Flinders Link

100% Design Noise Assessment Report

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Resonate

Document Information

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Revision Table

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B	20 December 2017	Final Issue
C	1 February 2018	Revised in Response to DPTI Comments
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E	28 November 2018	100% Design Report

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Glossary

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
Day	Between 7 am and 10 pm as defined in the RTNG and GANRI.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	Units of the A-weighted sound level.
DPTI	Department of Planning, Transport and Infrastructure.
GANRI	SA EPA *Guidelines for the assessment of noise from rail infrastructure*.
Insertion Loss (IL)	The insertion loss of a barrier is the difference in sound pressure levels at a specified receiver position before and after the installation of the barrier, provided that the noise source, terrain profiles, interfering obstructions and reflecting surfaces (if any) have not changed.
L_{eq}	Equivalent Noise Level—Energy averaged noise level over the measurement time.
$L_{eq,15h}$	Daytime road or rail traffic level, determined as the equivalent noise level from road or rail traffic over the daytime period.
$L_{eq,9h}$	Night time road or rail traffic level, determined as the equivalent noise level from road or rail traffic over the night time period.
L_{max}	Maximum noise level measured in a time period. Used to assess noise levels from individual train pass-bys.
mm/s	Millimetres per second, unit of vibration velocity.
Night	Between 10 pm on one day and 7 am on the following day as defined in the RTNG and GANRI.
Peak Particle Velocity (PPV)	The maximum speed of a particle in a particular component direction due to vibration during a measurement.
rms	Root-mean-square.
Residual exceedance	The remaining exceedance of a noise assessment criterion following the application of noise mitigation measures.
RTNG	DPTI *Road Traffic Noise Guidelines*
R_W	Weighted Sound Reduction Index—A laboratory measured value of the acoustic separation provided by a single building element (such as a partition). The higher the R_W the better the noise isolation provided by a building element.
$R_w + C_{tr}$	A measure of the sound insulation performance of a building element with a C_{tr} spectrum adaptation term placing greater emphasis on the low frequency performance.
SEL	Sound Exposure Level—the sound pressure level of an event within a defined duration, normalised to a duration of one second.

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1 Introduction

The Australian and South Australian Governments have committed $85 million to construct the Flinders Link Project. The Project is an extension of the existing Tonsley Passenger Rail Line to Flinders Medical Centre, creating new connections to the health precinct and Flinders University.

The project includes:

- A 650 metre extension of the Tonsley Passenger Rail Line linking the Flinders Medical Centre and Flinders University to the rail network, including 420 metres of elevated single track over Sturt Road, Laffer's Road and Main South Road
- A new station next to the Flinders Medical Centre
- An integrated shared pedestrian/cycle path adjacent to the rail line.

The operational phase of the project will have potential rail traffic noise impacts on noise sensitive receivers adjacent to the project area. These impacts require assessment against relevant guidelines for rail traffic noise.

This report is the Noise Assessment Report for the Flinders Link Project based on the 100% design. It presents:

- The relevant rail noise assessment criteria for the project.
- Predicted rail noise levels at noise sensitive receivers adjacent to the project for the existing and project opening scenarios.

1.1 Rail vibration

The nearest receivers to the existing and proposed rail alignment are approximately 25m from the closest section of track. At this distance there are rarely vibration or ground-borne noise associated with passenger rail movements. Based on previous experience and measurements on the SA passenger rail network, we expect that vibration and ground-borne noise will comfortably comply with the relevant criteria. No further detailed assessment has been undertaken.

1.2 Non-rail noise sources

The CSTR (Rev K, Part D20, Section 8.4.5) requires that a noise assessment for other ancillary buildings / structures such as sewer and stormwater pump stations is undertaken in accordance with and demonstrate compliance with the Environment Protection (Noise) Policy 2007.

Noise data for ancillary mechanical or hydraulic plant is not available at this stage. It is expected that with standard mitigation measures such as siting plant away from noise sensitive locations, selection of low-noise equipment, attenuation, and screening, noise levels can comply with Environment Protection (Noise) Policy 2007.

2 Assessment Criteria

2.1 General environmental duty

Under the South Australian *Environment Protection Act 1993* (EP Act), the Flinders Link Project has a duty of care for the environment due to rail infrastructure works. This *General Environmental Duty* is defined in Section 25 of the EP Act as:

> *A person must not undertake an activity that pollutes, or might pollute, the environment unless that person takes all reasonable and practicable measures to prevent or minimise any resulting environmental harm.*

As discussed in the following sections, guidelines produced for management of rail noise provide guidance as to the requirements for satisfying the *General Environmental Duty* as part of a transport infrastructure project.

2.2 Rail noise

The South Australian EPA has developed the *Guidelines for the assessment of noise from rail infrastructure* (GANRI). GANRI was released in April 2013, and specifies the assessment methodology and noise and vibration criteria for rail infrastructure projects, and is therefore relevant to the Flinders Link Project.

2.2.1 Rail noise criteria

Table 1 presents the rail noise criteria relevant for noise-sensitive receivers adjacent to the Flinders Link project. GANRI requires compliance with the noise criteria to be achieved both at project opening and 10 years into the future.

Table 1 Rail noise assessment criteria

Sensitive receiver	Type of project	Noise criteria, dB(A)	
		Day	Night
Residential	Upgraded rail line	65 $L_{eq,15h}$	60 $L_{eq,9h}$
		85 L_{max} OR No increase on existing, whichever is the greater	85 L_{max} OR No increase on existing, whichever is the greater
	New railway line	60 $L_{eq,15h}$	55 $L_{eq,9h}$
		80 L_{max}	80 L_{max}
Hospitals	New railway line	60 $L_{eq,1h}$	
Educational Institutions	New railway line	65 $L_{eq,15h}$	N/A
Active recreation areas such as sporting fields	New railway line	65 $L_{eq,15h}$	N/A

A proposed development is considered as a ‘new railway line’, and as such should meet the relevant noise criteria where:

- A new railway is being constructed in a new rail corridor where nearby noise sensitive receivers are not already exposed to rail noise or

- An additional railway line is being constructed within an existing corridor, and noise levels generated by existing rail operations in the corridor meet the criteria for new railway lines outlined in Section 2

or

- A substantial realignment of an existing railway within an existing corridor. Normally it involves change of the corridor boundaries or significant alteration of separation distances to the nearest sensitive receivers within the existing corridor.

Noise sensitive receivers to the north of Sturt Road are generally already exposed to rail noise from the existing alignment. The Project does not involve an additional railway line or substantial realignment of an existing railway within the existing corridor.

However, the viaduct section is within a new/extended rail corridor. Based on the above, receivers to the north of Sturt Road are assessed against the upgraded rail line criteria in, while receivers to the south of Sturt Road are assessed against new railway line criteria.

We note that the Sturt Police Station, SA Ambulance Service and other commercial buildings to the west of the proposed viaduct are not considered to be noise sensitive receivers in accordance with GANRI. The project team has received no indication that these receivers are particularly noise or vibration sensitive.

The Mark Oliphant Building at 5 Laffer Drive, Bedford Park is owned by Flinders University and has been assessed as an Educational Institution.

2.3 Noise assessment location

It is a requirement of the GANRI that noise levels are predicted at a position one metre from the facade of each noise sensitive building at a height of 1.5 metres above each floor level. The noise assessment location should correspond to a facade where a door or window to a noise sensitive area is contained. Note that a facade where no windows/doors exist or where the only windows serve non-sensitive areas such as bathrooms should not be treated as noise sensitive.

Noise levels at these locations are influenced by reflections from the building facade, and all predictions are to include a facade reflection factor. For rail noise, a conservative reflection factor of +2.5 dB has been applied in accordance with the rail noise prediction methodology recommended by GANRI.

Each floor level of a multi-storey building has also been considered separately when predicting noise levels for comparison against the applicable noise criteria.

For active and passive recreation areas, the assessment location should be at the most affected location of the recreation area, and no facade reflection factor will be applicable.

3 Existing environment

3.1 Noise sensitive receivers

The primary noise sensitive receivers relevant to the Flinders Link Project are residential properties in the suburbs of Mitchell Park and Tonsley. Other than residential properties, the Flinders Medical Centre and Sports Fields are located near the terminus and proposed new station.

As noted in Section 2.2.1, the Sturt Police Station and other commercial buildings are not considered noise sensitive receivers according to GANRI.

Noise sensitive receiver locations and IDs are shown on the Figure in Appendix A.

3.2 Existing noise environment

The existing noise environment in the project area varies over the project site. Residences in Mitchell Park and Tonsley are currently controlled by rail noise from the existing Tonsley Passenger Rail Line, station and associated activities including car parking; in addition to local road traffic. South of Sturt Road, the noise environment is controlled by road traffic noise from Sturt Road and South Road, with no existing rail noise.

The existing rail noise levels at the residential locations are controlled by the distance between the residence and the Tonsley Passenger Rail Line, and the presence of any intervening structures.

3.2.1 Rail noise

Ambient rail noise levels were measured by AECOM in 2010 at three locations along the existing Tonsley line as part of the Darlington Transport Study[1]. Median rail noise levels from measurements adjacent the Tonsley Passenger Rail Line are presented in Table 2.

Table 2 Measured existing noise levels in project area

Catchment Area	Description	Measured noise level, dB(A)	
		Day $L_{eq,15h}$	Night $L_{eq,9h}$
A	Adjacent existing Tonsley Passenger Rail Line from Woodlands Park railway station to Sturt Road	52	47

Maximum levels (L_{max}) were reported at the nearest properties to the Tonsley Passenger Rail Line to range from 82 to 87 dB(A). Daytime noise levels ($L_{eq,15hr}$) at the nearest properties were stated to range from 53 to 56 dB(A). As the Tonsley Passenger Rail Line currently is in service only between 7am and 7pm, there is no significant night time rail noise within the study area.

Note that the measured daytime noise levels may be influenced to some degree by extraneous noise from local traffic, birds and wind in the trees.

We understand that measurements were carried out in general accordance with GANRI. Due to ongoing Darlington Upgrade construction works it was not considered practicable to undertake more recent ambient noise measurements.

[1] http://www.infrastructure.sa.gov.au/__data/assets/pdf_file/0016/54304/DTS_Exec_Summary_for_Web.pdf

4 Rail noise assessment methodology

Rail noise models were developed for the Flinders Link Project for the following scenarios:

- Existing scenario – year 2017
- Project opening scenario – year 2019.

Both the project opening and existing scenario have been modelled with the existing Adelaide Metro A-City Class 4000 Electric Multiple Units (EMUs), assuming three car sets.

We note that 3000 Class Diesel Railcars may be used on rare occasions (for example in the event of a line fault). We understand that the frequency of use is expected to be very low, such that an assessment of noise emissions from 3000 Class trains is not warranted.

It is understood that a timetable for implementation on commencement of operation of the extended line has been developed. This would result in 66 day (7am to 10pm) and 10 night (10pm to 7am) movements through the Project area. These figures account for both the up and down movements through the area.

A future 2029 scenario has not been modelled at this stage as the opening scenario is understood to be representative of the future scenario.

4.1 Project assessment area

The Flinders Link project will involve a considerable vertical realignment of the Tonsley Passenger Rail Line near the current Tonsley Station. The rail line will then extend as an elevated structure over Sturt Road, Laffer Drive and Main South Road before terminating north of the Flinders Medical Centre.

The project assessment area for rail noise and vibration considers the area between the start of works near Woodland Road in Mitchell Park, through to the Flinders Medical Centre in Bedford Park.

4.2 Prediction methodology and model inputs

Rail noise predictions for existing and future scenarios have been carried out using the Nordic Rail Prediction Method (Kilde Report 130), as implemented by SoundPlan software version 8.0. The Nordic Rail Prediction Method is specified as a suitable method for the prediction of L_{eq} and L_{max} rail noise levels by GANRI.

The inputs included in the three-dimensional SoundPlan noise models were:

- +2.5 dB facade reflection factor in accordance with the Nordic Rail Prediction Method
- topographical contours provided by Gateway South
- existing rail alignment from the topographical contours and aerial photography
- rail alignment and viaduct cross section information provided by Jacobs Group
- continuously welded rail for the rail structure
- hard ground, in accordance with GANRI
- building footprints from aerial photography and building heights based on surveys of the site
- existing fences based on surveys of the site.

4.3 Calibration

The Nordic Rail Prediction Method algorithms predict noise levels based on the number, speed and length of trains, and require calibration to site conditions. Noise levels from 4000 class trains were previously measured by Resonate to calibrate the predicted noise levels. The measured reference Sound Exposure Level (SEL) and L_{max} level used to calibrate the rail noise model are presented in Table 3.

Table 3 Reference train noise levels for calibration

Train	Reference distance	Reference speed	SEL, dB(A)	L_{max}, dB(A)
4000 class	20 m	70 km/h	84	80

Noise from the 4000 class passenger trains comprise of noise from the rolling stock on the track. Rolling stock source has been located at 0.5 m above ground.

4.4 Train volumes, lengths and speeds

Table 4 presents the train volumes, lengths and speeds for the two noise modelling scenarios carried out for Flinders Link.

Table 4 Train volumes, lengths and speeds for noise modelling

Scenario	Track direction	Speed, km/h	Length, m	Train movements	
				Day	Night
Existing	Up (to Adelaide)	70	75	24	0
	Down (from Adelaide)	70	75	24	0
Project opening (2019)	Up	50-70	75	33	5
	Down	50-70	75	33	5

The design speed of the viaduct is understood to be 50 km/h. We have assumed this speed on the viaduct and Flinders Station (Terminus) sections and 70 km/h on the at-grade section north of the viaduct.

4.5 Curve squeal

Curve squeal (sometimes referred to as wheel squeal) occurs where there is a relatively tight radius to negotiate such as on the viaduct section of the Flinders Link proposal. Further discussion including mitigation measures described in Section 7 of this report, entitled Rail Noise Mitigation, and the Resonate report *Curve Squeal Risk and Mitigation Measures*.

Measurements taken by Sydney Trains (formerly RailCorp) at a 284 m radius curve at Beecroft, NSW, indicate that maximum noise levels from passenger train movements are between 6 and 15 dB higher than noise levels from the same trains on straight track sections.

The noise model includes the following allowances (independent of speed) for localised increase in noise emission on the curved section of track assuming no curve squeal mitigation:

- +5 dB L_{AE}
- +14 dB L_{Amax}

The above adjustments are consistent with modelling recently carried out by SLR for the Epping to Thornleigh Third Track Project in NSW, on similar radius curves.

4.6 Structure-borne noise

Structure-borne noise refers to rail vibration regenerated as airborne noise by the bridge structure. This can both increase the received noise level at residences adjacent to the bridge structure and change the character of the noise. Structure-borne noise from steel box structures tends towards the lower frequencies and can be tonal in nature[2], with tonal noise having the potential to increase annoyance for the same overall level of noise. Note that structure-borne noise is different to ground-borne vibration.

The level and character of structure-borne noise will depend on the structure of the bridge, the track construction and the type and speed of trains passing over.

Figure 1 compares the level of structure-borne and airborne noise for different bridge structures from the *Handbook of Engineering Acoustics*[3]. It can be seen that the steel bridges result in higher levels than concrete structures. The presence of noise at 63 Hz corresponds to a speed-dependent relationship between the train and the structure and will therefore vary between situations.

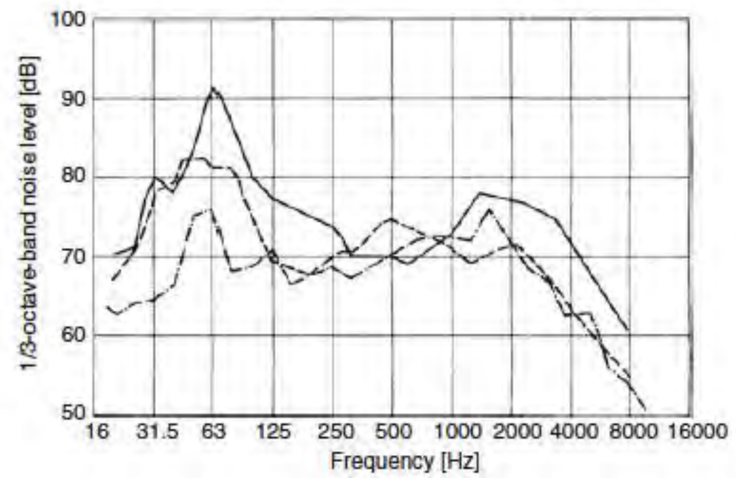

Fig. 16.21 Airborne noise at a distance of 25 m to the side of three bridges of different types of construction with ballasted track during the drive over of passenger trains with disc brakes at a speed of approx. 130 km/h: ——— steel hollow-box girder bridge, measurement height 1.5 m above top of rail: 97 dB(lin), 87 dB(A); - - - - - - - steel lattice-girder bridge, measurement height 3.5 m above top of rail: 89 dB(lin), 80 dB(A); —·—·— reinforced concrete hollow-box girder bridge, measurement height 3.5 m above top of rail: 85 dB (lin), 82 dB(A)

Figure 1 Comparison of structure-borne and airborne noise for different bridge structures from *Handbook of Engineering Acoustics* (Fig. 16.21)

[2] Ngai KW & Ng CF, 2002, *Structure-Borne Noise and Vibration of Concrete Box Structure and Rail Viaduct*, Journal of Sound and Vibration, Vol 255(2), pp 281—297.

[3] Müller G & Möser M (eds), 2012, *Handbook of Engineering Acoustics*, Chapter 16.

A recent study, conducted for the Glenelg Tram Overpass of South Road, considered the relative contribution of structure-borne noise and airborne noise based on measurements conducted at the older tram line overpass at Goodwood which had no specific structure-borne noise mitigation included in the design. It was found that the overall contribution of structure-borne noise was broadly similar to airborne noise at the older structure and therefore, if noise mitigation was required as part of the new overpass design, it would be necessary to mitigate both structure-borne noise and airborne noise.

To reduce structure-borne noise (or bridge-borne noise), which cannot be mitigated via railside noise barriers, being emitted via vibration transmission to the overpass structure, it is important that vibration isolation is included between the rail and the overpass structure.

The rail noise predictions for the Flinders Link project have been prepared on the basis that the track will be installed on a concrete slab with vibration isolation installed between the rail and the slab. It is understood that Pandrol Vipa SP resilient rail fasteners will be installed.

An adjustment of +4 dB (for ballasted steel box girder structures) has been applied in accordance with the *NSW Rail Noise Database: Stage III Measurements and Analysis* (January 2015).

We note that the viaduct structure is steel and concrete with resiliently fixed track as described above. The NSW Rail Noise Database: Stage III Measurements and Analysis (January 2015) notes that "Unballasted steel bridges typically generate the highest noise emissions, whereas noise emissions from concrete bridges with ballasted or resiliently fixed track may be almost as low as “at grade” noise emission levels."

There is no correction in the NSW Rail Noise Database for steel/concrete structures with resiliently fixed track, as is proposed here. A recent study[4] found that a noise from a comparable bridge was +4 dB or less in each octave band, with a 0 dB(A) overall increase compared to at-grade rail.

The application of a + 4dB correction to overall A-weighted levels is therefore considered a conservative approach.

4.7 Track decay rate

The use of resilient rail fasteners as recommended in Section 4.6 may result in a low track decay rate (TDR) which has the potential to increase the contribution of rail noise to overall noise levels. A low TDR may also lead to higher curve squeal noise in situations where rail movement is a contributing factor.

Rail dampers are a potential option to reduce rail noise emissions if required.

[4] *Noise Prediction of a steel-concrete railway bridge using a FEM*, J. Oostjijk (2015)

5 Existing rail noise levels

Table 5 presents the modelled existing rail noise levels for each noise sensitive receiver within the project assessment area. The location of each receiver is shown in Appendix A.

Modelled noise levels at each receiver are shown in Table 5 below, and noise contour maps are shown in Appendix C. The modelled existing rail noise levels indicate that noise sensitive receivers located adjacent to the Tonsley Passenger Rail Line are currently exposed to day time rail noise levels in the order of 50 to 55 dB(A) $L_{eq,15h}$ and maximum noise levels of 76 to 83 dB(A) L_{max}.

Table 5 Predicted existing rail noise levels

Location	Receiver ID	Predicted existing rail noise levels, dB(A)	
		Day $L_{eq,15h}$	L_{max}
Woodland Road and Timothy Court	RA038	50	78
	RA039	50	78
	RA040	50	77
	RA041	49	77
Lynton Avenue	RA042	46	74
	RA043	48	76
	RA044	48	75
	RA045	48	75
	RA001	45	71
	RA002	45	71
	RA003	44	72
	RA004	44	72
	RA005	47	74
	RA006	44	71
	RA007	44	71
	RA012	39	70
Ash Avenue and Birch Crescent	RA025	55	82
	RA026	55	84
	RA014	56	84
	RA027	55	84
	RA028	55	84
	RA029	55	83
	RA030	54	83
	RA008	53	82
	RA009	53	82

Location	Receiver ID	Predicted existing rail noise levels, dB(A)	
		Day $L_{eq,15h}$	L_{max}
	RA010	52	82
	RA011	47	78
	RA013	44	74
	RA046	40	70

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6 Future rail noise levels

This Section presents predicted rail noise levels for the 100% Flinders Link design. Corrections for curve squeal and structure-borne noise have been applied to emissions from the viaduct as described in Sections 4.5 and 4.6.

6.1 2019 rail noise levels without mitigation

Table 6 presents the predicted 2019 rail noise levels for each noise sensitive receiver within the project assessment area with no noise mitigation. Noise contour maps are presented in Appendix C.

Predicted noise levels that exceed the relevant upgraded rail line criteria from GANRI of 65 dB(A) $L_{eq,15h}$ or 85 dB(A) L_{max} are highlighted in bold type.

Table 6 Predicted 2019 rail noise levels without mitigation

Location	Receiver ID	Predicted 2019 rail noise levels with no mitigation, dB(A)		
		Day $L_{eq,15h}$	Night $L_{eq,9h}$	L_{max}
Woodland Road and Timothy Court	RA038	57	51	80
	RA039	57	51	80
	RA040	57	51	80
	RA041	56	50	81
Lynton Avenue	RA042	59	53	84
	RA043	58	52	81
	RA044	57	51	81
	RA045	60	54	86
	RA001	59	53	85
	RA002	59	53	84
	RA003	61	55	**86**
	RA004	61	55	**86**
	RA005	60	54	85
	RA006	59	53	84
	RA007	59	53	84
	RA012	58	52	82
Ash Avenue and Birch Crescent	RA025	57	51	83
	RA026	58	52	83
	RA014	59	53	83
	RA027	58	52	83
	RA028	59	53	82
	RA029	60	54	82
	RA030	60	54	83

Location	Receiver ID	Predicted 2019 rail noise levels with no mitigation, dB(A)		
		Day $L_{eq,15h}$	Night $L_{eq,9h}$	L_{max}
	RA008	63	57	**87**
	RA009	65	59	**91**
	RA010	**66**	60	**91**
	RA011	65	59	**89**
	RA013	64	58	**89**
	RA046	60	54	82
Flinders Sports Fields		49	N/A	N/A
Flinders Medical Centre		52 ($L_{eq,1hr}$)	N/A	N/A

The predictions indicate that, without additional mitigation measures, the current rail overpass design is predicted to result in exceedances of the upgraded rail line L_{max} criteria at seven residences located on both sides of the Tonsley Passenger Rail Line. The exceedances of the L_{max} noise criteria range from 1 to 6 dB. At one residence the L_{eq} criteria is also exceeded by 1 dB.

The predicted increase in L_{max} noise levels compared to the existing scenario is primarily due to potential additional noise from curve squeal from the tight radius curve, and potential structure-borne noise due to the steel viaduct structure. The predicted increase in L_{eq} noise levels compared to the existing scenario is primarily due to the increase in train frequency and changes in the track alignment.

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7 Rail noise mitigation

This section describes the noise mitigation assessment undertaken to address rail noise associated with the 100% Flinders Link design.

7.1 Curve squeal

The assessment of predicted 2019 maximum noise levels (L_{max}) showed that some receivers could be in excess of the upgraded rail line criteria of 85 dB(A) L_{Max} by up to 6 dB without mitigation. This exceedance was primarily driven by curve squeal over the section of tight curvature, where a conservative adjustment is applied in the model to account for the potential additional noise.

As described in the Resonate Report *Curve Squeal Risk and Mitigation Measures*, a friction modification system is recommended to mitigate curve squeal noise. However, it is noted that even in successful applications of such systems, curve squeal noise has not generally been eliminated, but rather reduced.

Notwithstanding the above, Table 7 presents the predicted 2019 rail noise levels for each noise sensitive receiver within the project assessment area, with no adjustments applied for curve squeal (i.e. assuming that curve squeal is able to be eliminated).

The predictions indicate that in the event that curve squeal noise is eliminated, noise levels are expected to comply with GANRI criteria at all noise sensitive locations. However, as noted above, there is a risk of residual curve squeal noise (albeit at a reduced level and frequency of occurrence) even with the use of track/wheel friction modifiers.

Whilst we expect that curve squeal will be mitigated to some extent with the appropriate mitigation, the degree of noise level reduction cannot be quantified with certainty. Noise levels with partial curve squeal mitigation are expected to be between the levels presented in Table 6 and Table 7, for each receiver.

There are other techniques to mitigate effects of noise including at or near source and at the receiver. Preference according to GANRI is source treatment, followed by mitigation along the transmission path, such as the installation of a noise barrier.

Table 7 Predicted 2019 rail noise levels with curve squeal mitigation

Location	Receiver ID	Predicted 2019 rail noise levels with no curve squeal, dB(A)		
		Day $L_{eq,15h}$	Night $L_{eq,15h}$	L_{max}
Woodland Road and Timothy Court	RA038	56	50	80
	RA039	56	50	80
	RA040	56	50	80
	RA041	56	50	81
Lynton Avenue	RA042	58	52	84
	RA043	56	50	81
	RA044	56	50	81
	RA045	57	51	81
	RA001	55	49	80
	RA002	54	48	78
	RA003	54	48	79
	RA004	55	49	81
	RA005	56	50	82
	RA006	53	47	77
	RA007	53	47	76
	RA012	50	44	74
Ash Avenue and Birch Crescent	RA025	57	51	83
	RA026	58	52	83
	RA014	58	52	83
	RA027	57	51	83
	RA028	58	52	82
	RA029	58	52	82
	RA030	57	51	82
	RA008	57	51	82
	RA009	58	52	83
	RA010	59	53	84
	RA011	57	51	82
	RA013	56	50	81
	RA046	52	46	77
Flinders Sports Fields		47	N/A	N/A
Flinders Medical Centre		52 ($L_{eq,1hr}$)	N/A	N/A

7.2 Noise barriers

Noise barriers within the rail corridor are one option to mitigate the risk of curve squeal noise (in addition to general airborne rail noise). The recommended extent of preferred noise barriers is shown in Appendix B. The effectiveness of noise barriers is dependent on their height and location in relation to the source and receiver, with barriers close to the source generally providing the greatest noise reduction.

We recommend that 1.6m noise barriers are incorporated into the ‘throw screen’ design, for the viaduct section, and to the rail corridor barrier for the ramp/RSS wall section as shown in Figure 2 and Figure 3 below.

Barriers should have a surface mass of at least 12 kg/m^2 and are constructed without gaps between panels.

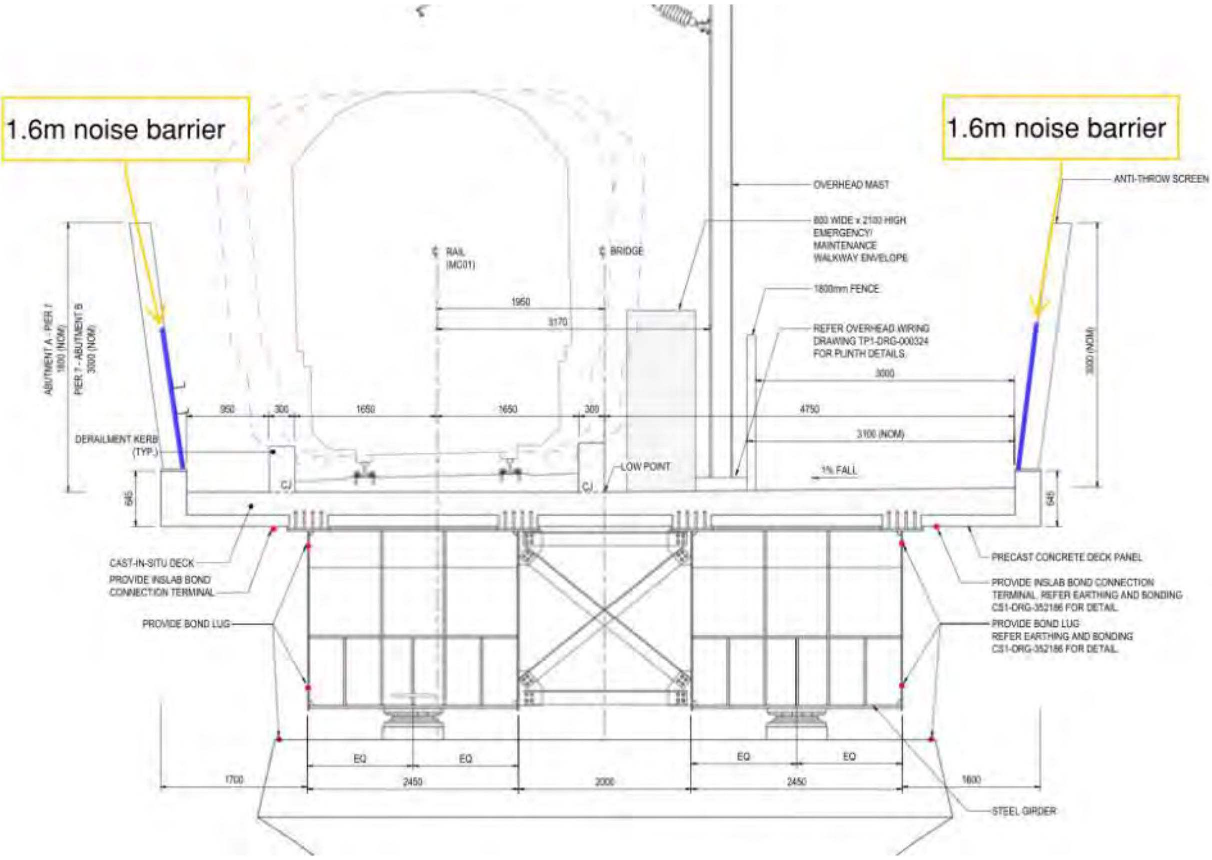

Figure 2 Recommended barrier locations – viaduct section (typical)

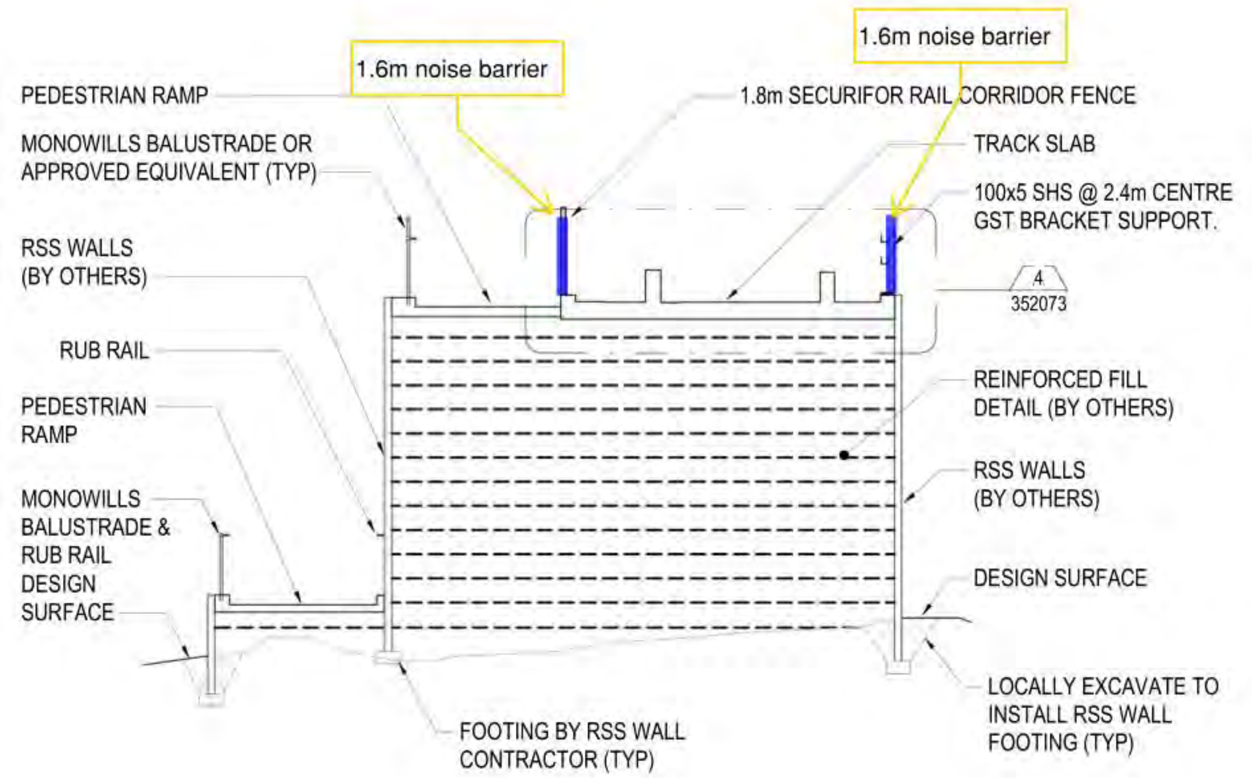

Figure 3 Recommended barrier locations – RSS section (typical)

We note that despite the expected noise reduction benefits provided by noise barriers, they can sometimes result in an overall poor outcome in relation to urban design and amenity. We recommend that the noise reduction benefit of barriers is considered in conjunction with visual effects, safety/security, requirements for access, cost and other relevant factors. In some cases, alternative treatments (for example treatments to affected individual houses) may be preferred.

Table 8 presents the predicted 2019 rail noise levels for each noise sensitive receiver within the project assessment area, with noise barriers as described above. The results include adjustments for curve squeal (assuming curve squeal is not mitigated)

Table 8 Predicted 2019 rail noise levels with recommended noise barriers.

Location	Receiver ID	Predicted 2019 rail noise levels with recommended barriers, dB(A)			Barrier insertion loss, dB
		Day $L_{eq,15h}$	Night $L_{eq,15h}$	L_{max}	
Woodland Road and Timothy Court	RA038	57	51	79	1
	RA039	56	50	80	0
	RA040	56	50	80	0
	RA041	56	50	80	1
Lynton Avenue	RA042	60	53	83	1
	RA043	58	51	81	0
	RA044	57	50	80	1

Location	Receiver ID	Predicted 2019 rail noise levels with recommended barriers, dB(A)			Barrier insertion loss, dB
		Day $L_{eq,15h}$	Night $L_{eq,15h}$	L_{max}	
	RA045	58	52	82	4
	RA001	59	52	84	1
	RA002	58	52	83	1
	RA003	60	53	85	1
	RA004	60	54	85	1
	RA005	58	52	83	2
	RA006	58	52	83	1
	RA007	58	51	83	1
	RA012	56	50	80	2
Ash Avenue and Birch Crescent	RA025	57	50	82	1
	RA026	58	52	82	1
	RA014	59	53	82	1
	RA027	58	52	82	1
	RA028	59	53	81	1
	RA029	60	53	82	0
	RA030	60	53	83	0
	RA008	60	54	85	2
	RA009	62	55	**86**	5
	RA010	61	54	**86**	5
	RA011	60	53	84	5
	RA013	59	53	84	5
	RA046	58	52	82	0
Flinders Sports Fields		47	N/A	N/A	0
Flinders Medical Centre		52 (Max $L_{eq,1hr}$)	N/A	N/A	0

The results show that with the proposed barriers, noise levels are expected to comply with GANRI criteria at all noise sensitive locations, with the exception of RA009 and RA010, where an exceedance of 1 dB(A) L_{max} is predicted. We note that these predictions include a conservative adjustment for curve squeal (assuming no reduction is achieved through mitigation). Higher barriers (up to 2.4m) were investigated and found to provide negligible additional benefit.

As described above, with the adoption of curve squeal mitigation measures in addition to barriers, a further reduction in noise levels is expected. Whilst there is some uncertainty regarding the level of reduction that will be achieved, it is likely that levels will be reduced by at least 1 dB, such that full compliance is expected at all locations.

7.3 Individual receiver treatments

As discussed above, noise mitigation at receiver locations may be considered in the event that noise barriers within the rail corridor are deemed not reasonable or practicable. In this case, treatment should be considered for the seven residential receivers identified in Table 6 as exceeding GANRI criteria. Consideration may also be given to treatment of neighbouring properties with similar levels of rail noise exposure, to avoid a perception of unfairness.

In accordance with GANRI, receiver treatments may consist of new fences on each property, or upgrades to the facades of any affected dwelling. We note that for this project, fences are not likely to be practicable based on the elevated noise source.

Facade treatments should be designed to achieve the internal noise criteria described in the *Minister's Specification SA 78B: Construction requirements for the control of external noise*.

8 Risk assessment

The presence of a tight radius curve on this project, in combination with a viaduct structure, introduces a level of uncertainty not typically encountered on new rail projects, particularly in South Australia. To aid in the understanding of pre and post-mitigation risk, an analysis is presented in Table 9.

Table 9 Risk assessment matrix

Mitigation measure	Likelihood of occurrence	Number of receivers potentially affected, by magnitude of potential GANRI criteria exceedance		
		0 to 2 dB	3 to 5 dB	6 dB +
No mitigation(1)	Almost certain	3	2	2
Barriers only	Likely	2	0	0
Curve squeal mitigation(2) only	Possible	3	2	2
Curve squeal mitigation and barriers	Very unlikely	2	0	0

(1) Other than resilient fasteners
(2) Vehicle mounted or trackside friction modification system

Based on this analysis, adoption of both curve squeal mitigation and barriers presents the lowest level of risk. Where mitigation is found to not be practicable, the residual risk may be mitigated by implementing individual receiver treatments as described in Section 7.3.

9 Conclusion

This Noise Assessment Report has been prepared for the Flinders Link Project based on the 100% design. Rail noise impacts from the project have been assessed against the relevant guidelines.

Due to the tight radius curve on the viaduct section of track, noise levels are predicted to exceed the relevant GANRI criteria at seven residences, by up to 6 dB, based on no mitigation of wheel squeal. A vehicle mounted or track-based friction modification system (or both) is recommended in order to mitigate curve squeal noise.

The extent to which these mitigation measures will reduce curve squeal noise is not able to be predicted or measured with any accuracy prior to operation. There is a moderate level of risk that residual noise levels exceed the relevant criteria despite implementation of curve squeal mitigation as recommended.

To mitigate this risk, it is recommended that 1.6 m high noise barriers on both sides of the track are adopted for the extent of the alignment shown in Appendix B.

With both curve squeal mitigation measures and noise barriers, rail noise levels are expected to comply with GANRI criteria at all locations, assuming curve squeal mitigation is at least partially effective.

Resonate

Appendix A - Noise sensitive receptor locations

Resonate

Legend

- Viaduct
- Rail Alignment
- Existing Barrier
- Receivers

Flinders Link Project

70% Design
Noise Assessment
Noise Sensitive Receivers

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FIGURE

A1

Resonate

Appendix B – Proposed noise barrier locations

Resonate

Legend

- Viaduct
- Rail Alignment
- Existing Barrier
- Proposed Noise Barriers

Flinders Link Project

70% Design
Noise Assessment
Recommended Noise Barrier Extent

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FIGURE

B1

Appendix C – Predicted noise level contours

Legend

- Extent of major works
- Existing Rail Alignment
- Existing Barrier

Predicted Noise Level, dB(A) L

- 53 - 56 dB(A)
- 56 - 59 dB(A)
- 59 - 62 dB(A)
- 62 - 65 dB(A)
- >65 dB(A)

Flinders Link Project

30% Design
Noise Assessment
Existing Rail Noise Levels (Leq)

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FIGURE

C1

Resonate

Legend

- Extent of major works
- Existing rail alignment
- Existing barrier

Rail Noise Level, dB(A) Lmax

- 73 - 76 dB(A)
- 76 - 79 dB(A)
- 79 - 82 dB(A)
- 82 - 85 dB(A)
- >85 dB(A)

Flinders Link Project

100% Design
Noise Assessment
Existing Maximum Rail Noise Levels

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FIGURE

C2

Resonate

Legend

- Extent of major works
- Viaduct
- Rail Alignment
- Existing Barrier

Noise Sensitive Receivers

- Exceeds GANRI Criteria
- Complies with GANRI

Predicted Noise Level, dB(A) Leq

- 53 - 56 dB(A)
- 56 - 59 dB(A)
- 59 - 62 dB(A)
- 62 - 65 dB(A)
- >65 dB(A)

Flinders Link Project

100% Design
Noise Assessment
2019 Rail Noise Levels (Leq)
No Mitigation

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FIGURE

C3

Resonate

Legend

- Extent of major works
- Viaduct
- Rail Alignment
- Existing Barrier

Noise Sensitive Recievers

- Exceeds GANRI Criteria
- Complies with GANRI

Rail Noise Level, dB(A) Lmax

- 73 - 76 dB(A)
- 76 - 79 dB(A)
- 79 - 82 dB(A)
- 82 - 85 dB(A)
- >85 dB(A)

Flinders Link Project

100% Design
Noise Assessment
2019 Maximum Rail Noise Levels
No Mitigation

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FIGURE

C4

Resonate

Legend

- Extent of major works
- Viaduct
- Rail Alignment
- Existing Barrier
- Proposed Barriers

Predicted Noise Level, dB(A) Le

- 50 - 53 dB(A)
- 53 - 56 dB(A)
- 56 - 59 dB(A)
- 59 - 62 dB(A)
- 62 - 65 dB(A)
- >65 dB(A)

Flinders Link Project

100% Design
Noise Assessment
2019 Rail Noise Levels (Leq)
Proposed Noise Barriers

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FIGURE

C5

Resonate

Legend

- Extent of major works
- Viaduct
- Rail Alignment
- Existing Barrier
- Proposed Noise Barriers

Rail Noise Level, dB(A) Lmax

- 73 - 76 dB(A)
- 76 - 79 dB(A)
- 79 - 82 dB(A)
- 82 - 85 dB(A)
- >85 dB(A)

Flinders Link Project

100% Design
Noise Assessment
2019 Maximum Rail Noise Levels
Proposed Noise Barriers

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FIGURE

C6

Resonate

Legend

- Extent of major works
- Viaduct
- Rail Alignment
- Existing Barrier

Predicted Noise Level, dB(A) Le

- 53 - 56 dB(A)
- 56 - 59 dB(A)
- 59 - 62 dB(A)
- 62 - 65 dB(A)
- >65 dB(A)

Flinders Link Project

100% Design
Noise Assessment
2019 Rail Noise Levels (Leq)
Curve Squeal Mitigation

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FIGURE

C7

Resonate

Legend

- Extent of major works
- Viaduct
- Rail Alignment
- Existing Barrier

Rail Noise Level, dB(A) Lmax

- 73 - 76 dB(A)
- 76 - 79 dB(A)
- 79 - 82 dB(A)
- 82 - 85 dB(A)
- >85 dB(A)

Flinders Link Project

100% Design
Noise Assessment
2019 Maximum Rail Noise Levels
Curve Squeal Mitigation

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FIGURE

C8