4 Biodiversity in the project area and study areas

This chapter describes biodiversity in the project area and study areas, and has been informed by the detailed desktop assessment and extensive field surveys completed for the project. It provides an overview of biodiversity in the project area and study areas, identifies the threatened species, populations and communities recorded or predicted to occur, and identifies and characterises potential groundwater dependent ecosystems. The information in this chapter has informed the assessment of direct and indirect impacts for the project.

4.1 Native vegetation

4.1.1 The project area

The majority of the project area including proposed surface infrastructure areas, comprises cleared land dominated by exotic grasses and herbs. Remnant native vegetation is mainly restricted to the north-west of the project area, though some occurs in the central northern area, associated with creeks, and there are isolated paddock trees in places. There are also scattered patches of poorer condition native vegetation in agricultural areas in the centre of the project area, generally comprising isolated stands of native trees with an exotic groundcover. Remnant native vegetation covers approximately 1,800 ha (or 20%) of the project area.

A total of 90 introduced plant species were recorded in plots completed in the project area and its immediate surrounds, comprising 20% of all plant species recorded. A large part of the north-western terrestrial study area is covered by pine plantation, containing Radiata Pine (*Pinus radiata*) and Maritime Pine (*P. pinaster*). Weeds are prevalent in the eastern part of the terrestrial study area that is cleared, particularly exotic grasses. Some Weeds of National Significance including Blackberry (*Rubus fruticosis spp. agg*), Fireweed (*Senecio madagascariensis*), Serrated Tussock (*Nassella trichotoma*) and Willows (*Salix* spp.) occur in this area. Significant infestations of an invasive weed, Gorse (*Ulex europaeus*), are present in the central southern and central northern parts of the terrestrial study area. A full list of weeds recorded in the terrestrial study area and immediate surrounds is provided in Appendix C.

A total of 353 native flora species have been recorded in the project area and its immediate surrounds by the current study (Appendix C). Plot data collected and the vegetation map prepared for the project area were compared to the broader vegetation map prepared for the Wingecarribee local government area by EcoLogical (2003). The map was found to be generally consistent in the eastern part of the project area on shale soils. However, the vegetation map prepared for the project area differed from that of EcoLogical (2003) in the prediction of vegetation communities that would occur on basalt (ie Robertson Basalt Tall Open Forest) and shale soils (ie Southern Highlands Shale Woodland) in Belanglo State Forest. These soil and vegetation types were found to be absent from Belanglo State Forest which was characterised primarily by sandstone, with some outcropping of the Illawarra Coal Measures observed at the bottom of sandstone gullies.

A high level of survey effort was employed during the current study to characterise vegetation types within the project area (ie 64 plot and transect flora surveys) in comparison with EcoLogical (2003). The focus of the EcoLogical (2003) mappingwas to characterise vegetation across the entire Wingecarribee LGA, and therefore they undertook limited ground-truthing of vegetation in the project area.. The detailed plot and transect data collected for the current study provides a higher level of accuracy than the EcoLogical (2003) vegetation mapping for the project area, and therefore it has been adopted as the vegetation map for this biodiversity assessment.

Eight native vegetation communities have been recorded in the project area, generally comprising eucalypt forests and woodlands, as follows:

- wet sclerophyll forest:
  - River Peppermint (*E. elata*) Narrow-leaved Peppermint (*E. radiata*) tall open forest;
- dry sclerophyll forests/woodlands:
  - Grey Gum (*E. punctata*) Blue-leaved Stringybark (*E. agglomerata*) open forest;
  - Brittle Gum (*E. mannifera subsp. gullickii)* Scribbly Gum shrubby woodland; and
  - Gully Gum (*E. smithii*) Scribbly Gum open woodland.
- grassy woodlands:
  - Gully Gum Narrow-leaved Peppermint open woodland;
  - Broad-leaved Peppermint (*E. dives*) Argyle Apple (*E. cinerea*) grassy woodland;
  - Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland; and
  - Snow Gum (*E. pauciflora*) Black Sallee (*E. stellulata*) grassy woodland.

These communities have been classified into plant community type (PCT) in accordance with Section 5.2 of the Framework for Biodiversity Assessment (OEH 2014), applying the classifications described in OEH's NSW Vegetation Information System (VIS) Classification Database.

A detailed analysis of the plot and transect data collected for the current study was completed against the PCTs in the VIS Classification Database in order to characterise the PCTs present in the project area. This detailed analysis is provided in Appendix C, which also provides detailed descriptions of each vegetation type present in the project area. A summary of the PCTs in the project area is provided in Table 4.1, and a native vegetation map is presented as Figure 4.1.

The project area also contains two exotic vegetation types, comprising Pine Forest and Cleared Land. These exotic vegetation types are described in Appendix C.

The area's landscape features are assessed in Chapter 3, with consideration to attributes such as native vegetation coverage, connectivity and patch sizes.

Table 4.1 Plant community types in the project area

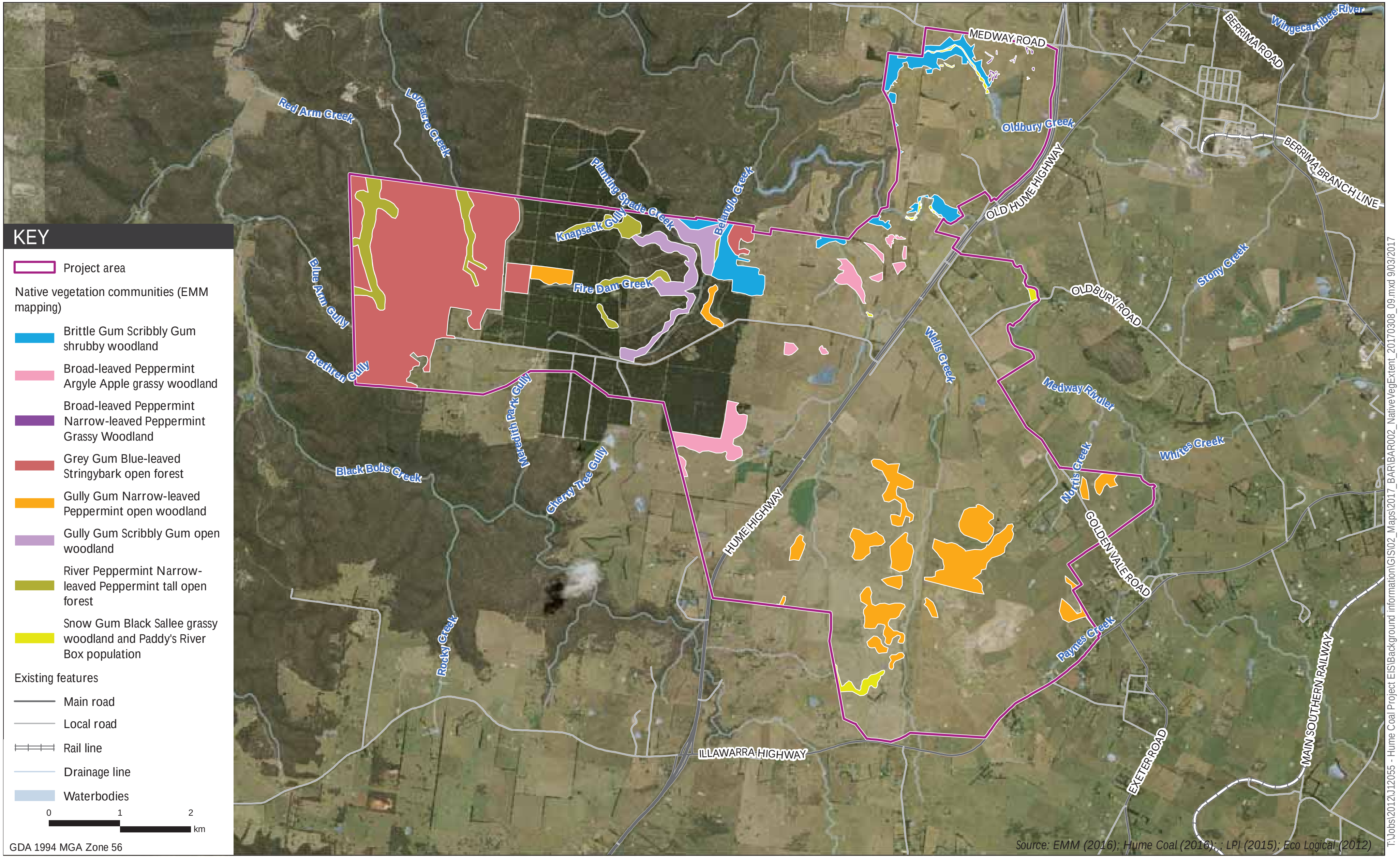
Formation	Class	Community name	Plant Community Types	Biometric Vegetation Type	Dominant canopy species	Dominant midstorey species	Dominant groundcover species	Condition	Percentage cleared in major catchment area	Conservation status
Dry Sclerophyll Forests (shrub/grass sub-formation)	Central Gorge Dry Sclerophyll Forests	Grey Gum Blue-leaved Stringybark open forest	PCT 838 Grey Gum – Blue-leaved Stringybark open forest on gorge slopes, southern Sydney Basin Bioregion and north east South Eastern Highlands Bioregion	HN531 Grey Gum – Blue-leaved Stringybark open forest on gorge slopes, southern Sydney Basin Bioregion and north east South Eastern Highlands Bioregion	Blue-leaved Stringybark (*Eucalyptus agglomerata*), Grey Gum (*E. punctata*), White Stringybark (*E. globoidea*), Silvertop Ash (*E. sieberi*)	Black She-oak (*Allocasuarina littoralis*), Hairpin Banksia (*Banksia spinulosa*), Narrow-leaved Geebung (*Persoonia linearis*), Sydney Golden Wattle (*Acacia longifolia subsp. longifolia*)	Lance Beard Heath (*Leucopogon lanceolatus*), Wiry Panic (*Entolasia stricta*), *Hydrocotyle peduncularis*, Small St John's Wort (*Hypericum gramineum*), Forest Goodenia (*Goodenia hederacea subsp. hederacea*)	Moderate to good	20	N/A
Dry Sclerophyll Forests (shrub/grass sub-formation)	Central Gorge Dry Sclerophyll Forests	Gully Gum Scribbly Gum open woodland	PCT 1093 Red Stringybark – Brittle Gum – Inland Scribbly Gum dry open forest of the tableland, South Eastern Highlands Bioregion	PCT 1093 is linked with HN 570 Red Stringybark – Brittle Gum – Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands	Gully Gum (*E. smithii*), Scribbly Gum (*E. racemosa*)	Hairpin Banksia, Broad-leaved Hakea (*Hakea dactyloides*)	Bracken, Spiny-headed Mat Rush (*Lomandra longifolia*), Forest Goodenia, Weeping Meadow Grass	Moderate to good	55	N/A
Dry Sclerophyll Forests (shrub/grass sub-formation)	Southern Tableland Dry Sclerophyll Forest	Brittle Gum Scribbly Gum Shrubby Woodland	PCT 1093 Red Stringybark – Brittle Gum – Inland Scribbly Gum dry open forest of the tableland, South Eastern Highlands Bioregion, however is not a good match	HN 570 Red Stringybark – Brittle Gum – Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands	Brittle Gum (*Eucalyptus mannifera subsp. gullickii*), Narrow-leaved Scribbly Gum (*E. racemosa*), Broad-leaved Peppermint (*E. dives*)	Hairpin Banksia, Broad-leaved Hakea, Tantoon (*Leptospermum polygafolium subsp. polygafolium*), Leptospermum *trinervium*, *Bossiaea rhombifolia subsp. rhombifolia*	Shrubby Platysace (*Platysace lanceolata*), Forest Goodenia, *Dampiera purpurea*, Silky Purple Flag (*Patersonia sericea*), Spiny-headed Mat Rush	Moderate to good	55	N/A

Table 4.1 Plant community types in the project area

Formation	Class	Community name	Plant Community Types	Biometric Vegetation Type	Dominant canopy species	Dominant midstorey species	Dominant groundcover species	Condition	Percentage cleared in major catchment area	Conservation status
Wet Sclerophyll Forest (shrubby sub-formation)	Southern Escarpment Wet Sclerophyll Forest	River Peppermint Narrow-leaved Peppermint tall open forest	PCT 1107 River Peppermint – Narrow-leaved Peppermint open forest on sheltered escarpment slopes, Sydney Basin Bioregion and South East Corner Bioregion	This community aligns with HN 575 River Peppermint – Narrow-leaved Peppermint open forest on sheltered escarpment slopes, Sydney Basin Bioregion and South East Corner Bioregion	River Peppermint (*E. elata*) and either Brown Barrel (*E. fastigata*) or Narrow-leaved Peppermint	River Lomatia (*Lomatia myricoides*), Dolly Bush (*Cassinia aculeata*), Lance Beard Heath (*Leucopogon lanceolatus*), *Notelaea longifolia f. longifolia*	Weeping Meadow Grass (*Microlaena stipoides var. stipoides*), *Hydrocotyle peduncularis*, Spiny-headed Mat Rush (*Lomandra longifolia*), Bracken (*Pteridium esculentum*)	Moderate to good	10	N/A
Grassy Woodlands	Southern Tablelands Grassy Woodland	Gully Gum Narrow-leaved Peppermint open woodland	PCT 731 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion	HN514 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands	Narrow-leaved Peppermint (*Eucalyptus radiata*), Gully Gum (*E. smithii*)	Spearthistle (*Cirsium vulgare**), Prickly Sowthistle (*Sonchus asper**)	White Clover (*Trifolium repens**), Subterranean Clover (*Trifolium subterraneanum**), Plantain (*Plantago lanceolata**), Prairie Grass (*Bromus cartharticus**), Blackberry (*Rubus fruticosis spp. agg*)	Moderate to good	80	N/A
Grassy Woodlands	Southern Tablelands Grassy Woodland	Broad-leaved Peppermint Argyle Apple grassy woodland	PCT 731 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion	HN514 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands	Argyle Apple (*E. cinerea*), Broad-leaved Peppermint, Brittle Gum, Scribbly Gum, Narrow-leaved Peppermint, Candlebark (*E. rubida*)	Dolly Bush, *Daviesia latifolia*	Weeping Meadow Grass, Snowgrass (*Poa sieberiana var. cyanophylla*), Kangaroo Grass (*Themeda australis*), Bluebottle Daisy (*Lagenophora stipitata*), Small St John's Wort, Forest Goodenia, *Lomandra filiformis subsp. coriacea*	Moderate to good	80	This community is a component of the Southern Highlands Shale Woodland in the Sydney Basin Bioregion EEC

Table 4.1 Plant community types in the project area

Formation	Class	Community name	Plant Community Types	Biometric Vegetation Type	Dominant canopy species	Dominant midstorey species	Dominant groundcover species	Condition	Percentage cleared in major catchment area	Conservation status
Grassy Woodlands	Subalpine Woodland	Snow Gum Black Sallee grassy woodland	PCT 677 Black Gum Grassy Woodland of damp flats and drainage lines of the Southern Highlands	HN504 Black Gum grassy woodland of damp flats and drainage lines of the eastern Southern Tablelands, South-eastern Highlands Bioregion	Paddys River Box (*Eucalyptus macarthurii*), Snow Gum, Black Sallee (*E. stellulata*), White Stringybark	Glossy Nightshade (*Solanum americanum*)	Paddock Lovegrass (*Eragrostis leptstachya*), Weeping Meadow Grass, *Rytidosperma racemosum var. racemosum*, Kangaroo Grass (*Themeda australis*), Spiny-headed Mat Rush, *Oxalis spp*	Low	80	This community is a component of the TSC Act-listed Tableland Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions EEC
Grassy Woodlands	Southern Tablelands Grassy Woodland	Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland	PCT 731 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion	HN514 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands	Broad-leaved Peppermint (*Eucalyptus dives*), Narrow-leaved Peppermint (*E. radiata*)	None	Kikuyu (*Pennisetum clandestinum**), Finger Grass (*Dactyloctenium radulans*), Cocksfoot (*Dactylis glomerata**) and Lambs Tongues (*Plantago lanceolata**)	Low	80	N/A



Native vegetation in the project area
Hume Coal Project
Biodiversity Assessment Report
Figure 4.1

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4.1.2 The terrestrial study area

As this biodiversity assessment examines potential indirect impacts of underground mining on biodiversity, vegetation types for the terrestrial study area (outside those mapped during the current study in the project area) were reviewed to determine if threatened species or ecological communities were likely to be present in this area.

Vegetation mapping for the Wingecarribee Biodiversity Strategy (EcoLogical 2003) indicates that 18 native vegetation types are present in the terrestrial study area (Figure 4.2) outside those mapped in the project area. A description of these vegetation communities is provided in Table 4.2 and shown in Figure 4.2. A full description of the communities is provided in EcoLogical (2003).

Table 4.2 Vegetation communities in the terrestrial study area

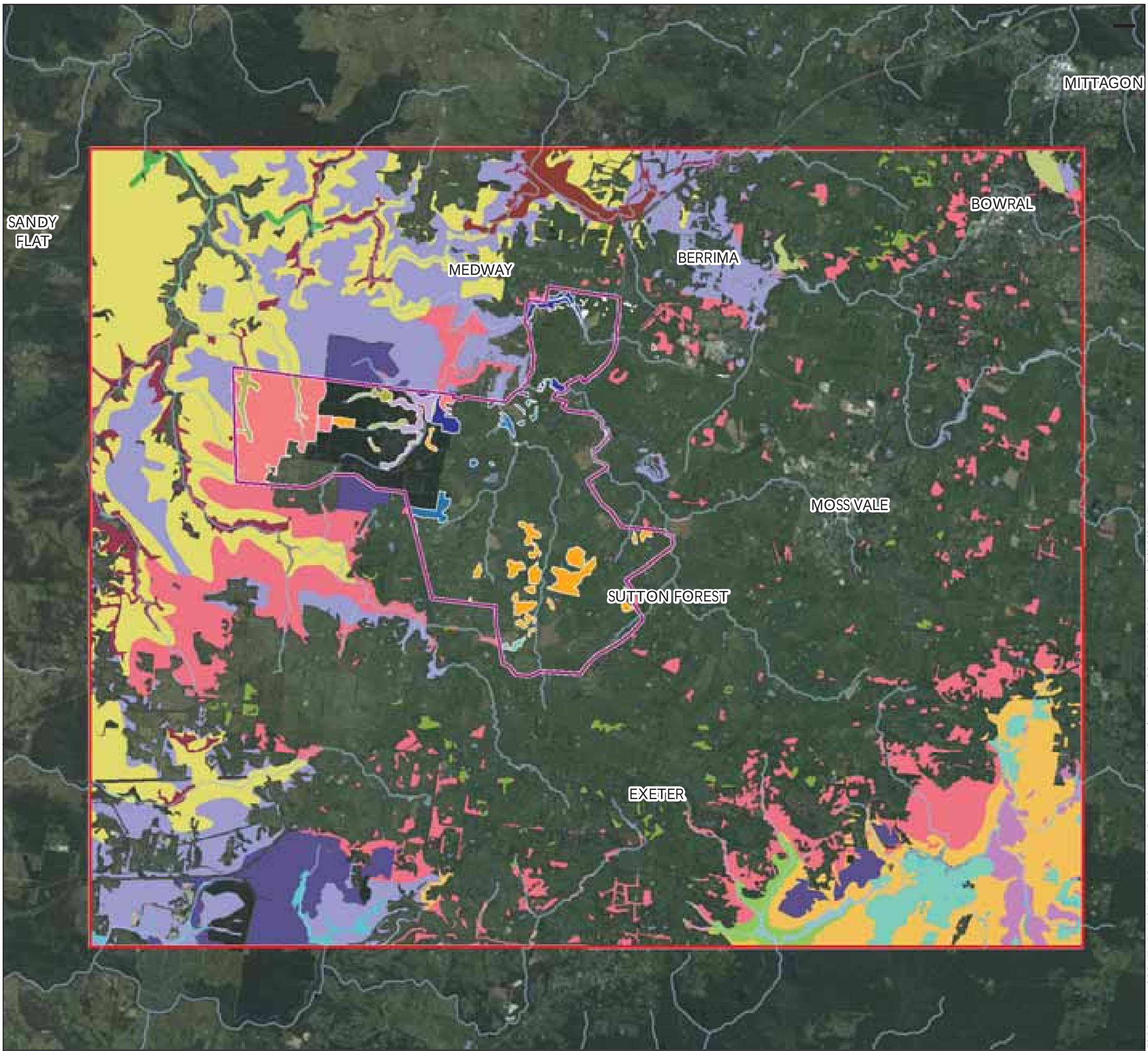
Vegetation type	Equivalent vegetation type in the project area	Dominant canopy species	Dominant midstorey species	Dominant understorey species
Bindook Porphyry Dry Woodland	N/A	Forest Red Gum (*Eucalyptus tereticornis*), Kurrajong (*Brachychiton populneus*) and Yellow Box (*E. melliodora*)	Sticky Daisy Bush (*Olearia viscidula*), Peach Heath (*Lissanthe strigosa*) and Blackthorn (*Bursaria spinosa*)	Kidney Weed (*Dichondra repens*), Poison Rock Fern (*Cheilanthes sieberi*) and Slender Tick-trefoil (*Desmodium varians*)
Bundanoon Sandstone Woodland	N/A	Sydney peppermint (*E. piperita*), SIlvertop Ash (*E. sieberi*) and Scribbly Gum (*E. sclerophylla*)	Conesticks (*Petrophile pedunculata*), Black-eyed Susan (*Tetratheca thymifolia*) and Mountain Devil (*Lambertia formosa*)	Fish Bones (*Lomandra obliqua*), Native Holly (*Lomatia ilicifolia*) and Cadigal (*Patersonia glabrata*)
Dry Nattai Escarpment Complex	N/A	Smooth-barked Apple (*Angophora costata*), Rough-barked Apple (*Angophora floribunda*) and Sydney Peppermint	Insufficient data (ID)	ID
Hawkesbury Sandstone Woodland	N/A	Red Bloodwood (*Corymbia gummifera*), Sydney peppermint and SIlvertop Ash	Hairpin Banksia (*Banksia spinulosa*), Sunshine Wattle (*Acacia terminalis*) and Broad-leaved Geebung (*Persoonia levis*)	Fish Bones, Curly Wig (*Caustis flexuosa*) and Sheath Rush (*Cyathochaeta diandra*)
Joadja Tall Open Forest	River Peppermint Narrow-leaved Peppermint tall open forest	River Peppermint (*E. elata*), Hickory Wattle (*Acacia falciformis*) and Grey Gum (*E. punctata*)	Common Cassinia (*Cassinia aculeata*), Sticky Daisy Bush and Narrow-leaved Geebung (*Persoonia linearis*)	Weeping Grass (*Microlaena stipoides*), Apple Berry (*Billadiera scandens*) and Blue Flax-lily (*Dianella caerulea*)
Mittagong Sandstone Woodland	Grey Gum Blue-leaved Stringybark open forest	Blue-leaved Stringybark (*E. agglomerata*), Grey Gum and Black She-oak (*Allocasuarina littoralis*)	Broad-leaved Geebung, Narrow-leaved Geebung and Black-eyed Susan	Wiry Panic (*Entolasia stricta*), Ivy Goodenia (*Goodenia hederacea*) and Cadigal
Moist Nattai Escarpment Complex	N/A	Blue-leaved Stringybark (*E. agglomerata*), Narrow-leaved Ironbark (*E. crebra*) and Mountain Blue Gum (*E. deanei*)	ID	ID

Table 4.2 Vegetation communities in the terrestrial study area

Vegetation type	Equivalent vegetation type in the project area	Dominant canopy species	Dominant midstorey species	Dominant understorey species
Mount Gibraltar Forest	N/A	Sydney Peppermint, Narrow-leaved Peppermint (*E. radiata*) and Brown Barrel (*E. fastigata*)	Lance Beard-heath (*Leucopogon lanceolatus*), Elderberry Panax (*Polyscias sambucifolia*) and Tangled Guinea-flower (*Hibbertia empetrifolia*)	Blue Flax-lily, Spiny-head Mat-rush (*Lomandra longifolia*) and Austral Bracken (*Pteridium esculentum*)
Riparian Casuarina Forest	N/A	River She-oak (*Casuarina cunninghamiana*)	River Bottlebrush (*Callistemon sieberi*)	Lesser Joyweed (*Alternanthera denticulata*), Old Man Weed (*Centipeda cunninghamii*) and *Eleocharis acuta*
Robertson Basalt Tall Open Forest	N/A	Australian Blackwood (*Acacia melanoxylon*), Mountain Grey Gum (*E. cypellocarpa*) and Yellow Stringybark (*E. muelleriana*)	Thimbleberry (*Rubus parviflorus*), Prickly Currant Bush (*Coprosma quadrifida*) and Fireweed Groundsel (*Senecio linearifolius*)	Wombat Berry (*Eustrephus latifolius*), Weeping Grass and Austral Bracken
Sandstone Wet Heath/Sedge	N/A	Mountain Swamp Gum (*E. camphora*)	Flax-leaf Heath-myrtle (*Baeckea linifolia*), Prickly Tea Tree (*Leptospermum juniperinum*) and Coral Heath (*Epacris microphylla*)	Spreading Rope Rush (*Empodisma minus*), Razor Sedge (*Lepidosperma limicola*) and Tall Yellow-eye (*Xyris operculata*)
Scribbly Gum Open Woodland	N/A	Snap Gum (*E. racemosa*), Scribbly Gum and Parramatta Red Gum (*E. parramattensis*)	Finger Hakea (*Hakea dactyloides*), Hairpin Banksia and Dwarf Banksia (*Banksia oblongifolia*)	*Dampiera stricta*, *Goodenia bellidifolia* and Screw Fern (*Lindsaea linearis*)
Shoalhaven Gorge Tall Open Forest	N/A	Red Bloodwood, White Stringybark (*E. globoidea*) and Yertchuk (*E. consideniana*)	Narrow-leaved Geebung, Hairpin Banksia and Stiff-leaf wattle (*Acacia obtusifolia*)	Wiry Panic, Cadigal and Blue Flax Lily (*D. caerulea* var. *caerulea*)
Southern Highlands Shale Woodland	Broad-leaved Peppermint Argyle Apple grassy woodland	Blueberry Ash (*Elaeocarpus reticulatus*), Corkwood (*Endiandra sieberi*) and Veined Mock-olive (*Notelaea venosa*)	Lance Beard-heath, Prickly Currant Bush and *Coronidium elatum*	Blue Flax-lily, Austral Bracken and Apple Berry
Swamp	N/A	None	*Leptospermum obovatum* and Prickly Tea-tree	*Baumea rubiginosa*, *Eleocharis sphacelata* and Soft Water Fern (*Blechnum minus*)
Warm Temperate Rainforest	N/A	Australian Blackwood, Sassafras (*Doryphora sassafras*) and Sweet Pittosporum (*Pittosporum undulatum*)	Tree Violet (*Melicytus dentata*), Staff Climber (*Celastrus australis*) and Prickly Currant Bush	Wombat Berry, Rock Felt Fern (*Pyrrosia rupestris*) and Scrambling Lily (*Geitonoplesium cymosum*)

Table 4.2 Vegetation communities in the terrestrial study area

Vegetation type	Equivalent vegetation type in the project area	Dominant canopy species	Dominant midstorey species	Dominant understorey species
Wingecarribee Mallee	N/A	Scribbly Gum, Black Cypress Pine (*Callitris endlicheri*) and *Callitris muelleri*	Finger Hakea, Broom Spurge (*Amperea xiphoclada*) and Hairpin Banksia	Ivy Goodenia, Poison Rock Fern and Needle Mat-rush (*Lomandra cylindrica*)
Wingecarribee Woodland	Brittle Gum Scribbly Gum shrubby woodland	White Stringybark, Grey Gum and Brittle Gum (*E. mannifera*)	Narrow-leaved Geebung, Hoary Guinea-flower (*H. obtusifolia*) and Sticky Daisy Bush	Weeping Grass, Apple Berry and Blueberry Flax-lily (*D. revoluta*)



KEY

Project area

Biodiversity study area

EMM vegetation mapping inside the project area

- Brittle Gum Scribbly Gum shrubby woodland
- Broad-leaved Peppermint Argyle Apple grassy woodland
- Broad-leaved Peppermint Narrow-leaved Peppermint Grassy Woodland
- Grey Gum Blue-leaved Stringybark open forest
- Gully Gum Narrow-leaved Peppermint open woodland
- Gully Gum Scribbly Gum open woodland
- River Peppermint Narrow-leaved Peppermint tall open forest
- Snow Gum Black Sallee grassy woodland and Paddy's River Box population

Wingecarribee Shire Council vegetation mapping

- Bindook Porphyry Dry Woodland
- Bindook Porphyry Moist Woodland
- Bundanoon Sandstone Woodland
- Hawkesbury Sandstone Woodland
- Joadja Tall Open Forest
- Mittagong Sandstone Woodland
- Mt Gibraltar Forest
- Riparian Casuarina Forest
- Robertson Basalt Tall Open Forest
- Sandstone Wet Heath/Sedge
- Scribbly Gum Open Woodland
- Shoalhaven Gorge Tall Open Forest
- Southern Highlands Shale Woodland
- Swamp
- Warm Temperate Rainforest
- Water
- Weeds/exotics/pine plantations
- Wingecarribee Mallee
- Wingecarribee Woodland
- Watercourse
- Waterbodies

0 2 4 km

GDA 1994 MGA Zone 56

Source: EMM (2016); GA (2016)

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Native vegetation in the project area and study area

Hume Coal Project

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Figure 4.2

4.2 Threatened flora species and populations

4.2.1 The project area

Of the 353 native plant species recorded in the project area by the current study, one species, Paddys River Box (*Eucalyptus macarthurii*), is listed as endangered under the TSC Act. The locations where it has been recorded are shown in Figure 4.5. Paddys River Box was listed as an endangered species under the EPBC Act on 5 May 2016.

The endangered Dwarf Phyllota (*Phyllota humifusa*), Dwarf Kerrawang (*Commersonia prostrata*), Cambage Kunzea (*Kunzea cambagei*) and Cotoneaster Pomaderris (*Pomaderris cotoneaster*) have a moderate likelihood of occurrence in the terrestrial study area based on the presence of potentially suitable habitat. However, targeted surveys in suitable habitat did not record any of these species.

There are historical records of an endangered population and threatened species, namely Black Gum, on OEH's Atlas of NSW Wildlife, along Oldbury Road in the east of the project area. These locations were visited. However, as they occur on private property, the species presence could not be confirmed. It is however likely that Black Gums still occur in these areas. While potentially suitable habitat exists within the Snow Gum Black Sallee Woodland (refer to Figure 4.1), targeted surveys conducted in this suitable habitat did not record any Black Gums. Further information on Black Gum is provided in Section 7.3.

The following plant species listed in the register of Rare or Threatened Australian Plants (ROTAP) have been recorded in the project area:

- *Olearia burgesii* (3K);
- *Pseudanthus divaricatissimus* (2RCa);
- *Geranium graniticola* (3RCi); and
- Narrow-leaved Mallee Ash (*Eucalyptus apiculata*) (3RC-).

4.2.2 The terrestrial study area

A number of threatened plants listed under the TSC Act and EPBC Act are predicted to occur in the terrestrial study area, which includes Long Swamp and Stingray Swamp. These comprise Dwarf Phyllota and Broad-leaved Sally. Paddys River Box is also known to occur in Stingray Swamp and Long Swamp (Figure 4.7).

4.3 Threatened ecological communities

4.3.1 The project area

Seventeen TECs have the potential to occur within the Burragorang and Moss Vale IBRA sub-regions (Table 4.3). Of these, two TECs, were considered to have high potential to occur in the project area:

- Southern Highlands Shale Woodland in the Sydney Basin Bioregion (also listed under the EPBC Act as Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion); and

- Tableland Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions. There is also a preliminary listing under the TSC Act to increase the conservation status of this community to critically endangered (OEH 2014).

Their presence was confirmed by the field assessments. A discussion of these TECs and their occurrence in the terrestrial study area is provided in the following sections, and their distributions are mapped in Figure 4.3.

Table 4.3 Threatened ecological communities known to occur within the Burragorang and Moss Vale IBRA sub-regions and identified in the Protected Matters Search Tool

Threatened ecological community	Status		Potential for occurrence in project area
	TSC Act	EPBC Act	
Blue Mountains Basalt Forest in the Sydney Basin Bioregion	E	-	None
Blue Mountains Shale Cap Forest in the Sydney Basin Bioregion	E	CE	None
Coastal Upland Swamps in the Sydney Basin Bioregion	E	-	None
Cumberland Plain Woodland in the Sydney Basin Bioregion	CE	CE	None
Moist Shale Woodland in the Sydney Basin Bioregion	E	CE	None
Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps Bioregions (TSC Act) and Temperate Highland Peat Swamps on Sandstone (EPBC Act)	E	E	None
Mount Gibraltar Forest in the Sydney Basin Bioregion (TSC Act) and Upland Basalt Forests of the Sydney Basin Bioregion (EPBC Act)	E	E	None
Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory	-	E	None
River Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	E	-	None
Robertson Basalt Tall Open Forest in the Sydney Basin Bioregion (TSC Act) and Upland Basalt Forests of the Sydney Basin Bioregion (EPBC Act)	E	E	None
Robertson Rainforest in the Sydney Basin Bioregion	E	-	None
Shale/Sandstone Transition Forest in the Sydney Basin Bioregion	CE	CE	None
Southern Highlands Shale Woodland in the Sydney Basin Bioregion (TSC Act) and Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion (EPBC Act)	E	CE	High
Southern Sydney sheltered forest on transitional sandstone soils in the Sydney Basin Bioregion	E	-	None
Tableland Basalt Forest in the Sydney Basin and South Eastern Highlands Bioregions	E	E	None
Tableland Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions	E	-	High
Western Sydney Dry Rainforest in the Sydney Basin Bioregion	E	CE	None
White Box Yellow Box Blakely’s Red Gum Woodland (TSC Act) and White Box Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native Grassland (EPBC Act)	E	CE	None

Source: *OEH 2015, DoE 2015.*

Notes: *1. TSC Act – Threatened Species Conservation Act 1995, EPBC Act – Environment Protection and Biodiversity Conservation Act 1999, E – endangered ecological community, CE- critically endangered ecological community.*

i Southern Highlands Shale Woodland in the Sydney Basin Bioregion

a. TSC Act listing

The final determination (ie legal description of the listed community under the TSC Act) for Southern Highlands Shale Woodland in the Sydney Basin Bioregion (NSWSC 2011) states that the listed community ranges in structure from open forest to woodland and scrub, though is predominantly a woodland. Typical tree species in the listed community comprise Narrow-leaved Ironbark, Paddys River Box, Snow Gum, White Stringybark (*E. globoidea*), Monkey Gum (*E. cypellocarpa*), White-topped Box (*E. quadrangulata*), Cabbage Gum (*E. amplifolia*) and Swamp Gum (*E. ovata*). Other trees can include Gully Gum (*E. smithii*), Messmate (*E. obliqua*), Brown Barrel (*E. fastigata*), Ribbon Gum (*E. viminalis*), River Peppermint (*E. elata*), Grey Gum (*E. punctata*), Forest Red Gum (*E. tereticornis*), Brittle Gum (*E. mannifera*) and Argyle Apple (*E. cinerea*).

Southern Highlands Shale Woodland in the Sydney Basin Bioregion contains a variety of small trees including Blackwood (*Acacia melanoxylon*), Two-veined Hickory (*A. binervata*), Sweet Pittosporum (*Pittosporum undulatum*) and shrubs including Native Indigo (*Indigofera australis*), Prickly Beard-heath (*Leucopogon juniperinus*), *Olearia microphylla* and Blackthorn (*Bursaria spinosa*). Groundcovers can include Kangaroo Grass (*Themeda australis*), Longhair Plumegrass (*Dichelachne crinita*) and Weeping Meadow Grass (*Microlaena stipoides*).

The community occurs on clay soils derived from Wianamatta Shale on the Southern Highlands between 600 to 800 m ASL. Disturbed remnants are considered to form part of the community including areas where the vegetation would respond to assisted natural regeneration, such as where the natural soil and associated seedbank is still at least partially intact.

Broad-leaved Peppermint Argyle Apple grassy woodland was compared to the NSW Scientific Committee’s (NSWSC’s) final determination for Southern Highlands Shale Woodlands in the Sydney Basin Bioregion (NSWSC 2011), an TEC listed as endangered under the TSC Act. The Broad-leaved Peppermint Argyle Apple open woodland in the terrestrial study area meets the description of the listed community as:

- the terrestrial study area is in the Sydney Basin Bioregion;
- Broad-leaved Peppermint Argyle Apple open woodland occurs on clay soil;
- Broad-leaved Peppermint Argyle Apple open woodland contains eucalypt species characteristic of the listed community including Narrow-leaved Peppermint, White Stringybark, Cabbage Gum, Gully Gum, Brittle Gum, Candlebark, Broad-leaved Peppermint and Argyle Apple; and
- Broad-leaved Peppermint Argyle Apple open woodland contains a variable groundcover of small trees, shrubs and grasses described in the NSWSC’s final determination for the listed community.

Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland was compared to the final determination for Southern Highlands Shale Woodland in the Sydney Basin Bioregion given the presence of some representative canopy species. Although representative canopy species are present (ie Narrow-leaved Peppermint, Paddys River Box and Cabbage Gum), a native midstorey is absent and the understorey is dominated by exotic grass and forb species. The sparse native groundcovers present (ie Rats-tail Grass (*Sporobolus creber*) and Finger Grass (*Dactyloctenium radulans*) are disturbance-tolerant species, while characteristic disturbance-sensitive groundcovers including Kangaroo Grass (*Themeda australis*) are absent. The area has a long history of grazing, and is currently in use for cattle grazing purposes. The grass height across much of the community was often less than 0.1 m in height, indicating high grazing pressure. Given the long history of disturbance it is unlikely that the soil profile and seedbank are intact.

Although some representative canopy species are present, the Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland in the project area does not represent the EEC Southern Highlands Shale Woodland in the Sydney Basin Bioregion as:

- a native midstorey is absent;
- the understorey is exotic-dominated; and
- the soil profile and seedbank are unlikely to be intact given the long disturbance history.

Gully Gum Narrow-leaved Peppermint open woodland was also compared to the final determination for the Southern Highlands Shale Woodlands in the Sydney Basin Bioregion listing (NSWSC 2011) given the presence of representative canopy species. Although the community is located in the Sydney Basin Bioregion, the soils on which it occurs are predominantly clay loams. It contains two characteristic canopy species (Gully Gum and Narrow-leaved Peppermint), however does not contain a variable groundcover of native small trees, shrubs and grasses characteristic of the community. The groundcover has been heavily modified for agricultural purposes, with evidence of soil ripping, and groundcover predominantly comprises exotic species. Given the level of modification, the natural seedbank is unlikely to be intact and the community would not respond to assisted natural regeneration. For these reasons, Gully Gum Narrow-leaved Peppermint open woodland does not meet the description of the listed community.

b. EPBC Act listing

Southern Highlands Shale Forest and Woodland of the Sydney Basin Bioregion is listed as a critically endangered ecological community (CEEC) under the EPBC Act. It is a similar community to Southern Highlands Shale Woodland in the Sydney Basin Bioregion, listed as an EEC under the TSC Act. Given the presence of representative canopy species, Broad-leaved Peppermint Argyle Apple Forest and Gully Gum Narrow-leaved Peppermint open woodland have been compared to the *Approved Conservation Advice (including listing advice) for Southern Highlands Shale Forest and Woodland of the Sydney Basin Bioregion* (TSSC 2015) below.

In accordance with the *Approved Conservation Advice (including listing advice) for Southern Highlands Shale Forest and Woodland of the Sydney Basin Bioregion* (TSSC 2015), to be a component of the listed community (and therefore considered a matter of national environmental significance under the EPBC Act), the ecological community must meet the following criteria:

- the key diagnostic characteristics:
  - is an open forest or woodland with a canopy dominated by one or more eucalypt species listed in Table 1 of the Approved Conservation Advice (TSSC 2015);

- has a ground layer including native grasses and/or other herbs;

- occurs in the Southern Highlands in the Sydney Basin Bioregion; and

- occurs at elevations between 470 to 830 m ASL on clay soils derived from Wianamatta Shale; and

- at least the minimum condition thresholds for moderate quality.

The Broad-leaved Peppermint Argyle Apple open woodland, Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland and Gully Gum Narrow-leaved Peppermint open forest share similarities with the CEEC. They have an open woodland structure with canopies dominated by characteristic species including Argyle Apple, Broad-leaved Peppermint, Gully Gum, White Stringybark and Narrow-leaved Peppermint, listed in Table 1 of the Approved Conservation Advice. Each of these communities has been compared to the Approved Conservation Advice to determine if they represent the listed community.

Broad-leaved Peppermint Argyle Apple open woodland has a groundlayer comprising a mix of native grasses and forbs. However, the groundcover of Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland and Gully Gum Narrow-leaved Peppermint has been heavily modified by grazing, which has resulted in a ground layer dominated by exotic grasses. All three communities occur in the Southern Highlands, and within the required elevations. Broad-leaved Peppermint Argyle Apple Woodland and Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland occur predominantly on shale soils, while soils in the Gully Gum Narrow-leaved Peppermint open forest are predominantly on clay loams.

Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland was compared to the final determination for Southern Highlands Shale Woodland in the Sydney Basin Bioregion given the presence of some representative canopy species. Although representative canopy species are present (ie Narrow-leaved Peppermint, Paddys River Box and Cabbage Gum), a native midstorey is absent and the understorey is dominated by exotic grass and forb species. The sparse native groundcovers present (ie Rats-tail Grass (*Sporobolus creber*) and Finger Grass (*Dactyloctenium radulans*)) are disturbance-tolerant species, while characteristic disturbance-sensitive groundcovers including Kangaroo Grass (*Themeda australis*) are absent. The area has a long history of grazing, and is currently in use for cattle grazing purposes. The grass height across much of the community was often less than 0.1 m in height, indicating high grazing pressure. Given the long history of disturbance it is unlikely that the soil profile and seedbank are intact.

Although some representative canopy species are present, the Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland in the project area does not represent the EEC Southern Highlands Shale Woodland in the Sydney Basin Bioregion as:

- a native midstorey is absent;
- the understorey is exotic-dominated; and
- the soil profile and seedbank are unlikely to be intact given the long disturbance history.

Broad-leaved Peppermint Argyle Apple open woodland meets the key diagnostic characteristics of the listed community and satisfies the minimum condition thresholds for ‘B1 moderate condition class’. Therefore it is considered to form part of the CEEC. However, Gully Gum Narrow-leaved Peppermint grassy woodland does not meet the key diagnostic characteristics of the listed community as it occurs on clay loam soils and has a predominantly exotic understorey, nor does it satisfy the minimum condition thresholds for moderate quality. Therefore it does not form part of the CEEC. An assessment against the condition categories, classes and thresholds for Southern Highlands Shale Forest and Woodland described in the Approved Conservation Advice (TSSC 2015) is presented in Table 4.4.

Table 4.4 Assessment against condition categories, classes and thresholds for Southern Highlands Shale Forest and Woodland (TSSC 2015)

Category and rationale	Thresholds	Assessment of Broad-leaved Peppermint Argyle Apple open woodland against thresholds	Assessment of Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland against thresholds	Assessment of Gully Gum Narrow-leaved Peppermint open woodland against thresholds
A1. High condition class A larger patch with good quality native groundcover	Patch size ≥ 2 ha **And** ≥ 50% of the perennial groundcover vegetation cover* is made up of native species **Or** ≥ 30 native groundcover species per ha	Although patch size is ≥ 2 ha, <50% of the perennial native groundcover vegetation cover comprises native species. Smaller patches of the community close to 1 ha contain between 11 and 19 native groundcover species. Therefore, it does not meet category A1.	Although patch size is ≥ 2 ha, the understorey does not contain native perennial understorey species, as it is dominated by annual grasses. It only contains 1 – 2 native grass species per ha. Therefore, it does not meet category A1.	Although patch size is ≥ 2 ha, the groundcover does not contain native perennial groundcover species, as it is dominated by annual grasses. It only contains 1 to 2 native grass species per ha. Therefore, it does not meet category A1.
A2. High condition class A patch with very good quality native groundcover	Patch size ≥ 0.5 ha **And** ≥ 70% of the perennial groundcover vegetation cover is made up of native species	Although patch size is ≥ 0.5 ha, <70% of the perennial native groundcover vegetation cover comprises native species. Groundcover vegetation cover totals approximately 50% in the community. Therefore, it does not meet category A2.	Although patch size is ≥ 0.5 ha, the understorey does not contain native perennial understorey species, as it is dominated by annual grasses. Therefore, it does not meet category A2.	Although patch size is ≥ 0.5 ha, the groundcover does not contain native perennial groundcover species, as it is dominated by annual grasses. Therefore, it does not meet category A2.
B1. Moderate condition class A patch with good quality native groundcover	Patch size ≥ 0.5 ha **And** ≥ 50% of the perennial groundcover vegetation cover is made up of native species **Or** ≥ 15 native groundcover species per ha	The patch size is ≥ 0.5 ha, ≥ 50% of the perennial groundcover vegetation cover is made up of native species and ≥ 15 native groundcover species per ha (range of 11-19 per ha). Therefore, the community meets category B1.	Although patch size is ≥ 0.5 ha, the understorey does not contain native perennial understorey species, as it is dominated by annual grasses. It only contains 1 – 2 native grass species per ha. Therefore, it does not meet category B1.	Although patch size is ≥ 0.5 ha, the groundcover does not contain native perennial groundcover species, as it is dominated by annual grasses. It only contains 1 to 2 native grass species per ha. Therefore, it does not meet category B1.

Table 4.4 Assessment against condition categories, classes and thresholds for Southern Highlands Shale Forest and Woodland (TSSC 2015)

Category and rationale	Thresholds	Assessment of Broad-leaved Peppermint Argyle Apple open woodland against thresholds	Assessment of Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland against thresholds	Assessment of Gully Gum Narrow-leaved Peppermint open woodland against thresholds
B2. Moderate condition class A moderate sized patch with connectivity to a native vegetation area, or a mature tree, or a tree with hollows	Patch size ≥ 0.5 ha **And** ≥ 30% of the perennial groundcover vegetation cover is made up of native species **And**	N/A	Although patch size is ≥ 0.5 ha, the understorey does not contain native perennial understorey species, as it is dominated by annual grasses.	Although patch size is ≥ 0.5 ha, the groundcover does not contain native perennial groundcover species; it is dominated by annual grasses.
	The patch is contiguous ** with another type of native vegetation remnant (ie any native vegetation where cover in each layer present is dominated by native species) ≥1 ha in area **Or** The patches are not within 100 m of another type of vegetation remnant with native vegetation in each strata. Patches that are proximal to each other contain the tree component of the community, but do not contain any native herbs, and the understorey is a mix of native and exotic grasses typical of its agricultural setting. All patches contain at least one tree with hollows per 0.5 ha. However, as the understorey does not contain native perennial understorey species as well as hollows, it does not meet category B2.	N/A	N/A	The patches are not within 100 m of another type of vegetation remnant with native vegetation in each strata. Patches that are proximal to each other contain the tree component of the community, but do not contain any native herbs. The understorey is predominantly exotic grasses. Most patches contain at least one tree with hollows per 0.5 ha. However, as the groundcover does not contain native perennial groundcover species as well as hollows, it does not meet category B2.

Notes: *1.dbh – diameter at breast height, * perennial groundcover vegetation cover includes vascular plant species of the ground and shrub layers (where present) within a life cycle of more than two growing seasons. The ground layer includes herbs (ie graminoids, forbs and low shrubs [woody plants ≤ 0.5 m high]). Measurements of perennial groundcover vegetation cover exclude annuals, cryptogams, leaf litter or exposed soil. **Contiguous means the patch of the ecological community is continuous with, or in close proximity to (within 100 m) to another area of vegetation that is dominated by native species in each vegetation layer present.*

ii Tableland Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions

Given the presence of characteristic canopy species, Snow Gum Black Sallee grassy woodland was compared to the final determination of Tableland Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions, an EEC listed under the TSC Act.

Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland occurs in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions (NSWSC 2011b). It typically forms an open-forest, woodland or open woodland that transitions into grassland at low tree cover. The canopy is dominated by Snow Gum, Candlebark (*E. rubida*), Black Sallee and Ribbon Gum (*E. viminalis*), either as single species or in combinations. A shrub layer may be present and sub-shrubs are often a component of the ground stratum. Characteristic shrub species include Tree Violet (*Hymenanthera dentata*) and Urn Heath (*Melichrus urceolatus*). The ground layer is dominated by grasses and other herbaceous species including Kangaroo Grass (*Themeda australis*), Snowgrasses (*Poa* spp), Speargrasses (*Austrostipa* spp.), Wallaby Grasses (*Rytidosperma* spp.), *Leptorhynchos squamatus*, Common Everlasting (*Chrysocephalum apiculatum*) and Common Woodruff (*Asperula conferta*). This community may also occur as secondary grassland where the dominant trees have been removed but the ground stratum remains.

Snow Gum Black Sallee open woodland in the project area meets the description of the listed community as:

- it is located in the Sydney Basin Bioregion;
- it is an open woodland dominated by a characteristic species, Snow Gum, and also contains Black Sallee, another characteristic species; and
- the ground layer is dominated by characteristic grasses and other herbaceous species including Kangaroo Grass, Common Everlasting, Wallaby Grasses and Speargrasses.

No other threatened ecological communities (TECs) were recorded in the project area.

4.3.2 The terrestrial study area

The vegetation types mapped by EcoLogical (2003) were reviewed to indicate the threatened ecological communities that may occur in the terrestrial study area, outside those mapped in the project area. Three threatened ecological communities are predicted to occur in the terrestrial study area. These are described in Table 4.5 and shown in Figure 4.4.

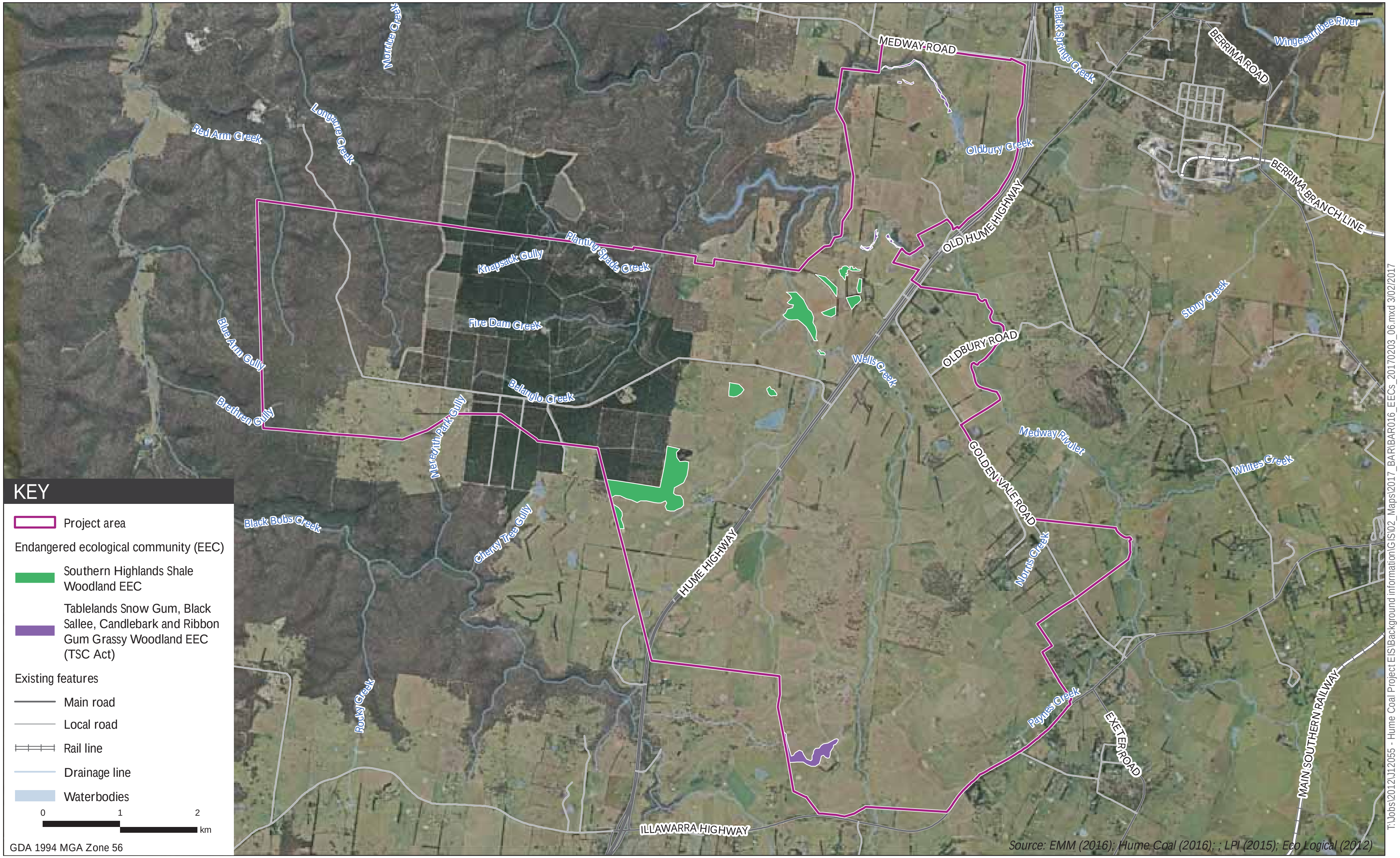
Table 4.5 Threatened ecological communities in the terrestrial study area

Vegetation community[1]	TSC Act conservation status	EPBC Act conservation status
Robertson Basalt Tall Open Forest	Robertson Basalt Tall Open Forest of the Sydney Basin Bioregion (endangered)	Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion (endangered)
Southern Highlands Shale Woodland	Southern Highlands Shale Woodland in the Sydney Basin Bioregion (endangered)	Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion (critically endangered)
Swamp	Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps Bioregions (endangered)	Temperate Highland Peat Swamps on Sandstone (endangered)

Notes: *1. Source: EcoLogical (2003).*

2. TSC Act - Threatened Species Conservation Act 1995, EPBC Act - Environment Protection and Biodiversity Conservation Act 1999.

Figure 4.4 shows that a swamp community occurs at Stingray Swamp. Although not predicted by the mapping (EcoLogical 2003) shown in Figure 4.4, Long Swamp also contains swamp vegetation. These areas are known to contain the listed Temperate Highland Peat Swamps on Sandstone. The swamps are located approximately 7 and 15 km south-west of the project area.



Threatened ecological communities in the project area

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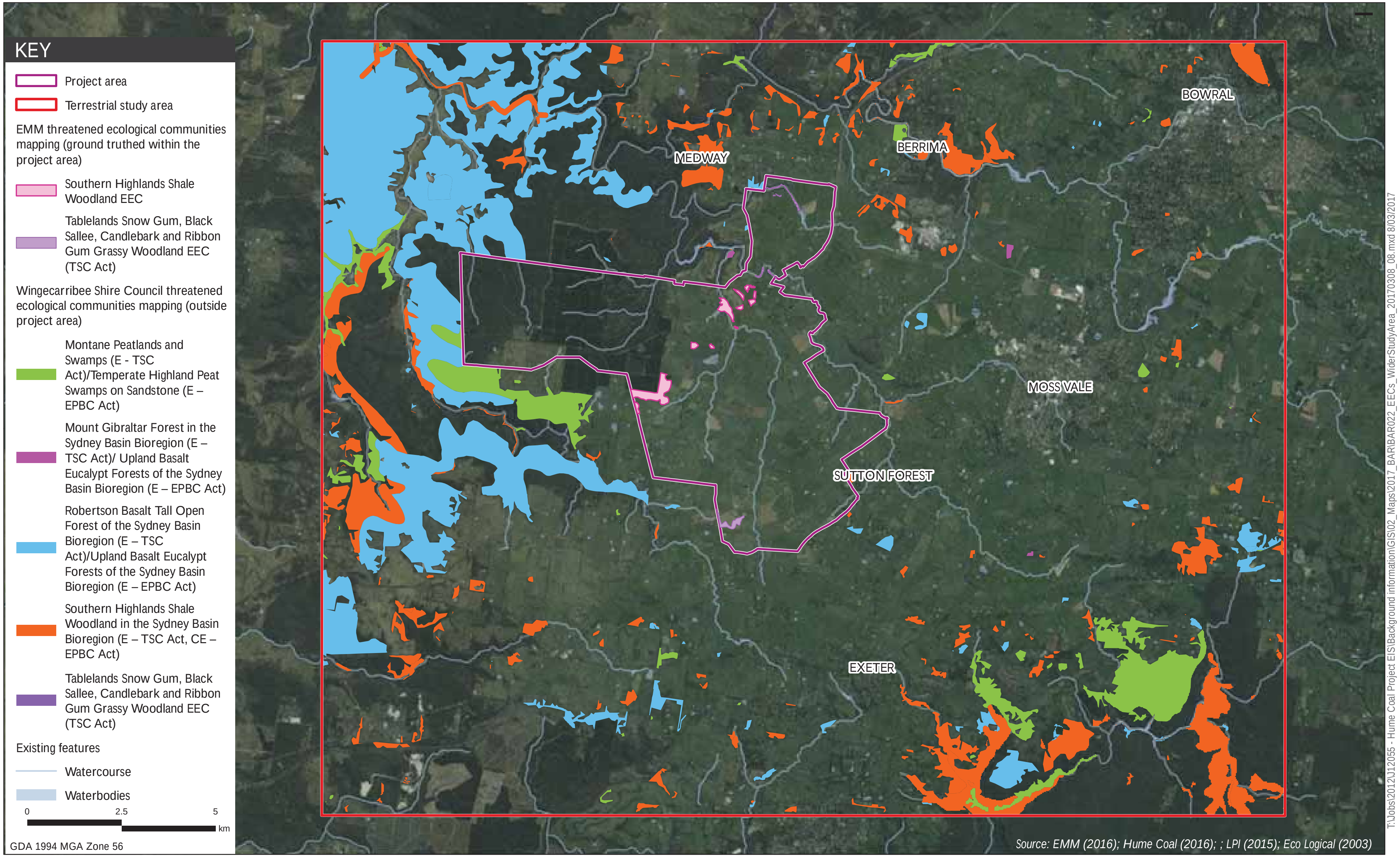
Figure 4.3



Threatened ecological communities in the project area and terrestrial study area

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Figure 4.4

4.4 Threatened fauna species

4.4.1 The project area

There is limited fauna habitat in the central and eastern parts of the project area, though scattered trees may provide hunting and nesting habitat for raptors and foraging habitat for granivorous birds. Farm dams also provide habitat for aquatic birds.

Higher quality fauna habitat is present in remnant native vegetation in Belanglo State Forest and along the lower reaches of Medway Rivulet and Oldbury Creek. Fauna habitat in these areas occurs in:

- gully forests with dense ground cover;
- fallen timber and hollows; and
- ridgelines, creeks and gullies containing caves and rocky overhangs.

These areas include a variety of foraging resources for fauna, including flowering plants, seeds, fruits, insects and prey species. Creeks in the project area provide a drinkingsource for fauna in deeper pools or more widely when flowing. However, the nearby Medway Dam is a permanent water source which provides higher quality fauna habitat. Raptors including the White-bellied Sea Eagle (*Haliaeetus leucogaster*) and Little Eagle (*Hieraeetus morphnoides*) have been observed in the vicinity of Medway Dam.

A total of 180 terrestrial fauna species have been recorded in the project area and its immediate surrounds, comprising:

- 119 native and three introduced bird species;
- 11 native reptile species;
- 10 native frog species; and
- 32 native mammal species (15 microbat, 6 arboreal, 10 ground-dwelling and 1 semi-aquatic) and 8 introduced mammal species.

A full species list is provided in Appendix D.

A population of feral Red Deer (*Cervus elaphus*) and Fallow Deer (*Dama dama*) occupies the pine plantations and remnant native vegetation in Belanglo State Forest. Several individuals were seen with young during surveys, indicating that they are established and breeding in the area. However, very little native vegetation damage was observed from deer.

Red Fox (*Vulpes vulpes*) scats were observed in agricultural parts of the project area where this species is expected to be prevalent. A small number of scats were also observed in Belanglo State Forest. European Rabbits (*Oryctolagus cuniculus*) are also prevalent across most of the agricultural area.

4.4.2 Threatened fauna species listed under the TSC Act recorded or likely to occur in the project area

Much of the project area contains cleared land, and does not provide habitat for fauna species listed under the TSC Act. Higher quality fauna habitat is present in remnant native vegetation in the Belanglo State Forest and the lower reaches of Medway Rivulet and Oldbury Creek. The following species listed under the TSC Act were recorded during targeted surveys, at the locations shown in Figure 4.5:

- woodland birds: Brown Treecreeper, Diamond Firetail, Little Eagle, Glossy Black Cockatoo, Gang-gang Cockatoo, Little Lorikeet, Powerful Owl, Scarlet Robin and Varied Sittella.

- mammals: Koala, Southern Myotis, Eastern False Pipistrelle, Eastern Freetail Bat, Eastern Bentwing Bat, Little Bentwing Bat, Large-eared Pied Bat and Yellow-bellied Sheathtail Bat.

It is noted that the exact locations of the Little Eagle, Glossy Black Cockatoo and Gang-gang Cockatoo have been removed in accordance with OEH's sensitive species data policy.

Calls likely to have been from the Masked Owl (*Tyto novaehollandiae*) were recorded in the terrestrial study area, however the record could not be confirmed. Using the precautionary principle and given the presence of suitable habitat, it is assumed that this species is present.

In addition, based on the presence of suitable habitat, several bird, mammal and reptile species listed under the TSC Act are considered to have a moderate likelihood of occurrence in higher quality fauna habitats of the project area, though were not recorded during targeted surveys. Specifically, these comprise:

- birds: Blue-billed Duck, Flame Robin, Hooded Robin, Australasian Bittern, Australian Painted Snipe, Turquoise Parrot, Speckled Warbler and Freckled Duck;

- mammals: Spotted-tail Quoll, Yellow-bellied Glider and Greater Broadnosed Bat; and

- reptiles: Broad-headed Snake and Rosenberg's Goanna.

4.4.3 Threatened fauna species listed under the EPBC Act recorded or likely to occur in the project area

The likelihood of occurrence of listed fauna species predicted to occur by the Protected Matters Search Tool was assessed (Appendix E). Much of the project area contains cleared land, and does not provide habitat for listed fauna species. However, two of the State-listed species recorded in the terrestrial study area, the Koala and Large-eared Pied Bat, are also listed as vulnerable under the EPBC Act. Native vegetation in the north-western and central northern parts of the project area provides habitat for these listed fauna species.

Five Koalas were identified in total, comprising two adult females and three adult males. These were recorded in Belanglo State Forest (Figure 4.5). One adult male was heard calling along Belanglo Creek in Belanglo State Forest during the breeding season, and therefore it is likely that they are breeding in this area. Koala scats were also found in a patch of native vegetation on the upper reaches of Oldbury Creek. All Koalas observed were in good health and appeared to be free of Chlamydia symptoms.

The Southern Highlands Koala Conservation Project has recorded Koala sightings as part of ongoing monitoring and research to map koala habitat and movement corridors. Numerous Koala sightings have been made in the terrestrial study area, in the Belanglo State Forest and with a single record from Medway, along the Wingecarribee River (Southern Highlands Koala Conservation Project 2016).

The Koala habitat assessment tool from the *EPBC Act referral guidelines for the vulnerable Koala (combined populations of Queensland, NSW and Australian Capital Territory)* (DoE 2014b) was used to assess the quality of habitat in the terrestrial study area (Appendix F). The majority of the terrestrial study area comprises cleared land and infrastructure corridors, which do not provide Koala habitat. Cleared land in the terrestrial study area contains isolated paddock trees, however they are generally in poor condition, including due to continued grazing pressures, and offer poorer habitat value to the Koala than intact woodland and forest. Large expanses of cleared land would make movement for the Koala through these areas difficult. The Hume Highway also acts as a major barrier to the east-west movement of Koalas through the project area. Therefore, the vast majority of the project area does not represent Koala habitat.

The north-western and central northern parts of the project area are however located on the eastern edge of an area of high quality Koala habitat. When assessed against the EPBC Act referral guidelines, the open forest and woodlands in these areas scored 8/10 for Koala habitat quality. They are considered to be part of a larger area containing habitat critical to the survival of the Koala, as defined by DoE (2014b). Habitat in these areas connects to a large vegetated corridor of Koala habitat to the west, north and south, spanning several state forests and national parks including Bangadilly, Nattai, Blue Mountains and Kanangra-Boyd national parks.

The north-western and central northern parts of the project area contain primary, secondary and supplementary Koala food trees, as defined in the *Recovery plan for the Koala* (DECC 2008). The project area is located on the boundary of the Central Coast Koala Management Area (CCKMA) and South Coast Koala Management Area (SCKMA), which are identified in the DECC (2008) recovery plan. It contains vegetation communities with feed tree species identified for both KMAs. Specifically, the project area contains:

- primary Koala habitat in the SCKMA: within Broad-leaved Peppermint Argyle Apple grassy woodland, which covers approximately 59.03 ha;
- secondary Koala habitat in the SCKMA: within Brittle Gum Scribbly Gum shrubby woodland and Snow Gum Black Sallee grassy woodland, which cover approximately 111.05 ha;
- secondary Koala habitat in the CCKMA: within Grey Gum Blue-leaved Stringybark open forest (containing Grey Gum, a secondary feed tree species), which covers approximately 479.50 ha; and
- supplementary Koala habitat in the CCKMA and SCKMA: also within Grey Gum Blue-leaved Stringybark open forest (containing Blue-leaved Stringybark and White Stringybark, both supplementary feed tree species), covering approximately 479.50 ha.

Threatened species locations

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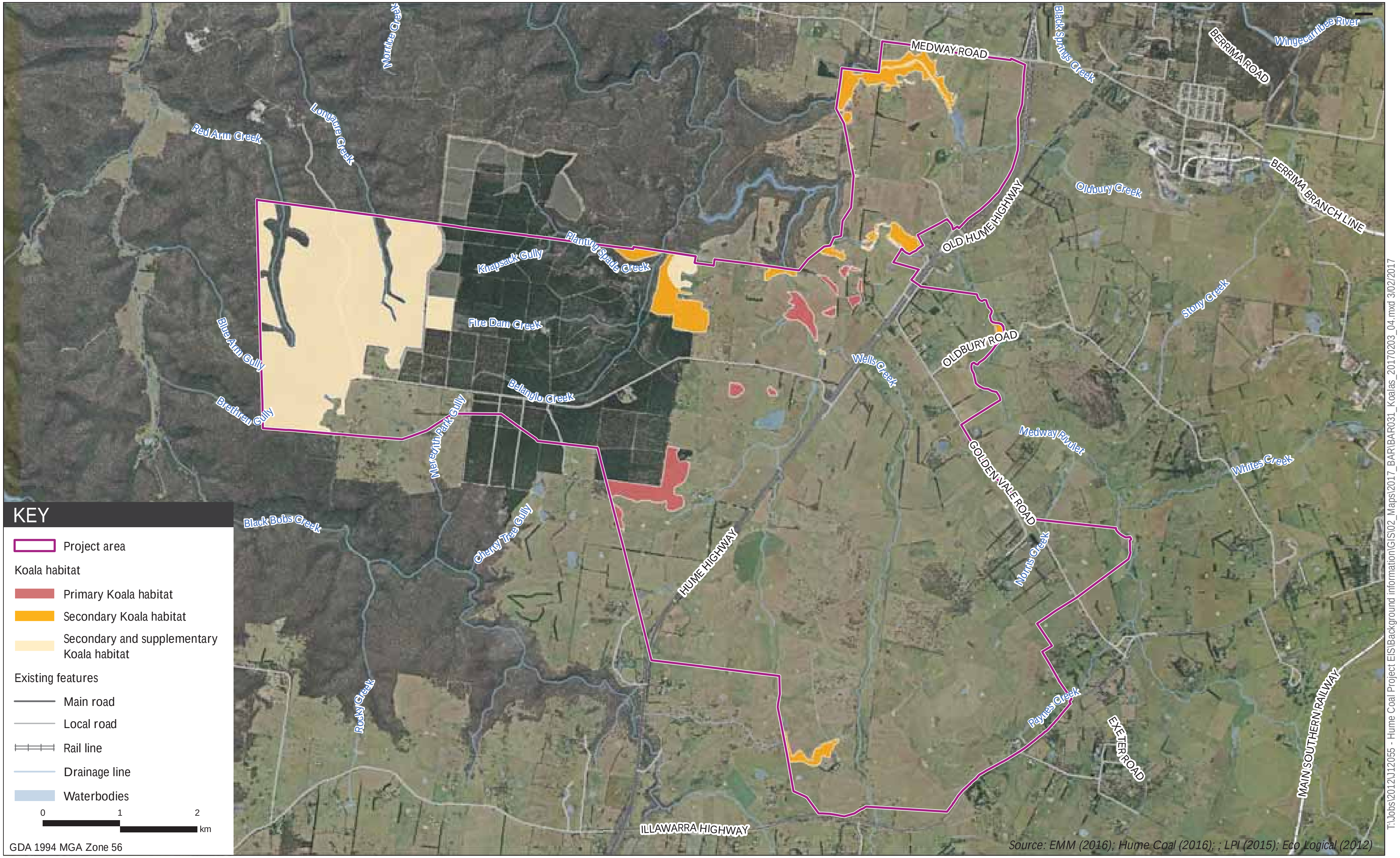
Figure 4.5



Vegetation types that represent potential Koala habitat in the project area

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Figure 4.6

Three confidently identified calls belonging to the Large-eared Pied Bat were recorded on an ultrasonic detector north of the project area in Belanglo State Forest in April 2013 and also at Oldbury Creek in the north of the project area in February 2015 (Figure 4.5). No individuals were sighted during surveys, despite targeted trapping programmes and roost searches. The north-western part of the project area contains potential habitat for the species in dissected sandstone cliffs. The *National Recovery Plan for the Large-eared Pied Bat* (DERM 2011) identifies habitat critical to the survival of the species as sandstone cliffs and nearby fertile wooded valley habitat. The project area contains sandstone cliffs; however the formerly wooded valleys to the east have been largely cleared for agriculture. Targeted roost searches were completed in sandstone cliffs of the project area, and no evidence of use by the Large-eared Pied Bat was recorded. It is likely that native vegetation in the north-west of the project area (Belanglo State Forest) and the central northern project area (vegetation on Oldbury Creek) represents a stepping stone to the surrounding national parks, and does not form important habitat for the species.

Up to 80 individuals of the Greater Glider (*Petaurus volans*) were recorded in the Belanglo State Forest in 2013. These species were not listed at the time and therefore their locations were not recorded. The Greater Glider was listed as a vulnerable species under the EPBC Act on 5 May 2016 (TSSC 2016).

The likelihood of occurrence of threatened fauna species not recorded, but predicted to occur by the protected matters search tool was assessed (Appendix E). Sandstone escarpments and drainage lines of the project area may provide habitat for the Broad-headed Snake (*Hoplocephalus bungaroides*) and Spotted-tail Quoll (*Dasyurus maculatus maculatus*).

The escarpments above drainage lines and ridgelines in the north-western and central northern parts of the project area (Figure 1.3) may contain limited shelter and foraging habitat for the Broad-headed Snake. Targeted surveys during autumn and winter did not identify the species however revealed a small number of suitable exfoliated shelter rocks on the sandstone escarpments. It is considered that there is potentially suitable summer habitat for the species in the large hollow-bearing trees and rock crevices near the escarpments.

The drainage lines and escarpments may also provide habitat for the Spotted-tail Quoll, although no evidence of the species was found during surveys. These areas contain hollow-bearing trees, fallen logs, rocky overhangs, cliff faces, crevices and animal burrows, which this species could use for breeding and shelter habitat. Despite adequate survey effort, this species was not detected, though this may have been due to its typically large home ranges and movements which can make detection difficult.

Farm dams in the project area have a moderate potential to provide habitat for the Australasian Bittern and Australian Painted Snipe.

4.4.4 Threatened fauna predicted to occur in the study areas

A number of threatened species are known or predicted to occur in Long Swamp and Stingray Swamp, comprising:

- invertebrates: Giant Dragonfly (*Petalura gigantea*);
- birds: Australasian Bittern and Australian Painted Snipe;
- Littlejohns Tree Frog; and
- Koala.

4.5 Ecosystems potentially reliant on shallow groundwater

A desktop assessment was completed to identify ecosystems which potentially utilise groundwater in the project area and study areas. It included reviewing the Groundwater Dependent Ecosystem Atlas (Bureau of Meteorology 2013), previous studies completed in the region, groundwater monitoring data and groundwater modelling results. Ecosystems with potential for reliance on either the surface or subsurface expression of groundwater are those associated with:

- creeks where groundwater is connected and provides baseflows at times, for instance Medway Rivulet and some drainage lines in incised gullies in the north and west of the project area;
- groundwater systems;
- springs associated with basalt hills south of the project area and springs at the shale/sandstone boundary near creeks;
- upland swamps in the wider locality, namely Stingray Swamp and Long Swamp; and
- terrestrial vegetation overlying shallow groundwater (within the vegetation's root zone).

These ecosystems have been classified into the three categories described in Section 2.10, according to their dependence on groundwater.

One spring was recorded in cleared land on a basalt hill in the south of the project. Given its location in a cleared area, there are no surrounding drainage lines that would be reliant on spring flow. Several springs were recorded in cleared areas during surveys north and south of Oldbury Creek and Medway Rivulet. These springs would make a minor contribution to surface flows in the area to Oldbury Creek and Medway Rivulet, and therefore these systems are considered to be non-dependent.

Paddys River Swamps are recognised in the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 as a high priority groundwater dependent ecosystem. Paddys River Swamps comprise Hanging Rock Swamp, Mundego Swamp, Long Swamp and Stingray Swamp. Only Long Swamp and Stingray Swamp are within the study areas of this assessment (Figure 4.7), and therefore have been assessed further in Section 7.2 of this report. Hanging Rock Swamp and Mundego Swamp are outside the zone of influence of potential groundwater impacts, and therefore have not been assessed further.

Wingecarribee Swamp, located approximately 13 km east of the project is also identified as a high priority groundwater dependent ecosystem under the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011. Wingecarribee Swamp is also outside the zone of influence of potential groundwater impacts, and therefore has not been assessed further.

Long Swamp and Stingray Swamp would have a facultative (proportional) dependence on groundwater as it would take a portion of its water requirements from the surface expression of groundwater and a portion from rainfall and surface flows.

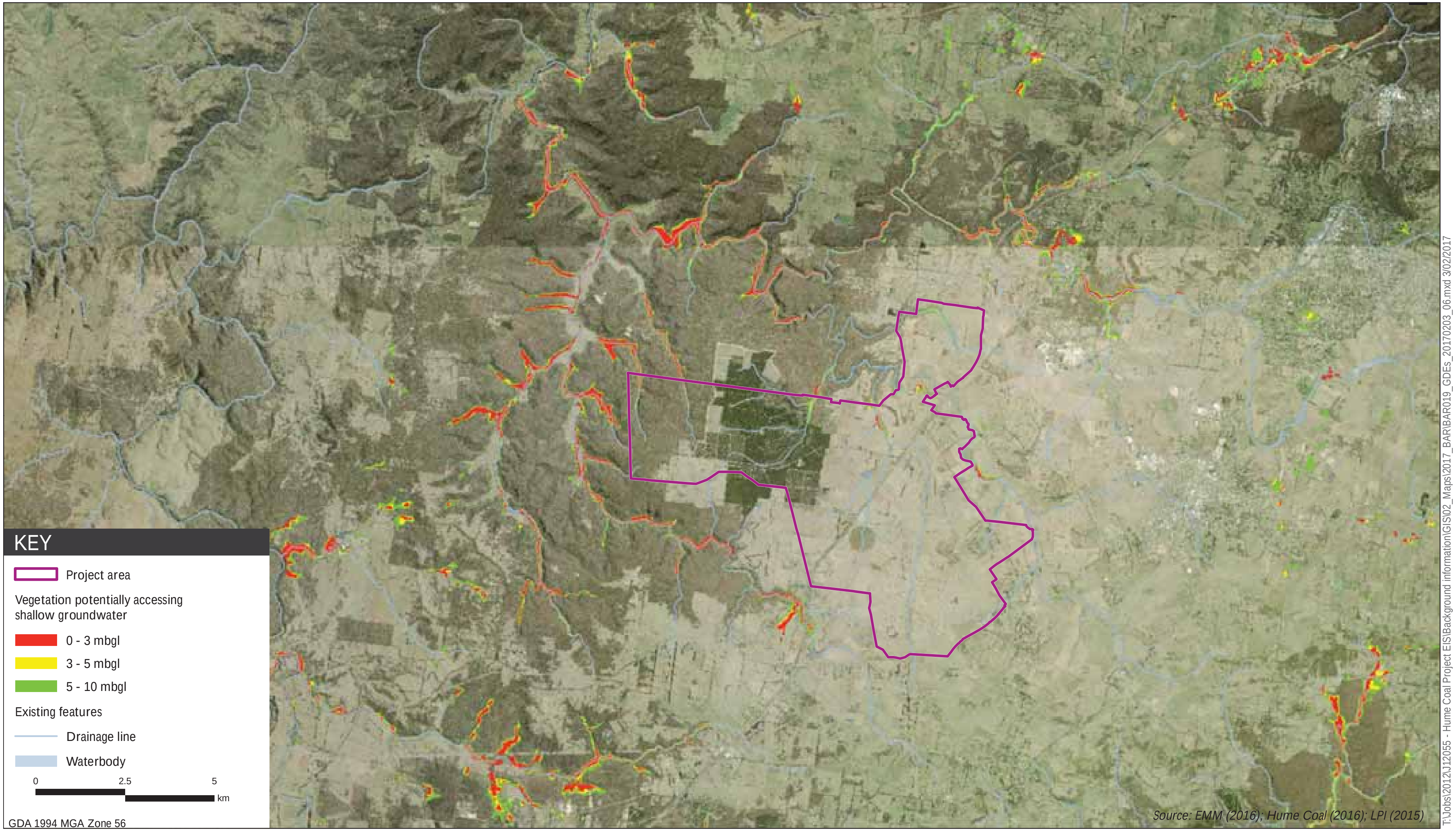
Terrestrial vegetation overlies shallow groundwater (0 to 10 m below ground level) in some places and in the project area, mainly along rivers and drainage lines. These include Medway Rivulet, Wells Creek, Belanglo Creek, Longacre Creek and Red Arm Creek. Six of the native vegetation types in the terrestrial study area occur where the depth to groundwater is less than 10 m and so have potential to access groundwater during low rainfall periods at these locations. One of these, namely Broad-leaved Peppermint Argyle Apple grassy woodland, contains the endangered Paddys River Box tree. Terrestrial vegetation also overlies shallow groundwater south of the project area, along Bundanoon Creek and to the north along Wingecarribee River (Figure 4.7). A number of threatened fauna species utilise the resources provided by terrestrial vegetation where shallow groundwater is present and would be considered to form part of the ecosystem which accesses groundwater at these locations. These include the Glossy Black Cockatoo, Large-eared Pied Bat, Koala and Southern Myotis. Terrestrial vegetation would have a facultative (opportunistic) dependence on groundwater.

Groundwater systems in the south of the aquatic study area are an entirely/obligate groundwater dependent ecosystem. An individual of the family Bathynellidae was recorded in this location, which is entirely dependent on the presence of groundwater in the Illawarra Coal Measures under Penrose State Forest, in the south of the study areas.

None of these ecosystems have a facultative (highly dependent) dependence on groundwater. A summary of the groundwater dependence of ecosystems in the study areas is shown in Table 4.6.

Table 4.6 Dependence of potential GDEs

GDE type	Non-dependent	Facultative			Entirely dependent/ obligate
		Opportunistic	Proportional	Highly dependent	
Baseflow to drainage lines			Medway Rivulet		
Groundwater systems					Fractured rock
Springs	Oldbury Creek Wells Creek				
Upland swamps			Long Swamp Stingray Swamp		
Terrestrial vegetation		Wingecarribee River Longacre Creek Red Arm Creek Oldbury Creek Medway Rivulet Wells Creek Belanglo Creek Bundanoon Creek			



Ecosystems potentially reliant on groundwater

Hume Coal Project

Biodiversity Assessment Report

Figure 4.7

EMM HUMECOAL

4.6 Aquatic species and habitats

4.6.1 Surface water quality

The water quality results were compared against the ANZECC Guidelines trigger values for Slightly – moderately disturbed ecosystems: Upland Rivers (ANZECC 2000) (Table 4.7). Exceedances of trigger values indicate poorer surface water quality.

Surface water quality results were generally consistent for pH, turbidity, conductivity, temperature and dissolved oxygen across all the sites in both seasons, with all the sites falling outside the acceptable ranges for upland rivers for most water quality parameters, indicating poor water quality. General water quality trends observed comprised the following (refer to Figure 2.3 for locations):

- most sites were elevated above the maximum guidelines for pH, indicating alkaline conditions. The exceptions were sites SWQ08, SWQ10, Medway Dam (Medway Dam), Medway Rivulet (SIA9) and SWQ02, SWQ03, (Black Bobs Creek in spring) which fell within the guideline ranges and Knapsack, Belanglo and Longacre Creeks which fell below the guideline ranges indicating slightly acidic conditions.

- approximately half the sites were within guideline ranges for turbidity except for SWQ02 (Black Bobs Creek) and SWQ03 (Medway Rivulet) in spring, SWQ05 (Wells Creek tributary), SIA7 (Oldbury Creek) and SIA9 (Stony Creek) in autumn and SWQ12 (Wells Creek) in both seasons and Knapsack, Belanglo and Longacre Creeks in spring 2015.

- conductivity levels at most sites were elevated above guideline ranges, including SWQ02 (Black Bobs Creek), SWQ08 (Long Swamp Creek) and SWQ10 (Hanging Swamp Creek) in spring, SWQ05 (Wells Creek tributary) in autumn and SWQ03 (Medway Rivulet), SWQ04 (Medway Rivulet) and SWQ12 (Wells Creek) in both seasons and Belanglo Creek in spring 2015.

- average temperatures ranged from 12.86°C in autumn to 14.84°C in spring across the sites. There are no specific guideline values for temperature.

- dissolved oxygen levels across the sites in both seasons were below the guideline ranges, except at SIA 7 and SIA9. Levels at SWQ08 (Long Swamp Creek) Knapsack and Longacre Creeks during spring were lower when compared with all other sites.

Water quality results are provided in Table 4.7.

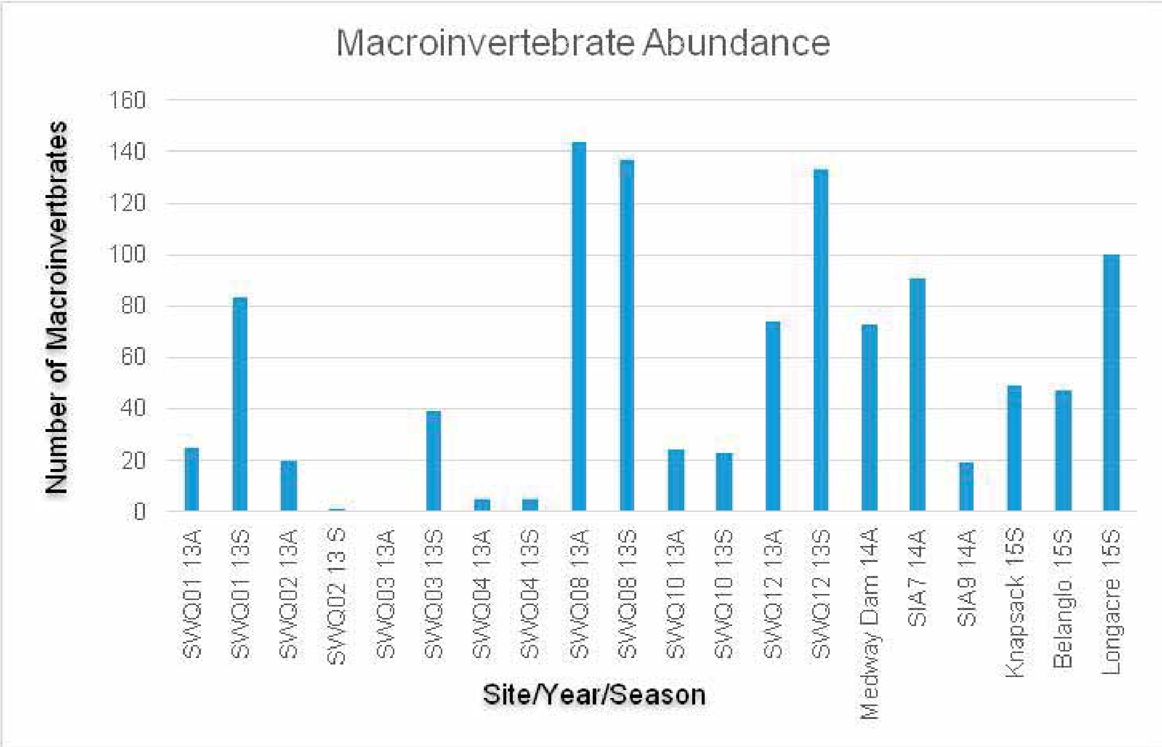
Table 4.7 Surface water quality results

Site	Date	pH	Turbidity (NTU)	Conductivity (µs/cm)	Temperature (°C)	Dissolved Oxygen (% saturation)
		ANZECC Trigger Values				
		6.5-7.5	2-25	30-350	na	90-110%
SWQ01	16.5.2013	7.93	16.9	262	9.16	58
SWQ01	6.11.2013	8.03	3.1	315	13.96	53.4
SWQ02	15.5.2013	7.55	2.8	321	11.9	79.6
SWQ02	4.11.2013	6.06	115.7	388	11.76	40.4
SWQ03	16.5.2013	7.55	6.9	692	15.46	35.8
SWQ03	5.11.2013	8.3	28.4	492	13.8	56.2
SWQ04	16.5.2013	7.98	21.3	396	9.86	46.5
SWQ04	5.11.2013	8.14	10.1	516	14.45	53.9
SWQ05	15.5.2013	8.05	68.8	415	12.82	57.4
SWQ08	15.5.2013	6.65	3.2	129	9.78	66
SWQ08	6.11.2013	8.64	15.9	374	21.88	24.2
SWQ10	14.5.2013	6.74	4.5	58	10.32	75
SWQ10	6.11.2013	6.88	3.9	470	11.71	58.4
SWQ12	15.5.2013	8.19	35.5	530	8.38	66.5
SWQ12	4.11.2013	10.04	102	570	16.32	79.5
Medway Dam	17.5.2014	7.31	34.3	310	18.64	80.9
SIA7	19.5.2014	7.71	41.5	672	16.01	93
SIA9	17.5.2014	6.98	32	549	16.15	105.4

4.6.2 Macroinvertebrates

A total of 1,092 individual macroinvertebrates were recorded from the sites over four seasons (autumn and spring 2013, autumn 2014 and spring 2015) (Figure 14). The communities were diverse supporting 52 families of macroinvertebrates (Plate 4.1). The abundance and diversity of macroinvertebrate families varied between season and between sites. General trends observed across the sites included the following:

- communities supported larger or similar numbers of taxa in spring than in autumn the exception to this was site SWQ02 (Black Bobs Creek) SWQ08 (Long Swamp Creek);
- sites SWQ08 (Long Swamp Creek), SWQ12 (Wells Creek) and Longacre Creek in spring supported large numbers of macroinvertebrates. SW08 supported high numbers of taxa during autumn also;
- most sites were moderately diverse with the most diverse sites being; SWQ08 (Long Swamp Creek) and SWQ12 (Wells Creek) and Belanglo Creek in spring and Medway Dam and SIA7 (Oldbury Creek) in autumn; and
- site SWQ02 (Black Bobs Creek) decreased in diversity between autumn and spring, while site SWQ03 (Medway Rivulet) increased in diversity greatly in spring.



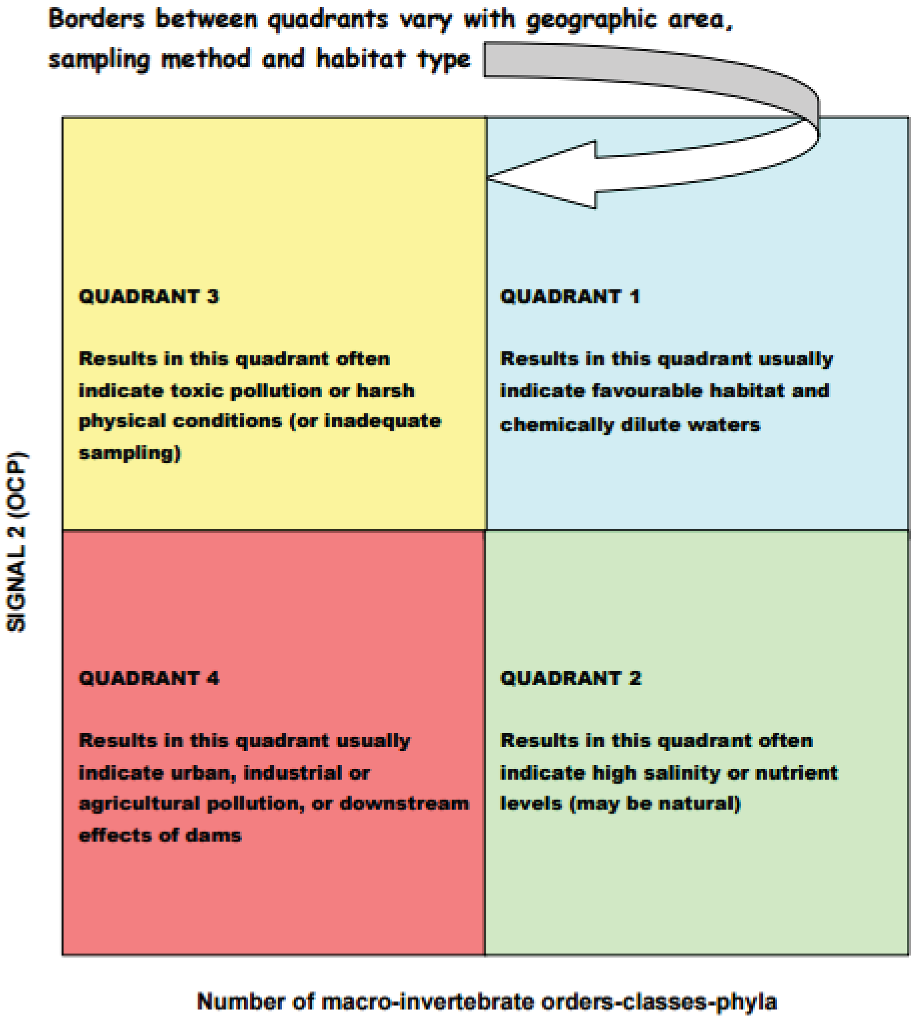
(note: site names ending 13 to 15 indicate the year of survey (ie 2013 to 2015) and sites ending in A denote autumn surveys, while those ending in S denote spring surveys)

Plate 4.1 Macroinvertebrate abundance

4.6.3 SIGNAL 2

A SIGNAL 2 score gives an indication of water quality in the river from which the sample was collected. Rivers with high SIGNAL scores are likely to have low levels of salinity, turbidity and nutrients such as nitrogen and phosphorus. They are also likely to be high in dissolved oxygen. When considered together with macroinvertebrate richness (the number of types of macroinvertebrates), SIGNAL can provide indications of the types of pollution and other physical and chemical factors that are affecting the macroinvertebrate community (Chessman 2002).

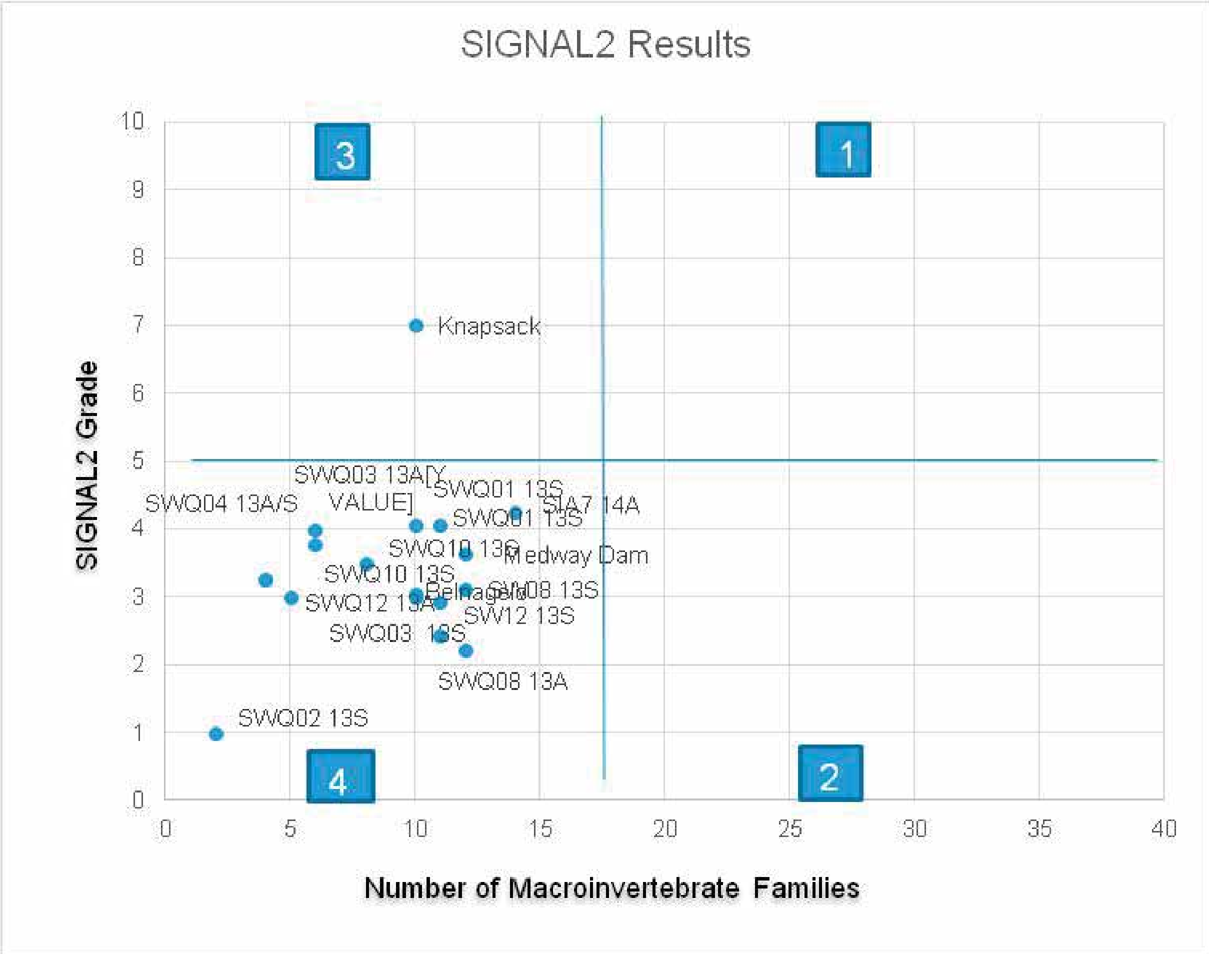
The SIGNAL scores fall into one of four quadrants, with Quadrant 1 indicating favourable habitat and chemically dilute waters and Quadrant 4 indicating environments disturbed by urbanisation, industry, agriculture or dams (see Plate 4.2).



(Note that Longacre Creek results could not be included as the results fell above the graph's boundaries).
Plate 4.3

Plate 4.2 The quadrant diagram for the Order-Class-Phylum version of SIGNAL2

The SIGNAL2 results for all sites (except Knapsack and Longacre Creeks) fall into Quadrant 4 of Plate 4.3, indicating the sites support low values of both the SIGNAL2 score and the number of invertebrate types. Most sites falling into this quadrant would be subject to one or more forms of human impact. Results in this quadrant usually indicate urban, industrial or agricultural pollution, or downstream effects of dams.



(Note that Longacre Creek results could not be included as the results fell above the graph's boundaries).

Plate 4.3 SIGNAL2 results

Knapsack and Longacre Creeks fall into Quadrant 3 indicating toxic pollution or harsh physical conditions. Longacre Creek SIGNAL2 results fell above the graph's boundaries and could not be presented on the graph. Sites in this quadrant represent high values of SIGNAL 2 but few macroinvertebrate types. Sites with toxic pollution, such as those below old mine sites where acid drainage can result in low pH and high concentrations of trace metals, usually fall either in this quadrant or in Quadrant 4. This occurs because the tolerances of some macroinvertebrate types differ according to the type of pollution. For example, snails and segmented worms are tolerant of most forms of pollution but sensitive to metals. Certain caddis fly families such as the Leptoceridae, stonefly families such as the Gripopterygidae and Notonemouridae and the alderfly family Corydalidae are tolerant of metals even though they are sensitive to many other forms of pollution.

4.6.4 EPT index

The EPT index is named after three orders of common benthic aquatic insects, namely the Ephemoptera (Mayflies), Plecoptera (Stoneflies) and Trichoptera (Caddisflies). The EPT index assesses pollution intolerant taxa and their richness within a community to determine water quality and habitat values that support macroinvertebrate communities. The EPT index is based on the premise that streams in high condition will have a higher species richness. The range of values that determine condition using the EPT index are provided in Table 4.8.

Table 4.8 EPT index

Rating	Excellent	Good	Good-Fair	Fair	Poor
EPT	>27	21-27	14-20	7-13	0-6

The EPT index results are shown below in Table 4.9.

The results indicate that most of the sites are considered in poor condition. The exceptions were:

- SWQ08 (Long Swamp Creek) and Longacre Creek which were in excellent condition;
- Belanglo Creek in spring which was in good condition; and
- SWQ12 (Wells Creek) in spring, SIA7 (Oldbury Creek) in autumn and Knapsack Creek in spring were in good to fair condition.

Table 4.9 EPT results

Season	Autumn 2013	Spring 2013	Autumn 2013	Spring 2013	Autumn 2013	Spring 2013	Autumn 2013	Spring 2013	Autumn 2013	Spring 2013	Autumn 2013	Spring 2013	Autumn 2013	Spring 2013	Autumn 2013	Autumn 2013	Autumn 2013	Spring 2013	Spring 2013	Spring 2013
Site	**SWQ01**		**SWQ02**		**SWQ03**		**SWQ04**		**SWQ08**		**SWQ10**		**SWQ12**		**Medway Dam**	**SIA7**	**SIA9**	**Knapsack Creek**	**Belanglo Creek**	**Longacre Creek**
EPT %	0.5	2.49	0.2	0	0	0.78	0	0	30.24	27.4	1.68	1.84	5.18	18.62	11.68	17.29	0.19	20	23	87

4.6.5 Fish and turtles

A total of 257 individual fish and turtles were recorded from the sites across spring and autumn (Table 4.10). The communities were limited in diversity and were composed of commonly occurring fish and reptile species and one pest species, the Mosquitofish. No threatened fish or turtles were recorded.

Table 4.10 Fish and turtles recorded

Site	Date	Longfin Eel	Mountain Galaxid	Mosquitofish	Firetail Gudgeon	Eastern Long neck Turtle	Total
		Anguilla reinhardtii	*Galaxias olidus*	*Gambusia holbrooki*	*Hypseleotris galii*	*Chelodina longicollis*	
SWQ1	16.5.2013	2	12				
SWQ1	16.11.2013		5	1		2	
SWQ2	15.5.2013		2				
SWQ2	4.11.2013		2				
SWQ3	16.5.2013		5				
SWQ3	5.11.2013		1			3	
SWQ4	16.5.2013		2				
SWQ4	5.11.2013		4				
SWQ5	14.5.2013			29			
SWQ5	6.11.2013						
SWQ8	15.5.2013		4				
SWQ8	6.11.2013						
SWQ10	14.5.2013		37				
SWQ10	7.11.2013			2			
SWQ12	15.5.2013		29				
SWQ12	4.11.2013		12	32			
Medway Dam	17.5.2014		12		32		
SIA7	19.5.2014		12				
SIA9	17.5.2014		15				
Total		2	154	64	32	5	257

4.6.6 Key fish habitat assessment

An analysis of the results determined that:

- qualitative water quality values were largely highly disturbed or experienced no flow conditions;
- instream habitat and riparian zones were largely highly disturbed;
- limited and disturbed habitat was present that may support some listed species. Six sites were identified as having some limited level of potential habitat. These sites were on Knapsack and Belanglo Creeks within the underground mining footprint.

- Medway Rivulet and Belanglo, Black Bobs and Wells Creeks that traverse the project area are considered DPI Fisheries key fish habitats. However, when these sites were sampled, the habitat available was classified as minimal to unlikely fish habitat. Four sites supported moderate fish habitat (SWQ01 on Black Bobs Creek, Medway Dam on Medway Rivulet, SWQ05 on Wells Creek and Habitat C at Medway Rivulet).

Table 4.11 Key fish habitat assessment results

Survey location	Disturbance Level			Threatened and protected species habitat	Waterway classification[1]
	Water Quality	Instream Habitat	Riparian Zone		
SWQ01	High disturbance	High disturbance	High disturbance	Low potential for Macquarie Perch to occur. The species was not recorded during targeted surveys.	Class 2: Moderate fish habitat
SWQ02	High disturbance	High disturbance	High disturbance	Low potential for Australian Grayling to occur. The species was not recorded during targeted surveys.	Class 3: Minimal fish habitat
SWQ03	High disturbance	High disturbance	High disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
SWQ04	High disturbance	High disturbance	High disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
SWQ05	High disturbance	High disturbance	High disturbance	Suitable habitat absent	Class 2: Moderate fish habitat
SWQ06	High disturbance	Low disturbance	Moderate disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
SWQ07	Moderate disturbance	Moderate disturbance	High disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
SWQ08	High disturbance	High disturbance	High disturbance	Low potential for Macquarie Perch to occur. The species was not recorded during targeted surveys.	Class 3: Minimal fish habitat
SWQ10	High disturbance	High disturbance	High disturbance	Low potential for Macquarie Perch, Australian Grayling, Adam's Emerald Dragonfly to occur. These species were not recorded during targeted surveys.	Class 3: Minimal fish habitat
SWQ11	Moderate disturbance	Moderate disturbance	High disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
SWQ12	High disturbance	High disturbance	Extreme disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
SWQ13	No flow	Moderate disturbance	High disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Medway Dam	No evidence of disturbance	No evidence of disturbance	No evidence of disturbance	Suitable habitat absent	Class 2: Moderate fish habitat
SIA7	High disturbance	High disturbance	Extreme disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
SIA9	High disturbance	High disturbance	Extreme disturbance	Suitable habitat absent	Class 3: Minimal fish habitat

Table 4.11 Key fish habitat assessment results

Survey location	Disturbance Level: Water Quality	Disturbance Level: Instream Habitat	Disturbance Level: Riparian Zone	Threatened and protected species habitat	Waterway classification[1]
Knapsack Creek	Low disturbance	Low disturbance	Low disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
Belanglo Creek	Low disturbance	Low disturbance	Low disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
Longacre Creek	Low disturbance	Low disturbance	Low disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
SWQ14	High disturbance	High disturbance	Moderate disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
Habitat C	Moderate disturbance	Moderate disturbance	High disturbance	Low potential for Australian Grayling to occur. The species was not recorded during targeted surveys.	Class 2: Moderate fish habitat
Habitat D	No flow	Moderate disturbance	Extreme disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat E	Moderate disturbance	Moderate disturbance	High disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
Habitat F	No flow	High disturbance	Extreme disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat G	Moderate disturbance	Moderate disturbance	High disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
Habitat H	No flow	Little disturbance	Little disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat I	Moderate disturbance	Moderate disturbance	Moderate disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat J	No flow	Moderate disturbance	Moderate disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat K	No flow	Moderate disturbance	Extreme disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
Habitat L	No flow	Moderate disturbance	Extreme disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat M	No flow	Moderate disturbance	Extreme disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat N&P	No flow	High disturbance	High disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat O	No flow	High disturbance	High disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat Q	No flow	Moderate disturbance	High disturbance	Suitable habitat absent	Class 3: Minimal fish habitat
Habitat R	No flow	High disturbance	High disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat S	No flow	Moderate disturbance	Low disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat T	No flow	Moderate disturbance	Moderate disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat U	No flow	Moderate disturbance	Low disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat

Table 4.11 Key fish habitat assessment results

Survey location	Disturbance Level: Water Quality	Disturbance Level: Instream Habitat	Disturbance Level: Riparian Zone	Threatened and protected species habitat	Waterway classification[1]
Habitat V	No flow	Moderate disturbance	Moderate disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat W	No flow	Moderate disturbance	High disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat X	No flow	High disturbance	High disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat Y	No flow	Moderate disturbance	High disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat Z	No flow	High disturbance	High disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat AA	No flow	Moderate disturbance	Low disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat AB	No flow	Low disturbance	Low disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat
Habitat AC	No flow	Low disturbance	Low disturbance	Suitable habitat absent	Class 4: Unlikely fish habitat

Notes 1. See Table 2.11 for waterway classification descriptions (DPI 2013).

4.6.7 Threatened and protected species

No state or federally listed species were recorded during the aquatic ecology surveys. There is a low potential for:

- the threatened Macquarie Perch to occur at SWQ01, SWQ08 and SWQ10;
- the Australian Grayling to occur at SWQ02, SWQ10 and Habitat C; and
- Adam's Emerald Dragonfly at SWQ10.

Some habitat features required by the Macquarie Perch (clear water and boulders), Australian Grayling (clear water and a gravel substrate) and Adam's Emerald Dragonfly (gravel substrate) are present at the above listed sites. Targeted surveys failed to detect these species, therefore they are considered to be absent from the aquatic study area.

The presence of the Giant Dragonfly has been assumed at Long Swamp and Stingray Swamp in the south of the aquatic study area, given the previous records in these locations.

Although not listed under any legislation, the Platypus (*Ornithorhynchus anatinus*) is considered to be a locally important species that is abundant in the locality. Targeted searches for Platypus (a protected species) habitats in the aquatic study area found that its preferred habitat (ie streams with sandy banks required for burrowing) was generally absent. The species is only expected to occur along the Wingecarribee River in the north of the aquatic study area. The Sydney Catchment Authority has undertaken long term studies of Platypus in the Wingecarribee River and they have been documented at least since 1968 onwards for most of the river. A study undertaken at the confluence of Black Bobs Creek and the Wingecarribee River identified that 'the lower river represents some of the best platypus habitat in NSW and supports a breeding population.' (Grant 2006).

The Platypus is a long-lived species and is totally dependent on aquatic ecosystems for its survival. The occurrence of platypus is dependent on adequate supplies of benthic invertebrates which they use as food and the availability of earth banks in which they build their resting and nesting burrows (Grant and Temple-Smith 1998). Rivers or streams with relatively steep earth banks consolidated by the roots of native vegetation, abundant invertebrate prey, cobbled or gravel substrates, overhanging shady vegetation and a sequence of pools and riffles are considered ideal platypus habitat. This species can also be found in lakes, farm dams and moderately-degraded streams. Platypus populations are vulnerable to degradation of suitable water bodies caused by agriculture, damming, drainage and pollution.

4.7 Stygofauna

4.7.1 Groundwater quality

Groundwater is generally fresh in the Hawkesbury Sandstone and Illawarra Coal Measures and comparable to surface water, indicating proximity to recharge areas. Groundwater quality is also fresh in the Robertson Basalt Group although the mean TDS is slightly higher compared to the sandstone and coal. The Wianamatta Group hosts brackish groundwater remnant from the marine depositional setting. The similarity of TDS measurements between the Illawarra Coal Measures and Hawkesbury Sandstone indicates that they are hydraulically connected between the units. Local variations in the Hawkesbury Sandstone TDS measurements are attributed to leakage of higher salinity groundwater from the overlying Wianamatta Group, where present. The fresher salinity observed in the Hawkesbury Sandstone in the west and north-west is indicative of recharge areas and absence of overlying shale.

pH conditions are typically neutral in the Robertson Basalt and Wianamatta Group. A larger range of pH results have been observed in the Hawkesbury Sandstone and Illawarra Coal Measures, with results ranging from acidic to neutral.

Concentrations of most dissolved metals are typically low for most samples collected of each groundwater systems, with many measurements below detection limits. This is typical of groundwater with reasonably neutral pH.

No organic compounds were detected above the limit of detection in the Wianamatta Group and Illawarra Coal Measures groundwater. Minor detections of naturally occurring toluene and petroleum hydrocarbons were observed in the Hawkesbury Sandstone and Wongawilli Seam groundwater.

Groundwater flow in the Hawkesbury Sandstone and the underlying Wongawilli Seam is via a dual porosity system comprising connected intergranular pore spaces and structural features including fractures, bedding planes and joints. The regional groundwater flow direction in the Hawkesbury Sandstone and Wongawilli Coal Seam is influenced by the location of major hydraulic boundaries in the landscape, including:

- recharge areas, particularly along the western boundary of the project area at elevated areas where the Hawkesbury Sandstone outcrops; and
- discharge areas - typically associated with lower or steep topographic gradients, such as cliff lines; and stratigraphic dip.

4.7.2 Stygofauna

i Overview

In NSW, large scale, targeted stygofauna studies have mainly been undertaken as a result of environmental assessment requirements for major projects, most commonly for large mining projects. The stygofauna information available in NSW is focussed on groundwater systems in the Hunter Valley, Gunnedah and Western Ranges regions, in karst formations. To date, only a very limited number of studies have been undertaken in the Southern Highlands region. Most studies in the region have focused on large projects in the Western Coalfields.

ii Regional stygofauna

Of the studies undertaken in the Southern Highlands region, a number have identified stygofauna communities within the area. Thurgate et al (2001) identified that the Eastern Highlands region (which is to the west of the aquatic study area) supports two-thirds of the stygofauna of New South Wales, and half of this total is concentrated at Wombeyan Caves. These surveys provide some of the most recent applicable information relating to styofauna in the region. Surveys at sites at Wombeyan (40 sites), Jenolan (15 sites) Wee Jasper (6 sites), and Colong (3 sites) identified stygofauna in the following orders:

- Neoniphargidae;
- Eusiridae;
- Psammaspididae;
- Phreatoicidae;
- Glacidorbidae; and
- Hydrobiidae.

A study was undertaken of groundwater systems in the Kangaloon region of the Southern Highlands, south east of the aquatic study area (Hose 2008). The study identified a range of taxa from perched and main groundwater systems. Stygofauna taxa richness and abundance varied across sampling sites. The results from this study indicate that stygofauna differ between perched and main groundwater system systems. Taxa identified in the study comprised:

- Copepoda: Cyclopoida, Harpacticoida;
- Syncarida: Bathynellidae, Psammspidae;
- Amphipoda: Paramelitidae;
- Acarina: Spp 1 and Spp2;
- Nematoda;
- Oligochaeta; and
- Tardigrada.

Hose (2009) identified widespread stygofauna assemblages in perched and main groundwater systems at Kangaloon, comprising:

- Copepoda Cylcopoida and Harpacticoida;
- Syncarinda Psammaspidae;
- Acarina spp 1 &2;
- Nematoda; and
- Oligochaeta.

Studies undertaken by SMEC in 2006 and 2007 for the Upper Nepean (Kangaloon) borefield project (KBR 2008) recorded three individuals from two crustacean taxa (belonging to Order Crustacea). They were: Syncarida (one specimen Psammaspides n.sp) and Copepoda (two specimens Diacyclops sp.).

A study undertaken in the Berrima region (to the east of the aquatic study area) (Bradbury and Williams 1997) identified stygofauna species from Wombeyan, comprising *Wombeyanus botulosus*, *Neoniphargidae secus*, and *N. richardi* and *N. simony* from Jenolan.

iii Stygofauna in the aquatic study area

The stygofauna surveys undertaken for the project recorded three taxa of terrestrial and one aquatic fauna (an ant, springtail and water strider) and one individual of the Syncarida Bathynellidae spp (a crustacean).

Bathynellidae spp was recorded in bore HU0044XPZB. This bore is in the southern part of the aquatic study area in Hanging Rock Swamp within Penrose State Forest. This bore was between 8-11 m in depth and located in the Illawarra Coal Measures, in particular the Wongawilli coal seam. Bathynellidae, and another taxa belonging to super order Syncarida (Psammaspidae) were recorded in the region in the Kangaloon studies. Therefore, stygofauna of this super order (Syncarida) and family (Bathynellidae) are not restricted to the aquatic study area, and were not recorded in the project area. No other stygofauna were recorded in the project area or aquatic study area.

Bathynellidae belong to the crustacean super order Syncarida and are relatively poorly known in Australia. The Syncarida includes 200 described species divided between two orders, the Anaspidacea and the Bathynellacea. The family Bathynellidae occurs worldwide in interstitial (spaces between sand grains) or groundwater habitats. According to Serov (2002), there is currently only one species of the family Bathynellidae described from Australia: *Bathynella primaustraliensis* from the Murray-Darling Basin. However, the family occurs more widely and, in Western Australia, undescribed species have been recorded from the Pilbara and Yilgarn as well as Eneabba. Bathynellidae typically inhabit freshwater interstitial species in alluvium (Bennelongia 2008).

Bathynellidae have very small ranges with two-thirds of species having known ranges of less than 10 km. However, two species had ranges extending across several hundred kilometres and studies have recently pointed out in their review of global diversity of syncarids that, when intensive sampling occurs, many species previously thought to be restricted are shown to have wide distributions (Bennelongia 2008).

5 Biodiversity in the surface infrastructure area

This chapter summarises the biodiversity recorded or predicted to occur within and adjacent to surface facilities. The information in this chapter has informed a detailed assessment of the project's direct and indirect impacts. The supporting data has informed the calculation of ecosystem and species credits in accordance with the FBA.

5.1 Terrestrial biodiversity in the surface infrastructure area

Four vegetation types are adjacent to the direct disturbance footprint of the surface infrastructure area (Figure 5.1). These comprise:

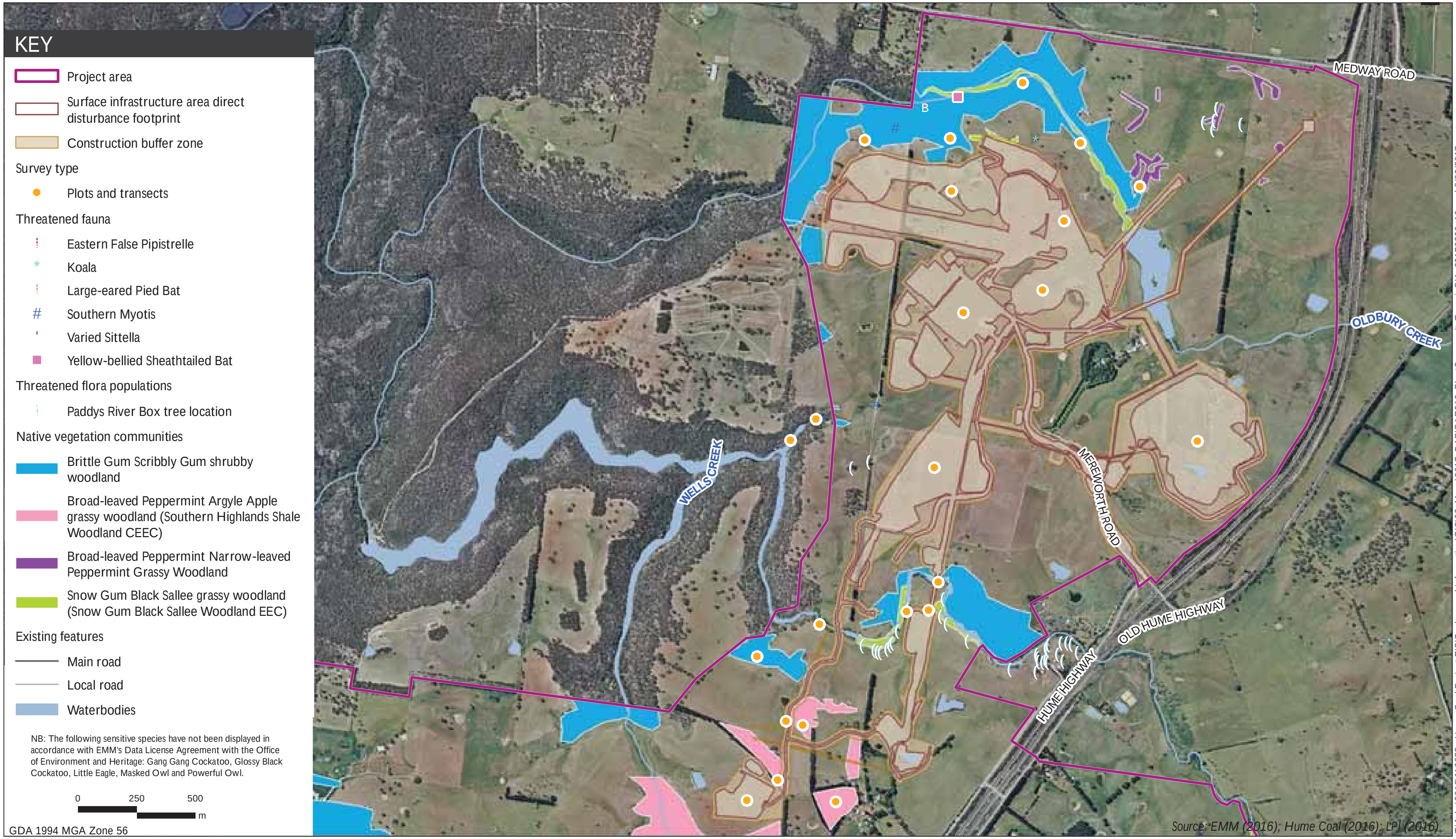
- Brittle Gum Scribbly Gum shrubby woodland;
- Broad-leaved Peppermint Argyle Apple grassy woodland;
- Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland; and
- Snow Gum Black Sallee grassy woodland.

Broad-leaved Peppermint Argyle Apple grassy woodland represents Southern Highlands Shale Forest and Woodland, listed as an EEC under the TSC Act and a CEEC under the EPBC Act (see Section 4.3.1). Snow Gum Black Sallee grassy woodland represents Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland, listed as an EEC under the TSC Act. The direct disturbance footprint of the surface infrastructure area avoids direct impacts to these listed communities (Figure 5.1). The project will result in minor impacts to Brittle Gum Scribbly Gum shrubby woodland, which is not a listed community.

Thirty-five Paddys River Box trees, listed as an endangered species under the TSC and EPBC Acts, were recorded adjacent to the direct disturbance footprint of the surface infrastructure area. The direct disturbance footprint of the surface infrastructure area avoids direct impacts to this endangered species (Figure 5.1).

Threatened fauna including the Little Eagle, Southern Myotis, Large-eared Pied Bat, Yellow-bellied Sheathtail Bat and Koala were recorded adjacent to the direct disturbance footprint of the surface infrastructure area. The direct disturbance footprint has been optimised such that impacts to these species habitats are minimised.

Direct impacts on vegetation types and threatened species habitats from the direct disturbance footprint of the surface infrastructure area are discussed in the following sections.



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Plant community types and threatened species in the surface infrastructure area

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Figure 5.1

5.2 Vegetation zones in the surface infrastructure area

A 'vegetation zone' is defined by OEH (2014) as "a relatively homogenous area of native vegetation on a development site (ie the surface infrastructure area) that is the same PCT and broad condition state". One vegetation zone occurs in the surface infrastructure area. The area calculation for Zone 1 has been derived from the paddock tree calculator (Section 5.2.1). While both vegetation zones are in low condition, their site value is greater than 17 and therefore they are required to be offset.

A summary of the vegetation zones is provided in Table 5.1 and they are mapped in Figure 5.2. All vegetation not mapped in Figure 5.2 has been classified as cleared land. Cleared land is shown in Figure 5.3 and is not required to be offset.

Table 5.1 Vegetation zones in the surface infrastructure area and survey effort by zone

Vegetation zone	Plant community type	Biometric vegetation type	Threatened ecological community	Condition class	Current site value	Plots/ transects required	Plots/ transects completed	Area (ha)
1	PCT 1093 Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion	HN570	N/A	Low (paddock trees)	36.46	2	2	8.3[1]
Total								8.3

Notes *1. The 8.3 ha represents the effective clearing area calculation provided by the paddock tree calculator. Assumptions for paddock tree calculations are provided in Section 5.2.1.*

5.2.1 Paddock tree calculations

The BioBanking Paddock Tree Calculator is a tool for estimating the percentage of foliage cover and the area cleared where trees are very sparse and survey data taken from transects and plots does not inform accurate BioBanking calculations. The BioBanking Paddock Tree Calculator can be used on a development site where the groundcover vegetation is in low condition, ie less than 50% of the groundcover is native or greater than 90% of the groundcover is cleared, such as the paddock trees to be cleared for the coal handling and processing plant (Figure 5.2). The inner assessment circle was used as the sample area in which paddock trees were counted.

The seven plots completed in this area demonstrate that less than 50% of the groundcover is native (average between 80-100% exotic), and therefore use of the paddock tree calculator is justified.

Four distinct patches of paddock trees are present within the area to be cleared (ie Zone 1). Variables required by the BioBanking Paddock Tree Calculator were measured for each of the four patches. The effective clearing area was totalled for the four distinct patches to provide a total effective clearing area and the total area of Zone 1, which is 8.3 ha.

A summary of the assumptions used to inform the paddock tree calculations is provided in Table 5.2.

Table 5.2 Assumptions informing paddock tree calculations

Criteria	Patch 1	Patch 2	Patch 3	Patch 4	Total
Percentage of foliage cover of paddock trees					
Average crown diameter (m)	14	5.5	10.1	10.3	-
Average percentage of foliage cover taken from a sample of paddock trees (%)	50	40	40	40	-
Number of paddock trees within sample area	40	16	6	2	64
Sample area in which the number of paddock trees were counted (ha)	65	0.5	0.6	3.2	-
Percentage of foliage cover (%)	0.2	3	2.7	0.2	-
Does the canopy meet the low condition definition?					
What is the lower benchmark canopy percentage of foliage cover (%)	17	17	17	17	-
Is canopy percentage of foliage cover (estimated above) <25% of the benchmark?	Yes	Yes	Yes	Yes	-
Calculation of the effective clearing area (where groundcover is in low condition)					
Effective clearing area (ha)	7.2	0.4	0.5	0.2	8.3
Calculation of average number of trees with hollow					
Number of hollow-bearing trees in the sample area	14	1	1	1	17
Average number of trees with hollows	0.14	0.25	0.25	0.5	-

5.3 Threatened species in the surface infrastructure area

5.3.1 Ecosystem credit species predicted to occur in the surface infrastructure area

The ecosystem credit species predicted by the BioBanking Calculator are listed in Table 5.3. Ecosystem credit species also recorded in the terrestrial study area, comprising the Diamond Firetail, Eastern False Pipistrelle, Eastern Freetail Bat, Masked Owl (unconfirmed record) and Yellow-bellied Sheathtail Bat are also listed in Table 5.3. The predicted species with the highest threatened species offset multiplier is the Powerful Owl, which determines the ecosystem credit requirements for the PCTs listed in Table 5.1.

Table 5.3 Ecosystem credit species

Ecosystem credit species	Threatened species offset multiplier	Tg value[1]	Likelihood of occurrence
Diamond Firetail	1.3	0.75	High. This species was recorded adjacent to the surface infrastructure area.
Eastern False Pipistrelle	2.2	0.45	Moderate. This species was recorded in the terrestrial study area.
Eastern Freetail Bat	2.2	0.45	Moderate. This species was recorded in the terrestrial study area.
Flame Robin	1.3	0.77	Moderate. This species was recorded in the terrestrial study area.
Gang-gang Cockatoo	2.0	0.5	High. This species was recorded adjacent to the surface infrastructure area.
Glossy Black-cockatoo	1.8	0.55	None. Suitable habitat is absent. This was retained as an ecosystem credit species, as the species with the highest offset multiplier determines the credit requirements.
Little Eagle	1.4	0.71	High. The species has a large home range and was recorded in the terrestrial study area.
Little Lorikeet	1.8	0.55	High. The species is highly nomadic and was recorded in the terrestrial study area.
Masked Owl	3.0	0.33	Moderate. This species was recorded (unconfirmed record) in the terrestrial study area.
Powerful Owl	3.0	0.33	Moderate. This species was recorded in the terrestrial study area.
Scarlet Robin	1.3	0.77	Moderate. This species was recorded in the terrestrial study area.
Turquoise Parrot	1.8	0.55	Moderate. This species was recorded in the terrestrial study area.
Varied Sittella	1.3	0.77	Moderate. This species was recorded in the terrestrial study area.
Yellow-bellied Sheathtail Bat	2.2	0.45	High. This species was recorded adjacent to the surface infrastructure area.

Notes *1. Tg value is a multiplier applied to ecosystem credits according to the ability of the threatened species to respond to improvements in site value due to management actions at an offset site. The lowest Tg value has the greatest influence on the multiplication of ecosystem credits. The multiplier on ecosystem credits is calculated as 1/Tg value.*

5.3.2 Species credit species predicted to occur in the surface infrastructure area

The species credit species predicted by the BioBanking Calculator are listed in Table 5.4. Additional species credit species recorded in the project area, although not predicted to occur, are also listed in Table 5.4 and included in species credit calculations (ie. the Eastern Bentwing Bat, Little Bentwing Bat and Southern Myotis).

Table 5.4 Species credit species

Species credit species	Survey type	Species recorded?	Species abundance in the project area	Habitat features in surface infrastructure area	Species polgyon (ie area of habitat impacted)	Can the species withstand further loss?[1]
Bynoe's Wattle	Targeted survey	No	The species is not predicted to occur in the project area as it was not recorded during targeted surveys.	The area contains one canopy tree normally associated with this species, namely Scribbly Gum. However, targeted surveys for the species failed to detect any individuals.	0	Yes. However, this is not applicable as the species is absent, and will not be impacted.
Eastern Bentwing Bat	Targeted survey	Yes	The species abundance is unknown as it was recorded on an ultrasonic bat detector.	The threatened species profile database states that the species does not occupy paddock trees, and therefore the area of Zone 1 has not been included in the area of habitat impacted.	0	The species cannot withstand the loss of breeding or roosting habitat. Breeding and/or roosting habitat is absent from the area to be cleared, therefore it will not be impacted.
Eastern Pygmy Possum	Targeted survey	No	The species abundance is unknown as it was not recorded.	The area contains tree hollows that are potentially suitable for the species, however the understorey has been heavily modified and contains little shrub and groundcover which would provide foraging habitat and protection from predators. Surveys failed to detect the species.	0	Yes. However, this is not applicable as the species is absent, and will not be impacted.
Giant Burrowing Frog	Targeted survey	No	The species abundance is unknown as it was not recorded.	The threatened species profile database states that the species does not occupy paddock trees, and therefore the area of Zone 1 has not been included in the area of habitat impacted.	0	The species cannot withstand the loss of breeding habitat. Breeding habitat is absent from the area to be cleared, therefore it will not be impacted.
Hoary Sunray	Targeted survey	No	The species abundance is unknown as it was not recorded.	The species can occur in grassy woodlands and shrubby forests, which occur in the surface infrastructure area. However, targeted surveys failed to detect the species.	0	Yes. However, this is not applicable as the species is absent, and will not be impacted.

Table 5.4 Species credit species

Species credit species	Survey type	Species recorded?	Species abundance in the project area	Habitat features in surface infrastructure area	Species polgyon (ie area of habitat impacted)	Can the species withstand further loss?[1]
Koala	Targeted survey	Yes	Five individuals were recorded in Belanglo State Forest.	Feed trees identified by the Koala Recovery Plan (DECC 2008), comprising Brittle Gum, are present. The threatened species profile database states that the species can occupy paddock trees, and therefore the area of Zone 1 has been included in the area of habitat impacted.	8.3	Can sustain up to 5% loss in foraging habitat provided clearing does not increase fragmentation.
Large-eared Pied Bat	Targeted survey	Yes	The species abundance is unknown as it was recorded on an ultrasonic bat detector.	The threatened species profile database states that the species does not occupy paddock trees, and therefore the area of Zone 1 has not been included in the area of habitat impacted.	0	Cannot sustain loss of breeding habitat. Can sustain up to 10% loss of foraging habitat within 500m of breeding habitat. Habitat will not be impacted.
Little Bentwing Bat	Targeted survey	Yes	The species abundance is unknown as it was recorded on an ultrasonic bat detector.	The threatened species profile database states that the species does not occupy paddock trees, and therefore the area of Zone 1 has not been included in the area of habitat impacted.	0	The species cannot withstand the loss of breeding or roosting habitat. Breeding and/or roosting habitat is absent from the area to be cleared, therefore it will not be impacted.
Paddys River Box	Targeted survey	Yes	35 individuals were recorded in the project area.	PCT731 and PCT677 contain potential habitat for the species. Targeted searches recorded the species adjacent to the surface infrastructure area. These species will not be directly impacted.	0	No. Direct impacts to the species will be avoided.
Rosenberg's Goanna	Targeted survey	No	The species is not predicted to occur given the absence of suitable breeding habitat.	The open forest of PCT1093 provides potential habitat for the species. However, termite mounds, a critical habitat component are absent from the area. No individuals were recorded.	0	The species cannot withstand the loss of breeding habitat. Roosting habitat is absent from the area to be cleared, therefore it will not be impacted.

Table 5.4 Species credit species

Species credit species	Survey type	Species recorded?	Species abundance in the project area	Habitat features in surface infrastructure area	Species polgyon (ie area of habitat impacted)	Can the species withstand further loss?[1]
Southern Myotis	Targeted survey	Yes	Twenty individuals were trapped along Medway Rivulet, west of the direct disturbance footprint.	The threatened species profile database states that the species can occupy paddock trees within 500 m of foraging habitat (ie Oldbury Creek), and therefore the area of Zone 1 has been included in the area of habitat impacted.	8.3	Yes. Up to 10% of habitat.
Squirrel Glider	Assumed	N/A	The species abundance is unknown as it was not recorded during surveys.	The threatened species profile database states that the species can occupy paddock trees within 75m of moderate to good condition vegetation (ie Oldbury Creek), and therefore the area of Zone 1 has been included in the area of habitat impacted.	8.3	Yes. Up to 10% of foraging habitat and 5% of breeding habitat.

Notes 1. Species that cannot withstand further loss are determined by the Threatened Species Profile Database (OEH 2016).

5.4 Areas requiring offset

The areas requiring offset comprise:

- Zone 1: ecosystem credits for paddock trees from PCT 1093 (converted to an effective clearing area of 8.3 ha); and
- Species credits for the Koala, Southern Myotis and Squirrel Glider in Zone 1.

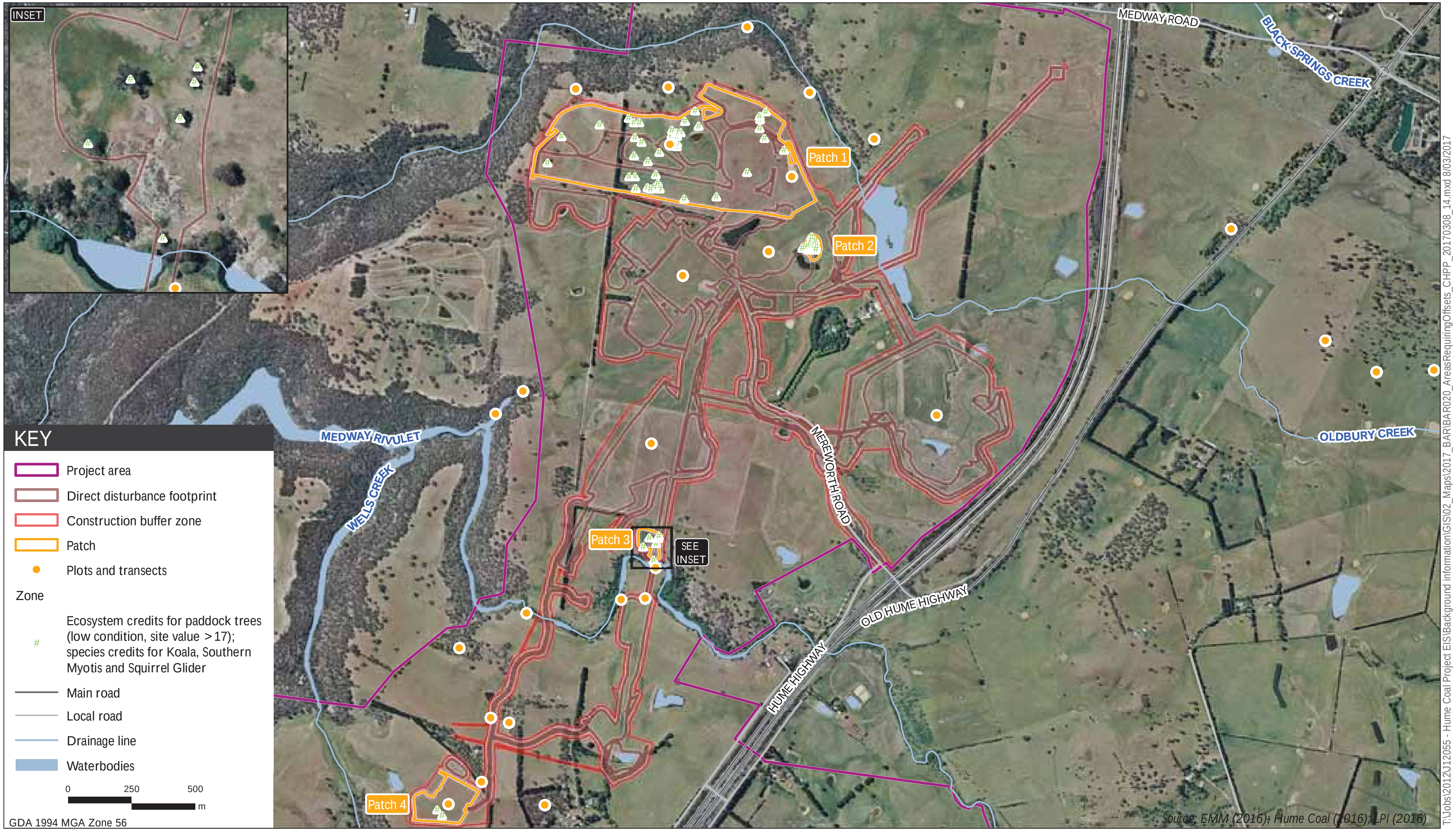
The areas requiring offset are shown on Figure 5.2.

5.5 Areas not requiring offset

The areas not requiring offset comprise:

- cleared land in the direct disturbance footprint; and
- species credits where habitat will not be impacted (see Table 5.4).

Areas not requiring offset are shown on Figure 5.3.



Areas requiring offset - surface infrastructure area

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Figure 5.2

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Areas not requiring offset - surface infrastructure area

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Figure 5.3

5.6 Aquatic biodiversity in the surface infrastructure area

Streams in the surface infrastructure area comprise the fish habitats in Table 5.5. Two moderate fish habitats are present, comprising SWQ05 on Wells Creek and Habitat C on Medway Rivulet (see Figure 3.1).

No threatened species were recorded in these locations, and none are considered to be present due to the absence of preferred habitats and their non-detection during targeted surveys.

Table 5.5 Fish habitat in the surface infrastructure area

Survey location	Waterway classification[1]
SWQ05	Class 2: Moderate fish habitat
SWQ06	Class 3: Minimal fish habitat
Habitat C	Class 2: Moderate fish habitat
Habitat K	Class 3: Minimal fish habitat
Habitat L	Class 4: Unlikely fish habitat
Habitat R	Class 4: Unlikely fish habitat

Notes 1. See Table 2.11 for waterway classification descriptions (DPI 2013).

6 Impact avoidance and mitigation

This chapter describes the avoidance, minimisation and mitigation strategies applied to the project, in accordance with Chapter 8 of the FBA. It also contains a justification for the proposed measures and an assessment of their effectiveness, in accordance with the supplementary SEARs.

6.1 Avoidance and minimisation

6.1.1 Overview

Impacts on biodiversity from an underground mining project can occur as a result of vegetation clearance for surface infrastructure, subsidence related impacts, changes to surface hydrology and groundwater drawdown. Hume Coal undertook an extensive project planning and design phase to avoid and minimise these impacts.

Several alternative project layouts were considered during development of the project through an iterative design process, resulting in the final project design presented in Chapter 2 of the EIS (EMM 2017a) and assessed in this BAR. A number of fundamental aspects were given particular scrutiny during this design process. These were:

- mining method: consideration of numerous mining methods and layouts, comprising longwall, miniwalls, bord and pillar and non-caving methods;
- underground mine layout, including panel widths and mine footprint;
- surface infrastructure location was chosen to avoid threatened species habitat;
- water management;
- site access;
- management and disposal of rejects; and
- accommodation for construction workers.

Each alternative was assessed against the following objectives:

- minimise groundwater impacts;
- minimise subsidence impacts;
- have the flexibility to deal with surface and geological constraints; and
- be able to accommodate underground reject emplacement.

The key areas of the project design which were adopted to specifically avoid potential impacts to biodiversity are discussed in the sub-sections below.

6.1.2 Surface infrastructure layout

Hume Coal looked for options within and adjacent to the project area for the location of the surface infrastructure area, and identified several sites that met all or most of the above criteria. Numerous locations and variations to these were considered, which can all be summarised in four general areas shown indicatively in Figure 7.1 of the EIS. The chosen location and layout has the advantage of meeting each of the afore-mentioned criteria and is also viable in terms of functionality, cost and efficiency. A full description of the alternatives considered is provided in Chapter 7 of the EIS.

As part of the evaluation process of alternative surface infrastructure location options, ecologists surveyed proposed infrastructure areas. Areas of potential sensitivity were identified, such as areas containing threatened species and communities, riparian vegetation and waterways as well as areas of ‘low constraint’, which represented opportunities for positioning surface infrastructure with minimal impact. In particular, a narrow corridor of vegetation along Oldbury Creek was found to provide potential habitat for threatened microbats and Koalas. The original coal handling and processing plant design extended much closer to Oldbury Creek than what is now proposed. Management and mitigation measures were recommended to address potential impacts. However, Hume Coal went beyond these measures and moved the proposed CHPP site south to avoid this area and the associated potential for ecological impacts. The layout was also reconfigured to fit within a smaller footprint to avoid the catchment of Medway Dam, a number of sites containing the endangered Paddys River Box (*Eucalyptus macarthurii*) trees and Snow Gum Black Sallee Candlebark grassy woodland. The resultant design completely avoids direct impacts to these threatened species and communities.

Hume Coal implemented further avoidance measures when considering the location of the surface infrastructure area’s direct disturbance footprint. The administration buildings, bathhouse and workshops were originally designed to avoid all direct impacts to an area of Southern Highlands Shale Forest and Woodland south of Medway Rivulet (shown in Figure 5.1), a TEC listed as endangered under the TSC Act and critically endangered under the EPBC Act. Despite avoidance of direct impacts to these listed communities by the structures themselves, the mine infrastructure area would have required an asset protection zone for the purposes of bushfire protection. This asset protection zone would have required the clearing or thinning of 3.9 ha of Southern Highlands Shale Forest and Woodland to meet the objectives of the APZ. This portion of the infrastructure area was then moved north to its preferred location in an area of exotic pasture south of the proposed CHPP, avoiding all direct impacts to Southern Highlands Shale Woodland, and habitat for several threatened species.

6.1.3 Mine design

In addition to avoiding impacts through the careful placement of surface infrastructure, the mining method was also chosen in consideration of avoiding the potential for surface or aquatic impacts as a result of subsidence. A first workings only mining method was chosen for the project, enabling a project design that will result in negligible subsidence and therefore no subsidence related impacts at the surface or in streams.

6.1.4 Groundwater management

Potential groundwater impacts have been minimised through the following actions:

- the first workings mine design and layout;
- placement of rejects into mined-out voids;
- sealing of mine panels immediately following mining and co-disposal tailings emplacement; and
- injection of intercepted water behind sealed bulkheads as mining progresses.

These minimisation strategies are focused on reducing the volume of groundwater inflow to the mine workings, and enhancing the recovery time and reducing impact in the overlying groundwater systems.

6.1.5 Surface water management

The project has been designed to avoid or minimise potential impacts on surface water flow and associated erosion and scour impacts in local streams. Key aspects of the design that avoid or minimise impacts are as follows:

- the project does not involve the take of water directly from streams as a water supply for the project; and
- the project does not involve any stream diversions (WSP Parsons Brinkerhoff 2016).

The water management system for the project has been designed to minimise the impacts of changes to the catchment area within the project area associated with the construction and operation of the surface infrastructure area. These mitigation measures that focus on protecting aquatic ecology values include:

- diverting water from undisturbed areas around mine infrastructure areas and into local streams via diversion drains to minimise flow impacts associated with loss of catchment area; and
- maximising the reuse of water on-site to minimise off-site discharge of water to local streams, which could alter the natural flow regime.

The discharge points for water from SB03, SB04 and the WTP to Oldbury Creek will be designed with appropriate rock protection at outlet pipes and channels to prevent scour due to high outlet flow velocities. Detailed mitigation measures to address potential impacts of scouring associated with the discharge are provided in the Surface Water Flow and Geomorphology Assessment (Parsons Brinkerhoff 2016b).

The following environmental management plans will be prepared and implemented during the project:

- construction environmental management plan, which will include pollution and erosion/sedimentation control measures; and
- operations environmental management plan, which will contain a water management sub plan.

These measures will reduce potential impacts on aquatic species and habitats in the aquatic study area.

6.1.6 Waterway crossings

The waterway crossings and culverts will be designed and constructed in accordance with the national guidelines entitled '*Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*' (Fairfull and Witheridge 2003), *Policy and Guidelines for fish habitat conservation and management* (DPI 2013) and *Guidelines for watercourse crossings on waterfront land* (NOW 2012).

6.2 Impact mitigation

6.2.1 Construction and operational management plans

A construction environmental management plan (CEMP) and an operational environmental management plan (OEMP) will be prepared for the project, that will include the biodiversity management measures provided in Table 6.1. A biodiversity management plan (BMP) will be included in the CEMP and OEMP. The BMP will describe the measures to manage, monitor and report on biodiversity during the life of the project.

An annual review will be prepared each year during construction and operation of the project to document the mitigation and monitoring measures implemented in accordance with the CEMP and OEMP. The annual review will document the mitigation and monitoring measures implemented in accordance with the BMP, assess the performance of the project on these measures, and document any corrective actions implemented. The BMP would be prepared prior to construction of the Hume Coal Project and will be implemented during the life of the mine.

6.2.2 Construction biodiversity mitigation measures

The BMP will include methods to manage, protect and enhance retained native vegetation and fauna habitat within the surface infrastructure area during construction. Specifically, it will include:

- an overview of the important ecological values of the surface infrastructure area and their locations;
- roles and responsibilities for implementation of the BMP;
- procedures for pre-clearance surveys;
- methods to demarcate clearing boundaries;
- fauna rescue and relocation protocols;
- methods for the management of noxious weeds and pest animals;
- methods to mitigate the loss of hollow bearing trees (eg nest box installation or hollow relocation);
- methods to monitor mitigation measures; and
- rehabilitation management measures, including:
  - seed collection methods;
  - topsoil management techniques to preserve soil seed banks;

- planting guides including species and recommended planting densities;
- watering regimes;
- key thresholds for survival of planted tube stock/broadcast seed; and
- measures to determine success of revegetation and rehabilitation activities and contingencies with triggers for failed rehabilitation.

Construction biodiversity mitigation measures to be included in the BMP are outlined in Table 6.1.

6.2.3 Operational biodiversity mitigation measures

The BMP will include methods to manage, protect and enhance retained native vegetation and fauna habitat in areas of potential indirect impact during operation. Specifically, it will include:

- measures to manage erosion and sedimentation;
- measures to manage weeds and pest animals;
- measures to monitor potential impacts on groundwater dependent ecosystems during drought periods; and
- meausres to minimise bushfire risk adjacent to vegetation and fauna habitats.

Operational biodiversity mitigation measures to be included in the BMP are outlined in Table 6.1.

6.2.4 Proposed mitigation measures

The BMP will include measures to mitigate direct and indirect impacts of the Hume Coal Project on terrestrial biodiversity. These measures, and the timing of their implementation are described in Table 6.1.

Table 6.1 Mitigation measures

Impact	Action	Outcome	Timing	Responsibility
Direct impacts				
Clearing of native vegetation and fauna habitats	A ground disturbance permit system will be developed that will be implemented for all clearing activities.	Prevention of inadvertent clearing	During development of the BMP, implementation prior to clearing	Hume Coal Environmental Manager
	The clearing limits are to be clearly delineated in the field.	Prevention of inadvertent clearing	Before vegetation clearing	Hume Coal Environmental Coordinator

Table 6.1 Mitigation measures

Impact	Action	Outcome	Timing	Responsibility
	A pre-clearance survey will be completed by a suitably qualified and trained ecologist to identify and mark hollow-bearing trees, hollow logs, burrows and nests that require management during clearing. The pre-clearance survey method will be detailed in the BMP.	All hollow-bearing trees to be removed in the disturbance footprint will be marked for later management during construction	Before vegetation clearing	Hume Coal Environmental Coordinator
	Identify and fence all Paddys River Box trees in the construction footprint.	Prevention of inadvertent damage to trees	Before commencement of construction	Hume Coal Environmental Coordinator
	Hollow-bearing trees removed are to be replaced with salvaged hollows or nest boxes. These measures will be detailed in the BMP.	Maintenance of hollows in the locality	Before vegetation clearing	Hume Coal Environmental Coordinator
Fauna injury and mortality	A clearing procedure will be included in the BMP to be prepared. The following methods must be implemented during clearing: • felling of hollow-bearing trees will follow a two-stage clearing protocol, where surrounding non-hollow vegetation is cleared 24 hours prior to the hollow trees to allow fauna time to move.	Hollow-dependent fauna are given the opportunity to self-relocate, avoiding handling stress	Before and during vegetation clearing	Hume Coal Environmental Manager
	• a suitably trained fauna handler will be present during hollow-bearing tree clearing to rescue and relocate displaced fauna if found on site.	Hollow-dependent fauna are rescued and relocated safely	During vegetation clearing	Hume Coal Environmental Coordinator
Indirect impacts				
Erosion and sedimentation	Erosion and sedimentation will be managed in accordance with the measures specified in the Water Assessment (EMM 2017b).	Minimisation of indirect impacts from erosion and sediment transport offsite (ie increased weed growth)	Before and during vegetation clearing, during project operation	Hume Coal Environmental Coordinator

Table 6.1 Mitigation measures

Impact	Action	Outcome	Timing	Responsibility
Edge effects and fragmentation	Areas not disturbed by surface infrastructure will be managed for weeds. Access will be restricted to these areas. Weed and pest animal mitigation measures will be detailed in the BMP.	Adjacent habitats are not impacted by additional weed invasion	During construction and operation of the project	Hume Coal Environmental Coordinator
	Design waterway crossings in accordance with *Policy and Guidelines for fish habitat conservation and management* (DPI 2013) and *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (DPI 2004)	Maintain fish passage and connectivity	During detailed design	Hume Coal Mine Engineer
Increased noise, dust and light	Noise and dust will be managed in accordance with the measures specified in the Noise and Vibration Impact Assessment (EMM 2017c) and Air Quality Impact Assessment (Ramboll Environ 2016).	Minimisation of noise and dust impacts on biodiversity adjacent to the surface infrastructure area	During construction and operation of the project	Hume Coal Environmental Coordinator
	Directional lighting will be installed at the mine infrastructure area and coal handling and processing plant and will face away from native vegetation and fauna habitats where possible. Lighting measures will be investigated during preparation of the BMP.	Minimisation of light impacts on biodiversity adjacent to the surface infrastructure area	During construction	Hume Coal Environmental Manager
Fauna strike	Fauna-friendly fencing will be installed to delineate the coal handling and processing plant from threatened species habitats along Oldbury Creek. Fencing measures will be detailed in the BMP.	Prevention of Koala strike in the surface infrastructure area	During construction	Hume Coal Environmental Manager
Changes to surface hydrology	Implement mitigation and monitoring measures in accordance with Section 6.1 and 6.2 of the Hume Coal Project Surface Water Flow and Geomorphology Assessment (WSP Parsons Brinckerhoff 2016).	Maintenance of fish passage and aquatic ecosystem condition	During detailed design and construction	Hume Coal Mine Engineer Hume Coal Environmental Manager

Table 6.1 Mitigation measures

Impact	Action	Outcome	Timing	Responsibility
Changes to groundwater regimes	Terrestrial vegetation on Belanglo Creek (approximately 6 ha) and south of Wells Creek (approximately 13 ha) identified on Figure 7.1 and 7.2 will be monitored during extended periods of drought. An appropriate response will be determined if the condition of the vegetation is observed to decline as a result of mine activities.	Maintenance of Southern Highlands Shale Woodland CEEC, Koala habitat and Paddys River Box trees during drought periods (if required)	During operation of the project	Hume Coal Environmental Manager
Bushfire risk to vegetation and fauna habitats	The EPBC Act referral guidelines for the vulnerable Koala (DoE 2014) identifies the construction of new mines adjacent to areas of habitat critical to the survival of the Koala as having potential impacts, due to the increased fire risk. Given the location of the surface infrastructure adjacent to an area of known Koala habitat along Oldbury Creek, the fire risk to habitat in this area may be increased. Measures to minimise the fire risk have been documented in the Hazard and Risk Assessment, in Appendix P of the EIS.	Minimisation of bushfire risk to Koala habitat adjacent to the surface infrastructure area	During operation of the project	Hume Coal Environmental Manager

6.2.5 Justification of avoidance and mitigation measures

The avoidance measures implemented are consistent with industry best practice. They were developed with consideration of Section 8.3.2 of the FBA, *Guidelines for the avoidance and minimisation of impacts to biodiversity values during the project life cycle.* Section 8.3.2 of the FBA provides guidance on suitable avoidance and minimisation measures to implement during the site selection, planning, construction and operational phase. Avoidance measures from Section 8.3.2 of the FBA have been implemented during the site selection and planning phases, while the measures for the construction and operational phases have been incorporated into the mitigation measures presented in Table 6.1.

Design measures for waterway crossings will be implemented in accordance with *Policy and guidelines for fish habitat conservation and management* (DPI 2013), *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings'* (Fairfull and Witheridge 2003) and *Guidelines for watercourse crossings on waterfront land* (NOW 2012) to maintain fish passage and aquatic ecosystem condition.

The avoidance measures incorporated into the design, combined with thos proposed mitigation measures, represent the full range of reasonable and feasibile measures that can be implemented for the project, which have resulted in minor residual impacts on biodiversity.

The proposed mitigation measures (Table 6.1) and preparation of a CBMP and OBMP (Section 6.2.1) are designed to mitigate any residual impacts to biodiversity following the implementation of avoidance and minimisation measures. The proposed measures have been developed with consideration of the threatened species and communities potentially impacted by the project and common flora and fauna species in the locality.

The proposed measures to mitigate the clearing of native vegetation and fauna habitats, fauna injury and mortality, edge effects and fragmentation and fauna strike are consistent with Section 8.3.2.10 and 8.3.2.11 of the FBA. The proposed measures to mitigate erosion, sedimentation, noise and dust are consistent with Section 8.4.1.4 of the FBA. They too were developed in accordance with published government guidelines comprising:

- *Managing urban stormwater: soils and construction* (Landcom 2004);
- *Interim Construction Noise Guideline* (DECC 2009); and
- *Coal Mine Particulate Matter Control Best Practice Site-specific Determination Guideline* (OEH 2011).

6.2.6 Effectiveness of avoidance and mitigation measures

The effectiveness of the avoidance measures has been demonstrated through the mine design's ability to avoid the majority of impacts to threatened ecological communities and threatened species habitats. This has resulted in the residual impact of the removal of 64 paddock trees. The coal handling and processing plant was originally located in an area of known habitat for threatened species. Therefore, it was moved into an area containing paddock trees, which are of lower value to threatened biodiversity. The minor residual biodiversity impacts and potential indirect impacts will be managed through the BMP. The effectiveness of the mitigation measures will be evaluated through the monitoring and evaluation of performance measures in the BMP. The BMP will detail trigger levels for the implementation of corrective actions, and a clear monitoring and reporting structure.

7 Impact assessment

This chapter discusses the residual impacts of the project after avoidance, minimisation and mitigation measures have been applied. It discusses potential impacts on terrestrial biodiversity resulting from construction of the surface infrastructure area. It also discusses potential impacts on groundwater dependent ecosystems and the threatened species and communities they support in the project area and study areas as a result of underground mining.

7.1 Residual impacts on terrestrial biodiversity from construction of surface infrastructure

7.1.1 Direct impacts

i Clearing of native vegetation and fauna habitats

Careful placement of surface infrastructure has largely avoided the clearing of native vegetation, resulting in a small area of native vegetation to be cleared. Careful placement of the coal handling and processing plant has avoided the clearing of Brittle Gum Scribbly Gum shrubby woodland along Oldbury Creek which is considered to be in a moderate to good condition, containing known habitat for the threatened Koala, Large-eared Pied Bat, Southern Myotis and Yellow-bellied Sheathtail Bat.

The coal handling and processing plant was moved south and will now require the removal of approximately 64 paddock trees (Brittle Gums and Scribbly Gums) underlain by exotic pasture (Figure 5.2). Brittle Gum is a secondary food tree species for the Koala, and therefore potential Koala feed trees will be removed. Impacts to known Koala habitat along Oldbury Creek have been largely avoided by moving the coal handling and processing plant south to avoid clearance of known habitat that is in higher condition than the paddock trees.

The removal of the 64 paddock trees will also result in the loss of 17 hollow-bearing trees. Hollows provide potential shelter and breeding habitat for threatened species including the Eastern False Pipistrelle, Eastern Freetail Bat, Masked Owl, Powerful Owl and Yellow-bellied Sheathtail Bat.

The clearing of riparian vegetation has been avoided by the project through the placement of the elevated conveyor though an area that does not contain trees or shrubs, and therefore it will not be impacted by the project.

The downcast shaft will be located in an area that contains pine forest, and therefore native vegetation and threatened species habitats will not be impacted.

All other remaining native vegetation in the surface infrastructure area, project area and terrestrial study area will not be directly impacted by the project.

ii Fauna injury and mortality

Several hollow-dependent common and threatened fauna species were recorded adjacent to the surface infrastructure area, comprising the Southern Myotis, Varied Sittella and Eastern False Pipistrelle. Without careful management, these threatened and other common species may be injured during clearing for the main infrastructure area and coal handling and processing plant. Measures will be implemented to minimise fauna injury and mortality during clearing.

iii Edge effects and fragmentation

An elevated conveyor will be installed near a patch of PCT 1093 Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion that lines Medway Rivulet. A population of Paddys River Box trees occurs on either side of the conveyor, which has been positioned to avoid direct impacts to the species. As the species is pollinated by mobile birds and insects, and seeds can be dispersed by wind (TSSC 2016), the conveyor is unlikely to fragment the population. No edge effects are expected to occur in the project area or terrestrial study area as a result of the project, as these areas will not be directly impacted.

iv Changes to streamflow

Infrastructure crossing streams, including bridges and culverts, have the potential to change the velocity of stream flow local to the infrastructure. An increase in the velocity of streamflow can cause erosion and scour of bed sediments and impact on surface water quality and the stability of instream structures. Peak velocities downstream of new infrastructure crossing areas were assessed in the Hume Coal Project Surface Water Flow and Geormorphology Assessment (WSP Parsons Brinkerhoff 2016) presented in Appendix E of the EISfor the following new infrastructure:

- the elevated conveyor crossing Medway Rivulet;
- the road crossing Medway Rivulet; and
- the embankment at the downstream end of the instream storages on Oldbury Creek, which will be raised and used to provide access between the CPP area and the train load out facility. The embankment will have an access road, a conveyor to transport coal and poles for electricity lines.

WSP Parsons Brinckerhoff (2016) concluded that the potential for stream bank erosion associated with the project is low considering the minimal change in flow regime and the confined valley setting of Medway Rivulet and Oldbury Creek adjacent to and downstream of the surface infrastructure area. Scour protection will be provided around the conveyor crossing pilings in Medway Rivulet and at the inlets and outlets of the culverts to prevent impacts to bed and bank stability. During construction, operation and rehabilitation, erosion and sedimentation control plans will be prepared to ensure the erosion and sedimentation induced by the project will not adversely affect the surrounding environment.

The above waterway crossings will be designed and constructed with consideration to*Policy and Guidelines for Fish Habitat Conservation and Management*(DPI 2013)) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*' (Fairfull and Witheridge 2003) to maintain fish passage and connectivity.

No changes to stream flow are predicted for Wingecarribee River, which contains a large breeding population of the Platypus. No platypus or their habitats were identified along Medway Rivulet or Oldbury Creek in the project area, and therefore they will not be impacted by any changes to stream flow resulting from the project.

v Subsidence

The potential environmental consequences of subsidence and the resulting settlement and surface cracking are defined by DoP (2008) as loss of surface flows to the subsurface, loss of standing pools, ponding, adverse water quality impacts, development of iron bacterial mats, cliff and rocks falls and impacts on aquatic ecology (DoP 2008). Whether subsidence impacts occur as a result of underground mining directly depends on the mining method used and the surface features in the underground mining area.

The project area contains streams and clifflines that support a variety of terrestrial and aquatic species and ecosystems, some of which are listed under the TSC and/or EPBC Act. These areas provide known or potential habitat for the following listed species:

- streams: Cotoneaster Pomaderris, Velvet Zieria, Koala, Large-eared Pied Bat and Spotted-tail Quoll; and
- clifflines: Dwarf Phyllota, Broad-headed Snake, Large-eared Pied Bat and Spotted-tail Quoll.

Long Swamp and Stingray Swamp in the study areas contain Temperate Highland Peat Swamps on Sandstone. Peat swamps are particularly sensitive to subsidence from longwall mining, by fracturing the underlying rock which leads the swamp to drain. Longwall mining is not the proposed mining method, and no mining is proposed to occur under Long Swamp or Stingray Swamp. Therefore, Long Swamp and Stingray Swamp are not predicted to be impacted by the project.

Mine Advice Pty Ltd (2016) conducted a subsidence assessment of the project (refer to Appendix L of the EIS), and estimated the predicted subsidence, tilt and horizontal strain arising from the proposed first workings underground mining method, which has been adopted to avoid subsidence. The maximum predicted value of surface subsidence above the mine panels is 20 mm.

The following maximum values for tilt, curvatures and horizontal strain have been determined:

- Maximum tilt = 0.26 mm/m.
- Maximum convex curvature = 0.07 km^{-1}.
- Maximum concave curvature = 0.063 km^{-1}.
- Maximum tensile strain = 0.36 mm/m.
- Maximum compressive strain = 0.33 mm/m.

The report concluded that “the predicted maximum subsidence parameters are sufficiently low such that any associated impacts fall into the ‘imperceptible’ or ‘negligible’ category for all of the surface features that can be evaluated according to pre-set or established numerical criteria” (Mine Advice 2015, p. 85). Therefore it follows that subsidence will have an imperceptible to negligible impact on important landscape features that support threatened biodiversity, Long Swamp and Stingray Swamp.

The subsidence assessment (Mine Advice Pty Ltd 2016) determined that subsidence will be imperceptible to negligible. For this reason, the Flow and Geormophology Assessment (WSP Parsons Brinckerhoff 2016) has concluded that the project will not impact upon water course flow and morphology. As such, subsidence is not expected to impact upon aquatic ecological values currently present within the water courses within the project or study areas.

7.1.2 Indirect impacts

i Construction buffer area

The design allows for a construction buffer around the direct disturbance footprint, for the purposes of machinery and vehicles driving to the surface infrastructure facilities. Some ecological constraints including Paddys River Box, Southern Highlands Shale Woodland CEEC, Tableland Snow Gum Black Sallee Grassy Woodland EEC and threatened species habitats intersect this construction buffer. Where these occur in the construction buffer, a fence will be erected for their protection to prevent inadvertent damage and driving and/or parking on tree roots.

ii Erosion and sedimentation

Appropriate erosion and sedimentation control measures will be implemented to avoid erosion and sedimentation related impacts in the drainage lines in the vicinity of the surface infrastructure area during construction and operation, namely Oldbury Creek, Medway Rivulet and Wells Creek. The measures implemented will be in accordance with the recommendations of the Water Assessment (Appendix E of the EIS) to minimise impacts to these streams.

iii Introduced species

Introduced species including the European Rabbit and Red Fox were observed throughout the agricultural parts of the project area, and within the surface infrastructure area. These pest species can spread into new areas and compete with native species with the creation of new roads. As the surface infrastructure area is already heavily cleared, and existing access tracks will be used, these species are not expected to spread to other parts of the project area or terrestrial study area as a result of the project.

Red Fox are known to prey on native animals and European Rabbits are known to degrade fauna habitats by digging burrows. Given the proximity of the surface infrastructure area to known threatened species habitats along Oldbury Creek and in Belanglo State Forest, it is recommended that Red Fox and European Rabbit control be undertaken, and ideally coordinated with pest management in Belanglo State Forest, west of the surface infrastructure area (Section 6.2).

iv Increased noise, dust and light

Without management, the surface infrastructure area, and particularly the coal handling and processing plant and conveyor, will result in increased noise, dust and light on adjoining areas of native vegetation and known threatened species habitats along Oldbury Creek (known habitat for Koala, Large-eared Pied Bat and Southern Myotis) and the adjacent Medway Dam and Wells Creek (known habitat for the Little Eagle, Southern Myotis and Eastern False Pipistrelle). Measures recommended to minimise noise, dust and light on native vegetation and adjacent fauna habitats are presented in Section 6.2.

v Fauna strike

Roadkills of the Eastern Grey Kangaroo (*Macropus giganteus*) and Common Wombat (*Vombatus ursinus*) were frequently observed on the Hume Highway during surveys. There will be a minor increase in traffic volumes on the Hume Highway (Traffic Assessment, Appendix M of the EIS) as a result of the project. Given the high existing traffic volumes on the Hume Highway, a significant increase in roadkill is not expected.

Koala roadkills have been recorded in the Southern Highlands, in the vicinity of Belanglo State Forest. Roadkill is known as a key threat to Koalas. The coal handling and processing plant will be located adjacent to an area of known Koala habitat. There is a risk that male Koalas may enter the coal handling and processing plant area and access roads during the breeding season when they are dispersing to find females. It is therefore recommended that a fauna-friendly fence be erected between the area of Koala habitat and the coal handling and processing plant with turnbacks to prevent Koalas accessing the area where heavy vehicles are operating (Section 6.2).

vi Changes to surface hydrology

The project will require the sporadic discharge of treated excess mine water into Oldbury Creek. Threatened biodiversity that occupy the riparian environment of Oldbury Creek to fulfill a portion of their water requirements comprise Paddys River Box trees and the Large-eared Pied Bat. Paddys River Box trees were always observed along streams or minor drainage lines in the project area, and therefore are likely to be dependent on surface flow to fulfill a portion of its water requirements. Sporadically discharging treated excess mine water is expected to have a negligible to positive impact on this species where it occurs along Oldbury Creek, as the area will receive additional (however sporadic) surface flows.

The Large-eared Pied Bat was recorded along Oldbury Creek and would partially dependent on the riparian zone as foraging habitat. As with Paddys River Box trees, the sporadic discharge of treated excess mine water is expected to have a negligible to positive impact on this species riparian foraging habitat along Oldbury Creek, as the area will receive additional (however sporadic) surface flows.

The surface water flow and geomorphology study (WSP Parsons Brinkerhoff 2016) determined that changes to runoff as a result of site water management would be limited to the two watercourses in the surface infrastructure area, namely Medway Rivulet and Oldbury Creek.

WSP Parsons Brinckerhoff (2016) concluded that the flow regimes in Medway Rivulet and Oldbury Creek will be similar to pre-mining conditions during operation of the project, assuming continuance of the constant low flow discharges from the Moss Vale and Berrima sewage treatment plants (STPs). When the low flow discharge from the Moss Vale STP is excluded from the analysis, changes in the low flow regime in Medway Rivulet below approximately 5ML/day would occur, with the number of no flow days increasing by up to 30%. However, this is unlikely to occur given that the STP is likely to continue to operate throughout the period of mining.

In the unlikely event that low flow discharges do not continue, local impacts on yield in the Oldbury Creek catchment will be up to 4.2%; however impacts will be less than 1.4% for the Medway Rivulet management zone overall (which includes the Oldbury Creek catchment). WSP Parsons Brinckerhoff (2016) concluded that alteration of the flow regime in Oldbury Creek during operation of the mine will be minor compared to pre-mining conditions, with discharges from SB03, SB04 and the WTP to some extent offsetting impacts to flow associated with a reduction in catchment for project storages and interception of baseflow associated with depressurisation of groundwater systems.

WSP Parsons Brinckerhoff (2016) also concluded that in the unlikely event that low flow discharges does not continue, the project has potential to impact flows in Medway Rivulet within the project area, decreasing the low flow regime and flow conditions during wet conditions. Potential impacts on aquatic ecosystems associated with changes in the flow regime in Medway Rivulet comprise reduced water availability for instream and riparian ecosystems associated with a reduction in streamflow and increased concentrations of water chemistry during low flow conditions.

A reduction in low flows in Medway Rivulet has potential to decrease habitat availablility for aquatic ecosystems by increasing potentially toxic concentrations of salinity and aluminium during low flows. The habitat value of Medway Rivulet is considered of lower value than surrounding watercourses within the management zone. The taxa present within Medway Rivulet are adapted to poorer habitat conditions. The pH levels within Medway Rivulet are not considered acidic and therefore unlikely to support an increase in aluminium concentrations. While reduced low flow conditions have the potential to exacerbate existing disturbance conditions, they are unlikely to have a significant long term impact on existing aquatic ecosystems given the poor habitat quality in Medway Rivulet.

No changes to surface hydrology are predicted for Wingecarribee River, which contains a large breeding population of the Platypus. No platypus or their habitats were identified along Medway Rivulet or Oldbury Creek in the project area, and therefore they will not be impacted by any changes to surface hydrology resulting from the project.

vii Ecotoxicology

Runoff to streams in the surface infrastructure area during construction and operation of the project has potential to degrade water quality and aquatic habitat. This impact will be managed through the implementation of appropriate measures for surface water, soils and erosion.

The project may result in changes to the groundwater environment for stygofauna, should they be present in the project area. There will be no impact on the Bathynellidae recorded at Hanging Rock Swamp in Penrose State Forest as it falls outside the project induced drawdown area.

7.2 Residual biodiversity impacts from underground mining

7.2.1 Groundwater dependent ecosystems in the study areas

Terrestrial vegetation in the terrestrial study area, Long Swamp and Stingray Swamp were identified as potential GDEs. Terrestrial vegetation has been classified as having a facultative (opportunistic) dependence on groundwater. Facultative (opportunistic) ecosystems will use groundwater where available, but can exist without the input of groundwater, as long as there is no prolonged drought. Long Swamp and Stingray Swamp have been classified as having a facultative (proportional) dependence on groundwater. Facultative (proportional) ecosystems take a proportion of their water requirements from groundwater, however there is no absolute threshold for groundwater availability below which ecosystem structure or function is impaired, and can respond to changes in groundwater at any level.

To assess potential impacts on terrestrial vegetation and downstream ecosystems (ie Long Swamp and Stingray Swamp) as a result of the project, drawdown contours from the groundwater model prepared for the project were plotted in GIS and cross-referenced with the potential GDE locations and the pre-mining water table levels shown in Figure 4.7.

Predictive drawdown simulations provided the extent of the groundwater depressurisation effects as a result of the project. This was used to quantify the potential impact at the water table under two scenarios:

- total impact, including the existing stresses of Berrima Colliery and landholder pumping as well as the project impact; and
- the project impact (not including the existing stresses). The full groundwater impact assessment is contained within the Water Assessment prepared for the project (refer to Appendix E of the EIS (EMM 2017a)).

The project impact (also referred to as differential drawdown) has been assessed against the groundwater system interference policy (refer to Appendix E of the EIS (EMM 2017a)) to determine the likely impact to potential groundwater dependent ecosystems.

The potential impacts of drawdown on groundwater systems containing stygofauna were assessed by examining the project impact across the aquatic study area at Years 17 and 30 of mining.

An ecosystem drawdown risk assessment matrix was developed (Plate 7.1) to assess the level of risk to terrestrial vegetation associated with drainage lines in the terrestrial study area (Figure 4.7) and Long Swamp and Stingray Swamp (described in Section 4.5).

Water table drawdown					
Pre-mining water table height (mbgl)		0-2 m water table drawdown	2-10 m water table drawdown	>10 m water table drawdown	Ecosystem drawdown risk
	0-3 mbgl High potential for groundwater interaction	Low risk	Low risk	Moderate risk	
	3-5 mbgl Moderate potential for groundwater interaction	Low risk	Moderate risk	High risk	
	5-10 mbgl Low potential for groundwater interaction	Moderate risk	Moderate risk	High risk	

Plate 7.1 Ecosystem drawdown risk assessment

The ecosystem drawdown risk assessment uses the pre-mining water table level (0-3, 3-5 and 5-10 metres below ground level (mbgl), shown in Figure 4.7) as an indication of the water table height prior to mining. The water table drawdown (0-2, 2-10 and >10 m) was then determined for the above areas where the water table was at 0-10 mbgl.

The ecosystem drawdown risk (ie low, moderate or high risk) was then assessed by determining the water table height following drawdown during mining, and was modelled at 17 years and 30 years following the start of mining. These modelling intervals were selected as the extent of the drawdown footprint achieves a maximum at 17 years, and 30 years and reflects the extent of the drawdown footprint post-mining.

Given the facultative (opportunistic) use of groundwater by terrestrial vegetation, an ecosystem drawdown risk is defined as the level of reduction in groundwater availability for terrestrial vegetation during periods of long drought. Based on the above water table drawdown matrix, a low to moderate ecosystem drawdown risk is predicted where the water table height is predicted to stay within the root zone of eucalypts (ie up to 10 mbgl), while a high ecosystem drawdown risk is predicted where the water table level falls below 10 mbgl. Drawdown of the water table to greater than 10 mbgl has been identified as the threshold for potential impact. This is based on the assumption that tree roots will access shallow groundwater up to 10 mbgl. The ecosystem drawdown risk for terrestrial vegetation and for Long Swamp and Stingray Swamp are discussed in the following sections.

i Terrestrial vegetation

A low risk of impact is expected for terrestrial vegetation with a moderate to high potential for groundwater interaction (pre-mining water level of 0-5 mbgl) where 0-10 m drawdown is modelled, as groundwater will remain within the expected root zone (up to 10 mbgl) of the eucalypts that comprise the main components of the ecosystem that would access groundwater during periods of prolonged drought.

A moderate risk of impact to the ecosystem is expected in areas of with a high potential for groundwater interaction (pre-mining water table level is 0-3 mbgl) and greater than 10 m water table drawdown is expected. A moderate risk of impact is also expected A moderate risk of impact is expected in areas of with moderate potential for groundwater interaction (pre-mining water table level of 3-5 mbgl) where 2-10 m of drawdown is modelled and areas of with low potential for groundwater interaction (pre-mining water level of 5-10 mbgl) where 0-10 m of drawdown is modelled. These scenarios have a moderate potential for impact as the water table would be around 10 mbgl, which would reduce the availability of groundwater to the eucalypts in the ecosystem during periods of prolonged drought.

Areas with low potential for groundwater interaction (pre-mining water table of 5-10 mbgl) and where >10 m of drawdown are expected have a higher risk of impact to the ecosystem, as groundwater availability would already be limited due to the water table height, and drawdown would reduce the ability of the eucalypts in the ecosystem to draw on groundwater during periods of prolonged drought.

Areas of low, moderate and high ecosystem drawdown risk are shown on Figure 7.1 and 7.2. The modelled drawdown at 17 and 30 years after the commencement of mining is shown on Figures 7.3 and 7.4, respectively. According to the ecosystem risk matrix, terrestrial vegetation in the upper reaches of Long Swamp Creek, Oldbury Creek, Medway Rivulet, Black Bobs Creek, Longacre Creek, Red Arm Creek and the Wingecarribee River show a low to moderate risk of impact. These drainage lines contain known and potential habitat for threatened species, comprising Paddy's River Box, Koala, Large-eared Pied Bat and Southern Myotis and Tablelands Snow Gum Black Sallee, Candlebark and Ribbon Gum Grassy Woodland EEC. The abovementioned ecosystems are not predicted to be impacted by drawdown given their facultative (opportunistic) dependence on groundwater and as the water table is predicted to be maintained at or above 10 mbgl during mining. This is within the root zone of the eucalypts, which would be the major component of the ecosystem drawing opportunistically on subsurface groundwater.

The upper reaches of Belanglo Creek and a patch of terrestrial vegetation south of Wells Creek show a high risk of impact (approximately 13 ha and 6 ha, respectively). Belanglo Creek contains known habitat for the Koala and potential habitat for the Large-eared Pied Bat, Southern Myotis and Yellow-bellied Sheathtail Bat, while the patch of terrestrial vegetation south of Wells Creek represents Southern Highlands Shale Woodland, a CEEC. The water table is predicted to exceed 10 mbgl for these ecosystems during mining and therefore has a higher risk of drawdown impact during periods of prolonged drought.

Hydrographs from virtual piezometers were reviewed for Belanglo Creek and Wells Creek to determine the modelled time of maximum drawdown and recovery at the abovementioned streams. The locations of the virtual piezometers are shown in Figure 7.1 and Figure 7.2. Hydrographs are presented in Plate 7.2.

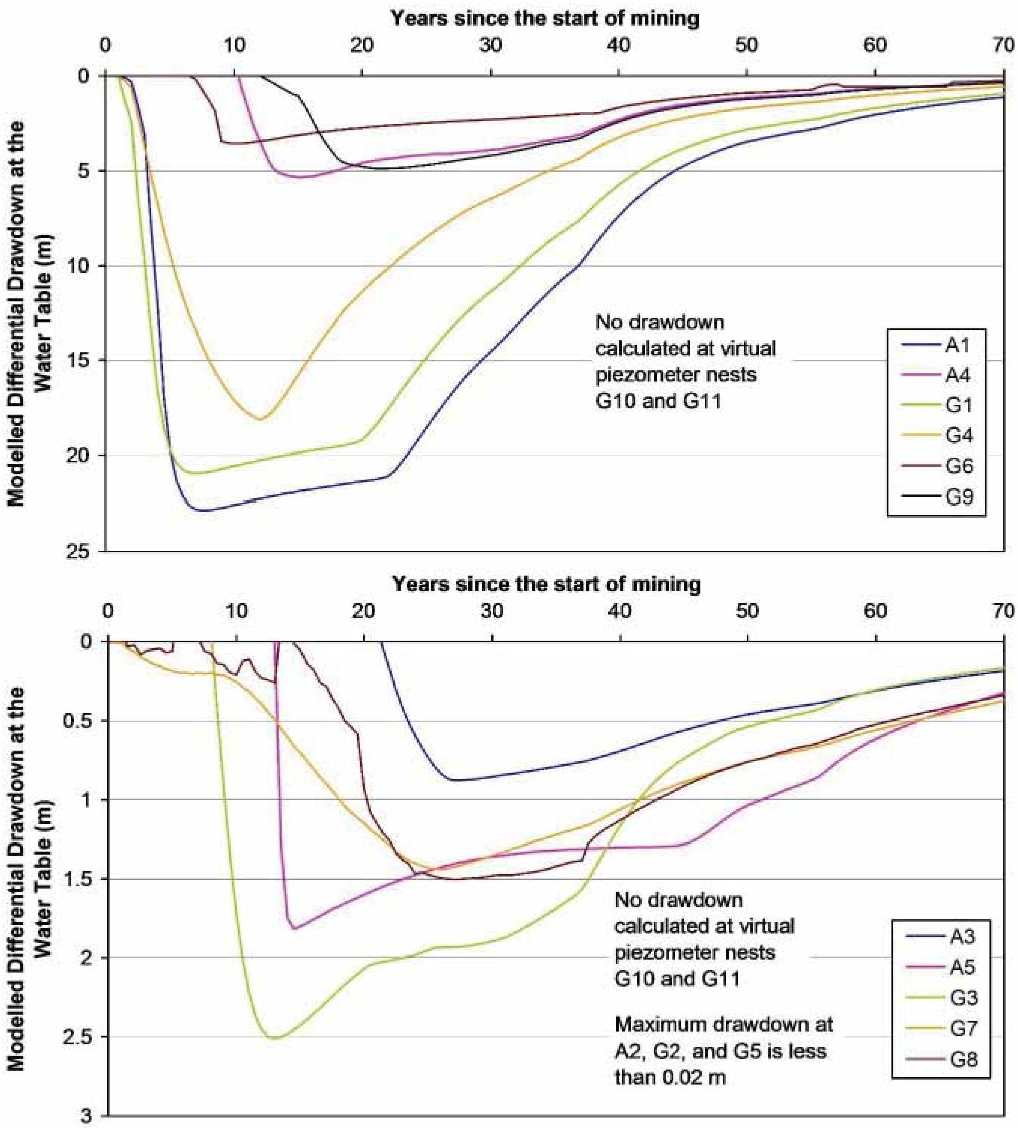


Plate 7.2 Differential drawdown at the water table at virtual piezometer sites (source: Water Assessment, Appendix E of the EIS)

Drawdown of greater than 10 mbgl is shown at virtual piezometers A1, G1 and G4, and an area on Wells Creek. There is a patch of Southern Highlands Shale Woodland CEEC on Wells Creek, G1 and G4 are located on Belanglo Creek, and A1 is to the south-east of G1. Drawdown occurs from about years 2-10, with recovery starting from years 10-30 of mining. The water table recovers to within 10 mbgl between 20 to 25 years following commencement of mining in G4 and 30 to 40 years in A1 and G1.

The risk of drawdown impact in the ecosystems identified in Figure 7.1 and Figure 7.2 must be interpreted in the context of the level of dependence of these ecosystems on groundwater. If the ecosystems had an entirely/obligate dependence on groundwater, any changes to the system would likely result in a permanent impact on the ecosystem's function. Terrestrial vegetation has a facultative (opportunistic) dependence on groundwater, but can exist using other water sources outside of periods of prolonged drought. Accordingly, no impacts are expected to these ecosystems on Belanglo Creek and south of Wells Creek if periods of prolonged drought are not experienced during mining. Monitoring and management triggers are therefore proposed in Section 6.2 for terrestrial vegetation in the event of prolonged drought during mining.

ii Long Swamp and Stingray Swamp

Long Swamp and Stingray Swamp contain Montane Peatlands and Swamp of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps Bioregions, listed as an EEC under the TSC Act, and Temperate Highland Peat Swamps on Sandstone, listed as an EEC under the EPBC Act. Long Swamp and Stingray Swamp have potential to provide habitat for threatened and migratory species including Paddys River Box, Broad-leaved Sally, Dwarf Phyllota, Giant Dragonfly, Littlejohns Tree Frog, Australasian Bittern, Australian Painted Snipe, Giant Dragonfly, Great Egret and Cattle Egret (see Appendix E).

Temperate Highland Peat Swamps on Sandstone have been classified into the following three categories (Commonwealth of Australia 2014):

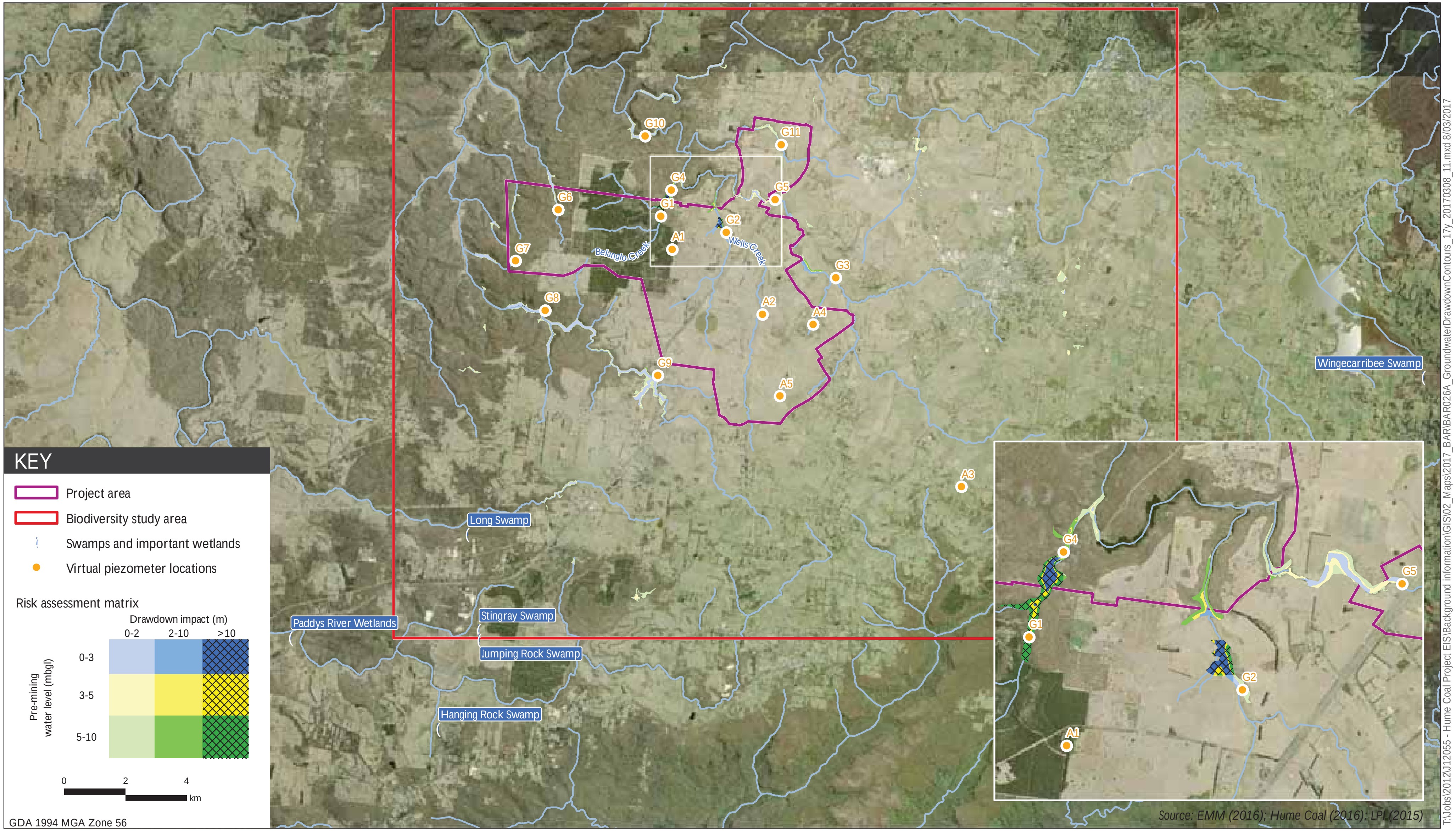
- headwater swamps - formed near catchment divides where topographic gradients are shallow;
- valley infill swamps - occur in steeper topographies filling the valley of incised second or third order streams; and
- hanging swamps - occur on steep valley sides where there is groundwater seepage.

Headwater swamps exist in the Southern Coalfield (Commonwealth of Australia 2014), particularly on the Illawarra and Woronora Plateaus. However, it is not clear whether any of the Southern Highlands swamps (including Long Swamp and Stingray Swamp) are considered to be headwater swamps. Stingray Swamp is on shallow topography near a stream headwater, and therefore is likely to be a headwater swamp.

Headwater swamps are often perched above the watertable and usually connected to a shallow perched groundwater system in the underlying sandstone. Headwater swamps (ie Stingray Swamp) are unlikely to be connected to the watertable as they occur in flat terrain in elevated topographies where regional groundwater is deep and perched groundwater systems are unlikely to be intersected by the swamp. Accordingly, the dominant water source for headwater swamps is from rainfall and surface runoff. Figure 7.1 and Figure 7.2 show a low to moderate drawdown risk in the upper reaches of Stingray Swamp. However, this drawdown is reflective of the shallow watertable in this area which is unlikely to be connected to the perched groundwater systems that provide water to the swamp. As the watertable is unlikely to be connected to the perched groundwater systems that provide water to the swamps and the dominant water source is from rainfall and surface runoff, no drawdown-related impacts are predicted to occur at Stingray Swamp. Therefore, it follows that Temperate Highland Peat Swamps and the threatened species it supports at Stingray Swamp would not be impacted by the project.

Long Swamp is located along Long Swamp Creek (a fourth order stream) which has a steeper topography and therefore is likely to be a valley infill swamp. Valley infill swamps are fed to some extent by perched groundwater system systems in the underlying strata. However, the steeper incision of valley infill swamps into underlying sandstone means that swamps are more likely to intersect the water table. Water sources for valley infill swamps comprise rainfall, surface runoff and groundwater (ie a facultative (proportional) ecosystem). Water flows through valley infill swamps as either sheet flow along the surface of the peat, up through the peat or through channels within the peat (Commonwealth of Australia 2014).

Although the water table is predicted to be shallow at Long Swamp (Figure 4.7), it is outside the maximum drawdown footprint at Year 17 of mining (Figure 7.1). Long Swamp would also access water from rainfall and runoff. A low to moderate risk of drawdown is predicted in terrestrial vegetation upstream of Long Swamp. However, this is not predicted to impact Long Swamp as its water sources also include rainfall and runoff which will not be impacted. Groundwater flows through valley infill swamps are predicted to be along the surface of the peat, up through the peat or channels within the peat. Considering the above, drawdown of the watertable upstream of this location is not predicted to impact Long Swamp. Therefore, it follows that Temperate Highland Peat Swamps and the threatened species it supports at Long Swamp would not be impacted by the project.



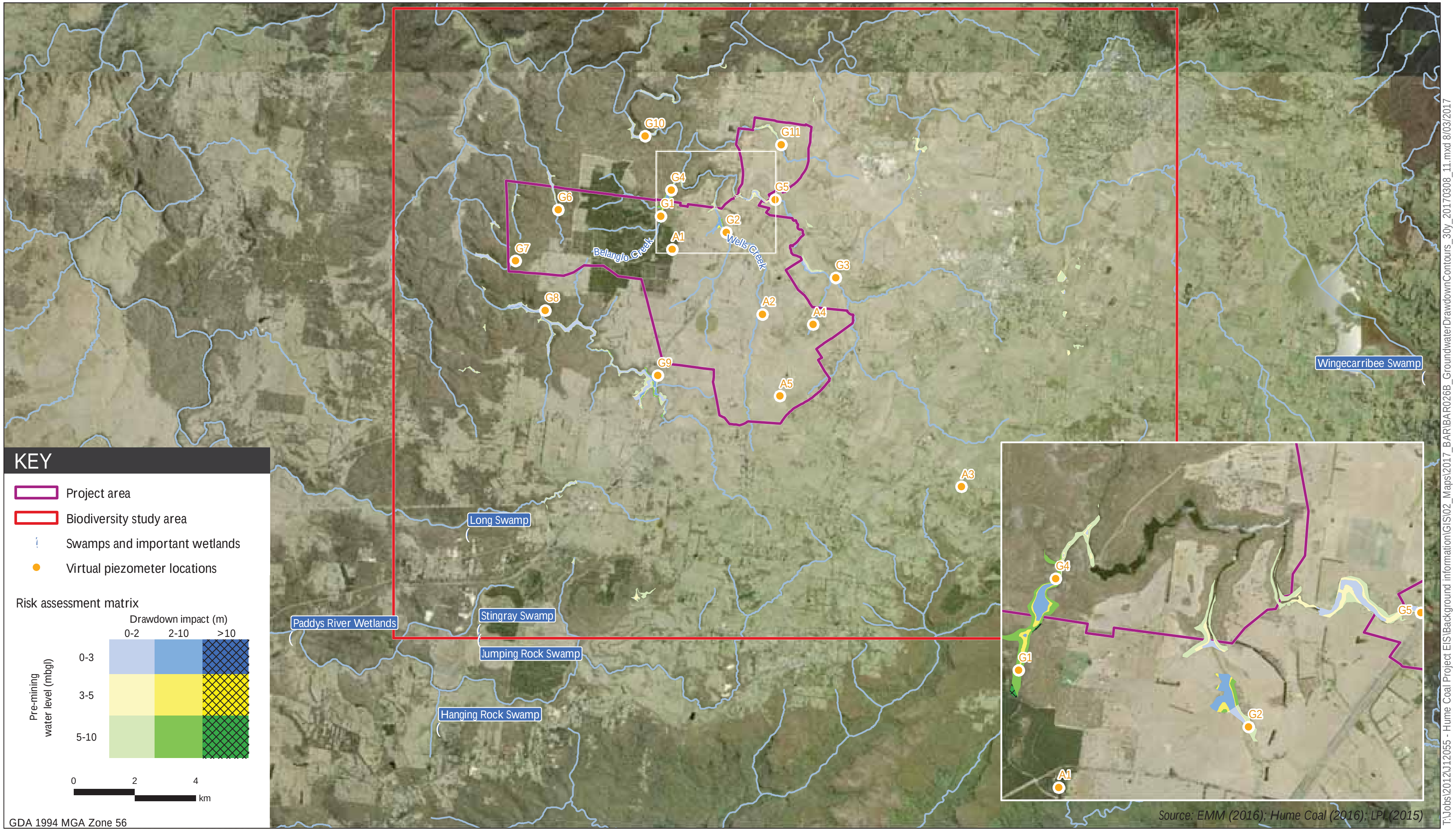
Potential ecosystem impacts - 17 years after start of mining

Hume Coal Project

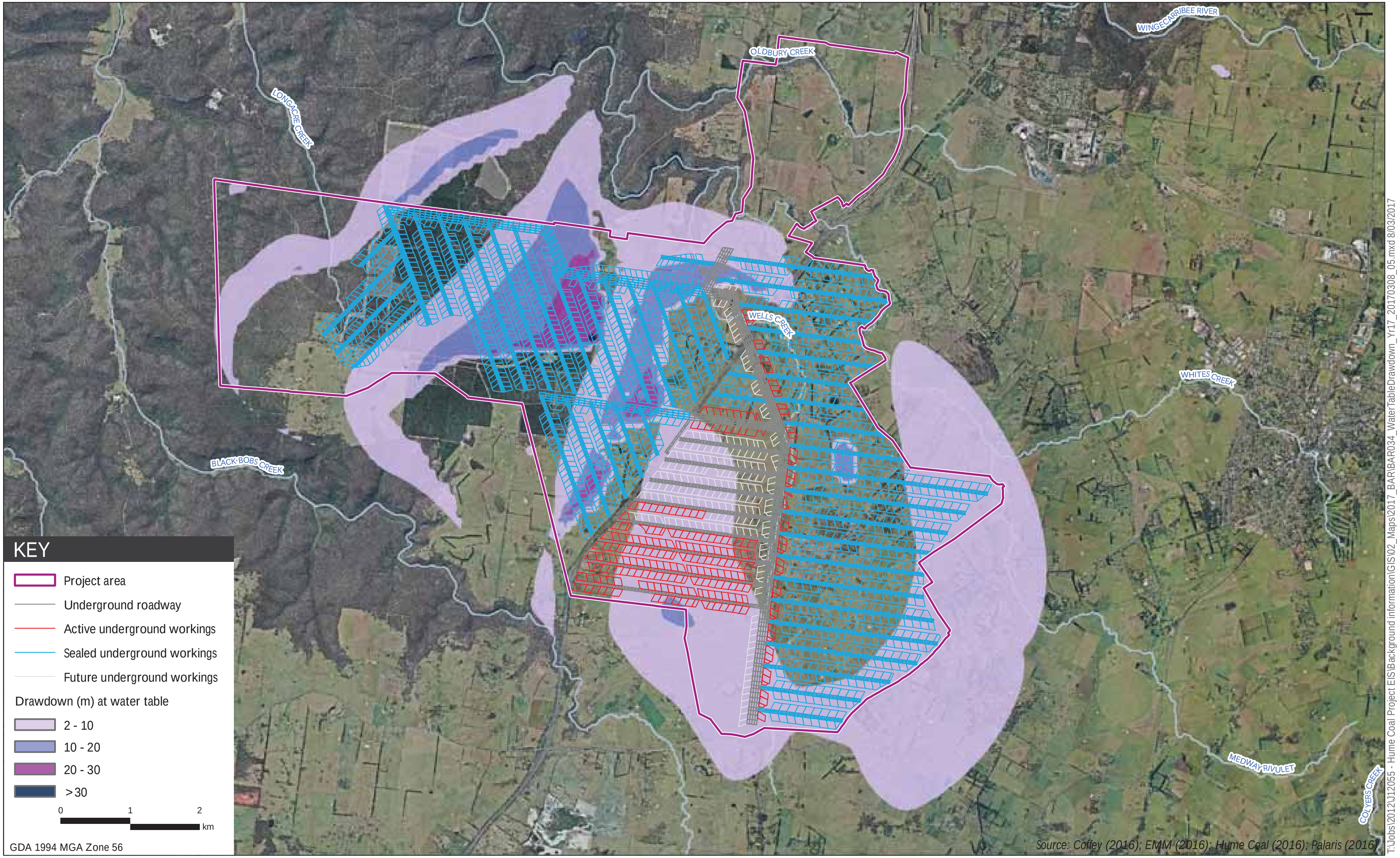
Biodiversity Assessment Report

Figure 7.1

EMM HUMECOAL



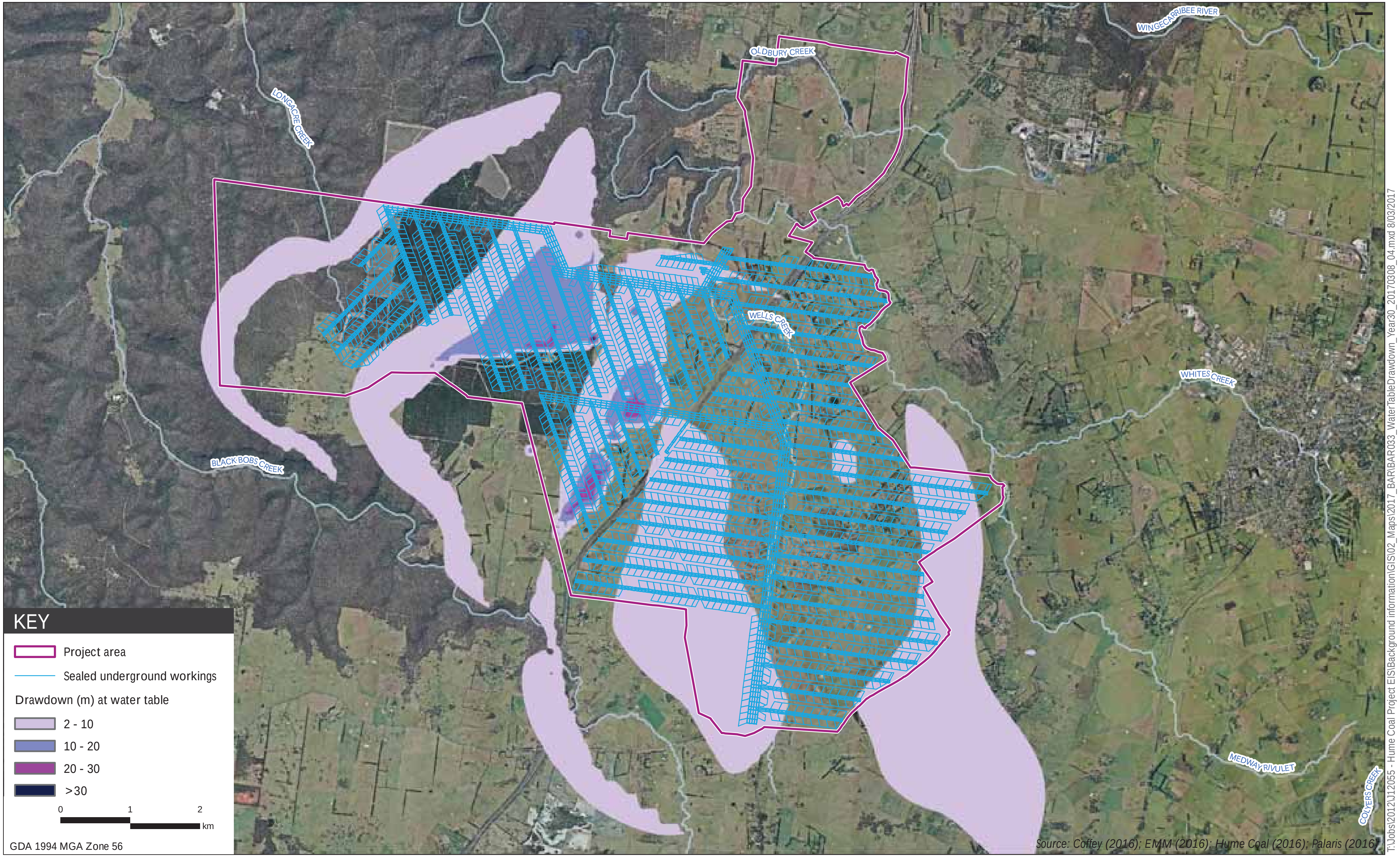
Potential ecosystem impacts - 30 years after start of mining
Hume Coal Project
Biodiversity Assessment Report
Figure 7.2



Project induced groundwater table drawdown at Year 17 of mining

Hume Coal Project
Biodiversity Assessment Report

Figure 7.3



Project induced water table drawdown at Year 30 of mining

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Figure 7.4

iii Groundwater systems

In Australia, stygofauna are known from alluvial, limestone, fractured rock, and calcrete groundwater systems. Stygofauna occur most commonly in alluvial aquifers. As yet, few species are known from coal groundwater systems (although this is changing as further targeted sampling is undertaken in Queensland and NSW). As stygofauna require a space to live, the porosity of the sediments, degree of fracturing, or extent of cavity development must be sufficient, as must the connectivity between the living spaces (GHD 2012).

Within these environments they, in association with the microbial/bacterial community, take on the same roles as surface water aquatic invertebrates, by contributing to water quality through processes such as biochemical processing and filtration. Due to this relationship with the the groundwater system, they are considered to be good indicators of groundwater health.

Stygofauna are linked both ecologically and physiologically to the groundwater environment in which they live and are adapted to the relative stability of their surroundings. Compared to surface water environments, groundwater fluctuates less both in level, electrical conductivity, temperature and pH. Groundwater is also generally lower in dissolved oxygen and has less available organic matter than surface water environments.

As there is no direct photosynthesis in groundwater systems, stygofauna rely on connections to the land surface to provide them with food. These connections may be hydrological, with infiltrating water bringing dissolved or particulate organic matter to form the basis of subterranean food webs, or may be more direct, with tree roots that extend below the water table providing leachates, organic carbon or fine rootlets for food.

Generally, stygofauna biodiversity is highest near the water table and declines with depth. Stygofauna biodiversity is also higher in areas of recharge, where the water table is close (< 20 m) to the land surface. This is because the water table is likely to have the highest concentration of oxygen and organic matter. Stygofauna still also occur at considerable depth below the water table, but are fewer in number, have lower diversity, and may change in community composition. In some karstic (limestone terrane characterized by sinks, ravines, and underground streams) groundwater systems, where there is relatively high vertical exchange, or flow does not come into contact with large microbial surface areas (such as occurs in sedimentary groundwater systems), stygofaunal communities can occur at depths exceeding 100 m. They have been recorded as deep as 600 m to 800 m below the ground surface in the Edwards groundwater system in Texas and near to 800 m deep within an groundwater system in Mexico (GHD 2012).

The groundwater and stygofauna values with potential to be impacted during construction and operation of the project include changes to water chemistry and hydrogeology. Impacts may occur as a result of groundwater drawdown, depressurisation of groundwater systems, groundwater flow into the mining area and changes to existing groundwater quality.

The vulnerability of stygofauna to impacts from the project relates largely to their inability to adapt to rapid environmental changes, their limited dispersal ability and often restricted range of species (Hancock et al 2005) as a result of potential impacts on groundwater. Due to this dependence, stygofaunal communities are considered to be particularly sensitive to a range of factors that alter groundwater conditions such as groundwater levels, pressure, chemistry and groundwater system structure.

A recent study has been undertaken to determine the impacts of groundwater drawdown in unconfined groundwater systems on the distribution of fauna close to the water table, and the tolerance of groundwater fauna to sediment drying once water levels have declined (Stumpp et al 2013). The distribution and response of stygofauna to water drawdown was taxon specific, but the common response of some fauna being stranded by water level decline. The survival of stygofauna under different levels of sediment saturation was variable. Syncarida (such as the Bathynellidae recorded in the south of the study area) were able to better tolerate drying conditions than the Copepoda, but mortality of all groups increased with decreasing sediment water content.

Stygofauna were not recorded in the area of project induced water table drawdown, and only one individual Bathynellidae was recorded south of the project area at Hanging Rock Swamp in Penrose State Forest. The absence of detection in the project area and project induced water table drawdown area (Figure 7.3 and Figure 7.4) may be attributable to the absence of alluvium, with which Stygofauna are most commonly associated. Localised, discontinuous groundwater is be associated with unconsolidated Quaternary alluvium in major streams and river valleys within the region (ie the upper reaches of the Wingecarribee River), although not within the project area (EMM 2017b).

The groundwater system present in the area of project induced water table drawdown is unconfined and has high connectivity, and therefore if Stygofauna was present, it would not be restricted to this area. While drawdown would impact on stygofauna (if present in the project induced water table drawdown area), it is considered unlikely that they would be endemic taxa whose distribution was confined solely to the project area.

iv Baseflow

Changes to stream baseflow in the project area were assessed for threatened fauna species that may depend on drainage lines, specifically the Southern Myotis. The Southern Myotis hunts for small fish and insects over deep pools in drainage lines.

Changes to baseflow were estimated as part of the numerical groundwater model (see Water Assessment, Appendix E of the EIS) for drainage lines in the groundwater model domain. Table 7.1 compares stream flow data for the main streams with the maximum rate of baseflow reduction for the individual streams which are tributaries of the larger streams (ie Black Bobs and Longacre Creeks are tributaries of the Wingecarribee River, and Oldbury Creek, Belanglo Creek and Wells Creek are tributaries of Medway Rivulet).

Baseflow is not predicted to be reduced in Black Bobs Creek. A maximum reduction of 6.8% and 28% of baseflow is predicted in the Lower Wingecarribee River and Medway Rivulet, respectively. Baseflow only contributes around 13% and 6% of total flows in each of these streams, respectively. Therefore, percentage loss of total stream flow as a result of baseflow reduction in the lower Wingecarribee (0.8%) and the Medway Rivulet (1.6%) and their tributaries can be assumed to be negligible (Table 7.1).

The maximum rates of baseflow reduction are not consistent throughout the mining period; the times taken to reach the maximum rate for each water source are shown in Table 7.1. For example, the rate of baseflow reduction at the Medway Rivulet water source only exceeds 0.9 ML/day for less than a year (at 11 years since the start of mining). The majority of drainage lines would see recovery towards pre-mining baseflow conditions by approximately year 18 (Appendix E of the EIS).

Table 7.1 Induced maximum baseflow reduction for surface water sources

Surface water source	Total flow (ML/day)	Modelled baseflow (ML/day)	Baseflow percent of total flow	Modelled maximum rate of baseflow reduction (ML/day)	Baseflow reduction as a percent of baseflow	Baseflow reduction as a percent of total flow	Time to modelled maximum rate (years since start of mining)
1. Lower Wingecarribee River (whole source)				0.849			13
Lower Wingecarribee River[1]				0.8			
a. Black Bobs Creek[2]	-	-		0			N/A
b. Longacre Creek[2]	-	-		0.311			13
2. Medway Rivulet (whole source)	51.8[1]	3.3	6%	0.927	28%	1.8%	11
Medway Rivulet[1]				0.841			11
a. Oldbury Creek[2]	-	-		0.002			11
b. Belanglo Creek[2]	-	-		0.017			9.5
c. Wells Creek[2]	-	-		0.075			1.5

Notes: 1. Data taken from stream gauge SW04 shown on Figure 4.1 of the Water Assessment, Appendix E of the EIS.

These negligible baseflow reductions are predicted to have a negligible impact on water availability in the streams that represent Southern Myotis hunting habitat.

Changes in base flow were also assessed for macroinvertebrates, fish and the Platypus. Groundwater provides base flow to the Medway Rivulet and various streams in incised gullies to the north and west of the project area at times. In much of the project area the streams are also considered ephemeral. Ephemeral streams are defined as those streams that do not flow continuously year round, and mainly flow following precipitation events. This is confirmed by analysis of the stream gauge data (refer to Parsons Brinckerhoff 2016) which indicates significant periods of no flow. During periods of no or low rainfall, the groundwater contribution to the streams is therefore likely to manifest as persistent connected or unconnected pools rather than continuous streamflow. Assessment of the impact of intercepted baseflow concluded that, while a small number of contaminants have lower concentrations in the groundwater, any change in water quality due to loss of baseflow from groundwater is likely to be negligible.

A reduction in baseflow will result in reduced loadings for all parameters. However, concentrations may increase due to reduced baseflow where groundwater concentrations are lower than surface water concentrations. To identify parameters where the concentration may increase due to reduced baseflow, the water quality of the streams in the project area has been compared to groundwater quality in the project area. Where groundwater concentrations are higher than surface water concentrations, a reduction in baseflow is likely to improve the quality of surface water. However, where groundwater concentrations are lower than surface water concentrations, a reduction in baseflow may reduce the dilution of contaminants and result in an increase in contaminant concentrations in the surface water. The results show that concentrations of contaminants were generally higher in groundwater than surface water, with the exception of the following parameters which were consistently higher in surface water:

- Nitrate;

- Calcium, sodium and sulfate; and
- Aluminium.

The 80th percentile of surface water results exceed guideline values of aluminium for aquatic ecosystems, but not guidelines for irrigation or livestock. The results indicate that there is potential for an increase in aluminium concentrations in surface water due to a reduction in groundwater baseflow to streams. The median water quality results for Medway Rivulet (WSP Parsons Brinkerhoff 2016) have been compared to the default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems: Upland rivers (ANZECC 2001). The baseline condition for ecosystem water quality fall within guideline ranges except for conductivity which is elevated. When the median results are compared against the trigger values for freshwater (µgL-1) 90% Level of protection for toxicants (ANZECC 2001), levels of aluminium (for pH >6.5) are elevated (120 µgL-1). The reduction in low flow conditions has the potential to increase conductivity and aluminium concentrations in the system.

Aluminium is toxic to aquatic organisms and its toxicity increases as pH decreases. Aluminium may be present in water through natural leaching from soil and rock, but its concentration is increased in surface water and in groundwater under acidic conditions. Aluminium in the aquatic environment comes from both natural and anthropogenic sources. Both the solubility and speciation of aluminium are pH dependent, under acidic and alkaline conditions (pH <6 or >8), aluminium solubility is enhanced. Aquatic plants are able to tolerate higher levels of aluminium than aquatic invertebrates, amphibians, or fish. Aluminium is known to be more toxic to invertebrates at pH 5.1 to 5.8 than at higher pH levels. Fish species are sensitive to aluminium concentrations. Key factors in aluminium sensitivity for fish are, species, life stage, and form of aluminium. Salmonids are more sensitive to the toxic effects of aluminium than are warm water fish species. Several studies have reported that juveniles tend to be the most sensitive life stage while embryos are the least sensitive in fish (Canadian Council of Ministers of the Environment 2003). The pH in Medway Rivulet ranges from 6.8-7.6, which is within guideline values indicating conditions that would not support increased concentrations of aluminium. The potential impacts of increased concentrations of aluminium is not expected to result in adverse impacts on aquatic ecosystems due to existing pH levels in the water courses.

Excess levels of nitrates can cause eutrophication (excessive nutrients) which can cause an increase in the growth of algae which results in a decrease in the amount of oxygen available in the watercourse. Surveys at sites within the Medway Rivulet Management Zone (including Oldbury, Wells, Whites, Belanglo and Planting Spade Creeks) identified all of the creeks are considered disturbed. Sites on Belanglo and Wells Creeks supported moderate to high levels of macroinvertebrate communities supporting good to fair numbers of pollution intolerant taxa. Sites on Medway Rivulet and Wells Creek (south of surface infrastructure area) had low taxa abundance and diversity and no pollution intolerant taxa. This indicates that macroinvertebrate communities within Medway Rivulet are accustomed to harsh conditions and have a higher tolerance to changes in water chemistry as a result of increased concentrations of conductivity and nitrates. The fish present across the Medway Rivulet management zone area were a commonly occurring Mountain Galaxid and the introduced pest Mosquito Fish species are considered resistant to poor water quality. No fish species were recorded from Medway Rivulet.

While reduced low flow conditions has the potential to exacerbate existing disturbance conditions it is unlikely to have an adverse long term impact on aquatic ecosystems given the minor base flow reduction expected.

A maximum base flow reduction of 6.8% is predicted in the Lower Wingecarribee River, which contains a large breeding population of Platypus (Grant 2006). Baseflow only contributes around 13% of total flow in the Lower Wingecaribee River. Therefore, the percentage loss of total stream flow as a result of baseflow reduction in the lower Wingecarribee (0.8%) and their tributaries can be assumed to be negligible (Table 7.1). Accordingly, it follows that impacts on water and habitat availability on the Platypus breeding population will also be negligible.

7.3 Matters for further consideration

Matters that require further consideration in accordance with Section 9.2 of the FBA are those that are considered to be complicated or severe. The SEARS have identified impacts to Black Gum, a threatened species and population in the Wingecarribee LGA, as a matter for further consideration in this BAR.

There are eight records of Black Gum in the terrestrial study area, although none in the surface infrastructure area (Figure 7.5). These records could not be confirmed during the study as they were located on private property. For the purposes of this study, it is assumed that they are still present. None of these individuals will be directly impacted by the project as they are located outside the surface infrastructure areas. In addition, no new individuals of the species were recorded from the surface infrastructure areas.

No other impacts related to the project meet the thresholds for matters for further consideration in accordance with Section 9.2.1.3 the FBA.

Black Gum records in the wider study area

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Figure 7.5

7.4 Impact assessment for threatened species and communities

7.4.1 Threatened and migratory species recorded outside the area of impact

A number of threatened species were recorded in the project area that will not be directly or indirectly impacted (Appendix E). Specifically, these are species that were recorded or are predicted to occur outside the areas of impact, which comprise the surface infrastructure areas and groundwater dependent ecosystems potentially impacted during periods of extended drought. These threatened species have potential to occur (with the exception of the Brown Treecreeper that was recorded) in the north-west of Belanglo State Forest and other parts of the terrestrial study area that will not be impacted by the project, and comprise:

- threatened plants: Bynoe's Wattle, Cambage Kunzea, Cotoneaster Pomaderris, Mittagong Geebung and Velvet Zieria;
- threatened birds: Speckled Warbler, Brown Treecreeper, Blue-billed Duck and Freckled Duck;
- migratory birds: Rainbow Bee-eater, Satin Flycatcher and Rufous Fantail;
- threatened mammals: Yellow-bellied Glider, Greater Broadnosed Bat, Eastern Pygmy Possum and Spotted-tail Quoll; and
- threatened reptiles: Broad-headed Snake and Rosenberg's Goanna.

Accordingly, further impact assessment has not been conducted for these species.

7.4.2 Threatened species in the surface infrastructure area

Impacts on ecosystem and species credit species recorded or predicted to occur within or adjacent to the surface infrastructure area have been assessed in Chapter 5.3. BioBanking calculations have been completed for these ecosystem and species credit species. Accordingly, further impact assessment has not been conducted for these species.

Assessments of significance (Appendix G) have been completed for EPBC Act listed threatened and migratory species relevant to the surface infrastructure area and study areas. The assessments were prepared to assess the residual direct and indirect impacts of the project on Southern Highlands Shale Forest and Woodland, Paddys River Box, Koala and Large-eared Pied Bat, recorded adjacent to the surface facilities.

The assessments concluded that the project is not expected to result in a significant impact on these threatened species and communities.

7.4.3 Threatened and migratory species in the study areas

Assessments of significance (Appendix G) were completed to assess indirect groundwater-related impacts on threatened species and communities associated with Long Swamp and Stingray Swamp in the study areas, comprising:

- threatened ecological communities: Temperate Highland Peat Swamps on Sandstone and Robertson Basalt Tall Open Forest;

- threatened flora: Paddys River Box, Dwarf Phyllota and Broad-leaved Sally;
- threatened fauna: Australasian Bittern, Australian Painted Snipe, Koala and Giant Dragonfly; and
- migratory fauna: Cattle Egret and Great Egret.

The assessments concluded that the project is not expected to result in a significant impact on these listed species and communities.

7.5 Key threatening processes

Key threatening processes (KTPs) are potential events and processes that threaten, or could threaten, the survival or evolutionary development of species, populations or ecological communities. Thirty six KTPs are currently listed in NSW under the TSC Act, eight are listed under the FM Act and nineteen KTPs are listed under the EPBC Act. Table 7.2 lists the KTPs with the potential to be exacerbated as a consequence of the project. The table also summarises the likely impacts of the project on these KTPs.

Table 7.2 Key threatening processes and significance of threat

Key threatening process	Relevance to the project
Alteration to the natural flow regimes of rivers and drainage lines and their floodplains and wetlands	Impacts to surface water and groundwater dependent ecosystems have been assessed in Section 7.1.2v and 7.2.1. The project is not expected to significantly impact these ecosystems and the threatened biodiversity they support. Should a prolonged drought occur during mining, monitoring and management triggers proposed in Section 6.2 for GDEs would be implemented.
Bush rock removal	The project requires the removal of embedded rock in some areas. Relocation of such material into the offset areas will be described in the BMP.
Clearing of native vegetation	Up to 64 paddock trees will be cleared in the project area. Vegetation of conservation significance has been avoided where possible through the design process. Offsets will be provided to compensate for the loss of native vegetation and fauna habitat.
Competition and grazing by the Rabbit	While Rabbits occur within the project area, their current impact appears to be minor. The project will not significantly increase the level of this threat. Feral animal control measures will be implemented in accordance with the BMP to be prepared.
Loss of hollow-bearing trees	The project will result in the loss of up to 17 hollow trees. Hollow replacement measures will be implemented as described in the BMP to be prepared.
Removal of dead wood and dead trees	The proposed works will remove some dead standing trees (stags) from the project area. Such habitat features will be salvaged during clearing works and reinstated as described in the BMP to be prepared.
Predation by Foxes	Foxes have direct impacts on a range of native animal species. They prey particularly on small to medium-sized, ground-dwelling and semi-arboreal mammals, and ground-nesting birds. Foxes and other pest fauna species will be managed in accordance with the BMP to be prepared.
Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams	Culverts will be installed at waterway crossings for the project. However, these culverts will not increase the operation of this key threatening process as they will be designed in accordance with '*Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*' (Fairfull and Witheridge 2003), *Policy and Guidelines for fish habitat conservation and management* (DPI 2013) and *Guidelines for watercourse crossings on waterfront land* (NOW 2012).

7.6 Critical habitat

The project area contains habitat critical to the survival of Southern Highlands Shale Forest and Woodland, listed as a CEEC under the EPBC Act. This project has been specifically redesigned to avoid any direct impact to this CEEC.

The project area contains habitat critical to the survival of the Koala. The surface infrastructure area has been redesigned to avoid intact areas of habitat along drainage lines including Oldbury Creek. However, construction of the surface infrastructure area will result in some residual impacts, including the removal of paddock trees which may provide koala foraging habitat. Offsets will be provided to compensate for the loss of these paddock trees on the Koala.

7.7 Cumulative impacts

The potential for cumulative biodiversity impacts have been assessed with the following projects:

- the proposed Berrima Rail Project - as previously described in this EIS, Hume Coal is also applying for development consent for the Berrima Rail Project to service the project.

- New Berrima Clay/Shale Quarry – The Austral Brick Company Pty Ltd (Austral) was granted Project Approval for the New Berrima Quarry in July 2012. This approval allowed the extraction of clay/shale from a resource within the Mandurama property, approximately 1.5 km east of New Berrima and 1.5 km north-east of the Berrima Cement Works, for transportation and use principally at Boral's Bowral brick plant. No construction or extraction operations have been undertaken since Project Approval was granted, and Austral recently sought a modification to the original project approval to allow the relocation of the extraction area. The PAC recommended approval to the modification in November 2015. The quarry location is approximately 4 km from the eastern boundary of the project area.

- Green Valley Sand Quarry – Rocla Materials Pty Ltd (Rocla) received approval on 21 June 2013 for the construction and operation of a sand quarry in an area 28 km south-west of Berrima and 14 km north-east of Marulan. The approval allows the extraction of sandstone, dry and wet processing operations and despatch of sand products to markets on the South Coast, Southern Highlands and Sydney. The quarry is not yet operational.

- Sutton Forest Quarry – SEARs for the Sutton Forest Quarry were issued on 7 February 2014. The SSD proposal involves the establishment of a quarry off the Hume Highway, approximately 20 km south-west of Moss Vale, to extract and process up to 1.15 Mtpa of sand from a total resource of approximately 25 million tonnes. A development application and accompanying EIS has not been submitted for the quarry. The cumulative impacts of this development have not been considered as the SEARS were issued greater than two years ago, and a development application has not been lodged.

Cumulative biodiversity impacts have been assessed for the relevant threatened species and communities that occur on each project.

EMM has also completed a biodiversity assessment for the Berrima Rail Project. While most impacts to native vegetation and habitat will be avoided by the Berrima Rail Project, it will result in minor residual impacts on potential Squirrel Glider habitat. Paddock trees representing potential Squirrel Glider habitat, which have been converted using the paddock tree calculator to an effective clearing area of 8.3 ha will be cleared for the Hume Coal Project and approximately 2 ha of potential habitat will be cleared for the Berrima Rail Project, resulting in a minor cumulative potential habitat loss of approximately 10.3 ha for both projects. Species credits have been generated for the Squirrel Glider for both projects, and appropriate offsets will be provided to offset the minor cumulative impact to their potential habitat.

A flora assessment was completed by Cunningham (2010) for the Berrima Shale/Clay Quarry. Cunningham (2010) concluded that no threatened flora species or ecological communities listed under the TSC or EPBC Acts occurred at the site. Therefore, there will be no cumulative impact on threatened flora species and communities between the project and the Berrima Shale/Clay Quarry.

A fauna assessment was completed by Aquila Ecological Surveys (2010) for the Berrima Shale/Clay Quarry. Aquila Ecological Surveys (2010) concluded that no threatened fauna species listed under the TSC or EPBC Acts occurred at the site. Therefore, there will be no cumulative impact on threatened fauna species between the project and the Berrima Shale/Clay Quarry.

A preliminary ecological assessment has been undertaken by Kevin Mills and Associates (2013) and Lesryk (2013) for the proposed Sutton Forest Quarry as part of the Request for SEARs document (RW Corkery 2013). Kevin Mills and Associates (2013) reports six native vegetation types from the Sutton Forest Quarry, namely Peppermint Tall Forest, Sydney Peppermint Forest, Stringybark Forest, Scribbly Gum Woodland, Regrowth Peppermint Forest, and Freshwater Wetland (Swamp). The broad descriptions of these vegetation types were compared to those that occur in the project area, and they were found to be different. Therefore, there will be no cumulative loss of similar vegetation types between the project and the proposed Sutton Forest Quarry, should it proceed.

Kevin Mills and Associates (2013) also recognise potential hydrological impacts on Montane Peatlands and Swamps endangered ecological community, occurring north of the proposed Sutton Forest Quarry. As Montane Peatlands and Swamp endangered ecological community is absent from the project area and surrounds, and no groundwater will be accessed for the project, no cumulative impacts on this community will occur.

Kevin Mills and Associates (2010) completed a Flora and Fauna Assessment for the proposed Green Valley Sand Quarry. Similar vegetation types were reported as for the proposed Sutton Forest Quarry (Kevin Mills and Associates 2013), which are different to the vegetation communities of the project area, and therefore no cumulative loss of similar vegetation types will occur. Kevin Mills and Associates (2010) recorded three threatened flora species, namely the Paddys River Box, Mountain Swamp Gum (*Eucalyptus aquatica*) and Dwarf Phyllota (*Phyllota humifusa*) at the proposed Green Valley Sand Quarry. While Paddys River Box occurs within the project area, none of these individuals will be impacted by the design. Therefore, there will be no cumulative loss of Paddys River Box between the project and the proposed Green Valley Sand Quarry. The same threatened fauna species were recorded by Kevin Mills and Associates (2010) as mentioned above for the proposed Sutton Forest Quarry (Kevin Mills and Associates 2013), with the exception of the Glossy Black Cockatoo. The Squirrel Glider was also recorded at the proposed Green Valley Sand Quarry, and its area of potential habitat was reported as 46.1 ha. Therefore there will be a minor cumulative impact on Squirrel Glider habitat, removing 64 paddock trees with an effective clearing area of 8.3 ha of potential Squirrel Glider habitat.

Cumulative impacts on aquatic ecosystems were also considered for the project and Berrima Rail Project. WSP Parsons Brinckerhoff (2016) concluded that the impact on flow and bed and bank stability associated with the project and Berrima Rail Project will be negligible because the Berrima Rail Project will not involve take of water from streams or discharge to streams. The rail infrastructure will not reduce the volume flow as culvert structures will be constructed where the rail crosses waterways and mitigation measures will be implemented upstream and downstream of culvert structures to prevent erosion and scour impacts. Therefore, the projects will result in minimal cumulative impacts on aquatic ecosystems.

7.8 Matters of National Environmental Significance

7.8.1 Threatened ecological communities

i Surface infrastructure area and project area

Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion, a CEEC listed under the EPBC Act is adjacent to the surface infrastructure area. The surface infrastructure area has been designed such that all direct impacts on Southern Highlands Shale Woodland have been avoided.

A patch of Southern Highlands Shale Woodland CEEC south of Wells Creek is predicted to have a facultative (opportunistic) dependence on groundwater. Using the ecosystem drawdown risk assessment (Section 7.2.1), this areas show a moderate to high risk of drawdown impact. Facultative (opportunistic) ecosystems can respond to changes in groundwater, and can exist using other water sources outside of periods of prolonged drought. Accordingly, no impacts are expected to these ecosystems if periods of prolonged drought are not experienced during mining. Monitoring and management triggers are proposed in Section 6.2 for terrestrial vegetation in the event of prolonged drought.

Accordingly, an assessment of significance (Appendix G) was completed to assess indirect impacts of the project on Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion. The assessment concluded that a significant impact was unlikely as:

- direct impacts had been avoided by the project design;
- the potential drawdown impacts described above were only expected to occur during periods of prolonged drought, given the vegetation's facultative (opportunistic) groundwater use; and
- such impacts can be effectively managed through implementation of the proposed monitoring and management measures.

ii Terrestrial study area

Four threatened ecological communities listed under the EPBC Act are predicted to occur in the terrestrial study area, including Southern Highlands Shale Woodland, Temperate Highland Peat Swamps on Sandstone and Robertson Basalt Tall Open Forest of the Sydney Basin Bioregion and Mount Gibraltar Forest in the Sydney Basin Bioregion (Figure 4.4). None of these EECs will be directly impacted by the project, as they occur outside the surface infrastructure areas.

The potential ecosystem impacts at 17 and 30 years after mining (Figure 7.1 and Figure 7.2) were reviewed to determine if any of these threatened ecological communities fell within the area of potential groundwater impact. Four small patches of Southern Highlands Shale Woodland CEEC in the east of the terrestrial study area are located in an area that has a low risk of drawdown impact. Robertson Basalt Tall Open Forest is predicted to occur along Black Bobs Creek that has a low to moderate risk of drawdown impact. As the risk of drawdown impact is low to moderate, the water table will stay within the root zone (<10 mbgl) of the eucalypts which would be the main component of the ecosystem opportunistically drawing on subsurface groundwater.

Stingray Swamp and Long Swamp are known to contain Temperate Highland Peat Swamps on Sandstone. An area of Stingray Swamp has a low to moderate risk of water table drawdown. Stingray Swamp is likely to be a headwater swamp (following Commonwealth of Australia 2014) fed by perched groundwater systems that are not connected to the water table. Therefore, no drawdown-related impacts are expected to occur at Stingray Swamp.

Long Swamp is likely to be a valley infill swamp (following Commonwealth of Australia 2014) that takes water from rainfall, surface runoff and groundwater. Although the water table is shallow at Long Swamp, it is outside the maximum drawdown footprint at Year 17 of mining. A low to moderate risk of drawdown is predicted in terrestrial vegetation upstream of Long Swamp. Groundwater flows through valley infill swamps are predicted to be along the surface of the peat, up through the peat or channels within the peat. Therefore, the low to moderate risk of drawdown in terrestrial vegetation upstream of Long Swamp is not predicted to result in drawdown-related impacts.

Accordingly, an assessment of significance (Appendix G) has been completed to assess indirect impacts of the project on these listed communities. The assessment concluded that the project was unlikely to result in significant impacts on the listed communities as:

- direct impacts on the communities have been avoided;
- drawdown impacts are not expected on Temperate Highland Peat Swamps on Sandstone or Robertson Basalt Tall Open Forest; and
- drawdown impacts on Southern Highlands Shale Forest and Woodland are only expected to occur during periods of prolonged drought, and can be effectively managed through implementation of the proposed monitoring and management measures.

7.8.2 Listed species

i Surface infrastructure area and project area

Species listed under the EPBC Act were not recorded in the footprint of the surface infrastructure area. The surface infrastructure area was redesigned such that impacts on listed species habitats were avoided or minimised (Figure 5.1 and Figure 5.2). This has resulted in a project design that has minor residual impacts to listed species.

Specifically, direct impacts on Paddys River Box and Large-eared Pied Bat habitat have been avoided. The CHPP was moved south to avoid the clearing of an area of native vegetation along Oldbury Creek containing known Large-eared Pied Bat habitat, and the elevated conveyor was repositioned such that no Paddys River Box would be removed. Impacts on Koala habitat were minimised when the CHPP was moved south to avoid the clearing of vegetation along Oldbury Creek, as Koala scats were recorded in this area. The solution was to move the CHPP south into an area that impacted paddock trees, which provided lower habitat value to the Koala than the intact vegetation along Oldbury Creek. Offsets will be provided in accordance with the Framework for Biodiversity Assessment to compensate for the loss of these paddock trees and potential Koala habitat (Section 5.2).

Assessments of significance (Appendix G) were completed to assess impacts of the project on Paddys River Box, Large-eared Pied Bat and Koala. The assessment of significance for Paddys River Box concluded that the project is unlikely to result in significant impacts on the species as:

- direct impacts have been avoided by the project design; and
- indirect impacts (ie potential drawdown during extended drought periods) could be effectively managed through implementation of the proposed monitoring and management measures.

The assessment of significance for the Koala concluded that the project is unlikely to result in significant impacts on the species as:

- the surface infrastructure design has been optimised to avoid direct impacts to critical Koala habitat;
- removal of up to 64 paddock trees is not expected to significantly impact the species;
- measures will be implemented to minimise bushfire risk to Koala habitat, and indirect impacts including light, noise and dust; and
- measures will be implemented to monitor and manage Koala habitat along Belanglo Creek in the event of prolonged drought.

The assessment of significance for the Large-eared Pied Bat concluded that the project is unlikely to result in significant impacts on the species as:

- an important population of the species does not occur in the area;
- direct impacts will not occur in habitat areas;
- the project will use a non-caving mining method; and
- potential drawdown impacts in their habitat can be effectively managed during periods of prolonged drought.

ii Study areas

Long Swamp and Stingray Swamp contain habitat for threatened and migratory species including Paddys River Box, Broad-leaved Sally, Dwarf Phyllota, Giant Dragonfly, Australasian Bittern, Australian Painted Snipe, Great Egret, Cattle Egret and Littlejohns Tree Frog (see Appendix E). The swamps will not be impacted by the project as they are located outside the surface infrastructure areas.

An area of Stingray Swamp has a low to moderate risk of water table drawdown. Stingray Swamp is likely to be a headwater swamp (following Commonwealth of Australia 2014) fed by perched groundwater systems that are not connected to the water table. Therefore, no drawdown-related impacts are expected to occur at Stingray Swamp.

Long Swamp is likely to be a valley infill swamp (following Commonwealth of Australia 2014) that takes water from rainfall, surface runoff and groundwater. Although the water table is shallow at Long Swamp, it is outside the maximum drawdown footprint at Year 17 of mining. A low to moderate risk of drawdown is predicted in terrestrial vegetation upstream of Long Swamp. Groundwater flows through valley infill swamps are predicted to be along the surface of the peat, up through the peat or channels within the peat. Therefore, the low to moderate risk of drawdown in terrestrial vegetation upstream of Long Swamp is not predicted to result in drawdown-related impacts.

Accordingly, assessments of significance (Appendix G) were completed to assess indirect impacts of the project on the habitat of these listed species. The assessment concluded that the project was unlikely to result in significant impacts on Paddys River Box, Dwarf Phyllota, Broad-leaved Sally, Littlejohns Tree Frog and Giant Dragonfly as:

- there will be no direct impacts to their habitat as a result of the project; and
- indirect habitat impacts such as drawdown-related impacts are not predicted at the swamps.

The assessment of significance completed for the migratory Cattle Egret and Great Egret concluded that the project would not result in significant impacts on the species as:

- important habitat will not be substantially modified;
- the project will not increase the spread of invasive species; and
- their lifecycle of an ecologically significant proportion of the population will not be disrupted.

7.8.3 Nationally important wetlands

Paddy's River Swamps, comprising Long Swamp, Stingray Swamp, Hanging Rock Swamp and Mundego Swamp are approximately 7, 8, 9 and 15 km south-west of the project area, respectively. Wingecarribee Swamp lies 13 km east of the project area. Hanging Rock Swamp, Mundego Swamp and Wingecarribee Swamp lie outside the zone of influence of potential groundwater impacts (Figure 7.1 and Figure 7.2), and therefore will not be impacted.

As they are located in the study areas, impacts on Long Swamp and Stingray Swamp and the listed community and species they support has been assessed in Section 7.8.1 and 7.8.2. An assessment of significance (Appendix G) has been completed to assess potential impacts of the project on the listed community and species in these nationally important wetlands. The project is unlikely to result in significant impacts on these nationally important wetlands.

8 Biodiversity credit report

This section summarises the impacts that are required to be offset, in accordance with Chapter 10 of the FBA. It describes the ecosystem and species credits required to offset the residual surface impacts of the project, which have been calculated using the BioBanking calculator, and in accordance with Section 10.2 of the FBA.

8.1 Impacts requiring offsetting

The following project impacts require offsetting in accordance with the FBA:

- the clearing of 64 paddock trees, with an effective clearing area (according to the paddock tree calculator) of 8.3 ha of PCT 731 Broad-leaved Peppermint - Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion (low condition); and
- the clearing of 64 paddock trees, with an effective clearing area of 8.3 ha, that represent habitat for the Koala, Southern Myotis and Squirrel Glider.

The areas requiring offsetting are shown in Figure 5.2.

The full BioBanking Credit Report is provided in Appendix H.

8.2 Quantification of impacts

The impacts of the project were assessed according to the FBA and associated BioBanking Credit Calculator. This method allows for impacts on native vegetation and threatened flora and fauna to be quantified, so that a suitable and proportionate offset can be identified. The method details the offset requirements in terms of ecosystem and species credits. Both ecosystem and species credits are required to compensate for the project's impacts on biodiversity. These are described in the following sections.

8.2.1 Ecosystem credits

Zone 1 has a site value score of greater than 17 (Table 5.1). Several ecosystem and species credit species were identified as having a moderate to high likelihood in the surface infrastructure area (Table 5.3 and Table 5.4). The species associated with the PCT with the highest threatened species multiplier was the Powerful Owl (Table 5.3).

Other ecosystem species for which ecosystem credits that will be provided comprise the Little Eagle, Gang-gang Cockatoo, Hooded Robin, Scarlet Robin, Diamond Firetail, Flame Robin, Masked Owl, Turquoise Parrot, Varied Sittella, Little Lorikeet, Eastern False Pipistrelle, Eastern Freetail Bat and Yellow-bellied Sheathtail Bat.

A total of 101 ecosystem credits are required to compensate for the project's impacts on vegetation and threatened species associated with the plant community type (Table 8.1). A full Biobanking Calculator Credit Report is provided at Appendix H.

Table 8.1 Ecosystem credits required

Vegetation zone	Plant community type	Area (ha)[1]	Threatened ecological community	Loss in site value score	Future site value score	Ecosystem credit species with the highest multiplier	Ecosystem credits required to offset impact
1 (Paddock trees)	1093 (low)	8.3	No	36.46	0	-	101

Note: 1. Based on an effective clearing area of 8.3 ha (see Table 5.2).

8.2.2 Species credits

Species credits are required for the Koala, Southern Myotis and Squirrel Glider. A total of 582 species credits are required to offset the project's impacts (Table 8.2). A full Biobanking Calculator Credit Report is provided at Appendix H.

Table 8.2 Species credits required

Species	Threatened species offset multiplier	Species credits required to offset impact
Koala	2.6	216
Southern Myotis	2.2	183
Squirrel Glider	2.2	183
Total	-	**582**

9 Biodiversity offset strategy

This chapter describes the proposed biodiversity offset strategy for the project.

9.1 Strategy

The strategy to identify offsets to compensate for the project's impacts will involve the following steps, in order of priority:

1. Identifying if suitable credits are available on the BioBanking Credit Register to meet offset requirements;

2. Finding potential offset sites with the biodiversity values required to compensate for the project's impacts;

3. In the absence of suitable offset credits or properties, applying the variation criteria rules of the FBA and finding suitable offsets to meet the requirements; and

4. A financial contribution.

The BioBanking Credit Register was searched on 12 October 2016 for ecosystem credits issued for PCT 1093 and species credits for the Koala, Southern Myotis and Squirrel Glider (Option 1). No suitable ecosystem credits for PCT 1093 were available on the register at this time. Species credits were available on the BioBanking Credit Register for the Koala and Squirrel Glider, however no credits were listed for the Southern Myotis. Details of the available species credits are shown in Table 9.1.

Table 9.1 Available species credits

Species credit species	Credit register ID/name	Credits available
Koala	212	965
Koala	214	109
Squirrel Glider	204	180

No ecosystem credits are available for PCT 1093, and the available species credits are in different locations. From a cost perspective, it would be more practical to find a single offset site that contains the required ecosystem and species credits for the project. Therefore, Option 2 was considered.

Vegetation mapping and threatened species records were reviewed for the project area to determine if potentially suitable offset areas were present, that would satisfy the offset requirements for both the Hume Coal Project and Berrima Rail Project (see Appendix H for potential offset calculations). A potential offset site was assessed in the north of the project area, along Oldbury Creek.

The potential offset site comprises 32 ha of two different vegetation types (HN570 and HN504), and two Paddys River Box trees, within the rail loop area. Table 9.2 summarises the credits generated by the offset site, and how these compare with the credit requirements for the Hume Coal Project and Berrima Rail Project. Although targeted surveys have not been completed for the Squirrel Glider, for the purposes of this investigation, its presence was assumed. Targeted surveys for the Squirrel Glider would be completed in the potential habitat to be removed and the potential offset site should it be included in the final biodiversity offset package.

Table 9.2 Credits generated vs credits required

Factor	Ecosystem credits		Species credits			
Vegetation type	**HN570**	**HN504**	**Koala**	**Squirrel Glider**	**Southern Myotis**	**Paddys River Box**
Area required (ha)	29.1	2.9	32	32	32	2 trees
Credits generated	332	40	227	227	227	14
Credits required for Hume Coal Project and Berrima Rail Project	101	2	216	227	183	14
Does the site satisfy the credit requirement?	Yes	Yes	Yes	Yes	Yes	Yes

The size of the potential offset site is governed by the need to find 227 species credits for the Squirrel Glider for both projects, conservatively assuming that the species is recorded during targeted surveys and species credits are required. All other ecosystem and species credits provide in excess of what is required, and therefore if selected, it would provide a suitable site that satisfies the offset requirements for the Hume Coal Project and Berrima Rail Project.

If a land-based offset (Option 2), the variation criteria will be applied (Option 3). Under the FBA, the offset rules can be varied to match ecosystem credits, using credits generated by a PCT from the same vegetation formation as the PCT to which the required ecosystem credit relates. Where possible and if needed, the variation rules will be applied to the project and suitable PCTs in the same vegetation class will be identified prior to matching by formation. The application of the variation criteria, if needed, will be completed in consultation with OEH and DP&E.

If Option 3 is not possible, a discussion would be held with OEH to determine if the proponent could pay into the BioBanking Trust Fund (Option 4).

Investigations will continue to secure a suitable offset for the project. The Biodiversity Offset Strategy will be finalised into a Biodiversity Offset Package in consultation with OEH and DP&E within 12 months of project approval.

9.2 Offset security

In accordance with the FBA, any property identified for offsetting will be secured under a biobanking agreement.

10 Conclusion

This biodiversity assessment report has been prepared to address the biodiversity-related SEARs, agency requirements and supplementary SEARs for the project, listed in Section 1.5. The study was conducted at multiple spatial scales to meet these SEARs, and has included detailed field surveys informed by a detailed desktop review of the project area to accurately assess ecological constraints to surface infrastructure facilities, and detailed desktop analysis of the study areas to accurately assess ecological constraints to underground mining.

Extensive ecological field surveys were completed between 2012 and 2016 that have resulted in a detailed understanding of the native vegetation, threatened species, populations, communities and their habitats in the project area. This detailed understanding has informed the selection of design measures that avoid and/or minimise impacts on threatened biodiversity. Such measures include the use of a non-caving mining method that has negligible surface impacts, and an iterative project design process that has minor residual impacts on native vegetation, threatened species, populations, communities and their habitats. Design measures will be implemented such that fish passage is maintained, and appropriate scour protection will be provided.

An assessment of potential groundwater dependent ecosystems has been undertaken by combining ecological, surface water and groundwater datasets. This approach has resulted in an accurate assessment of underground mining impacts on groundwater dependent ecosystems at several stages of the project.

Residual surface impacts include the removal of 64 paddock trees. The small areas to be removed are predicted to provide habitat for a number of ecosystem and species credit species. Offset calculations have been undertaken in the BioBanking Calculator to determine the number of credits required to compensate for the project's residual surface impacts. The project requires 101 ecosystem credits for the removal of vegetation and ecosystem credit species habitats, and a total of 582 species credits. An offset management strategy has been proposed to source offset areas containing the required ecosystem and species credits, and will be finalised into an offset package within 12 months of project approval.

Areas of terrestrial vegetation along Belanglo Creek and Wells Creek were identified as having a higher risk of drawdown impact from underground mining. However, these areas have a facultative (opportunistic) dependence on groundwater, and will be able to respond to changes in the water table outside of periods of prolonged drought. Monitoring and mitigation strategies have been proposed to manage these ecosystems in the event of prolonged drought. If present in the area affected by drawdown, Stygofauna would be impacted. However, they are unlikely to be restricted to this area given the high level of connectivity of groundwater to adjacent areas. The single Bathynellidae recorded at Hanging Rock Swamp in Penrose State Forest is outside the area affected by drawdown and therefore will not be impacted by the project.

A number of other impacts were identified for the project, including edge effects and fragmentation, fauna strike, increased noise, dust and light and erosion and sedimentation. These impacts will be managed under the project's BMP.

Assessments of significance were completed for terrestrial threatened species and communities. The project is not predicted to result in significant impacts for any of these species and communities.

No threatened aquatic species were recorded or are predicted to occur, due to the absence of suitable habitat, and therefore they will not be impacted.

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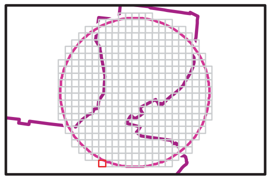
Appendix A

Compliance with FBA requirements

A.1 Site map and location map



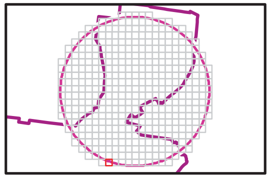
Site map - 1

Hume Coal Project

Environmental Impact Statement

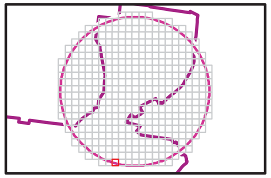
Appendix A

Figure 1

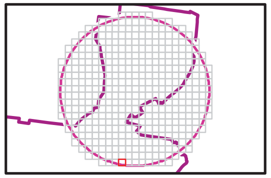


Site map - 2

Hume Coal Project
Environmental Impact Statement
Appendix A
Figure 2



Site map - 3
Hume Coal Project
Environmental Impact Statement
Appendix A
Figure 3



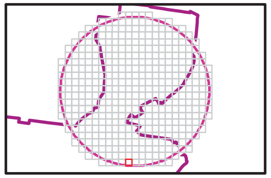
Site map - 4

Hume Coal Project

Environmental Impact Statement

Appendix A

Figure 4



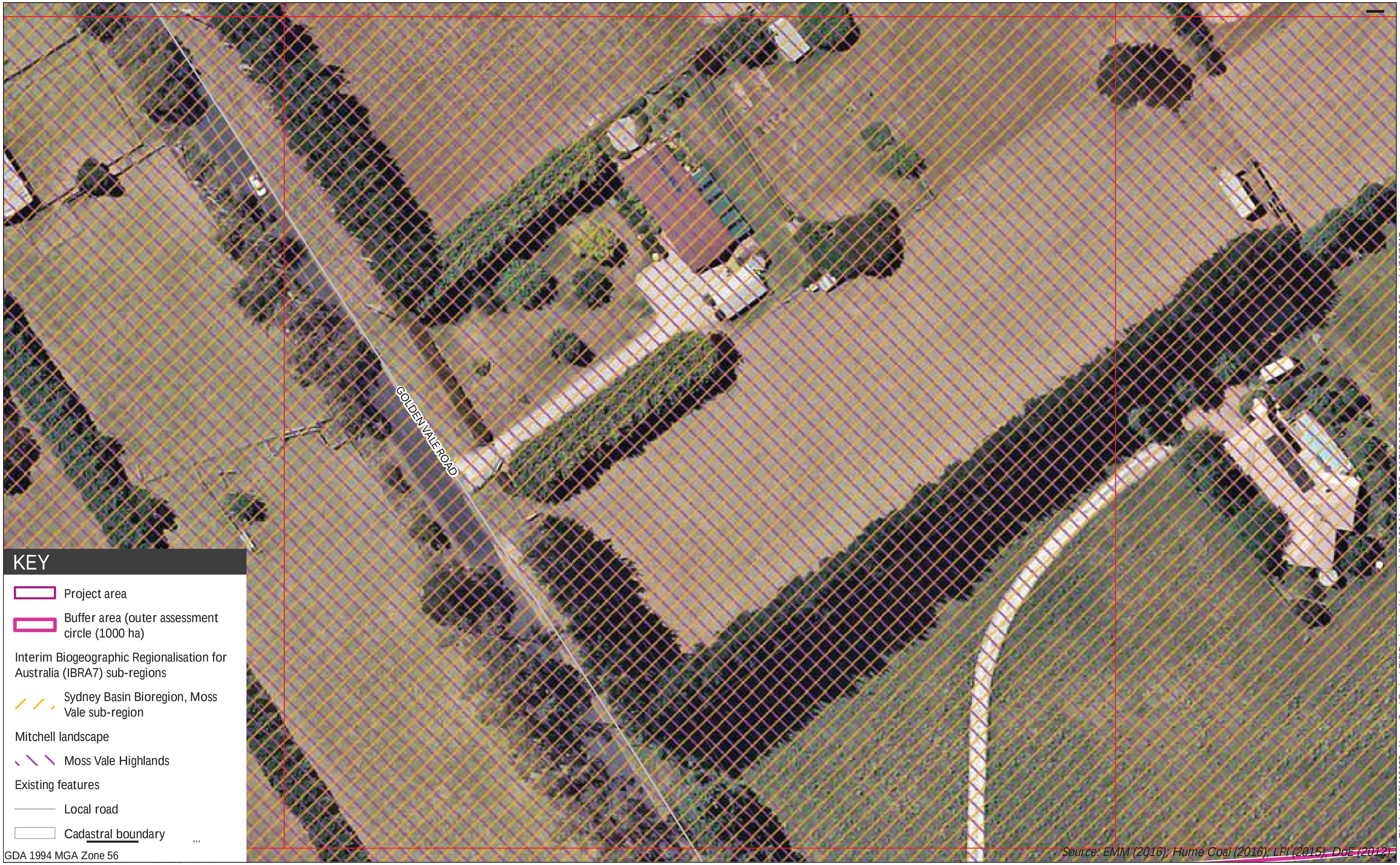
Site map - 5

Hume Coal Project

Environmental Impact Statement

Appendix A

Figure 5



KEY

- Project area
- Buffer area (outer assessment circle (1000 ha)

Interim Biogeographic Regionalisation for Australia (IBRA7) sub-regions

- Sydney Basin Bioregion, Moss Vale sub-region

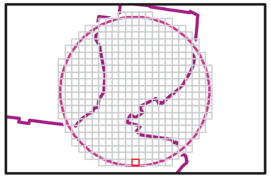
Mitchell landscape

- Moss Vale Highlands

Existing features

- Local road
- Cadastral boundary

GDA 1994 MGA Zone 56



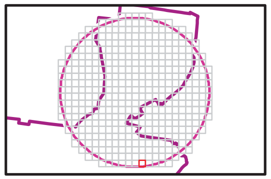
Site map - 6

Hume Coal Project

Environmental Impact Statement

Appendix A

Figure 6



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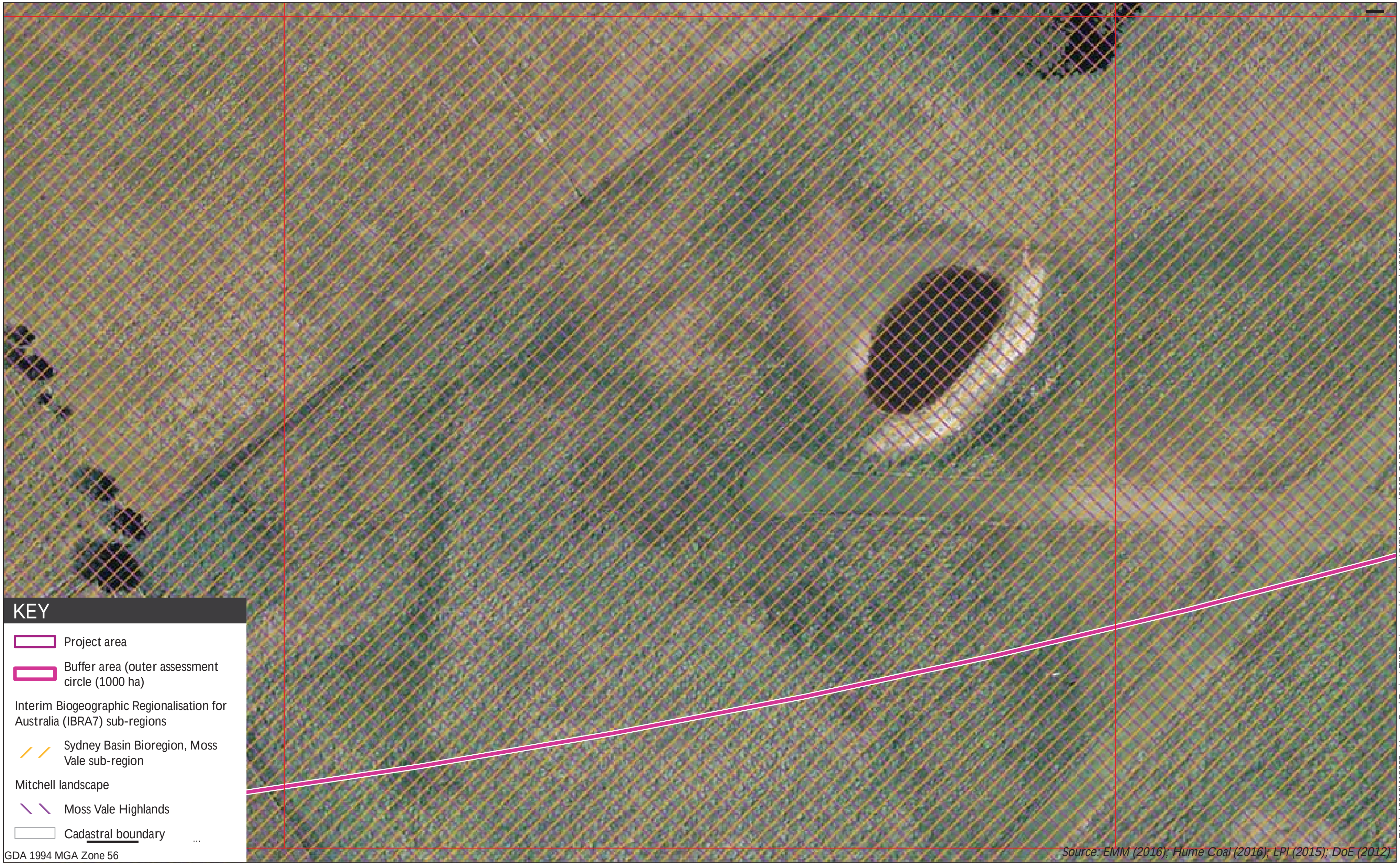
Site map - 7
Hume Coal Project
Environmental Impact Statement
Appendix A
Figure 7



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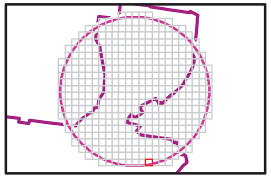


Site map - 8
Hume Coal Project
Environmental Impact Statement
Appendix A
Figure 8

KEY

- Project area
- Buffer area (outer assessment circle (1000 ha)

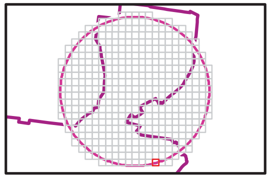
Interim Biogeographic Regionalisation for Australia (IBRA7) sub-regions

- Sydney Basin Bioregion, Moss Vale sub-region

Mitchell landscape

- Moss Vale Highlands
- Cadastral boundary

GDA 1994 MGA Zone 56



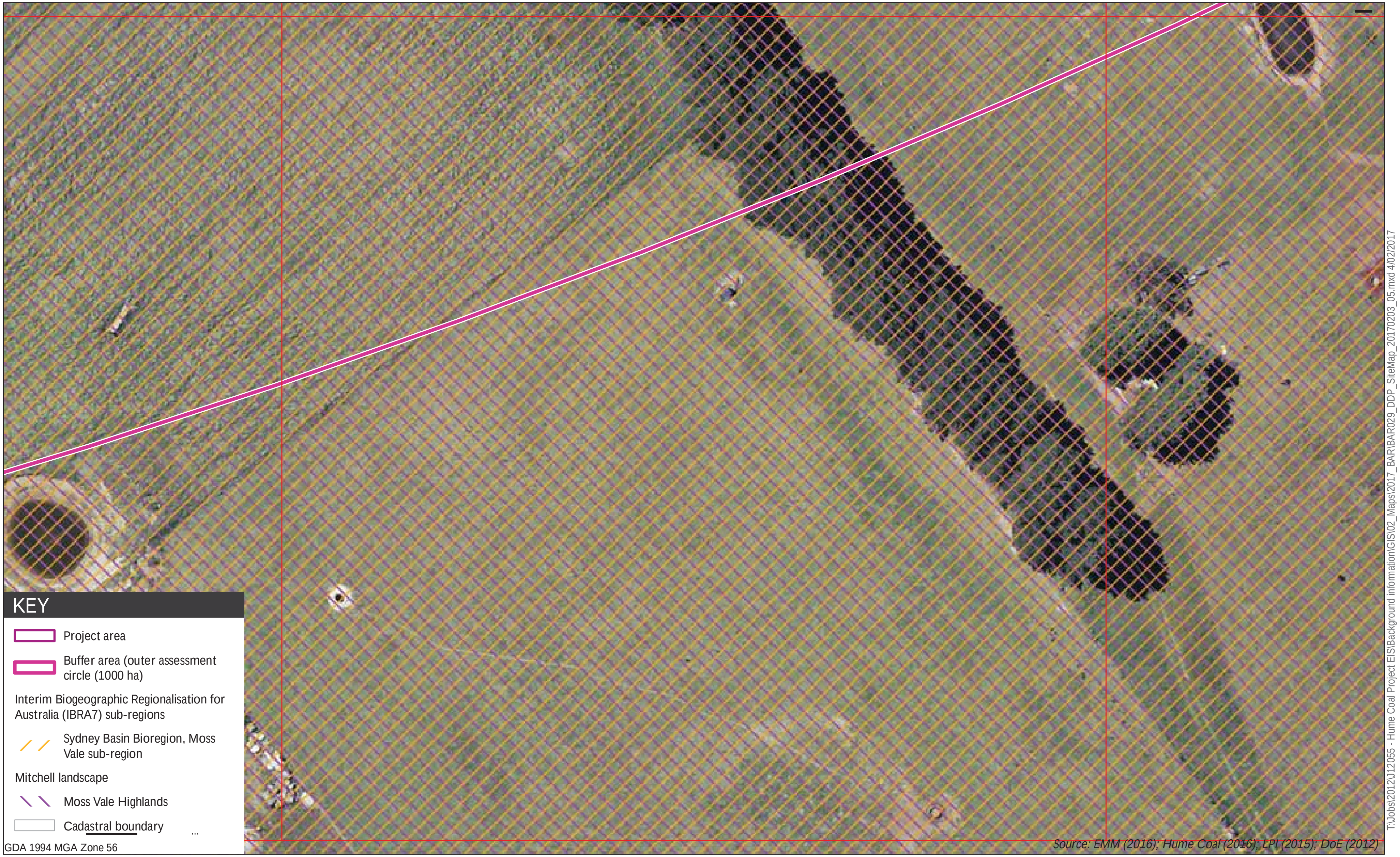
Site map - 9

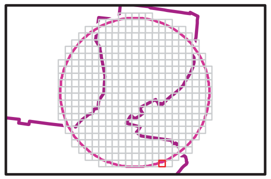
Hume Coal Project

Environmental Impact Statement

Appendix A

Figure 9





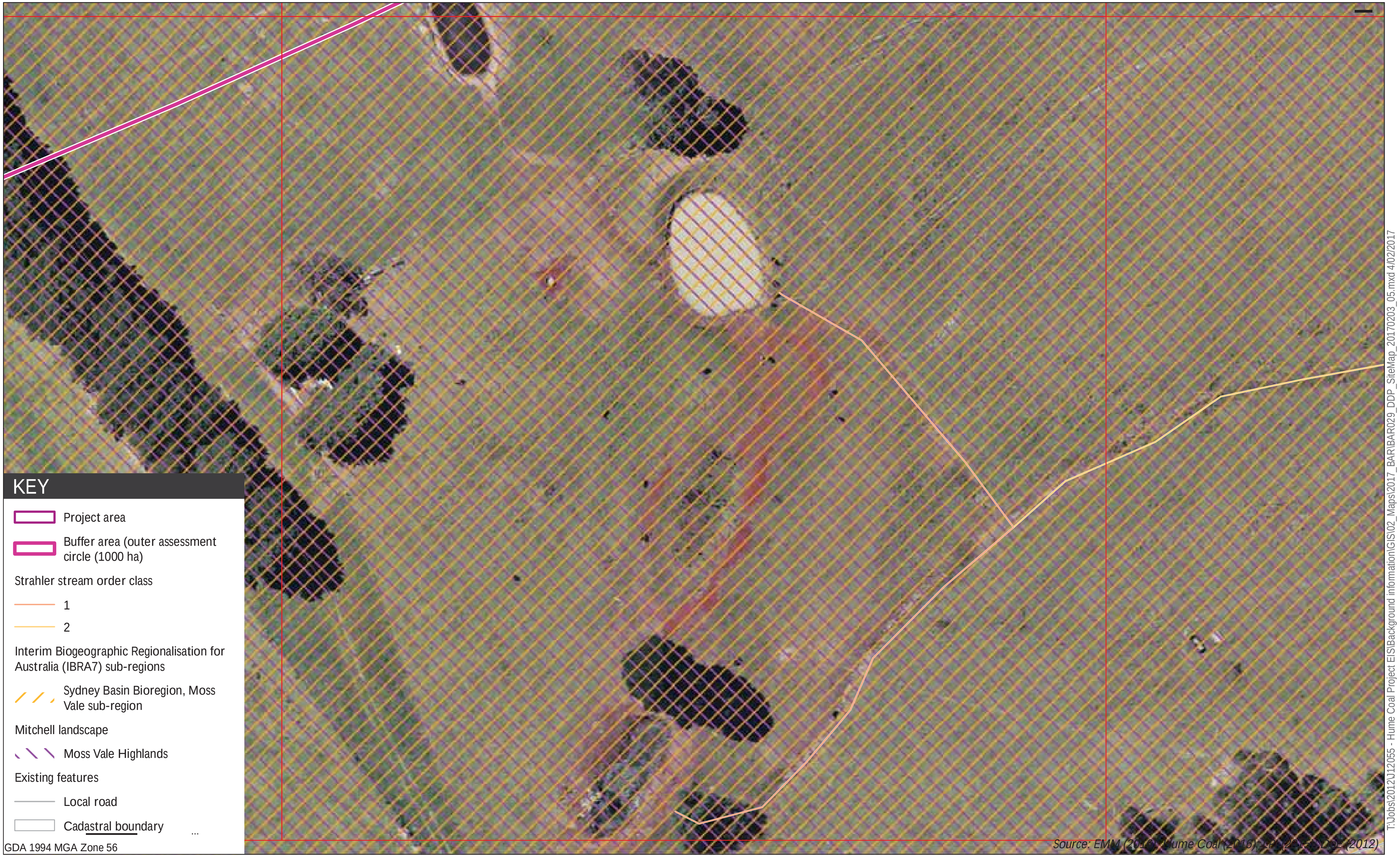
Site map - 10

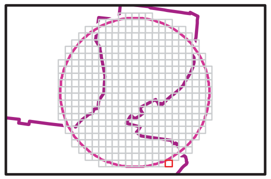
Hume Coal Project

Environmental Impact Statement

Appendix A

Figure 10





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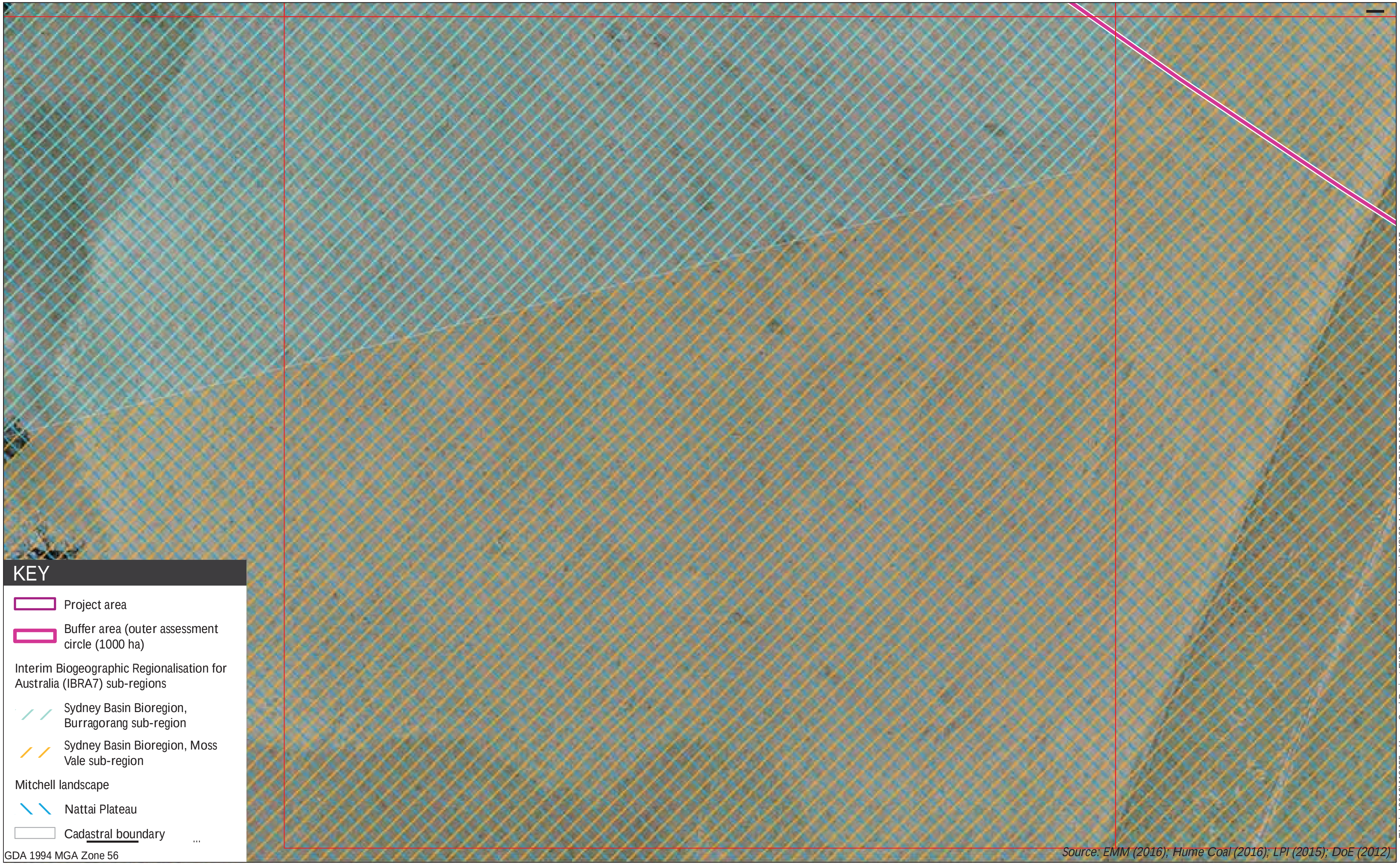

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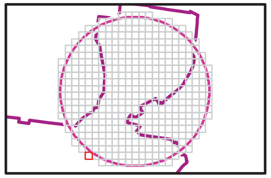

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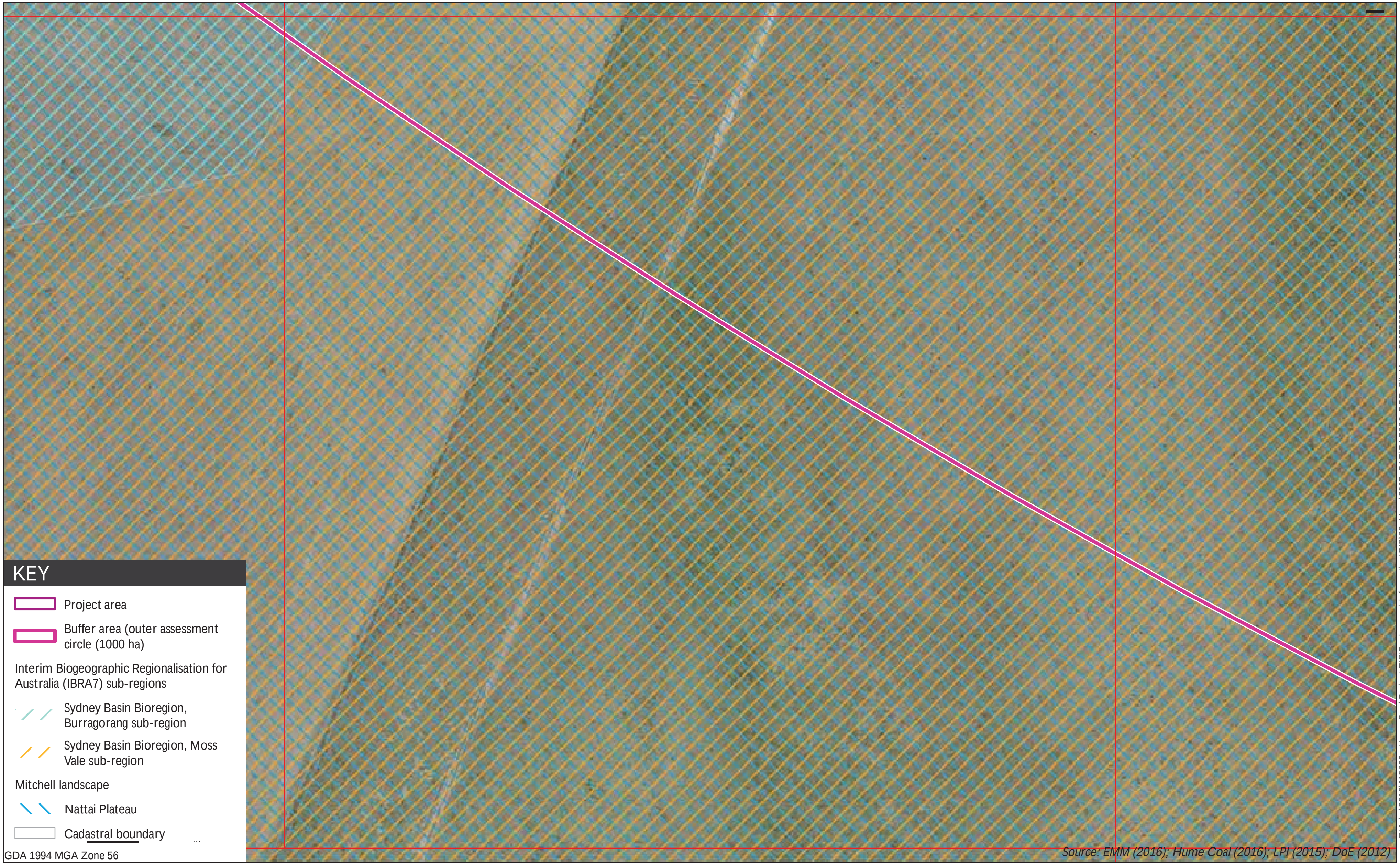

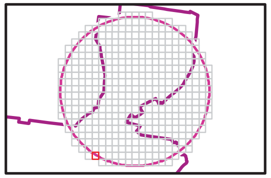

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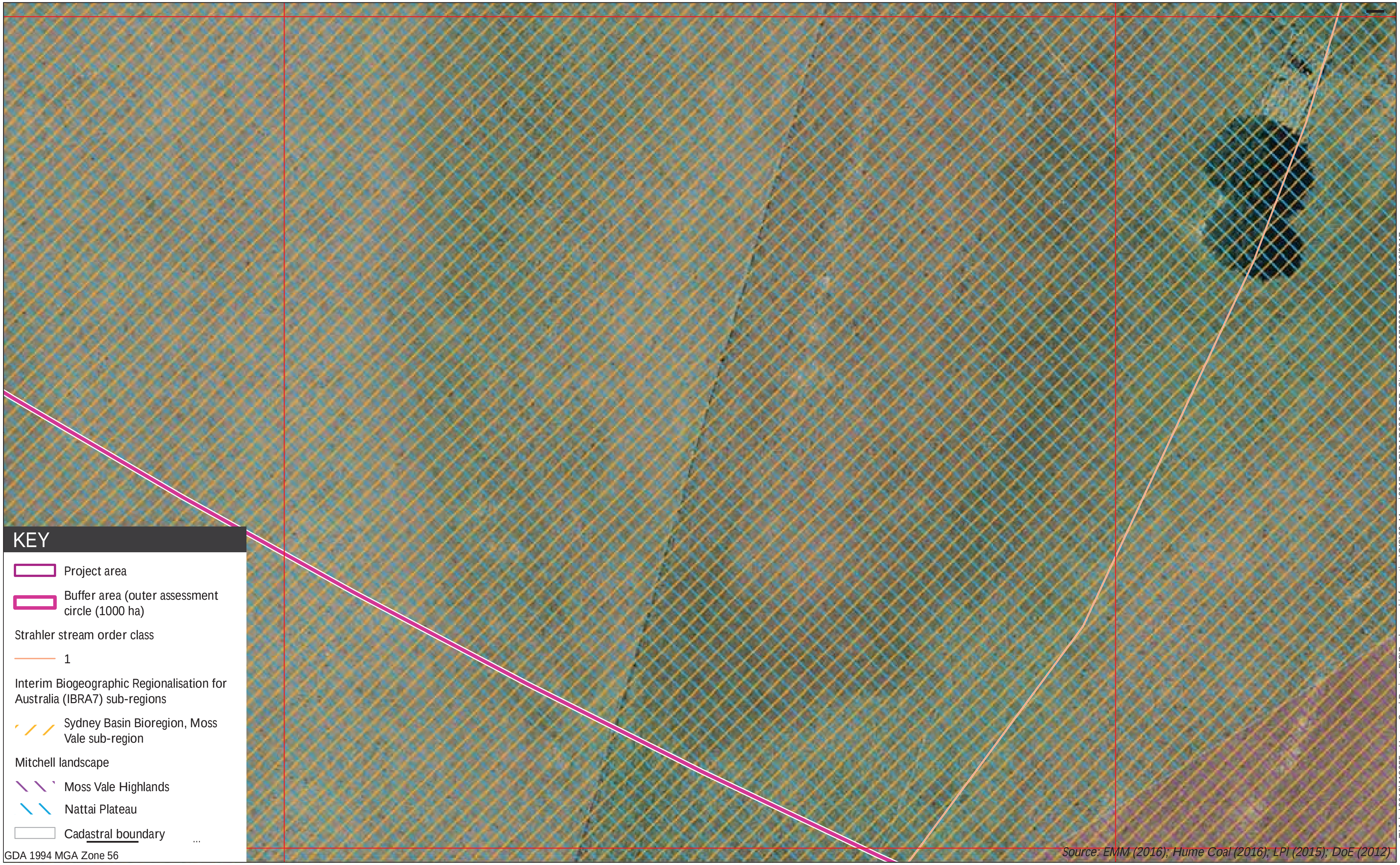
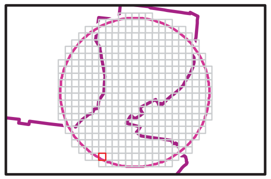
Figure 13





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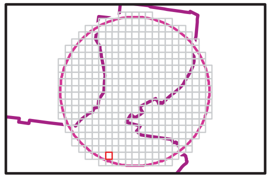

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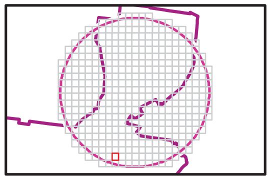

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Figure 16

KEY

- Project area
- Buffer area (outer assessment circle (1000 ha)

Interim Biogeographic Regionalisation for Australia (IBRA7) sub-regions

- Sydney Basin Bioregion, Moss Vale sub-region

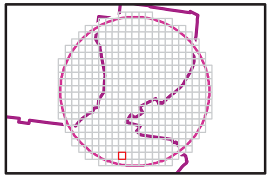
Mitchell landscape

- Moss Vale Highlands

Existing features

- Main road
- Cadastral boundary

GDA 1994 MGA Zone 56



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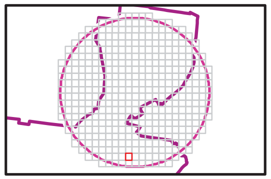

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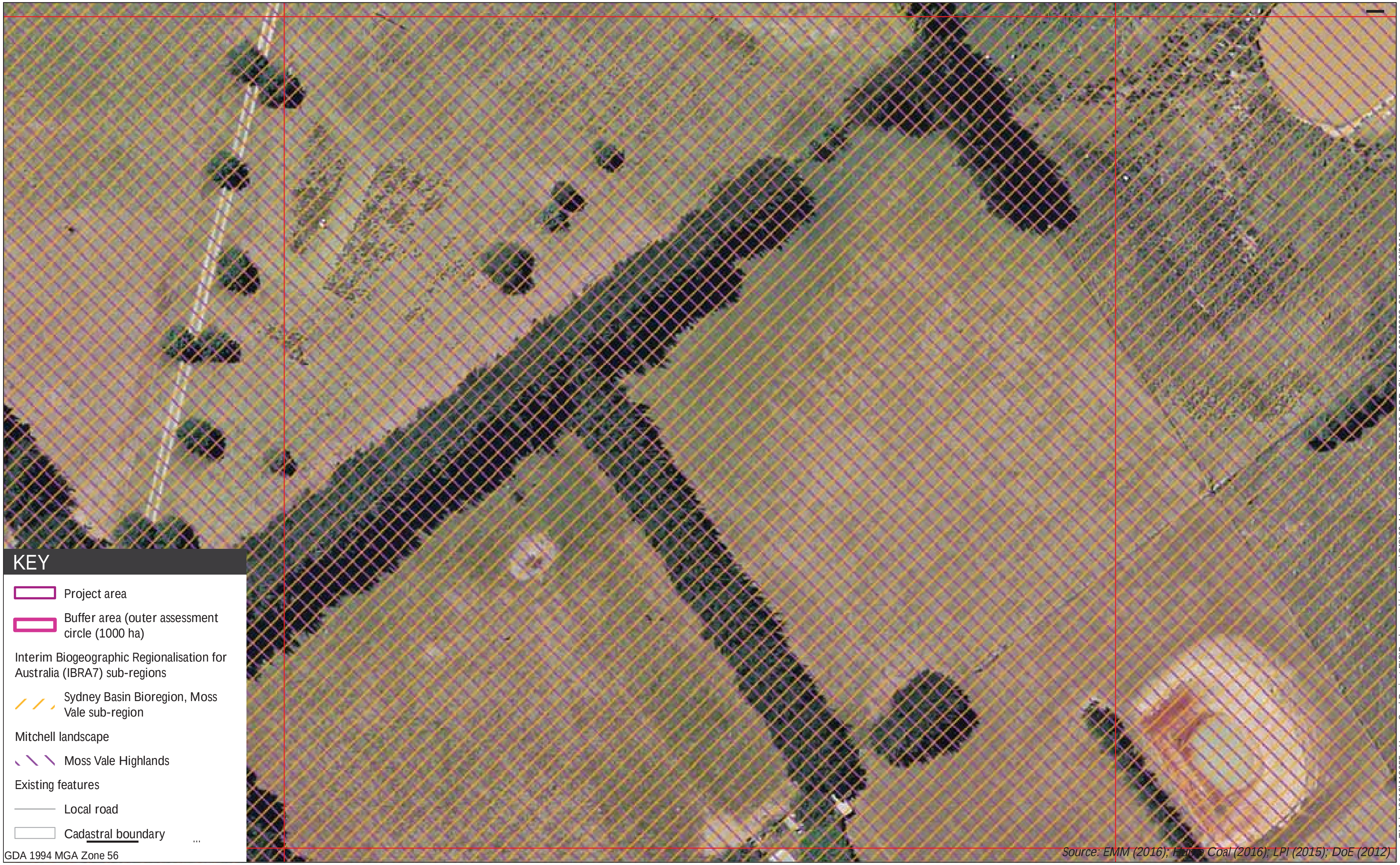


KEY

Project area

Buffer area (outer assessment circle (1000 ha)

Interim Biogeographic Regionalisation for Australia (IBRA7) sub-regions

Sydney Basin Bioregion, Moss Vale sub-region

Mitchell landscape

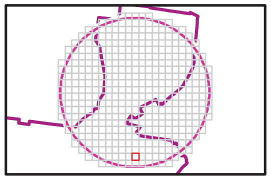
Moss Vale Highlands

Existing features

Local road

Cadastral boundary

GDA 1994 MGA Zone 56



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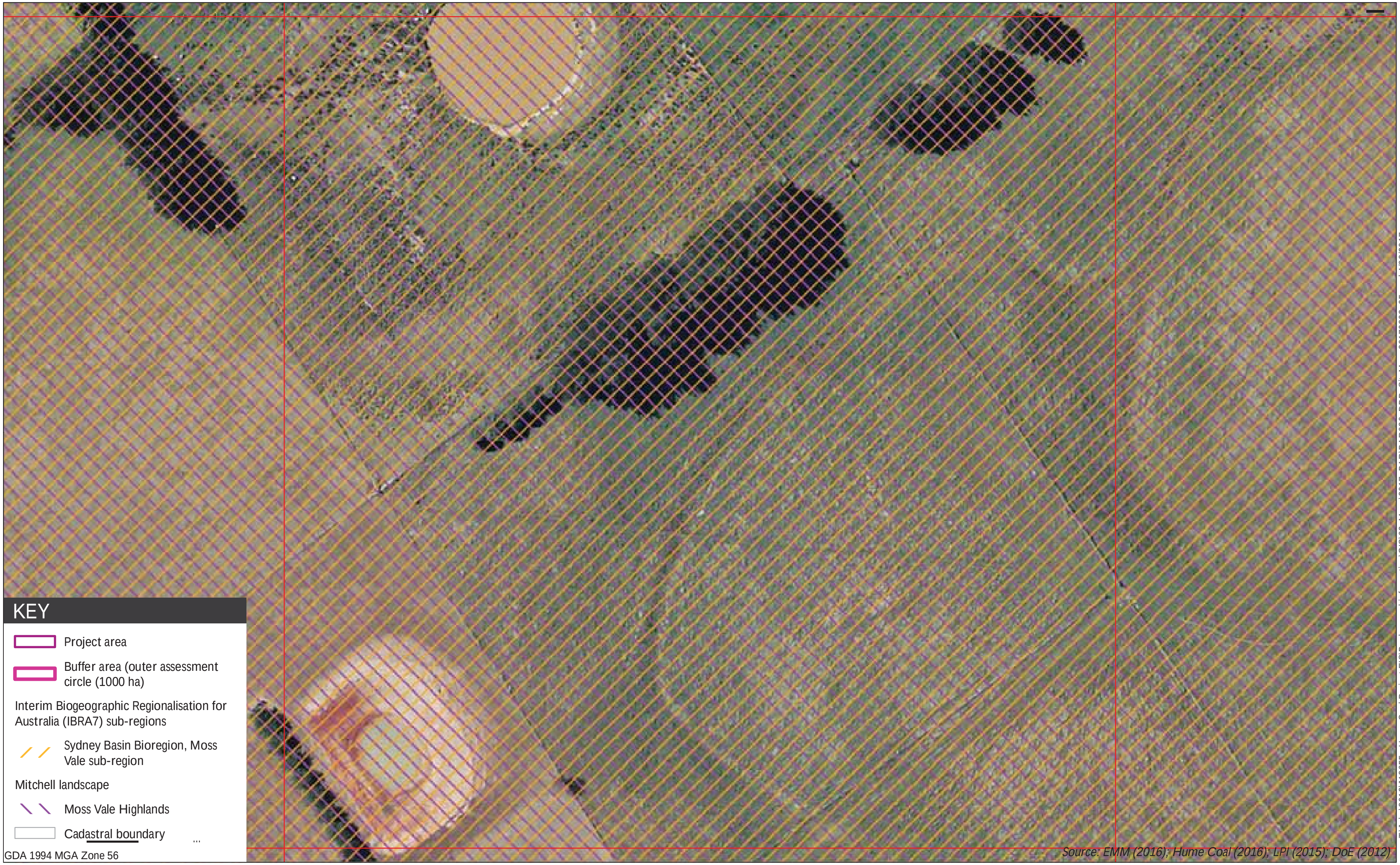

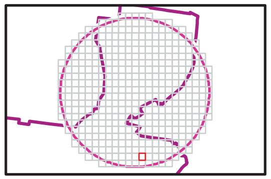

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Site map - 20

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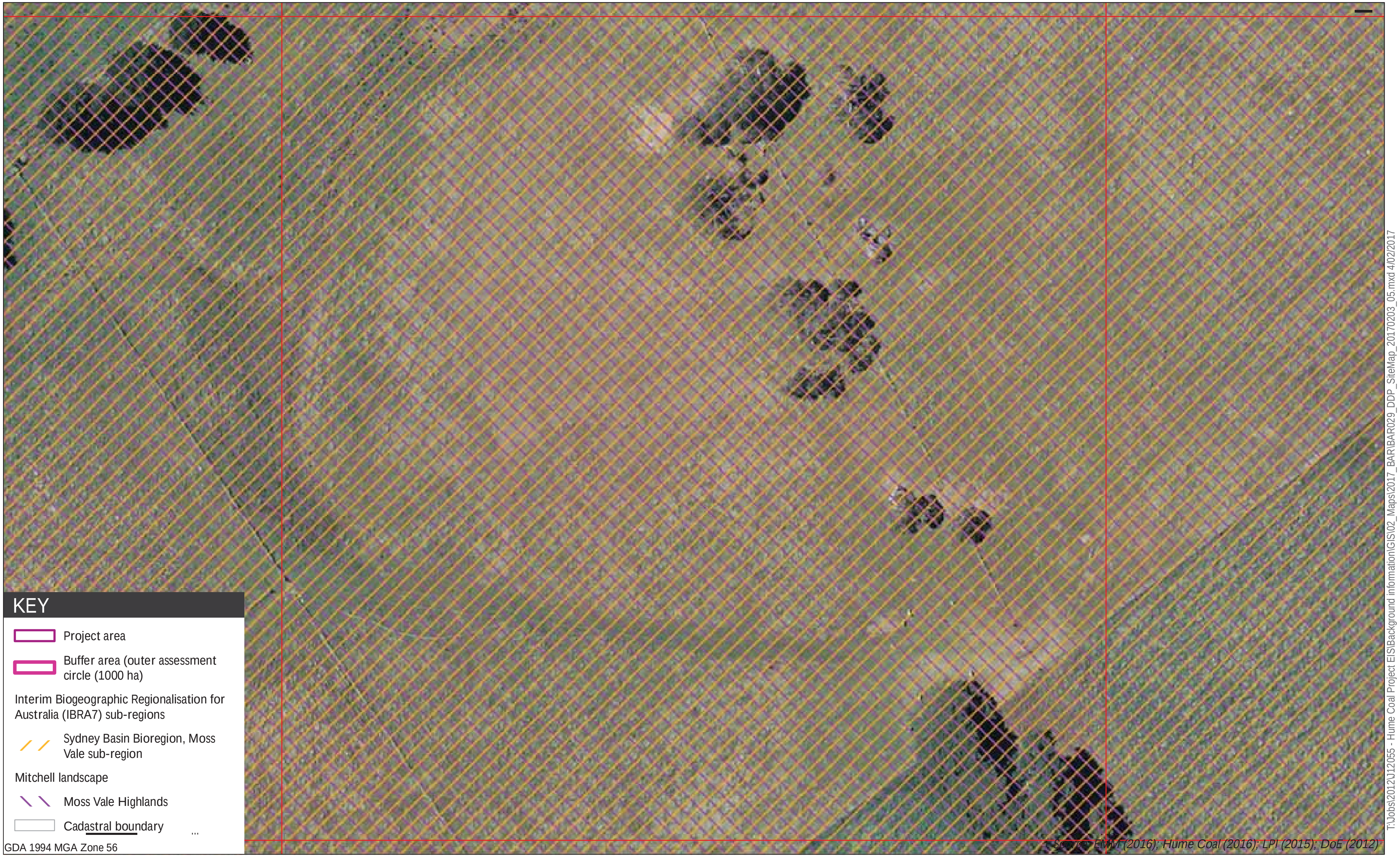

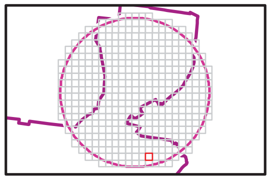

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