8 Soil and land resources

8.1 Introduction

The SEARs require an assessment of the project's potential impacts on soil and land resources. Accordingly, an assessment was conducted across the project area, involving a detailed soil survey, followed by laboratory analysis of collected soil samples. A BSAL assessment of the project area and surrounding buffer area was also undertaken in accordance with the requirements of the *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (NSWG 2013) (the interim protocol). No BSAL was found to be present in the project area, and an SVC was subsequently issued for the project by the DP&E on 22 April 2016.

Given the underground nature of the project and the first workings mining method to be used with negligible associated subsidence, impacts on soil resources will be limited to the direct surface disturbance footprint of the project, covering 2.3% of the project area. The land and soil capability class for the vast majority of the project area (ie 4,993 ha or 99%) will remain unchanged post-mining.

The soil and land assessment is presented in full in Appendix F and a summary provided in this chapter.

8.1.1 Assessment requirements and guidelines

The specific SEAR relating to soil and land resources is shown in Table 8.1.

Table 8.1 Land and soils resources related SEARs

Requirement	Section addressed
The EIS must address the following specific issues -	
Land – including:	
• an Agricultural Impact Statement, prepared in accordance with DPI's *Agricultural Impact Statement: Technical Notes*, to assess the likely impacts of the development on the soils and land capability of the site and surrounds, paying particular attention to any BSAL and having regard to DPI's requirements.	Chapter 9 and Appendix G

An assessment of the soil and land capability of the project area was necessary to enable the preparation of the AIS required by the SEARs. The outcomes of the soil and land assessment are presented in this chapter. An AIS has been separately prepared for the project, which is attached as Appendix G and discussed in Chapter 9.

Three agencies, the DRE, OEH and WaterNSW, also raised matters relevant to soil and land resources in their assessment recommendations. The matters raised are listed in Tables 8.2, 8.3 and 8.4 respectively, and were taken into account in preparing the assessment, as indicated in the tables.

Table 8.2 DRE's assessment recommendations – soil and land resources

Requirement	Section addressed
An assessment of the biological resources associated with the proposed disturbance area and how they can be practically salvaged for utilisation in rehabilitation (ie topsoil, seedbanks, tree hollows and logs, native seed), including an evaluation of how topsoil/subsoil of suitable quality can be direct-returned for use in rehabilitation.	8.2 – existing environment 8.4 – topsoil stripping, stockpile management and methods to achieve successful rehabilitation.
An evaluation of current land capabilities class and associated condition. The EIS should characterise soils across the proposed area of surface disturbance and assess their value and identify opportunities and constraints for use in rehabilitation.	8.2 – existing environment
Where an agricultural land use is proposed, the EIS should: - provide information on how soils would be developed in order to achieve the proposed stock capacity.	8.4

Table 8.3 OEH assessment recommendations – soil and land resources

Requirement	Section addressed
The EIS must map the following features relevant to water and soils including: a. Acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Planning Map).	8.2.2

Table 8.4 WaterNSW's assessment recommendations – soil and land resources

Requirement	Section addressed
A detailed assessment of the development on water resources which considers the design, construction, operational and decommissioning phases and have regard for operation during periods of wet weather and include: • The principles outlined in 'Managing Urban Stormwater – Soils and Construction – Mines and Quarries' Manual prepared by Department of Environment and Climate Change (2008).	Chapter 7 (water resources)
The EIS should provide concept plans/protocols/procedures for the following: Soils and Water Management Plan – including triggers, actions, responses.	Chapter 7 and Appendix E (Water Assessment Report)
Details of the practices proposed to ensure materials transported to and from the site do not spill or otherwise cause soil or water pollution.	Licensed transport contractors will be used for the transport of goods to and from site (refer to Appendix P (Hazard and Risk Assessment)

The assessment was also conducted with reference to the following standards, methods and guidelines:

- *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (NSWG 2013) (the Interim Protocol);
- *The land and soil capability assessment scheme: second approximation* (OEH 2012);
- *Guidelines for surveying soil and land resources* (McKenzie et al 2008);
- *Australian soil and land survey handbook* (NCST 2009);

- *The Australian soil classification* (Isbell 2002);
- *Soil data entry handbook* (DLWC 2001);
- *Agfact AC25: Agricultural Land Classification* (NSW Agriculture, 2002); and
- *Soil and Landscape Issues in Environmental Impact Assessment* (DLWC 2000).

8.2 Existing environment

8.2.1 Soil landscape units

Soil landscape units are defined as areas of land that have recognisable and specific topographies and soils that can be presented on maps and described by concise statements. The soil and land resources of the Hawkesbury-Nepean catchment map (1:100,000) (DECC 2009b) identifies 14 soil landscape units within the project area, as presented in Table 8.5. The most extensive landscapes in the project area are shown in bold in the table, and are the Soapy Flat landscape and the Moss Vale landscape, together comprising 50% of the area.

Table 8.5 Soil landscapes in the project area

Geological Origin	Soil landscape	Approx. area (ha)	Percentage of total (%)
Hawkesbury Sandstone	Hawkesbury	140.3	2.8
	Soapy Flat	**1317**	**26.1**
	Soapy Flat variant a	87.6	1.7
	Nattai Tablelands	318.4	6.3
	Nattai Tablelands variant a	41.6	0.8
Laterite and Ordovician Metasediments	Larkin	302.4	6.0
Quaternary Alluvium	Wingecarribee River	21.9	0.4
	Wingecarribee River variant a	17.3	0.3
	Wollondilly River	1.2	0.0
Tertiary Basalt	Kinnoul Hill	18	0.4
	Avoca	52.5	1.0
Wianamatta Group Shale	Kangaloon	591.6	11.7
	Lower Mittagong	919.6	18.2
	Moss Vale	**1221.6**	**24.2**
Total		**5051**	**100**

The Soapy Flat landscape unit covers 26% of the project area and occurs on rises and low hills on Hawkesbury Sandstone. Soils in this broader landscape unit (in the project area and/or beyond) include brown dermosols, yellow kurosols and chromosols, orthic tenosols on ridges and hydrosols (acid peats) in swamps, and slopes range from 2—10%. This landscape unit occurs within Crown reserve in the project area, which includes the Soapy Flat Reserve. Limitations to the unit include minor sheet erosion where ground cover has been cleared.

The Moss Vale soil landscape unit covers 24% of the project area and occurs on rises on the Wianamatta Group Shale, comprising mostly cleared pastureland, isolated paddock trees and no rocky outcrops. Soils across the broader landscape consist of yellow kurosols, red kurosols, brown kurosols and yellow kandosols, and limitations to this unit include minor to moderate gully erosion occurring in cleared drainage plains. Land uses within this landscape unit in the project area include beef cattle grazing and rural residential development.

The other soil landscapes comprising significant portions of the project area include the Lower Mittagong (18.2%) and the Kangaloon (11.7%). The Lower Mittagong occurs on rises and low hills on the Wianamatta Group Shale with slopes across the broader landscape ranging from 0—25% and minor sheet erosion being a common occurrence. Numerous land uses occur with this landscape unit including beef cattle grazing, rural residential development, olive tree plantations and vineyards. The Kangaloon landscape unit occurs on foot slopes within plains on Wianamatta Group Shale, and comprises extensively cleared grassland used for grazing.

8.2.2 Soil types

A field survey was undertaken in accordance with the standards and guidelines listed in Section 8.1.1 to identify the specific soil types in the project area. In accordance with the requirements of the Interim Protocol, the field survey involved investigation at three different levels of intensity:

1. check sites - low intensity investigation, high repetition, randomised locations and a limited description;

2. detailed sites - high intensity investigation, moderate repetition, randomised locations and a detailed description; and

3. profiles pits - very high intensity investigation, low repetition, targeted locations and a detailed description.

A total of 246 sites were surveyed with an average survey density of one site per 20.5 ha. Of the 246 sites, 141 were described in detail using the NSW Soil and Land Information System soil data card (of which 33 were subjected to laboratory analysis), and 105 were used as check sites.

The soil survey identified five major soil types within the project area, as follows:

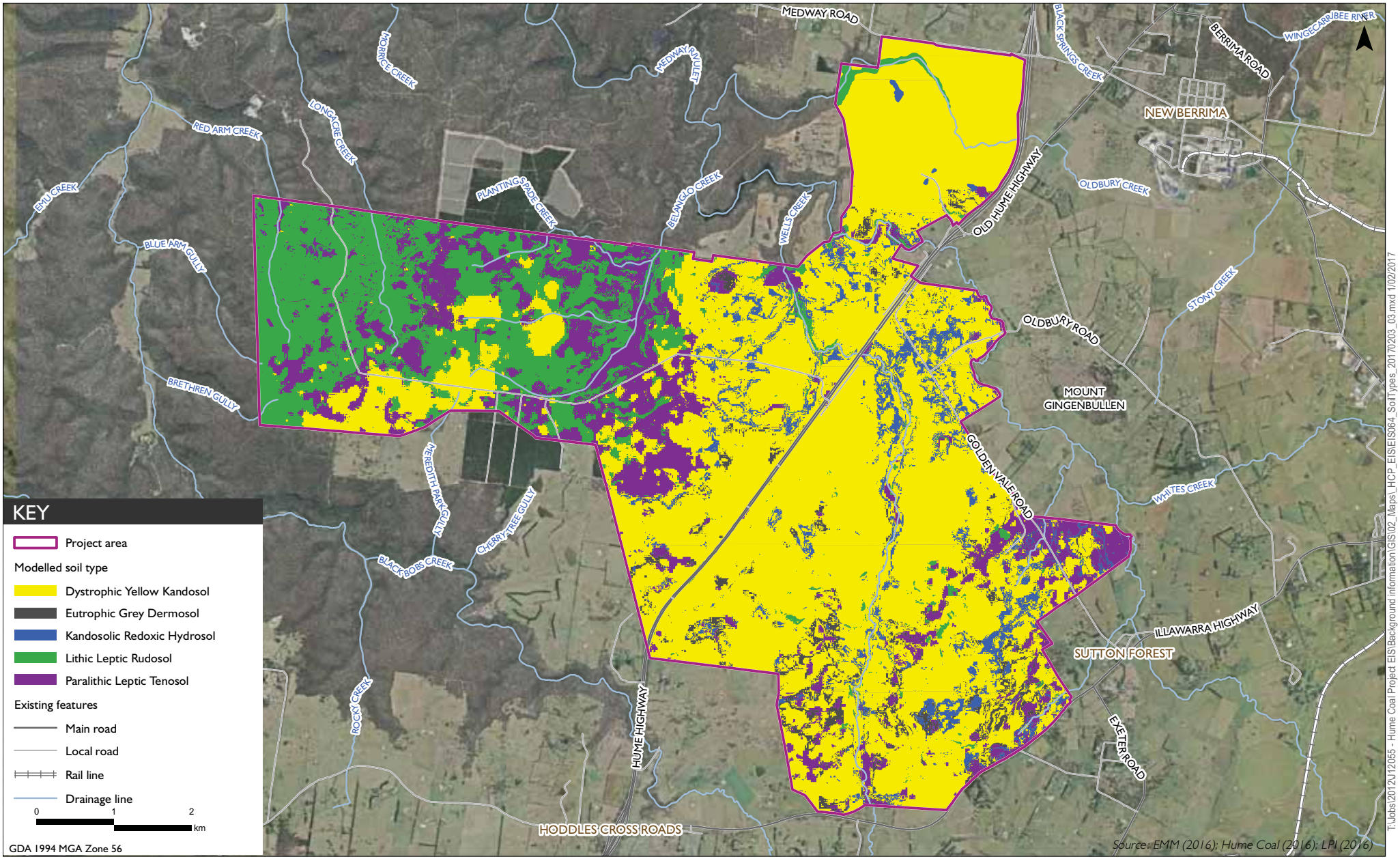
- Kandosols;
- Dermosols;
- Rudosols;
- Hydrosols; and
- Tenosols.

Yellow Kandosols are the dominant soil type of the project area (61%), followed by Rudosols (17%) and Tenosols (14%). Figure 8.1 illustrates the spatial distribution of the soil types within the project area and a description of each soil type is presented in Table 8.6.

Table 8.6 Soil types in the project area

ASC order (Soil type)	Description	Total area mapped within project area	
		(ha)	(%)
Kandosol	• Soils which lack strong texture contrast, have a massive or weakly structured B horizon, and are not calcareous. Typically increasing clay content with depth. • The Kandosols are further described in the project area as Dystrophic Yellow Kandosols, and are associated with predominantly cleared, gently undulating grazing lands.	3076	61
Rudosol	• Usually young soils where soil forming factors have had little time to pedagogically modify parent rocks or sediments. Negligible (rudimentary) pedologic organisation apart from a minimal development of an A1 horizon or possibly the presence of less than 10% of B horizon material. • In the project area the Rudosols are further classified as Lithic Leptic Rudosol.	852	17
Tenosol	• Weakly structured throughout the profile with the exception of the A horizon. Often shallow (ie bedrock is located near the surface). Very low agricultural potential with low chemical fertility, poor structure and low water-holding capacity. • The soils are mainly used for grazing based on native pastures. In better watered areas limited areas support forestry. • The Tenosol described in the project area is further classified as Paralithic Leptic Tenosol.	714	14
Hydrosol	• Soils that are seasonally or permanently wet, and experience saturation of the greater part of the profile for prolonged periods (2-3 months). • The Hydrosol described in the project area is further classified as Kandosolic Redoxic Hydrosol.	245	5
Dermosol	• Moderately deep and well-drained soils of wetter areas in eastern Australia. Lack a strong texture contrast and have a well structured B horizon. Dermosols have a gradual increase in clay content with depth and a more defined structure then Kandosols. • These soils can support a wide range of land uses including cattle and sheep grazing of native pastures, forestry and cropping. • The Dermosol described in the project area is further classified as Eutrophic Grey Dermosol.	164	3
TOTAL		**5051**	**100**

There are no acid sulphate soils in the project area, as per the *Guidelines for the Use of Acid Sulfate Soil Risk Maps* (DLWC 1998).



Soil types in the project area

Hume Coal Project

Environmental Impact Statement

Figure 8.1

8.2.3 Land and soil capability

The land and soil capability (LSC) classes of the project area were assessed in accordance with the requirements of the *Land and soil capability assessment scheme* (OEH 2012). This involved assessment using data sourced from field survey observations, desktop analysis and soil laboratory analysis.

The project area is predominately Class 4 (moderate capability land), covering 44% of the project area and associated with the large area of Kandosol soils, which are most suited for grazing and occasional cultivation with suitable soil conservation measures implemented. 32% of the project area is Class 6 (low capability land), while Class 5 (moderate to low capability land) was found to occur over 14% of the project area. Small areas of Class 7 (very low capability land) and Class 3 (high capability land) occur in 6% and 3% of the project area, respectively. The remaining 1% of the project area is covered by the Hume Highway or water bodies.

The LSC class definitions are provided in Table 8.7, along with the extent of each class mapped in the project area.

Table 8.7 Land and soil capability classes in the project area

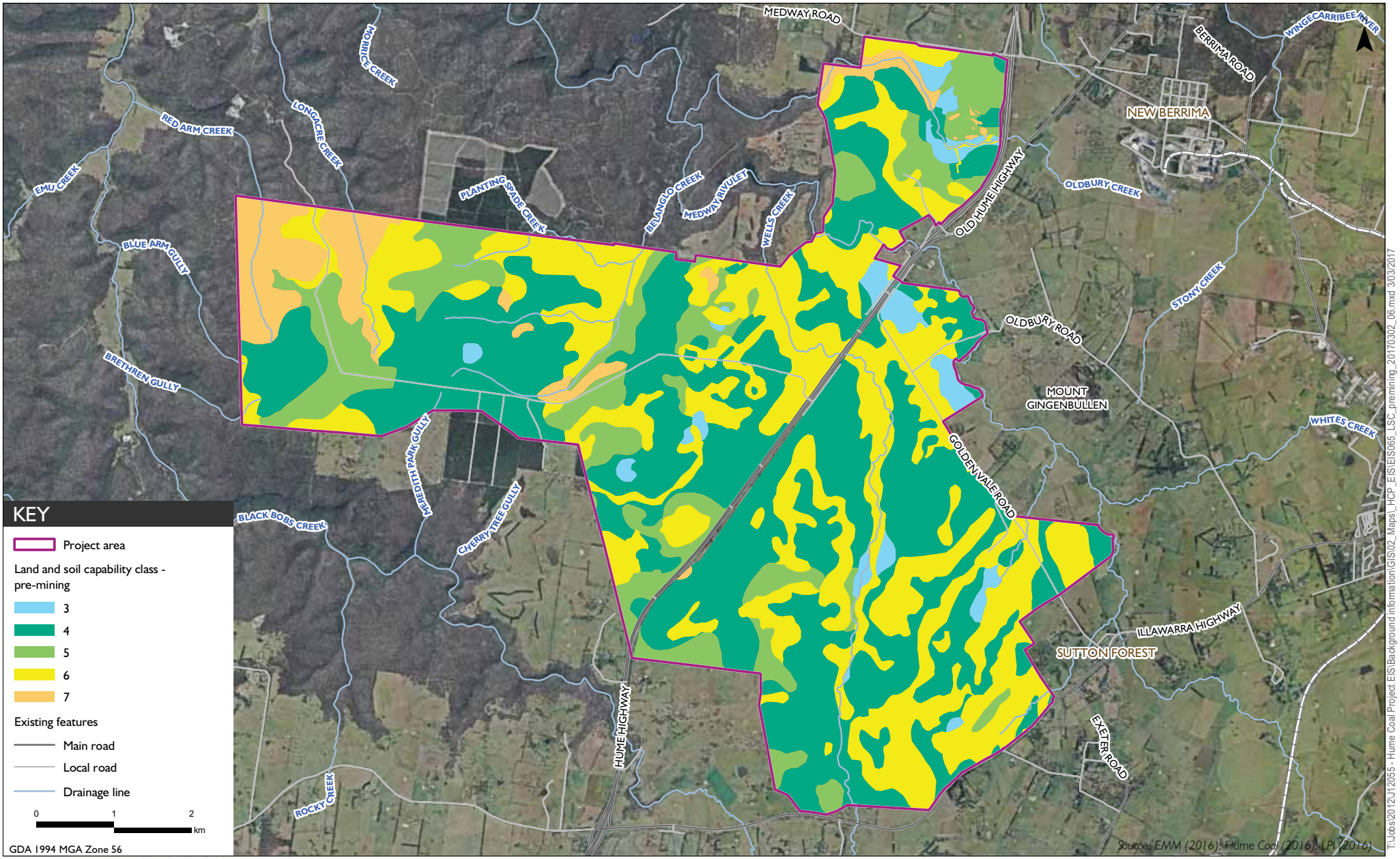
LSC Class	Description	Soil type	Area	%
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)				
1	**Extremely high capability land:** Land has no limitations. No special land management practices required. Capable of all rural land uses and land management practices.	-	0	-
2	**Very high capability land:** Land has slight limitations. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.	-	0	-
3	**High capability land:** Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.	Kandosols	144	3
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)				
4	**Moderate capability land:** Moderate to high limitations for high-impact land uses. It will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture; and the limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.	Kandosols Dermosols	2221	44
5	**Moderate-low capability land:** High limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.	Poorly drained Kandosols and Dermosols, slightly acidic Tenosols and Kandosols	704	14

Table 8.7 Land and soil capability classes in the project area

LSC Class	Description	Soil type	Area	%
Land capable for a limited set of land uses (grazing, forestry and nature conservation				
6	**Low capability land:** Very high limitations for high-impact land uses and is generally suitable for limited land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.	Hydrosols, acidic Tenososls Soils with steep slopes or shallow soils	1641	32
Land generally incapable of agricultural land use (selective forestry and nature conservation)				
7	**Very low capability land:** Severe limitations that restrict most land uses and generally cannot be overcome. Generally suitable only for selective forestry and nature conservation.	Shallow soils (mostly Rudosols and Tenosols)	300	6
8	**Extremely low capability land:** Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation.	-	0	-
None	**Water bodies, Hume Highway etc.**		41	1

Whilst most areas containing Kandosols were classified as Class 4 land, some small areas were classified as Class 3 or 5 instead of 4, based on the pH of the surface soil. The Hydrosols were classified as Class 6, based on being waterlogged for several months of the year, and the Rudosols as Class 7, based on the rockiness and/or shallowness of the soils.

Figure 8.2 illustrates the existing LSC classes identified across the project area.



Land and soil capability classes- pre-mining

Hume Coal Project

Environmental Impact Statement

Figure 8.2

8.2.4 Agricultural suitability

The five class system used by the NSW DPI – Agriculture classifies land in terms of its suitability for general agricultural use. The classification system relies on the evaluation of biophysical, social and economic factors and, whilst a useful tool for government land uses and planning purposes, is not used at a farm scale.

The 1:50000 scale *Agricultural Land Classification Map - Moss Vale* (Dept of Agriculture 1986) maps most of the project area as Class 3, with smaller areas of Class 4 and 5. The definitions of agricultural land class 3, 4 and 5 are as follows:

- Class 3: Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with sown pasture. The overall production level is moderate because of edaphic or environmental constraints. Erosion hazard, soil structural breakdown or other factors, including climate, may limit the capacity for cultivation and soil conservation or drainage works may be required.
- Class 4: Land suitable for grazing but not for cultivation. Agriculture is based on native pastures or improved pastures established using minimum tillage techniques. Production may be seasonally high but the overall production level is low as a result of major environmental constraints.
- Class 5: Land unsuitable for agriculture or at best suited only to light grazing. Agricultural production is very low or zero as a result of severe constraints, including economic factors which prevent land improvement.

8.2.5 Biophysical Strategic Agricultural Land

The NSW Government has mapped BSAL across the whole of NSW based on a desktop study, and the resultant maps accompany the Mining SEPP. The BSAL shown on the maps comprises land which meets the following criteria (as described in the Interim Protocol):

- access to a reliable water supply; and
- falls under the soil fertility classes 'high' or 'moderately high' under the OEH *Draft Inherent General Fertility of NSW*, where it is also present with land capability classes 1, 2 or 3 under OEH's *Land and Soil Capability Mapping of NSW* (OEH 2016b); or
- falls under the soil fertility class of 'moderate' under OEH's *Draft Inherent General Fertility of NSW*, where it is also present with land capability classes 1 or 2 under OEH's *Land and Soil Capability Mapping of NSW* (OEH 2016b).

The Biophysical Strategic Agricultural Land Map prepared by OEH and presented in the Interim Protocol indicates that there is no BSAL present within the project area. In accordance with the requirements of the Interim Protocol, the project area was further assessed at a local level to verify whether BSAL is actually present. The full site verification report is presented as Appendix A in the soil and land resource assessment (EMM 2017f, refer Appendix F).

Each soil type identified in the project area was assessed against the specified BSAL verification criteria and no type was found to satisfy the criteria, with most failing multiple physical and chemical soil criteria. In addition, an analysis of the slope in the project area determined that some land failed the slope criterion. The result is that no BSAL is present in the project area, a conclusion that is consistent with the results of the broader scale NSW Government's BSAL mapping.

8.3 Impact assessment

8.3.1 Direct disturbance

The underground nature of the proposed mine and the first workings mining method to be employed which will result in negligible subsidence, means that impacts on soil resources will be limited to areas where land clearing is required for the construction and operation of surface infrastructure.

The decommissioning of the mine will require short-term disturbance of soils as infrastructure is demolished, and access and internal roads and other supporting infrastructure are removed. The disturbed land will be rehabilitated with stockpiled soil, and the pre-mining land use returned.

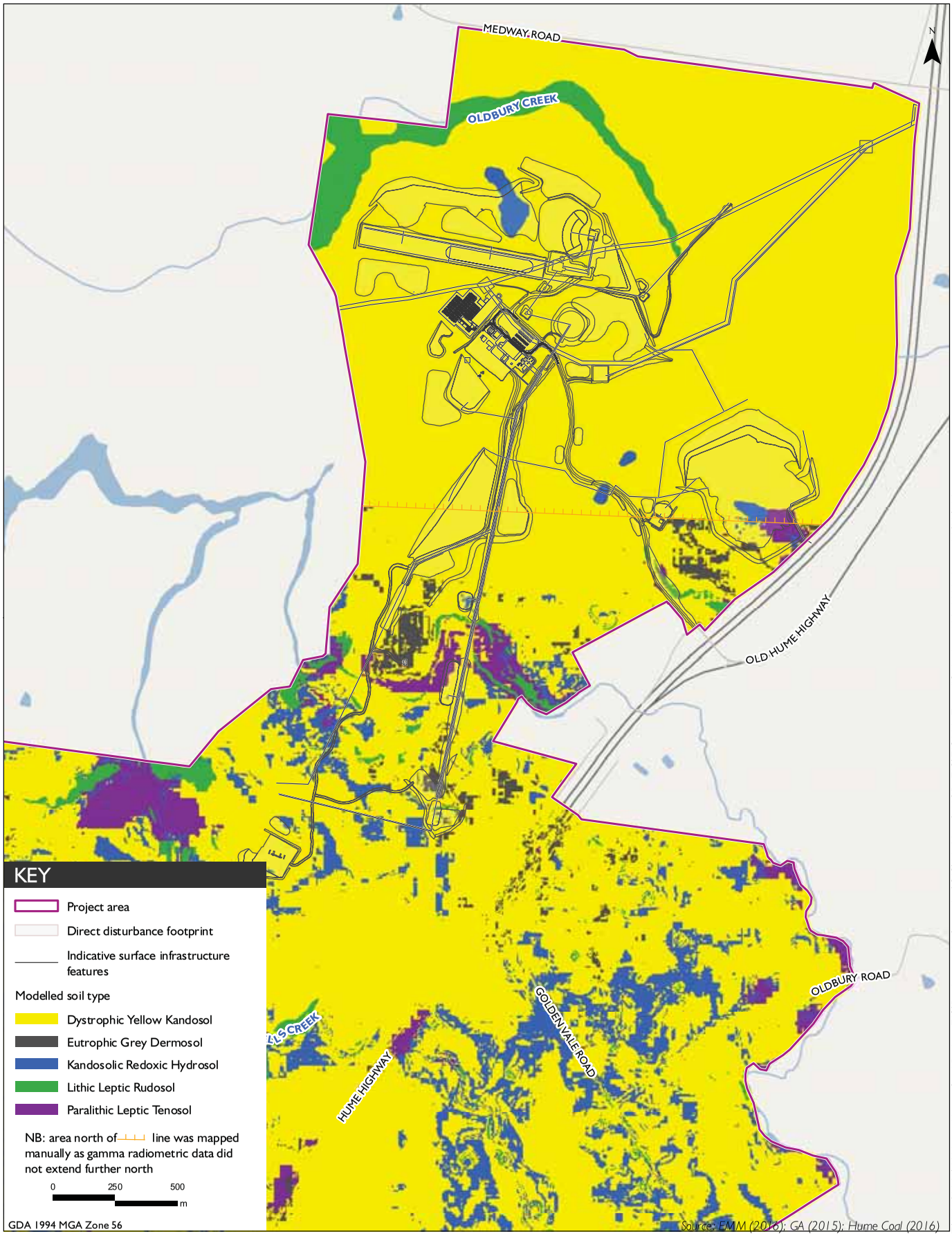
The mine will have a direct disturbance footprint of 117 ha. The majority of the surface infrastructure area will be positioned over one soil type, Dystrophic Yellow Kandosol soils, which generally have a LSC Class of 4. These soils are associated with gently undulating landscapes which have been predominately cleared and replaced with pasture grasses, and as such the location of major surface infrastructure components of the project have been specifically located in these areas.

The area and type of soils to be disturbed is summarised in Table 8.8 and illustrated in Figure 8.3.

Table 8.8 Soil types to be disturbed

Soil type	Ha	%
Dystrophic Yellow Kandosol	110.3	94.3
Eutrophic Grey Dermosol	1.1	0.9
Kandosolic Redoxic Hydrosol	3.6	3.1
Paralithic Leptic Tenosol	1.6	1.4
Lithic Leptic Rudosol	0.4	0.3
Total	**117**	**100**

The Kandosol soils will be the most useful soil for rehabilitation purposes due to their structure and depth. The Tenosol soils are generally shallow and not expected to provide a significant volume of useable material. Hydrosols are not considered suitable for use in rehabilitation as these soils are typically wet which would lead to them compacting and breaking down during stripping operations. Therefore, whilst the considerable majority of soils to be stripped (ie Kandosols) will be useful in rehabilitation works, soils in some areas to be disturbed will not be suitable and supplementary topsoil may need to be salvaged from areas of deeper soils to make up for this potential small deficit. Topsoil management, including recommended stripping depths, is discussed in Sections 8.4.2 and 8.4.3.



Soil types in the project surface disturbance footprint

Hume Coal Project
Environmental Impact Statement
Figure 8.3

8.3.2 Post-mining land capability

As discussed in Chapter 2, the overriding goal for the project's rehabilitation plan is to return disturbed land to a condition that is stable and supports the proposed post-mining agricultural land use; grazing with improved pasture.

Of the 117 ha to be subject to direct disturbance through the construction of surface infrastructure, the LSC class of approximately 58 ha of land is predicted to change following closure and rehabilitation of the mine. Therefore, within the 5,051 ha project area, 4,993 ha (or 99%) will not be subject to any change in land and soil capability as a result of the project. Within the 58 ha to be subject to change, the pre-mining LSC class (a combination of 3, 4 and 5) will change to LSC Class 6. The post-mining LSC classes across the project area are illustrated in Figure 8.4. Table 8.9 lists the pre and post-mining LSC class, illustrating the change for each LSC class within the project area.

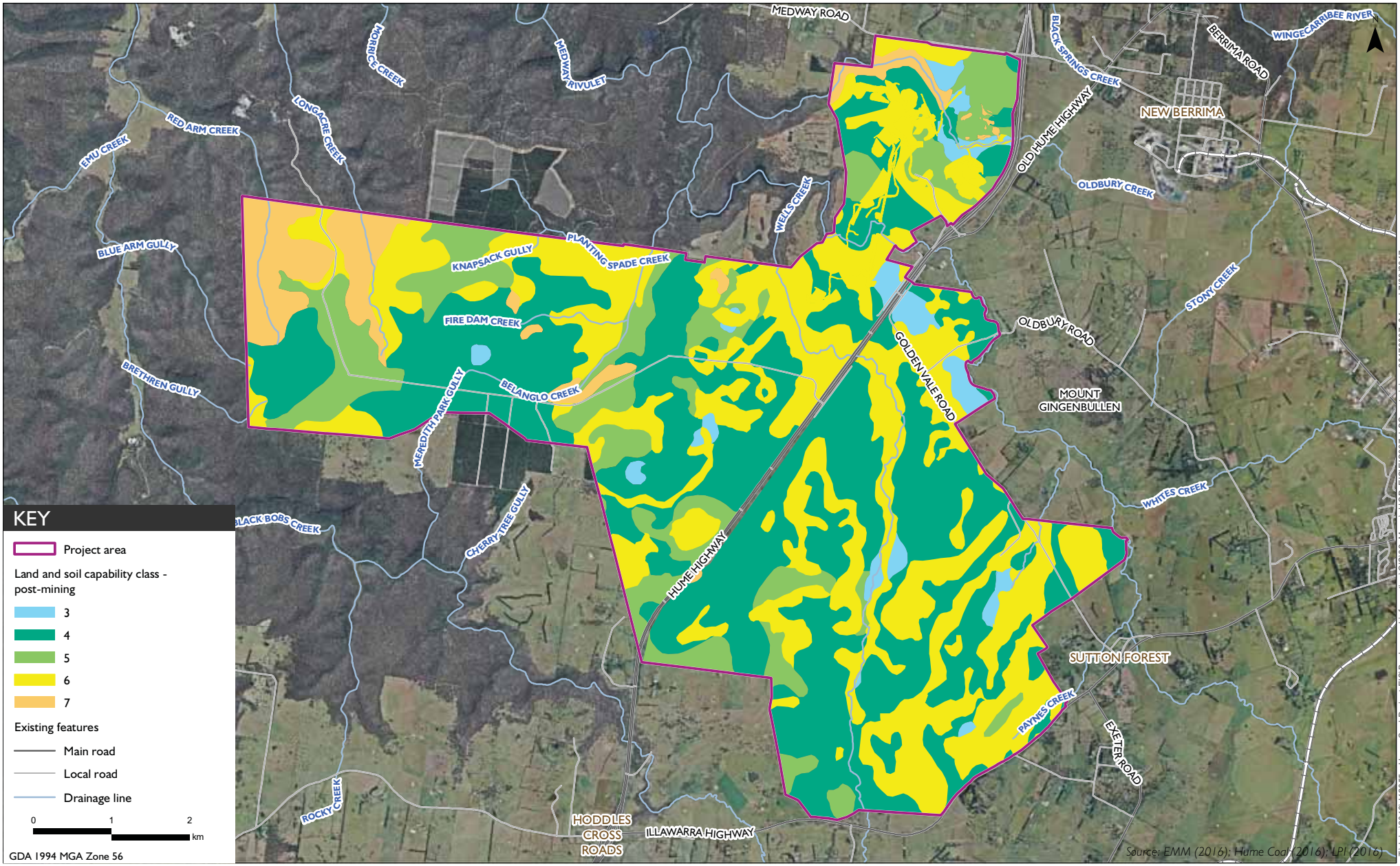
Table 8.9 LSC class pre- and post-mining

LSC Class	Capability	Pre-mining LSC (ha)	Post-mining LSC (ha)	Amount lost or gained (+/- ha)	% change
LSC of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)					
1	Extremely high	-	-		
2	Very high	-	-		
3	High	144	141	-3	-2%
LSC of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)					
4	Moderate	2221	2184	-37	-2%
5	Moderate-low	704	686	-18	-3%
LSC for a limited set of land uses (grazing, forestry and nature conservation)					
6	Low	1641	1699	+58	+4%
LSC generally incapable of agricultural land use (selective forestry and nature conservation)					
7	Very low	300	300		
8	Extremely low	-	-		
None	**Waterbodies, Hume Highway,etc**	41	41		

Despite a reduction in the land and soil capability over 58 ha, this land will still be suitable for grazing and improved pasture with appropriate management, allowing the continuation of agricultural land use post-mining. Regarding land management, the LSC guideline (OEH 2012) states the following in relation to Class 6 land:

> "...This land requires careful management to maintain good ground cover (maintaining grass or cover taller than 8 cm is a guide). Grazing pressures need to be lower than those used on Class 4 and 5 land. Rotational grazing systems with adequate recovery time for plant regrowth are essential. It is important to minimise soil disturbance, retain perennial ground cover and maintain high organic matter levels...."

The reduction in land and soil capability over 58 ha within the surface disturbance footprint of the project is due to an anticipated reduction in soil depth over these areas following rehabilitation. This is due to two reasons; it is expected that there will be a slight deficit in suitable soil for use in rehabilitation as the small areas of hydrolsols in the disturbance footprint, which are sodic and highly erosive, are unlikely to be useful in rehabilitation works. Secondly, whilst some of the disturbance footprint will be underlain by subsoil, the depth of soil may be constrained by chemical inhibition such as high salinity. Salt is highly water soluble and mobile and there is some potential that it may become concentrated overtime creating a chemical inhibition layer. Therefore, in determining the post-mining soil depth across the surface disturbance area it has been conservatively assumed that subsoil remains under the area and is constrained by this chemical inhibition. If it is found after rehabilitation that subsoil is not constrained by chemical inhibition, then the overall soil depth may increase resulting in a higher LSC class.



Land and soil capability classes – post-mining

Hume Coal Project

Environmental Impact Statement

Figure 8.4

8.4 Management and mitigation measures

8.4.1 Erosion and sediment control

110 ha of the 117 ha to be directly disturbed by the project consists of Dystrophic Yellow Kandosol soils. These soils are slightly sodic and have the potential to be subject to erosion, particularly on a slope. Soil erosion management will therefore be implemented during construction activities generally in accordance with the guideline *Managing Urban Stormwater, Volume 2E Mines and Quarries* (DECC 2008).

Drainage structures have been designed for the surface infrastructure area to safely convey stormwater runoff in and around the area for the life of the mine. These structures are shown in Figure 2.10 (refer to Chapter 2) and discussed further in Chapter 7 (water resources).

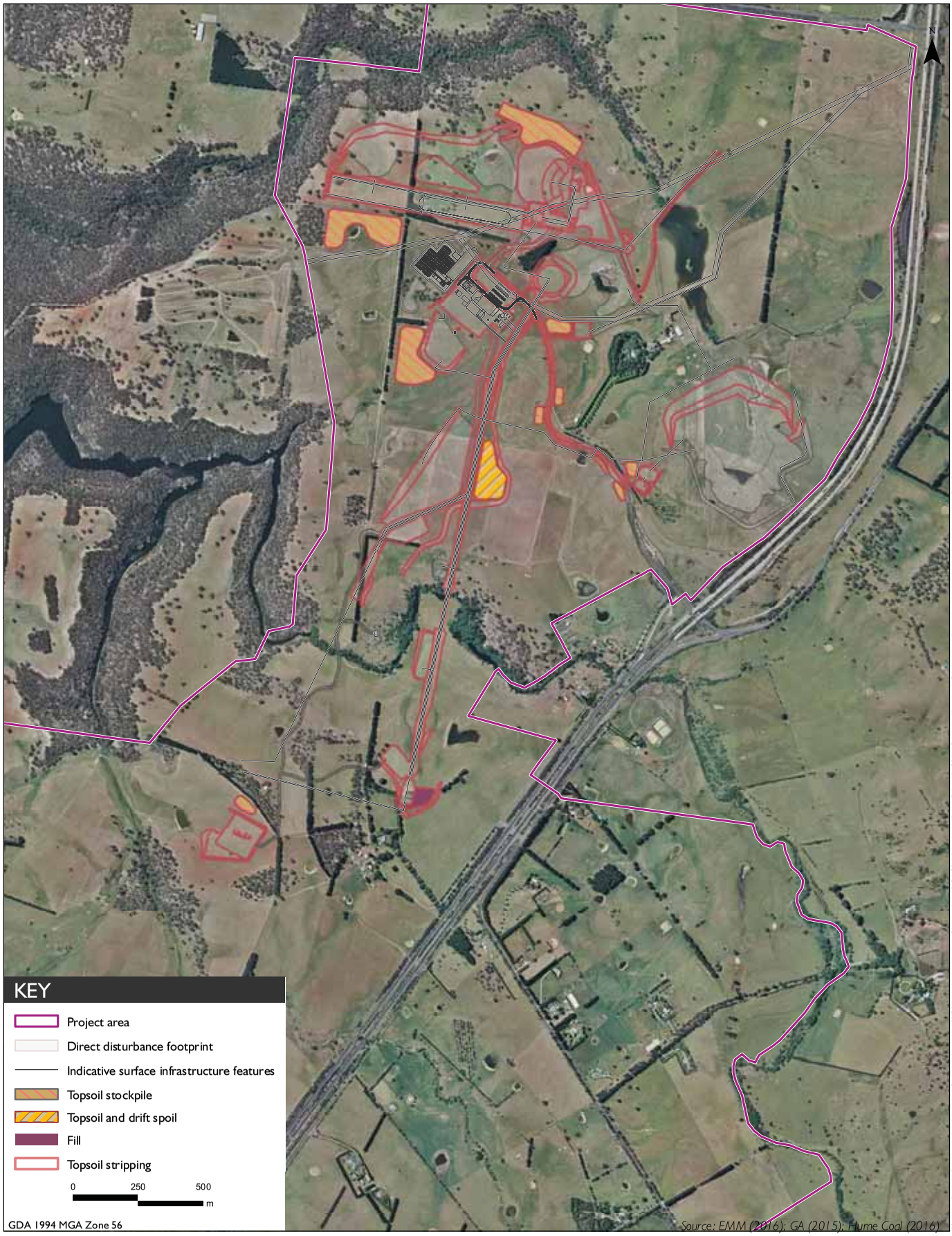
8.4.2 Topsoil stripping

To successfully rehabilitate the site, soil will be replaced generally at about 0.3 m over the disturbed land. The area of disturbance is 117 ha and therefore, approximately 351,000 m^3 of soil will be needed. An inventory of soil stripped will be prepared during the construction phase so that, whilst not anticipated, if a significant deficit is identified additional material can be sourced prior to rehabilitation.

The topsoil depth in the area of disturbance ranges between 0.15 m and 0.4 m. The subsoil depth in the area of disturbance ranges between 0.3 m and 0.9 m. The majority of the soils to be disturbed are Kandosols, of which the depth varies across the disturbance footprint. Topsoils on the upper slopes tend to be about 0.15 m in depth, whilst topsoils in the lower parts of the landscape are up to 0.4 m in depth.

The topsoil and drift spoil stockpile areas only require a shallow depth of topsoil to be stripped (mainly just to remove the vegetation before creating the stockpile), as only soil material is to be stockpiled on this land. Other areas with minimal surface disturbance can also be stripped with a minimal depth of topsoil. If the areas are not also subjected to significant compaction and long-term use, a return of the shallow topsoil will be sufficient for rehabilitation to be successful and limit the disturbance of the overall soil profile.

All other areas of surface disturbance will be stripped to at least 0.3 m depth to allow for sufficient soil to be replaced at the same depth. Whilst this topsoil will be replaced generally over land that is comprised of fill material during final rehabilitation works, meaning that the original soil profile has been substantially disturbed, a depth of 0.3 m is considered adequate to re-establish pasture for grazing. In areas where the original topsoil is less than 0.3 m in depth, subsoil will need to be stripped down to 0.3 m. If the depth to bedrock is less than 0.3 m, additional soil from an area with deeper soils will be obtained to make up the shortfall. Topsoil stripping depths across the surface disturbance footprint are shown in Figure 8.5.



T:\Jobs\2012\J12055 - Hume Coal Project EIS\Background information\GIS\02_Maps_HCP_EIS\EIS068_TopsoilStrippingDepths_20170303_04.mxd 3/03/2017

Topsoil stripping

Hume Coal Project

Environmental Impact Statement

Figure 8.5

Topsoil stripping and handling procedures will be employed during the construction phase of the project to maximise the salvage of suitable topsoil and subsoils, whilst minimising the degradation of the soil and retaining its value for plant growth. These measures are consistent with leading practice and incorporate the full range of reasonable and feasible mitigation methods for soil stripping. The topsoil stripping and handling procedures to be employed are described below.

- The area to be stripped will be clearly defined on the ground, avoiding any waterlogged or similarly constrained areas. The target depths of topsoil and subsoil to be stripped for each location will be clearly communicated to machinery operators and supervisors.
- A combination of suitable earthworks equipment will be used for stripping and placing soils in stockpiles. Machinery circuits will be located to minimise compaction of the stockpiled soil.
- All machinery brought onto the site for soil stripping will comply with any weed management and biosecurity protocols established for the mine site.
- Soil stockpile locations will be identified and stripped of topsoil (not subsoil) at a nominal 0.1 m depth before stockpiles are developed.
- Whilst the surface infrastructure area does not contain significant areas of native vegetation or trees, any trees present will be cleared and grubbed prior to topsoil salvage.
- Topsoil and subsoil will be stripped to the nominated depths and stockpiled. Subsoil will be stripped and stockpiled separately where identified as suitable. Depending on compaction and recovery rates, deep ripping may be required to maximise topsoil recovery. Where soils are shallower, topsoil and subsoils will be stripped and stockpiled together.
- Handling and rehandling of stripped topsoil will be minimised as far as practicable by progressively stripping vegetation and soil only as needed for construction activities.
- Soil stripping in very wet conditions will be avoided if practicable, because of the risk of compaction, nutrient deterioration and less volume of suitable materials being available. However, when possible, soils will be stripped when they are slightly moist to assist in their removal and retention of their structure.
- Where possible soil stripping will not occur during particularly dry conditions to avoid the generation of dust.

8.4.3 Topsoil stockpile management

Approximately 351,000 m^3 of soil will be stripped and stockpiled. Topsoil will be stockpiled in a manner that minimises degradation of soil characteristics and that is favourable for plant growth. These measures are consistent with leading practices and incorporate all reasonable and feasible mitigation methods, as listed below.

- Stockpiles will be located at an appropriate distance from watercourses and dams (so they are not washed away). Approximate locations of stockpiles in the surface infrastructure area are illustrated in Figure 2.3.
- Where practical, topsoil and subsoil will be stockpiled separately. Where this is not possible, combined topsoil and subsoil stockpiles will still be built to the specifications for topsoil stockpiles.
- Topsoil stockpiles will be designed and constructed to a height of no greater than 3 m in order to limit anaerobic conditions being generated within the stockpile and to minimise deterioration of nutrients, soil biota and seed banks.
- Soil stockpiles will have a slope grade of 1V:4H or less to limit erosion potential.

- Subsoil stockpiles may be over 3 m high; however the slope of the stockpile will need to be considered for erosion control, and should still be 1V:4H or less.

- The surface of the soil stockpiles will be left in a 'rough' condition to help promote water infiltration and minimise erosion via runoff. If required, sediment controls will be installed downstream of stockpile areas to collect any runoff.

- Overland water flow onto or across stockpile sites will be kept to a minimum and will not be concentrated to the extent that it causes visible soil erosion.

- Long-term stockpiles will be seeded with an appropriate pasture grass mixture to stabilise the surface, restrict dust generation, minimise erosion and weed growth.

- After the stockpiles are established, machinery and vehicles will be excluded for general access (stockpile maintenance works excepted). The stockpile locations will be surveyed and data recorded about the soil types and volumes present.

- The establishment of weeds on the stockpiles will be monitored and control programs implemented as required.

8.4.4 Methods to achieve successful rehabilitation

As discussed above soil stripping procedures will maximise the salvage of suitable materials for use in rehabilitation, enabling pastures to be reinstated to a condition that will support appropriate livestock carrying densities. Disturbed land will be re-profiled once surface structures are removed by re-instating depressions which were filled for mine development, removing dams and bunds so that water is not permanently retained (unless dams are required to support the future land use) and undertaking deep ripping of compacted areas.

Soil will be applied to provide sufficient depth for ripping and plant growth in a manner which minimises degradation of soil characteristics. A soil balance plan will be prepared prior to spreading, which will show the depths and volume of soils to be reapplied in particular areas. Topsoil and subsoil will be applied at a thickness appropriate to support the intended land capability. The soil will then be lightly scarified along the contour and seeded with pasture grasses.

Pasture grass species to be sown across the final landform will be chosen to suit the chosen grazing strategy, as well as species that are suitable for fast establishment of an initial cover crop.

The topsoil application procedure during rehabilitation will typically be the reverse of the stripping procedure. Generally, all soils will be applied with a thickness of approximately 0.3 m to provide sufficient depth for ripping and plant growth. If subsoil is stripped separately to the topsoil, the subsoil will need to be spread at approximately 0.15 m and then topsoil spread over the top at approximately 0.15 m deep to create an overall depth of 0.3 m.

If there is insufficient volume of topsoil available at the time of rehabilitation, or if the topsoil material has been degraded, the following contingency measures will be implemented:

- Topsoil will be spread at a shallower thickness and/or only on selected parts of the site.

- Subsoil will be used as a topsoil substitute rather than returned as subsoil under the topsoil.

- Fertilisers and other soil additives will be added to the topsoil and subsoil to improve fertility and structure.

Implementation of any of the above contingency measures will enable satisfactory rehabilitation to occur although re-establishment of the target levels of land capability may take longer.

8.5 Conclusion

Due to the underground nature of the mine and the first workings coal extraction method to be employed, impacts on soil resources will not be significant as a result of the project, as only localised land clearing will occur and subsidence will be negligible. The project's potential impacts on soil resources are limited to temporary loss of land due to construction and operation of mine infrastructure (117 ha). This area represents 2.3% of the total project area. There is no BSAL present within the project area.

The project will result in the temporary removal of 117 ha from the existing use of agriculture. Upon completion of mining all surface infrastructure will be removed and the area rehabilitated to a condition that is stable, and supports the proposed post-mining land use, which is grazing with improved pasture and is consistent with the existing land use. Approximately 94% of the soils to be stripped in the disturbance footprint are Dystrophic Yellow Kandosol soils, which will be the most useful soil for rehabilitation purposes due to its structure and depth. These soils are most suited for grazing and occasional cultivation as long as suitable soil conservation measures are implemented.

Post-mining there will be a change to the land and soil capability class over 58 ha of land disturbed by the surface infrastructure area. The original land class of these areas (3 ha of Class 3, 37 ha of Class 4 and 18 ha of Class 5) will change to Class 6 due predominantly to a change in soil depth. However, Class 6 land will still be suitable for grazing and improved pasture, allowing the continuation of agricultural land use post-mining.

9 Agricultural resources

9.1 Introduction

This chapter provides a summary of the AIS, which is presented in full in Appendix G. The AIS assessed the potential impacts of the project on agricultural resources and/or industries within and surrounding the project area. This chapter presents the assessment methodology, the existing agricultural environment and potential impacts from the project on this environment and the measures to avoid, manage and mitigate those potential impacts.

All mitigated risks on agricultural resources were assessed as low. Potential disturbance to agricultural land from the project is limited to the surface infrastructure area which will mostly occur on Hume Coal affiliated land (with the exception of a downcast shaft, which will be in the Belanglo State Forest). This land will be returned to its pre-mining land use once operations have ceased.

There will be an estimated minor temporary foregone loss of agricultural productivity of $1.72 million during the project's construction and operation (including the Berrima Rail Project).

9.1.1 Assessment requirements and guidelines

The AIS was prepared in accordance with the SEARs related to agriculture and assessment recommendations from the DRE. The relevant SEARs and DRE assessment recommendations and reference to where these have been addressed are provided in Tables 9.1 and 9.2, respectively.

Table 9.1 Agriculture related SEARs

Requirement	Section addressed
• An Agricultural Impact Statement, prepared in accordance with DPIs Agricultural Impact Statement: Technical Notes, to assess the likely impacts of the development on the soils and land capability of the site and surrounds, paying particular attention to any BSAL and having regards to DPIs requirements.	Chapter 9 and Appendix G
• An assessment of the likely agricultural impacts of the development.	Section 9.4
• An assessment of the compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements of Clause 12 of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007, paying particular attention to the agricultural uses in the region and the Belanglo State Forest.	Section 3.6.1

Table 9.2 DRE assessment recommendations

Recommendation	Section addressed
Where an agricultural land use is proposed, the EIS should:	
• demonstrate how Agricultural Suitability Class in the rehabilitated landscape would be returned to the existing Class/es or better.	Chapter 8
• where the intended land use is likely to be grazing, the existing capacity in terms of Dry Sheep Equivalent or similar must be calculated and a timeframe from vegetation establishment be given for the return to agricultural production to at least the existing stock capacity.	Consequential productivity effects are described in Section 9.4.2; Rehabilitation is detailed in Chapter 17
• provide information on how soils would be developed in order to achieve the proposed stock capacity.	Chapter 8

The assessment also considered the relevant government guidelines and policies; namely:

- *Strategic Agricultural Land Use Policy: Guideline for Agricultural Impact Statements* (NSW DP&E 2015) (the AIS guidelines); and
- *Agricultural Impact Statement technical notes: A companion to the Agricultural Impact Statement guideline* (DPI 2013a) (the AIS technical notes).

The AIS technical notes define an 'agricultural resource' as land on which agriculture is dependent, and the associated water resources (quality and quantity) that are linked to that land. The notes describe the requirements for the assessment of agricultural impacts associated with all State significant development applications. All information requirements as set out in the AIS guideline and AIS technical notes are addressed in the EIS (including the AIS), as shown in Table 9.3.

Table 9.3 AIS requirements

Information which must be included in an AIS	Section addressed
Details of the site and region	
• overview of the project, and a description of the area within an agricultural context; and	Section 9.3
• why this is a project which will benefit the community and the state.	Chapter 20 and 24
Detailed assessment of the agricultural resources and agricultural production of the project area	Appendix G - Chapters 3 and 4
This section should include detailed information (including maps) on:	
• the soils, slope, land characteristics, water characteristics (availability, quality);	Appendix G -Section 3.1
• BSAL needs to be verified for all land in a project including surrounding buffer zones and offset areas;	Appendix G -Section 3.5
• relevant history of the agricultural enterprises from within the project area and the development's buffer and/or offset zone;	Appendix G -Section 3.7
• location of areas of land to be temporarily removed from agriculture;	Appendix G -Sections 4.1 and 4.2
• location of areas of land to be returned to agricultural use post project;	Appendix G -Section 4.3
• location of area of land that will not be returned to agriculture, including areas to be used in environmental plantings or biodiversity offsets; and	Appendix G -Section 4.4
• agricultural enterprises to be undertaken on any buffer and/or offset zone lands for the life of the project.	Appendix G -Section 4.5
Identification of the agricultural resources and current enterprises within the surrounding locality (region) of the project area	
• Agricultural resources within the project area	Section 9.3
○ Soil characteristics – including soil types and depth	Appendix G -Sections 2.3.2 –2.3.3
○ Topography	Appendix G - Figure 2.2
○ Key agricultural support infrastructure	Appendix G -Section 2.3.1
○ Water resources and extraction locations	Appendix G -Sections 3.1.2 and 3.6
○ Location and type of agricultural industries	Appendix G -Section 2.3.3
○ Vegetation	Appendix G -Section 2.2.2
○ Climate conditions	Appendix G -Section 2.2.1
• Current agricultural enterprises within the region	Appendix G -Section 2.4

Table 9.3 AIS requirements

Information which must be included in an AIS	Section addressed
Assessment of impacts	
• Identification and assessment of the impacts of the project on agricultural resources or industries	Section 9.4
○ Effects on agricultural resources	Section 9.4.1
○ Consequential productivity effects on agricultural enterprises	Section 9.4.2
○ Uncertainty associated with the predicted impacts and mitigation measures	Appendix G -Section 7.4
○ Further risks (ie weeds, wind and water erosion, subsidence, dust, noise, vibration, traffic	Appendix G -Section 5.2
• Account for any physical movement of water away from agriculture	Appendix G -Section 5.2.1
• Assessment of socio-economic impacts	
○ Agricultural support services and processing and other value-adding industries	Section 9.4.2ii
○ Local and regional employment impacts	Section 9.4.3
○ Visual amenity, landscape values and tourism infrastructure	Appendix G – Section 6.2
Mitigation measures	
• Project alternatives	Chapter 6 and Section 9.5.1
• Monitoring programs to assess predicted verses actual impacts as the project progresses	Section 9.5.2
• Trigger response plans and trigger points at which operations will cease or be modified or remedial actions will occur to address impacts including a process to respond to unforseen impacts	Section 9.5.2 and Chapters 7 to 22
○ The proposed remedial actions to be taken in response to a trigger event	
○ The basis for assumptions made about the extent to which remedial actions will address and respond to impacts	
• Demonstrated capacity for the rehabilitation of disturbed lands to achieve the final land use and restore natural resources	Chapter 17
• Demonstrated planning for progressive rehabilitation that minimises the extent of disturbance	Chapter 17
Consultation	Appendix G - Chapter 8
• Detail the engagement strategy	

The Strategic Agricultural Land Use Policy: *Guideline for Agricultural Impact Statements* (NSW DP&E 2015) requires 'identification of the agricultural resources and current enterprises within the surrounding locality (region) of the project area'. Accordingly, together with the project area, the assessment also considers the wider Wingecarribee LGA.

9.1.2 Adoption of leading practice

As described in Section 2.3, Hume Coal has adopted a number of leading practices to result in a mine design that avoids and minimises impacts on agricultural land. Extensive technical investigations have taken place over several years to develop and refine the project, and arrive at the current design. The leading practices related to agriculture are summarised below.

- All coal reject material will be returned underground to partially backfill the mined-out void, rather than keeping it at the surface in a large above ground emplacement or trucking it off-site for emplacement elsewhere. This minimises the surface disturbance footprint, thereby reducing the land to be rehabilitated at closure.

- Hume Coal will use a non-caving coal extraction method, leaving coal pillars in place throughout the mine that are designed to provide indefinite long-term support to the overlying rock strata, to eliminate and/or minimise impacts on surface features and water resources. Using only first workings, there will be no associated subsidence impacts, and therefore the overlying aquifer and surface features will be protected.

9.2 Methods

To enable all requirements as set out in the SEARs related to agriculture, assessment recommendations from the DRE, and AIS guideline and AIS technical notes to be addressed, a comprehensive methodology was applied to the AIS. Relevant aspects from various studies were considered in the assessment including soils, water, rehabilitation and economics. The methodology included:

- detailed database searches and mapping review, such as ABS Agricultural Census Data, and DP&E, OEH and NSW Agriculture mapping;
- review of publically available information including tourism and agricultural industry publications, and real estate advertising;
- reference to the *Hume Coal Project - Biophysical Strategic Agricultural Land Verification Assessment* (EMM 2017g)*;*
- consultation with water engineers, soil scientists, geochemists, land management specialists, rehabilitation and closure specialists and agro-economists and, ultimately, the Soil and Land Assessment, Water Assessment, Hydrogeochemical Assessment, Rehabilitation and Closure Report and Economic Impact Assessment that form part of this EIS; and
- review of other relevant assessments such as the Berrima Rail Project EIS (EMM 2017a) and assessments forming part of this EIS including the Traffic and Transport Assessment, Biodiversity Assessment, Visual Amenity Assessment and Social Assessment.

9.3 Existing environment

9.3.1 Regional agricultural resources and enterprises

The land area available for agriculture in the Wingecarribee LGA is approximately 73,000 ha. The land class across the LGA has been mapped using the Land and Soil Capability Mapping of NSW (OEH 2015b). LSC class descriptions are provided in Table 8.6 of the soil and land resources chapter. Areas mapped as high capability land (Class 3) are limited to patches interspersed with moderate capability land (Class 4) in the centre of the Wingecarribee LGA. A large area of the Wingecarribee LGA has low capability land (Classes 6, 7 and 8). There is no Class 1 (extremely high capability) or Class 2 (very high capability) land mapped within the Wingecarribee LGA.

The agricultural suitability of the land, as defined using NSW Agriculture's (2002) five class system, in the majority of the Wingecarribee LGA is suitable for grazing but not cultivation (Class 4) or at best, light grazing (Class 5). No land is suitable for intensive cultivation (Class 1) and less than 20% is suitable for rotational cropping (Class 2 and 3).

The gross value of the agricultural production for the Wingecarribee LGA was $41.3 million in 2010-2011 (ABS 2011c). This represents 0.35% of the gross value of agricultural production in NSW. The agricultural industry directly employs 3.3% of the total employed population within the Wingecarribee LGA (ABS 2012).

Beef cattle accounts for 69% of all livestock within the Wingecarribee LGA (ABS 2011c), and most cattle are raised for beef or breeding purposes with dairying accounting for approximately 13% and sheep approximately 10%. While the beef cattle industry is the largest agricultural industry in the Wingecarribee LGA, it represents less than 1% of the beef cattle industry in NSW.

In the last 30 years, horse farms have become more common in the Wingecarribee LGA (ABS 2011c). Non-stud horse farms account for approximately 19% of the farms and horse stud farms approximately 6%. Horse studs account for almost 2.5% of horse studs in NSW.

Cropping is undertaken at a small scale and varies from year to year depending on rainfall with the main crops being wheat and fodder grasses.

The major transport routes used by agricultural producers to access supporting services and to move their products include the Hume Highway and the Illawarra Highway and some major local roads, such Golden Vale Road and Berrima Road, as well as the main north-south rail line to Sydney and Goulburn and the eastern rail line to Wollongong.

9.3.2 Project area agricultural resources and enterprises

i Overview

The majority of land within the project area is agricultural land, encompassing approximately 6.9% of the total land area available for use in agriculture in the Wingecarribee LGA.

Approximately 75% of the project area is privately owned land. The remaining 25% is the Belanglo State Forest. The property sizes in the project area vary from 0.2 ha to 560 ha, with the majority of the landholders (78%) owning blocks less than 100 ha.

Land and soil capability and agricultural suitability in the project area are described in Sections 8.2.3 and 8.2.4 of the soil and land resources chapter, respectively.

ii Biophysical strategic agricultural land assessment

A detailed BSAL assessment of the project area and surrounding buffer area was undertaken in accordance with the requirements of the *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (NSWG 2013) to determine if BSAL was present. Each soil type identified in the project area was assessed against the specified BSAL verification criteria and no soil type was found to satisfy the criteria, with most failing multiple physical and chemical soil criteria. There is no BSAL in the project area, a conclusion that is consistent with the results of the broader scale NSW Government's BSAL mapping. An SVC application for the project was lodged on 17 August 2015 and issued by the DP&E on 22 April 2016.

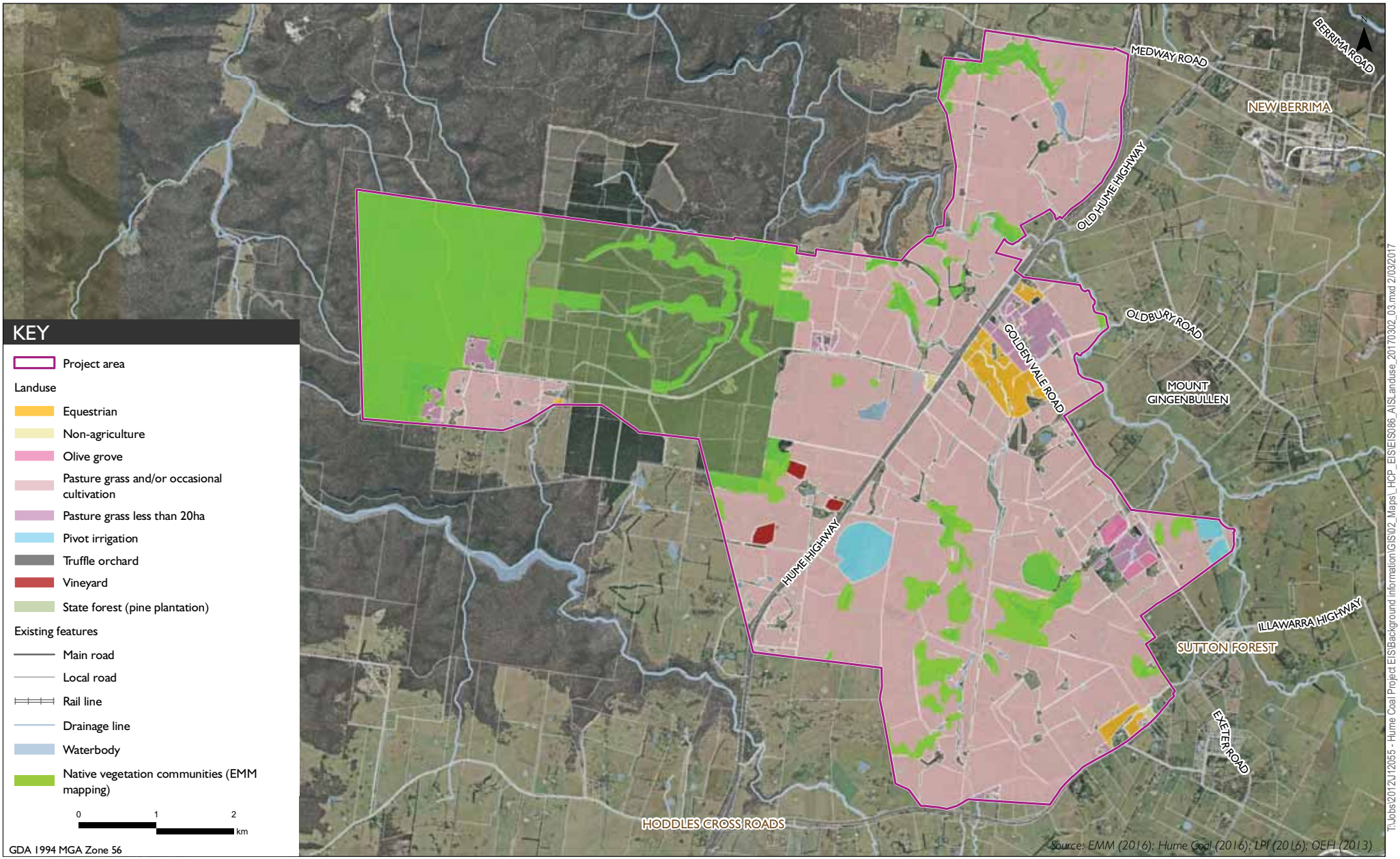
iii Agricultural enterprises

A number of the landholders in the project area have not allowed Hume Coal access to their land for assessments, and this precludes the ability to obtain information regarding the current and historical uses of the properties for agriculture. The land use assessment for the project area has been restricted to using aerial photos over different years to identify grazing or cultivation on parcels of land. Farm improvements such as outbuildings, dams, access tracks, fences, yards and gardens were only able to be identified by the use of the aerial photography of these properties. Distribution of property sizes and landholders are provided in Table 9.4 and illustrated in Figure 9.1, which shows the assumed general land use of the project area. Details for each property are provided in Tables 3.26 to 3.29 of Appendix G.

Table 9.4 Distribution of property sizes and landholders

Ownership and property type	% of land area	Number of Landholders	General description
State Forest	25%	-	Pine forest and native forest.
Private properties greater than 400 ha	37%	5	Properties are used for livestock grazing and occasional cultivation. Three of the five properties are owned by Hume Coal (and its affiliates).
Private properties between 100 and 400 ha	20%	7	Properties are generally used for livestock grazing. One property includes vineyards. One property has pivot irrigated paddocks.
Private properties between 20 and 100 ha	15%	22	Properties have some grazing paddocks. A variety of other land uses on these properties including olive groves, truffle orchards, equestrian cross-country eventing course, four hole golf course.
Private properties less than 20 ha	3%	22	Most properties have paddocks which may be used for grazing. One property is an Equestrian centre. Blocks smaller than 5 ha (11 properties) are mainly residential with one or two paddocks of pasture grass.

Notes: 1.Land use estimated using Google Earth.



Current land use in the project area

Hume Coal Project

Environmental Impact Statement

Figure 9.1

iv Surface infrastructure areas

All the land that will be subject to surface disturbance (with the exception of a downcast shaft, which will be in the Belanglo State Forest) is Hume Coal affiliated land and comprises of two properties; namely, Mereworth and Evandale which were purchased in November 2014 and July 2014, respectively. The properties are leased from Hume Coal (and its affiliates) by Princess Pastoral Company, along with the other Hume Coal affiliated land; namely, Wongonbra, Carlisle Downs, Stonington and the eastern properties (Leets Vale and 325 Berrima Rd).

The Mereworth property was partially stocked with breeding cattle and offspring at the time of the purchase. There was some pasture improvement with the growing of rye, barley and lucerne for fattening stock, but primarily it was a grazing operation. In the past, the property also had a good sheep breeding operation with infrastructure of sheep yards and shearing shed.

The Evandale property was stocked primarily with breeding sheep with some breeding cattle and offspring at the time of its purchase. The property was severely run down with little or no pasture improvement and significant weed infestation; consequently it was running at approximately 20% capacity (PPC 2016).

The pre-purchase stocking rates are unknown for Mereworth and Evandale, however the Wongonbra property (in the project area, but not subject to surface disturbance) was fully stocked when purchased and the stocking rate was approximately 9-10 Dry Sheep Equivalent (DSE)/ha (PPC 2016).

Princess Pastoral Company's goals of significantly enhancing the agricultural productivity of the properties, and to run the properties together as a sole agricultural commercial entity, have been achieved. This was accomplished by the application of leading pasture improvement and cropping practices based on its practices successfully employed during its many years of experience managing properties in the Goulburn area.

The number of cattle and sheep stocked, as at 20 July 2016 (PPC 2016) on the Mereworth and Evandale properties is presented in Table 9.5. The table compares the stocking rate on these properties with the average stocking rate for the Southern Tablelands region as reported by DPI 2016.

The Berrima Rail Project will be constructed on the Stonington and Eastern Properties, as well as portions of Mereworth. The impacts of this are addressed in the Berrima Rail Project EIS (EMM 2017a) but have also been incorporated into Table 9.5 to enable consideration of the cumulative impacts presented in Section 9.4.2.

As shown, the stocking rates achieved under the Princess Pastoral Company's are far superior to the average stocking rate achieved for the Southern Tablelands region as reported by DPI 2016.

Table 9.5 Stocking rates – Princess Pastoral Management compared with average for Southern Tablelands region

Property	Grazing land (ha)	Princess Pastoral farm management				Average management		
		Sheep[1]	Cattle[1]	DSE[2]/ha	Cattle/ha	DSE[3]/ha	Cattle/ha	Cattle
Hume Coal Project								
Mereworth	500	1,600	1,090	19.5	2.6	9	1.2	600
Evandale	200[4]	1,350	295	17.8	2.4	9	1.2	240
Berrima Rail Project								
Stonington	120	-	270	16.8	2.2	9	1.2	144
Eastern Properties	80	-	158	14.8	2	9	1.2	96

Notes: *1. Current stocking rates as per Hume Coal – Pre & Post Operations Overview (PPC 2016).*

2. Calculated using the assumption that cattle are 7.5 DSE.

3. Stocking rates as per average for Southern Tablelands (DPI 2016).

4. Livestock currently grazing on 200 ha of the property only.

9.4 Impact assessment

9.4.1 Potential impacts on agricultural land resources

A risk assessment was conducted to identify risks to agricultural land resources from the project. It followed the process outlined in the *Guideline for Agricultural Impact Statements at the Exploration Stage* (NSW Government 2015a).

The potential impacts from the project on agricultural resources are limited. All mitigated risks were assessed as low. This is predominately due to the mine design, which avoids many of the risks on agriculture that are common for an underground coal mine, such as subsidence impacts.

Disturbance of agricultural land will be limited to areas where land clearing is required for the construction and operation of surface infrastructure. This represents approximately 2% of the total project area. Land disturbed by the project is wholly owned by Hume Coal and its affiliates (with the exception of a downcast shaft, which will be in Belanglo State Forest); there is no other privately-owned land that will be directly disturbed by the project.

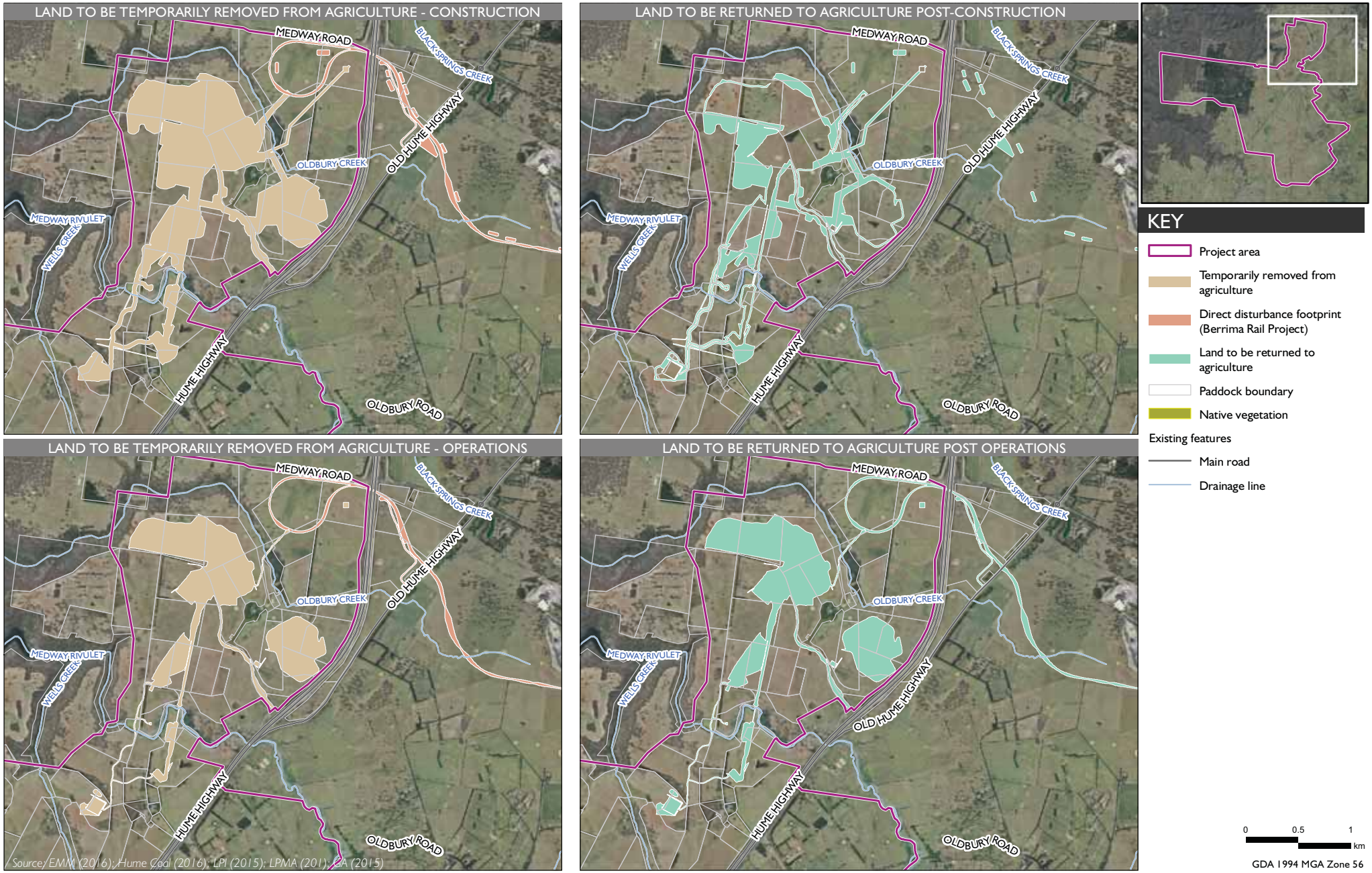
The change in land use will be temporary. At the cessation of mining, this land will be rehabilitated and the pre-mining agricultural land-use restored (refer to Chapter 17). Further details on the post-mining land capability are in Chapter 8 (soil resources).

The project's construction phase will occur over approximately two years. Additionally, there will be approximately one year of rehabilitation of temporary disturbance areas, ie accommodation village, buried services and topsoil stockpiles (equating to three years for the purpose of the AIS). The land temporarily removed from agriculture during this period will be approximately 190 ha. This area includes the direct surface infrastructure footprint of 117 ha and the construction buffer, as well as a small area of a paddock that will be isolated by infrastructure. Re-alignment of fences will take place to incorporate other fragmented paddocks into existing ones and, accordingly, the useability of this land will not be impacted.

The operations phase (for the purpose of the AIS comprising operations and rehabilitation) is assumed to be 21 years and the area which will be temporarily removed from agriculture is reduced to only 107 ha. The area includes all surface disturbance that has not been rehabilitated during the construction phase. Figure 9.2 shows the areas that will be temporarily removed from agriculture during the construction and operation of the project. The figure includes temporary disturbance associated with the Berrima Rail Project.

Of the 117 ha to be disturbed by infrastructure, 59 ha will be rehabilitated back to the original LSC class, as the soil profile will not be significantly altered. The pre-mining land class of the remaining 58 ha of disturbed land (3 ha of Class 3, 37 ha of Class 4 and 18 ha of Class 5) will change to Class 6. The change in LSC class is due to a reduction in soil depth to 0.3 m, as the replaced soil will overlie re-profiled fill materials. However, Class 6 land will still be suitable for grazing and improved pasture, allowing the continuation of agricultural land-use post-mining, as currently occurs.

The highest risk of the project to agricultural production, if left unmitigated. was identified as long-term groundwater bore drawdown associated with dewatering activities. Hume Coal is committed to implementing the necessary make good arrangements in accordance with the AIP to effectively manage the potential for adverse impacts on agricultural resources from bore drawdown. The residual level of risk was assessed as low. This matter is addressed in detail in Chapter 7.



T:\Jobs\2012\J12055 - Hume Coal Project EIS\Background information\GIS\02_Maps_HCP_EIS\EIS085_AISfigures_20170309_07.mxd 9/03/2017

Land temporarily removed from agriculture and returned following construction and operation

Hume Coal Project

Environmental Impact Statement

Figure 9.2

9.4.2 Consequential productivity effects on agricultural enterprises and support infrastructure

i Foregone agricultural production values

All land currently supporting agriculture and to be disturbed by the project will be rehabilitated back to land supporting agriculture. No land will be permanently removed from agriculture. The overriding goal of the project's rehabilitation plan is to return the disturbed land to a condition that is stable, and supports the proposed post-mining land use which is grazing with improved pasture. There will be some limited but permanent changes to land capability class; however as noted previously, this will not preclude achievement of rehabilitation objectives.

Minor agricultural productivity losses will occur temporarily due to construction and operation of the mine. The foregone agricultural values for these estimated productivity losses were calculated in the cost benefit analysis, prepared by BAEconomics for the project (refer to Appendix Q). These foregone values are also costs from a NSW perspective as they offset the direct and flow on benefits of the mine on NSW gross state product (GSP) and impact on the local economy.

Prior to Hume Coal and its affiliates becoming the owners of the Mereworth and Evandale properties, a lower than average stocking rate was achieved. Implementation of leading practice by Princess Pastoral Company has not only enabled the average stocking rate for the Southern Tablelands to be achieved, but a stocking rate that is far superior to the average for the Southern Tablelands. As a result, the foregone agricultural value is higher. For the purposes of the assessment, the average stocking rate for the Southern Tablelands (as per DPI 2016) and the stocking rates under Hume Coal ownership have been considered.

The net present value (NPV) of gross margins is an approximate value of the land removed from agriculture over a period of time. However, it excludes capital costs of farming and is therefore an over estimate. The degree of over estimation increases with the length of the time period, so the estimates are conservative in the context of the overall cost benefit analysis, and for the period of construction and operations. This overestimation may, to some degree, be offset as the time required to rehabilitate the disturbed land has not been directly taken into account. However, this would not have a large impact as the majority of the rehabilitation takes place at the end of the mine life, which at a discount rate of 7%, is heavily discounted (BAEconomics 2017). No calculation for losses in perpetuity has been completed as no land will be permanently removed from agriculture.

The areas of land used to calculate the foregone agricultural values are based on the areas identified as being temporarily lost to agriculture. The calculations include the land directly disturbed by construction and infrastructure as well as the additional land that has been fragmented which may not be economically viable to farm.

The total cost of foregone agriculture is:

- $0.63 million with average stocking rates; and
- $1.35 million with the leading farm practices implemented on Hume Coal owned land.

There will be flow-on impacts of the foregone value of agricultural output. Using a Type 1A value-add multiplier for NSW agriculture of 0.41, as described in BAEconomics 2017, these costs would be in the order of:

- $0.26 million with average stocking rates; and
- $0.55 million with the leading farm practices implemented on Hume Coal owned land.

The total cost of foregone agriculture arising from impacts on agricultural land from the Berrima Rail Project is:

- $0.22 million with average stocking rates; and
- $0.37 million with the leading farm practices implemented on Hume Coal owned land.

There would be flow-on impacts of the foregone value of agricultural output from the land impacted by the Berrima Rail Project. Using a Type 1A value-add multiplier for NSW agriculture of 0.41, as described in BAEconomics 2017, these costs would be of the order of:

- $0.09 million with average stocking rates; and
- $0.15 million with the leading farm practices implemented on Hume Coal owned land.

ii Agricultural support services, infrastructure and processing industries

The predominant impact on local throughput of agricultural production would be on beef cattle. Peak throughput losses would be cumulative, occurring in the construction phase of the project and the Berrima Rail Project. The total maximum reduction of livestock is estimated to be 665 for the construction phase and 278 for the operation phase. The Southern Regional Livestock Exchange has an annual throughput of about 60,000 head. Hence, potential loss of throughput ranges from 0.5 to 1.1%. The total number of cattle in Wingecarribee, as of the last agricultural census in 2012, was about 35,000 which suggest that more than 50% of plant throughput is sourced outside of the local region and that a 1.1 to 2.6% increase in imports would maintain production with a proportionally smaller increase in total transport costs.

The predicted reduction of the livestock production for the Wingecarribee region is 1.9% during construction, and 0.8% during operations, which will not adversely impact on the regional agricultural support services and processing industries.

The major transport routes used by agricultural producers to access supporting services and to move their products include the Hume Highway and the Illawarra Highway and some major local roads, such as Golden Vale Road and Berrima Road as well as the north-south rail line to Sydney and Goulburn and the eastern rail line to Wollongong. No significant adverse traffic impacts for general traffic or agricultural related traffic have been identified for the future project generated traffic movements (refer to Chapter 15).

iii Increased productivity on Hume Coal affiliated properties

The productivity and stocking rates of the Hume Coal affiliated properties would have been lower than the average stocking rates for the Southern Tablelands region (DPI 2016) prior to purchase, with many paddocks heavily infested with weeds. However, a lack of data means that the values cannot be accurately estimated. The weed management and soil improvements made to the land since the purchase of the properties have improved the productivity of each property. These improvements not only extend to properties to be temporarily disturbed by the project (Mereworth and Evandale), but also cumulatively with the Wongonbra, Stonington and eastern properties (Leets Vale and 325 Berrima Rd).

During construction and operation of the project, the Hume Coal affiliated properties will continue to be managed using leading land management practices. This will produce a net benefit when compared to the value which would have been realised using standard farm management with average stocking rates as described below.

To enable quantification of benefits, the area available for agriculture for each property was conservatively calculated. Calculations excluded the areas temporarily removed from agriculture during construction and operations, or unavailable due to native vegetation or Aboriginal Heritage protection (Table 9.6).

The NPV was calculated for the areas available for agriculture for all of the Hume Coal affiliated land, using both Hume farm management and average stocking rates (DPI 2016). The increase in productivity ($4.46 million) is calculated by using the difference between average stocking rates and management productivity implemented on Hume Coal owned land.

Table 9.6 Improved agricultural values for the Hume Coal properties – project duration

	Ha available for agriculture[1]		Farm management		Increased value
Property	**Construction**	**Operations**	**Hume Coal owned land**	**Average**	**Difference**
Mereworth	152	232	$2,470,000	$1,137,000	$1,333,000
Evandale	300	325	$3,130,000	$1,582,000	$1,549,000
Stonington	87	94	$948,000	$505,000	$442,000
Eastern properties[2]	63	68	$602,000	$366,000	$236,000
Wongonbra	418	418	$3,181,000	$2,279,000	$902,000
Total	**1,020**	**1,137**	**$10,331,000**	**$5,869,000**	**$4,462,000**

Notes: 1. Excludes areas temporarily removed from agriculture associated with Hume Coal Project and Berrima Rail Project, and other unavailable land (native vegetation, AHIP, etc).

2. Eastern Properties includes Leets Vale and 325 Berrima Rd.

9.4.3 Local and regional employment impacts

The project's impacts on the local and regional employment are addressed in Chapter 19. With specific regard to agriculture, the agricultural industry within the Wingecarribee LGA directly employs approximately 630 people (ABS 2012) which accounts for 3.3% of total employment in the Wingecarribee LGA.

The productivity losses, due to the temporary loss of land to agriculture during the construction and operation of the mine, will impact only the owners of the agricultural land (Hume Coal and its affiliates). The foregone agricultural values for these estimated productivity losses have been calculated in the cost benefit analysis (BAEconomics 2017).

The foregone agricultural values and flow on impacts of lost production associated with the project would equate to 0.2 FTE applying the DPI (2016) stocking rates and 0.4 FTE applying the stocking rates achieved under Hume Coal's ownership. There would also be minor flow-on effects of 0.14 FTE and 0.28 FTE applying the DPI (2016) stocking rates and stocking rates achieved under Hume Coal's ownership, respectively. This compares to a peak workforce of approximately 400 FTEs that will be required during the construction phase and, initially, an operations workforce of approximately 100 workers, which will grow to a peak of approximately 300 workers in Year 5 of the 19 year operations phase.

9.5 Avoidance, management and mitigation

9.5.1 Avoidance

Impacts on agriculture from an underground mining project can occur as a result of vegetation clearance for surface infrastructure, subsidence related impacts, and impacts on aspects such as groundwater and surface water.

Numerous alternative project layouts were considered during development of the project through an iterative design process, resulting in the final project design that avoids and minimises impacts on agriculture. These are described in Section 9.1.2 and Chapter 6.

9.5.2 Management and mitigation

A comprehensive suite of management plans will be prepared and implemented for the project, subject to its positive determination. These management plans will be prepared in consultation with relevant government agencies and other stakeholders for the approval of the Secretary of DP&E in accordance with development consent conditions. Management plans of relevance to agriculture will include the Groundwater Management Plan, Surface Water Management Plan, Subsidence Management Plan (or Extraction Plan), Topsoil Management Plan, Erosion and Sediment Control Plan, Pest and Weed Management Plan, Bushfire Management Plan and Rehabilitation Management Plan.

Management plans will include monitoring programs and, where appropriate, establishment of triggers and their appropriate responses. In addition, rehabilitation criteria will be used as the basis for assessing when rehabilitation of the project is complete. The interim completion criteria have been developed and are presented in Section 17.5.

9.6 Conclusions

The AIS was prepared in accordance with the SEARs related to agriculture and assessment recommendations from the DRE. It addressed all requirements of the NSW DP&E (2015) AIS guideline.

The extensive technical investigations that have taken place over several years, and the subsequent development and refinement of the project, has resulted in leading practices in mine design with an underground mining method and layout that results in negligible subsidence, and limited potential impacts on agricultural resources. All mitigated risks on agricultural resources have been assessed as low.

The potential disturbance of agricultural land from the project is limited to the temporary disturbance of the surface infrastructure area, which will occur on Hume Coal affiliated land (with the exception of a downcast shaft, which will be in Belanglo State Forest). This land will be returned to its pre-mining land use; that is, agriculture comprising grazing on improved pasture.

There will be minor temporary foregone agricultural production values during the construction and operation of the project.

A comprehensive management regime will be implemented to avoid and mitigate and monitor potential impacts on agricultural resources.

10 Biodiversity

10.1 Introduction

This chapter provides a summary of the biodiversity assessment report prepared by EMM and the aquatic ecology assessment completed by JSA Environmental. The biodiversity assessment report (BAR) is presented in full in Appendix H (EMM 2017h), which incorporates the methods and results of the aquatic ecology assessment.

This chapter presents the assessment methods, existing landscape and terrestrial and aquatic biodiversity values, the measures taken to avoid, minimise and mitigate impacts, an assessment of the residual direct and indirect impacts and the offset strategy for terrestrial biodiversity proposed to enable the project to have a net positive biodiversity outcome.

Avoidance and minimisation of impacts on biodiversity have been applied as guiding principles in the design of the project. Ecological investigations completed between 2012 and 2016 enabled a comprehensive knowledge of the project area's biodiversity and areas of low constraint to be identified.

Residual surface impacts from the project on biodiversity are limited to the removal of 64 paddock trees. The small areas to be removed are predicted to provide habitat for a number of ecosystem credit species (ie species whose occurrence can be reliably predicted by plant community type) and species credit species (ie those not reliably predicted by plant community type, and more reliably predicted by landscape features eg caves and waterbodies) predicted by the BioBanking Credit Calculator. Offset calculations have been undertaken in accordance with the *Framework for Biodiversity Assessment: NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014) (FBA) to determine the number of credits required to compensate for the project's residual surface impacts and enable the project to have a net positive effect on biodiversity. A biodiversity offset strategy is proposed to source offset areas containing the required ecosystem and species credits.

The project will not have any direct impacts on riparian vegetation. Potential impacts on groundwater dependent ecosystems are limited to areas of terrestrial vegetation containing a threatened ecological community and threatened species habitat along Belanglo Creek and Wells Creek, which 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.

No stygofauna were recorded in the project area. However, if any are present it is unlikely that they would be restricted to the area affected by groundwater drawdown given the high level of groundwater connectivity to adjacent areas. Minor reductions in base flow are expected in Medway Rivulet, which is unlikely to have an adverse long-term impact on aquatic ecosystems given the minor base flow reduction expected.

10.1.1 Assessment guidelines and requirements

The biodiversity assessment report was prepared to meet both State and Commonwealth assessment requirements. It was prepared in accordance with the biodiversity-related SEARs, supplementary Commonwealth SEARs, and assessment recommendations from the OEH and DPI Water and with reference to outcomes of stakeholder engagement. The SEARs specifically relating to biodiversity from DP&E and DoEE, and where they are addressed, are presented in Table 10.1.

Table 10.1 Biodiversity related SEARs

Requirement	Section addressed
NSW Department of Planning and Environment	
An assessment of the likely biodiversity impacts of the development, in accordance with the Framework for Biodiversity Assessment, by a person accredited in accordance with s142(B)(1)(c) of the Threatened Species Conservation Act 1995, and having regard to OEH's and DPI's requirements and recommendations.	Section 10.5, and Section 10.7, Chapter 6 and Appendix A of Appendix H.
A strategy to offset any residual impacts of the development in accordance with the NSW Biodiversity Offsets Policy for Major projects.	Section 10.7 and Chapter 9 of Appendix H
Commonwealth Department of Environment and Energy	
The precise location and description of all works to be undertaken (including associated offsite works and infrastructure), structures to be built or elements of the action that may have impacts on MNES;	Chapter 2 and Section 10.5
How the works are to be undertaken and design parameters for those aspects of the structures or elements of the action that may have relevant impacts on MNES;	Chapter 2 and Section 10.5
An assessment of the relevant impacts of the action on (i) threatened species and communities and (ii) water resources; including:	
- a description and detailed assessment of the nature and extent of the likely direct, indirect and consequential impacts, including short-term and long-term relevant impacts;	Section 10.5
- a statement whether any relevant impacts are likely to be known, unpredictable or irreversible, and analysis of the significance of the impacts;	Section 10.5
- any technical data and other information used or needed to make a detailed assessment of the impacts;	Appendix H
- a comparative description of the impacts of alternatives, if any, on the threatened species and communities.	Section 10.4 and Chapter 6
Information on proposed avoidance and mitigation measures to manage the relevant impacts of the action including:	
- a description of the proposed avoidance and mitigation measures to address the impacts of the action;	Section 10.4
- assessment of the expected or predicted effectiveness of the mitigation measures;	Section 10.4.3
- the cost of the mitigation measures;	Appendix H (BAR) and Q (Economic Assessment (cost of offsets is included in the financial model)
- a description of the outcomes that the avoidance and mitigation measures will achieve;	Section 10.4
- a description of the offsets proposed to address the residual adverse significant impacts and how these offsets will be established.	Section 10.7
The EIS must address the following issues in relation to Biodiversity in accordance with the Matters of National Environmental Significance - Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999 (Significant Impact Guidelines), and include:	
- identification of each EPBC Act listed threatened species and community likely to be significantly impacted by the development; and	Section 10.3 and Section 7.4 of Appendix H
- evidence why other EPBC Act listed threatened species and communities likely to be located in the project area or in the vicinity will not be significantly impacted.	Sections 10.3 and 10.5
For each of the relevant EPBC Act listed threatened species and communities likely to be significantly impacted by the development the EIS must:	
- describe the habitat and habits (including identification and mapping of suitable breeding habitat, suitable foraging habitat, important populations and habitat critical for survival), with consideration of, and reference to, any relevant Commonwealth guidelines and policy statements including listing advice, conservation advice and recovery plans, threat abatement plans and wildlife conservation plans;	Section 10.3, and Section 7.4 of Appendix H
- detail the scope, timing and methodology for studies or surveys used and how they are consistent with (or justification for divergence from) published Australian Government guidelines and policy statements; and	Section 10.2, and Chapter 2 and Appendix B of Appendix H
- describe the impacts of the action having regard to the full national extent of the species or community's range.	Section 10.5

Table 10.1 Biodiversity related SEARs

Requirement	Section addressed
For each of the relevant EPBC Act listed threatened species and communities likely to be significantly impacted by the development the EIS must:	
- identify significant residual adverse impacts likely to occur after the proposed activities to avoid and mitigate all impacts are taken into account;	Section 10.5 and Section 7.4 of Appendix H
- detail how the current published NSW Framework for Biodiversity Assessment (FBA) has been applied in accordance with the objects of the EPBC Act to offset significant residual adverse impacts; and	Section 10.7 and Chapters 8 and 9 of Appendix H
- detail the offsets to compensate for significant residual impacts, including details of the credit profiles required to offset the development in accordance with the FBA and/or mapping and descriptions of the extent and condition of the relevant habitat and/or threatened communities occurring on proposed offset sites.	Section 10.7 and Chapters 8 and 9 of Appendix H
Any significant residual impacts not addressed by the FBA may need to be addressed in accordance with the Environment Protection and Biodiversity Conservation Act 1999 Environmental Offset Policy. http://www,environment.gov.au/epbc/publications/epbc-actenvironmental-offsets-policy,	All significant residual impacts will be offset in accordance with the FBA.
The EIS should provide a description of the location, extent and ecological characteristics and values of the identified water resources potentially affected by the project.	Ecological characteristics are described in Section 10.3. Water resources are described in detail in Chapter 7.
The assessment of impacts should include information on:	
- the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the water resource being seriously affected;	Section 10.3 and Appendix H
- substantial and measurable change in the water quality and quantity of the water resource for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland; or water temperature that may adversely impact on biodiversity, ecological integrity, social amenity or human health.	Section 10.5, Chapter 7, and Appendix H

Table 10.2 Agency assessment recommendations relating to biodiversity

Requirement	Section addressed
DRE	
Provide a record of the flora, fauna and ecological attributes of the disturbed area and place in a regional context	Section 10.2
Fisheries NSW	
Identification of Key Fish Habitat within the proposal area.	Section 10.3.2iie, and Sections 3.3.2 and 4.6.6 of Appendix H
Description of aquatic and riparian environments in the vicinity of the development, particularly extent and condition of riparian vegetation and instream aquatic vegetation, water depth, and permanence of water flow and snags (large woody debris) within the footprint of the proposal area.	Section 10.3.2, and Section 4.6 and Appendix J of Appendix H
Analysis of any interactions of the proposed development with water quality and aquatic and riparian environments (including fish and aquatic and riparian vegetation) and predictions of any impacts upon those environments.	Section 10.5, and Section 7.4.1 vi and Section 7.2.1 iv of Appendix H
Analysis of impacts of groundwater interference and drawdown on water quality, water flow and aquatic and riparian environments within and downstream of all waterways within the proposal area.	Section 10.5.2, and Section 7.2.1 of Appendix H
Plan of proposed underground mine design overlaid with waterways	Figure 1.6 of Appendix H

Table 10.2 Agency assessment recommendations relating to biodiversity

Requirement	Section addressed
Safeguards to mitigate any impacts upon water quality, water flow and aquatic and riparian environments within and downstream of all waterways within the proposal area during construction and ongoing operation of the proposed coal mine. In particular, provide details on proposals for erosion and sediment control (to be incorporated into a Construction Environmental Management Plan - CEMP) and proposed stormwater and ongoing drainage management measures. Water quality management for the project should be designed to achieve no net increase in pollutant run-off to receiving waters within the proposal site.	Section 10.4, and Table 6.1, Sections 6.1.5 and 6.1.6 of Appendix H
Details of ongoing monitoring programs to assess any impacts upon water quality, water flow and aquatic and riparian environments within and downstream of all waterways within the proposal area.	Chapter 7 (7.7.3), Section 13 of Appendix E; and Table 6.1 of Appendix H
Fisheries NSW recommend the use of best practice sediment and erosion control, and water quality and stormwater management provisions to safeguard and mitigate impacts on water quality at the site and downstream. They also recommend inclusion of appropriate riparian corridors to provide a buffer between the development areas and adjacent waterways or natural drainage lines to provide protection to riparian and aquatic habitats.	Section 13 of Appendix E; Table 6.1 and Sections 6.1.5 and 6.1.6 of Appendix H
Design and construction of any watercourse crossings on the site should be undertaken in accordance with the Departments Policy and Guidelines for Fish Friendly Waterway Crossings (2004) and Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (2004)	Section 10.4.1 vi, and Table 6.1, Sections 6.1.5 and 6.1.6 of Appendix H
DPI Water	
Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, wetlands, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Sections 10 and 11 of Appendix E; and Table 6.1 and Section 7 of Appendix H
A detailed assessment of riparian and watercourse impacts, particularly with respect to watercourse crossings. The project should be designed to minimise impacts on watercourses and riparian land, and must have regard to the Department of Primary Industries' Guidelines for Controlled Activities on Waterfront Land – in particular the guideline on watercourse crossings.	Section 10.5
Assessment of predicted impacts on the following: • flow of surface water (including floodwater), sediment movement, channel stability, and hydraulic regime, • water quality, • flood regime, • dependent ecosystems, • existing surface water users, and • planned environmental water and water sharing arrangements prescribed in the relevant water sharing plans.	Section 10.5
Identify any potential impacts on GDEs as a result of the proposal including: • the effect of the proposal on the recharge to groundwater systems; • the potential to adversely affect the water quality of the underlying groundwater system and adjoining groundwater systems in hydraulic connections; and • the effect on the function of GDEs (habitat, groundwater levels, connectivity).	Section 10.5.2 ii, and Appendices H and I of Appendix E; and Sections 4.5 and 7.2.1 of Appendix H
Provide safeguard measures for any GDEs.	Section 10.4, and Sections 6.1.4 and 6.2.2 of Appendix H

Table 10.2 Agency assessment recommendations relating to biodiversity

Requirement	Section addressed
Scaled plans showing the location of: • wetlands/swamps, watercourses and top of bank; • riparian corridor widths to be established along the creeks; • existing riparian vegetation surrounding the watercourses (identify any areas to be protected and any riparian vegetation proposed to be removed); • the site boundary, the footprint of the proposal in relation to the watercourses and riparian areas; and • proposed location of any asset protection zones.	Section 5 of Appendix E; and Figures 1.6, 1.7, 4.1, 7.1 and 7.2 of Appendix H
A detailed description of all potential impacts on the wetlands, including potential impacts to the wetlands hydrologic regime; groundwater recharge; habitat and any species that depend on the wetlands.	Section 10.5.4b, Section 10 of Appendix E; and Section 7.8.3 of Appendix H
OEH	
Assessment of the potential impact on biodiversity, including threatened species, populations, ecological communities, or their habitats likely to occur within or near the subject site.	Section 10.5
Biodiversity impacts related to the proposed development are to be assessed and documented in accordance with the Framework for Biodiversity Assessment, unless otherwise agreed by OEH, by a person accredited in accordance with s142B(1)(c) of the Threatened Species Conservation Act 1995.	Section 10.1 and 10.5
The EIS must assess the impact of the development on hydrology, including: a. Water balance including quantity, quality and source. b. Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas. c. Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems. d. Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (eg river benches). e. Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water. f. Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options. g. Identification of proposed monitoring of hydrological attributes.	Sections 4, 10 and 13 of Appendix E; and Table 6.1 and Section 7.1.1 of Appendix H
Impacts on the following populations will require further consideration and provision of the information specified in s9.2 of the Framework for Biodiversity Assessment: • *Eucalyptus aggregata*	Sections 10.3.2b and 10.5.3, and Section 7.3 of Appendix H

The assessment also considered relevant guidelines and policies. Of particular note is the FBA which underpins the NSW Biodiversity Offsets Policy for Major Projects. It contains the assessment methodology that is adopted by the policy to quantify and describe the impact assessment and offset requirements that apply to Major Projects. The biodiversity assessment report was prepared in strict accordance with the FBA. This chapter refers to sections of the FBA as relevant and a checklist against each of the requirements is presented in Appendix A of the BAR (Appendix J of the EIS).

Aquatic impacts were assessed and mitigation measures designed with consideration of '*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 2013b) and *Guidelines for watercourse crossings on waterfront land* (NOW 2012c).

10.1.2 Adoption of leading practice

As described in Section 2.2, the project was developed following several years of technical investigations to define the mineable resource and identify and address environmental and other constraints. The extensive biodiversity knowledge gained during the desktop study and surveys informed these investigations. Numerous alternative conceptual designs were prepared and evaluated. This included various mining methods and extents, and surface infrastructure locations and designs.

Consideration was given to sensitive ecological features such as riparian vegetation, threatened ecological communities, threatened species habitat, as well as areas of 'low constraint', which represented opportunities for positioning surface infrastructure. The resultant design avoids most native vegetation and fauna habitats.

The proposed mining method will result in negligible subsidence related impcts on threatened biodiversity and has minimised potential impacts on groundwater dependent ecosystems. Accordingly, the resulting design has potential minor impacts on threatened biodiversity.

The leading practices adopted by Hume Coal are consistent with the requirements of the FBA, in demonstrating the design measures taken to avoid and minimise most biodiversity impacts and the offsets proposed to compensate for the minor residual impacts.

10.1.3 Project area and study area

The project and study areas are shown in Figure 10.1.

Within the project area, surface disturbance will mainly be restricted to the surface infrastructure areas shown indicatively on Figure 10.1, though will include some other areas above the underground mine, such as drill pads, access tracks and up to two downcast ventilation shafts.

In accordance with the SEARs and agency requirements, the biodiversity assessment considered direct surface impacts on biodiversity in the surface infrastructure area in accordance with the FBA, as well as impacts on aquatic ecosystems and biodiversity relating to changes in surface water and groundwater regimes as a result of the project.

Accordingly, two study areas (ie terrestrial and aquatic) were defined for the BAR, which expanded beyond the project area to the areas indicated in Figure 10.1, to consider aquatic, surface water and groundwater-related impacts (collectively referred to as the study areas) and encompass all aquatic and surface water sampling sites. The study areas also include the proposed downcast shafts in Belanglo State Forest and east of the Hume Highway.

A conservative approach was taken when identifying the terrestrial and aquatic study areas. Surveys commenced in 2012 when three different mining methods (ie longwall, miniwalls and other low impact methods) and four different surface infrastructure area locations were being considered (see Chapter 6). Accordingly, the project team assessed broad study areas to ensure adequate coverage.

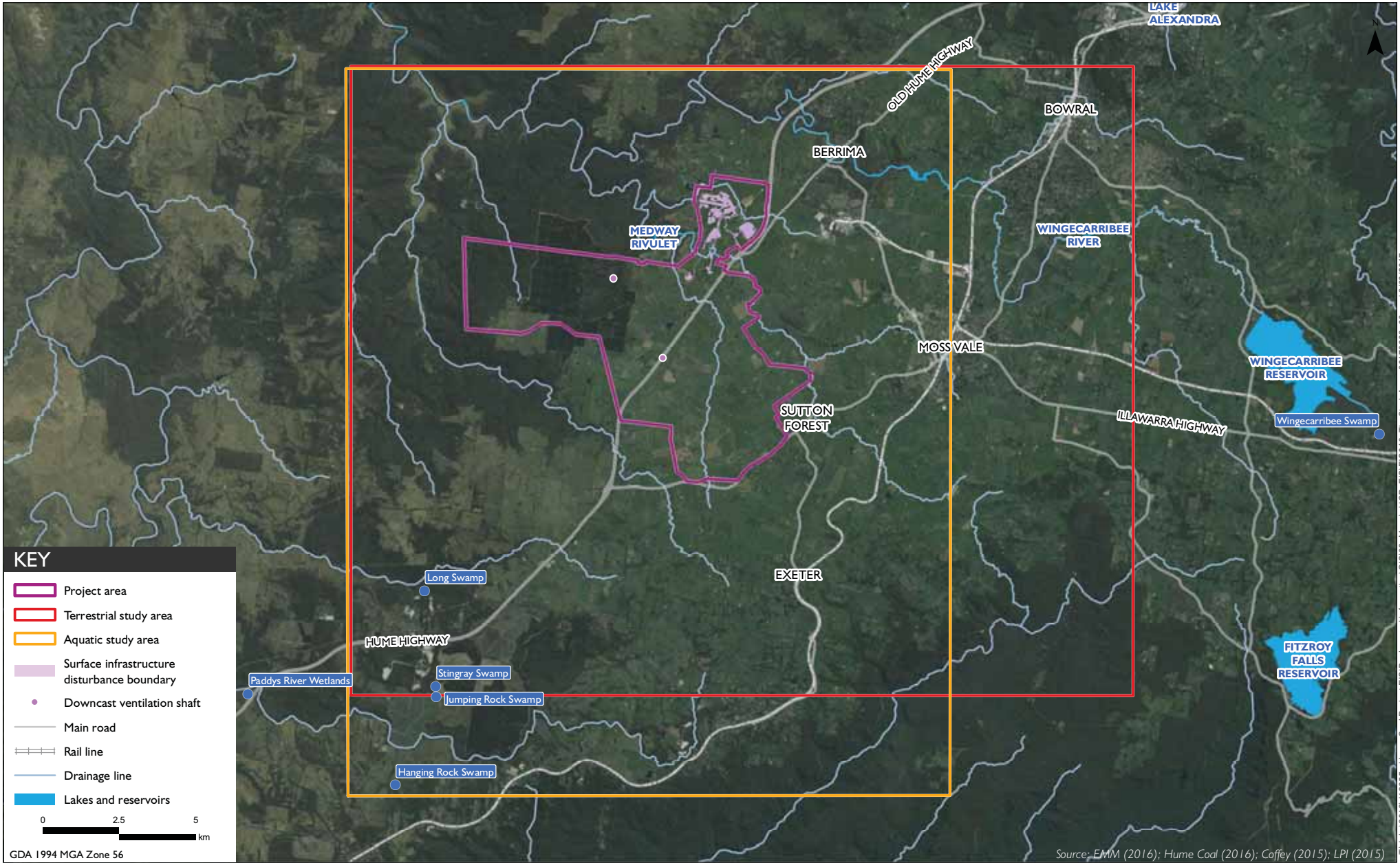
10.2 Methods

A desktop assessment and extensive field surveys were completed between 2012 and 2016 to accurately define biodiversity in the project area (ie the extent of the underground and surface facilities), with a particular focus on threatened species, populations and communities listed under the TSC Act, FM Act and EPBC Act. The study area was expanded to the extent of potential indirect impacts relating to groundwater. A detailed desktop assessment was completed to identify threatened biodiversity and potential groundwater dependent ecosystems in this area, in accordance with the DPI Water's assessment recommendations.

The method applied to the assessment of biodiversity was comprehensive. It included detailed literature review and database searches and hundreds of hours of targeted threatened species surveys. All surveys were completed in accordance with the relevant State and Commonwealth guidelines. This enabled:

- biodiversity values associated with the project area to be identified, and in particular any threatened species, populations or ecological communities listed under the TSC Act, FM Act and/or EPBC Act, or their habitats present or likely to occur;
- a project design that avoids and minimises potential impacts on biodiversity;
- development of appropriate mitigation measures; and
- a robust assessment of residual impacts and development of a biodiversity offset strategy in accordance with the FBA.

A summary of the methods applied is provided in the sub-sections below.



Project area and terrestrial and aquatic study areas

Hume Coal Project

Environmental Impact Statement

Figure 10.1

10.2.1 Literature review and database search

Relevant scientific literature and biodiversity studies previously undertaken within the study areas and surrounding region were reviewed to compile a list of threatened species, populations, communities and migratory species likely to occur.

Searches of relevant databases were also performed to identify any threatened terrestrial and aquatic flora and fauna species, important habitat for migratory species and/or critical habitats recorded in and surrounding the study area. Recent searches were completed in 2016 to determine if any new species, populations or communities that may occur in the project area had been listed since commencement of the biodiversity assessment in 2013. Threatened species, populations and communities listed under the TSC Act and/or EPBC Act and previously recorded or predicted to occur within approximately 20 km of the project area were identified for the terrestrial assessment. Threatened aquatic species listed under the EPBC Act previously recorded or predicted to occur within 5 km of the aquatic study area, and threatened species listed under the FM Act within the Wingecarribee LGA and Hawkesbury Nepean Major Catchment Area were identified. Materials reviewed, databases searched and species identified are provided in the BAR.

Preliminary listing advices were also consulted under the TSC, FM and EPBC Acts to determine any species, populations or communities that may be listed in the future, or existing species that may increase in conservation status (ie existing vulnerable species that is proposed to be uplisted to endangered).

Stygofauna studies were reviewed, which focused on determining the super orders and families of stygofauna (as few are identified to a species level) in the region to develop appropriate sampling methods for stygofauna. The development of the sampling methods is detailed in Appendix J of Appendix H (BAR).

10.2.2 Terrestrial field surveys

i Vegetation surveys

A preliminary site assessment was completed on 5 February 2013 to gain an appreciation of the vegetation and habitats present within the project area and surrounds. This included characterisation of the dominant species and habitat features to inform the threatened species likelihood of occurrence assessment and design of targeted surveys.

Vegetation types in the surface infrastructure area and study area were assessed in the field using a combination of plot-based surveys and rapid assessment surveys. These surveys were completed in April 2013, March 2014, April 2014, November 2014, January 2015, February 2015 and August 2016 and in accordance with the FBA. A total of 64 (20 x 20 m) plot and transect (50 m) flora surveys were undertaken across the study area. In addition, 45 rapid assessments were completed in areas of interest which could not be accessed for plot-based surveys.

Vegetation type boundaries were mapped in the field, either on foot or from a vehicle, using a global positioning system (GPS) receiver whilst referencing aerial and topographic maps. Flora survey locations are shown in Figure 2.1 of the BAR.

Vegetation plot data and rapid assessment data were reviewed against the Commonwealth and NSW government descriptions of threatened ecological communities (TECs) known from the region, to determine their presence (or otherwise) in the project area and surrounds.

ii Targeted flora species surveys

The results of the desktop study and preliminary site inspection were used to identify threatened species (listed under the TSC Act and/or EPBC Act) to target during field surveys. This included all species previously recorded or predicted to occur in or near the study area. Flora searches were timed to maximise the potential for identification of the targeted threatened species and were undertaken over 206 person hours within suitable or potentially suitable habitats.

A summary of flora survey methods, effort and timing employed for the project is provided in Table 10.3.

Table 10.3 Summary of flora survey effort

Survey method	Total survey effort
Plot and transect surveys	64 plot and transect flora surveys
Rapid vegetation assessments	45 locations
Targeted threatened flora searches	206 person hours

iii Fauna surveys

An assessment of fauna habitat types and habitat condition was undertaken at each of the 64 plot and transect locations to determine appropriate locations for fauna surveys. Following this, a range of fauna survey methods were employed. These comprised:

- active reptile searches;
- bird surveys using diurnal bird timed area search, and nocturnal bird spotlighting and call broadcasting techniques;
- microbat surveys using ultrasonic detection, harp trapping and roost search techniques; and
- arboreal and ground-dwelling mammals using Ground Elliot trapping, spotlighting and call broadcasting, and tracks, scats and signs identification, spot assessment and camera trap techniques.

Locations of fauna surveys undertaken are shown in Figure 2.2 of the biodiversity assessment report.

iv Targeted fauna species surveys

Survey methods for threatened fauna were determined following the results of the desktop study, preliminary site visit and assessment of the presence of suitable habitat.

In accordance with the TSC Act threatened species recorded within 20 km of the project area were targeted during surveys. Records for the listed species predicted by the Protected Matters Search Tool (DoE 2016) were interrogated on the Atlas of NSW Wildlife (OEH 2016) and Atlas of Living Australia (ALA 2016) to determine if they had been recorded within 20 km of the project area. Species on this list greater than 20 km from the project area and not likely to occur (ie coastal species) were excluded from targeted surveys. The exception to this rule was the completion of targeted winter surveys for the Regent Honeyeater and Swift Parrot, given the nomadic habits of these species. The remaining species were targeted during surveys.

A list of threatened and migratory fauna species (listed under the EPBC Act and/or TSC Act) which were identified as having a moderate to high potential to occur prior to surveys was developed. Their likelihood of occurrence was revised, following the completion of field surveys.

Surveys were completed for all threatened fauna in the optimal survey timing recommended by the relevant State and Commonwealth guidelines. A summary of fauna survey methods and effort employed for the project is provided in Table 10.4.

Table 10.4 Summary of fauna survey effort

Taxa group	Survey method	Total survey effort
General	Habitat assessments and searches for signs	167 person hours
Reptiles	Active searches	134 person hours
	Spotlighting	132 person hours
	Broad-headed Snake targeted searches	57 person hours
Birds	Timed diurnal searches	82 person hours
	Call broadcasting and spotlighting	132 person hours
Microchiropteran bats	Anabat detection	66 detector nights
	Harp trapping	38 trap nights
Non-flying mammals	Infrared camera surveys	76 trap nights
	Call broadcasting and spotlighting	132 person hours
Ground mammals	Elliott traps	320 trap nights
Koalas	Spot assessment technique	167 person hours
	Call broadcasting and spotlighting	132 person hours
Frogs	Call broadcasting and spotlighting	132 person hours

10.2.3 Aquatic field surveys

i Aquatic surveys and habitat assessments

Forty six sites were surveyed for macroinvertebrates and fish in the aquatic study area during autumn 2013 and 2014, and spring 2013 and 2015. Surveys were during spring and autumn in accordance with the *NSW AUSRIVAS Sampling and Processing Manual* (Turak et al 2004) to address species seasonality.

There were Habitat assessments, targeted habitat assessments for listed species, and waterway classifications at 32 sites. Twenty groundwater boreholes in the aquatic study area were surveyed for stygofauna in autumn 2013 and 2014 and spring 2013. A variety of depth profiles were sampled to target various groundwater systems (15.3 - 172 m depths).

10.2.4 Identification of groundwater dependent ecosystems

An approach to assessing groundwater dependent ecosystems was specifically developed for the project following the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NOW 2012a). This approach combined depth to groundwater information, native vegetation mapping, groundwater dependent ecosystem characterisation and drawdown contours from groundwater modelling to inform an accurate assessment of potential impacts. Potential GDEs were categorised, based on their degree of dependence on groundwater. GDEs were divided into three main categories, comprising:

- non-dependent (ie do not access groundwater);
- facultative (have some degree of dependence on groundwater); and
- entirely dependent/obligate (ie essential to ecosystem functioning).

Ecosystems with a facultative dependence were further divided into three sub-categories, comprising:

- opportunistic:-These ecosystems will use groundwater where available, but can exist without the input of groundwater, as long as there is no prolonged drought. Examples of opportunistic ecosystems include coastal mangroves, saltmarshes and Banksia woodlands.

- proportional: These 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. Examples of proportional ecosystems include glacial lakes and alpine bogs; and

- highly dependent: These ecosystems take a high proportion of their water requirements from groundwater and can only tolerate small changes in groundwater levels for short periods of time. Examples of highly dependent ecosystems include Paperbark swamps in northern Australia and wetlands of the basalt plains in Victoria.

Native vegetation maps were then overlaid on the shallow groundwater distribution maps, within geographic information system (GIS) software, to determine which patches could potentially access subsurface groundwater and which category of interaction these fit into (ie high, moderate or low interaction). This was done using native vegetation mapping prepared for the BAR (Figure 4.1 of Appendix H) along with mapping of the surrounding area, available in the *Wingecarribee Biodiversity Strategy* (EcoLogical 2003). Areas of overlap, that is where native vegetation communities coincided with shallow groundwater, were identified as 'potential GDEs', requiring further investigation to understand their groundwater dependence (or otherwise). The vegetation and fauna assemblages that rely on these areas for habitat were identified.

Other vegetation, hydrology and hydrogeology data were then analysed to understand the nature and likely degree of any groundwater dependence of the various ecosystems. In particular, groundwater hydrographs for representative bore locations (which provide information on groundwater levels, and the timing and likely availability of the groundwater resource to ecosystems in these areas) were analysed, in conjunction with potential rooting depths of key flora species. The timing and volume of groundwater contributions to creek baseflows, are as determined by groundwater modelling, were also considered.

10.3 Existing environment

10.3.1 Landscape values

As required by Chapter 4 of the FBA, the landscape values of the project area were described and used to inform Biobanking calculations for the project. An overview is provided below and details given in Chapter 3 of the BAR (EMM 2017h).

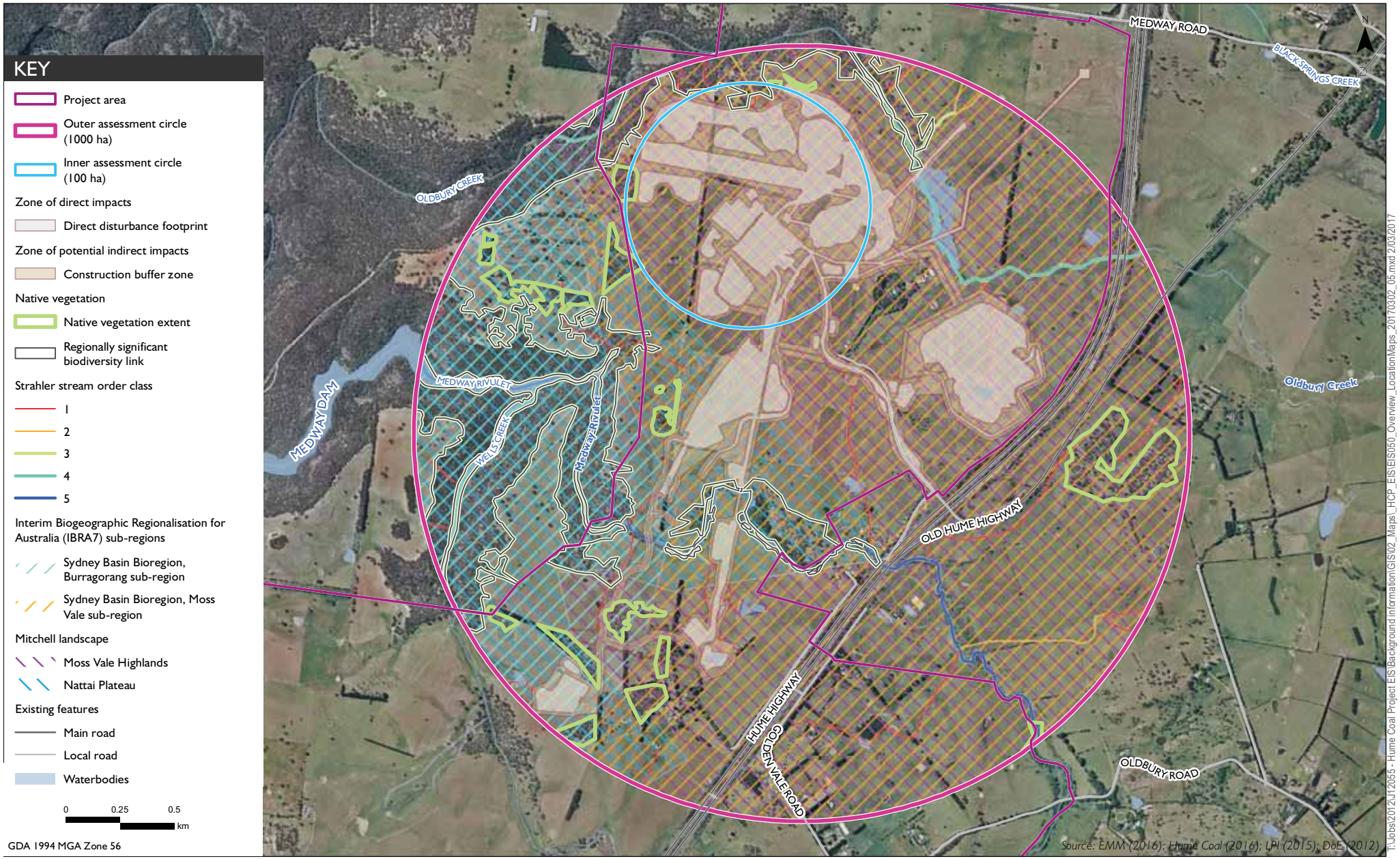
The project is in a setting that is highly modified due to historical and current agricultural and forestry practices and infrastructure development. The majority of the project area, and in particular the proposed surface infrastructure area, comprises cleared land dominated by exotic grasses and herbs. Native vegetation in the project area is highly fragmented and covers a relatively small proportion of the study area. It is principally restricted to the north-west corner, in parts of Belanglo State Forest, and small patches in the central northern study area, associated with creeks and gullies (see Figure 10.4). Isolated remnant paddock trees occur in the eastern and northern parts of the project area.

Landscape values are discussed in the following sections. An overview site map (Figure 10.2) and overview landscape map (Figure 10.3) have been prepared in accordance with the FBA to illustrate the landscape values of the project area. Individual site maps and landscape maps prepared in accordance with the scale requirements of the FBA are provided in Appendix A of the BAR (refer to Appendix H).

Biodiversity assessment site map - overview

Hume Coal Project
Environmental Impact Statement

Figure 10.2



Biodiversity assessment location map - overview

Hume Coal Project
Environmental Impact Statement

Figure 10.3

i IBRA Bioregion

The project is within the Sydney Basin Bioregion, and covers both the Burragorang and Moss Vale sub-regions of the Hawkesbury-Nepean major catchment area, as defined under the Interim Biogeographic Regionalisation for Australia (IBRA) system. The surface infrastructure area is located in the Moss Vale sub-region.

The project is located in the former Hawkesbury/Nepean Catchment Management Area, which now falls within the broader area now administered by South East Local Land Services, namely the Hawkesbury/Nepean Major Catchment Area (MCA). The IBRA subregion boundaries are shown on the overview site map (Figure 10.2) and overview landscape map (Figure 10.3). Individual site maps and landscape maps prepared in accordance with the scale requirements of the FBA are provided in Appendix A of the BAR.

ii Mitchell landscapes

The surface infrastructure area intersects two Mitchell landscapes, namely Moss Vale (Moss Vale Highlands) and Burragorang (Nattai Plateau). Mitchell Landscapes are defined by OEH as “areas of land with relatively homogenous geomorphology, soils and broad vegetation types which have been mapped at 1:250,000 scale”. These landscape units were mapped by the former DECC in 2002. Their coverage within and surrounding the project area is shown on the overview site map and location map describing the landscape (Figure 10.2 and 10.3).

iii Rivers and drainage lines

The study area contains several rivers and drainage lines. Medway Rivulet, a 5th order stream intersects the surface infrastructure area, while Oldbury Creek, a 4th order stream occurs north of the surface infrastructure area. These streams and their respective stream orders are shown in Figure 10.2 and 10.3.

iv Biodiversity links

There are no recognised state significant biodiversity links within the study area. The FBA states that for an area to be classified as a state or regionally significant biodiversity link, it must be identified as such in a plan approved by the Chief Executive of OEH. Additionally, a riparian buffer of 50 m on either side of a 6th order stream or greater, or around an important wetland or estuarine area, would also constitute a state significant biodiversity link.

A riparian buffer of 20 m on either side of a 4th or 5th order stream can be considered a regionally significant biodiversity link. Oldbury Creek and Medway Rivulet in the surface infrastructure area represent 4th and 5th order drainage lines, respectively. They each have vegetated riparian buffers in excess of 50 m in places, however the riparian corridor is much narrower on average. The conveyor will cross a section of Medway Rivulet where the riparian corridor is approximately 23 m wide in total (ie not 20 m on either side). As an elevated conveyor will be installed, no native vegetation will be impacted by its installation. Therefore the project will not impact regionally significant biodiversity links. The regionally significant biodiversity link is shown on the overview location map (Figure 10.3).

v Native vegetation extent

An inner assessment circle of 100 ha was placed around the area of greatest change in the surface infrastructure area. Given the avoidance of most intact patches of native vegetation for the project, the area of greatest change overlies paddock trees in exotic grassland. Accordingly, the inner assessment circle was placed over this area.

In accordance with the FBA (OEH 2014), native vegetation extent is calculated based on the patches of native vegetation that are present. Therefore, the area of intact patches of native vegetation was mapped and used to calculate native vegetation extent in the inner assessment circle.

The FBA requires that the outer assessment circle is ten times the size of the inner assessment circle. Accordingly, the outer assessment circle was calculated at 1,000 ha. The area of native vegetation shown on aerial mapping and observed in the field was greater than predicted by existing vegetation mapping (EcoLogical 2013), and therefore the entire extent of intact native vegetation was mapped and used to calculate the area of native vegetation in the outer assessment circle. The extent of native vegetation in the outer assessment circle was extrapolated from a combination of field results and regional mapping datasets. The inner and outer assessment circle, and the extent of native vegetation within them, is shown on the overview location map. Individual site maps and location maps prepared in accordance with the scale requirements of the FBA are provided in Appendix A of the biodiversity assessment report.

Native vegetation cover is currently highly fragmented in both the inner and outer assessment circle prior to disturbance. Table 10.5 summarises native vegetation cover in both the inner and outer assessment circle both pre and post project-related disturbance. There is no change in percentage of native vegetation cover in the inner or outer assessment circle following disturbance. The landscape score for the assessment circles provided by the BioBanking calculator is 12.

Table 10.5 Native vegetation in the assessment circles before and after development

Assessment circle	Before development (ha)	After development (ha)	Before development (% cover)[1]	After development (% cover)[2]
Inner assessment circle	2.00	2.00	<5	<5
Outer assessment circle	157.69	157.67	11-15	11-15

Notes 1. Prior to any vegetation clearing for the project.

2. Following any vegetation clearing for the project.

vi Key fish habitats in the Wingecarribee Shire

Key fish habitat is defined as an aquatic habitat that is important to the sustainability of recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species. In freshwater systems, most permanent and semi-permanent rivers, creeks, lakes, lagoons, billabongs, weir impoundments and any impoundments up to the top of the bank are considered key fish habitats. Small headwater creeks and gullies that flow for short periods after rain and farm dams on such systems are excluded, as are artificial waterbodies except for those that support populations of threatened fish or invertebrates. The key fish habitat map for the Wingecarribee LGA identifies the reaches of Medway Rivulet, Belanglo Creek, Black Bobs Creek and Wells Creek in the project area as key fish habitats.

10.3.2 Biodiversity values in the project area and study areas

Existing biodiversity values are described below for two discrete areas: the study areas and project area. The level of description in each area is commensurate with the level of potential impact. A more detailed description of the surface infrastructure area, which is the area of direct potential impact, is given in Section 10.3.3.

i Project area

a. Native vegetation

A total of 353 native flora species were recorded in the project area and its immediate surrounds by the BAR. A total of 90 introduced plant species were recorded in the project area, comprising 20% of all plant species recorded.

Eight native vegetation communities were 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 (*Eucalyptus sclerophylla*)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 were classified into plant community type (PCT) in accordance with Section 5.2 of the FBA, applying the classifications described in OEH's NSW Vegetation Information System (VIS) Classification Database.

The project area also contains two exotic vegetation types, comprising Pine Forest and Cleared Land.

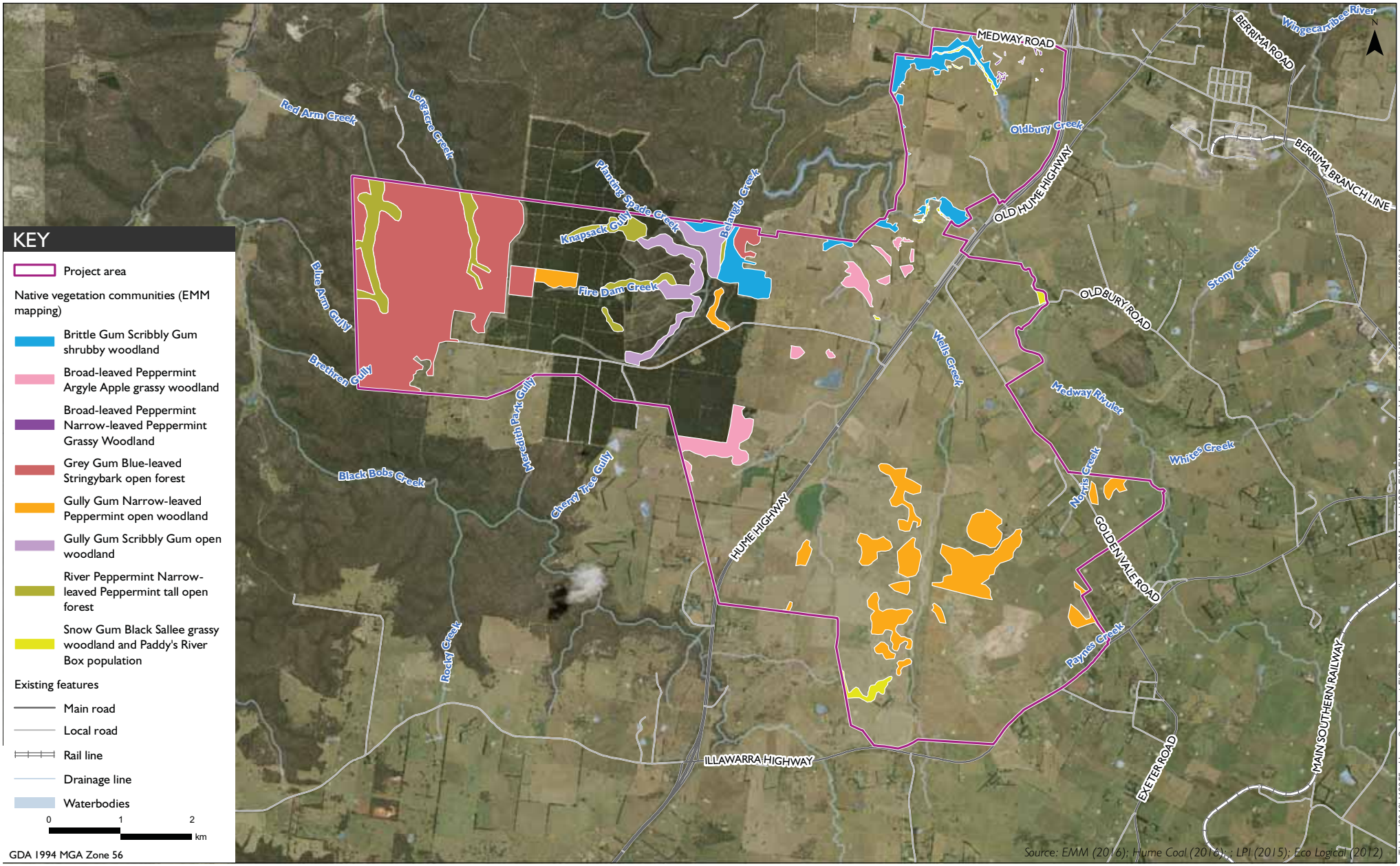
Native vegetation communities in the project area are shown in Figure 10.4. A detailed analysis of the plot and transect data collected for the current study was completed against the PCTs in the VIS Classification Database in order to characterise the PCTs present in the project area. This detailed analysis is provided in Appendix C of the BAR, which also provides detailed descriptions of each vegetation type present in the project area.

b. Threatened flora species and populations

Of the 353 native plant species recorded in the project area, 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 10.5. 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 Belanglo State Forest in the north-west of the 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 (*Eucalyptus aggregate*), 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. Notwithstanding, it is likely that Black Gums still occur in these areas. While potentially suitable habitat exists within the Snow Gum Black Sallee Woodland (refer to Figure 10.4), targeted surveys conducted in this suitable habitat did not record any Black Gums.



Native vegetation in the project area

Hume Coal Project

Environmental Impact Statement

Figure 10.4

Threatened species locations

Hume Coal Project

Environmental Impact Statement

Figure 10.5

c. Threatened ecological communities

Seventeen TECs have the potential to occur within the Burragorang and Moss Vale IBRA sub-regions. Five of these TECs may occur in the study area (Figure 10.6). Of these, two TECs were considered to have high potential to occur in the project area, namely:

- 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 field assessments.

d. Threatened fauna species listed under the TSC Act recorded or likely to occur

The majority of the project area contains land that has been cleared and does not provide habitat for fauna species listed under the TSC Act. Higher quality fauna habitats are 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 10.5:

- 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.

The exact locations of the Little Eagle, Glossy Black Cockatoo and Gang-gang Cockatoo are not shown in Figure 10.5 in accordance with OEH's sensitive species data policy.

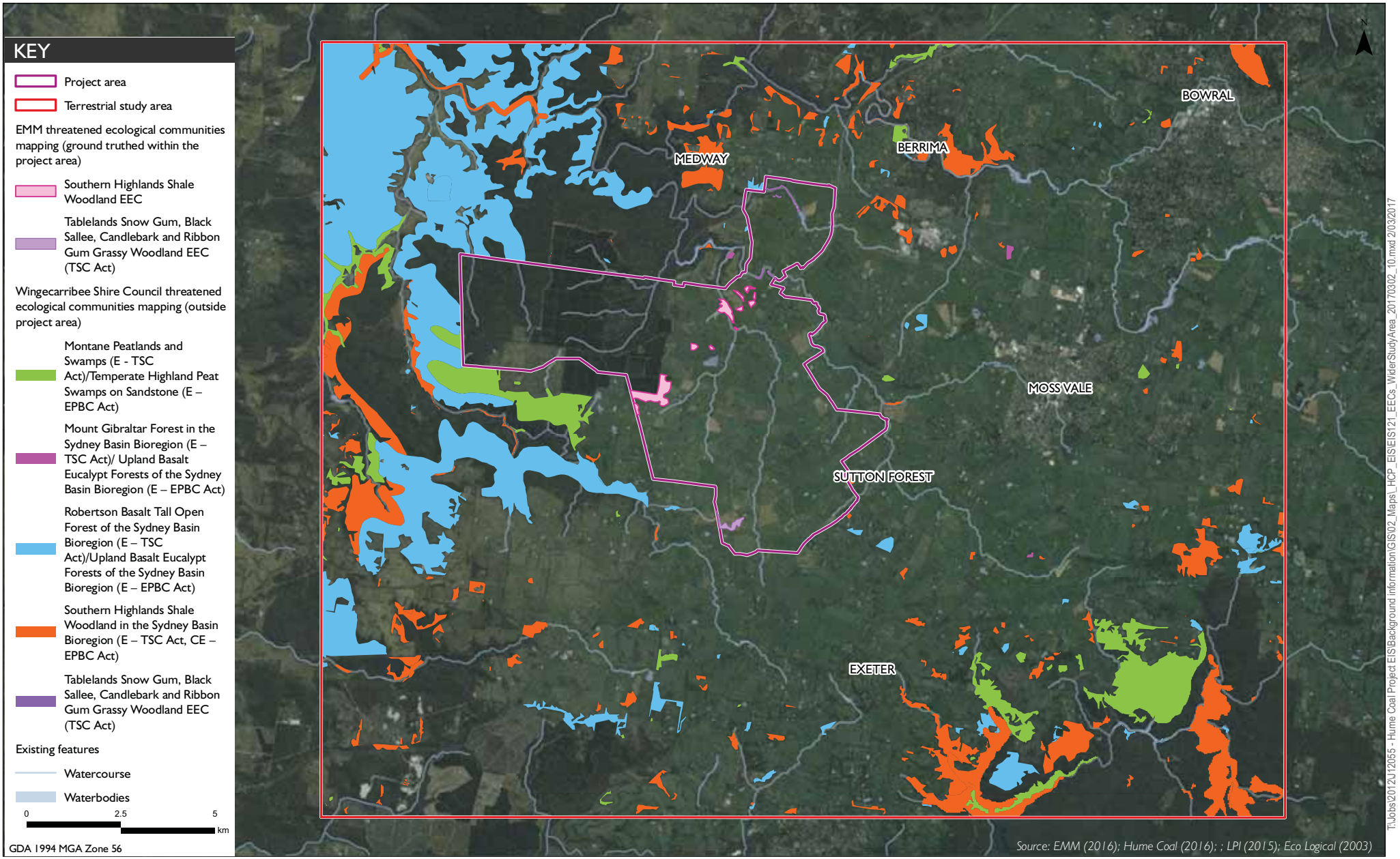
Calls likely to have been from the Masked Owl (*Tyto novaehollandiae*) were recorded in the study area; however the record could not be confirmed. Using the precautionary principle and given the presence of suitable habitat, it is assumed that this species is present.

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.

e. Threatened fauna species listed under the EPBC Act recorded or likely to occur

The likelihood of the occurrence of listed fauna species predicted to occur by the Protected Matters Search Tool was assessed (Appendix E of the BAR). The majority 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 study area, the Koala and Large-eared Pied Bat, are also listed as vulnerable species under the EPBC Act. Native vegetation in the north-west and central northern parts of the project area provides potential habitat for these listed fauna species.



Threatened ecological communities in the project area and terrestrial study area

Hume Coal Project

Environmental Impact Statement

Figure 10.6

ii Study area

a. Native vegetation

Vegetation mapping for the Wingecarribee Biodiversity Strategy (EcoLogical 2003) indicates that 18 native vegetation types are present in the study area outside those mapped in the project area. These are described in the BAR.

b. Threatened flora species and populations

There are a number of threatened plants listed under the TSC Act and EPBC Act which have been identified to occur at Long Swamp and Stingray Swamp, in the south of the study area. These comprise Dwarf Phyllota and Broad-leaved Sally. Paddys River Box is also known to occur in Stingray Swamp and Long Swamp.

c. Threatened ecological communities

The vegetation types mapped in EcoLogical (2003) were reviewed to indicate the threatened ecological communities that may occur in the study area, outside those mapped in the project area. These are shown in Table 10.6.

Table 10.6 Threatened ecological communities in the 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).

d. Threatened and migratory fauna

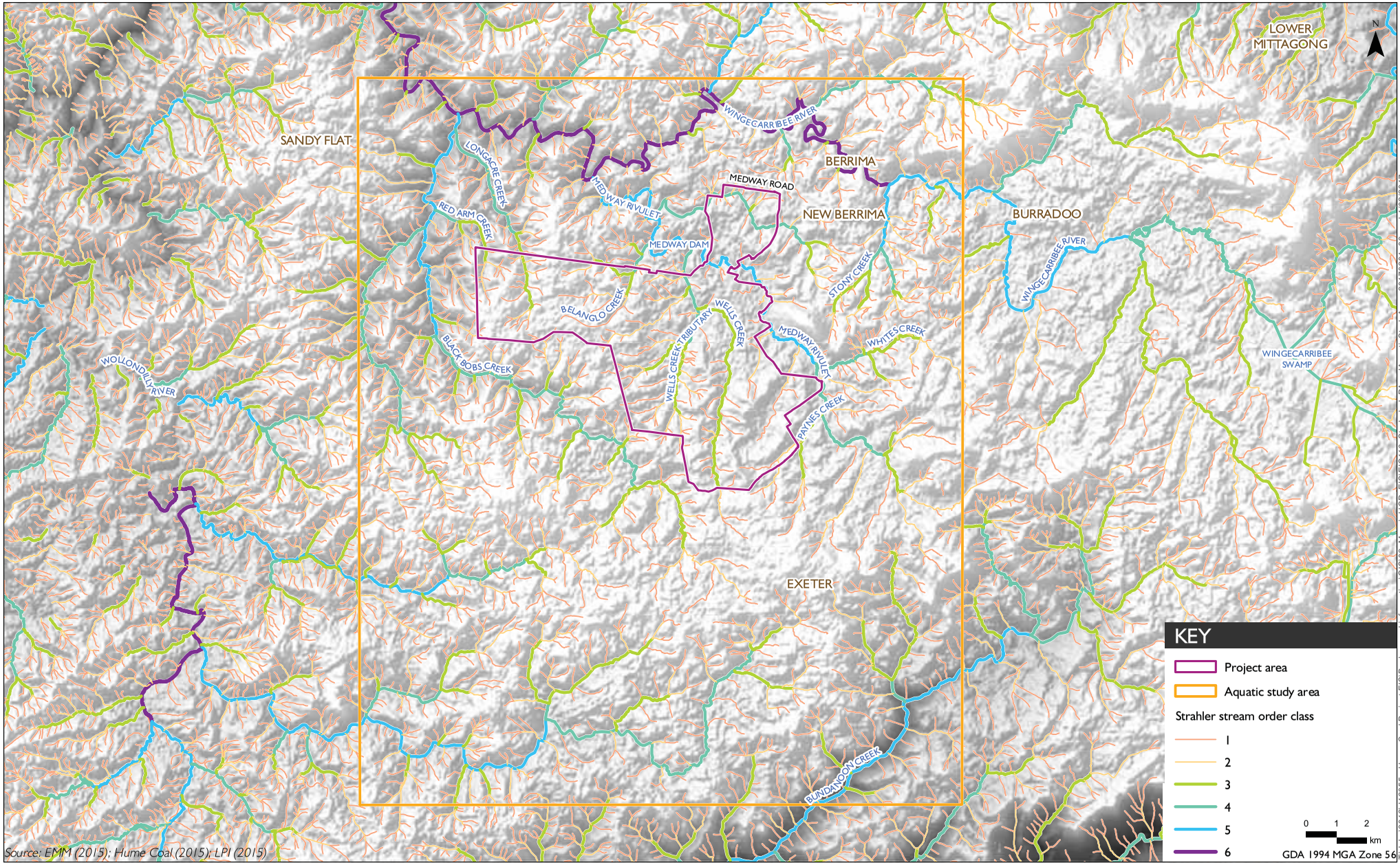
A number of threatened species are known or predicted to occur in Long Swamp and Stingray Swamp (refer to Figure 10.1), comprising:

- insects: Giant Dragonfly (*Petalura gigantea*);
- birds: Australasian Bittern and Australian Painted Snipe;
- Littlejohn's Tree Frog; and
- Koala.

Migratory species comprising Great Egret and Cattle Egret are also predicted to occur in Long Swamp and Stingray Swamp.

e. Aquatic species and habitats

The water quality results were compared against the ANZECC Guidelines trigger values for Slightly – moderately disturbed ecosystems: Upland Rivers (ANZECC/ARMCANZ 2000) (Table 4.7). Exceedances of trigger values indicate poorer surface water quality. Streams and their Strahler order are shown in Figure 10.7.



Stream order in the aquatic study area and surrounds

Hume Coal Project

Environmental Impact Statement

Figure 10.7

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. Dissolved oxygen levels at all but two sites in both seasons were below the guideline ranges.

1,092 individual macroinvertebrates were recorded from the sampled sites over four seasons (autumn and spring 2013, autumn 2014 and spring 2015). The communities were diverse supporting 52 families of macroinvertebrates. The abundance and diversity of macroinvertebrate families varied between season and between sites.

257 individual fish and turtles were recorded from the sites during spring and autumn. 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.

f. Key fish habitat

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.

g. Threatened and protected aquatic species

No state or federally listed species were recorded during the aquatic ecology surveys. There is a low potential for the following to occur at some sites; however, targeted surveys failed to detect these species:

- the threatened Macquarie Perch;
- the Australian Grayling; and
- Adam's Emerald Dragonfly.

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 habitats in the aquatic study area found that its preferred habitat (ie streams with sandy banks required for burrowing) was generally absent.

h. Stygofauna

Three taxa of terrestrial and one aquatic fauna (an ant, springtail and water strider) and one individual of the Syncarida Bathynellidae spp (a crustacean) were recorded.

Bathynellidae spp was recorded in a bore in the southern part of the aquatic study area. 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.

i. Ecosystems potentially using shallow groundwater

A summary of the dependence of potential GDEs in the study area (based on the categories described in Section 10.2.4) is shown in Table 10.7. None of these ecosystems have a facultative (highly dependent) or obligate dependence on groundwater.

Terrestrial vegetation in the 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. Base flow to Medway Rivulet was also 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. Oldbury Creek and Wells Creek are not dependent on groundwater flow from springs above the creeks.

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.

Table 10.7 Dependence of potential GDEs

GDE type[1]	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			

Notes 1. It is noted that aquifers are addressed in the aquatic ecology assessment report (refer to Apendix J of the BAR (Appendix H).

10.3.3 Biodiversity values in the surface infrastructure area

i Overview

As described in Section 10.1.2, the surface infrastructure area has been carefully designed to minimise vegetation disturbance. Accordingly, direct vegetation disturbance is limited to Brittle Gum Scribbly Gum shrubby woodland, which is not a listed community.

There are four vegetation types adjacent to the direct disturbance footprint of the surface infrastructure area (Figure 10.8). 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 10.3.2ic). 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, as shown in Figure 10.8.

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, 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 10.8). Paddys River Box adjacent to the direct disturbance footprint will be protected by fencing, and their condition will be monitored throughout the life of the mine.

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 (Figure 10.8). 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. The credits required to offset the project's direct impacts are summarised in Section 10.6.

ii Vegetation zones

To enable assessment requirements in accordance with the FBA, vegetation zones within the surface infrastructure area were defined.

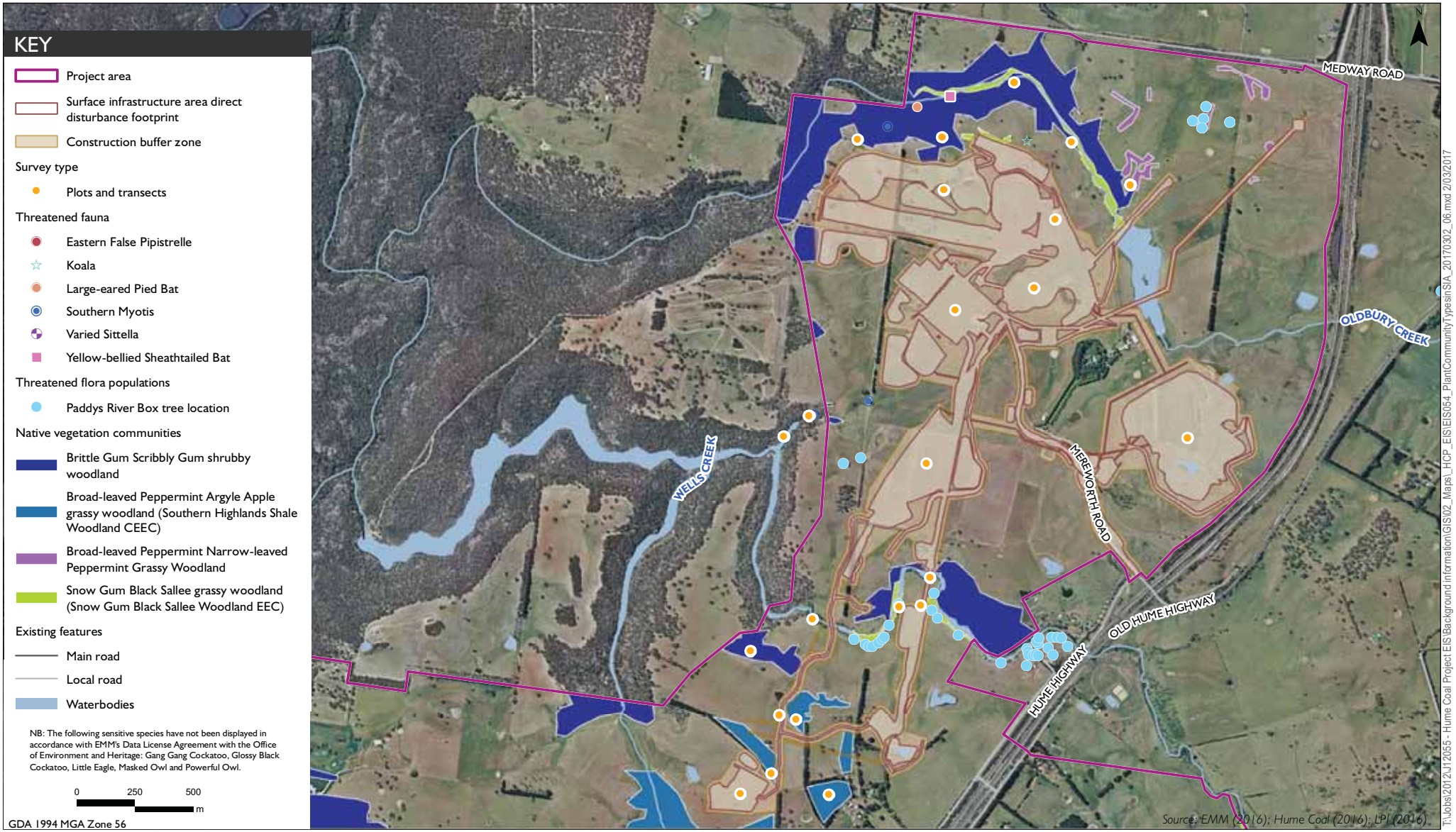
A 'vegetation zone' is defined by OEH (2014) as "a relatively homogenous area of native vegetation on a development site (ie the surface infrastructure area) that is the same PCT and broad condition state". One vegetation zone occurs in the surface infrastructure area. The area for Zone 1 has been derived from the paddock tree calculator (see Section iii below). While Zone 1 is in low condition, its site value is greater than 17 (which is the minimum threshold for which offsets must be provided under the FBA) and therefore offsets are required in accordance with the FBA.

A summary of the vegetation zone is provided in Table 10.8 and mapped on Figure 10.9. All vegetation not mapped on Figure 10.9 has been classified as cleared land which is not required to be offset.

Table 10.8 Vegetation zones in the surface infrastructure area and survey effort by zone

Vegetation zone	Vegetation community	Plant community type	Biometric vegetation type	Condition class	Current site value	Plots/ transects required	Plots/ transects completed	Area (ha)
1	Brittle Gum Scribbly Gum shrubby woodland	PCT 1093	HN570	Low (paddock trees)	36.46	2	2	8.3[1]

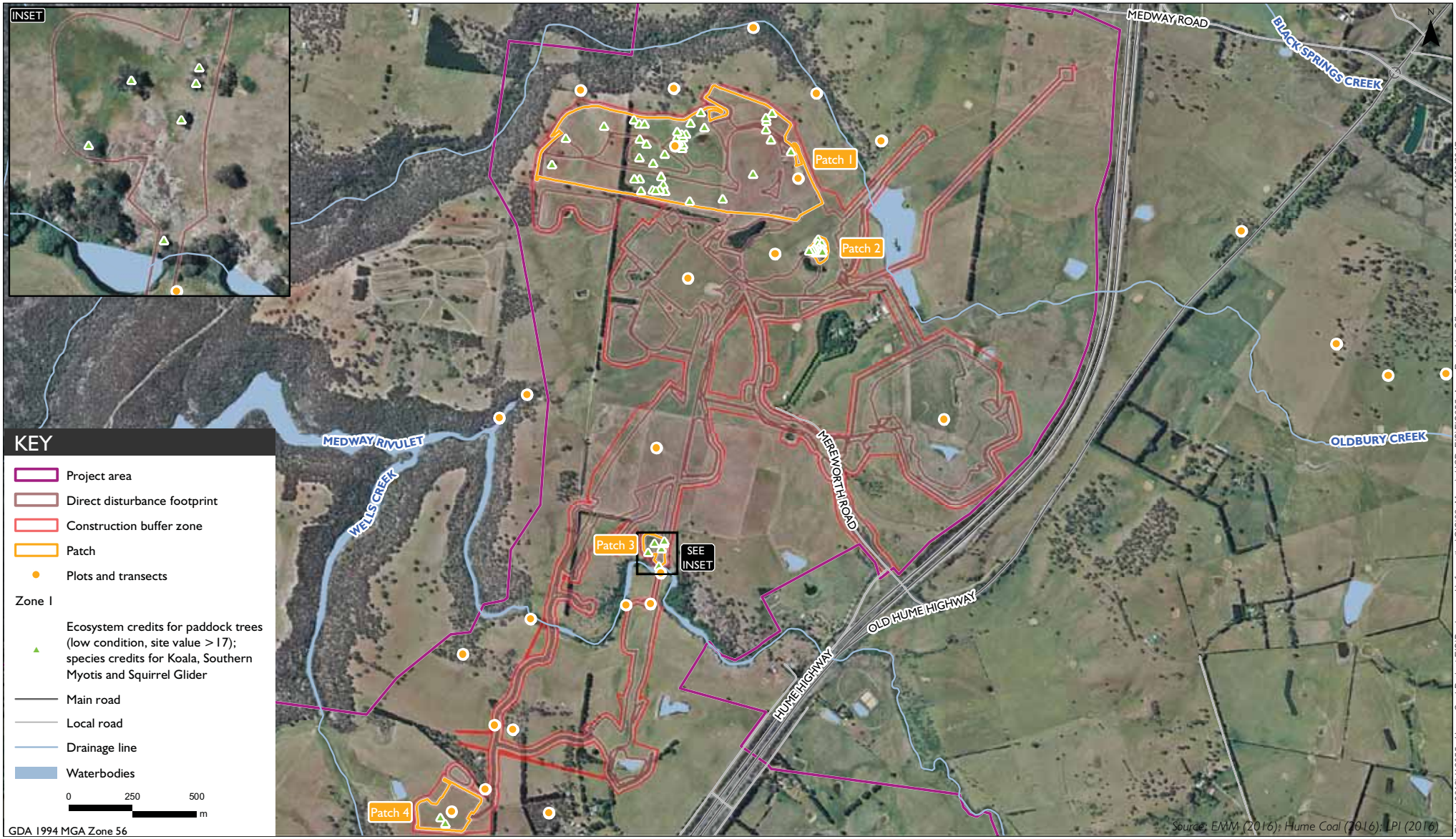
Notes *1. The 8.3 ha represents the effective clearing area calculation provided by the paddock tree calculator. The BioBanking Paddock Tree Calculator is a tool for estimating the percent foliage cover and the area cleared where trees are very sparse and survey data taken from transects and plots does not inform accurate BioBanking calculations (refer to Section 5.2.1 of the biodiversity assessment report).*



Plant community types and threatened species in the surface infrastructure area

Hume Coal Project
Environmental Impact Statement

Figure 10.8



Areas requiring offset - surface infrastructure area

Hume Coal Project
Environmental Impact Statement

Figure 10.9

iii Threatened species

a. Ecosystem credit species predicted to occur

Ecosystem credit species are threatened species predicted in a vegetation zone by the BioBanking Calculator, whose occurrence is strongly influenced by the presence of the PCT to be impacted. The ecosystem credit species predicted by the BioBanking Calculator are listed in Table 10.9.

Ecosystem credit species not predicted by the BioBanking Calculator, although recorded in the surface infrastructure 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 10.9. The predicted species with the highest threatened species offset multiplier is the Powerful Owl, which determines the ecosystem credit requirements for the PCT listed in Table 10.8.

Table 10.9 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 study area.
Eastern Freetail Bat	2.2	0.45	Moderate. This species was recorded in the study area.
Flame Robin	1.3	0.77	Moderate. This species was recorded in the 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 lowest Tg value determines the credit requirements.
Little Eagle	1.4	0.71	High. The species has a large home range and was recorded in the study area.
Little Lorikeet	1.8	0.55	High. The species is highly nomadic and was recorded in the study area.
Masked Owl	3.0	0.33	Moderate. This species was recorded (unconfirmed record) in the study area.
Powerful Owl	3.0	0.33	Moderate. This species was recorded in the study area.
Scarlet Robin	1.3	0.77	Moderate. This species was recorded in the study area.
Turquoise Parrot	1.8	0.55	Moderate. This species was recorded in the study area.
Varied Sittella	1.3	0.77	Moderate. This species was recorded in the 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.*

b. Species credit species predicted to occur

Species credit species are threatened species predicted to occur in a vegetation zone by the BioBanking Calculator, whose occurrence is strongly influenced by the presence of certain habitat types (ie caves, water), and less influenced by the PCT to be impacted. The species credit species predicted by the BioBanking Calculator are listed in Table 10.10.

Additional species credit species recorded in the surface infrastructure area, although not predicted to occur by the BioBanking Calculator, are also listed in Table 10.10. These species have been included in species credit calculations (the Eastern Bentwing Bat, Little Bentwing Bat and Southern Myotis), in accordance with the FBA.

Table 10.10 Species credit species

Species credit species	Survey type	Species recorded?	Species abundance in the project area	Habitat features in surface infrastructure area	Species polygon (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.
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.

Table 10.10 Species credit species

Species credit species	Survey type	Species recorded?	Species abundance in the project area	Habitat features in surface infrastructure area	Species polygon (ie area of habitat impacted)	Can the species withstand further loss?[1]
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.	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.
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.

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

c. 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 in Figure 10.9.

d. 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 10.10).

Areas not requiring offset are shown in Figure 10.10.

e. Aquatic biodiversity

Fish habitats in the surface infrastructure area are summarised in Table 10.11. Two moderate fish habitats are present, comprising SWQ05 on Wells Creek and Habitat C on Medway Rivulet. Aquatic survey locations are shown in Figure 2.3 of the BAR (Appendix H).

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 10.11 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

Note: 1. See Table 2.11 for waterway classification descriptions (DPI 2013b).

Areas not requiring offset - surface infrastructure area

Hume Coal Project
Environmental Impact Statement

Figure 10.10

10.4 Impact avoidance and mitigation

10.4.1 Avoidance and minimisation

i Overview

This section describes the avoidance, minimisation and mitigation strategies applied to the project, in accordance with Chapter 8 of the FBA.

Impacts on biodiversity from an underground mining project can occur as a result of vegetation clearance for surface infrastructure, subsidence related impacts, and groundwater drawdown. As described in Section 10.1.2, Hume Coal undertook an extensive project planning and design phase to avoid and minimise these impacts. Notably, a first workings mining method will be employed with negligible subsidence impacts.

Numerous alternative project layouts were considered during the development of the project through an iterative design process, resulting in the final project design that avoids and minimises impacts on native vegetation and fauna habitat.

ii Surface infrastructure layout

Hume Coal considered a number of options within and adjacent to the project area for the location of the surface infrastructure area.

As part of the evaluation process of alternative surface infrastructure locations, ecologists surveyed proposed infrastructure areas. Areas of potential sensitivity were identified, such as areas containing riparian vegetation, waterways, threatened species and communities, 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 CPP 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 CPP 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 on 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 on an area of Southern Highlands Shale Forest and Woodland south of Medway Rivulet (shown in Figure 10.8), 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 now proposed location in an area of exotic pasture south of the proposed CPP, avoiding all direct impacts to Southern Highlands Shale Woodland, and habitat for several threatened species.

iii 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 impacts or aquatic 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.

iv Groundwater management

Potential groundwater impacts have been minimised through the following actions:

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

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

v Surface water management

The project has been designed to avoid or minimise potential impacts to surface water flow and associated erosion and scour impacts in local streams hence mitigation measures are minimal. 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; and
- the project does not involve any stream diversions (WSP PB 2016c).

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 and SB04 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 (WSP PB 2016c).

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

vi 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 2013b) and *Guidelines for watercourse crossings on waterfront land* (NOW 2012c).

10.4.2 Mitigation

i Construction and operational management plans

A construction environmental management plan (CEMP) and an operational environmental management plan (OEMP) will be prepared for the project, based on the measures provided in Table 10.12. 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 will incorporate the measures listed in Table 10.12.

ii Proposed mitigation measures

The BMP will include measures to mitigate direct and indirect impacts of the project on terrestrial biodiversity. These measures and the timing of their implementation are described in Table 10.12.

Table 10.12 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
	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 disturbance footprint.	Prevention of inadvertent damage to trees	Before the commencement of construction	Hume Coal Environmental Coordinator
	Hollow-bearing trees removed will 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

Table 10.12 Mitigation measures

Impact	Action	Outcome	Timing	Responsibility
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 in the study area 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
Edge effects and fragmentation	Weeds will be managed within the surface infrastructure area. 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
	Waterway crossings will be designed in accordance with *Policy and Guidelines for fish habitat conservation and management* (DPI 2013b) 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

Table 10.12 Mitigation measures

Impact	Action	Outcome	Timing	Responsibility
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 2017).	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 generally 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 CPP from threatened species habitats along Oldbury Creek. Fencing measures will be detailed in the CBMP.	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 2017c).	Maintenance of fish passage and aquatic ecosystem condition	During detailed design and construction	Hume Coal Mine Engineer Hume Coal Environmental Manager
Changes to groundwater regimes	Terrestrial vegetation on Belanglo Creek (approximately 6 ha) and south of Wells Creek (approximately 13 ha) identified in Figure 10.12 and 10.13 will be monitored during extended periods of drought, and an appropriate response determined if the vegetation is found to be in decline, and the decline is attributable to mining.	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

Table 10.12 Mitigation measures

Impact	Action	Outcome	Timing	Responsibility
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 Q 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

10.4.3 Justification for 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 10.12. The avoidance measures incorporated into the design, combined with the proposed mitigation measures, represent the full range of reasonable and feasible measures that can be implemented for the project, which have resulted in minor residual impacts on biodiversity.

The proposed mitigation measures (Table 10.12) and the preparation of a BMP (Section 10.4.2) is designed to mitigate any residual impacts on biodiversity following the implementation of avoidance and minimisation measures (Section 10.4.1). 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 were also 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).

10.5 Impact assessment

This sections discusses the residual impacts of the project after avoidance, minimisation and mitigation measures have been applied.

10.5.1 Surface infrastructure

i Direct impacts from clearing of native vegetation and fauna habitats

The primary direct impact from the project is the clearing of vegetation to enable the construction of surface infrastructure. Careful placement of surface infrastructure has largely avoided the clearing of native vegetation, resulting in a small area of native vegetation to be cleared. The CPP was moved south and will now require the removal of approximately 64 paddock trees (Brittle Gums and Scribbly Gums) underlain by exotic pasture (Figure 10.9).

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 shafts will be located in an area that contains exotic vegetation and therefore native vegetation and threatened species habitats will not be impacted. The construction buffer around the surface infrastructure area also avoids impact on native trees and fauna habitat.

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

ii Changes to stream flow

Infrastructure that crosses streams, including bridges and culverts, has the potential to change the velocity of stream flow. Potential impacts on streamflows from the following proposed infrastructure were assessed (Appendix E):

- 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.

The assessment determined that the potential for stream bank erosion associated with the above is low. 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.

No changes to stream flow are predicted for Wingecarribee River, which contains a large breeding population of the Platypus. No platypus(es) 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.

iii Other direct impacts

Other direct impacts with the potential to occur from surface infrastructure construction are fauna injury and mortality and edge effects and fragmentation.

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. Hume Coal has committed to measures to minimise the risk of fauna injury and mortality during clearing and, therefore, it is assessed that these species will be not be significantly impacted.

The conveyor had potential to fragment 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 conveyor will be raised and the footings will be placed in an area of bare ground, PCT 1093 and Paddys River Box will not be directly impacted.

iv Indirect impacts

In addition to direct impacts of vegetation clearing and habitat loss, the project may have indirect impacts on retained vegetation and, therefore, habitats in and adjacent to the disturbance boundary, including:

- vehicle movements in the construction buffer area;
- erosion and sedimentation;
- introduced species;
- increased noise, dust and light;
- fauna strike; and
- changes to surface hydrology.

Mitigation measures have been devised to minimise adverse impacts from indirect impacts on biodiversity (refer to Table 10.12).

10.5.2 Underground mining

i Subsidence

The mine has been designed to have a maximum vertical subsidence of less than 20 mm. Subsidence less than 20 mm is commonly referred to as 'zero' subsidence as subsidence of this magnitude or less is widely adopted as being imperceptible for all practical purposes because the magnitude of natural, seasonal variations in ground level is commonly greater than 20 mm.

At this level, impacts on surface features are imperceptible or negligible and, therefore, landscape features and associated terrestrial biodiversity will not be adversely impacted.

The subsidence assessment (Appendix L) determined that subsidence will be imperceptible to negligible. Therefore, it is highly unlikely that water course flow and morphology will be impacted by subsidence (as also discussed further in Appendix E).

ii Groundwater dependent ecosystems in the study area

Terrestrial vegetation in the 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 of the biodiversity assessment report.

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).

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

An ecosystem drawdown risk assessment matrix was developed (refer to Figure 10.11) to assess the level of risk to terrestrial vegetation and Long Swamp and Stingray Swamp.

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 on Figure 4.7 of Appendix H) 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 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 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 Long Swamp and Stingray Swamp are discussed in the following sections.

	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
	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

Ecosystem drawdown risk

Figure 10.11 Ecosystem drawdown risk assessment

iii 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.

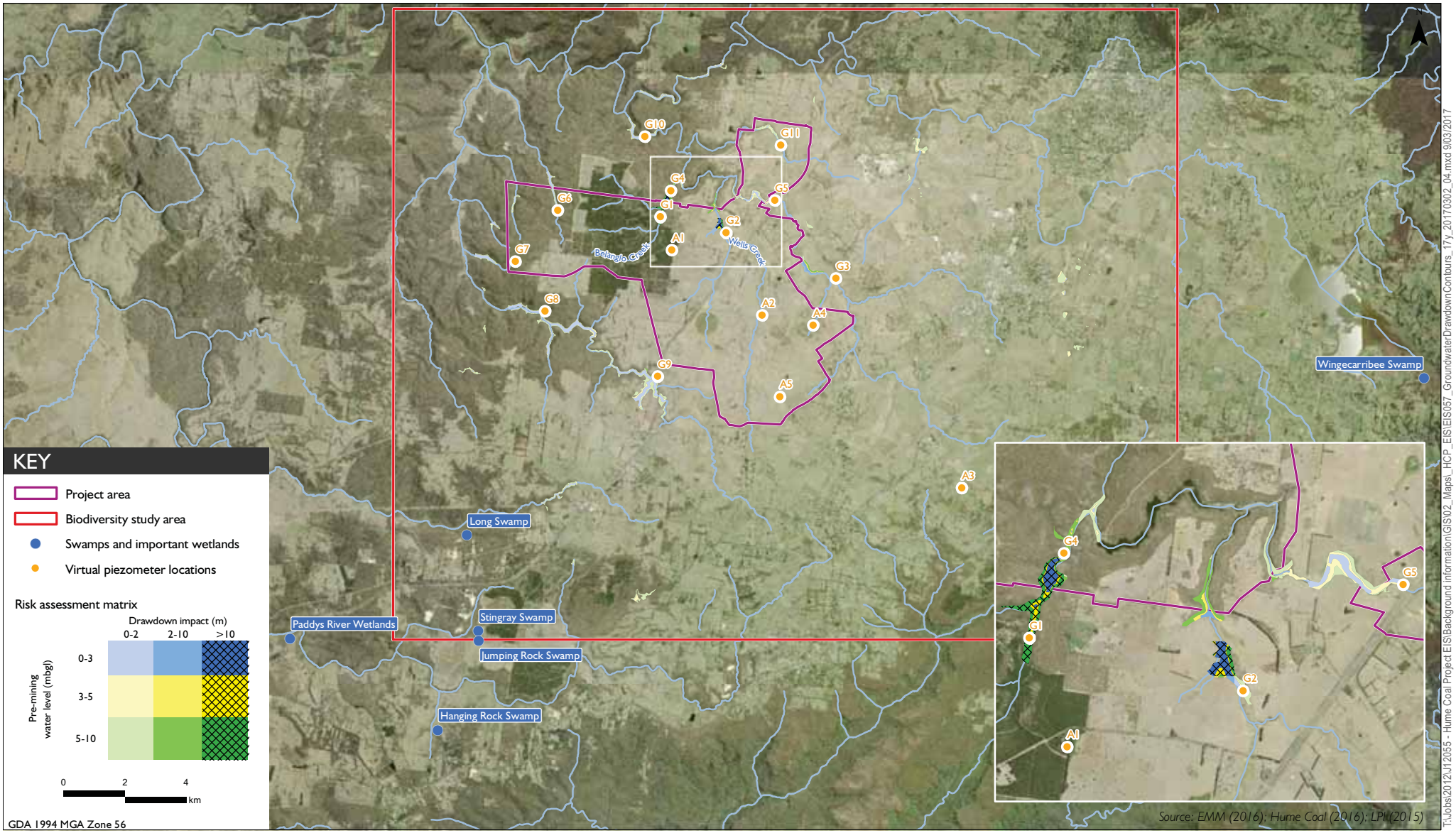
A moderate risk of impact to the ecosystem is expected in areas with a high potential for groundwater interaction (pre-mining water table level is 0-3 mbgl) and greater than 10 m water table drawdown is expected. A moderate risk of impact is also expected in areas with moderate potential for groundwater interaction (pre-mining water table level of 3-5 mbgl) where 2-10 m of drawdown is modelled, as well as in areas 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 in Figures 10.12 and 10.13, which show the modelled drawdown at 17 and 30 years after the commencement of mining. 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 Paddys 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.

The predicted project induced groundwater table drawdown in Year 17 and 30 after the commencement of mining is shown in Figures 10.14 and 10.15 respectively.

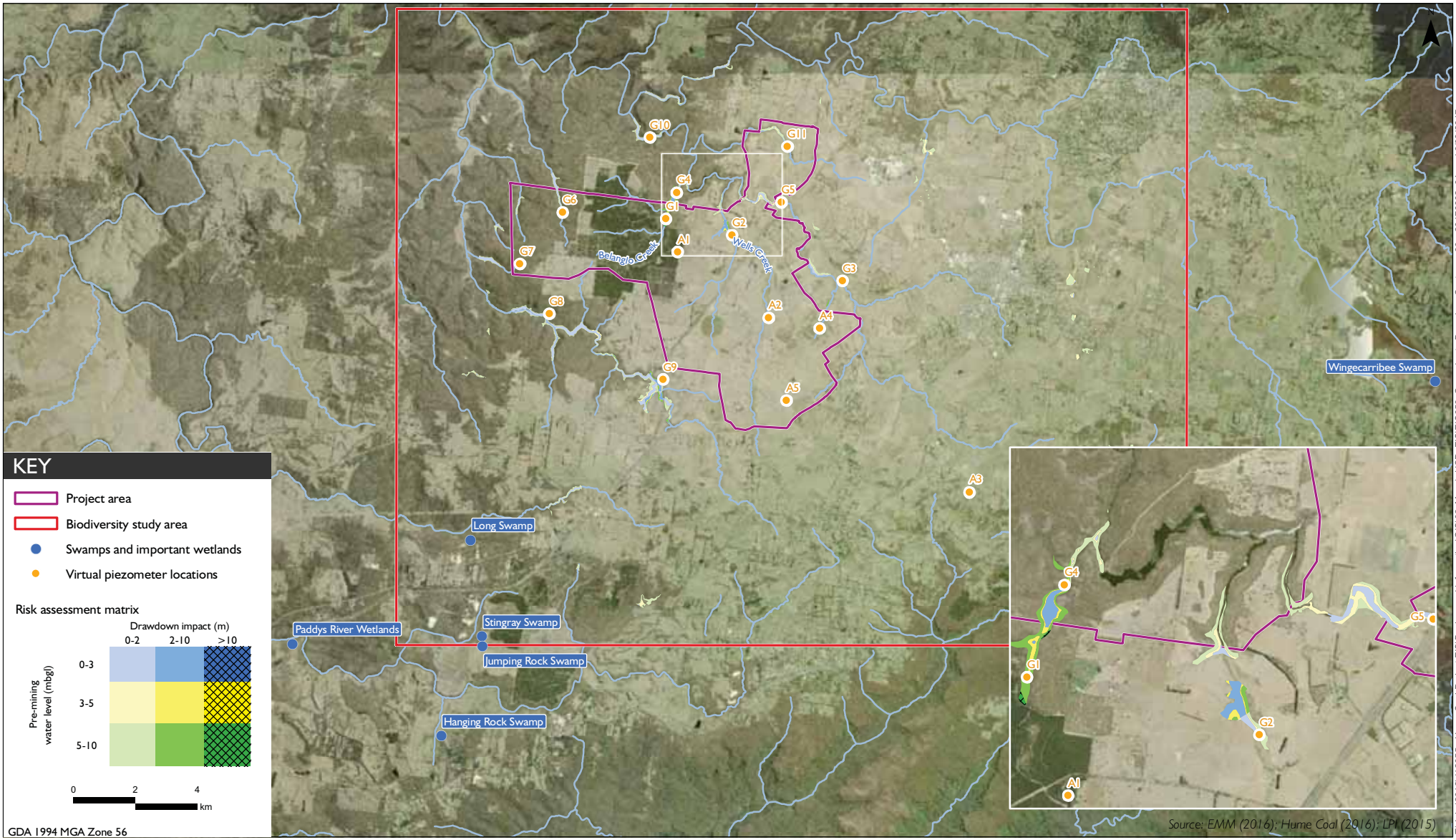


Potential ecosystem impacts - 17 years after start of mining

Hume Coal Project

Environmental Impact Statement

Figure 10.12

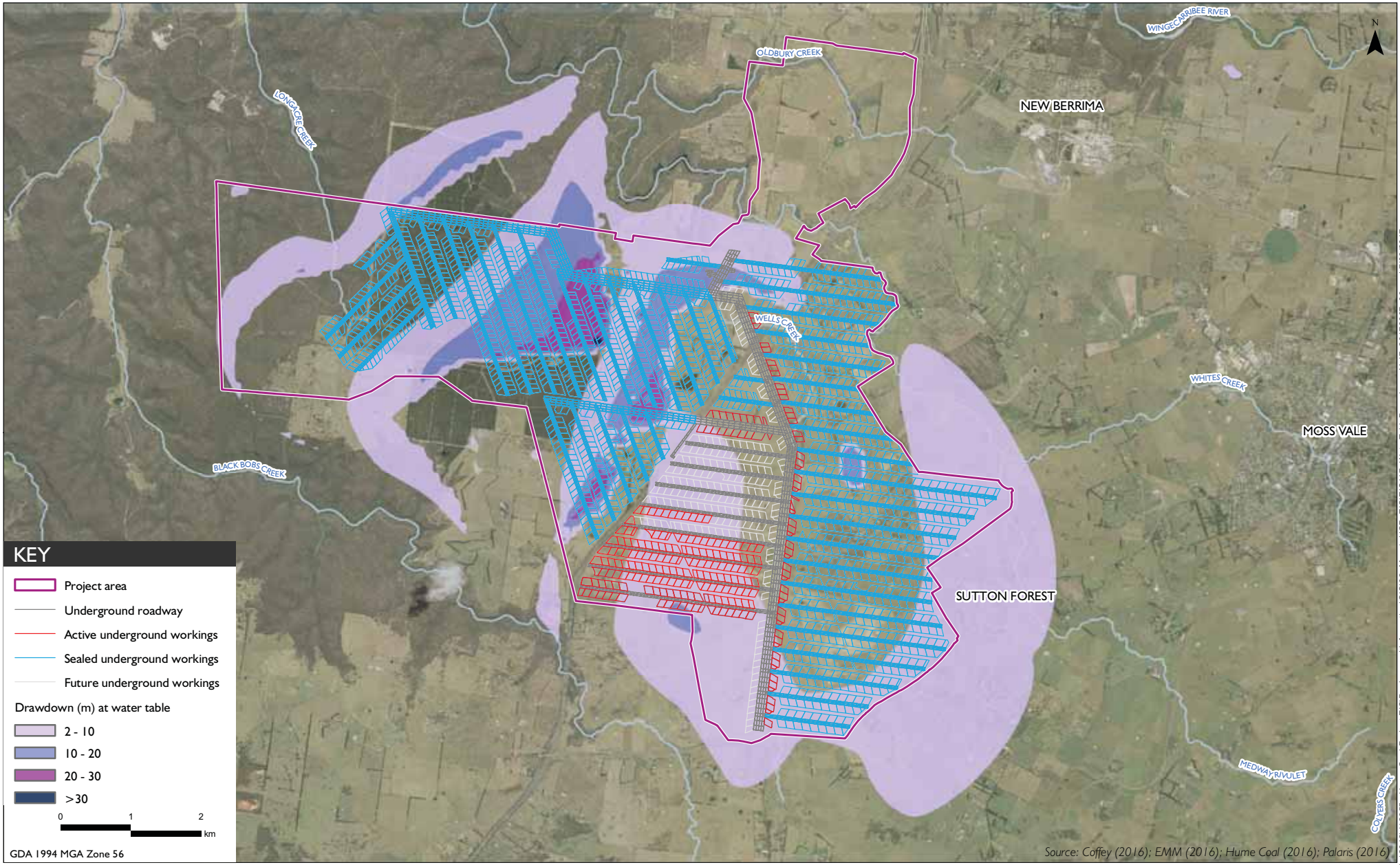


Potential ecosystem impacts - 30 years after start of mining

Hume Coal Project

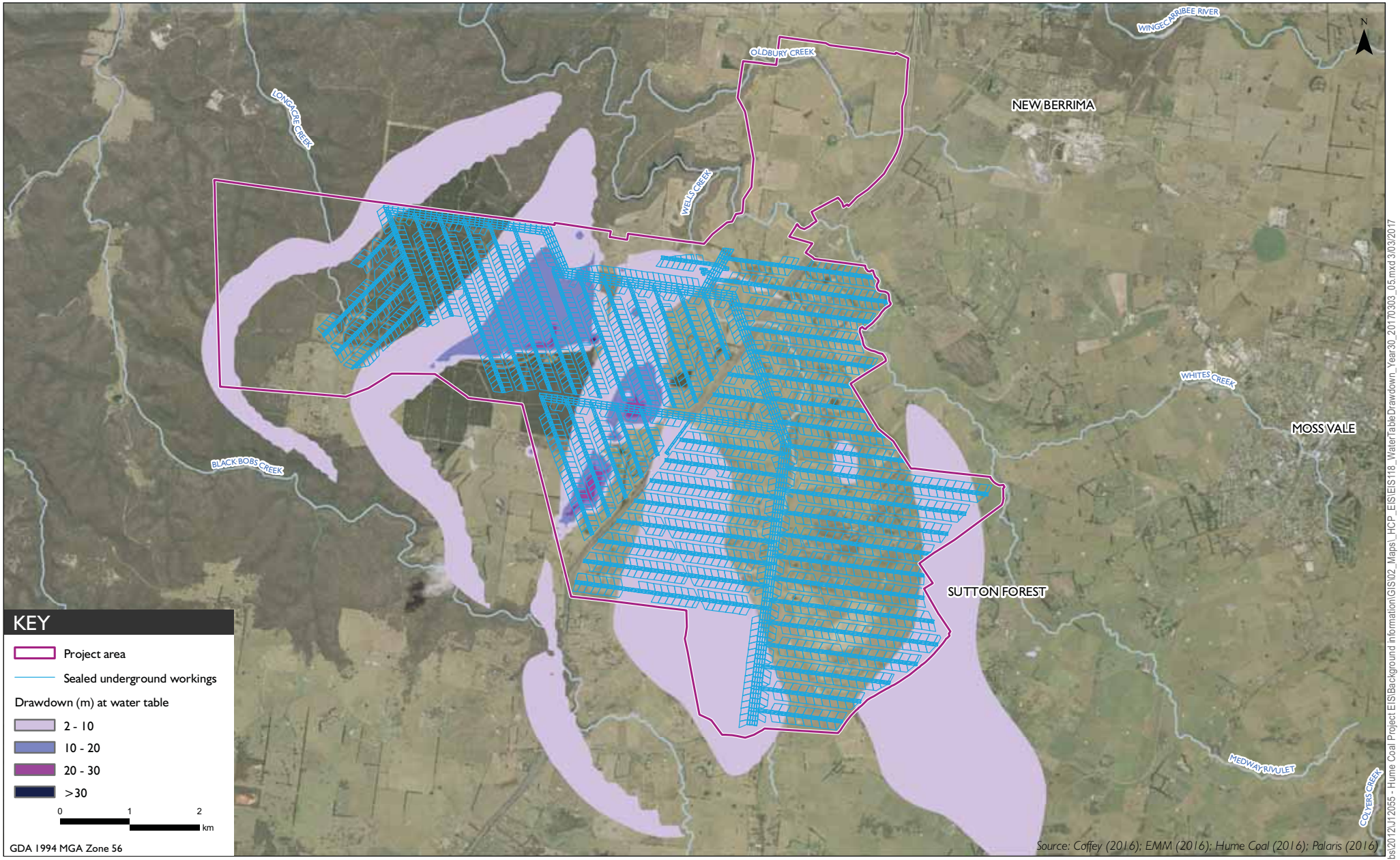
Environmental Impact Statement

Figure 10.13



Project induced groundwater table drawdown at Year 17 of mining

Hume Coal Project
Environmental Impact Statement
Figure 10.14



Project induced water table drawdown at Year 30 of mining

Hume Coal Project
Environmental Impact Statement
Figure 10.15

Hydrographs from virtual piezometers (ie a simulated bore at which drawdown is modelled) 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 10.12 and Figure 10.13. Hydrographs are presented in Figure 10.16.

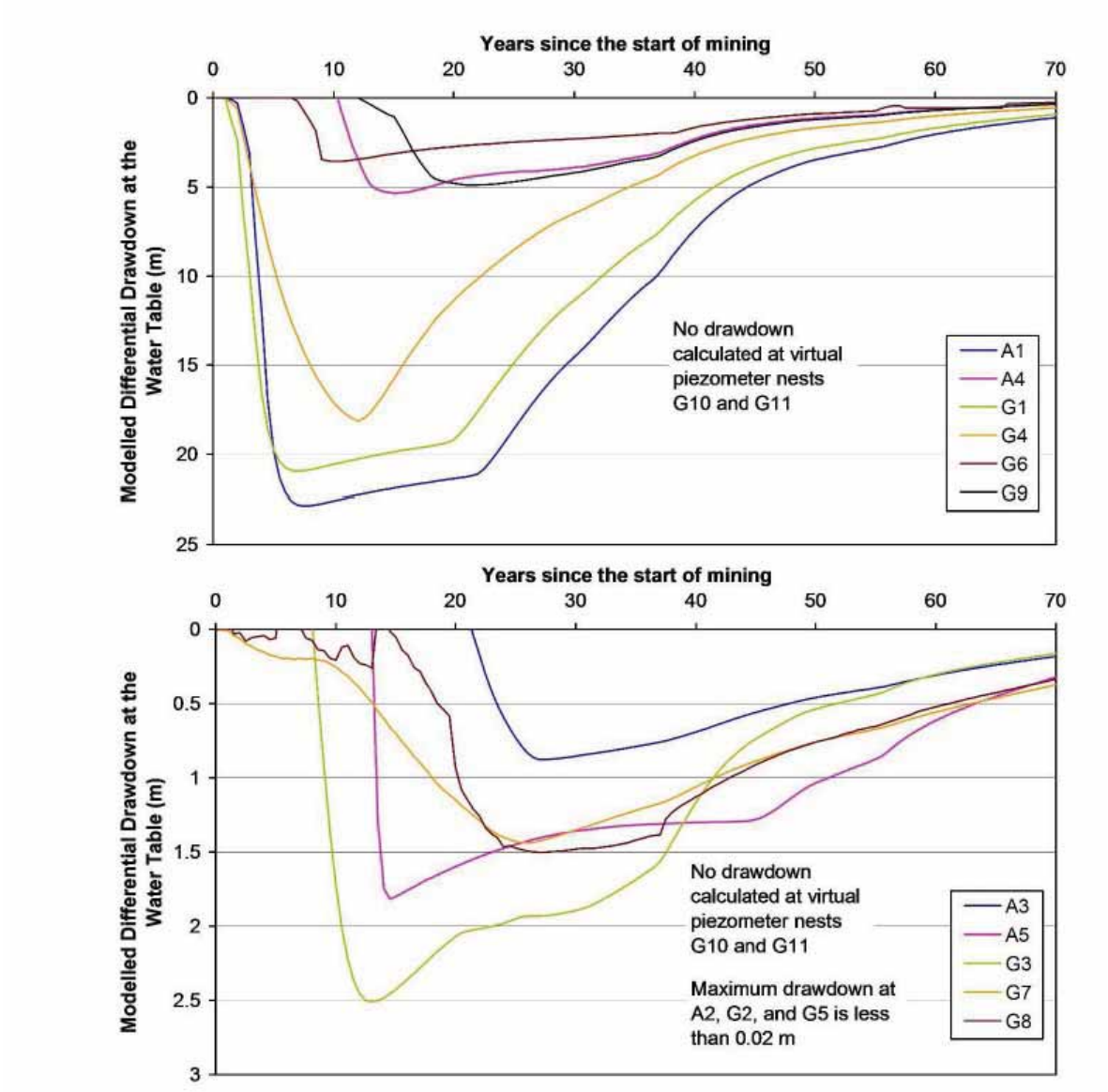


Figure 10.16 Differential drawdown at the water table at virtual piezometer sites (source: Water Assessment, Appendix E)

Drawdown of greater than 10 mbgl is shown at virtual piezometers A1, G1 and G4, on Belanglo Creek. Areas with a shallow water table that are predicted to have water table drawdown of >10 mbgl are identified as downstream Belanglo Creek (in the area of G1 and G4) and downstream Wells Creek (north of virtual piezometer G2) (refer figure 10.12). These areas have been investigated further to identify if potential GDEs exist there that may be affected.

There is a patch of Southern Highlands Shale Woodland CEEC on Wells Creek, and G1 and G4 are located on Belanglo Creek, which contains known habitat for the Koala and potential habitat for the Large-eared Pied Bat, Southern Myotis and Yelow-bellied Sheathtail Bat. Vitrual piezometer A1, south-east of G1, is not located in an area with a shallow water table, and therefore is not assessed as a potential GDE area.

At these virtual piezometers, water table 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 G1.

The risk of drawdown impact in the ecosystems identified in Figure 10.12 and Figure 10.13 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 10.4.2 for terrestrial vegetation in the event of prolonged drought during mining.

a. Baseflow

Changes to stream baseflow in the project area were assessed for threatened fauna species that may depend on drainage lines. As reported in Chapter 7, loss of stream flow resulting from base flow interception under the project will be imperceptible. Therefore, this process will not impact on threatened fauna species.

A maximum base flow reduction of 6.8% is predicted in the Lower Wingecarribee River, which according to Grant (2006) contains a large breeding population of Platypus. Baseflow only contributes around 13% of total flow in the Lower Wingecarribee 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 7.13). Accordingly, it follows that impacts on water and habitat availability on the Platypus breeding population will also be negligible.

b. Long Swamp and Stingray Swamp

Temperate Highland Peat Swamps on Sandstone, as occurs at Long Swamp and Stingray Swamp, 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 water table and are usually connected to a shallow perched aquifer in the underlying sandstone. Headwater swamps (ie Stingray Swamp) are unlikely to be connected to the water table as they occur in flat terrain in elevated topographies where regional groundwater is deep and perched aquifers are unlikely to be intersected by the swamp. Accordingly, the dominant water source for headwater swamps is from rainfall and surface runoff. Figure 10.12 and Figure 10.13 show a low to moderate drawdown risk in the upper reaches of Stingray Swamp. However, this drawdown is reflective of the shallow water table in this area which is unlikely to be connected to the perched aquifers that provide water to the swamp. As the water table is unlikely to be connected to the perched aquifers 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 will 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 may represent a valley infill swamp. Valley infill swamps are fed to some extent by perched aquifer 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, the swamp is outside the maximum drawdown footprint at Year 17 of mining (Figure 10.14), and therefore perched aquifers supplying water to the swamp would not be directly impacted. Long Swamp would also access water from rainfall and runoff. As rainfall and runoff will not be impacted by the project, water availability from these sources will not be impacted. Therefore, it follows that Temperate Highland Peat Swamps and the threatened species it supports at Long Swamp will not be impacted by the project.

c. Groundwater systems

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 may be attributable to the absence of alluvium, with which Stygofauna are most commonly associated.

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.

10.5.3 Matters requiring 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 identified impacts to Black Gum, a threatened species and population in the Wingecarribee LGA, as a matter for further consideration in the BAR.

There are eight records of Black Gum in the study area, although none in the surface infrastructure area (see Figure 10.17). 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 of the FBA.

Black Gum records in the terrestrial study area

Hume Coal Project
Environmental Impact Statement
Figure 10.17

10.5.4 Summary of potential impacts on threatened species and communities

The ecosystem and species credit species recorded or predicted to occur within or adjacent to the surface infrastructure area have been assessed in Section 5.3 of the BAR (Appendix H). BioBanking calculations have been completed for these ecosystem and species credit species, which are presented in Section 10.6. Accordingly, further impact assessment has not been conducted for these species.

i Potential impacts on MNES

a. Listed species and communities

The biodiversity assessment report concluded that threatened and migratory species recorded outside the areas of impact, which comprise the surface infrastructure areas and groundwater dependent ecosystems potentially impacted during periods of prolonged drought, will not be impacted by the project.

Assessments of significance were completed for EPBC Act listed threatened and migratory species relevant to the surface infrastructure area and study area. 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. Assessments of significance were also completed to assess indirect groundwater-related impacts on threatened species and communities associated with Long Swamp and Stingray Swamp in the study area, 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.

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

b. Nationally important wetlands

Paddys 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 study area. These swamps are outside the zone of influence of potential groundwater impacts (Figure 10.12 and Figure 10.13), and therefore will not be impacted.

As they are located in the study area, impacts on Long Swamp and Stingray Swamp and the listed community and species they support has been assessed in Section 10.5.2 iii b, above. An assessment of significance (Appendix G of the BAR) 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.

10.5.5 Cumulative impacts

An assessment of cumulative biodiversity impacts from the project together with the proposed Berrima Rail Project, new Berrima Clay/Shale Quarry, Green Valley Sand Quarry, and Sutton Forest Quarry, was completed for the relevant threatened species and communities.

No cumulative impacts from the project were identified with the exception of minor cumulative impacts from the proposed Berrima Rail Project and the Green Valley Sand Quarry. Species credits have been generated for the Squirrel Glider habitat for both projects (together with the Hume Coal Project), and appropriate offsets will be provided to offset the minor cumulative impact to their potential habitat.

Cumulative impacts on aquatic ecosystems were also considered for the Hume Coal Project and Berrima Rail Project. It was concluded that the impact on flow, bed and bank stability associated with the Hume Coal 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 (as discussed in detail in the Water AssessmentReport , refer to Appendix E). 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.

10.6 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.

10.6.1 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, providing for a net positive biodiversity outcome. 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 potential impacts on biodiversity. These are described in the following sections with the full BioBanking Credit Report given in the biodiversity assessment report.

i Ecosystem credits

The vegetation zone identified within the surface infrastructure area had a current site value score of >17 (Figure 10.9). Several ecosystem and species credit species were identified as having a moderate to high likelihood in the surface infrastructure area (Section 10.3.3 iii). A total of 101 ecosystem credits are required to compensate for the project's impacts on vegetation and threatened species associated with the PCT as shown in Table 10.13.

Table 10.13 Ecosystem credits required

Vegetation zone	PCT	Area (ha)[1]	TEC?	Loss in site value score	Future site value score	Ecosystem credit species with the highest multiplier	Ecosystem credits required to offset impact
1	1093 (low)	8.3	No	36.46	0	-	101

Note: 1. Based on an effective clearing area of 8.3 ha.

ii Species credits

Seven species credit species have a moderate to high likelihood of occurring in the surface infrastructure area. A total of 582 species credits are required to offset the project's potential impacts (Table 10.14).

Table 10.14 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**

10.7 Biodiversity offset strategy

In accordance with the FBA, the project requires 101 ecosystem credits and 582 species credits to offset the project's impacts on biodiversity.

10.7.1 Strategy

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

1. dentifying 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 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 10.15.

Table 10.15 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 of the BAR). 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 10.16 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 10.16 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) is not possible, 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 project could pay into the BioBanking Trust Fund (Option 4).

Investigations will continue to secure a suitable offset for the project. Hume Coal will prepare a Biodiversity Offset Package in consultation with OEH and DP&E, and will submit the draft to the Secretary for approval within 12 months of development consent being granted.

10.7.2 Offset security

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

10.8 Conclusions

A BAR was prepared to address the biodiversity-related SEARs, agency requirements and supplementary SEARs for the project. The study was conducted at multiple spatial scales to meet these SEARs, and 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 area to accurately assess ecological constraints to underground mining.

Extensive ecological field surveys were completed between 2012 and 2016 that have resulted in detailed information on the native vegetation, threatened species, populations, communities and their habitats in the project area. This detailed information has informed the selection of a non-caving mining method that has negligible surface impacts, and an iterative design process that has minor residual impacts on native vegetation, threatened species, populations, communities and their habitats. The leading practices adopted by Hume Coal are consistent with the requirements of the FBA, in demonstrating the design measures taken to avoid and minimise most biodiversity impacts and the offsets proposed to compensate for the minor residual impacts.

An assessment of potential groundwater dependent ecosystems was undertaken by combining ecological, surface water and groundwater datasets. This approach resulted in a dynamic and accurate assessment of underground mining impacts on GDEs 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 and enable the project to have a net positive effect on biodiversity. The project requires 101 ecosystem credits for the removal of vegetation and ecosystem credit species habitats, and a total of 582 species credits. A biodiversity offset strategy has been proposed to source offset areas containing the required ecosystem and species credits, and will be finalised into a biodiversity offset package within 12 months of development consent. Design measures will be implemented such that fish passage is maintained, and appropriate scour protection is provided.

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.

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. Platypus habitat was found to be absent from the project area and therefore they will not be impacted by any changes to streamflow or surface hydrology resulting from the project. The breeding population of Platypus on the Wingecarribee River will not be impacted by changes to base flow as a result of the project, as percentage loss of total stream flow as a result of baseflow reduction in the lower Wingecarribee (0.8%) and its tributaries can be assumed to be negligible.