9.3 Surface water and groundwater

Surface water and groundwater assessments were undertaken for the project as presented below. These are supported by *Technical Paper 3 — Surface Water* and *Technical Paper 4 — Groundwater* (Volume 2).

DGRs	Where addressed
Surface and groundwater (including but not limited to)	
Site water demands and water supply.	Sections 6.3.2, 9.3.3, 9.3.4 Technical Papers 3, 4 (Volume 2)
Existing and proposed water licensing requirements under the *Water Act 1912* and *Water Management Act 2000.*	Sections 9.3.2, 9.3.3 Technical Papers 3, 4 (Volume 2)
Impacts to watercourses, riparian corridors, wetlands and groundwater dependent ecosystems.	Section 9.1.3, 9.3.3, 9.3.4 Technical Papers 3, 4 (Volume 2)
Changes to existing flood regimes in accordance with the *NSW Floodplain Development Manual* (2005).	Section 9.3.3 Technical Paper 3 (Volume 2)
Impacts on water supply for identified local agri-businesses.	Section 9.3.3, 9.3.4 Technical Papers 3, 4 (Volume 2)

9.3.1 Assessment approach

Surface water

The surface water assessment built on the work undertaken for the *Hume Highway Town Bypasses: Tarcutta, Holbrook and Woomargama — Groundwater and Surface Water Preliminary Assessments* (PB 2008). A detailed description of the methodology for this assessment is provided in Chapters 1, 2 and 3 of Technical Paper 3 (Volume 2). The assessment included:

- Flood assessment of Mountain Creek to evaluate the impacts of the project on the existing flow regime, considering the 1 in 20, 1 in 100 and 1 in 2000 year average recurrence interval (ARI) and probable maximum flood (PMF) events, in accordance with the *NSW Floodplain Development Manual* (NSW Government 2005).
- Local catchment assessment to identify and assess the potential impacts of the project on receiving waters in the vicinity of the project.
- A water supply assessment including an estimation of the water requirements for construction and the impacts on water sources and users, including local agribusinesses.

A water quality assessment was also carried out as part of the surface water assessment. Results of this component of the assessment are provided in Section 10.2.

Groundwater

The groundwater assessment built on the work undertaken for the *Hume Highway Town Bypasses: Tarcutta, Holbrook and Woomargama — Groundwater and Surface Water Preliminary Assessments* (PB 2008). A detailed description of the methodology for this assessment is provided in Chapters 3 and 5 of Technical Paper 4 (Volume 2). The assessment included:

- Assessment of pre-construction groundwater levels, and local and regional flow systems.
- Consideration of the likely impacts on groundwater during construction and operation.

The results of the groundwater quality sampling are provided in Section 10.2.

9.3.2 Existing environment

Surface water

The project is located within the Mountain Creek catchment. Mountain Creek is a tributary of Billabong Creek, which itself is a tributary of the Murray River.

Local catchment

The project would cross Mountain Creek and a number of small drainage lines, two of which form the headwaters of Native Dog Creek and Sandy Creek.

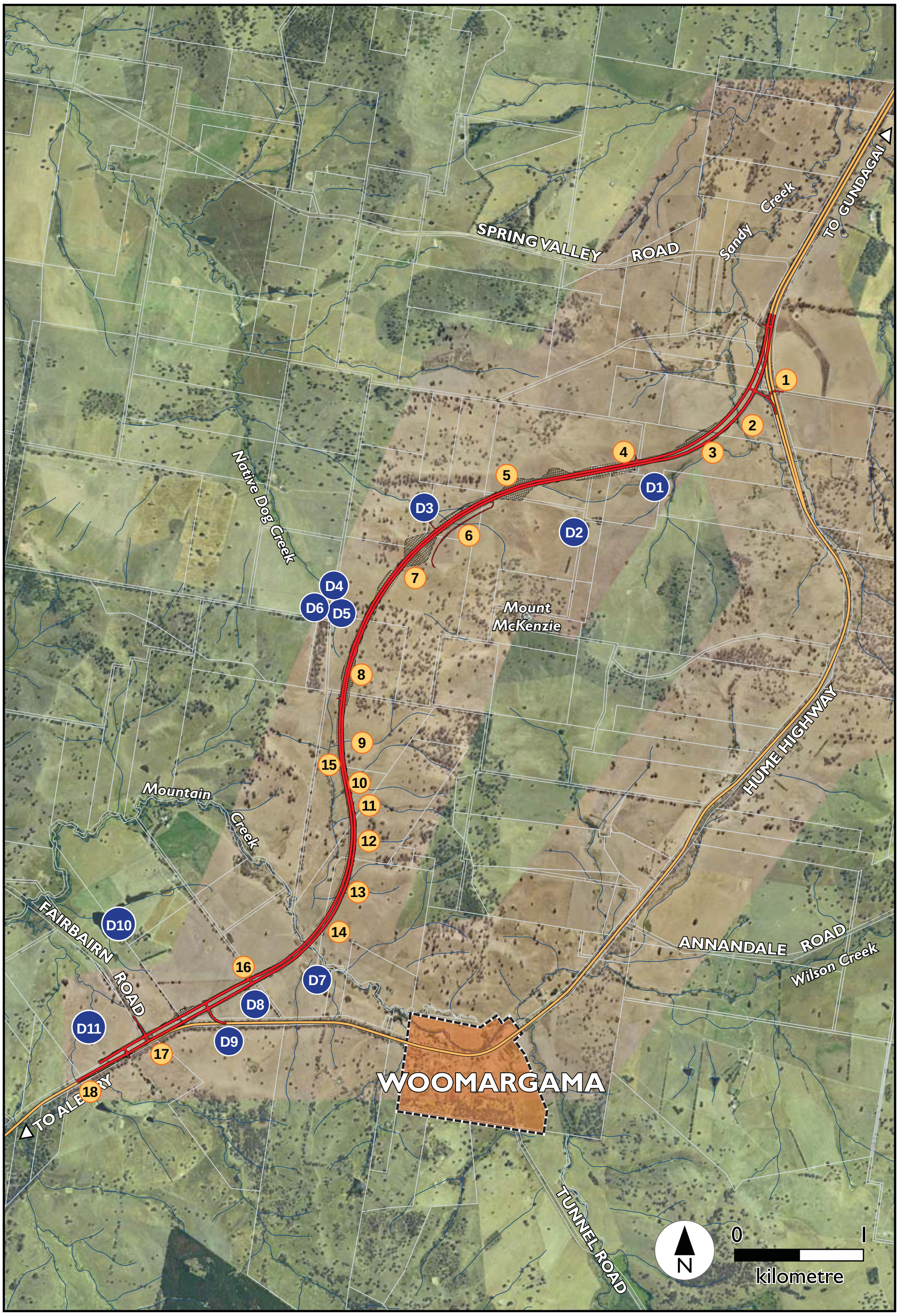
Major tributaries of Mountain Creek in the vicinity of the project include Spring Creek, Tunnel Creek, Wilson Creek and Four Mile Creek. Spring Creek and Tunnel Creek both join Mountain Creek upstream of Woomargama, while Wilson Creek joins Mountain Creek at Woomargama, downstream from the existing Hume Highway bridge. Four Mile Creek joins Mountain Creek just downstream of the Fairbairn Road bridge.

Upstream of the junction of Mountain Creek and Four Mile Creek, Mountain Creek has a catchment area of 130 square kilometres. The upper reaches of the catchment have steeper topography and are densely forested, containing areas of the Woomargama State Forest. The remaining sections of the Mountain Creek catchment are predominantly cleared with the upper end of the catchment mainly used for grazing and the lower catchment mainly used for cropping (including wheat, triticale, oats, lupins, barley and canola). The catchment is currently experiencing hydrological stress due to drought conditions.

Stream flow in Mountain Creek generally occurs only after catchment rainfall or when base flow from groundwater is sufficient. At other times, the creek is reduced to a series of disconnected pools. During the site investigation in February 2008, it was noted that Mountain Creek had an incised channel with sandy banks and floor. The creek had ponded water in locations at the time of the inspection, and was slowly flowing in some locations.

The project would also cross Sandy Creek, approximately 800 metres from the northern extent of the project. Sandy Creek flows in a generally northerly direction and is a tributary of Ten Mile Creek (joining the creek downstream of Holbrook). During the field investigations undertaken in May 2009, some flow was observed in Sandy Creek downstream of Spring Valley Road.

The drainage lines and surface water bodies that would be potentially affected by the project are described in Section 3.2 of Technical Paper 3 (Volume 2). The locations are shown in Figure 9-3.



Proposed bypass
Existing highway
Cadastral
Drainage
Woomargama Village
Potentially affected drainage lines
Potentially affected surface water bodies

Figure 9-3 **Locations of potentially affected drainage lines and surface water bodies**

Hydrology and flooding

Mountain Creek has a history of flooding, with significant events being recorded in September 1974, November 1975, August 1981, September 1983, August 1986, August 1990 and February 1991. No flooding events have been recorded since 1994 due to the decommissioning of the stream gauging station (410096). During discussions with local landowners it was identified that Mountain Creek experienced a large flood in 2003. Local landowners indicated that floodwaters are generally contained within the floodplain during flooding events. Hydraulic modelling has confirmed this to also be the case (see Technical Paper 3 (Volume 2) for results).

The existing peak design flows for Mountain and Wilson creeks, and the local catchment inflow to these creeks, were modelled for the 1 in 20 year, 1 in 100 year and 1 in 2000 year ARI events, and the probable maximum flood (PMF) event. These peak design flows represent the critical duration storm event, which is determined to be six hours. The peak design flows are presented in Table 9-10. The existing 1 in 100 year ARI flood depths and approximate flood extents are shown in Figure 9-4.

Table 9-10 Existing peak design flows in the assessment area

Location	Peak design flows (cubic metres per second)			
	1 in 20 year ARI	1 in 100 year ARI	1 in 2000 year ARI	PMF
Mountain Creek (upstream of existing highway)	76	134	493	1675
Wilson Creek (upstream of existing highway)	35	57	175	543
Lateral inflow to Wilson Creek	11	18	47	142
Lateral inflow to Mountain Creek	9	16	58	210

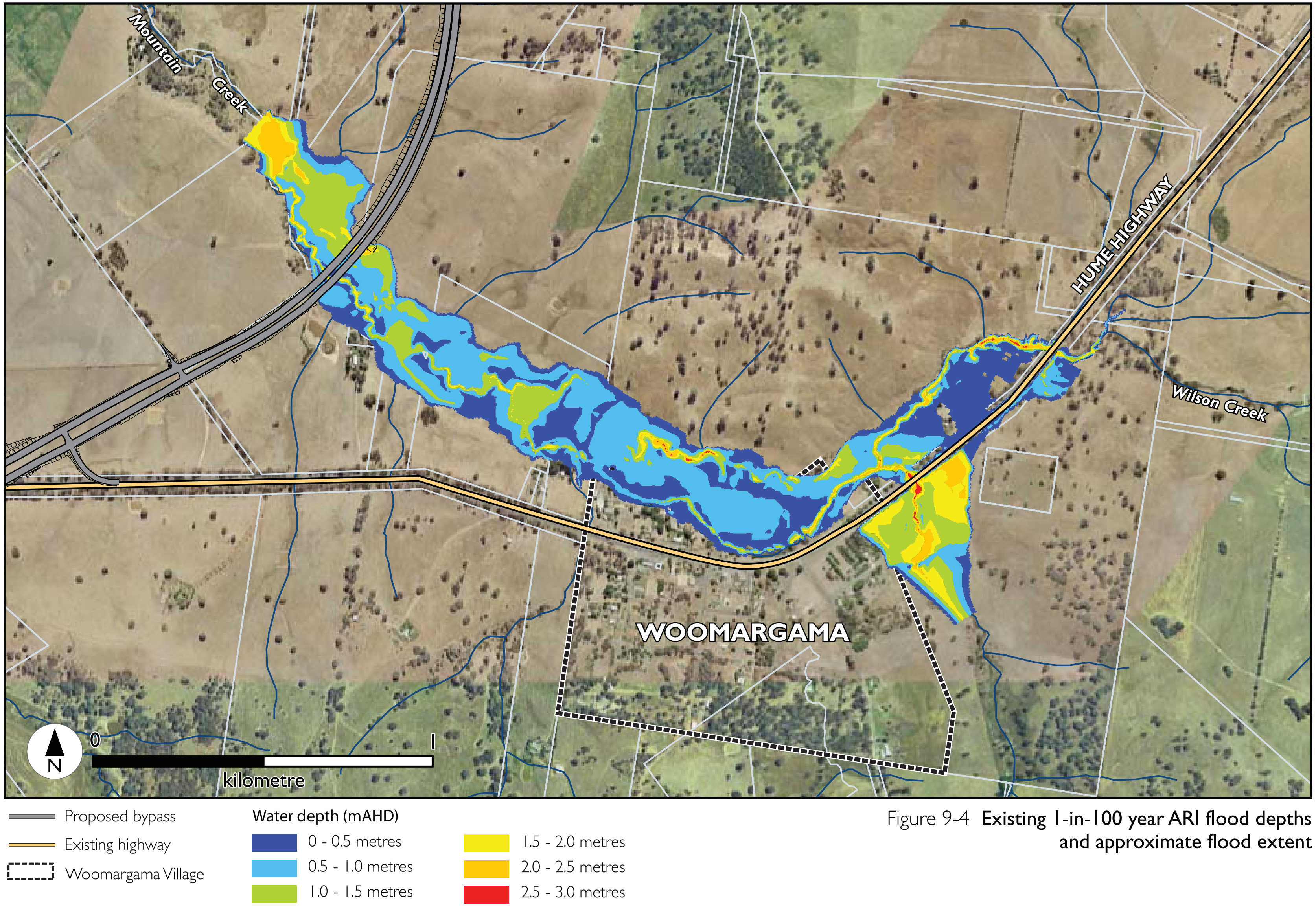


Figure 9-4 **Existing 1-in-100 year ARI flood depths and approximate flood extent**

Surface water use

The access, taking and use of water in the Mountain Creek catchment is managed under the *Water Act 1912*. In relation to water licensing and approvals, the *Water Management Act 2000* only applies where a water sharing plan has commenced. No water sharing plan exists for the Mountain Creek catchment.

The Mountain Creek catchment has a small number of active water users, with three water licences granted within the catchment. Two of these licences are for catchment dams and do not take water directly from the creek. Most water use in the catchment is for domestic and stock purposes. In addition, the catchment supports a large number of unlicensed users, which access water under domestic and stock rights. This includes water use by agribusinesses in the assessment area.

Groundwater

Geology

The project is located within the Wagga-Omeo Zone of the Lachlan Fold Belt, which is mapped on the *Wagga Wagga 1:250,000 Geological Series Sheet SI 55-15* (Adamson and Loudon 1960). The Lachlan Fold Belt is characterised by Ordovician metasediments and Silurian granites, which make up the higher relief areas of the landscape.

Quaternary alluvium has accumulated in lower-lying, major drainage lines and forms flats and floodplains on the valley floors. No major structural features or faults have been identified, however, the trend of faults and fractures is generally north-westerly, and this may reflect major joints, local faults, structural discontinuities or dykes.

Alluvial deposits are mainly present in the creeks and drainage lines. The alluvial deposits comprise sand, silt, gravel and clay. The thickness of alluvium generally ranges from approximately 10 to 20 metres. The alluvial deposits are underlain and surrounded by weathered Ordovician metasediments and Woomargama Granite.

Aquifer characteristics

Two main aquifer systems are present:

- Unconsolidated and unconfined alluvial aquifers: The majority of boreholes are shallow and obtain their supply from groundwater within the alluvial systems. The alluvium generally has a higher permeability than the surrounding fractured rock aquifers. Yields from bores constructed within the alluvial aquifer range from 0.1 to 6.25 litres per second and extend to between three and 30.5 metres below ground level (DWE 2009).
- Semi-confined fractured rock aquifers: The fractured rock aquifers generally produce low and unpredictable groundwater yields, with groundwater quality that is often variable and may be brackish or saline. Yields from bores constructed in the fractured rock, range from one to two litres per second where dense jointing occurs (Baker et al 2001) and are, therefore, typically connected with flow via secondary porosity. Bores constructed in fractured rock aquifers in the area have yields ranging between 0.16 and 2.4 litres per second, with good groundwater quality. Bore depths extend to between 25.9 and 100.1 metres below ground level.

The water table in the locality is generally a muted reflection of the land topography and there is hydraulic connectivity between the two aquifer systems. Under the influence of gravity, groundwater flows from recharge areas located higher up in the landscape toward discharge areas in lower-lying areas of the landscape. Groundwater discharge is likely to be in the lower lying areas of the landscape (springs), at the break of slopes and as base flow to surface water bodies (creeks). Groundwater movement within the two flow systems is from the south-east to the north-west, which is consistent with the local topography.

Groundwater levels

Bore depths and water level measurements were collected at 14 bores in the groundwater study area during the May 2009 field investigation (see Section 5 of Technical Paper 4 (Volume 2)). The results indicate that the groundwater levels within the alluvial aquifer are generally shallower than the fractured rock aquifer. Most bores access the alluvium associated with Mountain Creek and groundwater levels are less than three metres below ground level. One bore is associated with the Sandy Creek alluvium and this has a depth of around 12 metres below ground level.

The groundwater levels within the granite ranged between 3.93 and 22.35 metres below ground level. Water levels were generally shallower in bores installed in weathered granite sediments at lower elevations and deeper in bores located at high elevations in the deeper fractured rock.

In the alluvium, the groundwater flow is towards the west for Mountain Creek and the north for Sandy Creek. It is assumed that groundwater in the fractured rock aquifer follows the surface and general catchment topography, and likely to be towards the north/north-west.

Groundwater use

Most bores in the locality are licensed under Groundwater Management Area 811. The majority of bores are to supply domestic and stock requirements. There are also three boreholes registered and licensed for town water supply for Woomargama and two licensed for irrigation purposes (DWE 2009). The town water supply bores are located next to the existing Hume Highway in Woomargama village, on the up-gradient side of the project.

Four additional unregistered private bores were identified during the field investigation. Two of these were used for stock and domestic purposes and two were no longer in use.

Groundwater use by agribusinesses in the assessment area is generally for domestic and stock purposes.

9.3.3 Potential surface water impacts

Construction

Local catchment impacts

The project would cross several drainage lines, which would have the potential to be temporarily blocked or diverted during the construction of the project. Blocking or diverting drainage lines would have the potential to create areas of flooding or ponding on the upstream side of the project and could prevent flows from reaching downstream in-line farm dams and receiving waters.

Diversion of drainage lines may also create localised areas of flooding downstream of the project. These temporary impacts are expected to be minor and would be managed through the implementation of standard construction techniques.

Management of run-off from the construction site would have the potential to concentrate flows and erode the landscape.

Surface water and flooding impacts

Construction of the project would include site establishment and preparation works, drainage works (culverts, bridges, water quality basins), pavement construction and some ancillary works across the Mountain Creek floodplain. During construction, these works have the potential to affect flooding behaviour and change flood flow distribution as a result of blockage of usual flow paths. This could result in temporary impacts on the adjacent properties but these are likely to be minor. There is also the potential for construction works to be affected by flooding.

Bridges would be constructed across Sandy Creek. No impacts on the flooding behaviour of Sandy Creek as a result of construction of the project are anticipated.

Water supply impacts including for local agribusinesses

Section 6.3.2 discusses the water requirements for the project (approximately 400 megalitres over the two year construction period) and the potential sources of that water, which may include a combination of the following:

- Extraction of water from the Hume Weir.
- Recycled effluent from industry.
- Sediment basins constructed for the project.
- Existing or new on-site and off-site farm dams.

Impacts on the water supply as a result of extraction of water from the groundwater are addressed in Section 9.3.4. Extraction of water from the Hume Weir or pumped effluent from local industrial facilities would have no impact on the water supply for local users or landholders, including agribusinesses.

The Hume Weir has a maximum capacity of 3,038,000 megalitres. The capacity has dropped to as low as one per cent in recent years due to drought conditions, and currently stands at 25 per cent (as at 11 September 2009). Regional industrial facilities are known to be licensed (under the *Protection of the Environment Operations Act 1997*) to discharge up to 20 megalitres of treated effluent to the Murray River per day. Due to the large volumes of available water, the project would have a negligible impact on these resources.

Construction of offline water storages could potentially reduce local run-off that would otherwise flow to existing drainage lines and/or farm dams. This would have little impact to water supply for local users and would be managed through the measures provided in Table 9-12.

Sourcing water from local dams may also impact upon local water users, including agribusinesses. Access to, and the volume of, water to be extracted would only be in agreement with landholders and so impacts are likely to be minor.

There is currently an embargo in place on the granting of new licences for commercial purposes in the Murray-Darling Basin. Water for the project would not be sourced from Mountain Creek.

Operation

Local catchment impacts

Impacts on the local catchment during operation of the project are unlikely as the drainage system would be designed to ensure that distribution of flow is maintained to match the existing flow regime as far as possible. The project would create additional impervious areas that would potentially generate additional run-off. Potential impacts would be mitigated through the longitudinal drainage system for the project and the measures outlined in Section 9.3.5.

Extreme rainfall events due to climate change

'Climate change' refers to future changes in climate that are driven by an increase in heat from the sun, retained in the Earth's atmosphere. There is presently a general consensus amongst climate experts that climate change is occurring and that most of the warming observed over the last 50 years is attributable to human activities that have increased atmospheric concentrations of greenhouse gases (IPCC 2007). In Australia, evidence of climate change has been identified by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (2006) to include increased average temperatures, changes in annual rainfall and increased climate extremes (more intense droughts and extreme rainfall events).

In the Murray catchment (within which this project is located), the future climate is likely to experience increased extreme rainfall events. The CSIRO predicts between a seven per cent reduction and a 29 per cent increase in extreme rainfall (1 in 40 year ARI 1 day rainfall event) in this catchment in 2070 (CSIRO 2007). Further flood modelling assessment of potential climate change impacts would be undertaken, as necessary, during the detailed design, in consultation with DECCW. The project would adopt a factor of safety in the design of drainage structures.

Hydrology and flooding impacts

The concept design seeks to minimise change in afflux. The design objectives for the 1 in 100 year ARI event are as follows:

- Land without buildings or sensitive structures: minimise impacts.
- Land where buildings or sensitive structures are already below the 1 in 100 year ARI flood level: minimise and manage impacts.
- Land where buildings or sensitive structures previously not inundated in the 1 in 100 year ARI event would be at increased risk of inundation: no additional impacts.

Hydraulic modelling indicates that the project would affect the distribution of flow within the Mountain Creek floodplain both upstream and downstream of the proposed bridge by contracting flow through the bridges. As the proposed bridge spans almost the entire existing 1 in 100 year ARI floodplain extent, the impacts to the flow distribution are expected to be minimal. Changes in flow distribution as a result of the project may lead to increased flood levels, changes in flood inundation times and changes in velocity.

The concept design causes some afflux in the adjacent floodplain areas for the 1 in 100 year ARI event. Figure 9-5 shows the 1 in 100 year ARI design event afflux with the project.

It is expected that there would be minimal to no change in flooding duration as a result of the project.

Changes in velocity can lead to scour and/or sedimentation within the waterways and around structures, such as bridge piers and abutments. Scouring at structures can lead to undermining and failure. Sedimentation may lead to a reduction in conveyance area within the waterway or through bridge structures by filling of the channel, raising inverts and vegetation growth which in turn may lead to increases in water levels during flood events. It is expected that there would be slight increases in velocity locally at the proposed bridges over Mountain Creek. Impacts would not be substantial and scour protection would be installed around structures to further minimise impacts. Table 9-11 shows the expected changes in peak velocity at the proposed bridge over Mountain Creek.

Table 9-11 Changes to peak velocities at the proposed bridge due to the project

Location	Event (ARI)	Existing (metres per second)	Proposed (metres per second)	Impact (metres per second)
Existing Hume Highway bridge over Mountain Creek	1 in 20	1.6	1.6	0.0
	1 in 100	2.0	2.0	0.0
	1 in 2000	3.8	3.9	+0.1
Proposed Hume Highway bridge over Mountain Creek	1 in 20	1.4	1.6	+0.2
	1 in 100	1.7	1.8	+0.1
	1 in 2000	1.8	2.0	+0.2

Flood hazard within a floodplain is defined in the *NSW Floodplain Development Manual* (NSW Government 2005) and is based on flood depth, flood velocity and other relevant factors that affect the safety of structures and/or individuals. These other factors include flood warning, flood awareness, flood readiness and evacuation methods.

From a hydraulic perspective, if flood depths are greater than one metre and/or flood velocities are greater than two metres per second then the degree of flood hazard is considered to be high. Velocities presented in Table 9-11 indicate that flood hazard at these locations within Mountain Creek is considered to be high. This is the case under existing and proposed conditions. The flood impact assessment indicates that the project would not significantly increase flood depths or flood velocities, and the project is unlikely to change the flood hazard in the locality.

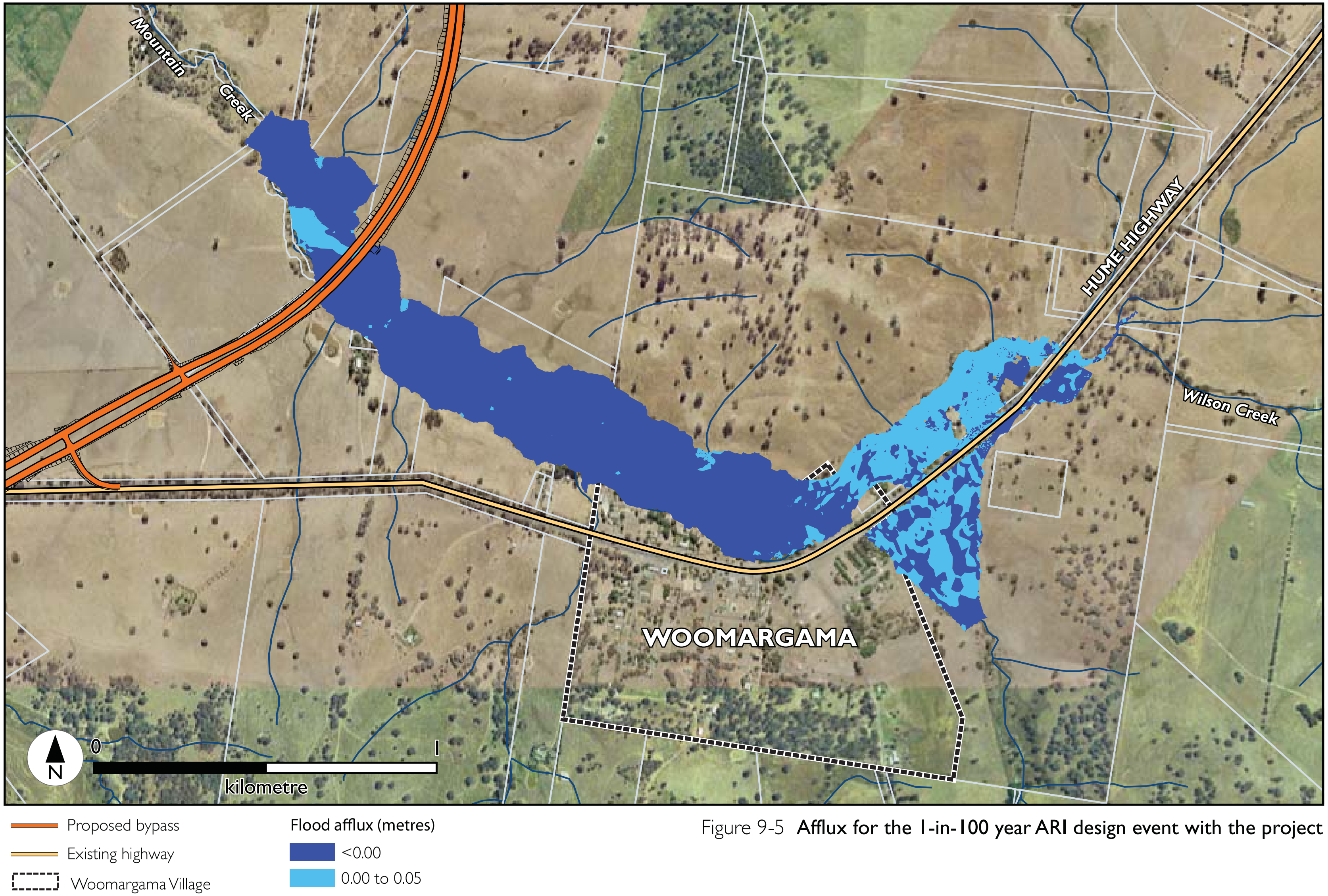


Figure 9-5 **Afflux for the 1-in-100 year ARI design event with the project**

Water supply impacts, including for local agribusinesses

No water would be required for the operation of the project. If new dams developed as part of the project were to remain during operation, these would be within the harvestable rights provisions to ensure minimal impacts on the downstream environment and water users.

During operation there are unlikely to be impacts on water supply for local agribusinesses.

9.3.4 Potential groundwater impacts

Construction

The works associated with the construction of the project would have short-term impacts on ground conditions and, therefore, potentially groundwater flows. Potential impacts would include:

- Potential short-term impact to unconfined alluvial aquifers may result from aquifer compaction caused by construction of controlled fills, structures and other compaction activities. The effects of ground compaction include aquifer compaction, which may result in impediment or prevention of the natural groundwater flow to the north-west. This may cause waterlogging and ponding to the immediate south-east of the construction site, and would also result in the lowering of the watertable to the west and north-west. Compaction is considered a minor issue for the locality.
- Potential short-term impacts from deep cuttings in the fractured rock, which may intersect fractures/springs. This may result in water seepage and any impacts would be managed through groundwater monitoring, if required.
- Three groundwater bores near the project may be removed or impacted and would be replaced as necessary. Any replacement would be in consultation with the relevant landowner. This would also ensure impacts on the operation of local agribusinesses are minimised.

Water supply impacts, including for local agribusinesses

- Section 6.3.2 discusses the water requirements for the project and that groundwater from the Woomargama township is a potential water source of potable water. Approximately five megalitres of groundwater would be purchased from Riverina Water Country Council over the two year construction period for use at the construction site compounds. Riverina Water County Council have a 100 megalitre (annual allocation) groundwater extraction licence, issued under the *Water Act 1912*. The Woomargama township uses approximately 13 megalitres of this allocation annually. Extraction of groundwater may result in some minor local groundwater drawdown. Due to the small volumes being extracted, it is unlikely that either the aquifer integrity or water quality would be affected. Consultation with Riverina Water County Council would continue throughout construction to identify and manage any potential or other impacts of groundwater extraction or local users including agribusiness.

Operation

During operation long-term impacts to groundwater may include:

- Impacts to unconfined alluvial aquifers as a result of aquifer compaction under the project. The potential consequences of long-term aquifer compaction are the same as those described above for construction impacts.

- The bore infrastructure may be upgraded as part of an agreement with Riverina Water County Council to extract water from the Woomargama Township Supply for use during construction.

Impacts on groundwater would be minimised through standard design and construction practice.

9.3.5 Management of surface and ground water impacts

Table 9-12 identifies mitigation and management measures that would be implemented for surface and ground water impacts. Impacts relating to soils and water quality and hazards and risks are detailed in Section 10.2 and 10.5 respectively. These measures have been incorporated into the draft statement of commitments in Chapter 11.

Table 9-12 Surface and ground water mitigation and management measures

Potential impact	Mitigation and management measure
Pre-construction	
Ground compaction inducing changes to shallow aquifer conditions	▪ Consider the impacts of ground compaction on the aquifer conditions through the road design.
Increased extreme rainfall events due to climate change increasing afflux	▪ As necessary, undertake further flood modelling assessment of potential climate change impacts during the detailed design, in consultation with DECCW.
Construction	
Inefficient water use	▪ Implement water efficient work practices, such as water reuse and recycling for road construction and revegetation irrigation.
Interaction with shallow groundwater flows	▪ Develop drainage infrastructure and, as necessary, land management initiatives to manage groundwater seepage during construction.
Flooding caused by blockages to flood flow paths during construction	▪ Maintain major flood flow paths during construction activities. ▪ Locate material stockpiles outside of the 1 in 10 year ARI floodplain. ▪ Use diversion bunds to divert flows around construction works.
Impact on groundwater system	▪ Undertake groundwater monitoring and reporting (to DECCW) during construction if geotechnical investigations determine likely impacts on the aquifer from deep cuttings. If required, implement mitigation measures where levels indicate that the project is potentially having an adverse impact.
Impacts on local water users	▪ Design construction water storage dams to ensure environmental and operational flows reach the downstream environment and water users.
Water extraction boreholes located near proposed alignment	▪ Decommission and relocate boreholes to maintain a reliable water supply for the landowners, if required.
Operation	
Afflux and increased inundation time at sensitive receivers	▪ Manage change in peak flood levels (afflux) in the 1 in 100 year ARI event through detailed design.
Changes in velocity at the proposed bridge over Mountain Creek	▪ Install appropriate scour protection measures around the bridges piers and abutments as required.

Potential impact	Mitigation and management measure
Impacts on local water users	▪ Ensure construction water storage dams that are to be retained for operation are within the harvestable rights provisions to ensure minimal impacts on the downstream environment and water users.
Potential blockages, diversions or erosion of waterways or drainage lines.	▪ Design drainage structures to convey flows under the project. ▪ Implement appropriate scour protection measures at the downstream end of new bridges.
Obstruction of groundwater flow	▪ Install appropriate subsurface drainage infrastructure, for example, blind ditches, in areas identified as having shallow groundwater levels.

9.4 Noise and vibration

A detailed noise and vibration assessment has been undertaken for the project and is presented below. This is supported by *Technical Paper No. 5 — Noise and Vibration* (Volume 2).

DGRs	Where addressed
Noise and vibration (including but not limited to)	
Construction noise and vibration, including construction traffic noise and blasting impacts.	Section 9.4.5 Technical Paper 5 (Volume 2)
Operational road traffic noise impacts, including consideration of local meteorological conditions (as relevant), and any additional reflective noise impacts from proposed noise mitigation barriers.	Section 9.4.4 Technical Paper 5 (Volume 2)
The assessment must take into account the following guidelines as relevant: Environmental Criteria for Road Traffic Noise (EPA 1999), Environmental Noise Management Manual (RTA 2001), Draft New South Wales Construction Noise Guideline (formerly published as chapter 171 of the EPA's Environmental Noise Control Manual), Assessing Vibration: A Technical Guideline (DEC 2006), and Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (ANZECC, 1990).	Sections 9.4.1, 9.4.2, 9.4.3 Technical Paper 5 (Volume 2)

During preparation of this environmental assessment, the Director-General of the Department of Planning issued a DGR clarification relating to the construction noise assessment requirements (see Appendix B for correspondence from the Department of Planning). The Director-General advised that the construction noise assessment is to take into account chapter 171 of the *Environmental Noise Control Manual* (ENCM) (EPA 1994) and not use the *Draft New South Wales Construction Noise Guideline* (DECC 2008c). This is addressed in Section 9.4.3.

9.4.1 Assessment approach

Technical Paper 5 (Volume 2) details the approach taken for the noise and vibration assessment. This involved noise monitoring (see Figure 9-6 for noise monitoring locations) and noise modelling.

The predicted noise levels are based on traffic predictions cited in *Technical Paper 6 — Traffic and Transport* (Volume 2). The traffic and transport assessment predicted that in 2011 between 10pm and 9am approximately 94 per cent of traffic would use the project instead of the existing Hume Highway through Woomargama. Between 7am and 10pm, the predicted number of vehicles using the project would remain consistently high at approximately 91 per cent.

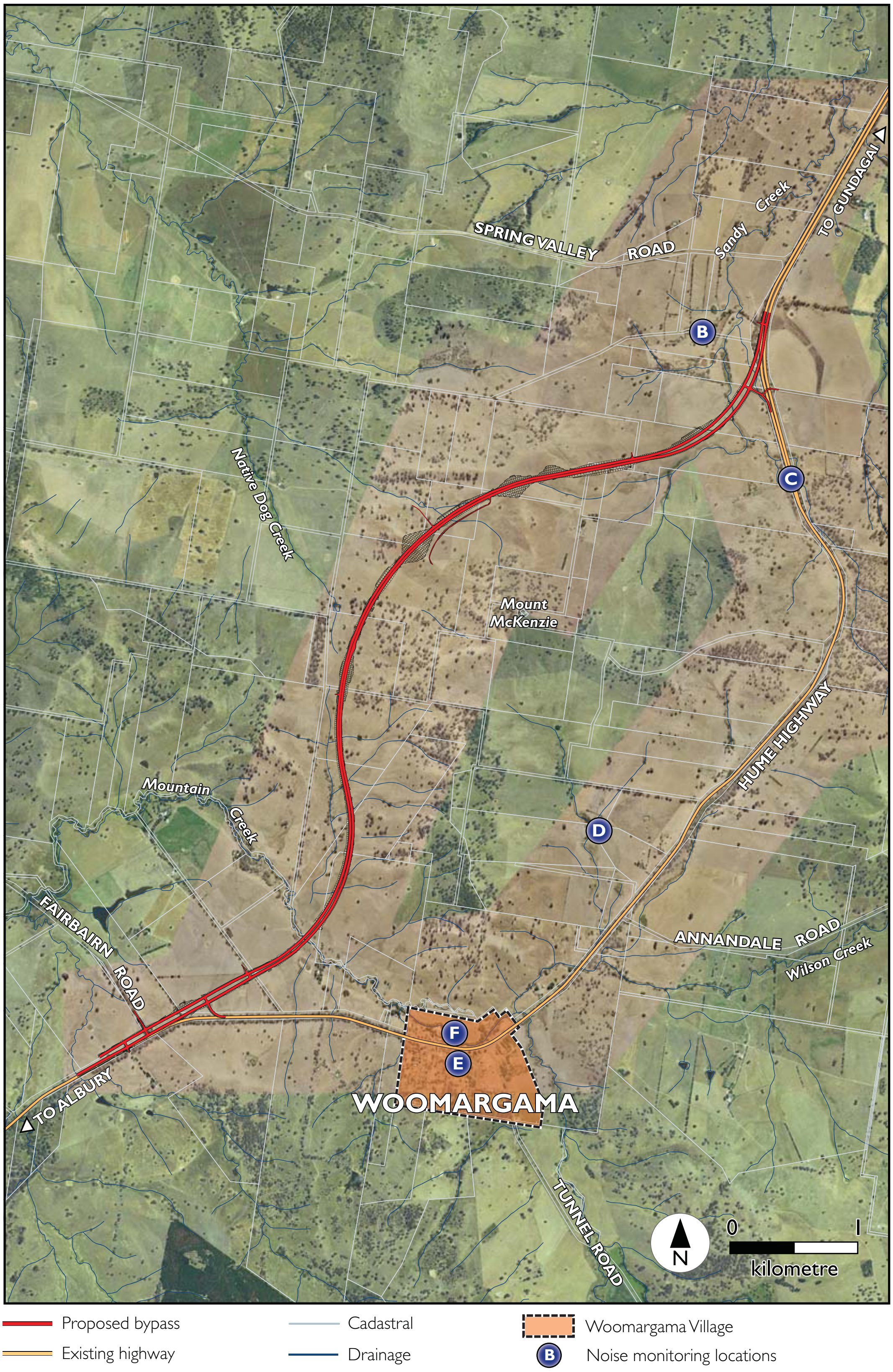


Figure 9-6 **Noise monitoring locations**

9.4.2 *Existing noise environment*

Noise monitoring was conducted to provide background noise levels to set appropriate criteria for the construction noise assessment and to allow validation of the noise model used to determine existing traffic noise levels at receivers.

There are approximately 63 residential receivers potentially exposed to traffic noise from the existing highway and/or the project, including 47 residential receivers in the village and 16 isolated residential receivers. Isolated residential receivers are considered independently. Non-residential, sensitive receivers potentially affected by the project include a community hall used as a childcare centre, a playground and park, and Saint Marks Church. The locations of the noise sensitive receivers are identified in Figure 9-7.

The long-term background noise levels, in terms of rating background level, are provided in Table 9-13. The time periods are as defined in the *NSW Industrial Noise Policy* (EPA 2000).

Table 9-13 Measured background noise levels

Monitoring location	Rating background level (dBA)		
	Daytime (7am to 6pm)	Evening (6pm to 10pm)	Night-time (10pm to 7am)
Isolated receivers			
B	41	45	36
C	38	43	31
D	36	42	31
Woomargama village			
E	38	44	33
F	41	45	38

The *NSW Industrial Noise Policy* recommends that, unless there is a specific cause for evening and night-time levels to be higher than daytime, the lowest rating background level measured throughout a 24 hour period should be used. In this case, the traffic counts in Woomargama show an increase in heavy vehicle traffic during the evening period (see Section 9.6), and the evening rating background levels are higher than those for the daytime and night-time periods. Accordingly, the rating background levels as measured have been used to set construction noise criteria.

L_{Aeq} is the standard descriptor of traffic noise. The measured L_{Aeq} levels over the periods used for assessing traffic noise are given in Table 9-14. The noise environment at all monitoring locations was dominated by traffic from the existing Hume Highway. It was considered that the measured L_{Aeq} represented traffic noise as there were no other significant noise sources.

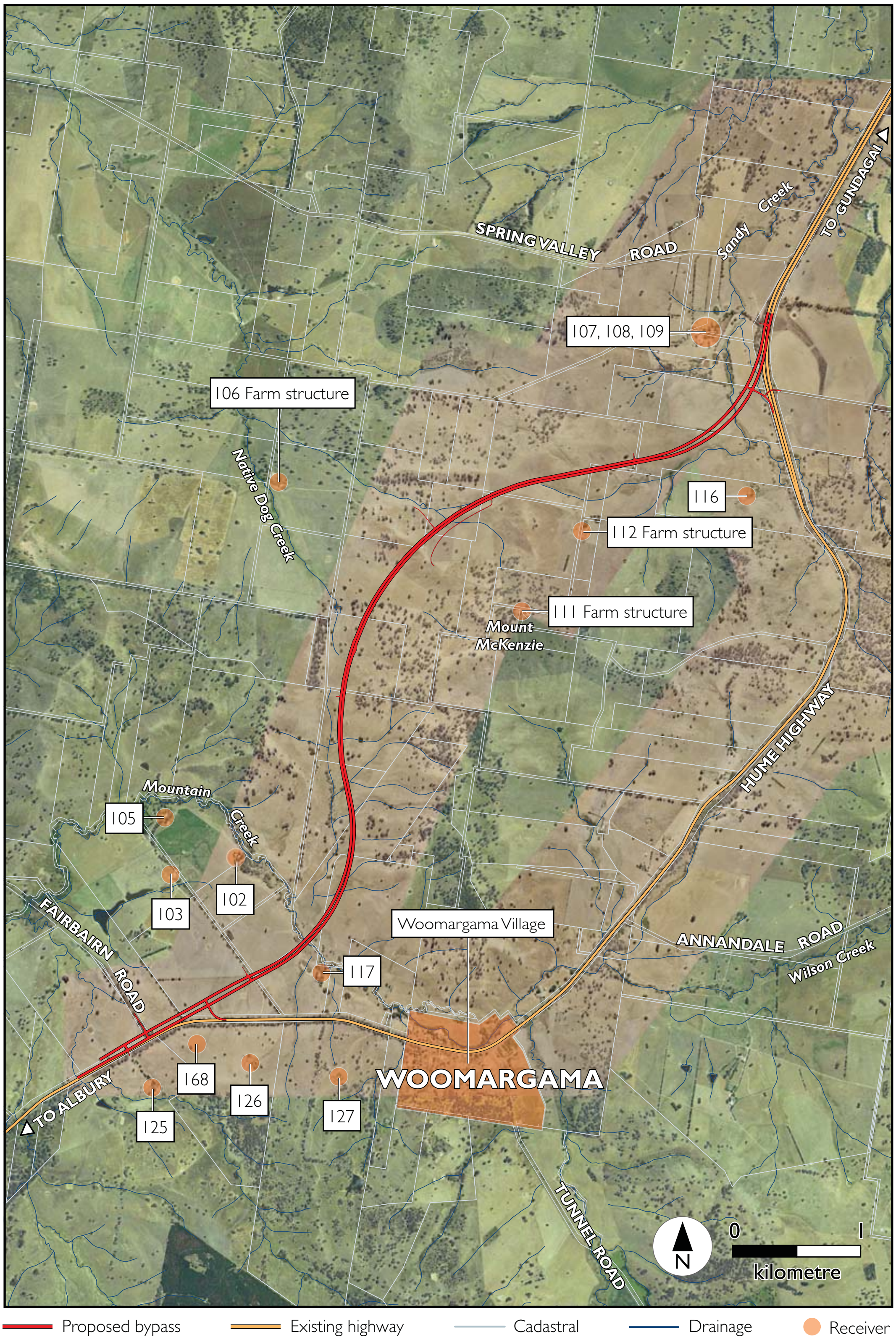


Figure 9-7 **Noise sensitive receivers**

Table 9-14 Measured L_{Aeq} levels

Location	LAeq (dBA)	
	Daytime (7am to 6pm)	Night-time (10pm to 7am)
Isolated receivers		
B	56	57
C	58	58
D	56	57
Woomargama village		
E	53	55
F	65	66

9.4.3 Assessment criteria

Construction noise and vibration

The Environmental Noise Control Manual (ENCM) (EPA 1994) provides construction noise objectives. It is considered that for construction periods longer than 26 weeks, as for this project, the L_{A10} noise level should not exceed the background (L_{A10}) level by more than 5 dBA.

In addition, the ENCM recommends the following time restrictions for the construction activities where noise is audible at residential premises:

- 7am to 6pm Monday to Friday.
- 8am to 1pm Saturday (if audible on residential premises, otherwise 7am to 1pm).
- No work on Sundays and public holidays.

If night-time construction is required for a project, it is recommended that the L_{A10} level should not exceed the existing night-time background (L_{A10}) level by more than 5 dBA.

In addition to those criteria, where any work is conducted during the night-time period 10pm to 7am, the ENCM recommends that, to protect against sleep disturbance, the L_{A1} noise levels should not exceed the background level by more than 15 dBA at any sensitive receiver. While there are no specific criteria relating to sleep disturbance in the NSW Government's *Environmental Criteria for Road Traffic Noise* (ECRTN) (EPA 1999), the document advises that maximum internal noise levels below 50 to 55 dBA are unlikely to cause awakening reactions.

Section 6.5 identifies that the majority of construction activities would take place between 6am and 7pm Monday to Friday and 7am and 4pm Saturday. The proposed working hours between 6am and 7am, and 6pm and 7pm are outside the standard construction hours in the ENCM. Background noise level surveys (provided in Appendix E of Technical Paper 5 (Volume 2)) indicate that noise levels in period between 6pm and 7pm are very similar to the daytime background levels. Hence, the criterion for L_{A10} construction in the 6pm to 7pm periods has been included with the daytime criterion. The background noise level surveys (provided in Appendix E of Technical Paper 5 (Volume 2)) indicate that noise levels in period between 6am and 7am are different to the daytime background levels and, therefore, this period is covered by an 'early morning' criterion.

Sleep disturbance criteria have been determined for the early morning and night-time periods. Table 9-15 shows the project-specific construction noise criteria for sensitive receivers in the village and isolated receivers. The latter criteria are based on the minimum level measured at any of the sensitive receivers.

Table 9-15 Project-specific construction noise criteria

Receiver location	L_{Aeq} construction noise criteria (dBA)				Sleep disturbance (L_{A1} (dBA))	
	Early morning (6am to 7am)	Daytime (7am to 7pm)[1]	Evening (7pm to 10pm)	Night-time (10pm to 6am)	Early morning (6am to 7am)	Night-time (10pm to 6am)
Woomargama village[2]	45	43	49	38	55	48
Isolated receivers[3]	45	41	47	36	55	46

Notes: 1. Includes early evening 6pm to 7pm.

2. Includes receivers 115, 118 to 124, 128 to160, 162 to 167.

3. Includes receivers 102 to109, 113, 114, 116, 117, 125-127, 161, 168.

Blasting

For assessment of annoyance due to blasting, the *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (ANZECC 1990) sets out the following criteria for any sensitive receiver:

- The maximum overpressure due to blasting should not exceed 115 dBA for more than five per cent of blasts in any year and should not exceed 120 dBA for any blast.
- The maximum peak particle ground velocity should not exceed five millimetres per second for more than five per cent of blasts in any year and should not exceed 10 millimetres per second for any blast.

At sufficiently high levels, blast overpressure may in itself cause structural damage to some building elements, such as windows. However, this occurs at peak overpressure levels of about 133 dB and above, which is well in excess of the criteria for annoyance.

Vibration

Chapter 18 of Technical Paper 5 (Volume 2) identifies the vibration criteria for blasting activities, which are established in accordance with Australian Standard *AS2187.2-1993 Explosives — Storage, Transport and Use*. Section 17.1 of Technical Paper 5 (Volume 2) identifies vibration criteria for construction activities (excluding blasting), which are established in accordance with the DECC's *Assessing Vibration: A Technical Guideline* (DEC 2006).

In regard to potential building damage, the recommended vibration level for dwellings ranges from 5.0 to 20.0 millimetres per second.

Operational traffic noise

Criteria for assessment of road traffic noise are set out in the ECRTN. The RTA has also published the *Environmental Noise Management Manual* (ENMM) (RTA 2001) to assist in implementing the ECRTN.

The ECRTN classifies various road developments depending on the type of road and nature of the development. Practice note (i) of the ENMM describes when each of these classifications applies. The project is considered a 'new freeway or arterial road corridor' ('new road') except for approximately one kilometre at the southern end of the project, where it is considered a 'redevelopment of existing freeway/arterial road' ('redevelopment') for two receivers (125 and

168). Table 9-16 lists the relevant ECRTN daytime and night-time criteria for different receiver types.

Table 9-16 Operational road traffic noise criteria for residential receivers

Location	Daytime criterion (7am to 10pm)	Night-time criterion (10pm to 7am)	Where criteria are already exceeded
Residential receivers			
'New road'	55 ($L_{Aeq,15hr}$)	50 ($L_{Aeq,9hr}$)	The new road should be designed so as not to increase existing noise levels by more than 0.5 dB.
'Redevelopment' (receivers 125 and 168 and receivers 107, 108 and 109 for façades facing the existing highway)	60 ($L_{Aeq,15hr}$)	55 ($L_{Aeq,9hr}$)	In all cases, the redevelopment should be designed so as to not increase existing noise levels by more than 2 dB. Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In many instances, this may be achievable only through long term strategies.
Non-residential receivers			
Place of worship	40 ($L_{Aeq,1hr}$) — Internal while place is in use	40 ($L_{Aeq,1hr}$) — Internal while place is in use	-
Community hall including childcare	45 ($L_{Aeq,1hr}$) — Internal at any time	45 ($L_{Aeq,1hr}$) — Internal at any time	-
Playground and park	55 ($L_{Aeq,1hr}$)	-	-

The ECRTN guidelines require consideration of combined noise (from the existing highway and project) against the base criteria. Where these criteria cannot be met, reasonable and feasible mitigation should be considered. Practice Note (iv) of the ENMM provides discussion of where additional controls would be 'reasonable and feasible'.

For road upgrades, the ECRTN and ENMM provide guidance on the likelihood of sleep disturbance. This is discussed in Section 15.1 of Technical Paper 5 (Volume 2). The ENMM suggests that the nominated noise levels and guidelines should be taken in consideration when determining noise mitigation measures to address general road traffic noise.

The quoted noise levels (of 50 to 55 dBA internal noise) are not intended as specific criteria for the purpose of implementing mitigation measures, but to highlight the potential for awakening reactions and the consideration of this in the design of those mitigation measures, where this is considered to be necessary to reduce overall noise levels.

Acute noise levels

Noise levels above $L_{Aeq,9hr}$ 60 dBA or $L_{Aeq,15hr}$ 65 dBA are considered 'acute' and would be considered for noise mitigation as part of the project, even if noise from the project complies with the allowance criterion.

9.4.4 Operational road traffic noise impacts

Predicted operational road traffic noise

Residential receivers in Woomargama village

Most of the residential receivers in Woomargama currently experience noise from the existing highway above the ECRTN criteria for new roads. If the project is built all residential receivers are predicted to experience a reduction in noise level as traffic moves from the existing highway to the project. A reduction in noise levels, in the order of 10 dBA, is predicted.

Some traffic would, however, still pass along the existing highway. Based on the project proceeding, those receivers located closest to the existing highway are predicted to experience traffic noise levels of around $L_{Aeq,9hr}$ 55 dBA, in the year 2021. The noise level at most receivers in the village, however, would be below 50 dBA.

As the project is predicted to significantly reduce noise levels, and no receiver would experience acute noise levels, no operational noise mitigation is required for receivers in the village.

Isolated residential receivers

The predicted noise levels at isolated residential receivers at the façade facing the project are shown in Table 9-17. At the existing highway façade most receivers (with the exception of receivers 107, 108, 109) would experience a decrease in noise level of approximately 10 dBA with the project (refer Table 12-1 Technical Paper 5 (Volume 2)). Table 9-18 shows the predicted noise levels at isolated receivers 107, 108 and 109 at the façade facing the existing highway.

Table 9-17 Predicted night-time noise levels, $L_{Aeq,9hr}$ at isolated residential receivers at the façade facing the project

Receiver[1]	Criterion $L_{Aeq,9hr}$ (dBA)	Predicted night-time noise level $L_{Aeq,9hr}$ (dBA)[2]		
		Highway 2011 (no project)	Combined project and existing highway 2011	Combined project and existing highway 2021
New Road				
107	50	52	54	55
108	50	50	53	54
109	50	49	51	52
116	50	50	52	53
102	50	44	48	49
103	50	43	47	48
105	50	41	44	45
117	50	46	55	56
126	50	54	52	53
127	50	54	49	50
Redevelopment				
125	55	52	53	54
168	55	55	53	54

Notes: 1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.
2. ***Bold italic*** numbers indicate an exceedance of the 50 dBA night-time noise criterion for 'new road'. There are no exceedances of the 55 dBA night-time noise criterion for 'redevelopment'.

Table 9-17 shows that the combined noise from the project and existing Hume Highway in 2021 is predicted to exceed the night-time criteria at six isolated residential receivers (107, 108, 109, 116, 117 and 126).

Table 9-18 Predicted night-time noise levels, $L_{Aeq,9hr}$ at isolated residential receivers at the façade facing the existing highway

Receiver[1]	Criterion $L_{Aeq,9hr}$ (dBA)	Predicted night-time noise level $L_{Aeq,9hr}$ (dBA)		
		Highway 2011 (no project)	Combined project and existing highway 2011	Combined project and existing highway 2021
Redevelopment				
107	55	52	54	55
108	55	50	53	54
109	55	49	51	52

Note: 1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.

Table 9-18 shows that the combined noise from the project and the existing Hume Highway is not predicted to exceed the night-time criteria for these receivers.

Non-residential receivers

Noise levels at non-residential receivers are provided in Table 9-19. The noise level is the $L_{Aeq,1hr}$ during the busiest hour of use.

For some receivers, the criterion is based on internal noise. For most buildings, if the windows are open the internal noise level is approximately 10 dBA less than the external noise level. Hence, for buildings with predicted external noise levels of more than 10 dBA above the internal noise criterion, an exceedance is noted.

Table 9-19 Predicted noise levels at non-residential receivers

Receiver[1]	Predicted external noise levels $L_{Aeq,1hr}$ (dBA)			Criterion $L_{Aeq,1hr}$ (dBA)	Comment (combined noise)	Change from existing
	Highway 2011 (no project)	Combined project and existing highway 2021	Estimated internal noise level with windows open 2021 (combined noise)			
Saint Marks Church (receiver 169)	64	54	44	40 (internal)	Exceeds	Decrease
Community hall and childcare (receiver 139)	63	53	43	45 (internal)	Complies	Decrease
Playground and park (between receiver 139 and the road)	59-66	49-55	-	55 (external)	Complies	Decrease

Note: 1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.

Impact on maximum noise levels

Section 15.2 of Technical Paper 5 (Volume 2) estimates maximum noise levels from the existing highway. The results show that the levels exceed the threshold at residential receivers and isolated residential receivers. As the existing Hume Highway will continue to be used after opening of the project, the analysis would change only by the number of vehicles using the existing highway. This means that for most receivers there would be only few exceedances of the threshold in any hour.

In general, the maximum noise levels from the project would be much lower in Woomargama village, but would increase at isolated residential receivers in close proximity to the project.

Meteorological effects

Neither the ECRTN nor the ENMM discuss assessment of traffic noise under changing meteorological conditions. Following advice from DECC (now DECCW), the *NSW Industrial Noise Policy* (EPA 2000) has been used to undertake a qualitative assessment of meteorological effects.

The *NSW Industrial Noise Policy* discusses the effect of temperature inversions and wind, which can both enhance noise propagation from a source to a receiver. The *Industrial Noise Policy* discusses that, for the best confidence in an assessment of meteorological effects on noise, meteorological data for the study area is required. In this case, meteorological data for Woomargama was unavailable. In such cases, the default conditions are the temperature inversions of three degrees per 100 metres in combination with a drainage wind of two metres per second from source to receiver, where the receiver is below the noise source. In this case, the receivers are typically above the height of the project, hence the drainage wind has not been considered.

Limited data are available to accurately predict traffic noise under different meteorological conditions. The following procedure was used to estimate the effect of these conditions for the project.

Noise propagation from the project was predicted using the RTA environmental noise model. A line source (to simulate the flow of traffic) representing the project was used and noise was predicted at all receivers under various meteorological conditions. The model resulted in the prediction of the noise level at any receiver from the project under isothermal still conditions and under a temperature inversion of three degrees per 100 metres. The difference in these two levels is typically 1 to 4 dBA, depending on the location of the receiver with respect to the highway. This difference was then added to the predicted traffic noise level.

The analysis shows that the temperature inversion increases noise levels by up to 3 dBA at any receiver. This increase in noise level exists only for the time of the temperature inversion. The *NSW Industrial Noise Policy* suggests that temperature inversions are most likely to occur during the hour immediately before and after sunrise. So while there may be a significant increase in noise level during those times (up to 3 dBA), the effect over the entire nine hour period of night-time is an increase in $L_{Aeq,9hr}$ of only 1 dBA at most receivers. Temperature inversion is not likely to be a significant contributor of increased operational noise from the project.

With respect to wind, there would be a similar increase in noise level if there was a continuous low velocity wind blowing toward a receiver. There is no meteorological data to suggest that these wind patterns exist around Woomargama. Wind is not likely to be a significant contributor of increased operational noise from the project.

9.4.5 Construction noise and vibration impacts

Construction noise and vibration sources

Table 6-3 identifies the construction activities that are proposed to occur during the daytime, evening and night-time periods. Sources of construction noise and vibration during these activities would comprise a range of heavy plant and equipment and hand tools. These sources, and their typical sound power levels, are listed in Table 16-4 of Technical Paper 5 (Volume 2).

Based on the typical sound power levels, noise level predictions have been undertaken for the construction activities outlined in Table 6-3. These predictions are provided in Table 9-20.

Table 9-20 Predicted sound power level of construction activities

Activity	Typical equipment used	Total L_{Aeq} sound power level (dBA)[1]
Site establishment	Excavators, chainsaws, mulching plant and chipper, cranes, generators.	111
Removal of vegetation	25-tonne excavator, mulcher, chainsaw, trucks, grader, combination backhoe FEL, bulldozer.	113
Earthworks	Road trucks, compactor, grader, steel, multi-tyred and vibratory rollers, concrete pour (including trucks and concrete vibrator), asphalt paving plant, backhoe, sweeper, compressors, generators, (excavator with hammer), scrapers, water carts.	114 (120)
Piling	Bored or driven piling rigs, pumps and generators.	115 (bored) – 120 (driven)
Bridge works	Piling rigs, cranes, hand tools, compressors, generators.	115–120 (possible when piling)
Paving	Road trucks, compactor, (jackhammers), steel, multi-tyred and vibratory rollers, concrete pour (including trucks and concrete vibrator), asphalt paving plant, backhoe, (concrete saw), profiler, sweeper, compressors, generators.	113 (116)
Landscaping of exposed areas	Excavator/bobcat, powered hand tools, air compressor, spoil, material or concrete truck, jackhammer (for concrete embedded parts).	111

Note: 1. The sound power level in brackets ( ) is for the occasional use of rock breakers, jackhammers and concrete saws.

Table 9-21 provides estimated vibration levels at a range of distances from various construction activities.

Table 9-21 Typical vibration emission levels from construction plant

Activity	PPV vibration level (millimetres per second)		
	10 metres	20 metres	30 metres
Concrete sawing	0.5	0.3	0.2
Four-tonne vibratory roller (high)	2.0 to 2.4	0.4 to 1.2	0.2 to 0.8
Hydraulic hammer (30 tonne)	3	1.5	1.0

Concrete batch plants

Section 6.6 identifies that up to three concrete batch plants are likely to be required for construction of the project (refer to Figure 6-3 for locations). Noise generating plant and activities associated with the concrete batch plants would include:

- Conveyor drive.
- Front-end loaders.
- Concrete batching, including concrete trucks.
- Trucks unloading into hopper.
- Cement bulk tanker unloading.

The typical overall sound power level of each concrete batch plant during full operation would be approximately 117 dBA ($L_{A10,15min}$). For the possibility of deliveries outside daytime working hours, the estimated source level is $L_{A10,15min}$ 115 dBA — the equivalent of one truck and one front-end loader.

Construction noise impacts

The noise level experienced at any receiver along the project would depend on many factors, such as distance to the construction site, topographic shielding between the site and the receivers, and the activity occurring at the construction site. The quietest activities, such as site preparation, would be up to 20 dBA quieter than the noisiest activities, such as earthworks using rock breakers. Furthermore, noise levels would be quieter whenever the construction takes place in a cut compared with that undertaken on fill. The length of the project and the transient nature of the construction activities could also alter noise levels experienced at individual receivers.

General construction activities

Table 9-22 shows the predicted noise levels of construction activities at sensitive receivers (or groups of receivers — 'village close' and 'village far') during the early morning and daytime periods (6am to 7am and 7am to 7pm, respectively). As mentioned in Section 9.4.3, because the background noise levels between 6pm and 7pm are similar to those experienced between 7am and 6pm, the daytime period includes working hours from 6pm to 7pm.

Table 9-22 Predicted noise levels from construction activities — early morning (6am to 7am) and daytime (7am to 7pm)

Receiver[1]	Criteria (L_{A10} (dBA))		Predicted noise levels (L_{A10} (dBA))[2]				
	Early morning (6am to 7am)	Daytime (7am to 7pm)	Site preparation	Earthworks	Piling	Bridge structures	Paving
102	45	41	39(*45*)	42(48)	43(49)	38(*44*)	41(*47*)
103	45	41	37(*43*)	40(*46*)	41(*47*)	36(*42*)	39(*45*)
105	45	41	34(40)	37(43)	38(44)	33(39)	36(*42*)
109	45	41	41(47)	44(50)	50(53)	45(48)	43(49)
113	45	41	10(16)	13(19)	19(25)	14(20)	12(18)
116	45	41	42(48)	45(51)	55(57)	50(52)	44(50)
117	45	41	48(54)	51(57)	63(64)	58(59)	50(56)
125	45	41	46(52)	49(55)	50(52)	45(47)	48(54)
168	45	41	47(53)	50(56)	51(54)	48(49)	49(55)
126	45	41	42(48)	45(51)	53(54)	48(49)	44(50)

Receiver[1]	Criteria (L_{A10} (dBA))		Predicted noise levels (L_{A10} (dBA))[2]				
	Early morning (6am to 7am)	Daytime (7am to 7pm)	Site preparation	Earthworks	Piling	Bridge structures	Paving
127	45	41	38(***44***)	41(***47***)	53(54)	48(49)	40(46)
121 village close[3]	45	43	31(37)	34(40)	35(41)	30(36)	33(39)
135 village far[4]	45	43	29(35)	32(38)	33(39)	28(34)	31(37)

Notes: 1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.

2. First number represents typical predicted noise level; number in brackets ( ) represents maximum predicted noise level; noise levels underlined indicate exceedances of the established criterion for the early morning 6am to 7am period; noise levels in ***bold italic*** text indicate exceedances of established criterion for the daytime 7am to 7pm period.

3. This includes receivers 118 to 122.

4. This includes receivers 115, 123, 124, 128 to 160, 162 to 167.

Table 9-22 shows that exceedances of the early morning and daytime criteria are predicted at most isolated receivers for most activities. No exceedances of the early morning or daytime criteria are predicted at the receivers in the village.

As described in Section 6.5, some construction activities would be required to take place in the evening and night-time periods. Tables 9-23 and 9-24 show the predicted noise levels of concrete paving and sawcutting at sensitive receivers (or groups of receivers — 'village close' and 'village far') during the evening (7pm to 10pm) and night-time (10pm to 6am), respectively.

Table 9-23 Predicted noise levels from construction activities — evening (7pm to 10pm)

Receiver [1]	Evening criterion (L_{A10} (dBA))	Predicted noise level (L_{A10} (dBA))[2]	
		Paving	Sawcutting
102	47	41(47)	44(50)
103	47	39(45)	42(48)
105	47	36(42)	39(45)
109	47	43(*49*)	46(52)
113	47	12(18)	15(21)
116	47	44(*50*)	47(53)
117	47	50(56)	53(59)
125	47	48(54)	51(57)
168	47	49(55)	52(58)
126	47	44(*50*)	47(53)
127	47	40(46)	43(49)
121 village close[3]	49	33(39)	36(42)
135 village far[4]	49	31(37)	34(40)

Notes: 1. Refer to Appendix C Technical Paper 5 (Volume 2) for receiver locations.

2. First number represents typical predicted noise level; number in brackets ( ) represents maximum predicted noise level; noise levels in ***bold italic*** text indicate exceedances of the established criterion for evening 7pm to 10pm period.

3. This includes receivers 118 to 122.

4. This includes receivers 115, 123, 124, 128 to 160, 162 to 167.

Table 9-23 shows that exceedances of the evening criterion are predicted at most isolated receivers for paving and sawcutting. No exceedances of the evening criterion are predicted at the receivers in the village.

Table 9-24 Predicted noise levels from construction activities — night-time (10pm to 6am)

Receiver [1]	Night-time criterion (L_{A10} (dBA))	Predicted noise level (L_{A10} (dBA))[2]	
		Paving	Sawcutting
102	36	41(47)	44 (50)
103	36	39(45)	42 (48)
105	36	36(42)	39 (45)
109	36	43(49)	46 (52)
113	36	12(18)	15 (21)
116	36	44(50)	47 (53)
117	36	50(56)	53 (59)
125	36	48(54)	51 (57)
168	36	49(55)	52 (58)
126	36	44(50)	47 (53)
127	36	40(46)	43 (49)
121 village close[3]	38	33(39)	36 ***(42)***
135 village far[4]	38	31(37)	33 ***(40)***

Notes: 1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.

2. First number represents typical predicted noise level; number in brackets ( ) represents maximum predicted noise level; noise levels in ***bold italic*** text exceedances of the established criterion for night-time 10pm to 6am period.

3. This includes receivers 118 to 122.

4. This includes receivers 115, 123, 124, 128 to160, 162 to 167.

Table 9-24 shows that exceedances of the night-time criteria are predicted at most isolated receivers for paving and sawcutting. Exceedances of the night-time criteria are predicted at the receivers in the village for maximum predicted noise levels for paving and saw cutting.

Table 9-25 shows the predicted sleep disturbance noise levels from concrete paving and sawcutting at sensitive receivers (or groups of receivers — 'village close' and 'village far') during the night-time (10pm to 6am) and early morning (6am to 7am).

Table 9-25 Predicted noise levels from construction activities — sleep disturbance — night-time (10pm to 6am) and early morning (6am to 7am)

Receiver [1]	Criteria (L_{A10} (dBA))		Predicted noise level (L_{A10} (dBA))[2]
	Night-time (10pm to 6am)	Early morning (6am to 7am)	Paving and sawcutting
102	46	55	46 <u>(52)</u>
103	46	55	44 <u>(50)</u>
105	46	55	41(<u>47</u>)
109	46	55	48 (54)
113	46	55	17 (23)

Receiver [1]	Criteria (L_{A10} (dBA))		Predicted noise level (L_{A10} (dBA))[2]
	Night-time (10pm to 6am)	Early morning (6am to 7am)	Paving and sawcutting
116	46	55	49 (55)
117	46	55	55 (61)
125	46	55	53 (59)
168	46	55	54 (60)
126	46	55	49 (55)
127	46	55	45 (51)
121 village close[3]	48	55	38 (44)
135 village far[4]	48	55	36 (42)

Notes: 1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.

2. First number represents typical predicted noise level; number in brackets ( ) represents maximum predicted noise level; noise levels underlined indicate exceedances of the established criterion for the night-time 10pm to 6am period; noise levels in ***bold italic*** text indicate exceedances of established criterion for the early 6am to 7am period.

3. This includes receivers 118 to 122.

4. This includes receivers 115, 123, 124, 128 to160, 162 to 167.

5. Noise levels (L_{A10}) from paving and sawcutting are predicted to be the same.

Table 9-25 shows that exceedances of the sleep disturbance criteria during the night time period are predicted at most isolated receivers for paving and saw cutting. Exceedances of the sleep disturbance criteria during the early morning period are predicted at three isolated receivers for paving and saw cutting. No exceedance of the night-time or early morning sleep disturbance criteria are predicted at the receivers in the village.

Concrete batch plants

There will be up to three new batch plants for the project (refer Section 6.6). As outlined in Section 6.5.3, batch plant operation and deliveries may be required during the evening, night-time and early morning periods. As the final layouts of the batch plants would be determined during detailed design, a range of noise levels have been predicted based on the likely layouts and distances from receivers to the batch plants. The likely distances are shown in Table 9-26.

Predicted noise levels during the early morning and daytime periods from the new batch plants are provided in Table 9-26.

Table 9-26 Predicted noise levels from batch plants — early morning (6am to 7am) and daytime (7am to 7pm)

Receiver[1]	Distance from receiver to batch plant (metres)	Criteria (L_{A10} (dBA))		Batch plant operation (L_{A10} (dBA)) [2]
		Early morning (6am to 7am)	Daytime (7am to 7pm)	
Northern batch plant				
109	800–1000	45	41	42-45
116	100–400	45	41	50-68
Central batch plant				
All receivers	>2000	45	41	<35

Receiver[1]	Distance from receiver to batch plant (metres)	Criteria (L_{A10} (dBA))		Batch plant operation (L_{A10} (dBA)) [2]
		Early morning (6am to 7am)	Daytime (7am to 7pm)	
Southern batch plant				
117	100–500	45	41	52-68
102, 103	>1000	45	41	<45
126	500–800	45	41	49-52
127	500–800	45	41	49-52
121 village close[3]	800–1000	45	43	<45
135 village far[4]	>1300	45	43	<45

Notes:
1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.
2: Noise levels underlined indicate exceedances of the established criterion for the early morning 6am to 7am period; noise levels in ***bold italic*** text indicate exceedances of established criterion for the daytime 7am to 7pm period.
3. This includes receivers 118 to 122.
4. This includes receivers 115, 123, 124, 128 to160, 162 to 167.

Table 9-26 shows that exceedances of the early morning criteria are predicted at one isolated receiver from the northern batch plant and most isolated receivers from the southern batch plant. Exceedances of the daytime criteria are predicted at all isolated receivers from the northern and southern batch plant operations. No exceedances of the early morning and daytime criteria are predicted from the central batch plant. Exceedances of the daytime criterion are predicted at some receivers in the village from the southern batch plant operations.

Table 9-27 shows the predicted noise levels during the evening from the new batch plants (operation and deliveries).

Table 9-27 Predicted noise levels from batch plants — evening (7pm to 10pm)

Receiver[1]	Evening criterion (L_{A10} (dBA))	Predicted noise level (L_{A10} (dBA)) [2]	
		Operation	Deliveries
Northern batch plant			
109	47	42-45	38-41
116	47	50-68	46-64
Central batch plant			
All receivers	47	<35	<35
Southern batch plant			
117	47	52-68	48-66
102, 103	47	<45	35-42
126	47	49-52	45-*50*
127	47	49-52	45-*50*
121 village close[3]	49	<45	<41
135 village far[4]	49	<45	<36

Notes:
1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.
2: Noise levels in ***bold italic*** text indicate exceedances of established evening criterion.
3. This includes receivers 118 to 122.
4. This includes receivers 115, 123, 124, 128 to160, 162 to 167.

Table 9-27 shows that exceedances of the evening criterion are predicted at one isolated receiver from the northern batch plant operations or deliveries and three isolated receivers from the southern batch plant operations or deliveries. No exceedances of the evening criterion are predicted from the central batch plant operations or deliveries. No exceedances of the evening criterion are predicted at receivers in the village.

Table 9-28 shows the predicted noise levels during the night-time from the new batch plants (operation and deliveries).

Table 9-28 Predicted noise levels from batch plants — night-time (10pm to 6am)

Receiver[1]	Night-time criterion (L_{A10} (dBA))	Predicted noise level (L_{A10} (dBA)) [2]	
		Operation	Deliveries
Northern batch plant			
109	36	42-45	38-41
116	36	50-68	46-64
Central batch plant			
All receivers	36	<35	<35
Southern batch plant			
117	36	52-68	48-66
102, 103	36	<45	35-42
126	36	49-52	45-50
127	36	49-52	45-50
121 village close[3]	38	<45	<41
135 village far[4]	38	<45	<36

Notes: 1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.

2: Noise levels in ***bold italic*** text indicate exceedances of established night-time criterion.

3. This includes receivers 118 to 122.

4. This includes receivers 115, 123, 124, 128 to160, 162 to 167.

Table 9-28 shows that exceedances of the night-time criterion are predicted at all isolated receivers from the northern and southern batch plant operations or deliveries. No exceedances of the night-time criterion are predicted from the central batch plant operations or deliveries. Exceedances of the night-time criterion are predicted at some receivers in the village from the southern batch plant operations or deliveries.

Table 9-29 shows the predicted L_{A1} noise level for sleep disturbance from the new batch plant (operations and deliveries).

Table 9-29 Predicted noise levels from batch plants — sleep disturbance — night-time (10pm to 6am) and early morning (6am to 7am)

Receiver[1]	Sleep disturbance criteria (L_{A1} (dBA))		Predicted noise level (L_{A1} (dBA)) [2]	
	Night-time (10pm to 6am)	Early morning (6am to 7am)	Operation	Deliveries
Northern batch plant				
109	48	55	45-48	42-46
116	48	55	53-***71***	51-***69***
Central batch plant				
All receivers	48	55	<38	<38
Southern batch plant				
117	48	55	55-71	52-***71***
102, 103	48	55	<48	40-47
126	48	55	52-55	50-55
127	48	55	52-55	50-55
121 village close[3]	46	55	<48	<46
135 village far[4]	46	55	<48	<41

Notes: 1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.

2: Noise levels underlined indicate exceedances of the established criterion for the night-time 10pm to 6am period; noise levels in ***bold italic*** text indicate exceedances of established criterion for the early morning 6am to 7am period.

3. This includes receivers 118 to 122.

4. This includes receivers 115, 123, 124, 128 to160, 162 to 167.

Table 9-29 shows that exceedances of the sleep disturbance night-time criteria are predicted at one isolated receiver from the northern batch plant operations or deliveries and three isolated receivers from the southern batch plant operations or deliveries. No exceedances of the sleep disturbance night-time criterion are predicted from the central batch plant operations or deliveries. A potential exceedance of the sleep disturbance night-time criterion is predicted at some receivers in the village from southern batch plant operations.

Exceedances of the sleep disturbance early morning criteria are predicted at one isolated receiver each from the northern and southern batch plant operations or deliveries. No exceedances of the sleep disturbance early morning criterion are predicted from the central batch plant operations or deliveries. No exceedances of the sleep disturbance early morning criterion are predicted at receivers in the village from batch plant operations or deliveries.

As discussed in Section 6.6.1, the Knox Road batch plant, currently in use for the adjacent Hume Highway duplication (Woomargama to Table Top) project, may be used for the project during the early phase of construction. A noise assessment and operational noise monitoring was carried out as part of the Hume Highway duplication (Woomargama to Table Top) project. Six residential receivers are located within 1500 metres of the Knox Road batch plant and may be impacted by the operation of the batch plant (see Figure 9-7 for the location of these receivers). Predicted and measured (where available) noise levels during the daytime, evening and night-time periods from the Knox Road batch plant are provided in Table 9-30.

Table 9-30 Predicted noise levels from Knox Road batch plant — daytime (7am to 6pm), evening (6pm to 10pm) and night-time (10pm to 7am)

Receiver[1]	Distance from receiver to batch plant (metres)	Daytime criterion (L_{A10} (dBA))	Evening criterion (L_{A10} (dBA))	Night-time criterion (L_{A10} (dBA))	Predicted noise level (L_{A10}(dBA))[2]
1	250	41	46	43	44 [3]
2	400	38	45	35	43[3]
3	600	38	43	35	<40[3]
4	1000	38	43	35	41
5	1200	36	43	38	39
6	1400	40	42	41	38

Notes: 1. Refer to Figure 9-7 for receiver locations.

2. Noise levels in ***bold italic*** text indicates exceedances of established criterion for the daytime 7am to 6pm period, underlined text indicates exceedances of established criterion for the night-time 10pm to 7am period.

3. Figures represent monitored noise levels during daytime operation of the Knox Road batch plant. The monitored levels were lower than the predicted levels as a result of relocation of the plant and the effectiveness of stockpiles in reducing noise impacts.

Table 9-30 shows that exceedances of the daytime criterion are predicted at the closest receiver. No exceedances of the evening criterion are predicted. Exceedances of the night-time criterion are predicted at five receivers.

Table 9-31 shows the predicted L_{A1} noise level for sleep disturbance from the Knox Road batch plant.

Table 9-31 Predicted noise levels from batch plants — sleep disturbance — night-time (10pm to 7am)

Receiver[1]	Sleep disturbance criteria (L_{A1} (dBA))	Predicted noise level (L_{A1} (dBA))[2]
1	53	57-62
2	45	55-60
3	45	51-56
4	45	46-51
5	48	44-49
6	51	43-48

Notes: 1. Refer to Figure 9-7 for receiver locations.

2: Noise levels in ***bold italic*** text indicate exceedances of established criterion for sleep disturbance.

Table 9-31 shows that exceedances of the sleep disturbance criteria are predicted at five receivers.

Should the Knox Rd batch plant be used for the project, noise assessment criteria would be re-established prior to operation of the batch plant to consider changes to the noise environment with the completion of the Hume Highway duplication (Woomargama to Table Top) project.

For the assessment at the Knox Road batch plant, noise levels for possible evening and night-time batch plant deliveries have not been predicted. The dominant source of noise during a delivery would be the engine noise of the truck as it approaches or leaves the site. As the dominant noise source close to the Knox Road batch plant, particularly at night, is traffic noise, the small number of extra trucks approaching and leaving the batch plant is not considered to result in a significant increase in this noise level. Figure 9-8 shows the location of the Knox Road compound and batch plant and surrounding sensitive receivers.

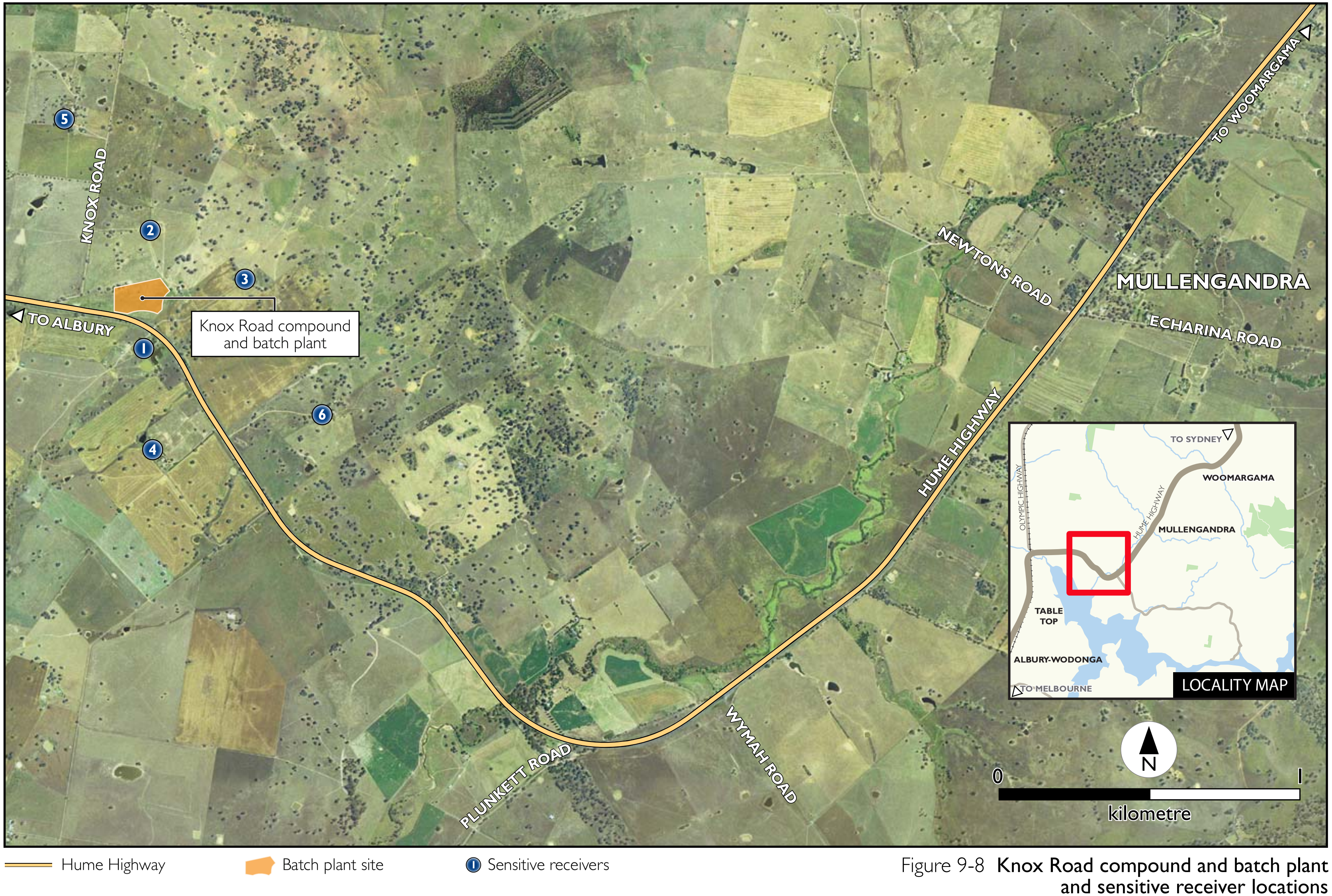


Figure 9-8 **Knox Road compound and batch plant and sensitive receiver locations**

Construction vibration impacts

The vibration levels during construction of this project would not result in levels that cause damage to buildings. Vibration from construction activities is predicted to be below the criteria for residential buildings at a distance of 100 metres away. As the minimum distance from any receiver to the construction site is more than 250 metres, no vibration impact is predicted.

Blasting impacts

As identified Section 6.1, blasting may be undertaken for construction in deep cuts. Locations of potential deep cuts are shown in Figure 5-1. Table 9-32 lists the likely blasting locations, the nearest receivers and the distance to those receivers, and recommended maximum instantaneous charges (MICs). MICs have been determined using relevant standards and guidelines.

Table 9-32 Recommended MIC to achieve criteria

Nearest receiver to cut[1]	Distance to cut (metres)		MIC to meet criteria (kilograms)			
			From nearest point of cut		From furthest point of cut	
	Minimum	Maximum	Vibration	Overpressure	Vibration	Overpressure
Cut 1						
116	550	700	550	290	700	598
Cut 2						
109	1050	1500	1056	2017	2156	5880
112	370	540	981	n/a	2089	n/a
Cut 3						
109	1650	1830	2608	7826	3208	10676
112	520	700	1791	n/a	3510	n/a
Cut 4						
111	1040	1100	7746	n/a	8666	n/a
102	2800	3000	7510	38000	8621	47000
Cut 5						
102	1380	1850	1825	4578	3279	11030
Cut 6						
168	310	420	93	52	169	129

Notes: 1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.

9.4.6 Management of impacts

Construction

Two residences (identified as receivers, 116 and 117) are located within the proposed construction site boundary. The construction noise impact assessment has predicted exceedances of construction criteria at these two residences. During construction these residences would not be occupied and as a result they would not be sensitive noise receivers during construction. The non-residential use of these houses would be via an agreement with the affected landowners (which may include the purchase of these residences). Discussions with these landowners are currently ongoing.

Operation

For receivers in Woomargama village, where the noise from the existing highway exceeds the base criterion, the project should seek to not increase the existing noise levels by more than 0.5 dBA for a new road or 2 dBA for a redevelopment (refer Table 9-16). The project would reduce noise levels (resulting from combined noise) at all residential receivers in the village by around 10 dBA. These would be above the ECRTN base criteria in many cases. Because the project would reduce noise levels at these receivers, it would not be considered reasonable and feasible to provide further mitigation unless the noise levels are acute.

Where the above cannot be achieved, reasonable and feasible mitigation would be considered in accordance with the ENMM.

In the assessment of reasonable and feasible mitigation for operational traffic noise, the ENMM gives guidance as to whether it is reasonable and feasible to offer noise mitigation. For new roads, it is generally not considered reasonable and feasible to offer mitigation if the combined levels of traffic noise are:

- Within 2 dBA of 'future existing' noise levels, and
- Not more than 2 dBA above the target noise levels.

Noise barriers are not considered appropriate as cost effective noise mitigation under Practice Note (iv) of the ENMM for isolated residences (in groups of three or less) and have not been considered for the project. Accordingly, there would be no reflective noise impacts from noise mitigation barriers.

Five receivers are to be considered for architectural treatment to mitigate noise impacts from the project. Those receivers, and the reasons for consideration of architectural treatment for each, are provided in Table 9-33.

Table 9-33 Summary of receivers to be considered for architectural treatment

Receiver[1]	Reason
107	▪ Exceeds criteria
108	▪ Exceeds criteria
109	▪ Exceeds criteria
116	▪ Exceeds criteria
117	▪ Exceeds criteria

Notes: 1. Refer to Appendix C in Technical Paper 5 (Volume 2) for receiver locations.

Mitigation and management measures for noise and vibration impacts are presented in Table 9-34. These measures have been incorporated into the draft statement of commitments in Chapter 11.

Table 9-34 Noise and vibration mitigation and management measures

Potential impact	Mitigation and management measure
Construction	
Noise impacts to sensitive receivers during construction activities	▪ Prior to the commencement of construction, prepare and implement a construction noise and vibration management plan as part of the CEMP. Typical construction noise mitigation measures that would be considered, and their anticipated noise reduction (dBA), are listed in Table 9-35. ▪ Prior to operation of the Knox Road batch plant (if used for the project), re-establish the noise assessment criteria for the batch plant to consider changes to the noise environment with the completion of the Hume Highway duplication (Woomargama to Table Top) project. ▪ Undertake monitoring to determine the effectiveness of mitigation measures. Implement additional mitigation measures where required if construction noise generates complaints and the monitoring confirms unreasonable noise impacts. ▪ Implement a notification and negotiation procedure where noise impacts from evening and night construction activities are above criteria. This would involve consultation with sensitive receivers to develop appropriate management measures. ▪ Develop a procedure for dealing with and responding to complaints.
Operation	
Noise levels from traffic exceeding criteria at sensitive receivers	▪ Develop and implement all reasonable and feasible mitigation measures to meet the noise criteria applicable to the project in consultation with the sensitive receiver.
	▪ Measure operational noise along the project between six months and one year after opening. Should the monitoring indicate that traffic noise impacts exceed the levels predicted, implement further reasonable and feasible mitigation measures in consultation with the sensitive receiver.

Table 9-35 Typical construction noise mitigation measures and anticipated noise reduction

Typical construction noise mitigation measures	Anticipated noise reduction (dBA)
Operating during approved hours	N/A
Monitoring of construction noise to determine impact of plant on sensitive receivers	N/A
Training staff	N/A
Responding to noise complaints	N/A
Turning off machinery when not in use	0-5
Respite periods for pile drivers	N/A
Portable temporary screens	5-10
Screen or enclosure for stationary equipment	10-15
Maximising offset distance between noisy plant items and sensitive receivers	3-6
Avoiding using noisy plant simultaneously and/or close together, adjacent to sensitive receivers	2-3