Box-Gum Woodland habitat in the assessment area generally occurs as remnant stands of moderate to highly disturbed vegetation. Given the role of remnant vegetation in providing connectivity within the surrounding cleared landscape, Box-Gum Woodland in the assessment area is considered as having moderate value to fauna species. This habitat provides a variety of tree hollows and dead trees suitable for nesting opportunities by open country and generalist species of bird, nesting dens for arboreal mammals (including the threatened Squirrel Glider; see Table 9-5) and roosting habitat. The effects of grazing are evident in this habitat, with only the upper canopy remaining in many communities. Shrub layers and leaf litter were largely absent. Box-Gum Woodland at the southern end of the project (particularly in the travelling stock reserve) is considered to be good condition fauna habitat. This area contains numerous hollow-bearing trees, a native shrub layer, native grasses and a good covering of leaf litter and fallen debris. This vegetation is part of a large patch of relatively undisturbed remnant Box-Gum Woodland that extends beyond the assessment area.

Riparian Woodland habitat along Tarcutta Creek contains a range of age classes of Eucalyptus species with patches of eucalypt regrowth within the creek channel. A dense eucalypt subcanopy with patches of exotic plants is present. This habitat provides habitat resources for common amphibian and bird species. Farm dams within the assessment area do not contain riparian vegetation. They do, however, provide water resources for birds and mammals.

Grazed pasture land comprises the majority of the habitats surrounding the assessment area. These areas provide limited habitat and are highly disturbed from grazing and other agricultural practices that have removed native understorey and groundcover vegetation. However, the isolated paddock trees within grazed pasture land are important in providing habitat for a range of fauna and maintaining connectivity between larger vegetation patches (Gibbons and Boak 2000).

Aquatic habitats

Tarcutta Creek is the only Class 1 waterway (major fish habitat in a permanently or intermittently flowing waterway), as defined by the Department of Industry and Investment (Fairfull and Witheridge 2003), within the assessment area. The section of the creek to the west of Tarcutta village is currently affected by riparian vegetation clearance, erosion and sedimentation, alteration to flow and bank instability as a result of stock access and vegetation removal. The riparian bank vegetation is dominated by exotic weeds. Pools and sediment deposits within the active creek channel are dominated by a mixture of native and exotic sedges, rushes and aquatic species. Habitats provided within Tarcutta Creek include undercut banks, sand/gravel shallow beds and a wide range of natural structures, including large dead trees.

Keajura Creek is a minor Class 3 waterway (minimal fish habitat in a named or unnamed waterway with intermittent flow), as defined by the Department of Industry and Investment (Fairfull and Witheridge 2003). The section of the creek to the south of Tarcutta village has also been modified as a result of anthropogenic disturbances, including altered drainage systems, artificially created channels, agricultural activities, clearing and cattle grazing. The riparian bank vegetation is dominated by exotic weeds. The creek is predominantly characterised by a dry bed with isolated pools for semi-permanent water and dense exotic pasture improvement species and weeds. Habitats provided within Keajura Creek are similar to those in Tarcutta Creek.

The aquatic habitats of both Tarcutta and Keajura creeks form part of the Lower Murray River endangered ecological community.

Terrestrial fauna, including threatened and migratory species

A total of 113 species of animal were recorded in the assessment area, of which 109 species were native. Native birds were the most diverse group of animals recorded (79 species), the majority of which were common, open country generalists or species common to grassy woodland environments (eg Sulphur-crested Cockatoo, Red-rumped Parrot, White-plumed Honeyeater). Sixteen species of native mammal, including 10 species of microchiropteran bat typical of open woodland areas, were recorded. Eleven reptile and three amphibian species were also recorded. Appendix B of Technical Paper 1 (Volume 2) lists all the animal species recorded in the assessment area.

Threatened fauna

Ten threatened fauna species listed under the *Environment Protection and Biodiversity Conservation Act 1999* have been recorded, are predicted to occur, or have potential habitat in the assessment area. No threatened species were identified during the field surveys for this project. Four of these ten species are considered to have a low likelihood of occurrence. The remaining six species are listed in Table 9-5.

Thirty-five threatened fauna species listed under the *Threatened Species Conservation Act 1995* have been recorded, are predicted to occur, or have habitat in the assessment area. Six of these species were identified during the field surveys for this project (see Table 9-5). Sixteen of the 35 species are considered to have a low likelihood of occurrence in the assessment area. The remaining 19 species are listed in Table 9-5.

Within the Wagga Wagga LGA, the Squirrel Glider is listed as an endangered population under the *Threatened Species Conservation Act 1995* (NSW Scientific Committee 2000). The Squirrel Glider was observed using Box-Gum Woodland habitat within the travelling stock reserve at the southern end of the project.

The Brown Treecreeper, a vulnerable species under the *Threatened Species Conservation Act 1995*, was recorded within three remnant woodland sites in the assessment area in the northern, middle and southern parts of the project.

Table 9-5 Threatened fauna recorded or predicted to occur in the assessment area

Scientific name	Common name	Conservation significance		Habitat within the assessment area	Likelihood of occurrence in assessment area[4]
		TSC Act[1]	EPBC Act[2]		
Birds					
Burhinus grallarius	Bush Stone-curlew	E		Box-Gum Woodland, Riparian Woodland	Moderate
Climacteris picumnus[3]	Brown Treecreeper	V		Box-Gum Woodland	High
Grantiella picta	Painted Honeyeater	V		Box-Gum Woodland	Moderate
Lathamus discolor	Swift Parrot	E	E	Box-Gum Woodland	Moderate
Melanodryas cucullata	Hooded Robin	V		Box-Gum Woodland	Moderate
Melithreptus gularis gularis	Black-chinned Honeyeater	V		Box-Gum Woodland	Moderate
Neophema pulchella	Turquoise Parrot	V		Box-Gum Woodland	Moderate
Ninox connivens[3]	Barking Owl	V		Riparian Woodland	High
Polytelis swainsonii	Superb Parrot	V	V	Riparian Woodland	Moderate
Pomatostomus temporalis	Grey-crowned Babbler	V		Box-Gum Woodland, Riparian Woodland	Moderate
Pyrrholaemus sagittatus[3]	Speckled Warbler	V		Box-Gum Woodland	High
Stagonopleura guttata	Diamond Firetail	V		Box-Gum Woodland	Moderate
Xanthomyza phrygia	Regent Honeyeater	E	EM	Box-Gum Woodland, Riparian Woodland	Moderate
Mammals					
Falsistrellus tasmainiensis[3]	Eastern False Pipistrelle	V		Box-Gum Woodland, Riparian Woodland	High
Nyctophilus timoriensis	Greater Long-eared Bat	V	V	Box-Gum Woodland, Riparian Woodland	Moderate
Petaurus norfolcensis[3]	Squirrel Glider	V		Box-Gum Woodland	High
Phascolarctos cinereus	Koala	V		Box-Gum Woodland, River Red Gum Forest	Moderate

Scientific name	Common name	Conservation significance		Habitat within the assessment area	Likelihood of occurrence in assessment area[4]
		TSC Act[1]	EPBC Act[2]		
Reptiles					
Aprasia parapulchella	Pink-tailed Worm Lizard	V	V	Derived native grasslands with emergent rocks	Moderate
Delma impar	Striped Legless Lizard	V	V	Derived native grasslands	Moderate

Notes: 1. *Threatened Species Conservation Act 1995*, V = Vulnerable, E = Endangered.

2. *Environment Protection and Biodiversity Conservation Act 1999*, V = Vulnerable, E = Endangered, M = Migratory.

3. Species was recorded during field surveys for this project.

4. Refer to Appendix D of Technical Paper 1 (Volume 2) for more information on likelihood of occurrence.

Migratory species

Migratory species are protected under the international agreements to which Australia is a signatory. Migratory species are considered matters of national environmental significance and are protected under the *Environment Protection and Biodiversity Conservation Act 1999*.

Two species of bird, the Great Egret and Rainbow Bee-eater, recorded during the field surveys are currently recognised under the migratory provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (see Appendix B of Technical Paper 1 (Volume 2)). A further eight species have the potential to occur in the project locality based on the EPBC Protected Matters Search Tool. However, the assessment area is only considered important habitat (providing foraging resources and potential nesting resources) for two of these 10 migratory species: Regent Honeyeater and Swift Parrot. Both species are listed as endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (see Appendix E of Technical Paper 1 (Volume 2)).

Introduced animals

Four introduced species were recorded in the assessment area. These were the Common Starling, Rabbit, Brown Hare and House Mouse. The four species were recorded primarily in grazed pasture land.

Aquatic biodiversity

Five species of fish were recorded during surveys of Tarcutta Creek (which is part of the Lower Murray endangered ecological community). The most abundant fish caught was the introduced Mosquito Fish (*Gambusia holbrooki*) followed by the Common Carp (*Cyprinus carpio*) and Redfin Perch (*Perca fluviatilis*). The only native fish caught were the Southern Pygmy Perch (*Nannoperca australis*) and Australian Smelt (*Retropinna semoni*). The Southern Pygmy Perch is listed as endangered under the *Fisheries Management Act 1994*.

Two species of crustacean were recorded during the surveys. These were the Freshwater Shrimp (*Paratya australiensis*) and Yabby (*Cherax* sp.).

Twenty-three macroinvertebrate taxa were collected from three survey locations in Tarcutta Creek. The most abundant were aquatic bugs (Corixidae) followed by mayflies (Caenidae). The relatively large number of pollution-tolerant macroinvertebrate taxa suggested that water quality in Tarcutta Creek was generally quite poor.

9.1.3 Impacts on flora and fauna

Loss of native vegetation and fauna habitats

The project would require the clearing of 16 hectares of native vegetation along the length of the project. This is based on complete vegetation clearance within the construction site boundary and presents a worst-case scenario. Clearance of native vegetation within the construction site boundary would be avoided where possible to minimise impacts. The clearing would comprise:

- Seven hectares of Box-Gum Woodland (an endangered ecological community under the *Threatened Species Conservation Act 1995*), six hectares of which fits the definition of the critically endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999*.

- Five hectares of Inland Grey Box Woodland, an endangered ecological community under the *Threatened Species Conservation Act 1995* (and preliminarily listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999*) would also be cleared.

Of this vegetation clearance, 16 hectares of identified fauna habitat would be cleared: 11 hectares of Box-Gum Woodland, four hectares of Riparian Woodland and one hectare of Derived Native Grassland. Table 9-6 details the vegetation and habitat loss required for the project.

Table 9-6 Vegetation communities and fauna habitat required to be cleared

Vegetation community	Corresponding threatened ecological community	Corresponding fauna habitat	Total clearing (within the construction site boundary) (hectares)
Blakely's Red Gum – Yellow Box Grassy Woodland	Box-Gum Woodland	Box-Gum Woodland	6
Apple Box Grass-forb Open Forest	Box-Gum Woodland	Box-Gum Woodland	1
Inland Grey Box Tall Grassy Woodland	Inland Grey Box Woodland	Box-Gum Woodland	4
River Red Gum Very Tall Open Forest	-	Riparian Woodland	4
Derived Native Grassland	Inland Grey Box Woodland	Grazed Pasture Land	1
Total			16

Clearing of native vegetation is listed as a Key Threatening Process under the *Threatened Species Conservation Act 1995* and *Environment Protection and Biodiversity Conservation Act 1999*.

Habitat fragmentation and wildlife corridor impacts

Habitat fragmentation is the division of a single area of habitat into two or more smaller areas, with the occurrence of a new habitat type in the area between the fragments. This new dividing habitat is often artificial and inhospitable to the species remaining within the fragments (Johnson et al 2007; Bennett 1993, 1990). Habitat fragmentation can result in a number of impacts, including:

- Barrier effects: where particular species are either unable or unwilling to move between suitable areas of fragmented habitat.
- Genetic isolation: where individuals from a population within one fragment are unable to interbreed with individuals from populations in adjoining fragments.
- Edge effects: where a zone of changed environmental conditions (ie altered light levels, wind speed and/or temperature) occurs along the edges of habitat fragments (see below).

The construction and operation of the project would further fragment habitat and increase the isolation of remnant vegetation. With the project traversing roadside and riparian corridor vegetation, a travelling stock reserve and modified agricultural landscapes, the level of fragmentation and isolation of some patches of vegetation would increase. The project would also present a barrier within the landscape (in an east–west direction) around the wildlife

corridors associated with the Tarcutta Creek riparian corridor and the travelling stock reserve. The barrier effect would be greatest for small and sedentary fauna, such as ground-dwelling/arboreal mammals, reptiles and amphibians. However, given the existing disturbances in the assessment area due to a history of agricultural land uses and the existing Hume Highway, the disrupted wildlife corridors are more likely to be used by highly mobile species, such as birds and bats, primarily as marginal foraging habitats within a greater foraging range. The project is unlikely to have a significant impact on these highly mobile species provided that the impacts to wildlife corridors are managed through the measures identified in Section 9.1.4.

Edge effects

Edge effects are zones of changed environmental conditions occurring along the edges of habitat fragments. These new environmental conditions along the edges can promote the growth of different vegetation types (including weeds) and allow invasion by pest animals specialising in edge habitats and/or change the behaviour of resident animals. Edge zones can be subject to higher levels of predation by introduced mammals and native birds.

The majority of vegetation within the assessment area occurs within relatively small, fragmented patches, many of which are subject to past and present disturbance regimes (eg grazing) so already consist of edge-affected habitats. Construction of the project is likely to introduce new edge effects to the larger remnants of vegetation. The change to habitat resulting from the introduction of edge effects into these remnant patches is likely to be approximately six hectares.

A change in the microhabitat conditions in remnant vegetation patches as a result of vegetation clearing and earthworks increases the likelihood of the germination and establishment of weeds. Given the significant disturbances associated with edge effects from grazing and adjoining agricultural land practices, any marginal increase in these effects caused by the project is not likely to be significant.

Vehicle strike and direct mortality of animals

Fauna injury or death could occur during construction when vegetation and habitats are being cleared. While some mobile species (eg birds) have the potential to move away from the path of clearing, other species that are less mobile, or those that are nocturnal and restricted to tree hollows, may have difficulty moving over relatively large distances.

During operation of the project, fauna injury or death could also occur as a result of collision with vehicles. Threatened fauna that may be affected by vehicle strikes include the Squirrel Glider, Swift Parrot and woodland bird species such as the Grey-crowned Babbler. The greatest roadkill risk for these species would likely occur in the southern portion of the project, where it traverses between existing remnant roadside vegetation and the travelling stock reserve.

As detailed in Table 9-8, the project would adopt measures to prevent fauna mortality during construction and operation.

Invasion and establishment of weeds

As identified in Section 9.1.2, 93 weed species were observed in the assessment area. The distribution of these weed infestations across the assessment area can generally be split into the following broad distributional areas:

- Riparian areas associated with the River Red Gum Open Forest vegetation community.

- Isolated pocket of the Derived Native Grassland and adjoining Inland Grey Box Woodland vegetation communities to the north-west of Tarcutta village, the roadside remnants north of Tarcutta village and the remnant vegetation communities within the travelling stock reserve.
- Remaining paddock remnants of natural vegetation communities and the roadside remnants south of Tarcutta village.

Construction of the project has the potential to disperse weeds into areas of remnant vegetation where weed species do not currently occur. The most likely causes of weed dispersal would include earthworks, movement of soil, and attachment of seed (and other propagules) to vehicles and machinery. Given that most of the vegetation within the assessment area already has considerable weed growth, the overall extent of habitat modification through weed establishment is not likely to increase significantly.

Weed management during operation would be carried out as part of regular maintenance activities, if required.

Aquatic flora and fauna impacts

The construction of waterway crossings for the project (temporary and permanent) has the potential to modify the natural hydrology of creeks within the assessment area, which could affect the aquatic assemblages that use these areas. Impacts from the construction of waterway crossings include:

- Excessive flow velocities.
- Modified water depths in the creeks.
- Increased water turbulence.

Barriers to fish passage from the installation of waterway crossings (including bridges and culverts) can occur temporarily (ie during construction) and/or over the long term if inappropriate structures are used. In addition to potential impacts from alteration of natural hydrology at waterway crossings, other impacts, such as decreased light levels and blocked debris, may affect fish passage. Existing culverts and bridge pillars are located within Tarcutta and Keajura creeks, which may potentially disrupt fish passage.

Fish and mobile invertebrate assemblages surveyed in Tarcutta Creek were fairly typical of freshwater habitats within the region and the fish assemblage consisted of mostly introduced species. A small area of the threatened Southern Pygmy Perch habitat could be removed as a result of constructing the proposed waterway crossing at Tarcutta Creek. However, no bridge piles would be located in the preferred habitat of this species (the low flow channel of the creek). Given that suitable habitat would remain upstream and downstream of the project, and provided that fish passage is maintained in accordance with the Department of Industry and Investment guidelines (Fairfull and Witheridge 2003), no long-term impacts from the proposed waterway crossings would be expected for the Southern Pygmy Perch or other fish species (see Appendix C of Technical Paper 1 (Volume 2)).

Both the Tarcutta and Keajura creeks form part of the Lower Murray River endangered ecological community. The project would include waterway crossings and minor creek realignments within these endangered ecological communities, which would add to the overall disturbance regime in the creeks. The waterways within the project are currently affected by riparian vegetation clearance, erosion and sedimentation, alteration to flows and bank instability due to stock access and vegetation removal. Given that suitable habitat exists upstream and downstream of the proposed creek crossings and minor creek alignment, and that all crossing would be constructed in accordance with the Department of Industry and Investment

(formerly the DPI) guidelines, it is unlikely that there would be long-term impacts on the endangered ecological community. Any realignment would be carried out in consultation with DECCW, the Department of Industry and Investment and other relevant stakeholders.

During construction, run-off from disturbed surfaces would have the potential to affect water quality in local creeks due to sedimentation. There is also potential for accidental spillage/leakage of road construction materials, fuels, lubricants and hydraulic oils from construction equipment (this is discussed in Sections 10.1 and 10.4). During operation, the paved surface of the project would increase stormwater run-off volumes and flows. This could increase flood levels and velocities in drainage lines downstream of the highway. This is not likely to be significant.

Impacts on groundwater dependent ecosystems

Groundwater dependent ecosystems are communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater (DLWC 2002). Within the assessment area, there are two main groundwater flow systems: alluvial and fractured rock aquifers (see Section 9.4.2). Much of the vegetation within the assessment area is likely to access these groundwater resources. However, given the broad regional distribution of these communities and the varied topography over which they occur, it is unlikely that they would be dependent on the groundwater resources. River Red Gums and other riparian vegetation may show a partial dependence on the groundwater but their extent and life processes are not wholly dependent on groundwater.

The project would require the excavation and shaping of the upper soil profile and minor alterations to the existing surface water drainage; some groundwater extraction is likely to be required during construction activities. However, this is not expected to have a significant impact on the existing subsurface aquifers and any associated groundwater dependent ecosystems.

Cumulative impacts

The cumulative biodiversity impacts of the project considered in this environmental assessment are likely to be more substantial as a result of biodiversity impacts from the surrounding Hume Highway duplication projects. These cumulative impacts would include a greater extent of clearing of native vegetation and habitats, including threatened ecological communities, as well as further fragmentation of habitats, including habitat for threatened flora and fauna. It is estimated that a total of approximately 125 hectares of native vegetation has been or would be cleared for the current duplication and town bypass projects on the Hume Highway. The current project would contribute 14 per cent of this clearing. The total extent includes an estimated 93 hectares of endangered ecological community, of which the project contributes 12 hectares. The loss of 93 hectares of endangered ecological communities is considered significant. To offset the loss of native vegetation as a result of the Hume Highway duplication projects, the RTA is implementing a biodiversity offset package.

Significance of impacts

Significance assessments were completed for threatened biodiversity that were known or likely to occur within the assessment area, including three threatened ecological communities, three species of plant and 21 species of animal. Table 9-7 summarises the significance assessments. This is supported by the detailed assessments in Appendix E of Technical Paper 1 (Volume 2).

Table 9-7 Summary of significance assessments for threatened biodiversity

Threatened biodiversity	TSC Act[1]	FM Act[2]	EPBC Act[3]	Likely significant impact
Ecological communities				
Box-Gum Woodland	E		CE	No
Inland Grey Box Woodland	E			No
Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment		E		No
Plants				
Ammobium craspedioides (Yass Daisy)	V		V	No
Diuris tricolor (Pine Donkey Orchid)	V		V	No
Amphibromus fluitans (River Swamp Wallaby-grass)	V		V	No
Animals				
Threatened woodland birds assessed as a group (Brown Treecreeper, Hooded Robin, Black-chinned Honeyeater, Painted Honeyeater, Grey-crowned Babbler, Speckled Warbler, Diamond Firetail)	V			No
Barking Owl	V			No
Bush Stone-curlew	E			No
Regent Honeyeater	E		EM	No
Superb Parrot	V		V	No
Swift Parrot	E		E	No
Turquoise Parrot	V			No
Squirrel Glider	V			No
Eastern False Pipistrelle	V			No
Eastern Free-tail Bat	V			No
Greater Long-eared Bat	V		V	No
Koala	V			No
Pink-tailed Worm Lizard	V		V	No
Striped Legless Lizard	V		V	No
Southern Pygmy Perch		E		No

Notes: 1. *Threatened Species Conservation Act 1995*, V = Vulnerable, E = Endangered.

2. *Fisheries Management Act 1994*, V = Vulnerable, E = Endangered.

3. *Environment Protection and Biodiversity Conservation Act 1999*, V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory.

These assessments suggest that the project is not likely to have a significant or long-lasting impact on any species or ecological community listed under the *Threatened Species Conservation Act 1995* or the *Environment Protection and Biodiversity Conservation Act 1999*.

9.1.4 Management of impacts

Management measures for flora and fauna impacts were developed following the general principles, in order of preference, of:

- Avoiding impacts.
- Minimising impacts.
- Mitigating impacts.
- Offsetting of residual impacts (this is considered a last resort, once the above options have been investigated).

The planning and route selection processes have, as far as possible, avoided impacts on flora and fauna habitats. Chapter 4 discusses the route selection process that was undertaken for the project, and particularly identifies biodiversity as a key consideration in the planning and route selection.

Table 9-8 identifies the mitigation and management measures that would be implemented for flora and fauna impacts. These measures have been incorporated into the draft statement of commitments in Chapter 11.

Table 9-8 Flora and fauna mitigation and management measures

Potential impact	Mitigation and management measure
Pre-construction	
Impacts on flora and fauna from construction of the project	▪ Prior to the commencement of construction, prepare and implement a Flora and Fauna Management Plan through the CEMP.
Construction	
Removal of native vegetation and increased edge effects	▪ Limit clearing of native vegetation to the minimum necessary to construct and operate the project through detailed design.
Removal of habitat	▪ Implement clearing protocols that involve checking hollow-bearing trees for the presence of bird nests and arboreal animals, such as possums, gliders and bats, prior to felling or pushing. Safely remove any animals found to be occupying trees. Have a qualified ecologist relocate any fauna with the potential to be harmed into suitable adjacent habitat. ▪ Implement a two stage clearing process for the removal of all hollow bearing trees. ▪ Attach salvaged sections of hollows or nest boxes to trees in a way that allows for tree expansion and does not poison the tree. When locating nest boxes or hollows, consider appropriate aspect, height and location for the target fauna species. ▪ Collect native seed prior to clearing, for use in the revegetation of disturbed areas. ▪ Landscape areas within the project corridor, including the use of native plant species endemic to the area. ▪ Implement strategic revegetation works in the highway corridor to increase fauna habitat linkages and enhance riparian areas.
Increased weed invasion in adjacent areas due to edge effects	▪ Undertake ongoing management of weeds in consultation with Wagga Wagga City Council.

Potential impact	Mitigation and management measure
Inadvertent disturbance of Box-Gum Woodland and other areas of habitat outside construction areas	▪ Clearly demarcate the limits of clearing within the construction site boundary prior to construction activities commencing to avoid unnecessary vegetation and habitat removal.
Cumulative loss of habitat	▪ Place natural and artificial habitat features into suitable areas to provide alternative habitat for fauna.
Fragmentation of habitat	▪ Develop fauna crossing treatments in consultation with relevant government agencies.
Changed hydrology and aquatic disturbance and barriers to fish passages	▪ Avoid works within the main watercourse of Tarcutta Creek during the breeding season of the Southern Pygmy Perch (September to January) unless mitigation measures are developed in consultation with the Department of Industry and Investment. ▪ Maintain fish passage during construction. ▪ Design waterway crossings, including temporary works, in accordance with the fish habitat classification of each waterway and in consultation with the Department of Industry and Investment. ▪ Follow Department of Industry and Investment guidelines, so as to maintain the natural flow of all water bodies directly affected by the project in the study area.
Decreased water quality	▪ Develop and implement standard best practice environmental management measures during construction in accordance with *Managing Urban Stormwater: soils and Construction, Volume 1, 4th Ed.* (Landcom 2006) and *Managing Urban Stormwater: Soils and Construction, Volume 2D, Main Road Construction* (DECC 2008b).
Operation	
Offset the loss of vegetation and fauna habitat, and residual impacts	▪ Develop a biodiversity offset package in consultation with DECCW to detail how the residual impacts on ecological values as a result of the project would be managed. The package would address the potential cumulative impacts resulting from the proposed Woomargama and Holbrook bypasses. This offset package would be guided by the RTA's (2007b) *Hume Highway Duplication Biodiversity Offset Strategy*.

9.2 Aboriginal heritage

An assessment of Aboriginal cultural heritage impacts has been undertaken for the project as presented below. This is supported by an Aboriginal Cultural Heritage Assessment Report (CHAR) in *Technical Paper 2 — Aboriginal Heritage* (Volume 2).

DGRs	Where addressed
Aboriginal heritage (including but not limited to):	
Objects, sites, natural and landscape values of the corridor and surrounding area, taking into account the *Draft Guidelines for Aboriginal Cultural Heritage Assessment and Community Consultation* (DEC 2005a).	Sections 9.2.1, 9.2.2, 9.2.3, 9.2.4 and 7.3.1 Technical Paper 2 (Volume 2)

9.2.1 Assessment approach

The Aboriginal cultural heritage assessment was undertaken in accordance with the *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (DEC 2005a), *Interim Community Consultation Requirements for Applicants* (DEC 2004) and the *RTA Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (RTA 2008d) (the Procedure).

The assessment of Aboriginal cultural heritage was undertaken. It consisted of desktop research database searches, Aboriginal community consultation, cultural interviews, cultural mapping, archaeological field surveys and test excavations. The assessment included the following elements:

- A search of the DECCW Aboriginal Heritage Information Management System (AHIMS) database within 10 kilometres of Tarcutta village.
- A review of previous archaeological surveys undertaken for the Hume Highway upgrade including Kelleher Nightingale Consulting Pty Ltd (2007a, b, c) and Cultural Heritage Connections Pty Ltd (2006).
- Identification, registration and consultation with Aboriginal stakeholders.
- Three Aboriginal focus group meetings were held to discuss the results of:
  - The preliminary archaeological assessment.
  - The survey and the methodology for the test excavation program.
  - The draft CHAR, prior to submission of comments.
- Aboriginal cultural knowledge holders were identified through the Aboriginal focus group process. Seven of the identified knowledge holders were provided the opportunity to participate in the cultural assessment process. As a result, three of the identified knowledge holders participated in the cultural heritage assessment through field surveys and interviews.
- A review of the preliminary archaeological assessment and cultural mapping undertaken as part of the preliminary environmental assessment.
- An archaeological surface survey of the assessment area was conducted on 5 and 6 November 2008. The survey consisted of two teams of five to six people, including archaeologists and Aboriginal stakeholders, walking the assessment area to identify areas of archaeological significance or potential significance.

- An assessment of Aboriginal cultural heritage was undertaken, consisting of both interviews and field surveys.
- Test excavations were undertaken in four locations (two sites and two PAD areas identified during the surface surveys) in order to determine the extent and significance of Aboriginal archaeology.
- An assessment of archaeological and cultural significance, in accordance with *Standards for Archaeological Practice in Aboriginal Heritage Management Guidelines* (NPWS 1997):
  - Archaeological significance rankings for archaeological sites includes consideration of archaeological research potential, representativeness and rarity. Levels of significance include low, moderate and high.
  - Cultural significance refers to the values of a place, feature or site to a particular community group and can include social, spiritual, historic and archaeological values. Cultural significance for the places and items identified in the Aboriginal cultural heritage assessment were given a relative ranking of low, medium, high or very high.
- An Aboriginal CHAR was prepared. This is Technical Paper 2 (Volume 2).

9.2.2 Existing environment

Aboriginal archaeology

Aboriginal people occupied the Tarcutta area for at least 6500 years and lived and used all parts of the environment. The archaeological surface survey indicated that the largest concentration of artefacts occurs along creek lines. Most archaeology in the area is located along the protected creek margins due to successive flooding having removed the majority of artefacts in unprotected areas.

Archaeological sites in the assessment area occur as artefact scatters, scarred trees and potential archaeological deposits (PADs). Artefact scatters are areas in the landscape that contain two or more stone artefacts, generally located within 100 metres of each other. They may result from the activities of a single person or a group of people and can be the result of a single occupation or multiple episodes of occupation of a single place. Scarred trees are trees that have had bark deliberately removed that leaves scars on the tree trunk, which indicates the Aboriginal use of an area. The bark was used for many purposes, including canoes, shelters, shields and container vessels. PADs are areas that potentially contain intact archaeological sub-surface deposits.

The AHIMS search identified nine previously recorded sites within the locality, including eight confirmed sites and one PAD. Eight of these sites were identified during previous surveys undertaken for the Hume Highway duplication project. Three of the previously recorded sites are located within the assessment area:

- Site T1 — scarred tree.
- Site T2 — scarred tree.
- Site T3 — scarred tree.

A total of 15 Aboriginal archaeological sites and two PAD areas were identified during the archaeological surface survey for the project. The sites were generally located within the margins of the Tarcutta Creek floodplain.

Test excavations were undertaken in four locations (two sites and two PAD areas identified during the surface surveys) to determine the extent and significance of Aboriginal archaeology. The methodology for the test excavations is summarised in Chapter 6 of Technical Paper 2 (Volume 2). The two PAD areas were reclassified to artefact scatter sites as a result of test excavations.

The identified Aboriginal archaeological items within the assessment area are listed in Table 9-9. The archaeological significance ranking of these sites is also provided. All identified sites were considered to be of high cultural significance to the Aboriginal stakeholders.

The approximate locations of the archaeological sites are shown in Figure 9-5.

Cultural places

Six locations of specific Aboriginal cultural value were identified by the knowledge holders within the assessment area. These places are recognised by the knowledge holders as being part of one interlinked element within the larger cultural landscape. The cultural significance of these places ranged from medium to very high. This ranking was developed in consultation with the knowledge holders. All identified places hold Aboriginal cultural heritage significance, the relative ranking is designed only to assist future planning. The identified Aboriginal cultural places are listed in Table 9-9. Locations of the identified places have been kept confidential due to the culturally sensitive nature of this information.

Table 9-9 Identified items of archaeological and cultural significance

Site	Site type	Significance
T1	Scarred tree	Moderate to high
T2	Scarred tree	Moderate to high
T3	Scarred tree	Moderate to high
T8	Artefact scatter	Moderate to high
T9[1]	Artefact scatter	Low to moderate
T10	Artefact scatter	Moderate to high
T11	Artefact scatter	Low
T12[1]	Artefact scatter	Moderate
T13	Isolated find	High
T14	Scarred tree	Moderate to high
T15	Artefact scatter	High
T16	Artefact scatter	Low
T17	Artefact scatter	Moderate to high
T18	Artefact scatter	Moderate to high
T19	Artefact scatter	Moderate
T20 (formally T-PAD-4)[1]	Artefact scatter	Moderate
T21 (formally T-PAD-5)[1]	Artefact scatter	Moderate
Place 1	Gendered ceremonial area marker	High
Place 2	Gendered ceremonial area marker	High
Place 3	Gendered ceremonial area marker	Moderate

Site	Site type	Significance
Place 4	Gendered teaching area	Very high
Place 5	Ceremonial area	High
Place 6	Cultural trees	High

Note: 1. Site subject to test excavation.

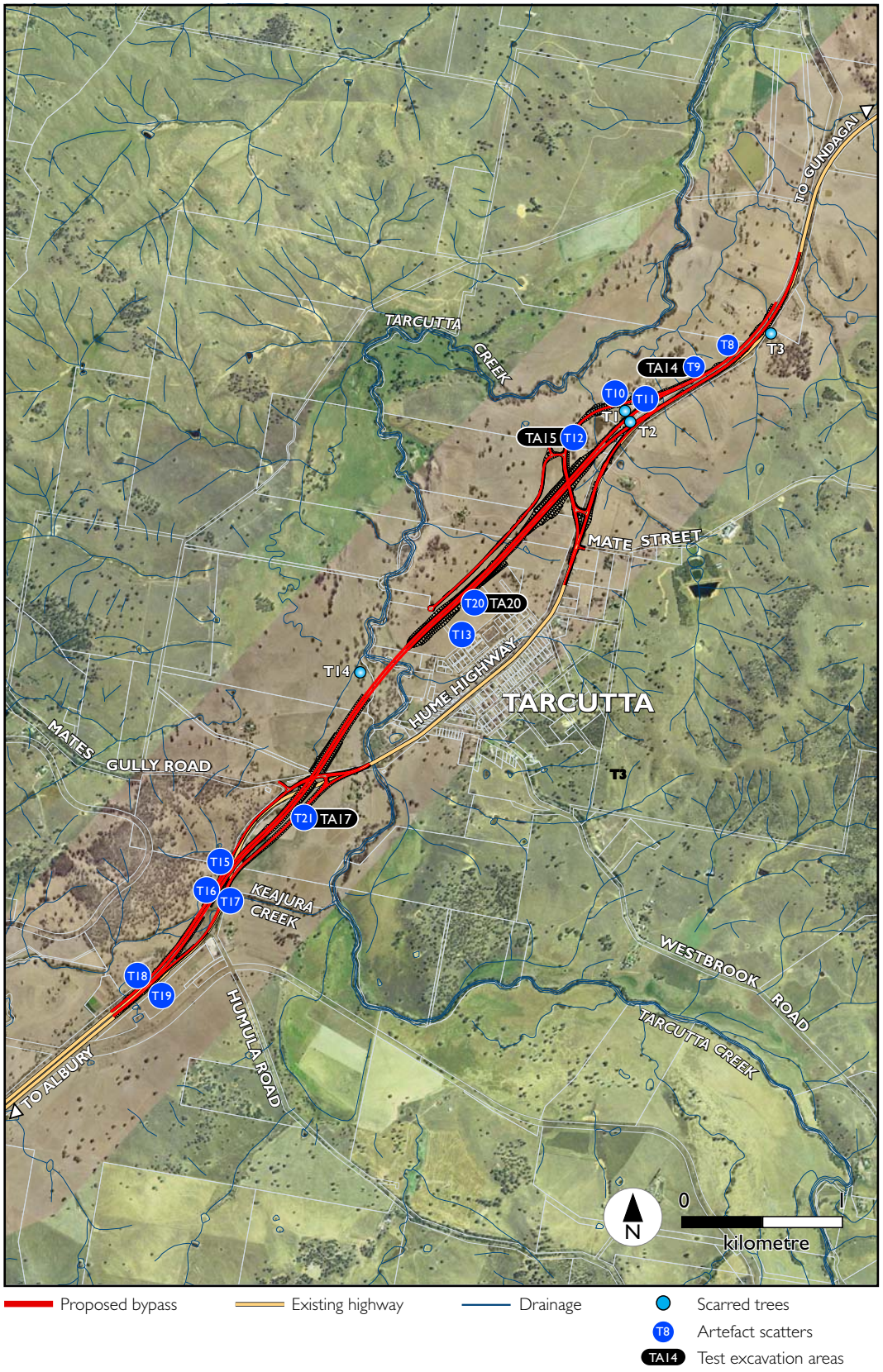

Figure 9-5 **Locations of identified Aboriginal archaeological sites**

9.2.3 Impacts on items of Aboriginal heritage significance

All identified Aboriginal cultural places and archaeological sites recorded within the assessment area have been considered throughout the environmental assessment process. Where significant sites or places were identified, the concept design has been modified where possible to avoid or limit the impact to the identified cultural places and archaeological sites. Some level of impact has been unavoidable.

Archaeological sites

Of the 17 archaeological sites identified, 12 are located wholly or partially within the concept design and would be directly impacted by the project. In most cases the impacts amount to only a relatively small portion of the site. Detailed design would seek to further minimise impacts on these archaeological sites, where feasible. The five archaeological sites located outside the concept design would not be directly impacted by the project. A summary of the archaeological heritage impacts is provided in Table 9-10.

The project provides an opportunity to increase understanding, strengthen interpretation and better recognition of Aboriginal culture and heritage within an area where little previous documented information exists.

Cultural places

Two of the six identified cultural places are located partially within the concept design and would be directly impacted by the project. Impacts on these places have been discussed and agreed to by the knowledge holders, subject to specific mitigation measures. A summary of the impacts to cultural places is provided in Table 9-10.

Table 9-10 Summary of impacts to, and mitigation measures for, Aboriginal archaeological sites and cultural places

Site	Extent of impact and mitigation measures
T1 — Scarred tree	No impact. Identify location of scar tree on heritage site map. Fence if within construction site boundary.
T2 — Scarred tree	No impact. Identify location of scar tree on heritage site map. Fence if within construction site boundary. T2 is a dead tree. Some lopping of limbs may be required to reduce the centre of gravity.
T3 — Scarred tree	No impact. Identify location of scar tree on heritage site map. Fence if within construction site boundary.
T8 — Artefact scatter	Would be impacted, partial impact only. Salvage excavation recommended if avoidance and a significant portion (eg 10 per cent or more) of the site is impacted.
T9 — Artefact scatter	Would be impacted, partial impact only. Eastern portion to be impacted. The eastern portion of the site is a moderate erosional area representing low archaeological significance with limited archaeological material. Test excavation undertaken. No further archaeological mitigation required.
T10 — Artefact scatter	Would be impacted. Salvage excavation recommended if avoidance not possible.
T11 — Artefact scatter	Would be impacted, partial impact only. No further archaeological works required. Artefacts should be salvaged by surface collection within the impact area.
T12 — Artefact scatter	Would be impacted. Test excavation undertaken. No further archaeological mitigation required.

Site	Extent of impact and mitigation measures
T13 — Artefact scatter	No impact. Identify location on heritage site map. Fence if within construction site boundary.
T14 — Scarred tree	No impact. Identify location of scar tree on heritage site map. Fence if within construction site boundary.
T15 — Artefact scatter	Would be impacted, partial impact only. Salvage excavation recommended if avoidance not possible.
T16 — Artefact scatter	Would be impacted. No further archaeological works required. Artefacts should be salvaged by surface collection within the impact area.
T17 — Artefact scatter	Would be impacted, partial impact only. Western portion to be impacted. No further archaeological works required.
T18 — Artefact scatter	Would be impacted, partial impact only. Salvage excavation recommended if avoidance not possible.
T19 — Artefact scatter	Would be impacted, partial impact only. Salvage excavation recommended if avoidance not possible.
T20 — Artefact scatter	Would be impacted. Test excavation undertaken. No further archaeological mitigation required.
T21 — Artefact scatter	Would be impacted, partial impact only. Test excavation undertaken. No further archaeological mitigation required.
Place 1	Partial impact. Identify location on heritage site map. Fence along construction site boundary. Knowledge holder has requested two site visits following construction adjacent to site. Sensitive area signage to be erected on construction site boundary fence. Any future work in this area or deviation from the concept design would require further consultation with the knowledge holder.
Place 2	No impact. Identify location on heritage site map. Fence if within construction site boundary.
Place 3	No impact. Identify location on heritage site map. Fence if within construction site boundary.
Place 4	No impact. Identify location on heritage site map. Fence if within construction site boundary.
Place 5	Partial impact. Identify location on heritage site map. Fence along construction site boundary. Knowledge holder has requested two site visits following construction adjacent to site. Sensitive area signage to be erected on construction site boundary fence. Any future work in this area or deviation from the concept design would require further consultation with the knowledge holder.
Place 6	No impact. Identify location on heritage site map. Fence if within construction site boundary.

9.2.4 Management of impacts

The planning and route selection process have, as far as possible, avoided impacts on Aboriginal archaeological and cultural heritage. Chapter 4 discusses the route selection process that was undertaken for this project, and particularly identifies that Aboriginal heritage was a key consideration in the planning and route selection.

Table 9-10 and Table 9-11 summarise the management measures to be implemented for identified archaeological and cultural sites. Further detail is provided in the CHAR (see Chapter 9 of Technical Paper 2 (Volume 2)). These measures have been incorporated into the draft statement of commitments in Chapter 11.

Table 9-11 Aboriginal heritage mitigation and management measures

Potential impact	Mitigation and management measure
Pre-construction	
Impacts to Aboriginal heritage	▪ Prior to the commencement of construction, prepare and implement an Aboriginal heritage management plan as part of the CEMP. ▪ Identify all archaeological sites and cultural heritage places located outside the construction site boundary on heritage site maps so that these areas can be avoided during construction.
Construction	
Impacts to Aboriginal heritage	▪ Manage Aboriginal heritage items in accordance with the Aboriginal Cultural Heritage Assessment Report (CHAR), which identifies mitigation measures, developed in consultation with Aboriginal stakeholders and DECCW. ▪ Prior to the commencement of construction activities, fence all archaeological and cultural sites within the construction site boundary that are not to be impacted in consultation with a qualified archaeologist and/or knowledge holders. ▪ Undertake salvage of impacted sites prior to construction commencing in those areas. ▪ Ensure all construction personnel receive training regarding Aboriginal heritage issues associated with the project.
Inadvertent impacts to identified cultural places	▪ Consult with the Aboriginal knowledge holder(s) if there are any changes to impacts on identified cultural places.
Potential for discovery of human skeletal materials	▪ If any skeletal remains are encountered immediately stop any works that would potentially impact the find. Do not re-commence works until appropriate clearance is received.

9.3 Non-Aboriginal heritage

The environmental risk assessment process carried out as part of the environmental assessment (refer Section 8.3) identified non-Aboriginal heritage as an additional key environmental issue for the project. A non-Aboriginal heritage assessment was undertaken to assess the impacts of the project on non-Aboriginal heritage, and to identify management measures to address these impacts. The outcomes of the assessment are summarised in this section.

9.3.1 Assessment approach

The non-Aboriginal heritage assessment was undertaken in accordance with the principles of the Australian International Council on Monuments and Sites (ICOMOS) Burra Charter and current heritage best practice guidelines, including the Department of Planning's (Heritage Branch) *NSW Heritage Manual publication Statements of Heritage Impact* (Heritage Branch and Department of Urban Affairs & Planning 1996).

The assessment of non-Aboriginal heritage built on the work undertaken for the *Hume Highway Upgrade Tarcutta Bypass: Preliminary Environmental Assessment* (RTA 2008a) and included:

- Preparing a revised regional historical overview of the locality.
- Searching all relevant statutory and non-statutory heritage registers.
- Consulting with relevant heritage authorities (including the Heritage Branch of the Department of Planning, RTA Document Management Centre and Wagga Wagga City Council), numerous local historical societies (including the National Trust of Australia) and landowners.
- Inspecting the assessment area to identify and record known and potential heritage items, archaeological artefacts, sites or features, and to assess the archaeological research potential of the assessment area.
- Preparing a non-Aboriginal archaeological assessment and statement of heritage impact (SoHI) for each item identified in the assessment area.

9.3.2 Presence of heritage items/sites

Early development of the area was centred upon the establishment of pastoral runs of numerous squatters. In 1836 the first properties of 'Umbutee' and 'Toonga' were established. From the 1860s the large pastoral runs were subdivided into smaller blocks and taken up by selectors, which resulted in the establishment of mixed farming. Tarcutta town was gazetted in 1890 and supported a couple of general stores, a bakery, a hotel, and postal and telegraphic services.

Pastoral expansion in the 1830s created an arterial route from Sydney as far as Lower Tarcutta, known as the Great Southern Road. By 1836 the main overland route from Sydney to Melbourne began its existence as the Port Phillip Road. In 1928 the road was renamed the Hume Highway.

This historical research formed the basis for the identification of potential heritage items and any areas of potential archaeology.

Five sites/items of heritage significance were identified in the assessment area through heritage inventory searches, historical research and site inspections. Figure 9-6 shows the location of these identified heritage sites/items.

THI2 — Tarcutta House

Tarcutta House is located south of Tarcutta village on the eastern side of the existing highway. Built between 1880 and 1883, Tarcutta House is one of the earliest constructed homesteads in Tarcutta. Tarcutta House is a red brick residence with a timber supported return verandah. It was probably used as a rectory for a period prior to 1923 and a temporary hospital prior to 1933. The orientation of the homestead has been altered due to the redirection of Keajura Creek and the Hume Highway in the 1940s.

Tarcutta House is listed in the Wagga Wagga Rural Development Control Plan, Wagga Wagga Local Environment Plan and on the National Trust Register. The item has not been subject to a conservation management plan.

This item is of local significance.

THI1 — Tarcutta House Well

An historic well located approximately 25 metres north-east of Tarcutta House thought to date to circa 1880 (same period as the construction of Tarcutta House, see below).

This item is of local significance.

THI3 — Ruin of an Old Farmhouse

This item is a ruin consisting of a timber structure with no walls, and is in a state of disrepair. It is located south of Humula Road on the eastern side of the existing highway. It is thought to be the remains of a farmhouse; however, this is unconfirmed.

This item is of local significance.

THI4 — Tarcutta General Cemetery

The Tarcutta General Cemetery was first used in 1893 and was dedicated in October 1898. The cemetery (still in use) currently contains approximately 300 headstones; a number of unmarked burials are also believed to be at the cemetery. The Tarcutta General Cemetery has strong social and cultural ties to the local community. It is located on the western side of the existing highway, adjacent to the village.

This item is of local significance.

THI5 — Hambledon Homestead Complex (including site THI5a — historic brick well)

The Hambledon Homestead Complex lies south-east of the existing Hume Highway bridge over Tarcutta Creek. Built between 1847 and 1849, Hambledon Homestead was a large single storey slab homestead with numerous outbuildings, including an early brick cottage, stables and a wash-house. The homestead is reported to have been the first Tarcutta Post Office, opened in 1849 and operating until 1886.

The complex is made of a number of elements — the main homestead building cluster, which lies in the northern portion of the property, the surrounding paddocks, and an historic brick well. The property is bound by Tarcutta Creek to the east and south, covering approximately 44 hectares.

The original Hambledon Homestead was destroyed by fire in 1987; however, a number of associated outbuildings remain *in situ*, including a brick cottage and bread oven, wash-house, machinery shed, horse stables and cattle yard. A number of cultural plantings line the driveway to the homestead complex. The surrounding paddocks are extensive and are currently used for agricultural practices including the production of fodder crops. An historic brick well (TH15a, see below) is located within the surrounding paddocks, within the western portion of the complex.

The Hambledon Homestead Complex is listed on the State Heritage Register, the Register of the National Estate, the Wagga Wagga Rural Development Control Plan, Wagga Wagga Local Environment Plan and on the National Trust Register. The item has not been subject to a Conservation Management Plan.

This item is of state significance.

THI5a Historic Brick Well

Located in the western portion of the Hambledon Homestead Complex paddocks, the historic well is in sound structural condition. The bricks of the well are consistent with the remaining extant structures associated with the outbuildings. It is likely that the well is contemporary with the outbuildings of the main building complex. This well was once connected to an old windmill. All that remains of the windmill is the frame over the well. It is no longer in use and only one blade remains attached to the hub. The windmill is regarded as being part of the well site.

Table 9-12 provides a summary of the identified sites/items, their heritage listing status and their assessed level of significance.

Table 9-12 Identified non-Aboriginal heritage sites/items in the assessment area

Site ID	Item	Heritage listing	Significance
THI1	Tarcutta House Well	Not listed	Local
THI2	Tarcutta House	National Trust of Australia (NSW) Wagga Wagga Local Environmental Plan (exterior only) (Site No. TAR17) Wagga Wagga Rural Development Control Plan (exterior only) (Site No. TAR17)	Local
THI3	Ruin of an Old Farmhouse	Not listed	Local
THI4	Tarcutta General Cemetery	Not listed	Local
THI5	Hambledon Homestead Complex (including site THI5a historic brick well)	Register of the National Estate National Trust of Australia (NSW) State Heritage Register (Site No. 00351) — this includes a curtilage of approximately 44 hectares Wagga Wagga Local Environmental Plan (Hambledon Homestead) Wagga Wagga Rural Development Control Plan (Hambledon Homestead; Site No. TAR13)	State

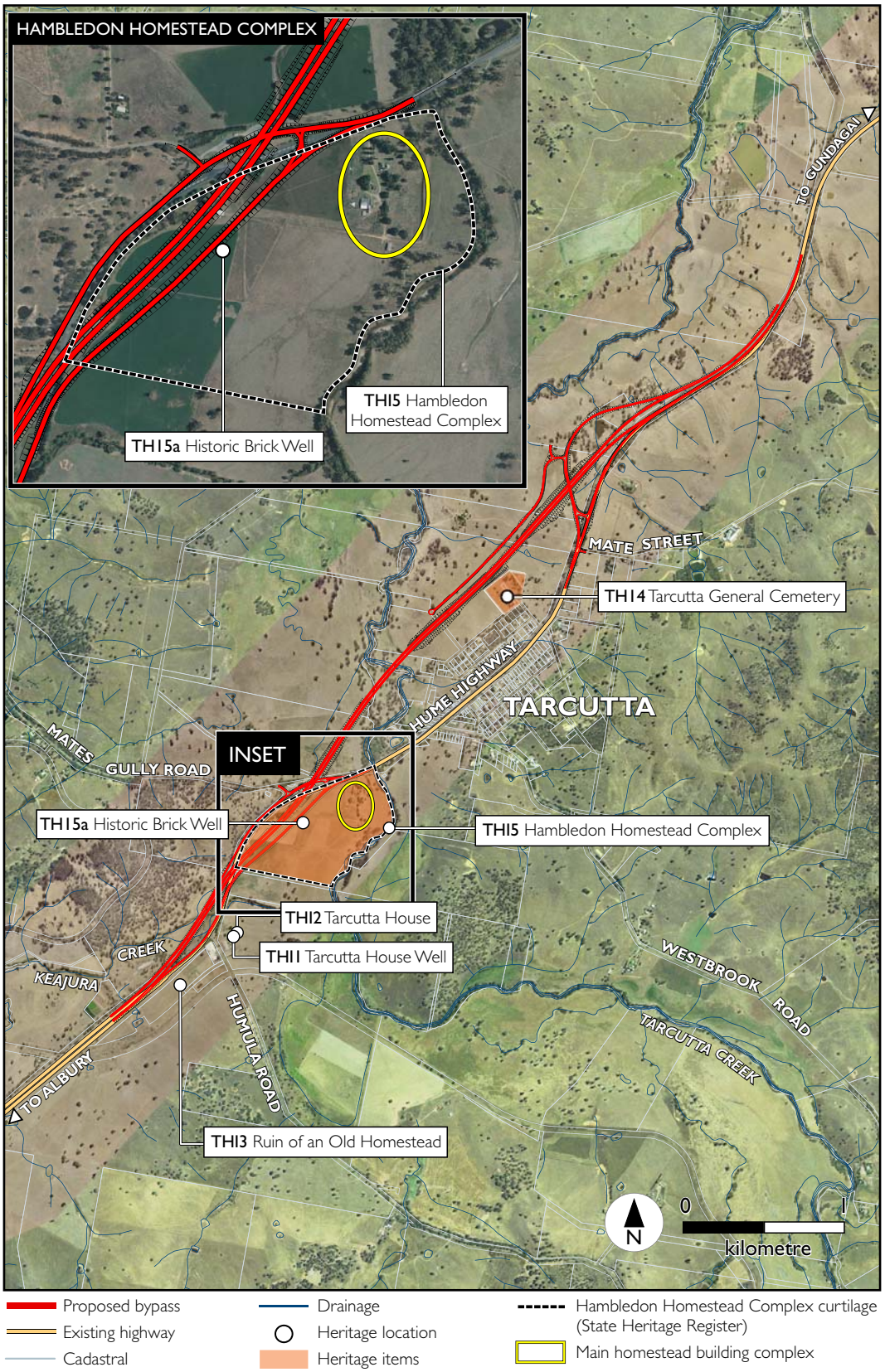

Figure 9-6 **Identified non-Aboriginal heritage in the assessment area**

9.3.3 Assessment of significance

An assessment of significance seeks to understand and establish the importance or value that a place, site, or item may have to the community at large. The concept of cultural significance is intrinsically connected to the physical fabric of the item or place, its location, setting and relationship with other items in its surrounds. A NSW heritage place, item or site may be assessed as having local, state, national or world significance.

To be assessed for listing on the State Heritage Register an item needs to meet one or more of the criteria identified in Table 9-13. A *statement of significance* should summarise the findings of the assessment process.

Table 9-13 State Heritage Register significance assessment criteria

Criterion	Theme	Description
A	Historic	An item is important in the course, or pattern, of NSW's cultural or natural history.
B	Associative	An item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history.
C	Technical/Aesthetic	An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW.
D	Social	An item has strong or special association with a particular community or cultural group in NSW for social, cultural or spiritual reasons.
E	Scientific/Technical	An item has the potential to yield information that will contribute to an understanding of NSW's cultural and natural history.
F	Rare	An item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history.
G	Representative	An item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places, or cultural or natural environments.

THI5 Hambledon Homestead Complex

An assessment of significance has been carried out for the Hambledon Homestead Complex against the State Heritage Register significance assessment criteria, drawing heavily upon previous heritage listings. The primary reason for listing of the Hambledon Homestead on the State Heritage Register was the presence of a large, intact vertical timber slab homestead, which was unusual in its form and, therefore, considered to be of high vernacular architectural importance. Due to a fire, the slab building was lost. This assessment of significance has been carried out for the Hambledon Homestead Complex in its current form, which is with the loss of the slab building. Section 5.3 of Technical Paper 3 (Volume 2) provides more detail on the assessment of significance.

Statement of significance

The Hambledon Homestead Complex in its current form has irreparably lost much of its rarity and ability to demonstrate technical and aesthetic significance. Assessment against the State Heritage Register criteria finds that the Homestead property remains of high local significance for its close association with a notable local figure and politician, Thomas Mate (Criterion B). Mate was a member of the NSW Legislative Assembly and a Magistrate of the Territory. It

was Mate's rise to regional prominence and the development of his business interests that allowed Tarcutta to flourish. Hambledon Homestead Complex, even in its compromised current form, is legible in recording the development of rural settlement at Tarcutta, and its relationship to communications along the Sydney–Melbourne road. This is also of high local significance (Criterion A).

The complex is also of probable high local significance in retaining original outbuildings and plantings dating from the 19th century (Criterion C). At a lower level of significance, but still important at a local level, the Homestead property is of importance to the community in representing the pioneer stage of their history, which forms part of the area's self-identity (Criterion D). It may be possible to salvage information about the original form of the homestead's building from archaeological investigation of the site, including material that may have survived the fire, or be preserved in built form (Criterion E).

The Homestead property is likely to be rare at a local level as an example of mid-19th century property, but this has been compromised by the loss of original buildings and the addition of later construction (Criterion F). The surviving form of the Homestead building complex clearly represents mid-19th century and later homestead properties, through its overall form, mature plantings and relationship to the highway. It is significant in this regard at a local level (Criterion G).

Heritage components of the Hambledon Homestead Complex

Once a heritage item or place has been assessed as having heritage significance, different elements or components of that item can be further assessed by looking at their contribution to the overall heritage value. An element or component of a heritage item can range from exceptional (contributes directly to the overall heritage significance) to intrusive (damaging to the overall heritage significance).

The Hambledon Homestead Complex has been identified as being of State significance, although this has since been severely affected by the loss of the main homestead building by fire. However, the various components of the complex contribute to its significance in differing ways and at differing levels. Table 9-14 identifies the principal components of the complex and how they contribute to its overall level of significance.

Table 9-14 Contributory components of the Hambledon Homestead Complex

Significant components	Contributory significance	Reason
Homestead building complex	Exceptional	The main homestead group of buildings located in the northern portion of the property is the most important component of the heritage item. The original vertical slab timber homestead, now lost, was considered to be of state heritage significance. The remaining buildings in the homestead complex contribute to the ability to perceive and understand the process of rural development through the 19th century (A) and a direct association with Thomas Mate (B). Less importantly, they retain some aesthetic character (C) and archaeological potential (E). The identification of the community with the site as part of their own history probably focuses on the building complex (D). The homestead complex is legible as a representative 19th century homestead in overall form, although individual

Significant components	Contributory significance	Reason
		components are of later date or may be missing (G). It is also rare at a local level as a 19th century homestead group, although compromised (F). This group of buildings, their associated mature plantings, including trees along the entry road, and their relationship to the highway, form the main component of the overall significance of the Hambledon Homestead Complex. While it has been compromised irreversibly by the loss of the homestead it retains individual outbuildings and overall form to demonstrate its significance. It may also contain archaeological evidence that contributes to an understanding of the site's development and vernacular architecture.
Surrounding paddocks	Moderate	The paddocks surrounding the Hambledon building complex derive their significance from being associated with the agricultural activities and land tenure of Thomas Mate (B). While these are historic themes under Criteria A of the Hambledon Homestead heritage listing, they are not State significant in isolation. The paddocks contribute to the overall significance of the item. They reinforce the setting of the homestead precinct and demarcate it spatially, and form part of the overall visual setting of the property (C).
Historic brick well	Moderate	The historic well derives its significance from being associated with the domestic and agricultural activities of the main Hambledon complex (A, C). The bricks of the well are consistent with the fabric of the remaining extant structures of the historic Hambledon outbuildings. It is likely that the well is contemporary with the later outbuildings at Hambledon, and not the original slab homestead. It does not appear to contain archaeological deposits (E). The well contributes to the heritage significance of the main building complex, as it provided a source of fresh water to residents, but has limited heritage significance in isolation.

Note: 1. Refer to Table 9-13 for reference to assessment of significance against State Heritage Register criteria (A) to (G), identified in brackets.

Hambledon Homestead Complex is listed on the State Heritage Register. Due to a fire the original timber slab homestead building, the main reason for listing, was lost. A reassessment indicates that the loss was irreversible and now the property is of high local heritage significance.

The main attributes of its high local significance are its historical importance in the area (Criterion A), and its association with the prominent Thomas Mate (Criterion B). It meets local significance thresholds for all other criteria C to G.

The main expression of the significance of the property is in the Homestead Complex (high significance). The other identified heritage elements are the surrounding paddocks, which is of moderate significance, and the historic well which is also of moderate significance.

Items TH11–TH14

An assessment of significance has been carried out for the four other items not impacted by the project. All other are items of local heritage significance. These are Tarcutta House (TH12) and well (TH11), an old Farmhouse (TH13) and Tarcutta General Cemetery (TH14). Section 5.3 of Technical Paper 3 (Volume 2) provides more detail on the assessment of significance.

9.3.4 Non-Aboriginal heritage impacts

Items TH11–TH14

The Tarcutta House Well, Tarcutta House, the Ruin of an Old Farmhouse and the Tarcutta General Cemetery are located outside the construction site boundary. They would not be directly impacted during construction or operation of the project. However, given their proximity to the project, there is potential that construction and ancillary works may impact these sites if they are not adequately protected.

Indirect impacts to these non-Aboriginal heritage items include the potential loss of visual landscape and modification to their landscape setting.

Items TH15 and TH15a

The project would directly impact two contributory elements of moderate significance (surrounding paddocks and historic brick well) of the Hambledon Homestead Complex and avoid the exceptionally significant element (homestead building complex) of the State Heritage Register listed item. None of the *in situ* outbuildings of the complex would be directly affected by the construction or operation of the project.

The project would impact on a portion (approximately 25 per cent) of the surrounding paddocks within the curtilage of the Hambledon Homestead Complex. This impact would permanently alter the heritage curtilage of the Hambledon Homestead Complex. Detailed design would seek to minimise the extent of impacts on the Hambledon Homestead Complex where possible.

Construction of the project is likely to result in additional temporary impacts on the surrounding paddocks, due to the construction of temporary sediment basins and the potential relocation of services and utilities.

Temporary sediment basins are required as part of the project soil and water management in order to protect water quality of adjacent waterways. Two temporary sediment basins are currently proposed within the construction site boundary. Detailed design would seek to minimise the encroachment of temporary sediment basins into the surrounding paddocks; however, some impact is likely.

Service relocations, including the relocation of underground telecommunications cable (Nextgen fibre optic and Telstra copper cable), are also likely to be required within the curtilage of the Hambledon Homestead Complex (refer Section 5.3.11). The relocation of services would be via methods that include ploughing and trenching. Final service relocation would be determined during detailed design. Services are, however, generally offset from the final property boundary.

Temporary sediment basins and service relocation impact would be limited to the surrounding paddocks, and be temporary in nature. Any ground disturbance would be rehabilitated in consultation with the landowner.

The project may impact on the historic brick well (and associated windmill), located within the curtilage of the Hambledon Homestead Complex. If impacted, the well would be partially dismantled and the windmill would be removed in consultation with the landowner. Detailed design would seek to avoid impact to this site, where possible.

It is considered that the likely impacts to the moderately significant contributory elements of the Hambledon Homestead Complex, the historic brick well and surrounding paddocks, would only moderately reduce the State heritage significance of the Hambledon Homestead Complex. The cultural landscape value of the remaining surrounding paddocks would continue to contribute to its heritage significance.

9.3.5 Management of impacts

Table 9-15 identifies mitigation and management measures that would be implemented for non-Aboriginal heritage impacts of the project. These measures have been incorporated into the draft statement of commitments in Chapter 11.

Table 9-15 Non-Aboriginal heritage mitigation and management measures

Potential impact	Mitigation and management measure
Pre-construction	
Direct and indirect impacts on non-Aboriginal heritage	▪ Manage impact to non-Aboriginal heritage through the CEMP for the project. ▪ Seek to minimise impacts to the State Heritage Register listed Hambledon Homestead Complex (and historic brick well) during detailed design. ▪ Implement relevant mitigation (archival record, test/salvage excavation) for impacted heritage items including the Hambledon Homestead Complex and historic brick well, prior to the commencement of construction works. Lodge the archival record with the Heritage Branch (Department of Planning), Wagga Wagga City Council and the RTA Archives. ▪ Prior to the commencement of construction activities, fence all identified historic items within the construction site boundary that are not to be impacted.
Construction	
Direct and indirect impacts on non-Aboriginal heritage	▪ Consider the heritage values of Hambledon Homestead Complex, Tarcutta House and Tarcutta General Cemetery in consultation with relevant landowner(s) and a suitably qualified heritage specialist as part of the landscaping and urban design.
Construction works uncovering unmarked graves outside of formal cemetery boundary	▪ Undertake a remote sensing survey of the area within 100 metres of the formal Tarcutta General Cemetery boundary to identify the presence of any potential burials or other features. ▪ Engage a suitably qualified heritage specialist to oversee the stripping of topsoil within 100 metres of the formal cemetery boundary (if required). No work would be permitted within 10 metres of the formal cemetery boundary.
Construction works uncovering previously unidentified non-Aboriginal heritage	▪ If any unknown non-Aboriginal heritage items are encountered, immediately stop all works that would potentially impact the find. Do not recommence works until appropriate clearance is received.

Potential impact	Mitigation and management measure
Operation	
Known historic value of the Hambledon Homestead complex not reflected in its heritage listing	▪ Engage a suitably qualified heritage specialist to prepare a revised and updated heritage listing that incorporates the impacts of the project on the Hambledon Homestead Complex and lodge with the Heritage Branch (Department of Planning). ▪ Provide assistance for the development of a conservation management plan for Hambledon Homestead Complex. This would be in consultation with the landowner and relevant government agencies.
Historic value of the Tarcutta General Cemetery not acknowledged through a heritage listing	▪ Make a recommendation to Wagga Wagga City Council to list the Tarcutta General Cemetery as a heritage item in the Wagga Wagga Local Environment Plan.

9.4 Hydrology

Surface water and groundwater assessments were undertaken for the project as presented below. These are supported by *Technical Paper 4 — Surface Water* and *Technical Paper 5 — Groundwater* (Volume 2).

DGRs	Where addressed
Hydrology (including but not limited to):	
Site water demands and impacts on water sources and users.	Sections 9.4, 6.3 Technical Papers 4, 5 (Volume 2)
Impacts to watercourses, riparian corridors and groundwater dependent ecosystems.	Sections 9.1.3, 9.4.3, 10.1.3, 10.1.4 Technical Papers 4, 5 (Volume 2)
Changes to existing flood regimes and characteristics, taking into account the *NSW Floodplain Development Manual* (NSW Government 2005).	Section 9.4.3 Technical Paper 4 (Volume 2)

9.4.1 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 2, 3 and 4 of Technical Paper 4 (Volume 2). The assessment included:

- Flood assessment of Tarcutta Creek to evaluate the impacts of the project on the existing flow regime and on the properties surrounding Tarcutta, undertaken in accordance with the *NSW Floodplain Development Manual* (NSW Government 2005), including a review of available flooding information and data, and hydrologic modelling.
- Local catchment assessment to identify water bodies and drainage lines potentially affected by the project and to determine the impacts to these water bodies and drainage lines.
- A water supply assessment of the project, including an estimation of the water requirements for construction and the impacts on water sources and users.

A water quality assessment was also carried out as part of the surface water assessment and is summarised in Section 10.1.

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 5 (Volume 2). The assessment included:

- Assessment of groundwater levels.
- Consideration of the likely impacts on groundwater during construction and operation.

The results of the groundwater quality sampling are provided in Section 10.1.

9.4.2 Existing environment

Surface water

The project is located in the Tarcutta Creek catchment. The Tarcutta Creek catchment area is part of the Murrumbidgee catchment area of NSW, with flows discharging into the Murrumbidgee River near Oura, north-west of Tarcutta.

Local catchment

Tarcutta Creek has two main tributaries: Keajura Creek and Umbango Creek. Tarcutta Creek is described as being under both environmental and hydrological stress due to prolonged drought conditions and water extraction (DLWC 1999).

Flows in Tarcutta Creek are characterised by a seasonal pattern with lower flows generally over summer and autumn, and flood events during winter and spring. During the site investigation in October 2008, the creek was noted to consist of stagnant pools within the creek bed with low flow. The creek banks were found to be densely vegetated, with long grass covering the creek bed where dry.

The project crosses Tarcutta Creek and a number of local drainage lines. Several dams exist along some of the drainage lines. The drainage lines and dams identified during the site investigation are shown in Figure 9-7 and are described in Section 3.2 in Technical Paper 4 (Volume 2).

Hydrology and flooding

Tarcutta Creek has a history of flooding with significant events being recorded in July 1939, October 1955, August 1970, October 1974, September 1978, August 1983, October 1992, and September 2005. In 1969, two levees were constructed on the upstream side of the existing Hume Highway to guide floodwaters under the Hume Highway bridges and provide some level of flood protection within the floodplain. Both levees were overtopped during a large storm event in the 1980s. The RTA subsequently raised the height of the levees to minimise flooding over the existing Hume Highway and to increase protection of adjacent properties.

Peak design flows for Tarcutta Creek, Keajura Creek and the downstream catchment area 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 18 hours. The peak design flows are presented in Table 9-16.

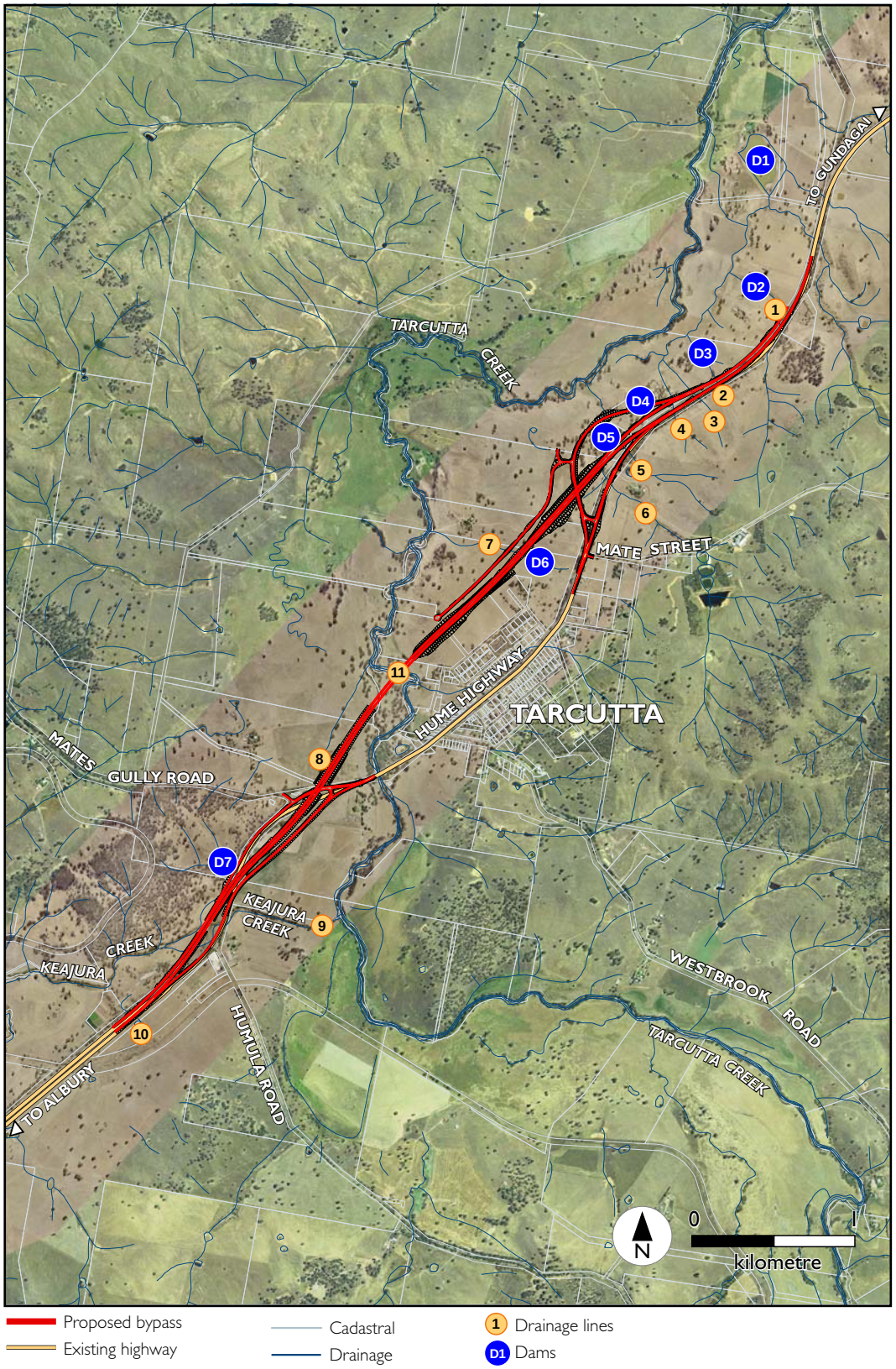

Figure 9-7 **Locations of drainage lines and dams**

Table 9-16 Peak design flows

Location	Peak design flows (cubic metres per second)			
	1 in 20 year ARI	1 in 100 year ARI	1 in 2000 year ARI	PMF
Tarcutta Creek	449	779	1956	7471
Keajura Creek	91	166	446	1697
Downstream catchment area	43	61	167	572

Peak design flood levels at key locations within the Tarcutta Creek floodplain, under the existing conditions, are presented in Table 9-17. Levels highlighted in ***bold italic*** text indicate that the finished floor level for a building on the property is currently below the flood level of the 1 in 100 year ARI event. The key locations represent existing or proposed structures, such as buildings and bridges, currently at risk of inundation during larger flood events. They are all located within the existing flood extent boundary (see Figure 9-8).

Table 9-17 Peak design flood level at key locations within the floodplain

Location	Finished floor level (metres AHD)[1]	Peak design flood level (metres AHD)[1,2]	
		1 in 20 year ARI	1 in 100 year ARI[3]
Properties			
Residential property 1	227.65	227.69	***228.02***
Residential property 2	228.46	Protected by levee	***229.61***
Water treatment plant[4]	227.15	Protected by levee	***227.72***
Tarcutta Hotel	227.35	227.33	***227.61***
Service station	228.01	Protected by levee	Not flood affected
Shop	228.58	Protected by levee	Not flood affected
Residential area			
Number 6 — Building 1	228.04	Protected by levee	227.71
Number 8 — Building 2	228.30	Protected by levee	227.72
Number 10 — Building 3	228.35	Protected by levee	227.87
Number 12 — Building 6	228.82	Protected by levee	Not flood affected
Police house — Building 4	228.40	Protected by levee	Not flood affected
Police station — Building 5	228.66	Protected by levee	Not flood affected

Location	Finished floor level (metres AHD)[1]	Peak design flood level (metres AHD)[1,2]	
		1 in 20 year ARI	1 in 100 year ARI[3]
Bridges			
Existing Hume Highway bridge over Tarcutta Creek	-	228.61	229.38
Existing Hume Highway bridge over Tarcutta Creek floodway	-	228.54	229.20
Existing Hume Highway bridge over Keajura Creek	-	230.53	231.44
Proposed bypass bridge over Tarcutta Creek	-	226.75	226.99
Proposed bypass bridge over Tarcutta Creek floodway	-	227.45	227.71
Proposed bypass bridge over Keajura Creek	-	230.66	231.54

Notes: 1. metres AHD = metres Australian height datum.

2. While values are listed to the nearest 0.01 metres, for the purpose of this assessment, the accuracy of the model is within the order of +/- 0.1 metres.

3. Levels in ***bold italic*** text indicate finished floor levels below the existing 1 in 100 year ARI flood level.

4. Riverina Water County Council has advised that the water treatment plant infrastructure (ie pump, electrical controls) is above 228 metres AHD. It is also noted that the old plant infrastructure is being replaced by new infrastructure, which will be operational in September 2009.

The 1 in 100 year ARI peak design flood event, with a critical rainfall event duration equal to 18 hours, results in approximately 45 to 50 hours of out-of-bank flooding. The following points document the existing 1 in 100 year ARI peak design flood behaviour in and around Tarcutta, as predicted from the hydraulic model:

- Flood waters generally remain within the main channels of Tarcutta and Keajura creeks for the first two hours of the event.
- The existing Hume Highway floodway bridge in the Tarcutta Creek floodplain begins to operate once flood waters reach approximately 226.1 metres Australian height datum (AHD).
- Left overbank flooding downstream of the existing Hume Highway and upstream of the confluence of Tarcutta and Keajura creeks, which causes ponding upstream of the highway embankment, occurs approximately 2.5 hours after the beginning of the event.
- Overtopping of the Tarcutta town levee, and subsequently the existing Hume Highway, begins approximately 8.5 hours after the beginning of the event.
- The levee for residential property 2 overtops approximately 9.5 hours after the beginning of the event.
- The peak flow and resulting peak water level occurs approximately 13 hours after the beginning of the event.
- Floodwaters subside over the next one to two day period.

During the 1 in 20 year ARI event, neither levees are overtopped, nor is the existing Hume Highway. Residential property 1, downstream of the existing Hume Highway, experiences some flooding.

Surface water use

The Tarcutta Creek catchment has a large number of active water users, with more than 100 water access licences under the *Water Management Act 2000* granted within the catchment. The *Water Sharing Plan for the Tarcutta Creek Water Source 2003* regulates the total share component for these licences. The total annual water entitlement is approximately 5600 megalitres. There is currently an embargo in place on the granting of new water licences for commercial purposes within the Murray-Darling Basin.

The major water uses in the locality include irrigation of grazing land, improved pastures and lucerne. Most riparian landholdings access Tarcutta Creek for domestic use (mostly non-potable) and stock watering under a basic landholder right. Based on the field investigations and review of aerial photography, there is no clear evidence of irrigation infrastructure (including irrigation channels) within the construction site boundary. Further downstream from the project there are several active water users, including a fully established dairy.

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, 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.

The Ordovician metasediments comprise low metamorphosed slate, greywacke, quartzites, phyllite, hornfels and schists in the lower reaches. Weathering and fracturing of the Ordovician metasediments has resulted in secondary porosity (fracturing) within the unit.

The unconsolidated alluvial deposits are all of Quaternary age and overlie the fractured rocks in the valleys and lower lying areas. The greatest thickness of alluvium is associated with Tarcutta and Keajura creeks, and their tributaries. The alluvial deposits comprise sand, silt, gravel and clay, with the thickness of the alluvium typically ranging between 10 and 30 metres; thickness is governed by bedrock topography.

Aquifer characteristics

Two main aquifer systems are present:

- Unconsolidated and unconfined alluvial aquifers: the majority of boreholes are shallow and obtain their supply from the groundwater within the alluvial systems. The alluvium, specifically of Tarcutta and Keajura creeks, has a higher permeability than the surrounding fractured rock aquifers. Yields from bores constructed within the alluvial aquifer at Tarcutta range from 0.3 to 1.5 litres per second. From the data contained in the DECCW (former Department of Water and Energy) database the bore depths in the alluvium range from four to 23 metres below ground level.
- Semi-confined fractured rock aquifers (Ordovician metasediments): The fractured rock aquifers generally produce low and unpredictable groundwater yields, and the groundwater quality 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. Only a small number of bores are installed within the fractured rock and from the data contained in the DECCW (former Department of Water and Energy) database bore depths extend to between 23 and 126 metres below ground level.

The water table is generally a muted reflection of the topography for both the alluvial and the fractured rock aquifers, and there is hydraulic connectivity between the two aquifer systems. Recharge into the groundwater systems occurs via direct rainfall and run-off and also via connection with overlying creeks. Groundwater discharge is likely to be in the lower lying areas of the landscape (springs), at the break of slope 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 October 2008 field investigation (see Section 5.5 of Technical Paper 5 (Volume 2)). The results indicate that the groundwater levels in the alluvium are generally shallow, ranging from 1.67 to 11.93 metres below ground level. The groundwater table in the alluvium was very flat, with a total fall of 5.26 metres between the maximum and minimum groundwater level for alluvial bores.

The groundwater levels within the fractured rock aquifer were slightly deeper below ground than the alluvial aquifer.

Once converted into metres AHD, there was minimal difference between the relative groundwater levels in the alluvium and fractured rock aquifers. The groundwater table within the fractured rock was relatively flat with a total fall of 8.4 metres between the maximum and minimum groundwater level across all of the bores gauged.

Groundwater use

The majority of bores in the locality are licensed to supply domestic and stock requirements. Three boreholes are registered and licensed for town water supplies for Tarcutta and two boreholes are licensed for commercial/industrial purposes (DWE 2008). No bores close to Tarcutta village were licensed for irrigation. However, there are groundwater irrigators within the greater Tarcutta Creek catchment.

The town water supply bores are located between Tarcutta village and Tarcutta Creek, to the south-west of the village. The bores are located on the up-gradient side of the project.

No bores registered with the DECCW (former Department of Water and Energy) and no bores identified during the field investigations were located within the alignment of the project.

The majority of high-yielding bores within the Tarcutta Creek catchment obtain their groundwater supplies from alluvial sediments. Within the Tarcutta alluvium the total volume of groundwater entitlements is 2453 megalitres, which is distributed between 18 renewable licences. During the 2007-08 water year, only 235 megalitres of the total allowable volume was reportedly extracted (Pers. Comm. DWE 2009; DLWC 2000).

There are some limited high-yielding bores within the Tarcutta catchment that are located within the fractured rock sediments. A total allocation of 397 megalitres from fractured rock aquifers is distributed between 12 irrigation licences (Pers. Comm. DWE 2009; DLWC 2000). Another groundwater extraction bore was licensed for the fractured rock aquifer in 2007. This bore was drilled by the Northern Hume Alliance as part of the Hume Highway duplication to the north of Tarcutta.

9.4.3 Potential hydrology impacts

Construction

Local catchment impacts

The project crosses several local drainage lines that have the potential to be temporarily blocked or diverted during the construction of the project. Blocking or diversion of drainage lines may result in localised areas of flooding on the upstream side of the project and may prevent flows from reaching downstream receiving waters or farm dams. 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.

Flooding and hydrology impacts

Construction of the project would include earthworks and construction of pavement and bridge structures across the Tarcutta Creek and Keajura Creek floodplain. During construction, these works have the potential to affect flood behaviour and change flood flow distribution (as a result of blockage of usual flow paths in the case of a flood extent). There is also potential for construction works to be affected by flooding. Depending on the location of flow blockages in relation to properties within the floodplain, there is the potential that these changes may impact properties.

Water supply impacts

Section 6.3 discusses the water requirements for the project (approximately 200 megalitres over the two year construction period) and the potential sources of that water. The embargo on the granting of new licences for commercial purposes within the Murray-Darling Basin means that water extraction from Tarcutta Creek would be unlikely for the project. Surface water extraction would likely be limited to water captured on site or existing farm dams. The project would, therefore, be unlikely to have an overall impact on surface water supplies and surrounding users.

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 much as possible. The project may, however, require the diversion or realignment of some minor waterways. This may cause localised flooding upstream and downstream of the project, impacts to flow velocity resulting in sedimentation, and may impact water supply to downstream dams and receiving waters. Potential impacts would be mitigated through the longitudinal drainage system for the project and the measures outlined in Section 9.4.5.

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 Murrumbidgee catchment (within which this project is located), the future climate is likely to experience increased extreme rainfall events. The CSIRO predicts a five per cent increase in extreme rainfall (1 in 40 year ARI 1 day rainfall event) 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.

Flooding and hydrology 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 alter the distribution of flow within the Tarcutta Creek floodplain both upstream and downstream of the proposed crossing. The project would reduce the floodplain storage area where it encroaches into the existing floodplain. Floodwaters would also be prevented from reaching some storage areas, specifically areas south of the existing highway within residential property 1 and areas in the left overbank immediately downstream of the project. The embankment would block the conveyance of flows except where bridges or openings are constructed. Changes in flow distribution may lead to increased flood levels (afflux) and changes in flood inundation extent and velocity.

The project would cause some afflux in the adjacent floodplain areas for the 1 in 100 year ARI event. Afflux for the 1 in 20 year ARI is a critical factor due to the two levees and the flood protection they provide under existing conditions. Afflux at key locations for the 1 in 20 year and 1 in 100 year ARI events is summarised in Table 9-18. Figure 9-8 shows the existing and proposed flood extents and afflux for the 1 in 100 year ARI flood event.

Table 9-18 Afflux at key locations during the 1 in 20 year and 1 in 100 year ARI events

Location	Existing 1 in 20 year ARI[1]	Proposed 1 in 20 year ARI[1]	Afflux (metres)	Existing 1 in 100 year ARI[1]	Proposed 1 in 100 year ARI[1]	Afflux (metres)
Properties						
Residential property 1	227.69	227.70	0.01	228.02	228.06	0.04
Residential property 2	Protected by levee	Protected by levee	-	229.61	229.62	0.01
Water treatment plant[2]	Protected by levee	Protected by levee	-	227.72	227.75	0.03
Tarcutta Hotel	227.33	227.34	0.01	227.61	227.71	0.10
Service station	Protected by levee	Protected by levee	-	Not flood affected	Not flood affected	-
Shop	Protected by levee	Protected by levee	-	Not flood affected	Not flood affected	-

Location	Existing 1 in 20 year ARI[1]	Proposed 1 in 20 year ARI[1]	Afflux (metres)	Existing 1 in 100 year ARI[1]	Proposed 1 in 100 year ARI[1]	Afflux (metres)
Residential area						
Number 6 — Building 1	Protected by levee	Protected by levee	-	227.71	227.75	0.03
Number 8 — Building 2	Protected by levee	Protected by levee	-	227.72	227.75	0.03
Number 10 — Building 3	Protected by levee	Protected by levee	-	227.87	227.87	0.00
Number 12 — Building 6	Protected by levee	Protected by levee	-	Not flood affected	Not flood affected	-
Police house — Building 4	Protected by levee	Protected by levee	-	Not flood affected	Not flood affected	-
Police station — Building 5	Protected by levee	Protected by levee	-	Not flood affected	Not flood affected	-
Bridges						
Existing Hume Highway bridge over Tarcutta Creek	228.61	228.62	0.01	229.38	229.40	0.02
Existing Hume Highway bridge over Tarcutta Creek floodway	228.54	228.55	0.01	229.20	229.21	0.01
Existing Hume Highway bridge over Keajura Creek	230.53	230.53	0.00	231.44	231.42	-0.03

Notes: 1. While all values are listed to the nearest 0.01 metres, for the purpose of the assessment, the accuracy of the model is within the order of +/- 0.1 metres.

2. Riverina Water County Council has advised that the water treatment plant infrastructure (ie pump, electrical controls) is above 228 metres AHD. It is also noted that the old plant infrastructure is being replaced by new infrastructure, which will be operational in September 2009.

Table 9-18 indicates that the afflux predicted to occur as a result of the project would be very minor: the Tarcutta Hotel is predicted to have the greatest afflux of 0.1 metres. The predicted afflux of 0.03 metres at the water treatment plant would not affect the infrastructure at that location, as it is positioned above 228 metres AHD.

The duration of inundation is the amount of time that a property experiences flooding during a particular storm event. The project would increase the estimated amount of time that some properties experience inundation during the 1 in 100 year ARI storm event, including:

- Water treatment plant: inundation time increased 1.5 hours (the infrastructure at the water treatment plant would not be inundated).
- Tarcutta Hotel: inundation time increased 1.5 hours.

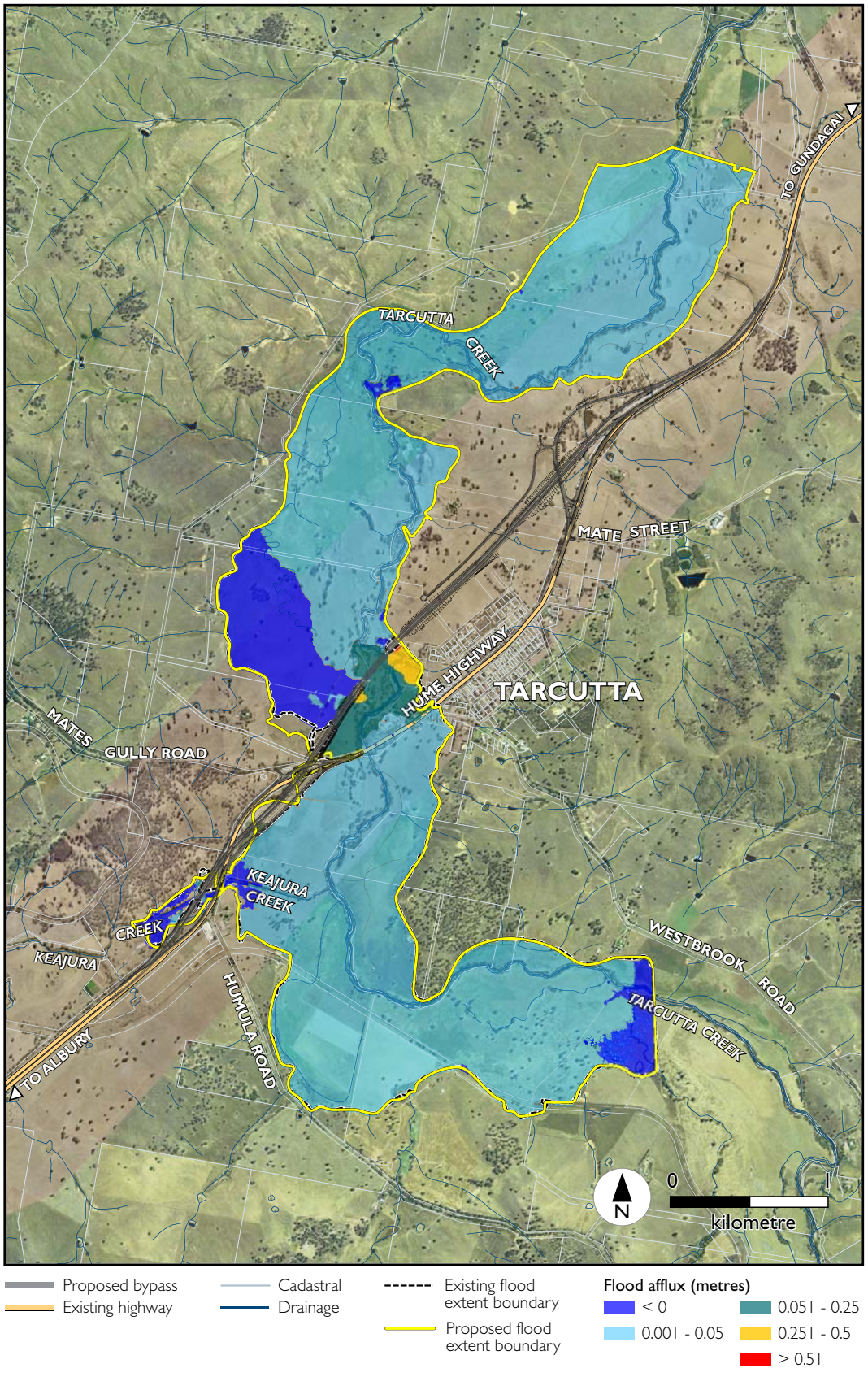

Figure 9-8 **Existing and proposed 1-in-100 year ARI flood extents and afflux**