Appendix H

Noise and vibration assessment

Murray River Council

Gee Gee Bridge replacement

Noise and vibration assessment

June 2017

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Glossary of acoustic terms

Abbreviation	Definition
Acute noise level	A level of road traffic noise of 65 dBA $L_{Aeq(15hr)}$ (Day) or 60 dBA $L_{Aeq(9hr)}$ (Night), 1 metre from the building façade.
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L_{A90} descriptor.
Controlling criterion	Whichever of the day or night time L_{Aeq} criteria (Noise Criteria Guideline) is exceeded by the greatest amount.
Cumulative limit	A total noise level that is 5 dBA or more above the Noise Criteria Guideline criteria in the build year.
dB	Decibel is the logarithmic unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics.
dBA	Frequency weighting filter used to measure 'A-weighted' sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at very low and very high frequencies.
DEC	Department of Environment and Conservation
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
Feasibility (NMG Definition)	"Feasibility" relates to engineering considerations (what can be practically built). These engineering considerations may include: The inherent limitations of different techniques to reduce noise emissions from road traffic noise sources Safety issues, such as restrictions on road vision Road corridor site constraints such as space limitations Floodway and stormwater flow obstruction Access requirements Maintenance requirements The suitability of building conditions for architectural treatments.
ICNG	Interim Construction Noise Guideline (DECC, 2009).
$L_{Aeq(period)}$	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{A90(period)}$	The sound pressure level exceeded for 90% of the measurement period.
L_{Amax}	The maximum sound level recorded during the measurement period.
$L_{Aeq(15hr)}$	The L_{Aeq} noise level for the period 7 am to 10 pm.
$L_{Aeq(9hr)}$	The L_{Aeq} noise level for the period 10 pm to 7 am.
$L_{Aeq(1hr)}$	The highest hourly L_{Aeq} noise level during the day and night periods.
NCG	Noise Criteria Guideline (RMS, 2014)
NMG	Noise Mitigation Guideline (RMS, 2014)

Noise sensitive receiver	An area or place potentially affected by noise including residential dwellings, schools, child care centres, places of worship, health care institutions and active or passive recreational areas.
Rating background level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period.
Reasonable (NMG Definition)	Selecting "reasonable" measures from those that are feasible involves judging whether the overall noise benefits provide significant social, economic or environmental benefits. The factors to be considered are: The noise reduction provided and the overall number of people that benefit from the mitigation Existing and future noise levels, including changes in noise levels in the build and design year and the extent of any exceedance of the noise criteria Potential for a mitigation measure to reduce noise during construction as well from road traffic after the project is complete The cost of mitigation, including the cost of noise mitigation measures as a percentage of the total project cost and the ongoing maintenance and operational costs Community views and wishes Visual impacts for the community surrounding the road project and for road users The wider community benefits arising from noise mitigation of the proposed road and road redevelopment Relative weighting of treatments with respect to protection of outdoor areas or only internal living spaces.
RNP	Road Noise Policy (DECWW, 2011)
Transition zone	The area either side of the physical transition point between road functional classes (e.g. arterial versus local) or road development types (e.g. new versus redeveloped road project).

1. Introduction

1.1 Overview

GHD Pty Ltd has been commissioned by the Murray River Council (Council) to undertake a noise and vibration assessment for the proposed replacement of the Gee Gee Bridge on Noorong Road (MR94) at the crossing of the Wakool River, Cunninyeuk, NSW ('the proposal'). This assessment forms part of the Review of Environmental Factors (REF) to fulfil the requirements of Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The proposal is located in the Noorong State Forrest, bordering the suburb of Wetuppa and Cunninyeuk, about 310 km west of Wagga Wagga, NSW.

This operational traffic noise assessment and construction noise and vibration assessment has been prepared in accordance with the following guidelines:

- *Road Noise Policy* (RNP) (DECCW, 2011)
- *Noise Criteria Guideline (*NCG) (RMS, 2014)
- *Noise Mitigation Guideline* (NMG) (RMS, 2014)
- *Interim Construction Noise Guideline* (ICNG) (DECC, 2009)
- *Assessing Vibration: A Technical Guideline* (DEC, 2006)
- *DIN 4150, Part 3: Structural Vibration in Buildings – Effects on Structures* (German Standard, 1999).

1.2 Proposal description

Roads and Maritime proposes to build a new concrete bridge downstream (north) of the existing Gee Gee Bridge at the Noorong Road (Main Road 94) crossing of the Wakool River. The proposal would also include realigning about 1.4 kilometres of Noorong Road. Following construction of the new bridge and realigned road, Roads and Maritime proposes to demolish the existing Gee Gee Bridge and flood relief bridge. An overview of the proposal is shown in Figure 2-1.

The proposal includes:

- A new two-lane concrete bridge across the Wakool River and floodplain, 15 to 20 metres downstream (north) of the existing Gee Gee Bridge and flood relief bridge. The bridge would have a length of about 245 metres
- Realignment of about 1.4 kilometres of Noorong Road
- Demolition and removal of the existing Gee Gee Bridge and flood relief bridge
- A new rest area near the southern abutment of the existing bridge
- Establishment of hard stand areas for crane and piling activities adjacent to the new bridge
- Landscaping treatments, including planting of vegetation on road batters and in the road reserve.

The proposal site is located about 33 kilometres east of Swan Hill. It is located in the Roads and Maritime South West Region and in the Murray River Council local government area.

1.3 Scope of works and limitations

1.3.1 Project stage 1 – construction

Bridge over the Wakool River

The proposed Gee Gee Bridge would have a length of about 245 metres (see **Error! Reference source not found.** and **Error! Reference source not found.**). It would be constructed of precast and poured concrete components.

The bridge would have a span of 32 metres over the Wakool River. On the northern side of the Wakool River, the bridge would have about 11 approach spans, 10 spans of 17m and the span closest to the river about 21m in length. On the southern side of the river, the bridge would have a single 21 metre approach span.

The bridge would have a road width of nine metres, including two 3.5 metre travel lanes and two 1.0 metre shoulders. Concrete safety barriers would be constructed along both sides of the bridge.

Approach roads

The northern approach road would have a length of 674 metres and would be realigned through the property north of Noorong Road (Lot 101, DP 914897). The southern approach road would have a length of 736 metres. The northern 530 metres of the southern approach road would be realigned close to the existing road alignment, within the road corridor. The southern 206 metres of the road would follow the existing road alignment.

The road would have a sealed road width of 9.0 metres, including two 3.5 metre travel lanes and two 1.0 metre shoulders, with two unsealed 0.75 metre verges. Guard rail safety barriers would be built on both sides of both approach roads for distances of 50 to 100 metres from the proposed bridge.

The northern 580 metres of the southern approach road would be built on a fill embankment, with a maximum height above ground level of about 1.8 metres. The western 300 metres of the northern approach road would be built on a fill embankment with a maximum height above ground level of about one metre.

Most of the eastern section of the northern approach road would be built through a cutting with a length of about 300 metres. The cutting would have a maximum depth of about 1.5 metres.

1.3.2 Project stage 2 – decommissioning

Stage 2 involves the demolition of the two existing bridges and removal of the existing road formation between these bridges.

The existing Gee Gee Bridge and flood relief bridge would be demolished and removed in sections before being taken off-site for recycling or disposal at an appropriately licensed landfill. Summary of construction activities

The project broadly includes:

- Compound and stockpile site establishment on northern side of the river upstream of the existing bridge. This area has previously been cleared and has previously been used for maintenance projects
- Tree removal within a 50 metre (maximum) corridor downstream of the existing bridge for constructing the new bridges and road
- Earthworks for the construction of the approach roads to the bridge

- Construction of the main bridge, approach bridge and new road
- Demolition and removal of the existing bridges and road formation
- Landscaping and rehabilitation of the site.

1.3.3 Limitations

This report: has been prepared by GHD for Murray River Council and may only be used and relied on by Murray River Council for the purpose agreed between GHD and the Murray River Council.

GHD otherwise disclaims responsibility to any person other than Murray River Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report ("Assumptions"), including (but not limited to):

- Measurement methodology assumptions detailed in Section 2.
- Operational noise modelling assumption detailed in Section 3.
- Construction noise and vibration level prediction assumptions detailed in Section 0.

The findings of the noise assessment represent the findings apparent at the date and time of the monitoring and the conditions of the area at that time. It is the nature of environmental monitoring that all variations in environmental conditions cannot be assessed and all uncertainty concerning the conditions of the ambient noise environment cannot be eliminated. Professional judgment must be exercised in the investigation and interpretation of observations.

Subject to the paragraphs in this section of the Report, the opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation of this Report.

GHD has prepared this Report on the basis of information provided by the RMS, which GHD has not independently verified or checked ("Unverified Information") beyond the agreed scope of work.

GHD expressly disclaims responsibility in connection with the Unverified Information, including (but not limited to) errors in, or omissions from, the Report, which were caused or contributed to by errors in, or omissions from, the Unverified Information.

2. Existing ambient noise environment

2.1 Study area

The study area width for a road proposal is defined by the RNP as "*600 metres from the centre line of the outermost traffic lane on each side of the subject road*". The NCG provides further guidance on selecting the appropriate study area width.

For rural areas, where the noise criteria may be exceeded beyond 600 metres, residences need to be assessed on a case by case basis.

For highly urban areas, where other roads within 600 metres of the proposal are likely to dominate the noise environment at sensitive receivers, the NCG advises that the study area width "*may be reduced to where the noise levels from the project contributes slightly less than half the total noise level. This is where the project adds no more 2.0 dBA (less than 2.1 dBA) to the total noise level. The boundary should then be expanded to include any receivers where the project contribution exceeds 65 dBA $L_{Aeq\ (15hr)}$ and 60 dBA $L_{Aeq\ (9hr)}$ and to meet close-by landmarks to provide a logical boundary*".

2.2 Noise sensitive receivers

The proposal is located in a rural environment with Noorong Road identified as a strategic freight route in NSW, linking Deniliquin and Swan Hill. The existing road traffic noise would be considered intermittent due to very low traffic volumes. The topography of the proposal study area is relatively flat terrain.

A single sensitive receiver has been identified and used for the operational road traffic noise assessment and an additional two sensitive receivers have been identified and used for the construction noise and vibration assessment.

The sensitive receiver used for the operational noise assessment is:

- R001 – Lot 41 DP756533, 3357 Noorong Road

Sensitive receivers used for the construction noise and vibration assessment include:

- R001 – Lot 41 DP756533, 3357 Noorong Road
- R002 – Lot 2 DP430998, Noorong Road
- R003 – Lot 1 DP 129621, 3400 Noorong Road

The identified sensitive receivers in relation to the project site are shown in Figure 2-1.

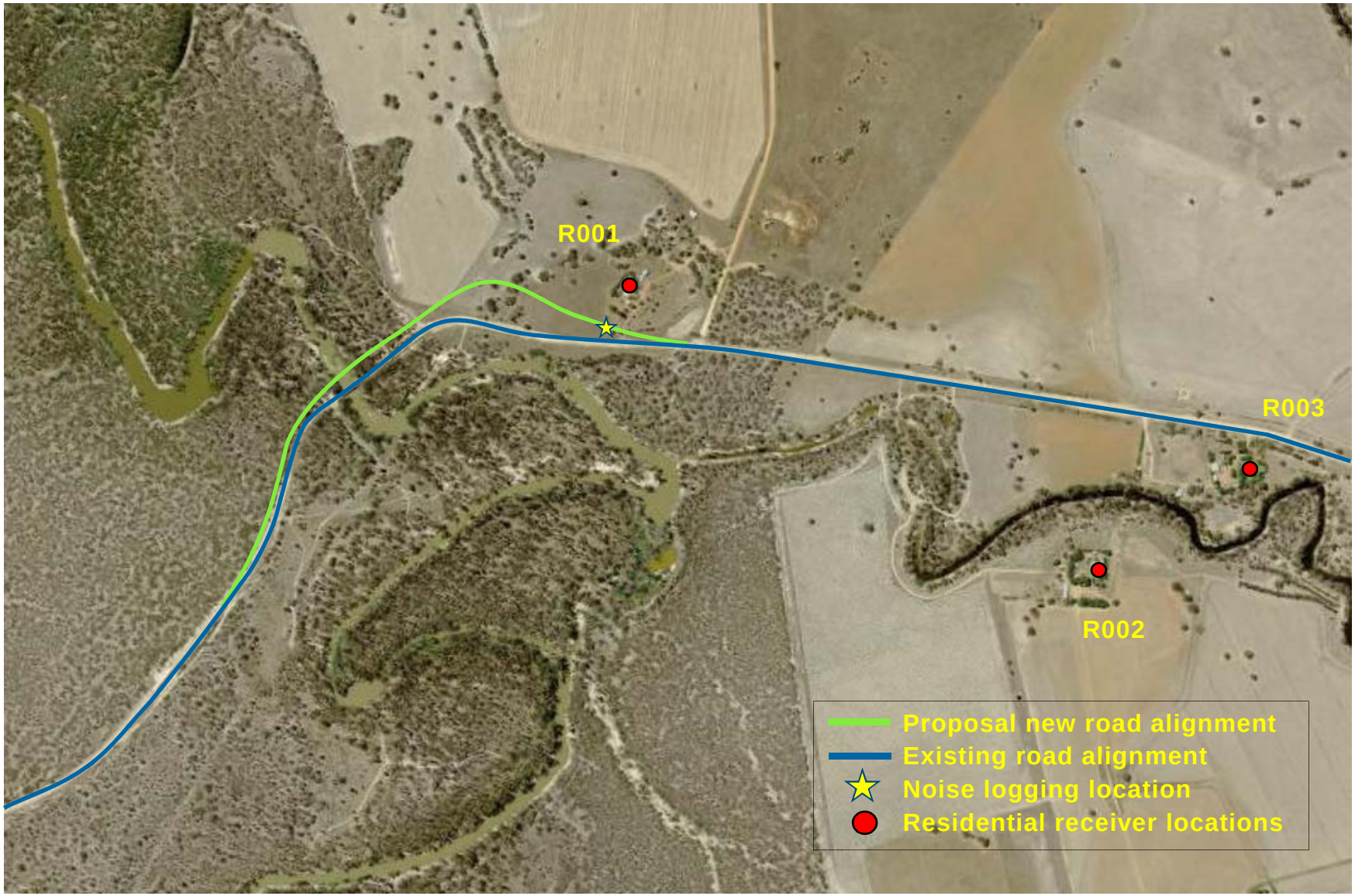


Figure 2-1 Proposal locations, noise sensitive receiver and noise monitoring location

2.3 Noise monitoring methodology

Noise monitoring was undertaken from 2 June to 10 June 2015 at the front boundary of the residence located at 3357 Noorong Road, Cunninyeuk, shown in Figure 2-1. Noise monitoring was undertaken to determine background noise levels for the construction noise assessment and existing road traffic noise levels for the operational noise assessment noise modelling verification process.

Noise monitoring was undertaken using a Rion NL-52 environmental noise logger. The instrument was programmed to accumulate environmental noise data continuously over sampling periods of 15 minutes for the entire monitoring period.

Field calibration checks were undertaken immediately before and after the monitoring period using an acoustic calibrator with a sound pressure level of 94 dBA at 1 kHz. At completion of the measurements, the meter's calibration was re-checked to ensure that the sensitivity of the noise monitoring equipment had not varied. The noise logger was found to be within the acceptable tolerance of ±0.5 dBA.

Details of the noise monitoring equipment are provided in Table 2-1.

Logged data was reviewed and filtered to exclude any extraneous data and data potentially affected by adverse weather conditions (defined as periods when wind speeds were greater than 5 m/s or when rainfall occurred) during the monitoring period. Meteorological data for the monitoring period was sourced from Swan Hill Aero dome, Bureau of Meteorology weather station number 77094 and set to record 30-minute averages.

2.4 Summary of noise monitoring results

Logger data results, including rating background level (RBL) and road traffic noise descriptors are summarised in Table 2-2 with monitoring charts presented in Appendix A.

The noise monitoring results are typical of a remote rural area with low ambient levels influenced by road traffic noise, which is expected due to the close proximity to Noorong Road.

Table 2-1 Unattended noise monitoring details

Noise Logger	Location
Monitoring location	3357 Noorong Road, Cunninyeuk NSW
Coordinates	Lat (-35.328739°), Long (143.934185°)
Logger Type/ Serial No.	Rion NL-52 / 00131630
Measurement started	11:15 hours, 02 June 2015
Measurement ceased	11:30 hours, 10 June 2015
Pre/Post calibration	93.9 / 93.9 dB @ 1 kHz
Freq. weighting	A
Time response	Fast
Photograph	

Table 2-2 Noise monitoring results (at Noorong Road), dBA

Period	Background noise descriptors			Road traffic noise descriptors		
	$L_{A90(Day)}$	$L_{A90(Evening)}$	$L_{A90(Night)}$	$L_{Aeq(15hr)}$	$L_{Aeq(9hr)}$	$L_{A10(18hr)}$
	7 am to 6 pm, Monday to Saturday; 8 am to 6 pm Sundays & Public Holidays	6 pm to 10 pm, Monday to Sunday & Public Holidays	10 pm to 7 am, Monday to Saturday; 10 pm to 8 am Sundays & Public Holidays	7 am to 10 pm weekdays	10 pm to 7 am weekdays	6 am to 12 am weekdays
Tuesday 02 June 2015	17.4	12.9	12.8	48.6	38.6	38.3
Wednesday 03 June 2015	14.9	12.8	12.7	50.6	37.4	40.4
Thursday 04 June 2015	22.3	13.7	13.3	48.7	36.3	40.7
Friday 05 June 2015	18.2	13.0	12.8	48.9	38.7	39.0
Saturday 06 June 2015	16.2	13.1	12.9	47.1	38.1	37.9
Sunday 07 June 2015	22.4	13.0	13.2	47.5	34.9	36.9
Monday 08 June 2015	20.9	14.2	19.5	47.1	39.3	38.4
Tuesday 09 June 2015	23.5	12.9	12.8	50.9	37.3	41.2
Overall	30[1]	30[1]	30[1]	49.3	38.1	40.4

Note 1: The rating background noise level is set at 30 dBA when background noise levels are measured to be below 30 dBA in accordance with the INP.

Note 2: '-' or red text indicates data excluded due to adverse weather as per the INP Appendix B

3. Operational noise assessment

3.1 Operational noise criteria

Noise criteria are assigned to sensitive receivers using the RMS Noise Criteria Guideline (NCG). The RMS NCG provides guidance on how to apply the NSW Road Noise Policy (RNP). The assessment timeframe for the criteria are in the year of opening and 10 years after opening.

The project assessment area extends to where noise levels are dominated by other roads that are not being assessed as part of this project as defined in the NCG. This is up to a maximum distance of 600 metres from the project works for rural areas.

Residential receivers may be assigned new, redeveloped, transition zone or relative increase criteria depending on how the project will influence noise levels. For each façade of the residential receiver the most stringent applicable criteria will be used in the assessment.

Criteria are based on the road development type which is affecting the residential receiver. In some instances residential receivers may be exposed to noise from both new and redeveloped roads. In this instance the proportion of noise from each road is used to establish transition zone criteria. A further check is made to prevent large increases in noise level using the relative increase criteria.

The project consists of both new and redeveloped road segments, with transition zones at either end of the road realignment. The noise criteria would be between the new and redeveloped NCG noise criteria at residences identified within the transition zone.

Note that a road is new where the road has been substantially realigned. The criteria for residences are summarised in Table 3-1.

The RNP relative increase criterion assesses any increase in the total traffic noise level at a receiver due to the proposal. The relative increase criteria is exceeded if the 'build option' noise levels increase by more than 12 dBA above the 'no-build' option noise levels.

Table 3-1 NCG assessment criteria for residential land uses, $L_{Aeq(period)}$, dBA

Road category	Type of project	Assessment criteria (external)	
		Day (7 am to 10 pm)	Night (10 pm to 7 am)
Arterial roads / sub-arterial roads	Existing residences affected by noise from new arterial road corridors	$L_{Aeq(15hr)}$ 55 (external)	$L_{Aeq(9hr)}$ 50 (external)
	Existing residences affected by noise from redevelopment of an existing arterial road	$L_{Aeq(15hr)}$ 60 (external)	$L_{Aeq(9hr)}$ 55 (external)
	Existing residences affected by both new roads and the redevelopment of existing arterial/sub-arterial roads in a Transition Zone	Between $L_{Aeq(15hr)}$ 55-60 (external)	Between $L_{Aeq(9hr)}$ 50-55 (external)

3.1.1 Noise criteria guideline

For residences exposed to noise from two road types, the NCG provides transition zone criteria. The NCG is read in conjunction with the RNP when establishing traffic noise criteria, with the NCG transition zones reflecting the degree to which the residence is exposed to each road type.

Two types of transition zones are defined in the NCG:

- Junction between a new road and a redeveloped road The transition noise criteria for these roads is shown below in Table 3-2, where the contribution difference is defined as the difference between the new road contribution and the redeveloped road contribution.
- An intersection between the road project and the existing road. In this case, the road project noise criteria is applied at all facades, except at the façade where:
  - *The project increases the noise level contribution from the existing road by more than 2 dBA following the upgrade and relative to the 'no-build' situation* **and**
  - *The contribution from the existing road is greater than the contribution from the road project.* At this facade, the existing road criteria apply.

Table 3-2 Assignment of new and redeveloped transition zone criteria

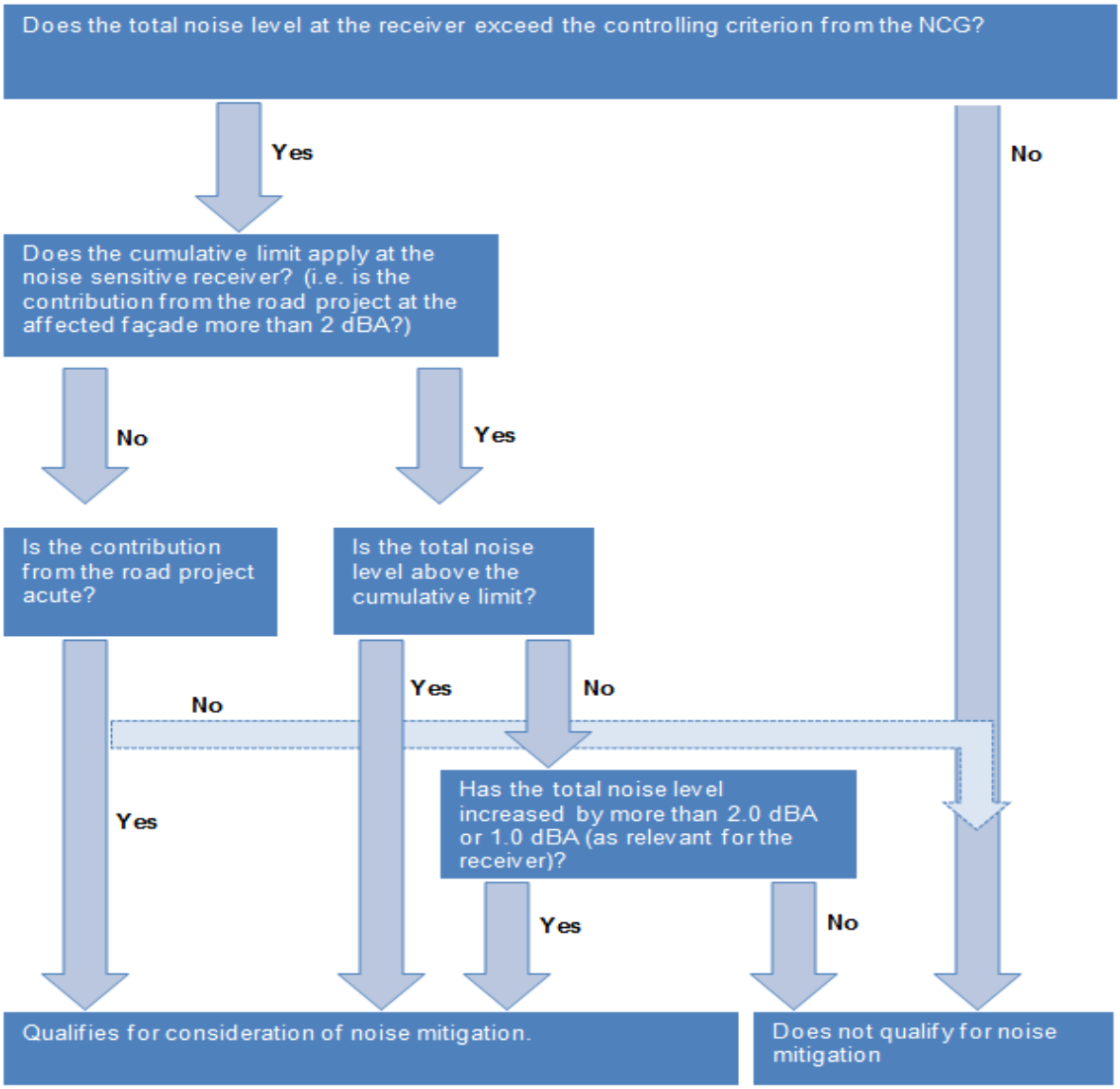
Contribution difference, dBA New minus redeveloped segments			Total noise levels, dBA	
			Daytime criteria	Night-time criteria
	Contribution difference	≥ +3.0	55	50
+3.0 >	Contribution difference	≥ +1.5	56	51
+1.5 >	Contribution difference	≥ 0	57	52
0 >	Contribution difference	≥ -1.5	58	53
-1.5 >	Contribution difference	≥ -3.0	59	54
-3.0 >	Contribution difference		60	55

When the transition zone criteria change across the façade of a sensitive receiver, the most stringent of the transition criteria apply.

3.1.2 Noise mitigation guideline

Residences experiencing exceedances to the NCG road traffic noise assessment criteria or the relative increase criteria should be considered for mitigation measures with consideration to the NMG. The NMG mitigation guidance is presented as a flowchart in Figure 3-1 where:

- The controlling criterion represents the noise criteria at each residential façade, in accordance with the NCG
- The cumulative limit represents the total noise level that is five dB(A) or more above the NCG criteria in the build year. The cumulative limit only applies when the contribution from the road project at the affected façade is more than two dB(A)
- The acute noise level is defined as a level of road traffic noise of 65 dB(A) $L_{Aeq(15hr)}$ (Day) or 60 dB(A) $L_{Aeq(9hr)}$ (Night), 1 metre from the building façade



- Mitigation should be assessed at each façade of the residence, as the worst affected façade may not be the façade with an increase of two dB(A)

Figure 3-1 Noise mitigation flowchart (derived from the NMG)

3.1.3 Sleep disturbance

The RNP provides a literature review for the assessment of sleep arousal due to traffic noise however does not set a sleep disturbance assessment criterion.

Sleep disturbance impacts are likely to be dependent on the following:

- Maximum noise level of an event
- Number of occurrences
- Duration of the event
- Level above background or ambient noise levels.

For continuous rather than intermittent traffic flow, the *Environmental Noise Management Manual* (RTA, 2001) recommends L_{Amax} noise pass-by events should not exceed $L_{Aeq\ (1hr)}$ noise levels by more than 15 dBA. The *Environmental Noise Management Manual* (RTA, 2001) advises that maximum noise levels can be used as a tool to prioritise and rank mitigation strategies, but should not be applied as a decisive criterion in itself.

3.1.4 Proposal specific operation noise criteria

A summary of the road classifications in the study area is provided in Table 3-3. Classification changes have been qualitatively assessed based on expected traffic flows as a result of the proposal.

Table 3-3 Road types and classifications

Road name	Road classification	Type of road (as per NCG)	Change in road classification?
Noorong Road from chainage 0.0 to 280.0	Sub-arterial	Redeveloped	No
Noorong Road from chainage 280.0 to 550.0	Sub-arterial	New	Yes
Noorong Road from chainage 550.0 to 1135.78	Sub-arterial	Redeveloped	No

Transition zones have been identified at the following road junctions:

- Noorong Road (Existing road section) to Noorong Road (Redeveloped road section). The proposal (redeveloped) noise criteria is applicable to all residences within this transition zone as the contribution from the proposal is not expected to increase the noise level contribution from the existing road by more than 2 dBA following the upgrade and relative to the 'no-build' situation (refer to section 3.1.1.
- Noorong Road (Redeveloped road section) to Noorong Road (New road section) from chainage 280.0 to 550.0. The noise criteria would be between the redeveloped and new RNP noise criteria at the resident identified within the transition zone.
- Noorong Road (Redeveloped road section) to Noorong Road (Existing road section). The proposal (redeveloped) noise criteria is applicable to all residences within this transition zone as the contribution from the proposal is not expected to increase the noise level contribution from the existing road by more than 2 dBA following the upgrade and relative to the 'no-build' situation (refer to section 3.1.1.

Contribution differences have been calculated and the RNP (and NCG) noise criteria at the single residential receiver (R001) within the transition zone at the Noorong Road (new road section) and Noorong Road (redeveloped road section) has been summarised in Table 3-4 (based on Table 3-2).

Table 3-4 Operational road traffic noise criteria

Receiver ID	$L_{Aeq(15hr)}$ (Day) dBA (7 am to 10 pm)	$L_{Aeq(9hr)}$ (Night) dBA (10 pm to 7 am)
R001	56	51

3.2 Noise modelling methodology

Road traffic noise has been assessed using a moving point source method with attenuation and propagation calculated with the ISO 9613 -2, *'Acoustics attenuation of sound during propagation outdoors'* algorithm. This method considers the number of pass-by movements, the speed and the L_{Aeq} noise source level. The CoRTN algorithm was not used due to very low traffic volumes', therefore a moving point source method was used.

Noise predictions were undertaken for the following cases:

- Year 2017 'no build option' (Traffic flow on the existing alignment for year opening)
- Year 2027 'no build option' (Traffic flow on the existing alignment 10 years after opening)
- Year 2017 'build option' (Proposed design for year opening)
- Year 2027 'build option' (Proposed design 10 years after opening).

3.2.1 Traffic data

The daily traffic volumes on Noorong Road are shown in Table 3-5. The forecast traffic volumes have been extrapolated using a traffic growth factor of four per cent per annum, assuming a linear growth rate.

Table 3-5 Daily traffic volumes on Noorong Road

Year	Data source	Daily traffic volume
2014	Traffic counts over a one month period	203
2017	Year opening forecast assuming a linear growth factor of 4% per annum and a 30% increase in heavy vehicles	239
2027	10 years after opening forecast assuming a linear growth factor of 4% per annum	335

3.2.2 Modelling inputs and assumptions

The noise model inputs and assumptions for the 2017 and 2027 No Build and Build scenarios are presented in Table 3-6.

Table 3-6 Noise model inputs and assumptions

Inputs / assumption	Data incorporated into noise model
Traffic speeds	70 km/h for Noorong Road based on traffic data results
Road gradient	Taken into account based on the road design
Facade correction	+2.5 dBA to account for sound reflected from the façade
Source height	Cars - 0.5 m Truck engines - 1.5 m Truck exhausts - 3.6 m
Receiver heights	1.5 m above building ground level
Ground absorption	G = 0.5 (Mixture of hard and soft ground)
CoRTN conversion factors	CoRTN predicts LA10(1hr) noise levels which are converted to the LAeq(1hr) descriptor with a -3 dBA correction factor. The moving point source method is based on LAeq values therefore no corrections have been applied.
Moving point source method noise source	A heavy vehicle source noise level of 112 dBA and a light vehicle source noise level of 105 dBA has been calculated from a vehicle pass-by measurement undertaken 20 metres from Noorong Road.

3.2.3 Noise modelling verification

The noise modelling process was validated against the road traffic noise monitoring data and simultaneous traffic counts, undertaken for the proposal in June 2015, and sign posted speed limits for Noorong Road.

The model is deemed to be verified if the average difference between the measured and calculated values of the descriptors is within +/-2 dBA.

A comparison of the modelling and monitoring results is shown in Table 3-7. The predicted results and measured results have an acceptable variance of within 2 dBA.

Table 3-7 Noise model verification, dBA

Location	$L_{Aeq(15hr)}$ (Day) dBA (7 am to 10 pm)		Change dBA	$L_{Aeq(9hr)}$ (Night) dBA (10 pm to 7 am)		Change dBA
	Measured	Modelled		Measured	Modelled	
3357 Noorong Road (Lot 41 DP 756533) (front boundary fence) (-35.323°, 143.934°)	49.3	49.5	+0.2	38.1	38.7	+0.6

3.3 Predicted noise levels

The day and night-time predicted receiver noise levels for the 'no-build option' and 'build option' for year 2017 and year 2027 are detailed in Table 3-8 and Table 3-9 including the road traffic criteria calculated with consideration to the RNP and NCG.

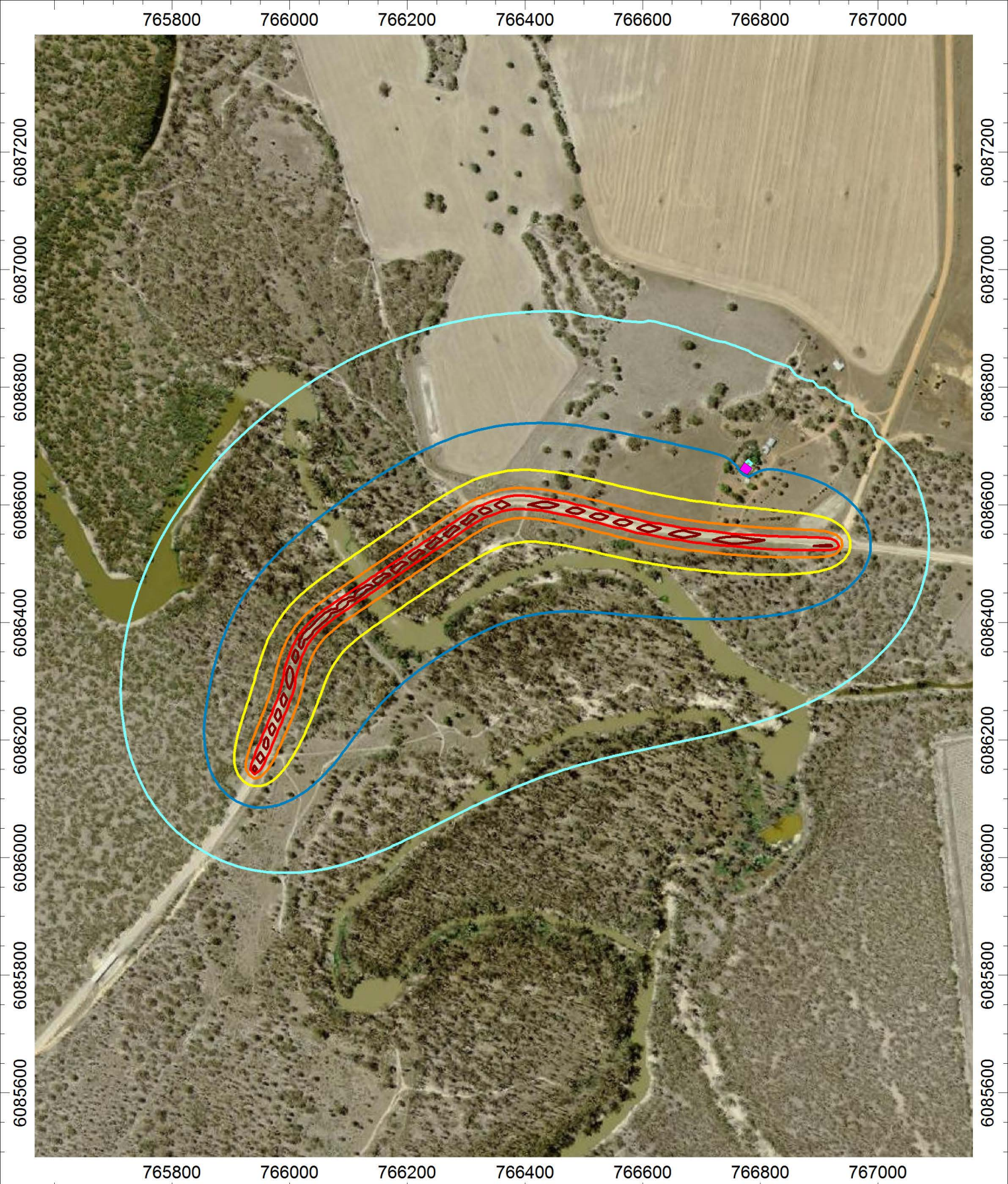
Day and night-time façade noise maps for the opening year 2017 and design year 2027 for the 'no build' and 'build' options are shown in Figure 3-2 to Figure 3-9. All road traffic noise levels include a +2.5 dBA façade correction and show the maximum overall road traffic noise level at the façade for each building.

Table 3-8 Predicted day operational noise levels, dBA

ID	Receiver Address	Floor	Facade	Controlling criteria	No build 2017	Build 2017	No Build 2027	Build 2027	Exceeds controlling criteria?	Exceeds cumulative criteria?	Build minus No build. 2027	Mitigation?
R001	3357 Noorong Road	GF	S	56	40.3	42.1	41.8	43.5	No	No	1.7	No
			W	56	37.4	39.6	38.9	40.5	No	No	1.6	No
			E	56	38.7	39.6	40.2	41	No	No	0.8	No
			N	56	29.9	30.6	31.4	32.1	No	No	0.7	No

Table 3-9 Predicted night operational noise levels, dBA

ID	Receiver Address	Floor	Facade	Controlling criteria	No build 2017	Build 2017	No Build 2027	Build 2027	Exceeds controlling criteria?	Exceeds cumulative criteria?	Build minus No build. 2027	Mitigation?
R001	3357 Noorong Road	GF	S	51	29.9	31.6	31.2	32.9	No	No	1.7	No
			W	51	27	29.2	28.3	29.9	No	No	1.6	No
			E	51	28.3	29.1	29.6	30.4	No	No	0.8	No
			N	51	19.4	20.1	20.7	21.4	No	No	0.7	No



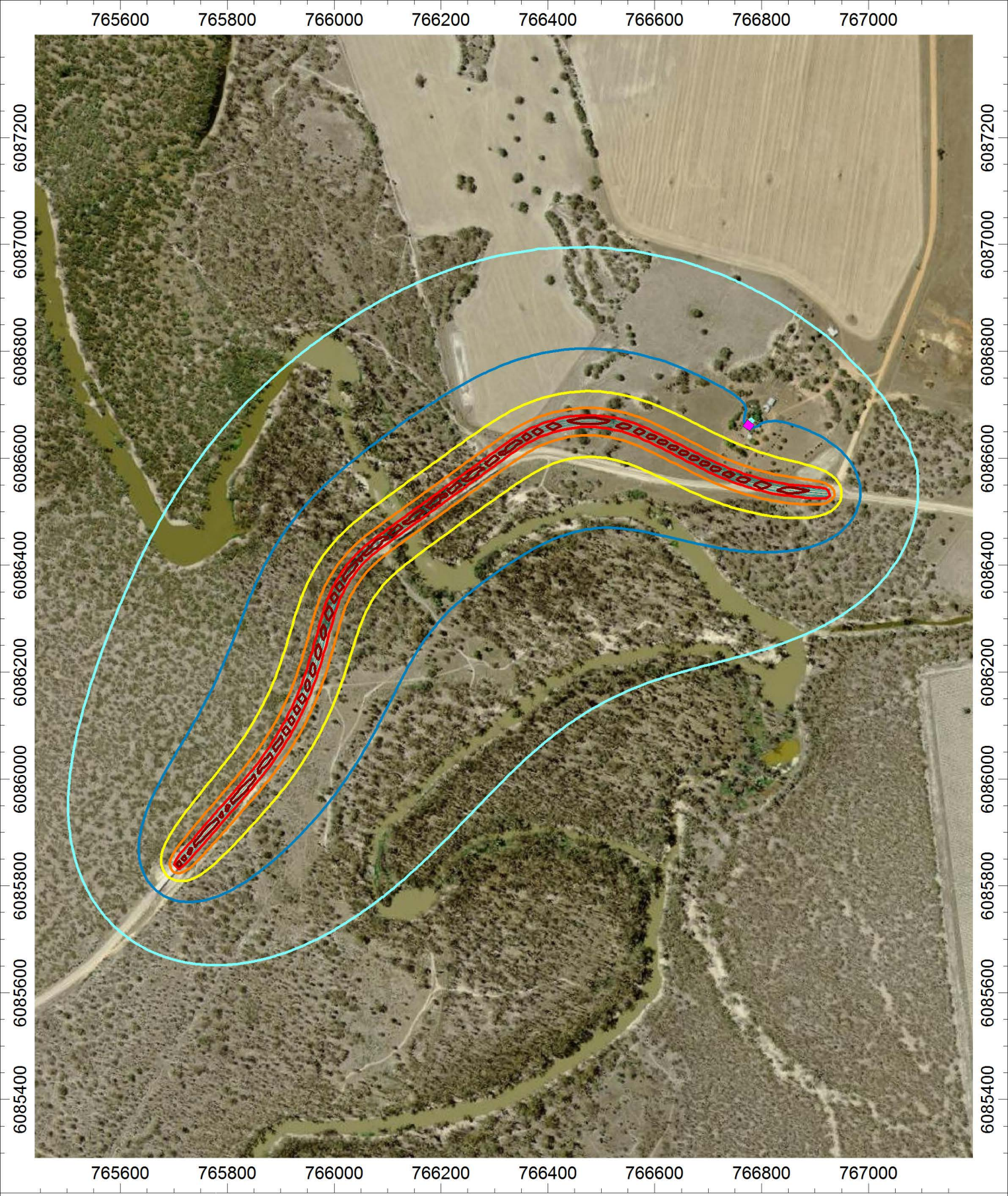
Sound Pressure Level dB(A)

- 35.0
- 40.0
- 45.0
- 50.0
- 55.0
- 60.0

Gee Gee Bridge Replacement
Operational Noise Contour Map

Figure 3-2 Predicted Road Traffic Noise Levels
No build 2017 Day (facade corrected)

GHD



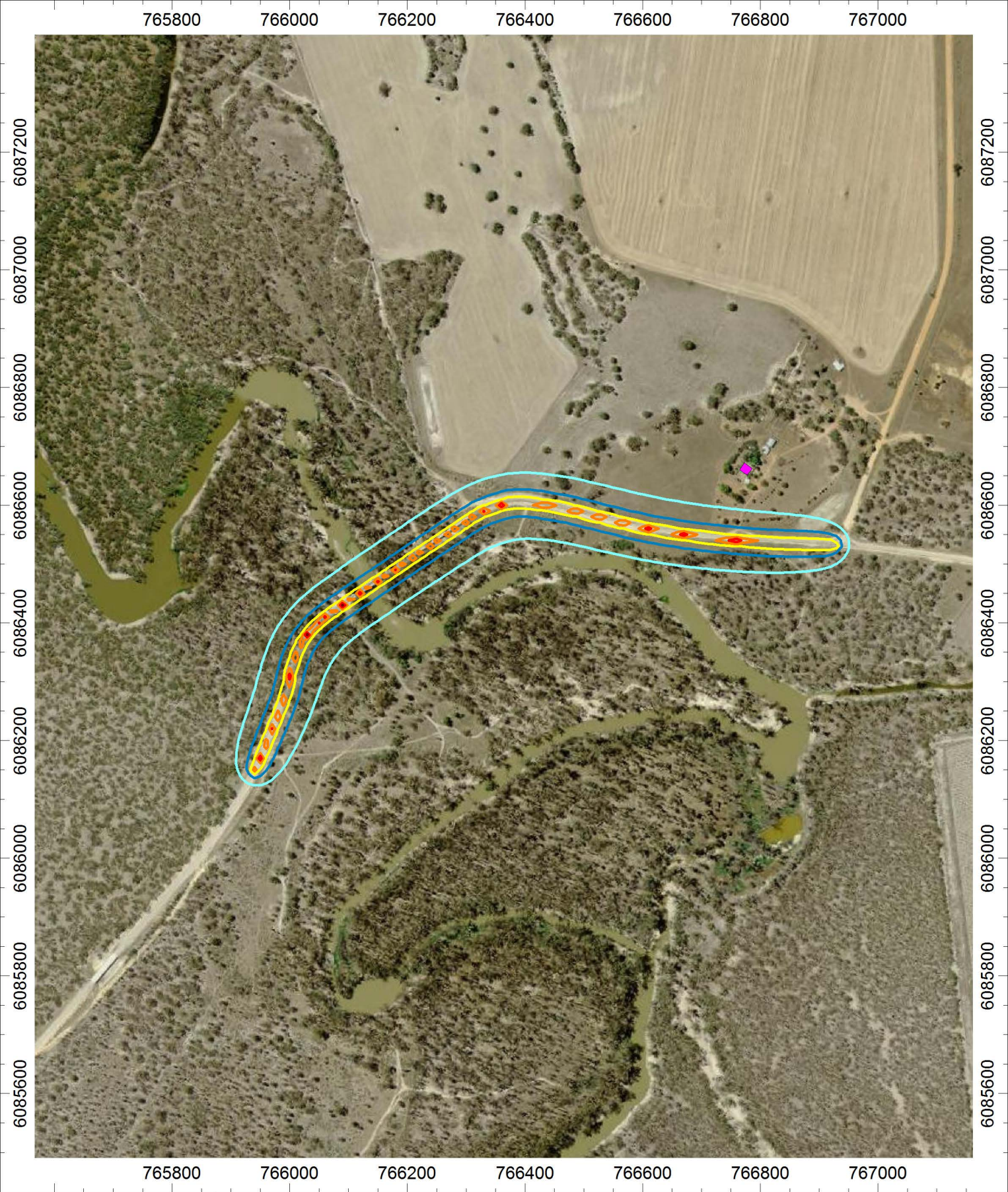
Sound Pressure Level dB(A)

- 35.0
- 40.0
- 45.0
- 50.0
- 55.0
- 60.0

Gee Gee Bridge Replacement
Operational Noise Contour Map

Figure 3-3 Predicted Road Traffic Noise Levels
Build 2017 Day (facade corrected)

GHD



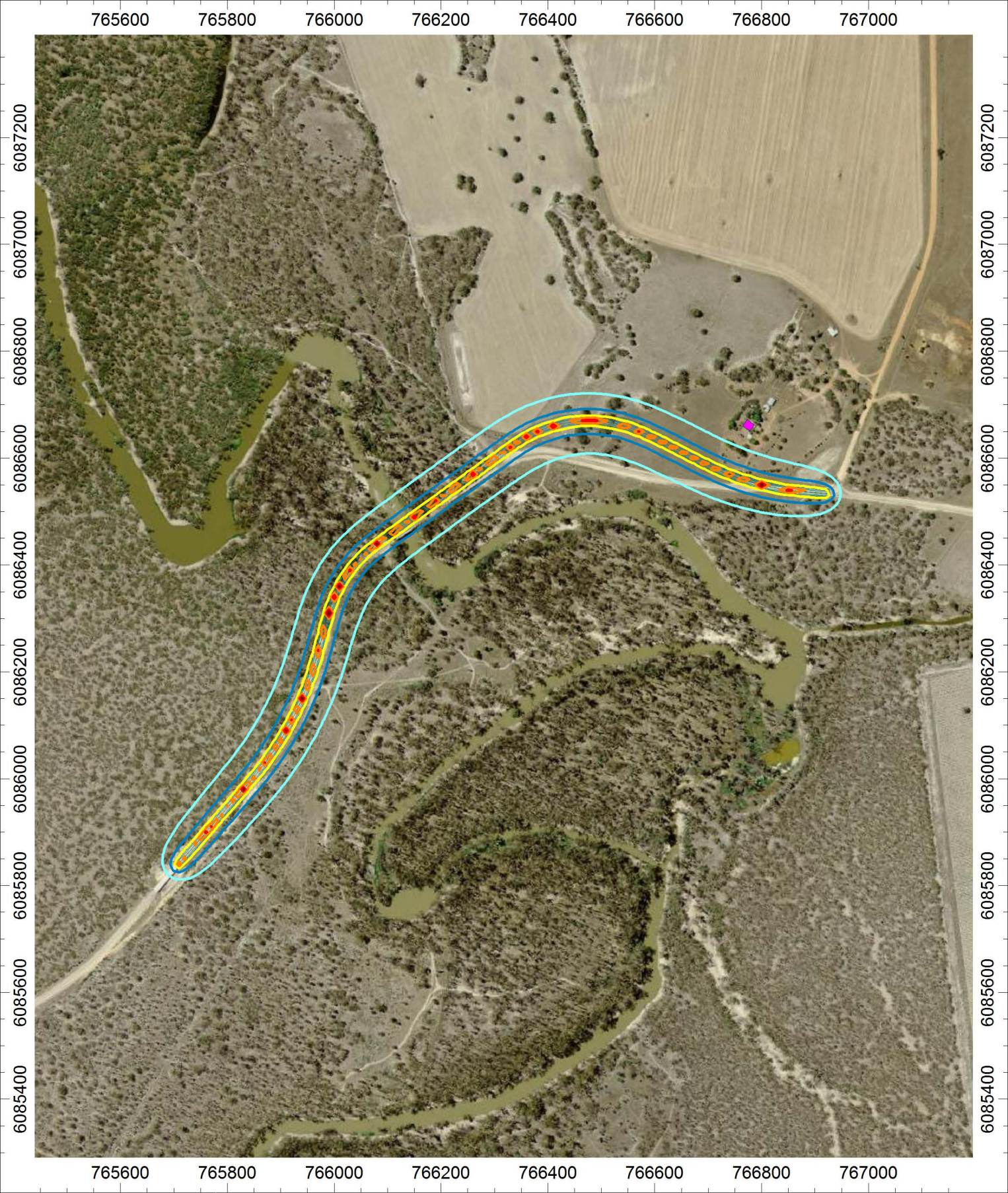
Sound Pressure Level dB(A)

- 35.0
- 40.0
- 45.0
- 50.0
- 55.0
- 60.0

Gee Gee Bridge Replacement
Operational Noise Contour Map

Figure 3-4 Predicted Road Traffic Noise Levels
No build 2017 Night (facade corrected)

GHD



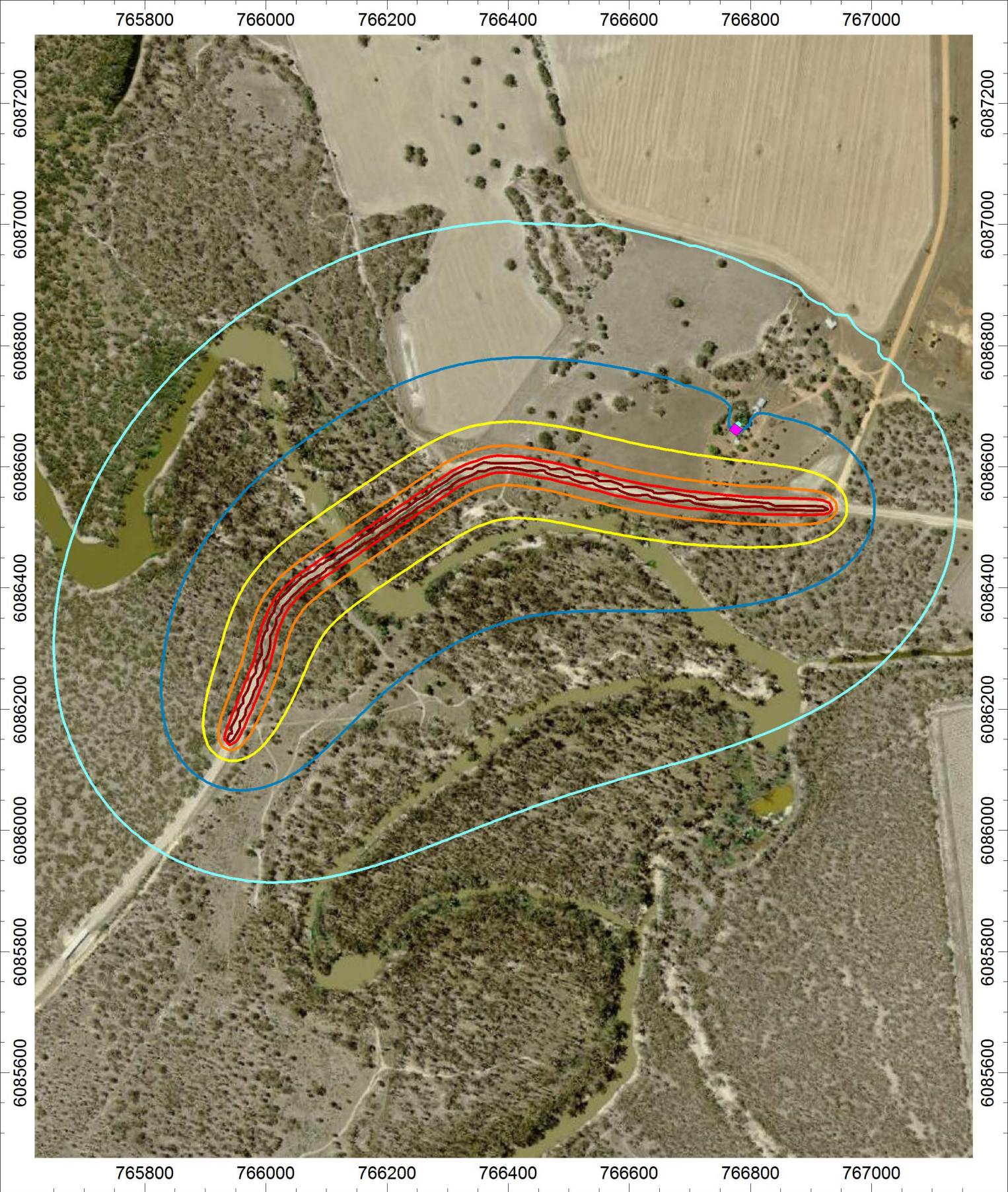
Sound Pressure Level dB(A)

- 35.0
- 40.0
- 45.0
- 50.0
- 55.0
- 60.0

Gee Gee Bridge Replacement
Operational Noise Contour Map

Figure 3-5 Predicted Road Traffic Noise Levels
Build 2017 Night (facade corrected)

GHD



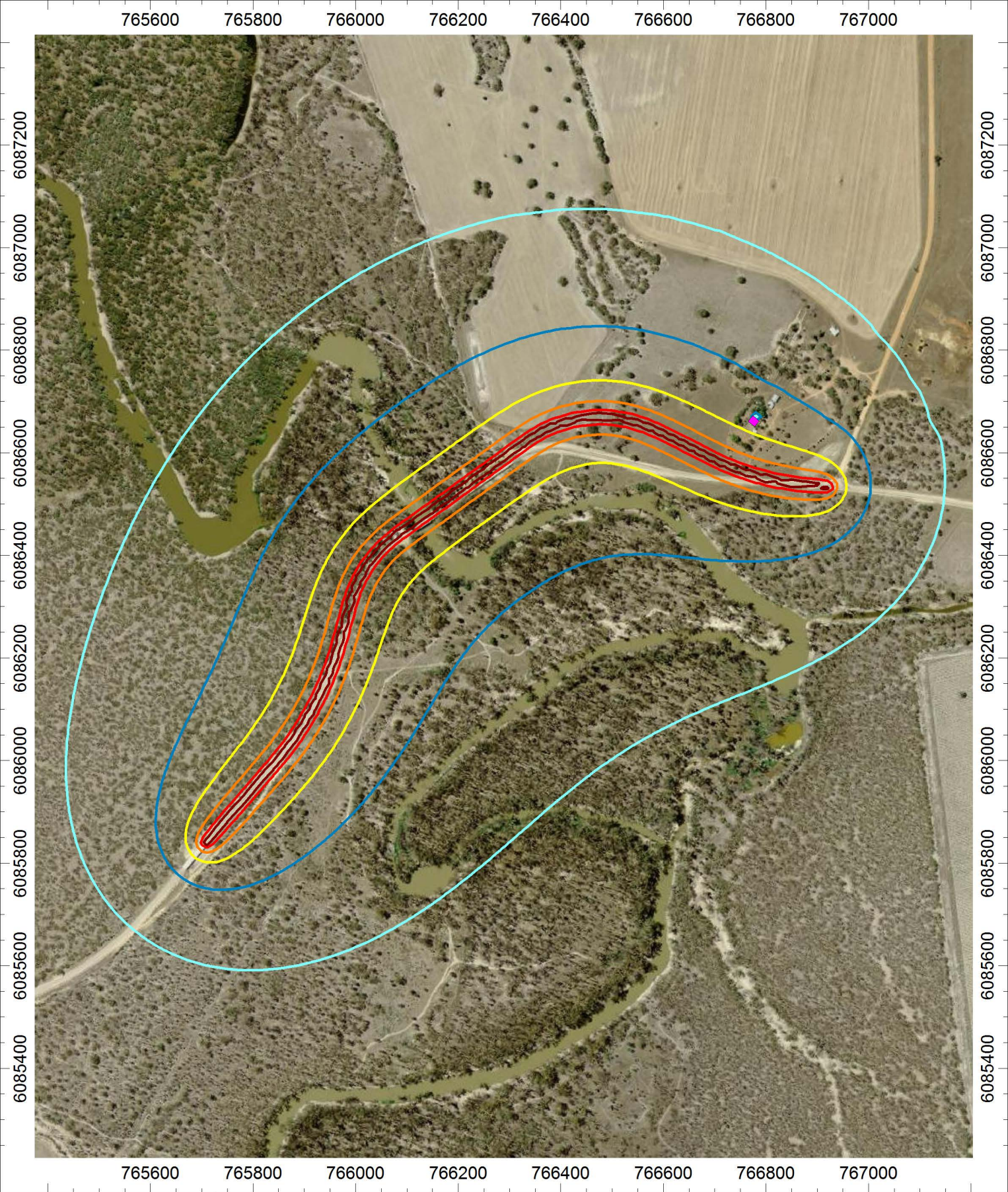
Sound Pressure Level dB(A)

- 35.0
- 40.0
- 45.0
- 50.0
- 55.0
- 60.0

Gee Gee Bridge Replacement
Operational Noise Contour Map

Figure 3-6 Predicted Road Traffic Noise Levels
No Build 2027 Day (facade corrected)

GHD



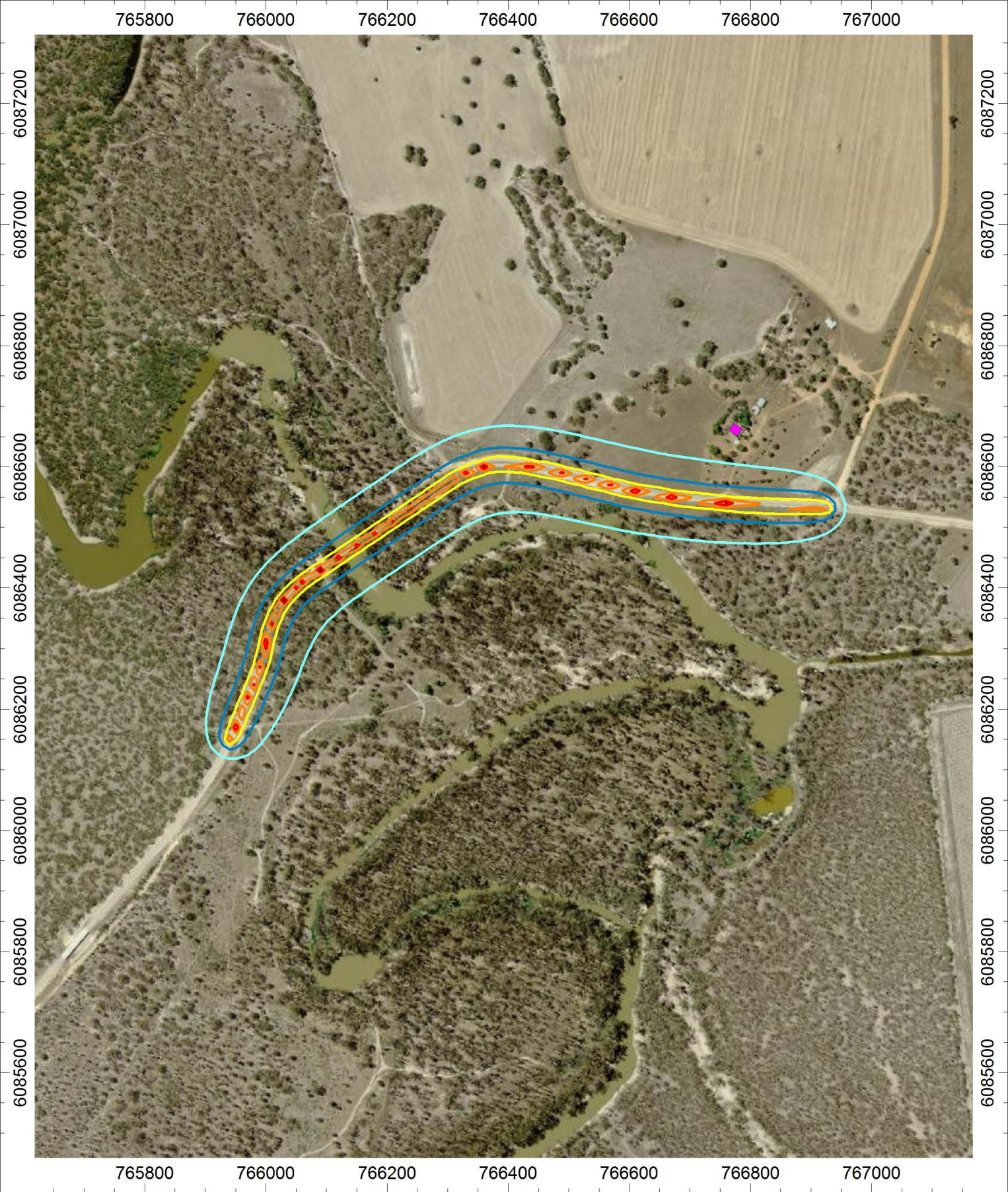
Sound Pressure Level dB(A)

- 35.0
- 40.0
- 45.0
- 50.0
- 55.0
- 60.0

Gee Gee Bridge Replacement
Operational Noise Contour Map

Figure 3-7 Predicted Road Traffic Noise Levels
Build 2027 Day (facade corrected)

GHD



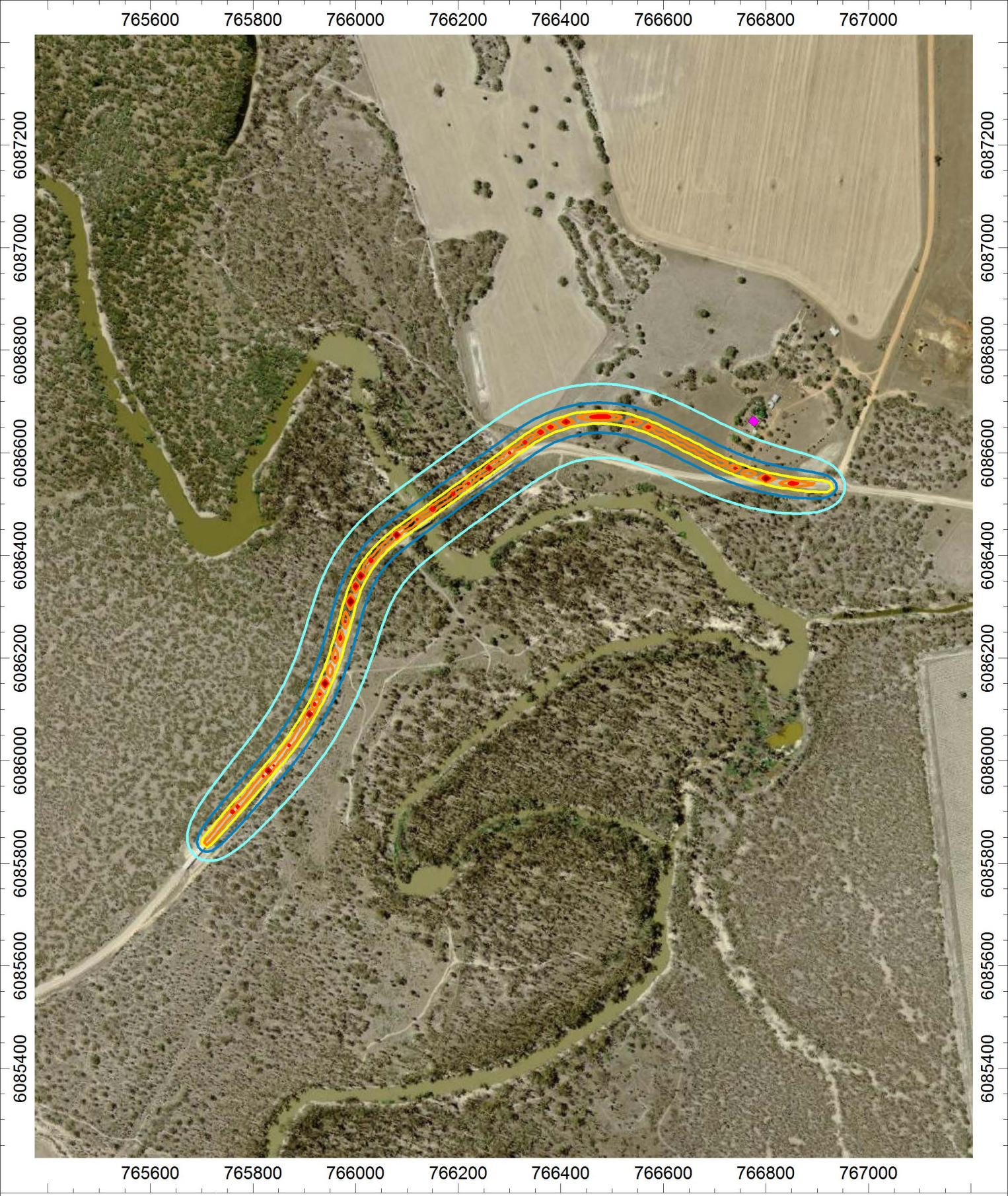
Sound Pressure Level dB(A)

- 35.0
- 40.0
- 45.0
- 50.0
- 55.0
- 60.0

Gee Gee Bridge Replacement
Operational Noise Contour Map

Figure 3-8 Predicted Road Traffic Noise Levels
No Build 2027 Night (facade corrected)

GHD



Sound Pressure Level dB(A)

- 35.0
- 40.0
- 45.0
- 50.0
- 55.0
- 60.0

Gee Gee Bridge Replacement
Operational Noise Contour Map

Figure 3-9 Predicted Road Traffic Noise Levels
Build 2027 Night (facade corrected)

3.4 Assessment of impacts

The controlling criterion from the NCG is predicted to comply at the sensitive receiver during the day time and night time period. The noise level at the southern façade is predicted to have the largest increase, yet the increase is predicted to be less than 2 dBA. The cumulative limit, the relative increase criteria and acute noise levels have not been exceeded. Hence, noise mitigation measures are not required for this proposal.

3.5 Maximum noise level / sleep disturbance assessment

The *Road Noise Policy* provides a literature review for the assessment of sleep arousal due to traffic noise however does not set a sleep disturbance assessment criterion. Sleep disturbance impacts are likely to be dependent on the following:

- Maximum noise level of an event.
- Number of occurrences.
- Duration of the event.
- Level above background or ambient noise levels.

For continuous rather than intermittent traffic flow, the *Environmental Noise Management Manual* recommends L_{Amax} noise pass-by events may lead to sleep disturbance if the L_{Amax} noise levels exceeds the L_{Aeq} noise level by more than 15 dBA when the L_{Amax} noise levels is greater than 65 dBA. The *Environmental Noise Management Manual* advises that the maximum noise level can be used as a tool to prioritise and rank mitigation strategies, but should not be applied as a decisive noise criterion for selection of mitigation treatments.

The road design, incorporating the new and redeveloped sections, is likely to reduce the maximum noise levels at the source. However, the road would be closer to receiver R001, potentially increasing the maximum noise level experienced at the receiver. A review of the traffic data for Noorong Road shows that the number of vehicles in the night time period is only 4 and consists mostly of light vehicles, meaning that there would be minimal noise events. Additional assessment of maximum noise levels from operational road traffic is not therefore required.

4. Construction noise and vibration assessment

4.1 Construction noise criteria

4.1.1 Noise management levels and project specific criteria

The ICNG provides guidance for assessment of construction noise. The guideline recommends standard hours for construction activities as Monday to Friday: 7 am to 6 pm, Saturday: 8 am to 1 pm and no work on Sundays or Public Holidays.

Should any out of hours work be required, work would be undertaken in line with procedures contained in Roads and Maritime *Environmental Noise Management Manual 2001* (ENMM) and *Practice Note vii – Roadworks Outside of Normal Working Hours* (RTA 2001). This would include notifying the local community of any work planned to be undertaken outside the standard hours.

The ICNG acknowledges that the following activities have justification to be undertaken outside the recommended construction hours assuming all reasonable and feasible mitigation measures are implemented to minimise the impacts to the surrounding community:

- The delivery of oversized plant or structure
- Emergency work
- Works for which it can be demonstrated that there is a need to operate outside the recommended standard hours
- Works which maintain noise levels at receivers to below the night-time noise affected construction noise management levels.

Table 4-1 details the noise management levels at sensitive residences. The noise management levels for each sensitive receiver are summarised in Table 4-2. The assessment point is 30 metres from the residence, or the resident boundary, whichever is the closest.

Table 4-1 Noise management levels at resident

Time of day	Management level $L_{Aeq(15min)}$	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected Rating background level + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (15min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected Rating background level + 5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Table 4-2 Project specific construction noise criteria, dBA

Receiver area	Construction noise management level, $L_{Aeq\ (15min)}$					Sleep disturbance criteria[1] L_{Amax}
	During standard recommended hours		Outside of standard recommended hours			
	7 am to 6 pm Monday to Friday, 8 am to 1 pm Saturday, No work on Sunday or public holidays		Day 7 to 8 am & 1 to 6 pm Saturday, 8 am to 6 pm Sunday & public holidays	Evening 6 to 10 pm Monday to Sunday & public holidays	Night 10 pm to 7 am, Monday to Saturday; 10 pm to 8 am Sunday & public holidays	Night 10 pm to 7 am, Monday to Saturday; 10 pm to 8 am Sunday & public holidays
	Noise affected	Highly noise affected				
Residence	40	75	35	35	35	60 to 65 dBA (external)

Note 1: External noise level based on RNP guidance and assuming windows partially open with 10 dBA reduction in noise from outside the building to inside the bedroom.

4.1.2 Sleep disturbance

The *Interim Construction Noise Guideline* states that where construction works are planned to extend over more than two consecutive nights, the analysis should include maximum noise levels and the extent and number of times the maximum exceeds the rating background levels. The *Industrial Noise Policy* application notes regarding sleep disturbance recommend that where the $L_{A1\ (1minute)}$ exceeds the $L_{A90\ (15minute)}$ by more than 15 dBA, a more detailed analysis is required. Further guidance for sleep disturbance is provided in the *Road Noise Policy* which concludes, based on the research to date, that:

Maximum internal noise levels below 50 – 55 dBA are unlikely to awaken people from sleep.

One or two noise events per night, with maximum internal noise levels of 65 – 70 dBA, are not likely to affect health and wellbeing significantly.

For sleep disturbance the assessment point is inside the residence's bedroom, where as the assessment point for the construction noise management levels is 30 metres from the residence, or the residence boundary, whichever is the closest.

4.2 Construction vibration criteria

4.2.1 Human comfort

Vibration criteria have been set with consideration to Assessing Vibration: a technical guideline (DEC, 2006). British Standard *BS 6472 – 1992, Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)* is recognised by the guideline as the preferred standard for assessing the 'human comfort criteria'.

Typically, construction activities generate ground vibration of an intermittent nature. Intermittent vibration is assessed using the vibration dose value. Acceptable values of vibration dose are presented in Table 4-3 for sensitive receivers.

Whilst the assessment of response to vibration in *BS 6472-1:1992* is based on vibration dose value (refer to Table 4-3) and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of a peak value, since this parameter is likely to be more routinely measured based on the more usual concern over potential building damage.

Humans are capable of detecting vibration at levels which are well below those causing risk of damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in British Standard, *BS 5228.2 – 2009, Code of Practice Part 2 Vibration for noise and vibration on construction and open sites – Part 2: Vibration* and are shown below in Table 4-4.

Table 4-3 Human comfort intermittent vibration limits (BS 6472-1992)

Receiver type	Period	Intermittent vibration dose value ($m/s^{1.75}$)	
		Preferred value	Maximum value
Residential	Day (7 am to 10 pm)	0.2	0.4
	Night (10 pm to 7 am)	0.13	0.26
Offices, schools, educational institutes & places of worship	When in use	0.4	0.8

Table 4-4 Guidance on effects of vibration levels for human comfort (BS 5228.2-2009)

Vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration at this level in residential environments will cause complaints, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure.

4.2.2 Structural damage

Currently, there is no Australian Standard that sets criteria for the assessment of building damage caused by vibration. Guidance of limiting vibration values is attained from reference to German Standard *DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structure*.

Table 4-4 presents guideline values for the maximum absolute value of the velocity *"at the foundation of various types of building. Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible."*

Measured values exceeding those listed in Table 4-5 *"does not necessarily lead to damage; should they be significantly exceeded, however, further investigations are necessary."*

Table 4-5 Guideline values for short term vibration on structures

Line	Type of structure	Guideline values for velocity, (mm/s)		
		1 to 10 Hz	10 to 50 Hz	50 to 100 Hz[1]
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (for example listed buildings under preservation order)	3	3 to 8	8 to 10

Note 1: At frequencies above 100 Hz the values given in this column may be used as minimum values.

4.3 Construction noise assessment

The noise emissions from construction have been assessed at the surrounding potentially affected receivers during the standard construction hours as well as outside the standard construction hours. A quantitative assessment has been undertaken with consideration to the *Interim Construction Noise Guideline* (DECC, 2009).

4.3.1 Construction program summary

Construction of approximately 1700 m of realignment works including the construction of a new bridge 35 km east of Swan Hill are shown in Figure 2-1. These works are expected to start in 2018 and completion is expected in 2019.

Construction activities

Construction is expected to involve the following work methodology (the final work methodology would be determined during detailed design).

Activities associated with construction of the bridge may include:

- Establishing a hardstand area on the northern river bank for cranes used to construct the bridge
- Cut and provide ramps in the river banks for providing access for construction of piers 11 and 12
- Installing a temporary coffer dam around pier 11 on the northern edge of the Wakool River. The coffer dam would have dimensions of about 20 metres by 20 metres. Coffer dams may be constructed by using clean rock or metal sheet piles. These would be removed after construction of the piers
- Minor cutting and ground levelling, and construction of crane platforms at several locations on the downstream side of the new bridge
- Installing temporary clean rock work platforms (about 10 metres in length) from each bank, adjacent to the downstream side of the proposed bridge
- Driving precast concrete piles
- Constructing piers and abutments up to the underside of the deck (poured concrete)
- Bridge headstocks would be cast, precast beams placed, and deck constructed. Precast parapets and rails would be installed and kerb infill/deck connection constructed. Bitumen seal would be applied to the completed bridge deck, and line marking and associated infrastructure would be installed.

Road construction activities would include:

- Clearing and grubbing vegetation
- Establishing environmental controls
- Constructing stormwater drainage
- Constructing bridge abutments
- Constructing the bridge
- Progressively stripping, stockpiling and managing topsoil across the site
- Cut and fill earthworks to construct the road formation
- Importing road base materials, compacting and preparing the final road surface

- Applying bitumen sealing and line marking
- Preparing the roadside batters to the final shape
- Constructing roadside drainage
- Progressively landscaping and revegetating the proposal site, including placing topsoil, seeding, planting trees and shrubs, installing weed mats and placing mulch
- Installing safety barriers, line marking, signs and guide posts
- Installing permanent fencing on both sides of the new road on the national park boundary
- Cleaning up the site including removal of the temporary site compound(s) and disposing of all surplus and waste materials.

Activities associated with the demolition and removal of the bridges may include:

- Cutting or trimming trees on the upstream side of the existing bridge
- Establishing site access, a compound site, stockpiling area and environmental controls including protecting the river from demolition debris
- Establishing an on-site area to stockpile and dismantle timber and steel bridge components before removing them from site
- Managing lead paint according to a contamination management plan
- Establishing a temporary work area including a hardstand for a crane to lift and manoeuvre existing bridge sections as they are progressively dismantled
- Installing temporary clean rock work platforms (about 10 metres in length) from each bank, adjacent to the existing bridge
- Removing decking timbers and girders, then removing the truss spans with a crane
- Salvaging reusable timbers and disposing of poor timbers
- Removing the timber piers by cutting through the piers and moving these sections to the temporary stockpiling area
- Disposing of contaminated soils from piers and abutments
- Salvaging road material from the approach road, reshaping and capping with topsoil and revegetating the site for stability
- Reshaping and revegetating the batters.

It is anticipated that work for the proposal would be undertaken during recommended standard hours for construction work according to the ICNG:

- Monday to Friday: 7 am to 6 pm
- Saturday: 8 am to 1 pm
- Sundays and public holidays: no work.

Should any out of hours work be required, works would be undertaken in line with procedures contained in *Environmental Noise Management Manual* (RTA, 2001), *Practice Notes vii – Roadworks Outside of Normal Working Hours.*

4.3.2 Noise generating equipment

Plant and equipment needed for the proposal would be determined during the construction planning phase by the contractor(s). The anticipated plant and equipment used for the proposal is shown in Table 4-6 with the corresponding noise emission sound power levels. Noise level

data has been obtained from AS2436[1] and the *Environmental Noise Management Manual* (RTA, 2001). Other equipment may be used however it is anticipated that this equipment would produce similar noise emissions.

The magnitude of off-site noise impact associated with construction will be dependent upon a number of factors:

- The intensity and location of construction activities
- The type of equipment used
- Existing background noise levels
- Intervening terrain and structures
- The prevailing weather conditions.

Construction machinery would likely move about the study area altering noise impacts with respect to individual receivers. During any given period, the machinery items to be used in the study area would operate at maximum sound power levels for only brief stages. At other times, the machinery may produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at their maximum sound power levels at any one time and certain types of construction machinery would be present in the study area for only brief periods during construction. Therefore noise predictions are considered conservative.

[1] Australian Standard, AS2436 – 2010, Guide to noise and vibration control on construction , demolition and maintenance sites

Table 4-6 Construction plant and equipment sound power levels, dBA

Plant and equipment	Sound power level dBA
Excavators	108
Backhoe	104
Water carts	107
Hand tools (including welding equipment)	102
Saw-cutting	117
Profiler for milling	111
Asphalt paver	108
Rollers/compactors	108
Grader	110
Tipper trucks	107
Kerb machine	100
Road sweepers	104
Generators	98
Trenching machine	100
Under boring rig	111
Line marking truck	102
Semi-trailers and large delivery trucks	108
Piling	137

4.3.3 Predicted construction noise impacts

For each item of equipment, the potential noise impacts on the surrounding sensitive receivers have been predicted. Noise modelling was undertaken using CadnaA 4.4.

CadnaA is a computer program for the calculation, assessment and prognosis of noise propagation. CadnaA calculates environmental noise propagation according to the *ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors* algorithm. The algorithms meteorological conditions are based on a moderately well-developed temperature inversion or sour to receiver wind.

The following assumptions and calculation parameters were used in the noise model:

- Surrounding land was modelled assuming a ground absorption coefficient of 0.5
- The noise model was used to predict noise levels during a typical worst case 15 minute period of operation where the specified item of equipment is running at full power
- Atmospheric absorption was based on an average temperature of 20 degrees Celsius and an average humidity of 50 per cent
- The noise source was located at the centre of either the existing or proposed alignment (whichever is closest to the receiver). In practice the equipment would move either side of these positions.

- The piling was modelled on the eastern extent of the bridge as this is worst case for the sensitive receivers

Table 4-7 shows that the majority of construction activities are predicted to exceed the construction noise management level of 40 dBA during standard construction hours at the closest sensitive receiver R001. Two residential receivers, R002 located at Lot 2 DP430998 (about 1 km from the closest construction activities) and R003 located at Lot 1 DP129621 (about 1.3 km from the closest construction activities), east of R001 have been included in the modelling as they are the only other residential receivers within the area. Exceedances are predicted to occur due to operation of a few of the construction activities, yet predictions do not take into account localised shielding or temporary barriers from other machinery and equipment. It is likely that actual noise levels would be lower than predicted as these levels are considered worst case. No sensitive receivers are predicted to exceed the highly noise affected level of 75 dBA. It is recommended that the noise mitigation measures detailed in Section 4.6 be implemented where feasible and reasonable and all potentially impacted residents should be informed of the nature of the works, expected noise levels, duration of works and a method of contact.

Table 4-7 Construction plant and equipment noise level at sensitive receivers, dBA

Construction Equipment	Predicted sound pressure level Range (minimum – maximum) dBA		
	R001 3357 Noorong Road (Lot 41 DP 756533)	R002 Noorong Road (Lot 2 DP 430998)	R003 3400 Noorong Road (Lot 1 DP 129621)
Excavators	**42 - 62**	35 - 40	34 - 38
Backhoe	38 **- 58**	31 - 36	30 - 34
Water carts	**41 - 61**	34 - 39	33 - 37
Hand tools (i.e. welding equipment)	36 **- 56**	29 - 34	28 - 32
Saw-cutting	**51 - 71**	**44 - 49**	**43 - 47**
Profiler for milling	**45 - 65**	38 - **43**	37 - **41**
Asphalt paver	**42 - 62**	35 - 40	34 - 38
Rollers/compactors	**42 - 62**	35 - 40	34 - 38
Grader	**44 - 64**	37 - **42**	36 - 40
Tipper trucks	**41 - 61**	34 - 39	33 - 37
Kerb machine	34 **- 54**	27 - 32	26 - 30
Road sweepers	38 **- 58**	31 - 36	30 - 34
Generators	32 **- 52**	25 - 30	24 - 28
Trenching machine	34 **- 54**	27 - 32	26 - 30
Under boring rig	**45 - 65**	38 - **43**	37 - **41**
Line marking truck	36 **- 56**	29 - 34	28 - 32
Semi-trailers and large delivery trucks	**42 - 62**	35 - 40	34 – 38

Construction Equipment	Predicted sound pressure level Range (minimum – maximum) dBA		
	R001 3357 Noorong Road (Lot 41 DP 756533)	R002 Noorong Road (Lot 2 DP 430998)	R003 3400 Noorong Road (Lot 1 DP 129621)
Piling	**63**	**51**	**49**

Bold text indicates exceedances to the noise management levels during standard construction hours

4.3.4 Sleep disturbance impacts

The ICNG Guideline states that "where construction works are planned to extend over more than two consecutive nights, the impact assessment should cover the maximum noise level from the proposed works".

Typically, $L_{A1\ (1minute)}$ noise levels are around 5 dB to 10 dB greater than the $L_{Aeq\ (15minute)}$ noise levels. Typically a window will provide a 10 dB reduction when partially open and a 20 dB reduction when closed. To be conservative, it is assumed that windows would be kept open during night-time construction activities.

The Office of Environment and Heritage publications acknowledges that based on the current level of understanding no absolute noise level criteria have been established that correlate to an acceptable level of sleep disturbance. However, the Road Noise Policy provides that maximum internal noise levels below 50 dBA to 55 dBA are unlikely to cause awakening reactions and one or two events per night, with maximum internal noise levels of 65 dBA to 70 dBA (inside dwellings) are not likely to significantly affect health and wellbeing. There is the potential for sleep disturbance impacts, with consideration to the Road Noise Policy sleep disturbance levels, if construction activities occur during the night-time period.

The project may require out of hours work and there is the potential that residential receivers will experience noise that exceeds the construction noise management levels and sleep disturbance criteria. Roads and Maritime should:

- Choose activities likely to generate the highest levels of noise and schedule them to occur at the beginning of the shift (before 11 pm) to minimise the potential for sleep disturbance. All workers would be briefed on the need to minimise noise as a result of their activities. This would be included in a noise management plan

The noise management plan would identify noise sensitive locations and the work practices to be implemented to minimise noise impacts.

4.4 Construction vibration assessment

Energy from construction equipment is transmitted into the ground and transformed into vibrations, which attenuates with distance. The magnitude and attenuation of ground vibration is dependent on the following:

- The efficiency of the energy transfer mechanism of the equipment (i.e. impulsive; reciprocating, rolling or rotating equipment)
- The frequency content
- The impact medium stiffness
- The type of wave (surface or body)
- The ground type and topography.

Due to the above factors, there is inherent variability in ground vibration predictions without site-specific measurement data. The Environmental Noise Management Manual (RTA, 2001) provides typical construction equipment ground vibration levels at 10 metres. The rate of vibration attenuation can be calculated from the following regression analysis formula:

$V = kD^{-n}$, where

V = Peak Particle Velocity

D = Distance

k = Site constant.

n = attenuation exponent. The value of n generally lies between 0.8 and 1.6 with a relatively common value of 1.0

The predicted ground vibrations at various distances are shown in Table 4-8 for typical equipment that may be used based on data from the Environmental Noise Management Manual (RTA, 2001). Piling has not been included in the vibration assessment as the distance from the proposed piling works to the nearest receivers is over 400 metres.

Table 4-8 Typical vibration levels at distances (mm/s peak)

Plant items	Distance from source				
	10 metres	20 metres	50 metres	75 metres	100 metres
Roller (15 tonne)	7 to 8	4.0	1.6	1.1	0.8
Compactor (7 tonne)	5 to 7	3.5	1.4	0.9	0.7
Dozer	2.5 to 4	2.0	0.8	0.5	0.4
Backhoe	1.0	0.5	0.2	0.1	0.1
Pavement breaker	4.5 to 6	3.0	1.2	0.8	0.6

4.5 Predicted construction vibration impacts

4.5.1 Building damage

Figures for predicted vibration levels presented in Table 4-8 indicate that buildings classified as dwellings or buildings of similar construction (DIN 4150-3 ‘line 2’ buildings) within approximately 20 m will experience vibration approaching the 5 mm/s PPV recommended limit.

The nearest residential receiver to construction activities is the residential dwelling located at 3357 Noorong Road (R001), about 100 metres from the existing road and about 75 metres from the new road alignment. This sensitive receiver is not expected to be impacted by vibration from construction works.

For construction activities or equipment that is not listed in Table 4-6 and is planned for the proposed works, it is recommended that predictions of vibration be undertaken prior to commencement of works to ensure building damage criteria are not exceeded.

4.5.2 Human Perception

Based on the activities and conservative estimates in Table 4-8, it is possible that construction vibration may be perceptible at time at distances up to 100 m from the work, however this is like to be a conservative estimate. It is recommended that the mitigation measures detailed in Section **Error! Reference source not found.** be considered and implemented where feasible and reasonable.

4.6 Construction noise and vibration mitigation measures

There is the potential that construction activities could exceed the construction noise and vibration management levels for the proposal. Recommended construction noise and vibration mitigation measures are listed below. As part of the detailed design stage of the project a construction noise and vibration management plan should be developed by the construction contractor to implement the construction noise and vibration mitigation measures and minimise the impacts to the surrounding residences.

4.6.1 Noise mitigation measures

The *Interim Construction Noise Guideline* (DECC, 2009) provides a summary of potential noise mitigation measures. It is recommended that the following construction noise mitigation measures be implemented to reduce the impact on the surrounding residences:

- The site configuration should be designed to minimise noise impacts to the surrounding community. The following should be considered in the design:
  - Construction compounds should be laid-out in such a way that the primary noise sources are at a maximum distance from residences, with solid structures (sheds, containers, etc) placed between residences and noise sources (and as close to the noise sources as is practical)
  - Compressors, generators, pumps and any other fixed plant should be located as far away from residences as possible and behind site structures
  - Material dumps, loading and unloading areas should be located as far as practical from the nearest residences
- All equipment should be selected to minimise noise emissions. Equipment should be fitted with appropriate silencers and be in good working order. Machines found to produce excessive noise compared to normal industry expectations should be removed from the site or stood down until repairs or modifications can be made
- To reduce the annoyance associated with reversing alarms, non-tonal reversing beepers (or an equivalent mechanism) will be fitted and used on all construction vehicles and mobile plant where practicable
- Satisfactory compliance with occupational health and safety requirements will need to be achieved and a safety risk assessment may need to be undertaken to determine that safety is not compromised. Refer to Appendix C of the *Interim Construction Noise Guideline* (DECC, 2009) for more information
- The final selection and design of noise mitigation measures should be undertaken with consideration to best management and economically achievable practice during the development of the construction noise and vibration management plan
- The construction noise and vibration management plan should be reviewed in response to complaints and amended where practical throughout the construction phase of the project

If works are planned outside of the recommended standard construction hours the construction contractor would also prepare an Out of Hours Works Procedure as part of the construction noise and vibration management plan for the project. *Environmental Noise Management Manual Practice Note (vii)* requires that 'out of hours' work should not affect residences on more than two consecutive nights, or on more than a total of six nights over a period of one calendar month. When night work is programmed in stages to comply with this requirement, the periods of work should be separated by not less than one week.

4.6.2 Work ethics

All site workers should be made aware of the potential for noise and vibration impacts on local residents and encouraged to take practical and reasonable measures to minimise the impact during the course of their activities. This should include:

- Avoid the use of loud radios
- Avoid shouting and slamming doors
- Where practical, machines should be operated at low speed or power and switched off when not being used rather than left idling for prolonged periods
- Keep truck drivers informed of designated vehicle routes, parking locations and delivery hours
- Minimise reversing
- Avoid dropping materials from height
- All engine covers should be kept closed while equipment is operating.

4.6.3 Compliance noise and vibration monitoring

Attended compliance noise or vibration monitoring should be undertaken to confirm the predicted noise or vibration levels upon receipt of a complaint. The ICNG guidelines state that complaint monitoring measurements should be taken at the complainant's location and the monitoring should cover the time of day when the impacts were reported to occur.

In the case that exceedances of the relevant annoyance criteria levels listed in this report are detected in relation to the complaint, the situation should be reviewed in order to identify means to minimise the impacts to residences.

In all cases, noise or vibration monitoring should be undertaken by a suitably qualified professional in accordance with ICNG guidelines.

4.6.4 Community relations

Consultation and cooperation between the site and surrounding residents will assist in minimising uncertainty, misconceptions and adverse reactions to noise and vibration.

The *Environmental Noise Management Manual* (RTA, 2001) *Practice Note (vii)* provides community consultation procedures for road works outside normal working hours. This includes the following:

- Contact the local community potentially affected by the proposed works (outside of recommended construction hours) and inform them by letter of the proposed work, location, type of work days and dates of work and hours involved. The contact should be made five days prior to commencement of works
- A suitable advertisement should be placed in local papers including a reference to night-time noise impacts
- A community liaison phone number and permanent site contact should be provided so that complaints can be received and addressed in a timely manner
- Upon receipt of a noise complaint monitoring should be undertaken and reported as soon as possible. If exceedances are detected, the situation should be reviewed in order to identify means to attempt to reduce the impact to acceptable levels.

5. Conclusions

The noise and vibration assessment presents relevant noise and vibration criteria for the proposal.

A set of standard mitigation measures for construction noise and vibration have been provided based on anticipated requirements of the project and community consultation is recommended for the project's construction stages.

Construction works during standard construction hours are predicted to exceed the noise criteria at the residential receiver R001 for the majority of work activities. R002 and R003 are predicted to exceed the noise criteria during five of the construction activities while at the closest point. These activities will move to the west, further away from these two residential receivers and noise levels will be lower. It should also be noted that all predicted levels are considered conservative and the actual noise levels received at the sensitive receiver locations are likely to be lower due to localised shielding and/or temporary barriers created by mobile equipment etc.

From the predicted levels in Table 4-7 the saw cutting, profiling, grader and under boring rig are the noisiest activities, yet with feasible and reasonable noise mitigation measures implementation, impacts at the surrounding residential receivers will be minimised. However, it is unlikely that implementation of all reasonable and feasible noise mitigation measures would reduce noise levels to below the construction noise criteria under all circumstances. These levels are anticipated to be short term for the single receiver as the works progress along the construction area.

Operational road traffic noise levels are not predicted to increase by more than 2 dBA for any facade at the identified sensitive receiver. Both the controlling criteria and the cumulative limit criteria are not exceeded. Therefore the sensitive residential receiver is not predicted to require mitigation treatments for operational noise.

6. References

Austroads Research Report, 2005, *Modelling, Measuring and Mitigating Road Traffic Noise*, (AP-R277/05)

Australian Standards, 2010, *AS 2436 – Guide to noise and vibration control on construction, demolition and maintenance site*s

British Standards, 1992, *BS 6472 Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*

British Standards, 2009, *BS 5228.2 Code of Practice for noise and vibration control on construction and open sites: Part 2 Vibration*

Bureau of Meteorology's Swan Hill Aero dome Automatic Weather Station data from 02 June to 10 June 2015

DECC, 2009, *Interim Construction Noise Guideline*

DECC, 2006, *Assessing Vibration: a Technical Guideline*

DECCW, 2011, *Road Noise Policy*

EPA, 2000, *Industrial Noise Policy*

German Standards, 1999, *DIN 4150-3 Structural Vibration Part 3: Effects of vibration on structures*

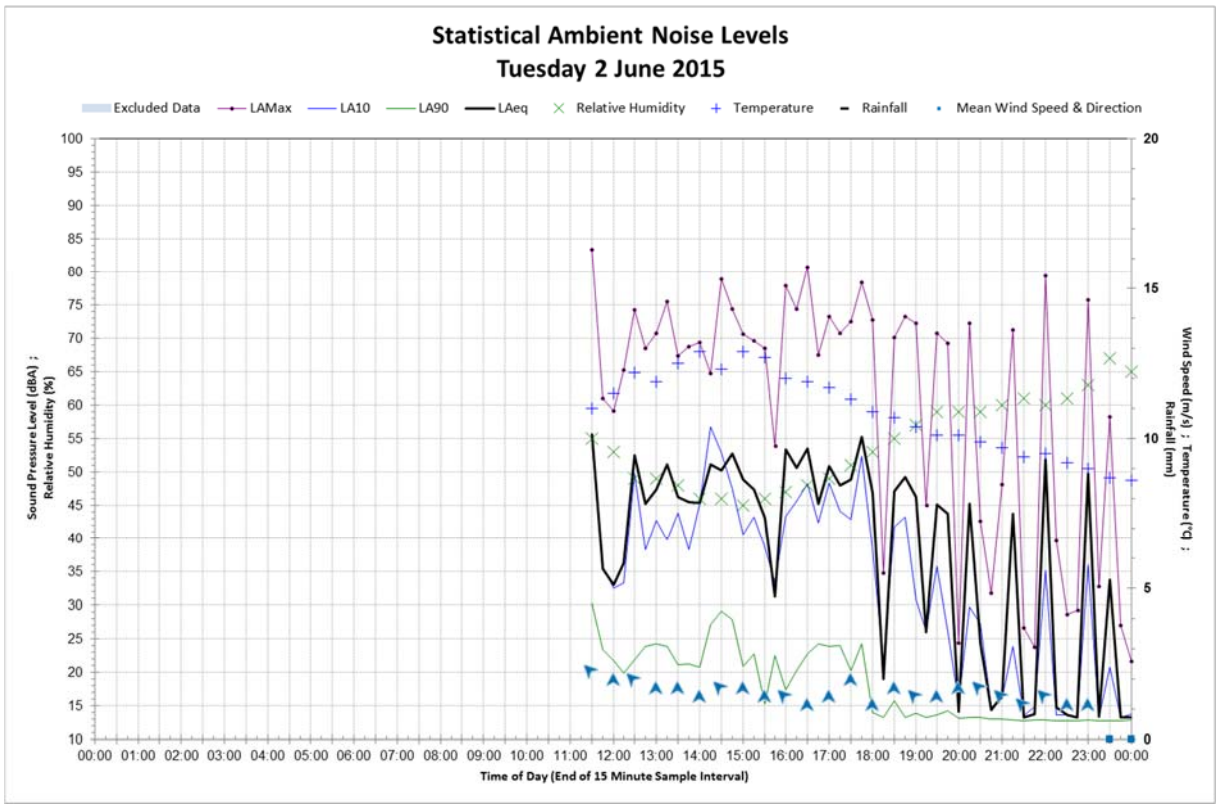
RMS, 2014, *Noise Criteria Guideline*

RMS, 2014, *Noise Mitigation Guideline*

RTA, 2001, *Environmental Noise Management Manual*

Appendices

Appendix A – Noise monitoring charts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LA90
LAeq
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Temperature
Rainfall
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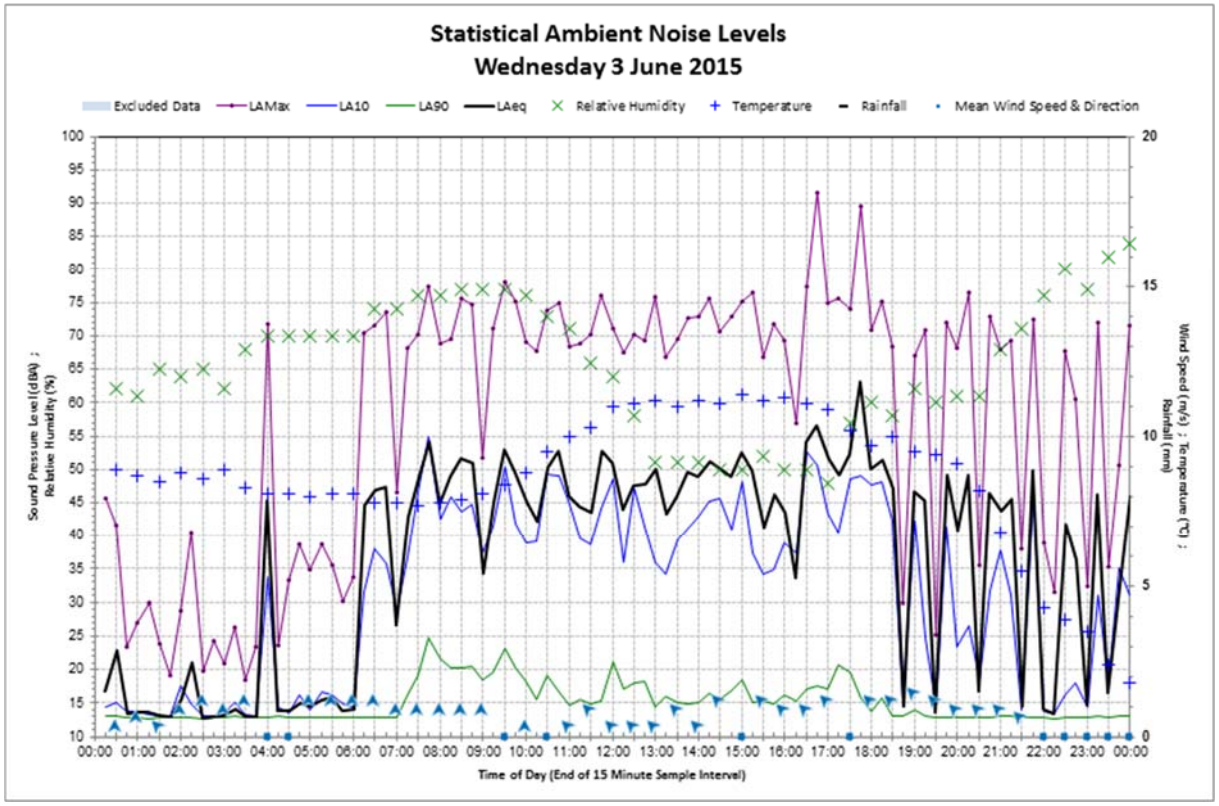
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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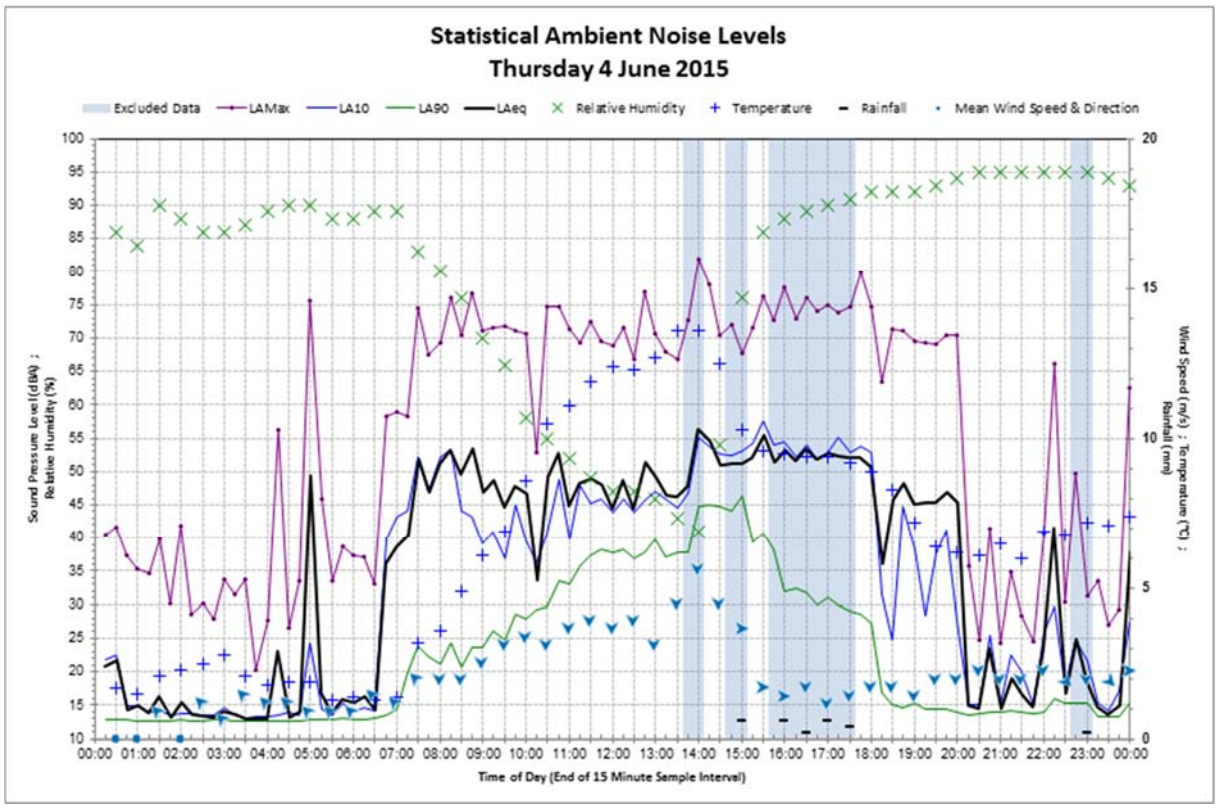
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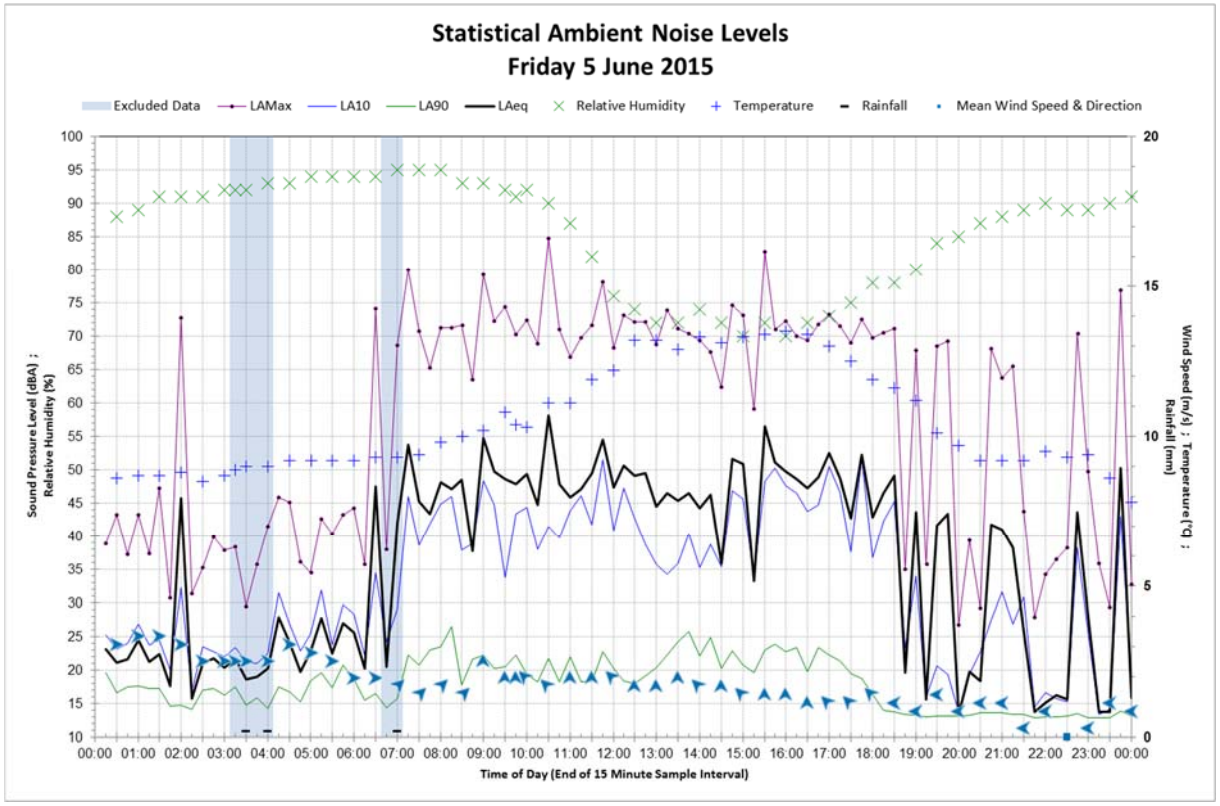
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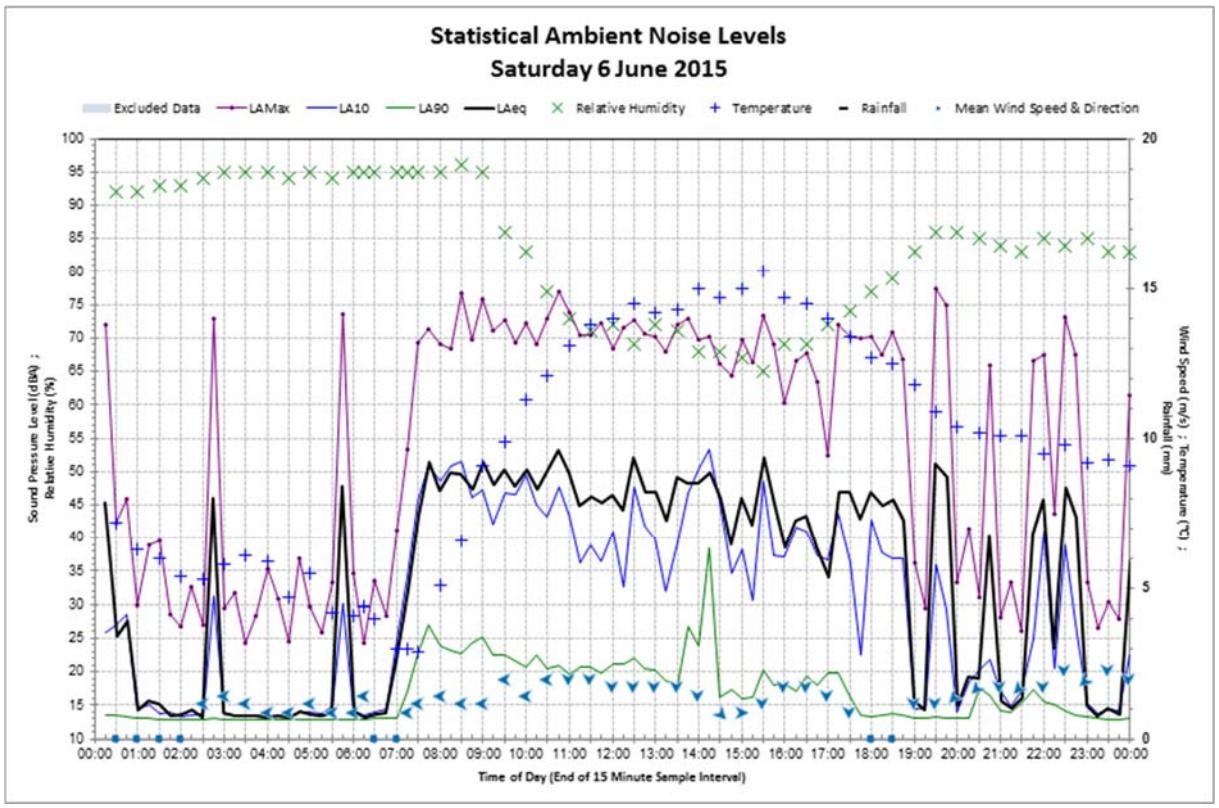
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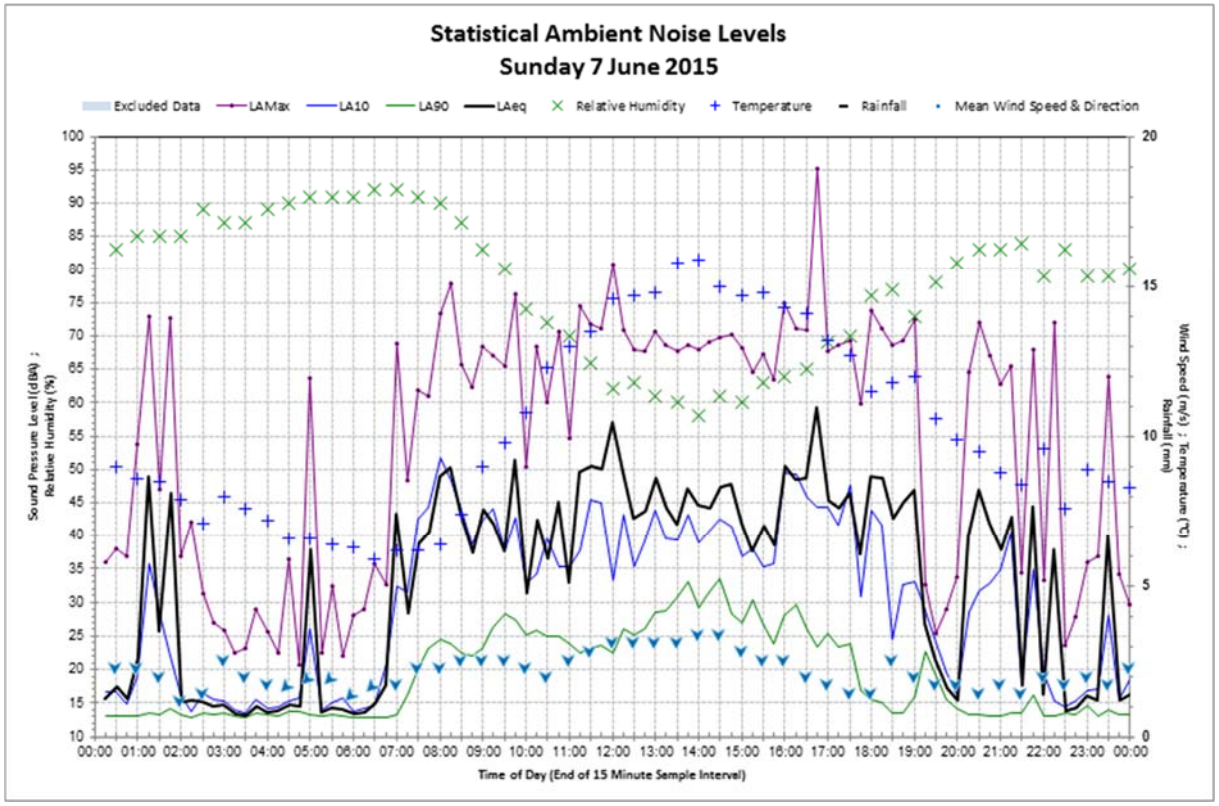
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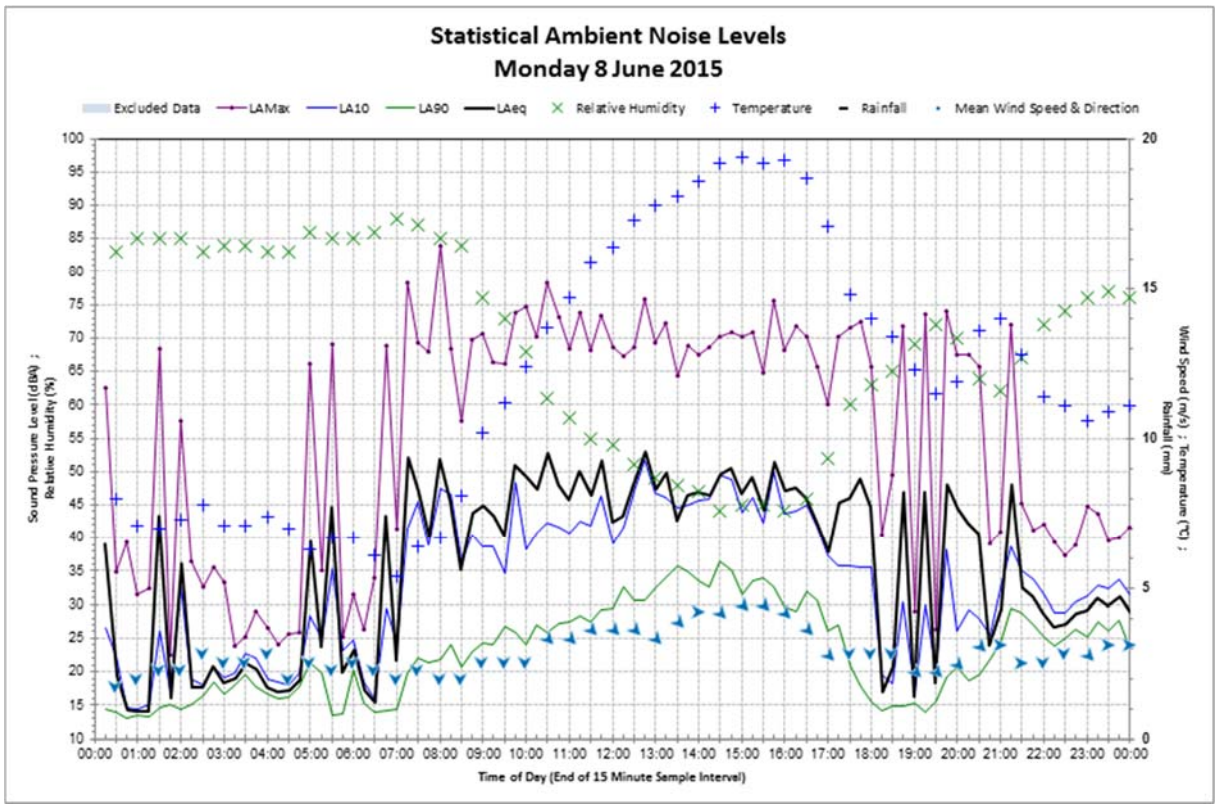
Time of Day (End of 15 Minute Sample Interval)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Temperature
Rainfall
Mean Wind Speed & Direction
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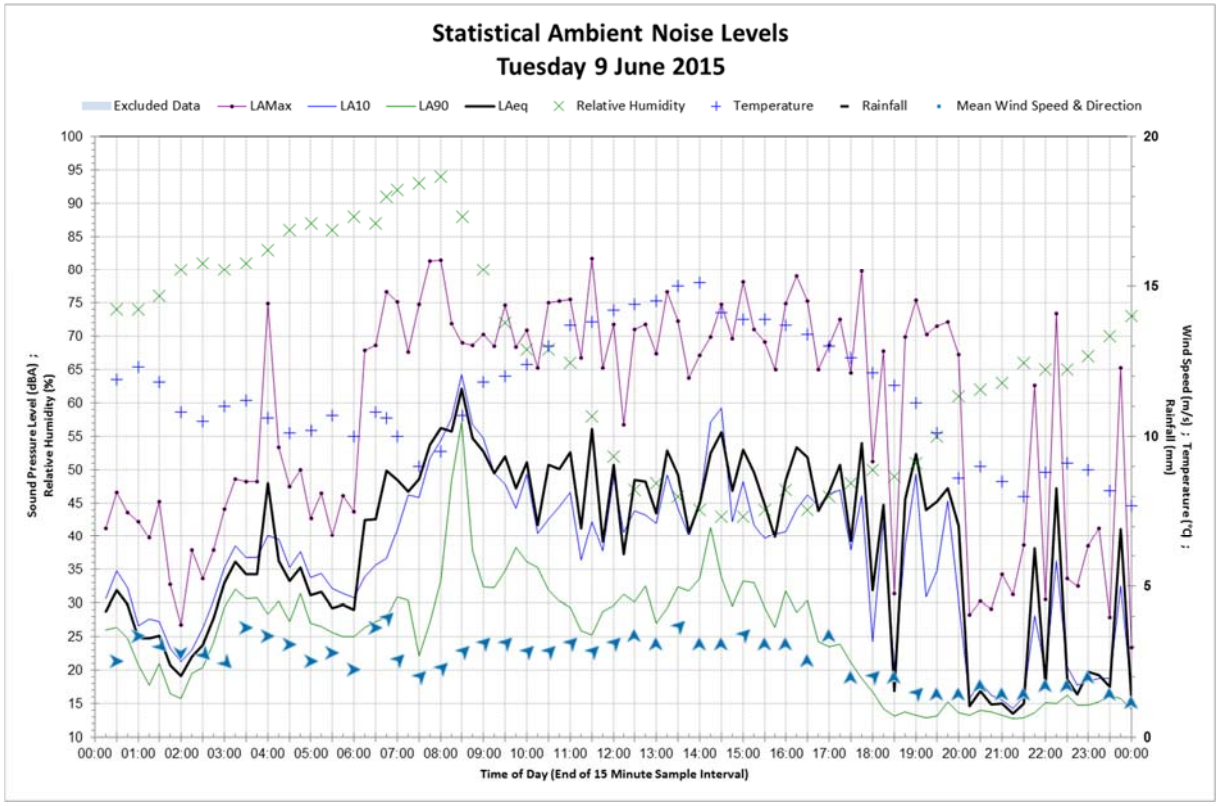
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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Temperature
Rainfall
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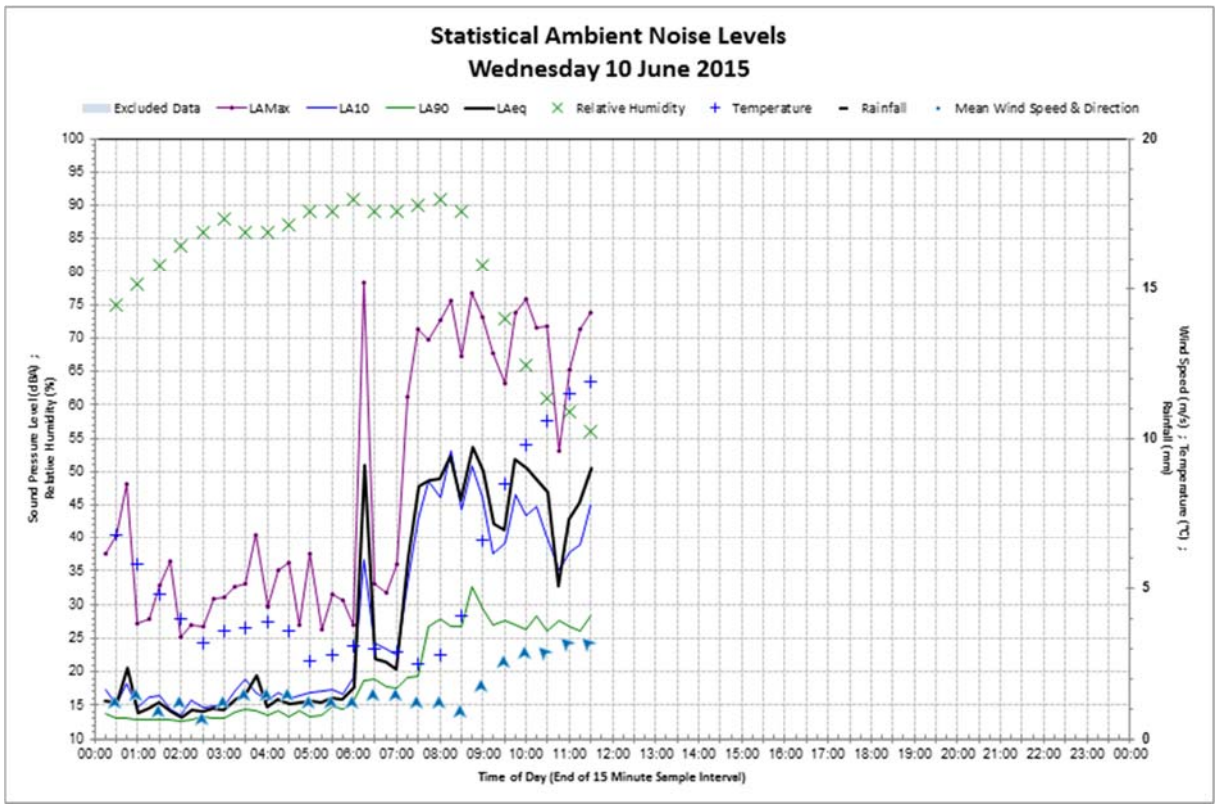
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

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1	E Smith	R. Robinson		S. Farrell		10/05/2017

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