				
Hydraulic rockbreaker	120	80	76	70
Bulldozer	118	78	74	68
Grader (200 kW)	116	76	72	66
Excavator (200 kW, 35 t)	114	74	70	64
Daytime Tunnelling		**Indicative external plant noise level @ Receptor[2] (L_{Aeq} dBA)**		
Front-end Loader (200kW, 25t)	92[1]	52-57	48-53	42-47
Semi-trailer	90[1]	50-55	46-51	40-45
Concrete pump	83[1]	43-48	39-44	33-38
Night-time Tunnelling		**L_{Aeq}** / **L_{Amax}**		
Front-end loader (200 kW, 25 t)	92[1]	52 / 60		
Concrete pump	83[1]	43 / 51		
Electric conveyor drive (600 kW)	78[1]	38 / 46		

1 Indicates the effective sound power level adjusted for a medium performance acoustic enclosure (high performance for night-time works)

North-western Worksite – in Lutwyche Road

Potential noise impacts would arise from daytime earthworks due particularly to the operation of hydraulic rock-breakers, with exceedances of 30dBA predicted for the residential areas west of Lutwyche Road. Without mitigation measures, noise from operation of this equipment would lead to significant acoustic impacts. Potential acoustic impacts of 20-26dBA are also predicted, without mitigation, for operation of some other plant and equipment during site preparation works. The acoustic impacts of site works in Lutwyche Road are much less significant for the Wooloowin State School and the commercial offices to the south in Lutwyche Road due to the greater separation distances to the noise sources.

As for the Kedron State High School, detailed construction planning in consultation with local residents and the administrations of the Wooloowin State School and the parish of St Andrew's Anglican Church, should take into account their respective activities and needs and for acoustic screening from construction activities. A performance-based approach will enable the construction to address the school's needs while maintaining steady and efficient construction progress.

Noise mitigation should be further examined to maintain a reasonable noise environment at these school and church locations. In these locations, temporary noise barriers may lead to flow-on impacts which would need to be resolved in consultation between the administration of both the school and the church. For this EIS, it has been assumed that an enclosed construction shed would be established at this worksite to mitigate both noise and dust impacts from the works.

Due to the significant separation distances between the site preparation works and the sensitive uses, vibration impacts are not expected to be significant.

North-eastern Worksite

Potential noise impacts may arise for residents of Kalinga Street and the residential area immediately south of the worksite (Alma Road, Stuckey Road) from the daytime earthworks and in particular the operation of rock-breakers leading to a predicted exceedance, without noise mitigation, of 24 dBA to 30 dBA. If no mitigation measures were taken, the predicted levels would be likely to result in acoustic impacts (e.g. interference with passive listening, resting and conversation) for residential areas immediately to the south of the worksite. Noise impacts from the operation of other plant and equipment are predicted, with exceedances in the range of 20 dBA to 26dBA, without mitigation measures. These levels would be noticeably higher than the prevailing levels of traffic noise.

For the residential areas along Parkland Street, the highest noise levels predicted for the rock-breaker operations would result in exceedances of 5 dBA. Levels of this magnitude would be audible within dwellings but not likely to result in any significant acoustic impacts. Noise mitigation measures (as listed below) for day-time construction works should be further examined to maintain a reasonable noise environment at these residences.

For day-time tunnelling, using a tunnel boring machine underground, noise predictions indicate that noise emissions will be less than the goal. Night-time tunnelling works would also be conducted underground or within a medium-performance acoustic enclosure. For night-time tunnelling, the predicted noise levels indicate compliance with the goals for residences in Kalinga Street and Parkland Street. For the residential area south of the worksite, exceedances of 5 dBA are predicted, which are below the prevailing traffic noise levels. Such levels would not result in acoustic impacts at these residences, particularly with the installation of a medium performance acoustic enclosure. A summary of the findings of the noise assessment for the north-eastern worksite is presented in **Table 10-15**.

- **Table 10-15 North-eastern Worksite – Construction Noise Impacts**

Factors		Representative Receptors		
		Kalinga Street Residences	Parkland Street Residences	Residences immediately south
Min. separation from works		30m	160m	15m
AS/NZS2107 max. internal noise goal (L_{Aeq} – dBA)		40 (day-time, living areas, major roads) 40 (night-time, sleeping areas, minor roads)	45 (day-time, living areas near major roads)	40 (day-time, living areas near minor roads)
Nominal façade reduction (dBA)		10	10	10
External noise goal (L_{Aeq} dBA)		**50**	**55**	**50**
Existing Daytime Levels)				
Average $L_{Aeq, 15\ min.}$ dBA		54	62	59
Average $L_{Amax, 15\ min.}$ dBA		72	79	70
Highest Noise Source		**Indicative external plant noise level @ Receptor (L_{Aeq} dBA)**		
	Plant Sound Power Levels ($L_{Amax, 15\ min.}$ dBA)			
Site preparation works				
Hydraulic rockbreaker	120	74	60	80
Bulldozer	118	72	58	78
Grader (200 kW)	116	70	56	76
Excavator (200 kW, 35 t)	114	68	54	74
Daytime Tunnelling		**Indicative external plant noise level @ Receptor[2] (L_{Aeq} dBA)**		
Electric conveyor drive (600 kW)	90[1]	44	30	50
Ventilation	Design to meet background LA90+3 dB @ residences	43	45	58

Night-time Tunnelling		L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}
Electric conveyor drive (600 kW)	90[1]	44	46	30	32	50	52
Ventilation	Design to meet background LA90+3 dB @ residences	43		45		58	

1 Indicates the effective sound power level adjusted for a medium performance acoustic enclosure

Mitigation Measures for Construction at Worksites

There are a range of effective mitigation measures for achieving the environmental objectives for construction noise management. While the following noise control measures are recommended for noise mitigation at worksites, detailed construction planning may indicate other equally or more effective measures having regard to the circumstances of the worksite and surrounding area:

- Provide advance notification of the time and duration of earthworks.
- Install temporary noise screens to reduce earthmoving noise during site preparation at residential boundaries. As an alternative, consideration could be given to upgrading the façade windows, and provision of air-conditioning to the affected residents.
- Use localised noise screens for particularly noisy operations such as rockdrilling and rockbreaking.
- Select plant and processes which minimise source noise levels
- Construction of a 'high' performance acoustic enclosure over portal and stockpile area at the southern and north-western (centre of Lutwyche Road) worksites, with indicative acoustic performance as shown in Table 28 of Technical Report No. 6 – Noise and Vibration in Volume 3 of the EIS.

- Construct noise screens along worksite boundaries to reduce earthmoving noise at adjoining residences:
  - Noise screens would need to be a minimum of 5 m in height as most residential dwellings in the area are double storeys;
  - At the southern end of the north-western (centre of Lutwyche Road) worksite, 4 residential buildings are 3 storeys high requiring a relatively high noise barrier. A solution to providing noise mitigation may be to provide architectural treatment to the upper levels, as it may prove more cost effective, provided it is favoured by the residents.
- Construction of a 'medium' performance acoustic enclosure over the portal and stockpile area for the north-western (north of Gympie Road) and north-eastern worksites, with indicative acoustic performance as shown in Table 28, Technical Report No. 6 – Noise and Vibration in Volume 3 of the EIS.
- Undertake a further examination of Kedron State High School and the office building adjacent to the southern side of the north-western (centre of Lutwyche Road) worksite, to confirm whether the windows are normally open (as assumed) or if the buildings are air conditioned, and hence the windows are normally closed.
- Design of continuously operating ventilation plant and any other plant that operates at night to meet 'reasonable' night-time noise objectives as defined above.
- For residences nearest and facing the worksites, assist owners to temporarily upgrade acoustical insulation and ventilation of rooms facing the worksite to mitigate construction noise during site preparation.
- Monitor noise levels from variable noise sources (e.g. rock-drill noise at the tunnel entrance which will diminish as tunnelling progresses) to ensure that such activities meet the 'reasonable' levels as defined above.

Surface Construction of Roadways

Southern Connection

Without mitigation measures being implemented, daytime construction of elevated structures adjacent to The Mews Apartments is predicted to result in significant exceedances of the design goal by 12dBA to 17 dBA, and is likely to be intrusive for the building occupants. This level of intrusion could interfere with normal indoor living (e.g. interference with passive listening, resting and conversation). Noise mitigation recommended for further consideration is:

- Advance notification of the time and duration of construction;
- Plant selection to consider noise emissions; and
- Location of plant items to maximise distance to residences.

There are no predicted exceedances of noise goals for night-time widening of the ICB underpass due primarily to the large offset distance and the higher building façade nominated for the Mews Apartments. A summary of the findings for construction of surface roadways is presented in **Table 10-16**.

- **Table 10-16 Southern Surface Roads – Construction Noise Impacts**

Factors		Representative Receptors			
		Mews Apartments		Residences south of Federation St	Residences north of Federation St
		Elevated Structures	ICB Underpass	Cut & Cover Construction	
Min. separation from works		50m	120m	50m	80m
AS/NZS2107 max. internal noise goal (L_{Aeq} – dBA)		45 (A/C, sleeping areas near major roads)	40 (A/C, sleeping areas near major roads)	45 (living areas near minor roads)	45 (living areas near minor roads)
Nominal façade reduction (dBA)		20	20	10	10
External noise goal (L_{Aeq} dBA)		**65**	**60**	**55**	**55**
External noise goal (L_{Amax} dBA)			**70**		
Internal sleep disturbance goal (L_{Amax} dBA)			**50**		
Average $L_{Aeq, 15\ min.}$ dBA		67	64	54	54
Average $L_{Amax, 15\ min.}$ dBA		78	75	72	75
Highest Noise Source		**Indicative external plant noise level @ Receptor (L_{Aeq} dBA)**			
Plant Sound Power Levels ($L_{Amax, 15\ min.}$ dBA)					
Hydraulic rockbreaker	120			70	66
Pile boring	118		60L_{Aeq} 68L_{Amax}	68	64
Excavator (200 kW, 35 t)	114	84	56L_{Aeq} 64L_{Amax}	64	60
Concrete truck (24 t)	112	82	54L_{Aeq} 62L_{Amax}	62	58

For the cut and cover construction in the vicinity of Federation Street, exceedances of day-time noise goals in the order of 15dBA is predicted for the operation of hydraulic rockbreaker equipment. If not mitigated, this exceedance would be a significant acoustical impact on the residential areas to the south of Federation Street (**Table 10-16**). As noted in section 10.2.4 above, these residences are expected to be acquired for the establishment of the southern worksite. For the residential areas to the north of Federation Street, the predicted exceedance for rock-breaker operations would be in the order of 11dBA. Such exceedances would represent a significant acoustical impact if no mitigation measures were implemented.

Due to the separation distances for the operation of vibration-generating equipment, such as vibratory rollers, vibration levels are not expected to be significant.

North-western Connection

Noise levels from daytime construction of elevated structures and cut and cover tunnelling works are likely to be found intrusive (19-23 dBA above the noise goals) at residences directly adjacent to Gympie Road and Lutwyche Road. This level of intrusion could interfere with normal indoor passive listening, resting and conversation. Noise mitigation should be examined so as to maintain a reasonable noise environment at these residences.

Night-time construction of elevated structures and cut and cover tunnelling works (to avoid road closures of Lutwyche Road during day time peaks) for residences directly adjacent to Gympie Rd and Lutwyche Rd would likely be found to be intrusive (24-26 dBA above the L_{Aeq} noise goals). This level of intrusion would interfere with normal indoor living (eg interference with passive listening, resting and conversation) and could cause

sleep disturbance. A summary of the findings of the assessment for surface road construction and other construction works in the north-western connections is presented in **Table 10-17**.

- **Table 10-17 North-western Surface Roads – Construction Noise Impacts**

Factors		Elevated Structure and Cut & Cover (night-time works values bracketed)					
		Nth Kedron Brook @ Gympie Rd		Sth Kedron Brook @ Lutwyche Rd		Sth Kedron Brook west Lutwyche Rd	
Min. separation from works		25m		15m		80m	
AS/NZS2107 max. internal noise goal (L_{Aeq} – dBA)		45 (living areas near major roads) 40 (sleeping areas near major roads)		45 (living areas near major roads) 40 (sleeping areas near major roads)		40 (living areas near minor roads) 35 (sleeping areas near major roads)	
Nominal façade reduction (dBA)		10	10	10	10	10	10
External noise goal (L_{Aeq} dBA)		**55**	(60)	**55**	(50)	**50**	(45)
External noise goal (L_{Amax} dBA)			(50)		(60)		(55)
Average $L_{Aeq, 15\ min.}$ dBA		60	(51)	65	(61)	53	(45)
Average $L_{Amax, 15\ min.}$ dBA		70	(62)	81	(76)	68	(58)
Highest Noise Source		**Indicative external plant noise level @ Receptor (L_{Aeq} dBA)**					
Plant Sound Power Levels ($L_{Amax, 15\ min.}$ dBA)							
		L_{Aeq}	**L_{Amax}**	**L_{Aeq}**	**L_{Amax}**	**L_{Aeq}**	**L_{Amax}**
Pile boring	118	74	82	78	86	64	72
Excavator (200 kW, 35 t)	114	70	78	74	82	60	68
Hydraulic crane (100 t)	112	66	74	70	78	56	64

It is recommended that noise mitigation measures be implemented to maintain a reasonable noise environment at residences indicated in **Table 10-17**. The following mitigation measures are recommended for further consideration guided by the 'reasonable' noise objectives for construction noise:-

- Construction of noise screens along the eastern boundary of the construction site north of Kedron Brook, where direct access to Gympie Rd is not required, to reduce construction noise on the eastern side of Gympie Rd due to elevated structure construction;
- Construction of noise screens along the western boundary of the construction site south of Kedron Brook, where direct access to Lutwyche Rd is not required, to reduce construction noise on the western side of Lutwyche Rd due to cut and cover construction;
- Advance notification of the time and duration of earthworks;
- If required, assist owners of properties along Gympie Rd and Lutwyche Rd to temporarily upgrade the acoustical insulation and ventilation of rooms facing the worksite to address noise during both road widening/regrading and trough excavation; and
- Advance notification of night roadworks.

North-eastern Connection

The highest potential for impacts at residential locations occurs during the construction of the open trough and cut and cover sections, where noise levels are predicted to significantly exceed goals by up to 28 dBA. This exceedance would likely result in acoustic impact on residences (e.g. interference with passive listening, resting and conversation). Night-time works would be limited to specific tasks of limited duration in Sandgate Road on

the East West Arterial, where day-time traffic flows would preclude efficient construction. A summary of the impact assessment is presented in **Table 10-18**.

- **Table 10-18 North-eastern Cut and Cover & Open Trough – Construction Noise Impacts**

Factors		Representative Receptors			
		Kalinga Pk (west) (cut & cover)	Kalinga Pk (south) (cut & cover)	Kalinga Pk (north) (cut & cover)	East West Arterial (south) (open trough)
Min. separation from works		30m	15m	160m	20m
AS/NZS2107 max. internal noise goal (L_{Aeq} – dBA)		40 (living areas near minor roads)	40 (living areas near minor roads)	45 (living areas near minor roads)	45 (living areas near minor roads) 40 (A/C, sleeping areas near major roads)
Nominal façade reduction (dBA)		10	10	10	10
External noise goal (L_{Aeq} dBA)		**50**	**50**	**55**	**60[1]**
Internal sleep disturbance goal (L_{Amax} dBA)					**50**
Average $L_{Aeq, 15\ min.}$ dBA		54	59	62	59
Average $L_{Amax, 15\ min.}$ dBA		72	70	79	76
Highest Noise Source		**Indicative external plant noise level @ Receptor (L_{Aeq} dBA)**			
Plant Sound Power Levels ($L_{Amax, 15\ min.}$ dBA)					
Pile boring	118	72	78	58	76
Excavator (200 kW, 35 t)	114	68	74	54	72
Concrete truck (24 t)	112	66	72	52	70

1 A 5dBA reduction has been assumed for the noise barrier south of the East West Arterial.

The following mitigation measures are recommended around roadworks, guided by the 'reasonable' noise objectives:

- Advance notification of the time and duration of works, especially any night works;
- Select construction processes and plant to minimise construction noise;
- Assist owners of properties nearest the construction site to temporarily upgrade the acoustical insulation and ventilation of rooms facing the construction area;
- Construction of noise screens along the southern and western boundaries of the construction site west of Sandgate Road; and
- Early construction of the noise barrier south of the East-west Arterial to protect residences in Wongara St.

Vibration

It is not anticipated that vibration levels associated with vibratory rolling during road surfacing works will be significant.

Underground Tunnelling Between Portals

Blasting

Only daytime blasting is envisaged, if at all, for tunnel construction. Blasting generally results in short, strongly noticeable vibrations lasting one to two seconds. The normal mitigation method in relation to human impacts is to give clear and concise pre-notification to all persons in the affected area.

The most sensitive receptors in terms of human comfort during blasting are Rosemount Hospital and Amarina Nursing Home, both of which provide palliative and dementia care. The mitigation options at these locations are careful notification, choice of time of day, and blast design to control vibration levels. It is suggested that design vibration levels for this receptor location should be no more than 4 mm/s vertical peak particle velocity, based on daytime transient vibration criteria for "low probability of reaction" derived from AS2670:1990.

Careful blast design is recommended to mitigate against building impacts, and if necessary, using gradually increasing trial blasts to establish safe design parameters. It is a requirement of Brisbane City Council to conduct pre- and post-blasting Building Condition Surveys where it is considered there may be potential for cosmetic building damage.

The impact assessment has found that, to achieve or stay within the limit of 10 mm/sec for cosmetic damage for residential and commercial buildings, the indicative maximum blast, or maximum instantaneous charge (MIC) ranged from 0.7kg at a depth of 1.3m to 10.8m, up to 5.0kg for depths ranging from 28.3 m to 35.9m.

Driven Tunnelling (by Roadheader)

Anticipated vibration levels generated by roadheading would be imperceptible in buildings throughout the tunnel alignment. The range of vibration for tunnel construction by roadheader is summarised in **Table 10-19**. No vibration mitigation measures are anticipated for this type of tunnelling. However, initial noise and vibration monitoring should be undertaken to confirm that source data utilised for this assessment are applicable.

Driven Tunnelling (byTunnel Boring Machine)

As indicated in Chapter 4 – Project Description of the EIS, the east – west tunnels are proposed to be constructed by means which can achieve stability in the working face, manage the inflow of groundwater and provide safe working conditions for the labour force. For the purposes of this EIS, tunnel construction for this part of the Airport Link Project has adopted the use of a particular type of tunnel boring machine the earth pressure balance machine (EPB). As discussed in Chapter 4, it is acknowledged that there may be other effective methods for construction in the soft and challenging conditions beneath Wooloowin and Clayfield.

For tunnelling, the criteria to achieve the environmental objectives of minimal sleep disturbance and cosmetic damage to buildings are 0.5mm/sec and 5mm/sec respectively. The impact assessment has predicted vibration levels on the surface above the mainline tunnels, due to work by EPB machines, would range from 0.16mm/sec to 0.33mm/sec. Vibration levels at the upper end of this range are approaching but remain below the threshold of perception and are below the threshold for sleep disturbance. A summary of the predicted vibration levels for EPB tunnel construction is presented in **Table 10-19**.

It is anticipated that EPB-type tunnelling vibrations and regenerated noise will generally not be noticeable in buildings along the tunnel path. However, noise and vibration monitoring should be undertaken at the commencement of EPB tunnelling to confirm that the source data utilised for this assessment are applicable to this project.

Sensitive Building Contents

For this project, a Building Sensitivity Study is recommended for the Rosemount Hospital. The Building Sensitivity Study should be conducted prior to construction activities to establish the sensitivity of the building and contents in greater detail.

Table 10-19 Summary – Predicted Surface Vibration for Tunnel Construction

Tunnel Section	Depth Range[1] (m)	Construction Method	Vibration Range (mm/sec)	Guide Value (mm/sec)	Possible Impact
Cedric St – Felix St					
(east side)	1.3 - 35.0	roadheader	0.006 – 0.067	0.5 (sleep) 5.0 (cosmetic damage)	Not felt Nil
(west side)	1.2 – 35.9	roadheader	0.006 – 0.079	0.5 (sleep) 5.0 (cosmetic damage)	Not felt Nil
Gorman St – Jackson St					
(north side)	13.5 – 26.5	TBM (EPB)	0.16 – 0.31	0.5 (sleep) 5.0 (cosmetic damage)	Threshold of perception Nil
(south side)	14.0 – 27.1	TBM (EPB)	0.16 – 0.33	0.5 (sleep) 5.0 (cosmetic damage)	Threshold of perception Nil

[1] Depth measured to crown of tunnel

Regenerated Noise from Tunnelling

Regenerated noise from tunnelling can usually only be perceived in rooms that are well insulated from outside air-borne noise, such as traffic noise. For many locations along the study corridor, existing and predicted future traffic levels are sufficiently high to mask the potential impacts of regenerated noise from tunnelling works. A summary of the predicted regenerated noise levels for tunnelling along the study corridor is presented in **Table 10-20**.

Table 10-20 Summary – Predicted Regenerated Noise for Tunnel Construction

Tunnel Section	Depth Range[1] (m)	Construction Method	Indicative max. regenerated noise level (dBA)	Guide Value (Residential) AS/NZS 2107(dBA)	Possible Impact
Cedric St – Felix St					
(east side)	1.3 - 35.0	roadheader	26 – 44	40 day 35 night	Very low-Moderate High (Cedric-Bryden St)
(west side)	1.2 – 35.9	roadheader	27 – 46	40 day 35 night	Very low-Moderate High (Cedric-Bryden St)
Gorman St – Jackson St					
(north side)	13.5 – 26.5	TBM (EPB)	32 – 38	40 day 35 night	Very low - moderate
(south side)	14.0 – 27.1	TBM (EPB)	32 – 38	40 day 35 night	Very low - moderate

1 Depth measured to crown of tunnel

Recommended Mitigation for Tunnelling Vibration and Regenerated Noise

The following impact management and mitigation strategies are recommended to minimise the effects of tunnelling vibration and regenerated noise:

- Comprehensive advance notice of intended tunnelling activities in localities near the tunnel alignment;

- Noise and vibration monitoring should be undertaken at the commencement of both roadheader and EPB tunnelling to confirm that source data utilised for this assessment are applicable to this project;
- Conduct night-time tunnelling subject to compliance with 'reasonable' night-time vibration and regenerated noise levels as defined above;
- If blasting is required in the vicinity of Amarina Nursing Home or Rosemount Hospital, consideration should be given to the adoption of a lower 'reasonable' blast vibration limit of 4 mm/s;
- Conduct building-specific vibration sensitivity investigations for the Rosemount Hospital to establish 'reasonable' vibration levels prior to finalisation of a management plan for construction vibration; and
- Conduct pre- and post-blasting Building Condition Surveys in accordance with Brisbane City Council requirements where potential exists for cosmetic (superficial) building damage from drill-and-blast methods.

Construction Traffic

Spoil traffic would generally not increase average traffic noise levels on spoil routes by more than about 0.5 dBA along major road corridors and would not represent an impact. The maximum traffic noise increase due to spoil traffic could occur on O'Connell Tce, where the increase is estimated to be 0.8 dBA $L_{A10(10hour)}$ over the 7am to 5pm period of spoil haulage.

For O'Connell Terrace and Montpelier Road, where the predicted increases are 5.2 and 3.5dBA respectively, there are a limited number of noise sensitive properties (i.e. residential) which in turn are surrounded by commercial and industrial activities, resulting in high ambient noise levels in these locations. Spoil traffic would not significantly impact on the noise environment of residential locations, with the exception of O'Connell Terrace and Montpelier Road where mitigation measures would be required and should be negotiated with property owners on a case-by-case, merits basis. A summary of the predicted construction traffic noise impacts is presented in **Table 10-21**.

- **Table 10-21 Construction Traffic Noise – Spoil Haulage Routes**

Route	Route Section	Change in Traffic Noise Level ($L_{A10(18hr)}$) (dBA)	Change in Traffic Noise Level ($L_{A10(1hr)}$) (dBA)
Lutwyche Rd	Norman St – Kedron Park Rd	+0.3	+1.4
Bowen Bridge Rd	Sth site – O'Connell Tce	+0.3	+1.7
O'Connell Tce	Bowen Bridge Rd – Hamilton Pl	+1.6	+5.2
Montpelier Rd	Abbottsford – Breakfast Ck Rd	+1.1	+3.5
Breakfast Ck Rd	Montpelier Rd – ICB	+0.5	+2.1
Kingsford Smith Dve	ICB – Crescent Rd	+0.3	+1.7
	Crescent Rd – Riverview Tce	+0.3	+1.8
	Racecourse Rd – Nudgee Rd	+0.3	+1.6
	Nudgee Rd – Woonah Ave	+0.4	+1.9
	Woonah Ave – Gateway M'way	+0.4	+2.0
East-West Arterial	Sandgate Rd – Widdop St	+0.1	0.0
	Widdop St – Gateway M'way	+0.1	0.0

Recommended mitigation measures include:

- Management of engine noise emissions by procurement and maintenance of a fleet that conforms to Australian Design Rule 28/01 for engine noise emissions, tested in accordance with the National Road Transport Commission document Stationary Exhaust Noise Test Procedures for In-Service Motor Vehicles.
- Adoption of airbag suspension throughout the fleet to minimise noise associated with empty trucks travelling over road irregularities.
- Satellite tracking and management of the position of the truck fleet to ensure that waiting queues are appropriate to space constraints, minimising noise from idling trucks.

10.3 Operational Phase

10.3.1 Assessment Criteria - Noise

The sources of operational noise with some potential to impact on properties or people within the study corridor include road traffic noise and noise from operating plant and equipment, such as the ventilation system. While a range of noise criteria are effective for a range of situations in Queensland, the operational noise goals for the Airport Link Project are adopted from those recommended by the Coordinator-General for the NSBT Project and presented here in **Table 10-22**.

Table 10-22 Operational Goals - Road Traffic Noise

Source	Reference Regulation, Standard or Guideline	Values
Airborne Traffic Noise	Environmental Protection (Noise) Policy 1997	The planning levels for a Public Road are as follows: - For a State-controlled road - 68 dBA LA10(18hour); - For another public road - 63 dBA LA10(18hour); - 60 dBA, assessed as the highest 1 hour equivalent continuous A-weighted sound pressure level between 10 pm and 6 am (60 dBA LAeq(1hour)); and - 80 dBA assessed as a single event maximum sound pressure level (80 dBA LAmax).
	Main Roads Code of Practice - Road Traffic Noise Management	Residential - 68 dBA LA10(18hour)

Note - Where the road traffic planning noise levels are already exceeded at sensitive locations it may not be reasonable and practicable to achieve compliance with these planning noise levels. In these instances, the "status-quo" noise levels should be maintained (i.e. maintain noise levels at levels anticipated in Y2021, the design year, without the Project).

The operational noise goals for the ventilation system, established in the Coordinator General's conditions for the NSBT Project, and recommended for the Airport Link Project, are set out in **Table 10-23**.

Table 10-23 Operational Goals - Ventilation System Noise

Ventilation System Noise (via outlets, portals, fan stations)	The overall A-weighted sound pressure level component from ventilation plant, assessed as an LAmax,adj level with tonality penalty adjustments determined in accordance with AS1055.1, should not exceed the Average Background Noise Level, as defined in AS1055.2, at a noise sensitive location at any time of the day or night

Source: BCC Noise Impact Assessment Planning Scheme Policy (NIAPSP)

10.3.2 Operational Impacts and Mitigation Measures

Road Traffic Noise Local to Tunnel Portals

The EPP(Noise) identifies Planning Levels for traffic noise emissions from roadways, but does not specify responses to road developments that may exceed Planning Levels. For the Airport Link Project, Planning Levels from the EPP(Noise) are generally already equalled or substantially exceeded at residential facades facing the major roads that connect to the tunnel.

The Department of Main Roads' Code of Practice is also applicable to this study as it outlines a strategy to control road traffic noise from State-controlled roads. Sections of State-controlled road within the study corridor are:

- Gympie Road - North of Kedron Brook
- East West Arterial Road - East of Sandgate Rd

The Interim Northern Busway, a TransLink (Queensland Transport) project also utilising the Bowen Bridge Road /Lutwyche Road corridor, is expected to be completed in 2022. The following situations have been modelled in accordance with the ToR:

- **Do minimum (2022)**: The predictions include all future (ie 2022) traffic utilising the existing road corridor, excluding the Airport Link and the Northern Busway Projects. This scenario represents the future traffic that would have arisen in the absence of these major transport initiatives, and represents the baseline noise projections against which some of the other scenarios are compared;
- **Airport Link without Interim Northern Busway (2022)** - traffic flows including Airport Link, but excluding the Interim Northern Busway Project. This scenario represents the change in traffic noise, attributable directly to the Airport Link project; and
- **Airport Link with Interim Northern Busway (2022)** - traffic flows including Airport Link and the Interim Northern Busway Projects.

The Ultimate Northern Busway design, (where the bus lanes are mostly in a tunnel along Bowen Bridge Road and Lutwyche Road) is expected to be completed in 2026. With usual practice, the acoustic design year would be 2036. Thus, for the Ultimate Northern Busway scenarios, the assessment has been undertaken for the year of opening (ie 2026). As the Ultimate Northern Busway Project develops in coming years, further environmental assessments will need to be undertaken to confirm the levels of impact presented herein. It may be more reasonable and feasible to assess the predicted traffic noise levels in 2036 (10 years after opening). Thus, for the assessment involving the Ultimate Northern Busway, the scenarios identified above are replicated using 2026 traffic data.

Two noise barrier designs have been undertaken for the Airport Link scenarios, with and without interim/ultimate Northern Busway, as outlined below.

"Status Quo" Noise Barrier Option

The objective used to develop the "status quo" barrier option for the two design years (2022 and 2026) is to develop road-side noise barriers, where practical and feasible, to achieve traffic noise levels comparable to the "Do Minimum" option.

"Planning Level" Noise Barrier Option

The objective used to develop the "planning level" barrier option for the two design years (2022 and 2026) is to develop road-side noise barriers, where practical and feasible, to limit traffic noise levels to the 63 dBA or 68 dBA (as applicable) $L_{A10(18hr)}$ planning levels wherever possible. As an example of the predicted noise levels **Table 10-24** shows the modelled noise levels at representative most exposed sites around each tunnel portal that would develop by 2022 if no works were undertaken, if the Airport Link project was built without any noise mitigation measures and after mitigation measures have been built. This sensitivity analysis has also been undertaken with and without the interim Northern Busway.

- **Table 10-24 Traffic Noise Changes without AL, with AL and Mitigated with AL in 2022**

	Existing 2005 Noise Level	2022 Predicted "Do Minimum" Noise Level	2022 Predicted Noise Levels with APL - No Barriers	2022 Predicted Noise Levels with APL and NB - No Barriers	2022 Predicted Noise Levels with APL		2022 Predicted Noise Level with APL and NB	
Southern Portal					Status Quo Barrier Design	Planning Level Barrier Design	Status Quo Barrier Design	Planning Level Barrier Design
38 Federation Street[1]	55	59	63	63	59	60	59	60
18 Federation Street[1]	60	62	65	65	62	63	62	63
57 Earle Street[1]	58	61	67	67	61[2]	63	61[2]	63
Gympie Road Portal								
20 Windsor Av	61	63	67	67	60	60	60	62
8 Perry Street	61	63	69	69	62	59	62	63
12 Park Terrace	64	66	79	79	65	66	64	66
6 Emerals St	62	64	65	65	63	64	63	64
Sandgate Road Portal								
85 Stuckey Rd	54	54	57	57	54	57	54	57
83 Alma Rd	64	65	69	69	64	63	64	63
32 Wongara Street	63	66	75	75	66	65	66	65
Hendra Secondary College	64	67	67	67	67	63	67	63
80 McIntyre St - West Building	69	73	73	73	73	66	73	66

1 Includes NSBT Project with Planning Level 63Dba LA10 (18hr) barrier design for all Year 2022 predictions

2. Assumes OGA road surface on "APL southbound to ICB" lanes.

The purpose of this option is to illustrate the scale of noise controls that would be necessary to achieve the "planning" traffic noise levels in accordance with the EPP(Noise) and Code of Practice. In many areas this would require noise controls to account for gradual increases in traffic noise over time that are not attributable to the tunnel.

In general, the recommendation of this assessment is that noise mitigation should be designed for compliance with the relevant planning levels (ie $L_{A10(18hour)}$ levels of 63/68 dBA) . Where this cannot be achieved, the barrier design should examine the feasibility and reasonableness of maintaining the "status-quo". In all areas it is considered that the recommended noise control options in this report represent a starting point for discussions between key stake-holders.

Southern Connection

Noise mitigation to achieve the '63 dBA criterion' where reasonable and feasible is shown in **Appendices J4, J7, J11** and **J14** (for the Airport Link without Interim Northern Busway (2022), Airport Link with Interim Busway (2022), Airport Link without Ultimate Busway (2026) and Airport Link with Ultimate Busway (2026) in Technical Report No. 6 – Noise and Vibration in Volume 3 of the EIS. It should be noted that south of Enoggera Creek, compliance with the 63 dBA criterion was not always feasible, particularly at The Mews Apartments, Tufton Street apartments and Wren Street properties, due to the impractical height the barriers would need to be to achieve the "planning" level. Consequently, at these locations, the barrier design aims to achieve the status quo levels, rather than the 63 dBA "planning" criterion.

All of the barriers presented in **Figure 10-1** are feasible but will need to be reviewed in the context of urban renewal concepts. Safety issues associated with sight lines would also need to be considered. In theory, long continuous commercial or residential building structures could provide noise screening in lieu of barriers, where space permits. The cost effectiveness of the alternative option of upgrading building envelopes could also be investigated as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that barriers would also control traffic noise increases in outdoor areas.

North-western Connection

Noise mitigation to achieve the "63/68 dBA criterion" where reasonable and feasible is shown in Appendices K4, K7, K11 and K14 (for the Airport Link without Interim Northern Busway (2022), Airport Link with Interim Busway (2022), Airport Link without Ultimate Busway (2026) and Airport Link with Ultimate Busway (2026), respectively) in Technical Report No. 6 – Noise and Vibration in Volume 3 of the EIS.

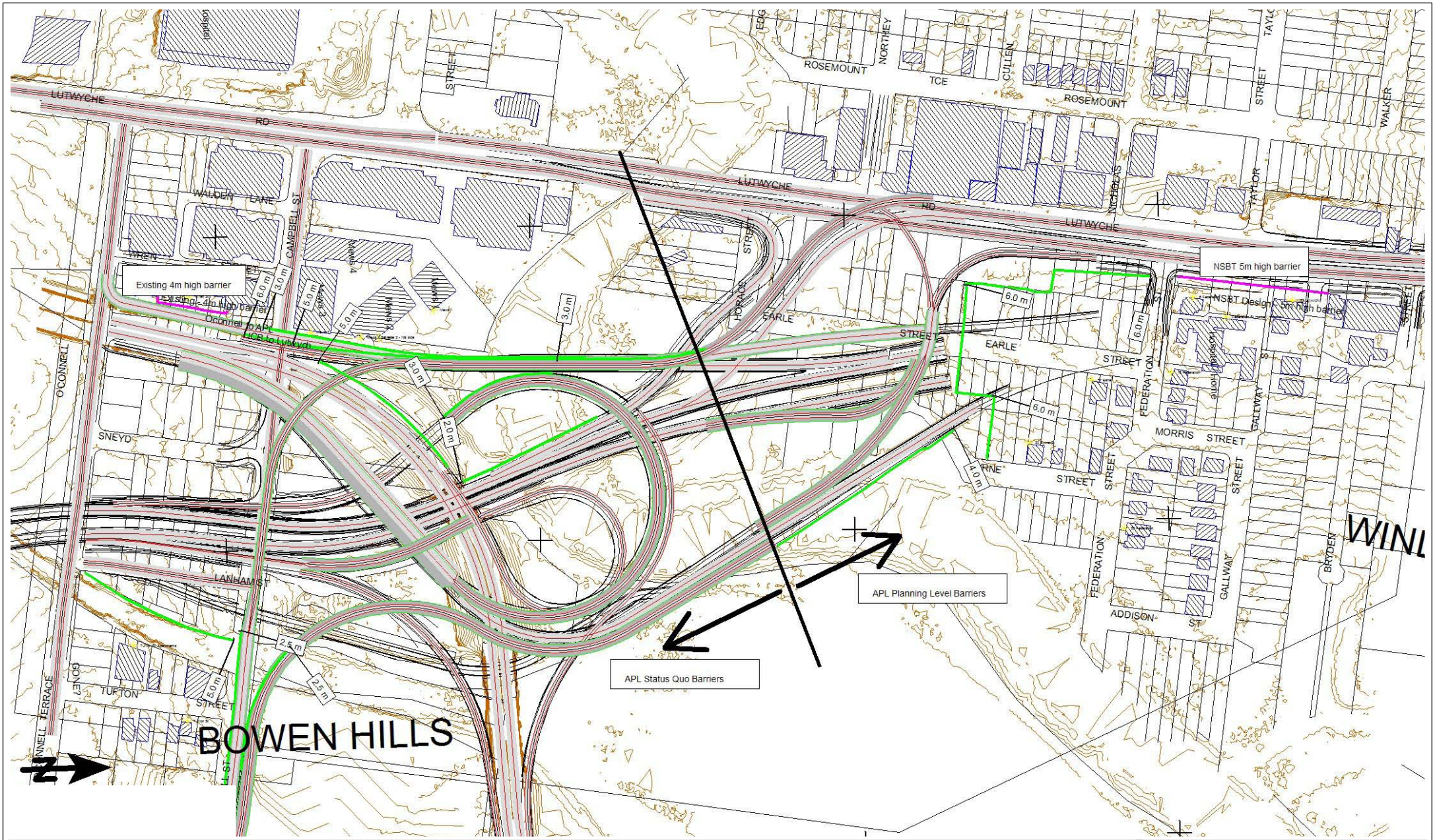
All of the barriers presented (**Figures 10-2A** and **10-2B**) are of a feasible scale, but need to be reviewed in the context of urban renewal concepts along this corridor. Safety issues associated with sight lines also need consideration. Long continuous commercial or residential building structures could provide noise screening in lieu of barriers, where space permits. The cost effectiveness of upgrading building envelopes could also be investigated as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that they would also control traffic noise increases in outdoor areas.

North-eastern Connection

Noise mitigation to achieve the "63/68 dBA criterion" where reasonable and feasible is shown in Technical Report 6 – Appendices L4, L7, L11 and L14 (for the Airport Link without Interim Northern Busway (2022), Airport Link with Interim Busway (2022), Airport Link without Ultimate Busway (2026) and Airport Link with Ultimate Busway (2026), respectively) in Technical Report No. 6 – Noise and Vibration in Volume 3 of the EIS.

Given the significant distance between the north-eastern Connection and Interim or Ultimate Northern Busway infrastructure, the resulting levels of road traffic noise in this area are due simply to changes in traffic volumes and compositions.

All barriers presented (**Figures 10-3A** and **10-3B**) are of a feasible scale but need to be reviewed in the context of urban renewal concepts along this corridor. Safety issues associated with sight lines also need to be considered. Long continuous commercial or residential building structures could provide noise screening in lieu of barriers, where space permits. The cost effectiveness of upgrading building envelopes could also be investigated as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that barriers also control traffic noise increases in outdoor areas.



LEGEND

- Emission line
- New or Upgraded Barriers
- Existing Barriers
- Building
- Point receiver
- Road axis
- Surface
- Line source

0 20 100m

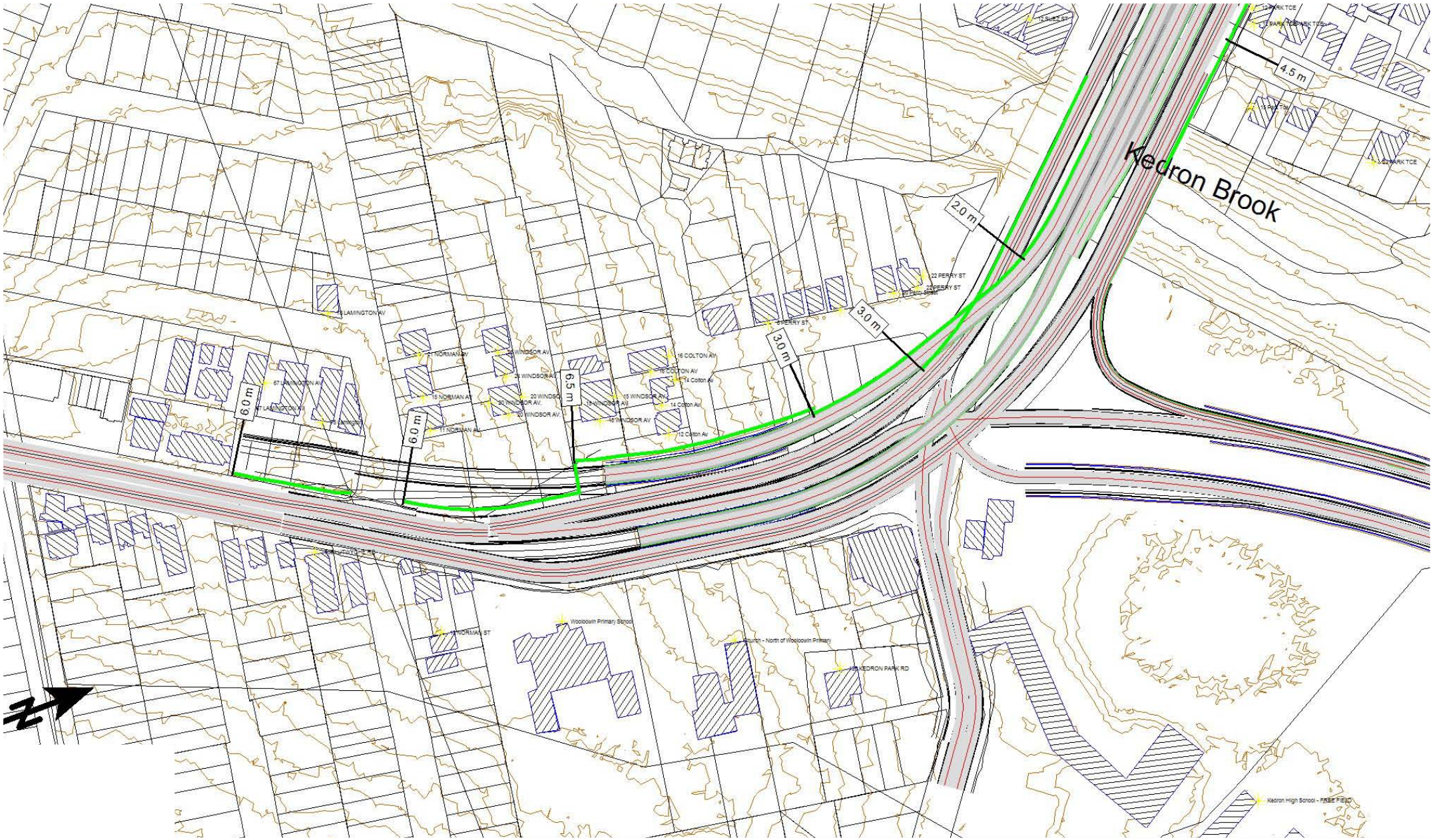
Scale 1:1000

AIRPORT LINK - Figure 10-1

Noise - Southern Connection

Airport Link

SKM Connell Wagner JOINT VENTURE



LEGEND

- Emission line
- Barrier
- Building
- Point receiver
- Road axis
- Surface

AIRPORT LINK - Figure 10-2a

Noise - NorthWest/South Connection

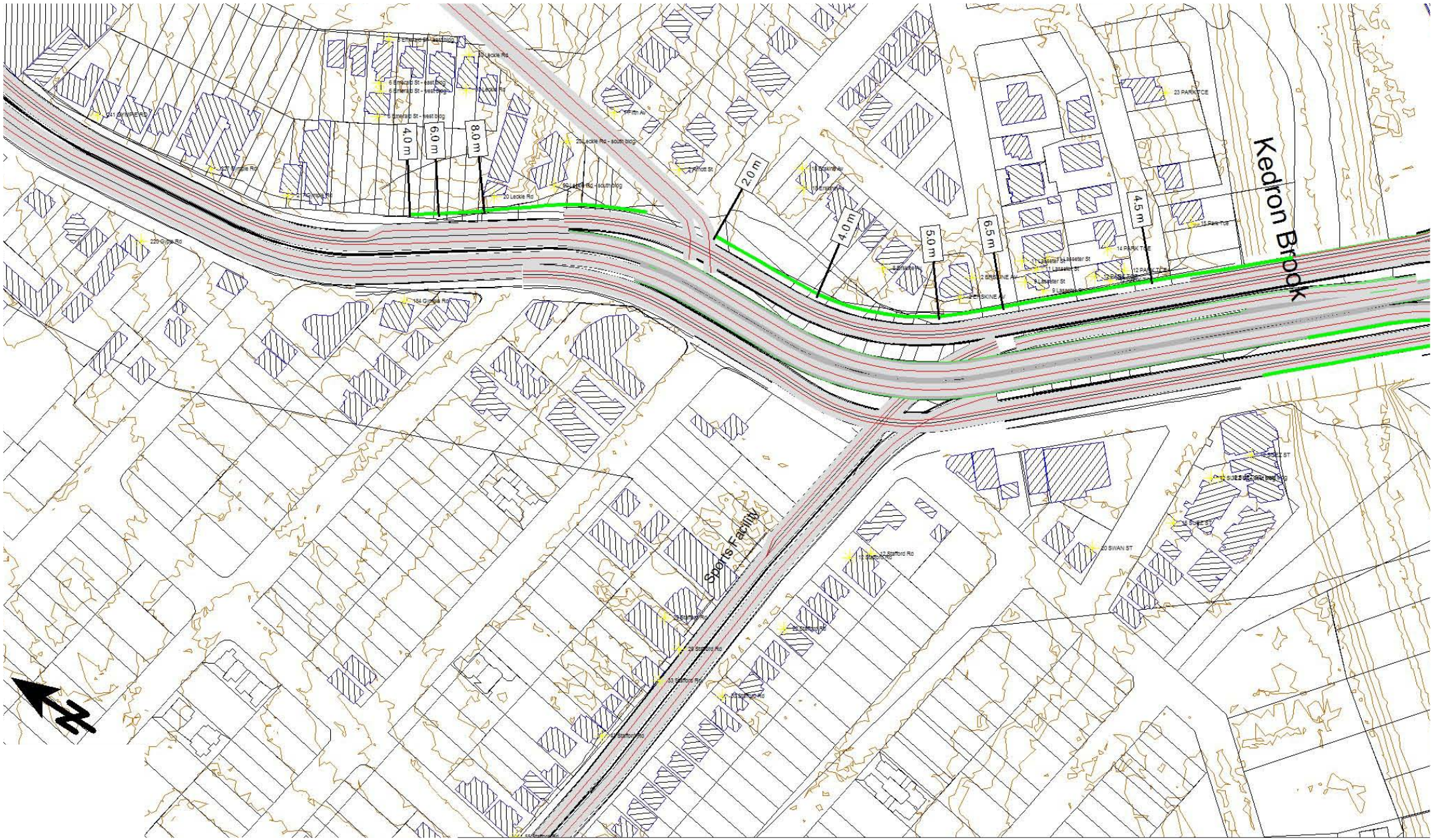
0 15 30 60m

Scale 1:3000

N

Airport Link

SKM Connell Wagner JOINT VENTURE



LEGEND

- Emission line
- Barrier
- Building
- Point receiver
- Road axis
- Surface

AIRPORT LINK - Figure 10-2b

Noise - NorthWest/North Connection

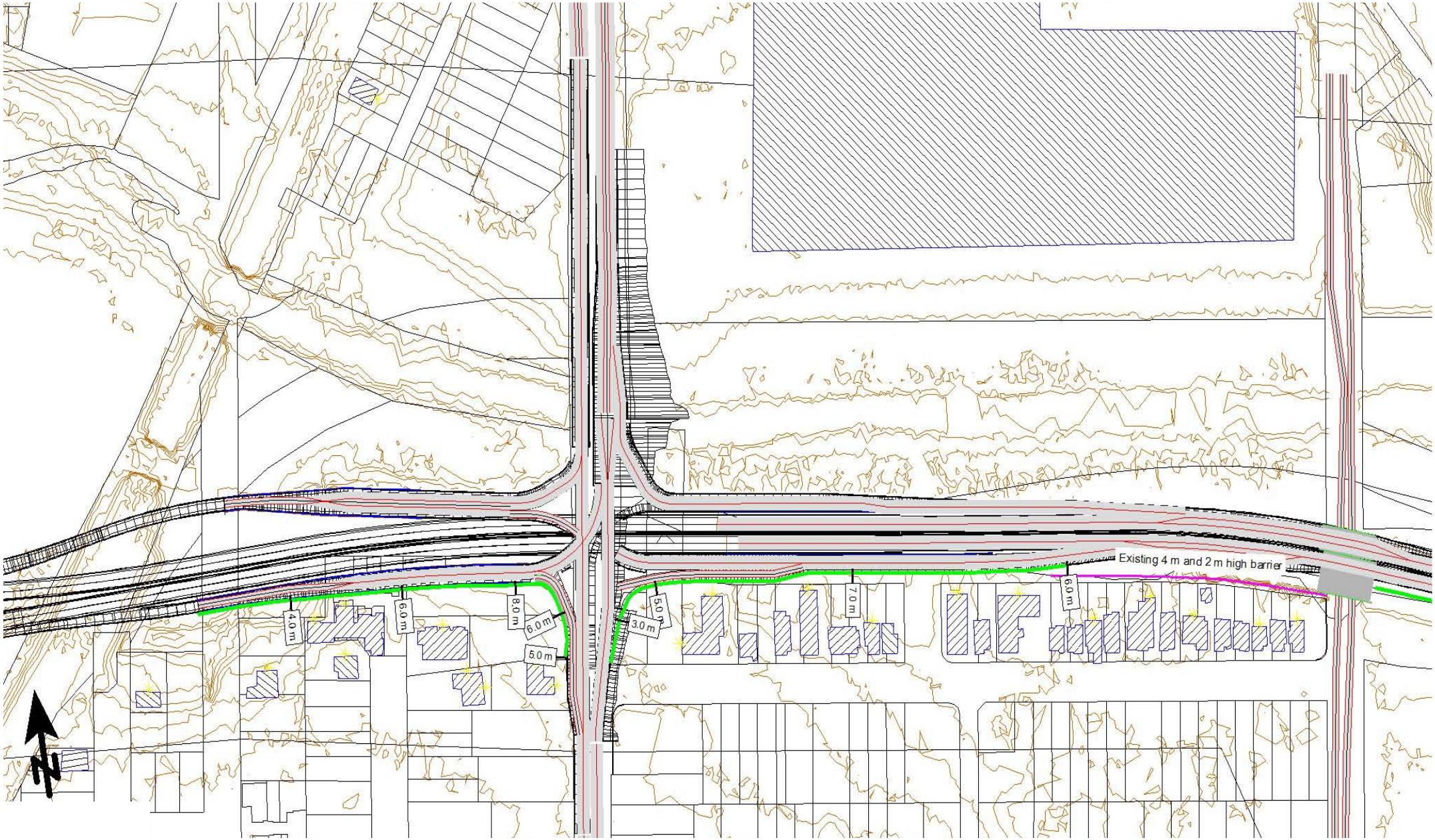
0 15 30 60m

Scale 1:3000

N

Airport Link

SKM Connell Wagner JOINT VENTURE



LEGEND

- Emission line
- Barrier
- Building
- Point receiver
- Road axis
- Surface

AIRPORT LINK - Figure 10-3a

Noise - NorthEast/West Connection

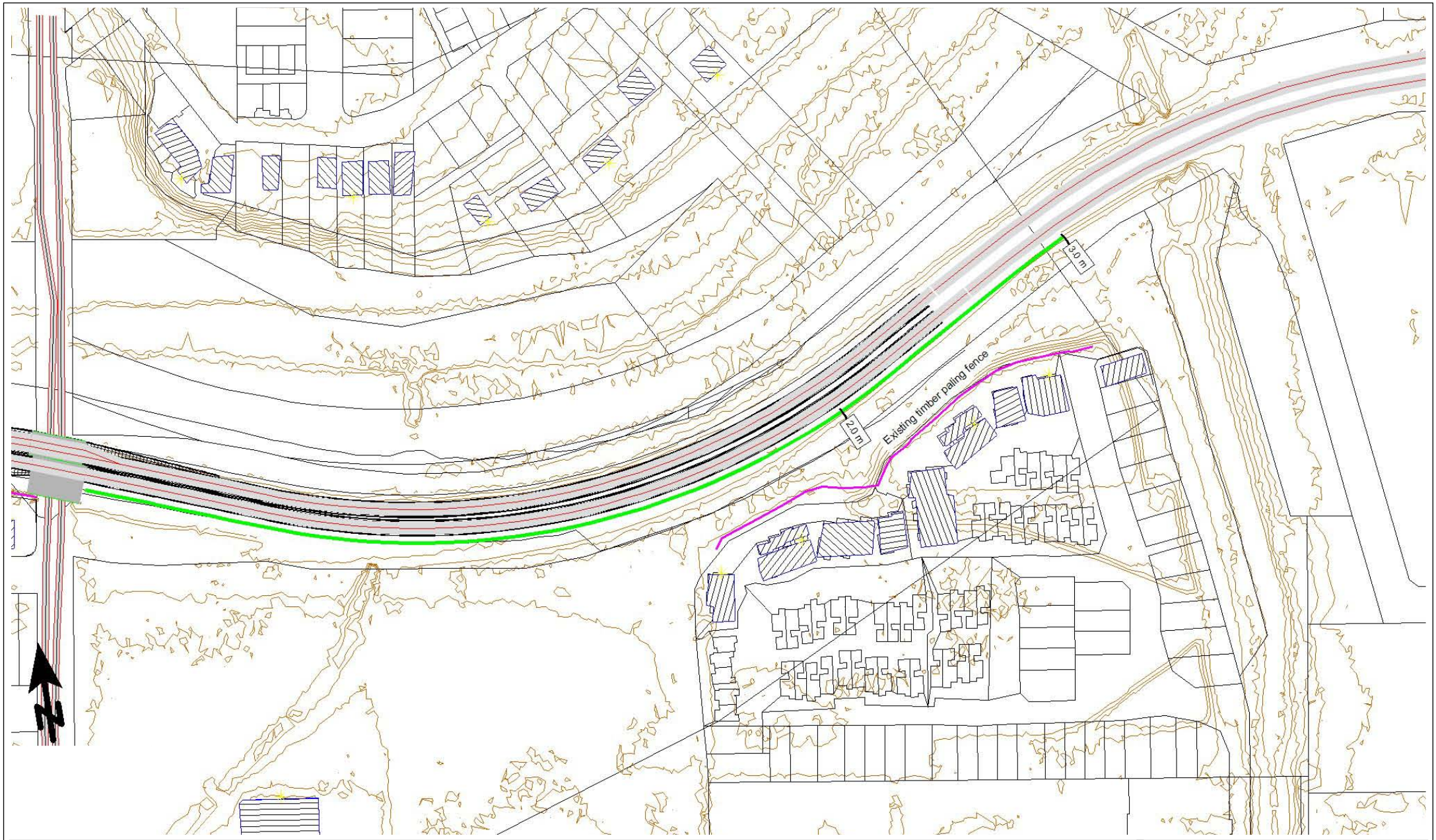
0 15 30 60m

Scale 1:3000

N

Airport Link

SKM Connell Wagner JOINT VENTURE



LEGEND

- Emission line
- Barrier
- Building
- Point receiver
- Road axis
- Surface

AIRPORT LINK - Figure 10-3b

Noise - NorthEast/East Connection

0 15 30 60m

Scale 1:3000

N

Airport Link

SKM Connell Wagner JOINT VENTURE

Road Traffic Noise Remote from Tunnel Portals

The effect of tunnel-related traffic on the noise emission from roadways remote from the tunnel connection areas has been assessed by calculating how traffic changes attributable to the tunnel would alter the $L_{A10(18hour)}$ value using the CoRTN prediction algorithms of the United Kingdom Department of Transport. The $L_{A10(18hour)}$ parameter is the average of hourly L_{A10} traffic noise levels between 6am and midnight.

Assuming that proportion of heavy vehicles, traffic speed and road surface remain constant, the relationship between increases in traffic volume on a roadway and the resulting increase in $L_{A10(18hour)}$ traffic noise emission is summarised in **Table 10-25**.

Table 10-25 Relationship Between Traffic Volume Changes & $L_{A10(18hour)}$ Noise Emission

Increase/Decrease in AADT Traffic	Resultant Change in $L_{A10(18hour)}$ Noise Emission
10%	0.4 dBA
25%	1.0 dBA
50%	1.8 dBA
75%	2.4 dBA
100%	3.0 dBA

Thus a doubling of traffic on a given roadway will result in a 3 dBA increase in the $L_{A10(18hour)}$ emission. A 3 dBA change in a dynamic noise, such as passing vehicles is difficult for most people to detect, whilst 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. It is acknowledged that people will probably notice increased traffic based on visual clues and perception of vehicle pass-by frequency before they will objectively notice an increase in the average noise level. For assessment purposes it is common to set the threshold of significance in relation to changes to the emission level from roads at 2 dBA. This threshold is adopted in this study.

Table 10-26 and **Table 10-27** present the changes in traffic noise levels for the Airport Link (without Busway) and Airport Link (with Busway) scenarios, relative to the Do Minimum option.

Table 10-26 2022 Traffic Noise on Road Network Remote from the Portal Areas

Location	Do Minimum		With Airport Link Only		With AL & Interim Busway		Change in $L_{A10(18hour)}$ Due to AL Only	Change in $L_{A10(18hr)}$ Due to AL & Interim Busway
	18hr Traffic Count	%CV	18hr Traffic Count	%CV	18hr Traffic Count	%CV		
Roads in Vicinity of Southern Portal								
Bowen Bridge Rd	71,130	7.1	53,780	6.6	50,410	6.7	-1.3	-1.6
Inner City Bypass	73,130	10.4	55,730	10.9	55,640	11.1	-1.1	-1.1
Breakfast Creek Rd	39,220	9.7	40,030	10.2	40,510	9.8	+0.2	+0.2
Kingsford Smith Drive	69,130	11.0	66,410	11.5	66,150	11.5	-0.1	-0.1
Roads in Vicinity of Gympie Rd Portal								
Stafford Rd	25,310	5.1	37,650	5.2	37,770	5.2	+1.7	+1.8
Gympie Rd (North of Stafford Rd)	73,300	5.3	93,830	5.3	92,010	5.6	+1.1	+1.0
Leckie Rd	6,370	7.1	5,650	7.0	5,470	7.4	-0.5	-0.6
Roads in Vicinity of Sandgate Rd Portal								
Sandgate Rd (North of East/West Arterial Rd)	59,930	5.6	50,660	5.8	51,210	5.8	-0.7	-0.6
Melton Rd	18,600	6.9	15,140	6.0	15,280	5.8	-1.1	-1.1
East-West Arterial Rd	64,580	7.1	75,040	6.8	75,020	6.9	+0.6	+0.6
Roads between Portals								
Lutwyche Rd	63,500	2.7	47,850	2.4	40,000	2.2	-1.4	-2.2
Junction Rd / Rose St	28,460	5.6	21,740	2.8	21,730	2.7	-1.9	-1.9
Park Rd	24,590	5.7	18,360	2.5	18,200	2.6	-2.1	-2.2
Sandgate Rd (South of East/West Arterial Rd - North of Junction Rd)	61,240	5.3	44,380	2.4	45,040	2.3	-2.2	-2.2
Sandgate Rd (South of Junction Rd)	53,040	5.2	37,050	4.0	37,490	1.6	-1.9	-2.5
Newmarket Rd	41,440	4.0	32,170	3.3	32,440	3.3	-1.3	-1.2

Table 10-27 2026 Traffic Noise on Road Network Remote from the Portal Areas

Location	Do Minimum		With AL Only		With AL & Ultimate Busway		Change in LA10(18hour) Due to AL Only	Change in LA10(18hour) Due to AL & Interim Busway
	18hr Traffic Count	%CV	18hr Traffic Count	%CV	18hr Traffic Count	%CV		
Roads in Vicinity of Southern Portal								
Bowen Bridge Rd	74,430	7.3	56,690	6.5	53,640	6.2	-1.4	-1.7
Inner City Bypass	72,220	11.6	57,110	11.4	57,580	11.2	-1.0	-1.1
Breakfast Creek Rd	42,890	8.3	42,760	8.7	42,570	8.8	+0.1	+0.1
Kingsford Smith Drive	69,930	11.0	68,050	11.2	68,100	11.1	+0.9	+0.9
Roads in Vicinity of Gympie Rd Portal								
Stafford Rd	25,270	4.7	38,810	4.9	38,820	5.0	+1.9	+1.9
Gympie Rd (N of Stafford))	74,890	13.9	95,880	5.6	94,430	5.7	-0.6	-0.6
Leckie Rd	6,940	8.2	5,710	9.8	5,610	8.4	-0.5	-0.9
Roads in Vicinity of Sandgate Rd Portal								
Sandgate Rd (North of East/West Arterial Rd)	61,010	5.1	52,700	5.4	53,080	5.4	-0.6	-0.5
Melton Rd	19,170	7.2	16,040	5.6	16,040	5.6	-1.1	-1.2
East-West Arterial Rd	66,880	6.3	76,080	6.5	76,180	6.6	+0.6	+0.6
Roads between Portals								
Lutwyche Rd	64,160	5.9	48,620	2.3	40,840	1.9	-2.2	-3.1
Junction Rd and Rose St	29,140	5.0	22,690	2.3	22,740	2.3	-1.8	-1.8
Park Rd	24,270	5.0	18,510	2.0	18,460	1.8	-2.0	-2.1
Sandgate Rd (South of East/West Arterial Rd, North of Junction Rd)	62,430	5.0	47,770	2.5	47,960	2.2	-1.9	-1.9
Sandgate Rd (South of Junction Rd)	54,280	5.3	40,070	3.8	40,180	3.8	-1.7	-1.7
Newmarket Rd	43,880	4.2	34,170	3.2	34,090	3.3	-1.4	-1.4

For the Years 2022 and 2026, the introduction of the Airport Link is predicted to result in a small change in the levels of road traffic noise on the wider road network. Generally noise levels decrease, but at a number of locations the noise levels are predicted to increase. **Table 10-28** presents a summary of the highest and lowest changes across the wider road network. Such changes are considered to be minor and unnoticeable.

Table 10-28 Summary of Changes

Year	Comparison of Do Minimum to Airport Link - No Busway		Comparison of Do Minimum to Airport Link - with Busway	
	Highest Increase	Highest Decrease	Highest Increase	Highest Decrease
2022	+1.7	-2.2	1.8	-2.7
2026	+1.9	-2.0	1.9	-2.1

For roads beyond the immediate tunnel infrastructure, the following options could be explored to mitigate increases in traffic noise if attributable to the tunnel:-

- Open-graded or stone mastic asphaltic road surfacing; and
- Building insulation upgrade programmes.

Road-side barriers are generally not a feasible option along local streets due to the requirement for property access from the street frontage.

Road Traffic Noise Mitigations

For the purposes of this EIS, a conventional approach has been adopted for mitigating traffic noise on the major roads leading to and from the Project. This approach entails the erection of noise barriers of varying heights, according to the magnitude of noise impact and the nature of adjacent land uses predicted to be impacted by increases in road traffic noise.

The appendices to Technical Report 6 Noise and Vibration in Volume 3 of the EIS provides predictions of road traffic noise in graphic form, including indications as to the required barrier heights to achieve either planning level noise or status quo noise outcomes for the design years 2022 and 2026. For many locations, the scale of noise barriers required to mitigate increases in traffic noise is in keeping the with character of the road and the scale and amenity of the locality. However, in other locations, the scale of the noise barriers is significant in terms of impacts on visual amenity, local connectivity and urban character. A summary of the range of barrier heights in key locations is provided in **Table 10-29**.

- **Table 10-29 Traffic Noise Barriers Required to Achieve 'Status quo' Noise - 2026**

Connection / Key Road	Road Section	Barrier Height (m)
Southern connections		
Inner City Bypass	adjacent to The Mews apartments	5.0
NSBT	ICB off-ramp to Lutwyche Rd	3.0 – 6.0
	Lutwyche Rd (east side), between Horace St & Newmarket Rd	5.0 (for NSBT)
	Connections to Airport Link	5.0 – 7.0
Campbell St	Hamilton Pl to railway	2.5
North-western connections		
Lutwyche Rd	west-side, south of Norman Ave to Perry St	7.0 – 8.0
	Airport Link connections to elevated Gympie Rd	4.0 – 6.0
Gympie Rd	Elevated connections to Airport Link	3.0 – 4.0
	North-side, Park Tce to Leckie Rd	4.0 – 6.5
	North-side, Leckie Rd to Broughton St	2.0 – 5.0
	West-side, Stafford Rd to Brookfield St	3.0
North-eastern connections		
East West Arterial	Melton Rd to Sandgate Rd	2.0 – 4.0 (existing)
	Sandgate Rd to entry portal west-bound	3.0 – 8.0

It is notable that if the planning levels (63/68dBA) are adopted for traffic noise mitigation, the heights of barriers increase in some locations, including:

- NSBT connections (O'Connell Tce on-ramp to Airport Link) increases to 8.0m south of Campbell St;
- Gympie Road north of Leckie Road to 8.0m in one location, and west of Park Terrace to

- Sandgate Road at the west-bound entry ramp to 6.0 – 8.0m.

Alternative Mitigation Strategies to Reduce Road Traffic Noise Impacts

Many communities are familiar with the use of noise barriers to mitigate traffic noise impacts of development, but often express concerns about the impacts of noise mitigation measures, some of which include loss of views, changes in perceptions of pedestrian safety in places where barriers have been erected, changes in visual amenity, changes in pedestrian circulation patterns.

During the detailed design phase of the works, consideration should be given to the following options as alternative means of noise control, where noise barriers prove to be unreasonable or feasible:

Road Surface Treatments: The prevailing road surface directly influences the noise emissions from the roadway. The use of Open Graded Asphaltic Concrete (OGAC), for example, would result in noise levels that are 3dBA lower than Dense Graded Asphaltic Concrete (DGAC) which is the road surface that has been modelled for all roads in this study. Other similar surfaces include Stone Mastic Asphalt (SMA), where noise reductions of 1 - 2 dBA are reported (compared to DGA), depending on the stone size.

This option has some limitations:

- It is relatively costly to lay;
- It needs to be periodically replaced due to wear
- In tunnels, OGAC cannot be used as it is a potential fire hazard. In the case of a petrol or other flammable liquid spill the roadway encourages the absorption of the volatile liquid rather than letting it stay on the surface.

Architectural acoustic treatment of existing dwellings: As an alternative to noise barriers, it may be possible to provide upgrading to the façade windows and doors in some circumstances.

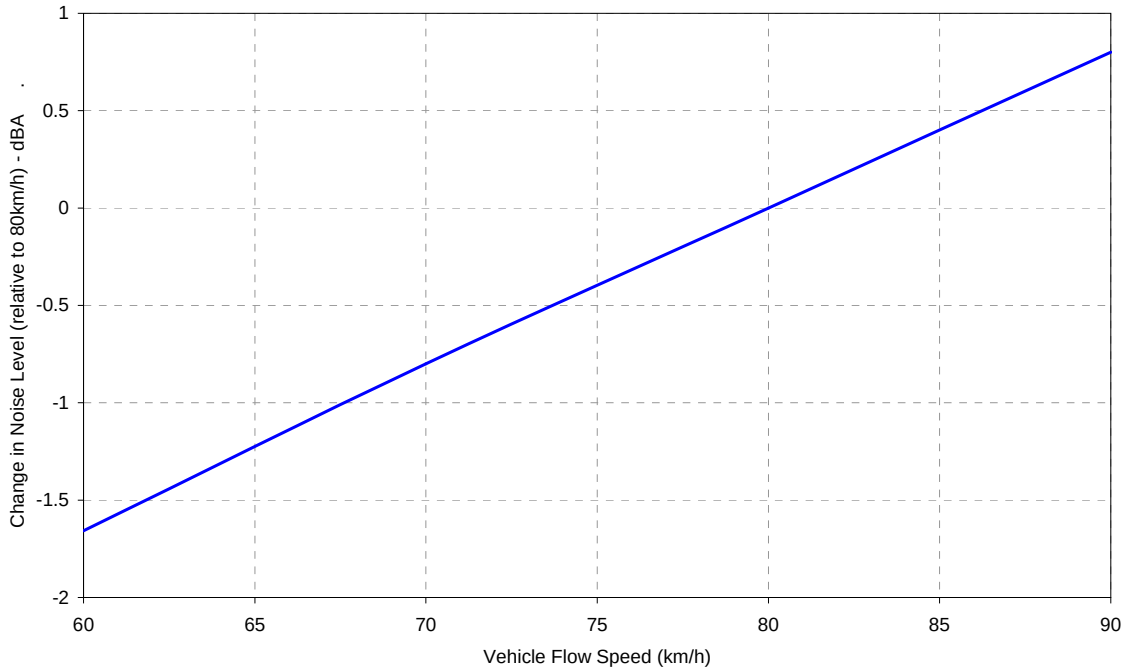
Depending on the extent of impacts, consideration should be given to the supply of fresh air and/or air-conditioning into habitable rooms (allowing the windows to remain closed for noise control purposes) and to the upgrading of facade windows and doors (subject to qualifications).

Resumptions: In consultation with the property owners, Council could consider the purchasing of properties severely impacted by a project.

Urban Renewal: Councils and other authorities can consider an urban renewal program for areas or buildings that are adversely impacted by road traffic noise, replacing noise sensitive buildings (e.g. homes) with non-noise sensitive buildings (e.g. commercial). For example, the future use of the construction worksites at the southern connection could include a non-residential component which would provide an effective screen for traffic noise and reduce if not remove the need for noise barriers in that location.

Vehicular Speed: The overall traffic noise could be reduced by the lowering of the vehicular flow speed. At the higher speeds, noise is emitted from the interaction of the tyres and the roadway, whilst at lower speeds, the noise tends to arise from the engine and exhaust. **Figure 10-4** presents the relationship between noise level and speed, relative to 80 km/h.

- **Figure 10-4 Noise Levels and Vehicular Speed**



Reducing road speed is generally not considered a viable form of noise mitigation due to the relatively small changes involved, and it opposes one of the primary functions of road infrastructure projects which is to decrease travel times between destinations.

Reductions in Vehicle Noise Emissions: Noise emissions for new vehicles are defined within the Australian Design Rule 28/01, within the Motor Vehicles Standard ACT. Over time, changes to the standards would result in lower noise levels in the community.

Regenerated Noise

Regenerated noise from roadways in shallow tunnel areas is not considered to be an issue at any of the tunnel portals.

Ventilation System Noise

Preliminary calculations of ventilation outlet noise emissions indicate that it would be feasible for noise emissions to comply with the BCC's Noise Impact Assessment Planning Scheme Polices and EPA licensing. Providing that emissions at residential locations are free of distinct tonal characteristics, and do not exceed background noise levels, the normal licensing requirements would allow the ventilation outlets to be developed with negligible noise impact to residents.

For the assessment in this EIS, the design criteria for ventilation noise are to maintain noise levels equal to existing background levels. **Table 10-30** presents a summary of the assessment locations and design criteria for the ventilation stations and outlets for the Airport Link Project.

- **Table 10-30: Ventilation Stations & Outlets – Noise Design Criteria**

Vent Station	Nearest Assessment Point	Representative Noise Monitoring Location	Exist Night Background Noise (dBA)	Design Criteria (dBA – L90)
Southern	Byrne St	49 Earle St	43	43
	Gallway St	46 Gallway St	42	42
North-western	Kedron State High School	34 Park Rd	34	34
	Park Tce	12 Park Tce	40	40
	Haines St	12 Park Tce	40	40
North-eastern	Alma Rd	86 Alma Rd	40	40
	Kalinga St	72 Kalinga St	41	41
	Parklands St	27 Parklands St	42	42
	Wongara St	30 Wongara	40	40
	Masefield St	30 Wongara	40	40
	Melton Rd	30 Wongara	40	40

Applying the design criteria topredicted noise levels for the fans adopted, the level of attenuation required to achieve the design criteria are set out in **Table 10-31**. Some additional noise reduction is required to be incorporated into the ventilation system. The requirements are achievable and not considered excessive or restrictive.

- **Table 10-31 Noise Attenuation Required – Ventilation Station Noise**

Vent Station	Predicted Noise Emission Levels	Attenuation Required	Comments
Southern	39	Nil	Desirable to attenuate the low and high frequencies (ie 63Hz and 2KHz)
North-western	50	16 dBA (overall)	Exceedances in the low and high frequencies (125Hz and 2KHz) – intermediate frequencies do not exhibit exceedances
North-eastern	43	3 dBA (overall)	Exceedances in the low and high frequencies (125Hz and 2KHz) – intermediate frequencies do not exhibit exceedances

Vibration and regenerated noise issues may need to be addressed if the ventilation outlets are to be integrated into a residential or commercial building. This issue would be manageable through appropriate mechanical and structural design.