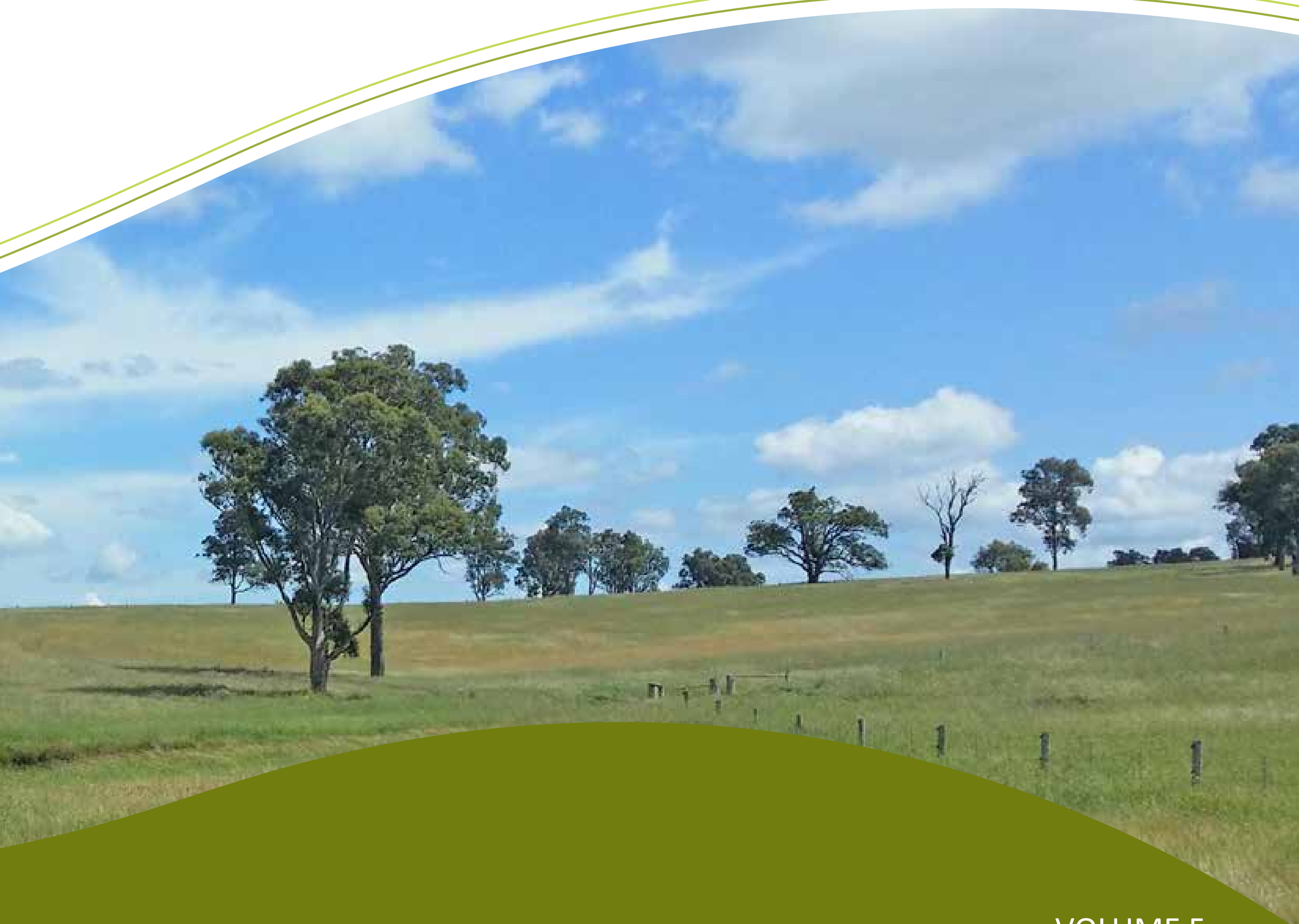


VOLUME 5

Hume Coal Project

Environmental Impact Statement

Appendices F and G

Prepared for Hume Coal Pty Limited
March 2017

EMM

Appendix F

Soil and Land Assessment Report

www.humecoal.com.au

Hume Coal Project

Environment Impact Statement | Appendix F | Soils and Land Assessment Report

Prepared for Hume Coal Pty Limited | 13 Macrh 2017

Hume Coal Project

Environmental Impact Statement | Appendix F
| Soil and Land Assessment Report

Prepared for Hume Coal Pty Limited | 13 March 2017

Ground Floor, Suite 01, 20 Chandos Street
St Leonards, NSW, 2065

T+61 2 9493 9500
F+61 2 9493 9599
Einfo@emmconsulting.com.au

www.emmconsulting.com.au

Hume Coal Project

Final

Report J12055RP1 | Prepared for Hume Coal Pty Limited | 13 March 2017

Prepared by	**Celeste Ellice**	Approved by	**Timothy Rohde**
Position	Senior Environmental Scientist	Position	Associate – Land capability and rehabilitation services manager
Signature		Signature	
Date	13 March 2017	Date	13 March 2017

Document Control

Version	Date	Prepared by	Reviewed by
1	24 Feb 2016	C Ellice	T Rohde
2	19 September 2016	C Ellice	N. Armit/T. Rohde
3	13 October 2016	C. Ellice	N. Armit
4	24 November 2016	M. Roberts	M. Roberts
5	13 March 2017	M. Roberts	M. Roberts

EMM

T +61 (0)2 9493 9500 | F +61 (0)2 9493 9599

Ground Floor | Suite 01 | 20 Chandos Street | St Leonards | New South Wales | 2065 | Australia

www.emmconsulting.com.au

Executive Summary

This Soil and Land Assessment forms part of the environmental impact statement to support a development application for the Hume Coal Project (the project); for which approval is sought under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979.*

A detailed soil survey to identify the soils in the Hume Coal Project area (5,051 ha) was carried out, and included field assessment and laboratory analysis. A total of 246 sites were surveyed within and immediately adjacent to the project area and an average survey density of about one site per 20.5 ha was achieved. The soil survey identified five major soil types within the project area. The soil types identified and their relative distribution are: Dystrophic Yellow Kandosol (61%), Lithic Leptic Rudosol (17%), Paralithic Leptic Tenosol (14%), Kandosolic Redoxic Hydrosol (5%), and Eutrophic Grey Dermosol (3%).

The Dystrophic Yellow Kandosol soil unit occurs on all slopes and crests of low rolling hills on shale surface geology in the project area. The soils are lacking strong texture contrast with silty clay loams over light clays, transitioning to medium clays at depth. The soil surface is mostly firm when dry and without surface coarse fragments. The Dystrophic Yellow Kandosol can be strongly acidic in the A1 horizon with pH values ranging from 3.8 to 6.2. The Dystrophic Yellow Kandosol soils are slightly sodic and have the potential to be subject to erosion, particularly on a slope. Land within the project area that is characterised by this soil type is extensively cleared primarily for grazing of improved pastures and pine forestry.

The Lithic Leptic Rudosol is a shallow soil that occurs on the plateaus, scarps and benches of steep hills on Hawkesbury Sandstone (sandstone-quartz and shale). Slopes vary from very gently inclined on the plateaus to steeply inclined on scarps with an average gradient of around 17%, most commonly found within Belanglo State Forest. Lithic Leptic Rudosol soils are shallow and weakly developed sands (most commonly clayey sands) to a depth of approximately 0.18 m over weakly to highly weathered sandstone. The soil surface is loose with common surface coarse fragments and rock outcrops. Lithic Leptic Rudosol is very strongly acidic throughout the profile and is outside the desirable range for agriculture throughout most of the profile. Within the project area, common land uses on this soil type are low intensity grazing on native pastures and forestry.

The Paralithic Leptic Tenosol soil unit occurs on rises and low hills on the Hawkesbury Sandstone formation (sandstone-quartz) and less commonly on depositional foot slopes on shale geology. Their location is independent of elevation, with Tenosols just as likely to be present on low gradient hilltops as in stable low lying areas. Within the project area, they are most commonly found within and immediately surrounding the Belanglo State Forest. The Paralithic Leptic Tenosols soils are weakly developed with a slight increase in clay content and lightening of soil colour with depth. They are typically sandy in the A1 horizon and the A2 horizon is a sandy loam. Paralithic Leptic Tenosols are typically extremely acidic, highly permeable, rapidly drained and non-saline. Within the project area, land use on this soil type is typically for native and pine forestry, with low intensity grazing in some locations.

The Kandosolic Redoxic Hydrosol is limited to drainage depressions and associated floodplains that experience regular inundation. This soil unit is spread throughout the project area and is directly associated with drainage lines and water bodies. Kandosolic Redoxic Hydrosols are weakly to moderately developed, with variable textures and colour grades depending on the localised site morphology. A horizons are silty clay loam to light clay grading with depth towards medium to heavy clay B horizons. Kandosolic Redoxic Hydrosol have moderately low fertility, are strongly acidic, slowly permeable, poorly drained, sodic in the B horizon and are moderately saline in the A horizon. The soils in this soil unit are therefore generally unsuitable for cultivation, and restricted to grazing. Within the project area, land use on this soil type is generally for improved and native pastures.

Eutrophic Grey Dermosols occur on gently to moderately inclined rolling low hills to rolling hills on small, randomly distributed, isolated basalt intrusions. Eutrophic Grey Dermosol soil lacks strong texture contrast and has increasing clay content with depth. A horizons are typically greyish brown silty loam over grey medium to heavy clay B horizons. Eutrophic Grey Dermosols are of moderately high fertility, moderately permeable, poorly drained and have moderate to low salinity. They have sodic B horizons and very strongly acidic A horizons. Within the project area, land use on this soil type is for grazing of native and improved pastures.

A detailed Biophysical strategic agricultural land (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) (interim protocol). 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 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. A Site Verification Certificate (SVC) application was lodged on 17th August 2015 and issued on 22 April 2016.

An assessment of the land and soil capability (LSC) classes of the project area was undertaken in accordance with the requirements of the *Land and soil capability assessment scheme* (OEH 2012). The assessment used the information collected during the site soil survey and supplemented this with information gathered during the desktop assessment. The LSC assessment mapped 58% of the project area as moderate (Class 4 – 44%) to moderate-low (Class 5 – 14%) capability land. This means that the land has moderate to high limitations for high – impact land uses, which may restrict cropping, high intensity grazing and horticulture (OEH 2012). These limitations can be managed with the implementation of suitable soil conservation measures.

Low capability land (Class 6) was mapped over 32% of the project area, which is land suitable for a limited set of land uses such as grazing, forestry and nature conservation. Very low capability land (Class 7) is mapped across 6% of the project area, suitable for selective forestry and nature conservation.

High capability land (Class 3) is mapped in 3% of the project area. None of the individual areas mapped as Class 3 are greater than 20 ha. OEH state that 20 ha is the minimum area required for commercial food production and therefore, use this as a requirement for defining BSAL in the interim protocol (DP&E 2015).

Due to the underground nature and first workings coal extraction method to be employed, impacts to soil resources are not expected to be significant during the operational phases, as only very localised land clearing will occur and subsidence will be negligible. The project's potential impacts on soil resources are associated with temporary loss of land due to construction and operation of mine infrastructure (117 ha). This area represents 2.3% of the total project area.

The majority of the proposed surface infrastructure area is positioned over one soil type, Dystrophic Yellow Kandosol soils (94.3%). Small patches of Kandosolic Redoxic Hydrosol (3.1%) have been mapped in the disturbance footprint. The conveyor corridor crosses Oldbury Creek where it is expected to encounter Kandosolic Redoxic Hydrosol, or very wet soils. These waterlogged soils are not suitable for rehabilitation purposes. The rest of the disturbed soils are mapped as Lithic Leptic Rudosol (0.3%), Paralithic Leptic Tenosol (1.4%), and Eutrophic Grey Dermosol (0.9%).

Potential impacts to land and soil resources from the proposed surface infrastructure will be managed through appropriate mitigation techniques aimed at returning the site to a land use similar to the pre-existing land use of grazing. The topsoils of the area to be disturbed will be stripped (approximately 0.3m deep) prior to construction and stockpiled for use in later rehabilitation. The soil stripping procedure has been designed to maximise the salvage of suitable materials so pastures can be reinstated to a condition that will support appropriate livestock carrying densities. These measures will be consistent with leading practice and incorporate the full range of reasonable and feasible mitigation methods for soil stripping, with the goal of minimising the degradation of soil nutrients and micro-organisms. Topsoil and subsoil will be stockpiled, with stockpiles designed and located to prevent contamination, development of anaerobic conditions, and to avoid erosion and dust generation. Stockpiles to be in place for the long term (ie throughout the operational life of the mine) will be seeded with grasses so that they remain stable and be regularly inspected for weeds.

Post-mining, the land and soil capability class for the vast majority of the project area (ie 4,993 ha or 99%) will remain unchanged due to the underground nature of the project and the first workings mining method, with negligible associated subsidence, to be employed. Of the 117 ha to be disturbed, there will be a change to the land and soil capability class over 58 ha. 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 because the soil depth will be 0.3 m as the replaced topsoil will overlie re-profiled fill materials. However, Class 6 land will still be suitable for grazing and improved pasture, allowing the continuation of an agricultural land-use post-mining.

Table of contents

Table of contents *(Cont'd)*

Table of contents *(Cont'd)*

Appendices

Tables

Tables

Figures

Photographs

1 Introduction

1.1 Overview

Hume Coal Pty Limited (Hume Coal) is seeking State significant development consent to construct and operate an underground coal mine and associated mine infrastructure (the 'Hume Coal Project') in the Southern Coalfield of New South Wales (NSW). Hume Coal holds exploration Authorisation 349 (A349) to the west of Moss Vale, in the Wingecarribee local government area (LGA). The underground mine will be developed within part of A349 and associated surface facilities will be developed immediately north of A349. The project area and its regional and local setting are shown in Figures 1.1 and 1.2.

The project has been developed following several years of technical investigations to define the mineable resource and identify and address environmental and other constraints. Low impact mining methods will be used which will have negligible subsidence impacts and thereby protect the overlying aquifer and surface features and allow existing land uses to continue at the surface. Post-mining, the mine infrastructure will be decommissioned and these areas rehabilitated to a state where they can support land uses similar to the current land uses.

Approval for the Hume Coal Project is being sought under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). An environmental impact statement (EIS) is a requirement of the approval processes. This Land and Soil Assessment forms part of the EIS.

1.2 Project description

The project involves developing and operating an underground coal mine and associated infrastructure over a total estimated project life of 23 years. Indicative mine and surface infrastructure plans are provided in Figure 1.3 and Figure 1.4. A full description of the project, as assessed in this report, is provided in Chapter 2 of the main EIS report (EMM 2017a).

In summary it involves:

- Ongoing resource definition activities, along with geotechnical and engineering testing, and other fieldwork to facilitate detailed design.
- Establishment of a temporary construction accommodation village.
- Development and operation of an underground coal mine, comprising of approximately two years of construction and 19 years of mining, followed by a closure and rehabilitation phase of up to two years, leading to a total project life of 23 years. Some coal extraction will commence during the second year of construction and hence there will be some overlap between the construction and operational phases.
- Extraction of approximately 50 million tonnes (Mt) of run-of-mine (ROM) coal from the Wongawilli Seam, at a rate of up to 3.5 million tonnes per annum (Mtpa). Low impact mining methods will be used, which will have negligible subsidence impacts.
- Following processing of ROM coal in the coal preparation plant (CPP), production of up to 3 Mtpa of metallurgical and thermal coal for sale to international and domestic markets.

- Construction and operation of associated mine infrastructure, mostly on cleared land, including:
  - one personnel and materials drift access and one conveyor drift access from the surface to the coal seam;
  - ventilation shafts, comprising one upcast ventilation shaft and fans, and up to two downcast shafts installed over the life of the mine, depending on ventilation requirements as the mine progresses;
  - a surface infrastructure area, including administration, bathhouse, washdown and workshop facilities, fuel and lubrication storage, warehouses, laydown areas, and other facilities. The surface infrastructure area will also comprise the CPP and ROM coal, product coal and emergency reject stockpiles;
  - surface and groundwater management and treatment facilities, including storages, pipelines, pumps and associated infrastructure;
  - overland conveyors;
  - rail load-out facilities;
  - a small explosives magazine;
  - ancillary facilities, including fences, access roads, car parking areas, helipad and communications infrastructure; and
  - environmental management and monitoring equipment.
- Establishment of site access from Mereworth Road, and construction of minor internal roads.
- Coal reject emplacement underground, in the mined-out voids.
- Peak workforces of approximately 414 full-time equivalent employees during construction and approximately 300 full-time equivalent employees during operations.
- Decommissioning of mine infrastructure and rehabilitating the area once mining is complete, so that it can support land uses similar to current land uses.

The project area, shown in Figure 1.2 is approximately 5,051 hectares (ha). Surface disturbance will mainly be restricted to the surface infrastructure areas shown indicatively on Figure 1.4 though will include some other areas above the underground mine, such as drill pads and access tracks. The project area generally comprises direct surface disturbance areas of up to approximately 117 ha, and an underground mining area of approximately 3,472 ha, where negligible subsidence impacts are anticipated.

A construction buffer zone will be provided around the direct disturbance areas. The buffer zone will provide an area for construction vehicle and equipment movements, minor stockpiling and equipment laydown, as well as allowing for minor realignments of surface infrastructure. Ground disturbance will generally be minor and associated with temporary vehicle tracks and sediment controls as well as minor works such as backfilled trenches associated with realignment of existing services. Notwithstanding, environmental features identified in the relevant technical assessments will be marked as avoidance zones so that activities in this area do not have an environmental impact.

Product coal will be transported by rail, primarily to Port Kembla terminal for the international market, and possibly to the domestic market depending on market demand. Rail works and use are the subject of a separate EIS and State significant development application for the Berrima Rail Project.

1.3 Project area and study area

The entire project area is considered as part of this soil and land assessment. The impact assessment focuses on the surface infrastructure areas within the project area as these areas will experience the greatest level of disturbance.

1.4 General site description

The project area is approximately 100 km south-west of Sydney and 4.5 km west of Moss Vale town centre in the Wingecarribee LGA (refer to Figure 1.1 and Figure 1.2). The nearest area of surface disturbance will be associated with the surface infrastructure area, which will be 7.2 km north-west of Moss Vale town centre. It is in the Southern Highlands region of NSW and the Sydney Basin Biogeographic Region.

The project area is in a semi-rural setting, with the wider region characterised by grazing properties, small-scale farm businesses, natural areas, forestry, scattered rural residences, villages and towns, industrial activities such as the Berrima Cement work and Berrima Feed Mill, and some extractive industry and major transport infrastructure such as the Hume Highway.

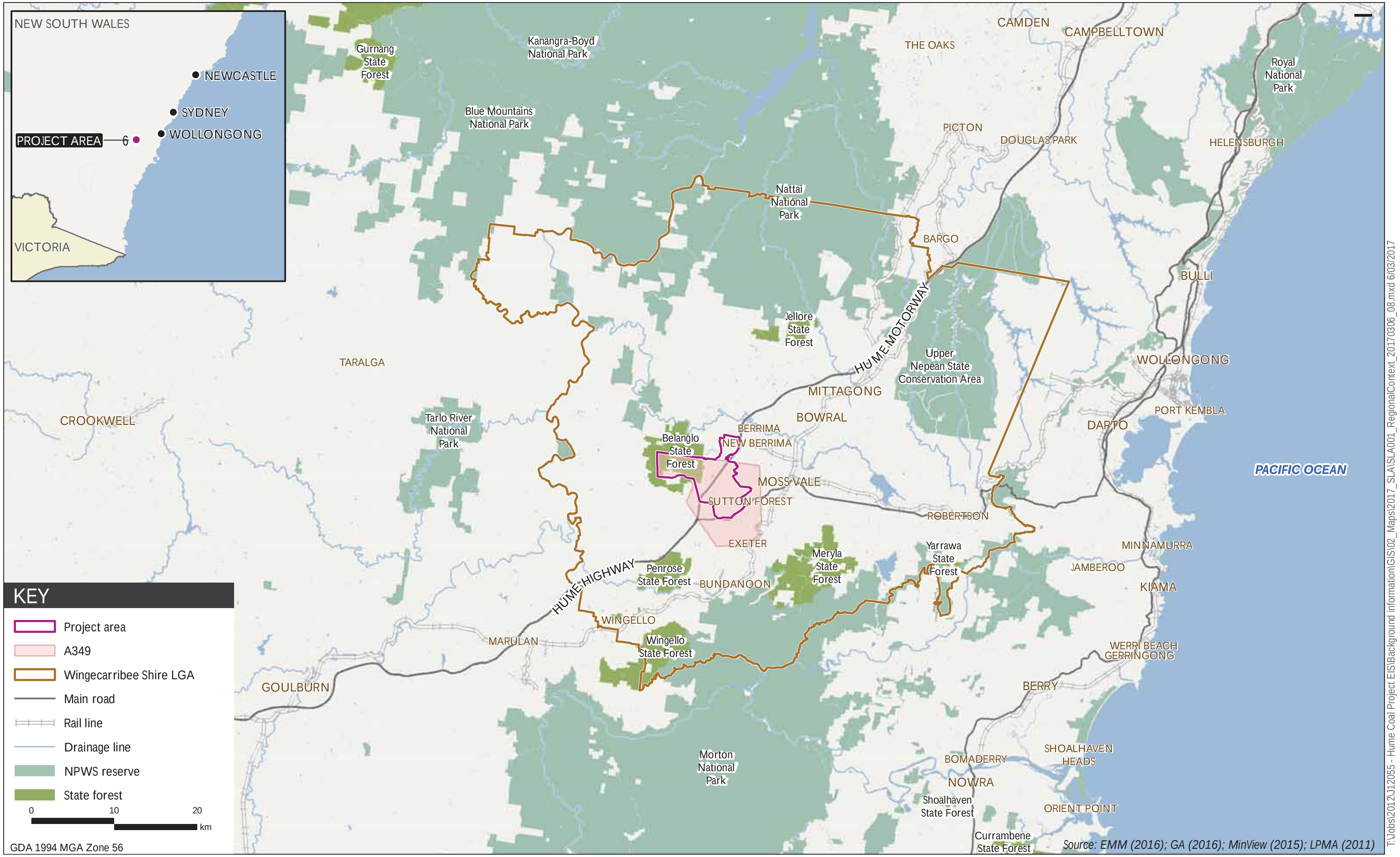
Surface infrastructure is proposed to be developed on predominately cleared land owned by Hume Coal or affiliated entities, or for which there are appropriate access agreements in place with the landowner. Over half of the remainder of the project area (principally land above the underground mining area) comprises cleared land that is, and will continue to be, used for livestock grazing and small-scale farm businesses. Belanglo State Forest covers the north-western portion of the project area and contains introduced pine forest plantations, areas of native vegetation and several creeks that flow through deep sandstone gorges. Native vegetation within the project area is largely restricted to parts of Belanglo State Forest and riparian corridors along some watercourses.

The project area is traversed by several drainage lines including Oldbury Creek, Medway Rivulet, Wells Creek, Wells Creek Tributary, Belanglo Creek and Longacre Creek, all of which ultimately discharge to the Wingecarribee River, at least 5 km downstream of the project area (Figure 1.1). The Wingecarribee River's catchment forms part of the broader Warragamba Dam and Hawkesbury-Nepean catchments. Medway Dam is also adjacent to the northern portion of the project area (Figure 1.2).

Most of the central and eastern parts of the project area have very low rolling hills with occasional elevated ridge lines. However, there are steeper slopes and deep gorges in the west in Belanglo State Forest.

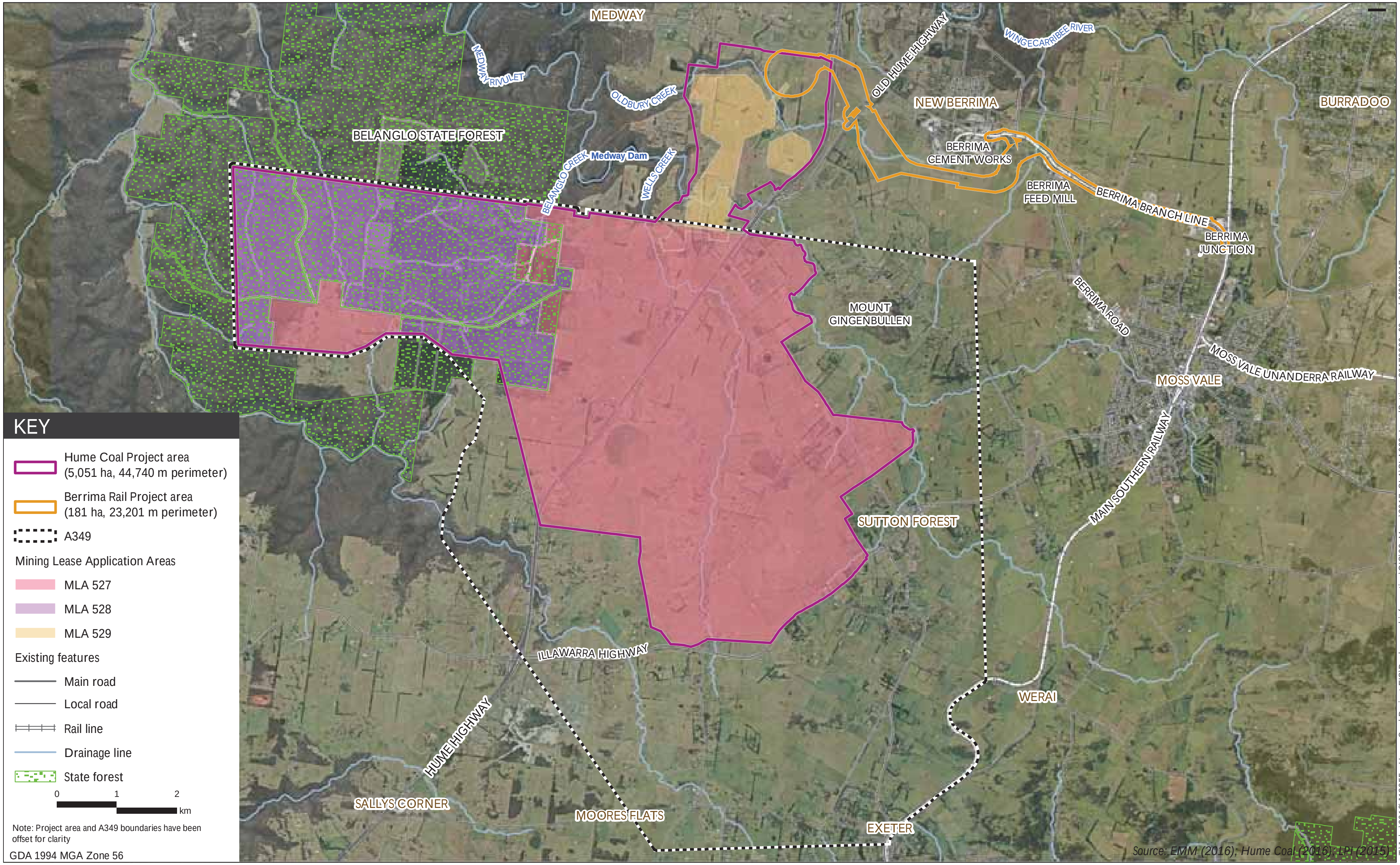
Existing built features across the project area include scattered rural residences and farm improvements such as outbuildings, dams, access tracks, fences, yards and gardens, as well as infrastructure and utilities including roads, electricity lines, communications cables and water and gas pipelines. Key roads that traverse the project area are the Hume Highway and Golden Vale Road. The Illawarra Highway borders the south-east section of the project area.

Industrial and manufacturing facilities adjacent to the project area include the Berrima Cement Works and Berrima Feed Mill on the fringe of New Berrima. Berrima Colliery's mining lease (CCL 748) also adjoins the project area's northern boundary. Berrima colliery is currently not operating with production having ceased in 2013 after almost 100 years of operation. The mine is currently undergoing closure.



EMM HUMECOAL

Regional context
Hume Coal Project
Soil and Land Assessment Report
Figure 1.1



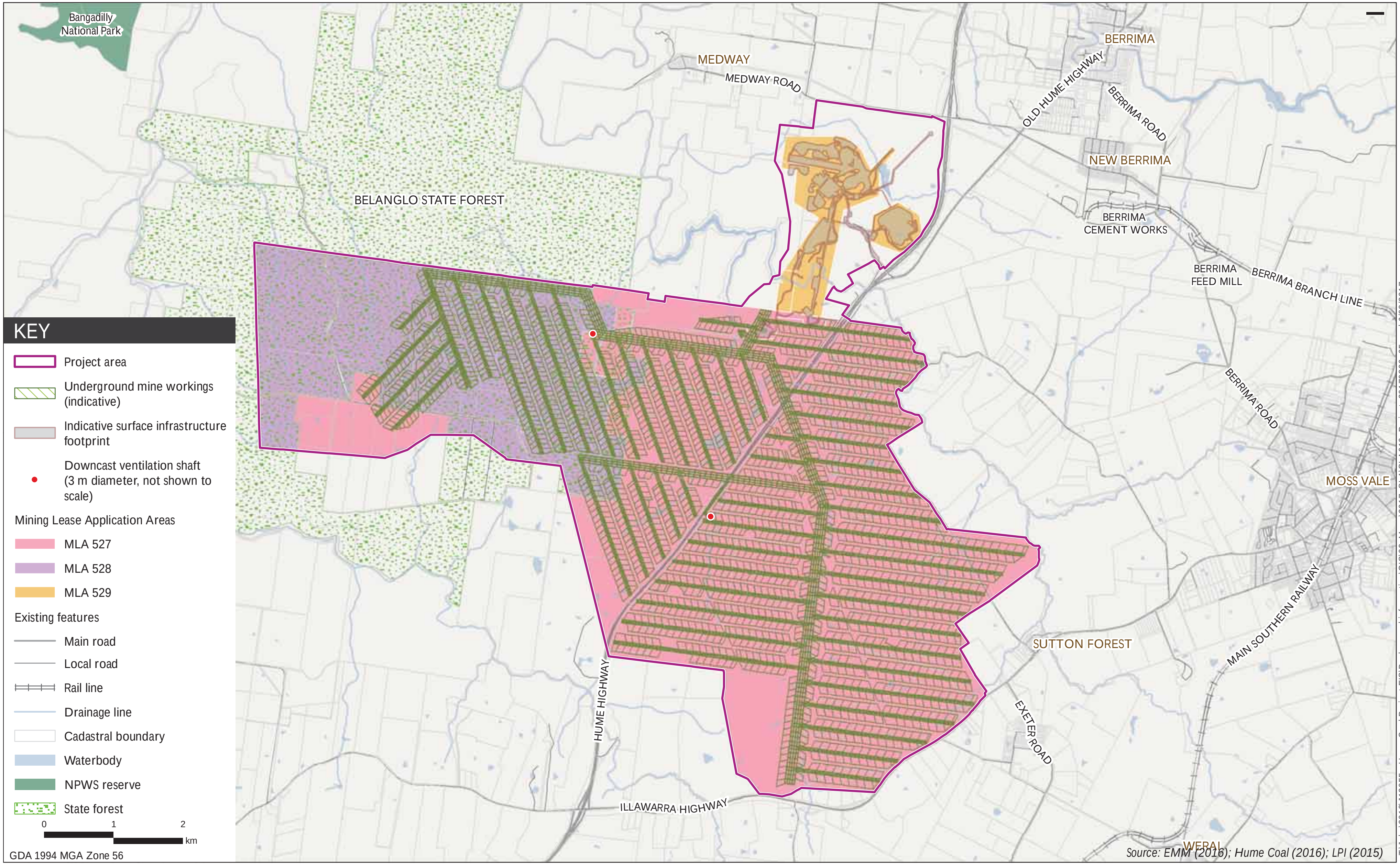
T:\Jobs\2012\J12055 - Hume Coal Project EIS\Background information\GIS\02_Maps\2017_SLA\SLA002_LocalSetting_20170306_09.mxd 6/03/2017

Local context

Hume Coal Project

Soil and Land Assessment Report

Figure 1.2



T:\Jobs\2012\J12055 - Hume Coal Project EIS\Background information\GIS\02_Maps\2017_SLA\SLA019_Project_20170306_05.mxd 6/03/2017

EMM HUMECOAL

Indicative project layout

Hume Coal Project
Soil and Land Assessment Report
Figure 1.3

Indicative surface infrastructure layout

Hume Coal Project
Soil and Land Assessment Report

Figure 1.4

1.5 Assessment guidelines and requirements

This land and soil assessment has been prepared following the appropriate guidelines, policies and industry requirements, and in consultation with relevant government agencies.

Guidelines and policies referenced are as follows:

- *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Land* (NSW Government 2013);
- *Soil and Landscape Issues in Environmental Impact Assessment* (DLWC 1997);
- *The land and soil capability assessment scheme (OEH 2012);* and
- *Agfact AC25: Agricultural Land Classification* (NSW Agriculture, 2002);

This assessment has been prepared in accordance with requirements of the Commonwealth Department of the Environment (now the Department of Environment and Energy (DoE)) and the NSW Department of Planning and Environment (DP&E). These were set out in the Secretary's Environmental Assessment Requirements (SEARs) for the Hume Coal Project, issued on 20 August 2015, and supplementary SEARs issued on 1 December 2015 2015. The SEARs identify matters which must be addressed in the EIS and essentially form its terms of reference. A copy of the SEARs is attached to the EIS (EMM 2017a) as Appendix B, while Table 1.1 lists individual requirements relevant to this land and soil assessment and where they are addressed in this report.

Table 1.1 Relevant SEARs for this assessment

Requirement	Section addressed
An assessment of the likely impacts of the development on the environment, focusing on the specific issues identified below, including:	
- a description of the existing environment likely to be affected by the development, using sufficient baseline data (soils);	Section 2-5
- an assessment of the likely impacts (soils) of all stages of the development, including any cumulative impacts, taking into consideration any relevant legislation, environmental planning instruments, guidelines, policies, plans and industry codes of practice;	Section 7
- a description of the measures that would be implemented to mitigate and/or offset the likely impacts (soils) of the development, and an assessment of:	Section 8
▪ whether these measures are consistent with industry best practice, and represent the full range of reasonable and feasible mitigation measures that could be implemented;	
▪ the likely effectiveness of these measures, including performance measures where relevant; and	
▪ whether contingency plans would be necessary to manage any residual risks.	

To inform preparation of the SEARs, DP&E invited other government agencies to recommend matters for address in the EIS. These matters were taken into account by the Secretary for DP&E when preparing the SEARs. Copies of the government agencies' advice to DP&E was attached to the SEARs.

Two agencies, the Department of Industry - Resources and Energy (DRE), and the NSW Office of Environment and Heritage (OEH), raised matters relevant to the land and soil assessment. The matters raised are listed in Table 1.2 and Table 1.3 respectively, and have been taken into account in preparing this assessment, as indicated in the tables.

Table 1.2 DRE assessment recommedations

Recommendation	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 (i.e. topsoil, seed banks, tree hollows and logs, native seed etc.) This should include an evaluation of how topsoil/subsoil of suitable quality can be direct-returned for use in rehabilitation.	Section 8.1
An evaluation of current land capability class and associated condition.	Section 6
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.	Section 4
"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."	Section 8.1.5

Table 1.3 OEH assessment recommendations

Recommendation	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).	Section 3.6

1.6 Adoption of leading practices

Hume Coal is committed to adopting leading practices in the planning, construction, operation, closure and rehabilitation of the project. This includes leading practice measures to avoid, minimise and/or mitigate potential environmental and social impacts. In particular, in relation to rehabilitation the leading practices adopted are:

- 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.
- To eliminate and/or minimise impacts on surface features and water resources, Hume Coal will use an innovative non-caving coal extraction method, leaving coal pillars in place throughout the mine that are designed to provide long-term support to the overlying rock. Given this mining system is first workings only, the overlying aquifer and surface features will be protected and therefore will be negligible associated subsidence impacts.

1.7 Scope and purpose of this report

The scope of the land and soil assessment is as follows:

- to address the SEARs and government agency assessment requirements relating to soil and land resources;
- to describe, classify and map the soils and land suitability within the project area;
- to assess the suitability of soil units for recovery and use as topsoil/growth media in the rehabilitation of areas impacted during mining;
- to identify any potentially problematic soil, such as highly sodic, acidic or saline soil, that may require special management if disturbed during project activities;
- to assess the immediate and long term impacts of the Hume Coal Project on the soil resources and land and soil capability, including the potential post mine land and soil capability; and
- to identify appropriate soil management measures.

The land and soil assessment has drawn on related technical assessments for the project which have been appended to this report, namely:

- *Biophysical Strategic Agricultural Land Verification Assessment* (EMM 2015) – Appendix A.
- *Land and Soil Capability Assessment – Decision Tables* (EMM 2017b) – Appendix B.

Reference was also made to the findings of the the subsidence report (Mine Advice 2016).

2 Soil assessment methodology

2.1 Overview of assessment process

The soil assessment comprised the following steps:

- a desktop review of existing information (incorporated into Section 3);
- a soil survey to characterise soil types of the project area, including field assessment and laboratory analysis (Section 4);
- an assessment of Biophysical Strategic Agricultural Land Assessment (BSAL) using results from the soil survey (Section 5);
- an assessment of land and soil capability (LSC) using results from the soil survey (Section 6); and
- an assessment of potential impacts on soil resources (section 7) and proposed management and mitigation methods (Section 8).

2.2 Desktop survey

Existing information on soils and soil environments for the project area was sourced from the following regional mapping published by government departments. The relevant information has been summarised and presented in Section 3.

- *Map Sheet 8928 Moss Vale 1:100,000 Geological Map* (Trigg and Campbell 2009);
- *Soil and land resources of the Hawkesbury-Nepean catchment* (DECC 2008);
- *Australian soil classification (ASC) soil type map of NSW* (OEH 2016a);
- *Great soil group soil type mapping of NSW* (OEH 2016b);
- *Hydrological soil group mapping* (OEH 2016c);
- *Inherent soil fertility mapping* (OEH 2016d);
- *Land and soil capability classes mapping* (OEH 2016e);
- *NSW soil and land information system* (SALIS) (OEH 2016f);
- *Soil profile attribute data environment* (eSPADE) online database (OEH 2016g); and
- *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) - Strategic Agricultural Land Map of NSW (DP&I 2013).

2.3 Field survey

2.3.1 Survey guidelines

All field assessment methods used in this survey have been conducted in accordance with the following guidelines:

- *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); and
- *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (NSW Government 2013).

This survey has taken particular note of the requirements of the *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (NSWG 2013) (referred to as the Interim Protocol). The field survey therefore required investigation at three different levels of intensity (the sites):

- check sites - low intensity investigation, high repetition, randomised locations and a limited description;
- detailed sites - high intensity investigation, moderate repetition, randomised locations and a detailed description; and
- profiles pits - very high intensity investigation, low repetition, targeted locations and a detailed description.

2.3.2 Survey density

A total of 246 sites were surveyed within and immediately adjacent to the project area and an average survey density of about one site per 20.5 ha was achieved. The average survey density achieved meets the conservative target adopted (as per the Interim Protocol), which was at least one site per 25 ha or 202 sites. Of the 246 sites, 141 were described in detail using the SALIS detailed soil data card (of which 33 were subjected to laboratory analysis), and 105 used as check sites. This is in accordance with the relevant guidelines.

2.3.3 Site selection

Initial positioning of the soil survey sites was based on stratified random sampling across the project area, though designed to provide a relatively even distribution of detailed and check sites. In accordance with the requirements of stratified random sampling, a greater frequency of sampling was proposed for soil types that cover a greater proportion of the project area. Also, topographic maps were reviewed to ensure surveying was representative of the different landform types in the project area.

The exact locations of the sites were finalised with consideration to land access constraints and site factors, particularly past disturbance, vegetation cover and infrastructure. These constraints meant that some sites initially identified were not available or suitable for surveying. In these inaccessible or unsuitable areas, the nearest available locations with similar landscape features were sampled and spatial co-ordinates recorded. The sites are shown in Figure 2.1.

2.3.4 Timing of surveys

The survey of the project area were undertaken on a number of separate occasions in 2013 (July 15-19, September 11-17 and November 25-29) and 2015 (February 11-13, March 22-23, July 2-8, and September 7-8). These surveys logged check and detailed sites within and surrounding the project area using hand auguring and/or split tubes so that the soil could be classified and samples collected. A targeted survey involved the digging of five profile pits by backhoe. These surveys collected detailed information on the physical characteristics and morphology of the specific soil units identified from hand augering and split tube sampling.

2.3.5 Sampling method

Soil sampling was carried out primarily using a 4WD-mounted push tube machine. This method created a typical disturbance area of approximately 300 x 300 millimetres (mm) to a depth of at least 750 mm, with an additional surface area disturbed to a lesser extent by the vehicle footprint. Sampling was undertaken using a hand auger in some locations where landholder access requirements and vehicular access were constraints and to minimise disturbance, with sample depth to 750 mm. Soil core holes were backfilled immediately upon completion of classification and sampling.

Field observations were recorded (including GPS locations) and SALIS data completed and submitted to NSW OEH. Soils are described with photographs in section 4. Soil profiles were assessed in accordance with the *Australian Soil and Land Survey Handbook* (NCST 2009).

During the field surveys, observations of surface geology were made. Geology is an important determinant of soil characteristics and a strong relationship between the two has been identified within the project area. Further detail on the methodology can be found in Appendix A.

2.4 Laboratory testing

Laboratory analysis for the survey was undertaken based on the requirements of the following NSW Government guidelines:

- *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (NSWG 2013); and
- *The land and soil capability assessment scheme: second approximation* (OEH 2012).

In the majority of cases the analysis undertaken meets or exceeds the requirements of these two guidelines. The remaining sites conform with the nationally accepted standards laid out in the *Australian soil and land survey handbook* (NCST 2009). A National Association of Testing Authorities (NATA) accredited laboratory (ALS Global) was used to ensure that laboratory analysis were undertaken using scientifically correct methods.

Three levels of analysis were undertaken relevant to the importance of each soil survey point. In ascending importance:

- check sites were analysed in the field for texture, pH and electrical conductivity EC only using accepted methods described in the Australian soil and land survey field handbook (NCST 2009);
- detailed sites were sampled with representative sites receiving full laboratory analysis; and
- profile pits were analysed in the field for texture, pH and EC only.

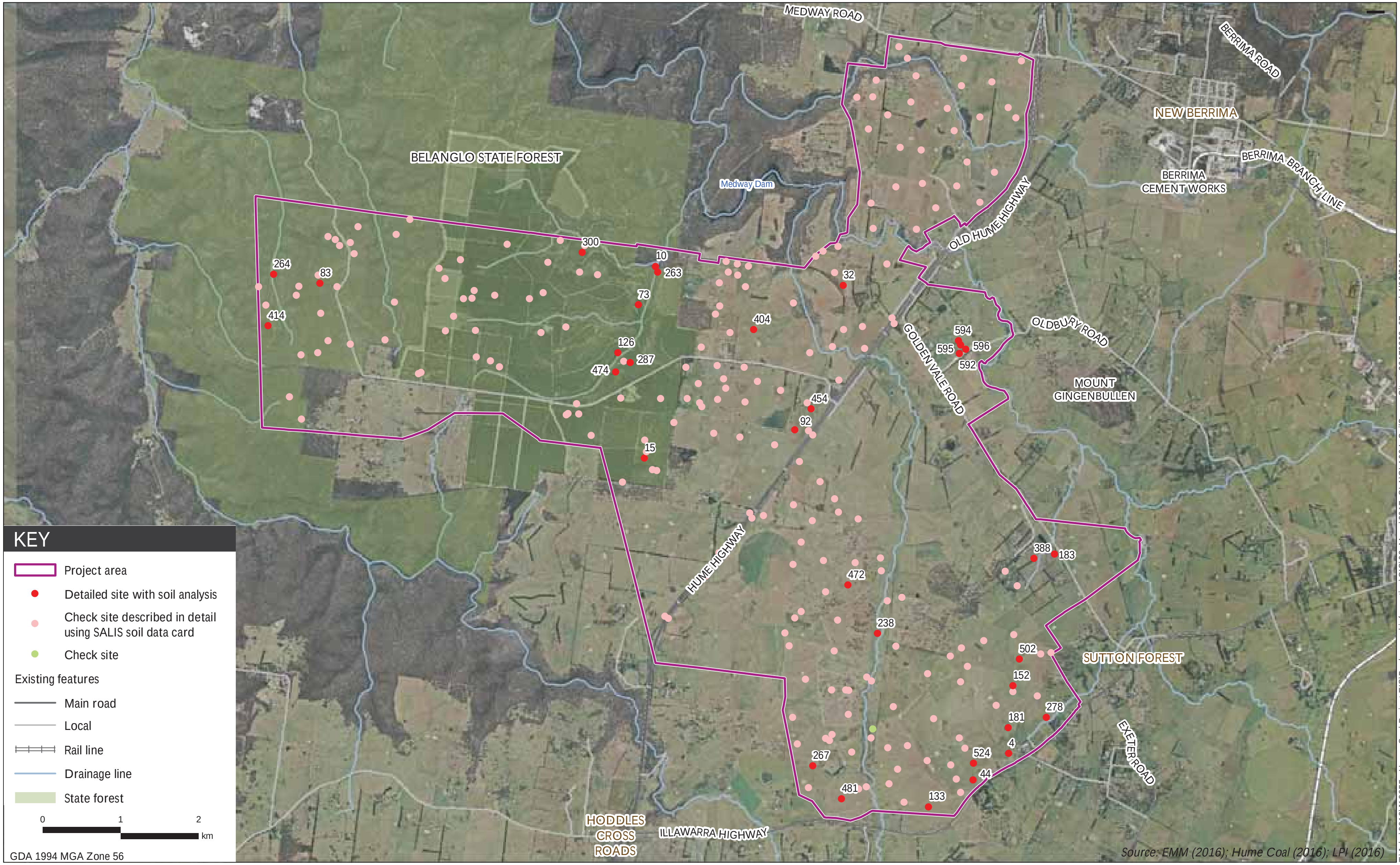
Physical and chemical analysis was undertaken on selected soil samples (Table 2.1). A summary of the number of samples analysed from each soil type present in the project area is presented in Table 2.2. Full laboratory results, including the naming of analytical method and sampling depths, are included in Appendix A.

Table 2.1 Laboratory analytes

Physical Soil Properties	Chemical Analyses
Soil texture	Organic carbon
Moisture content	pH_{water}
Particle size analysis (<2 mm diameter)	EC
Gravel content	Totalnitrogen, nitrate and nitrite
Plant available water capacity (PAWC)	Total and extractable phosphorus (P)
	Total and extractable potassium (K)
	Total sulfur and sulphate
	Calcium:Magnesium ration (Ca:Mg Ratio)
	Chloride (Cl-)
	Cation exchange capacity (CEC)
	Exchangeable cations (sodium (Na), calcium(Ca), potassium (K), magnesium (Mg))
	Exchangeable sodium percentage (ESP)
	Extractable metals (Iron (Fe), Zinc (Zn), Manganese (Mn), Boron (B))
	Total metals (Aluminium (Al), Molybdenum (Mo))

Table 2.2 Samples analysed from each soil type

Soil types	Number of sites subjected to laboratory analysis	Site numbers	Horizons analysed
Dystrophic Yellow Kandosol	15	15, 32, 44, 133, 183, 267, 388, 404, 472, 481, 502, 592, 594, 595, 596	72
Paralithic Leptic Tenosol	6	73, 83, 126, 263, 287, 300	29
Kandosolic Redoxic Hydrosol	6	4, 10, 92, 238, 454, 524	28
Lithic Leptic Rudosol	3	264, 414, 474	7
Eutrophic Grey Dermosol	3	152, 181, 278	14



T:\Jobs\2012\J12055 - Hume Coal Project EIS\Background information\GIS\02_Maps\2017_SLA\SLA004_SoilSurveySites_20170203_07.mxd 4/02/2017

Soil survey sites

Hume Coal Project

Soil and Land Assessment Report

Figure 2.1

3 Biophysical environment

3.1 Climate

The Southern Highlands is in the temperate climatic zone. It has a warm summer and cold winter, with uniform rainfall (BOM, 2012). The nearest weather station to the project area is located in the town of Moss Vale (Station 068045), 5 km to the east of the project area. The region experiences four distinct seasons. Temperatures range between 12 and 24 °C in summer and 2 to 12 °C in winter. The area experiences a mean rainfall of 970 mm with more cloudy days than clear throughout the average year. Figure 3.1 shows the mean monthly temperature and rainfall over the last 100 years, sourced from the Moss Vale weather station (Station 068045).

The NSW and ACT Regional Climate Modelling (NARCILiM) Project has released climate prediction maps for 2060-2079 (NARCLiM 2015), which is well beyond the duration of the project. By this time, the project area may expect increased overall temperatures with colder nights, and less rainfall in spring with more rainfall occurring in the autumn months.

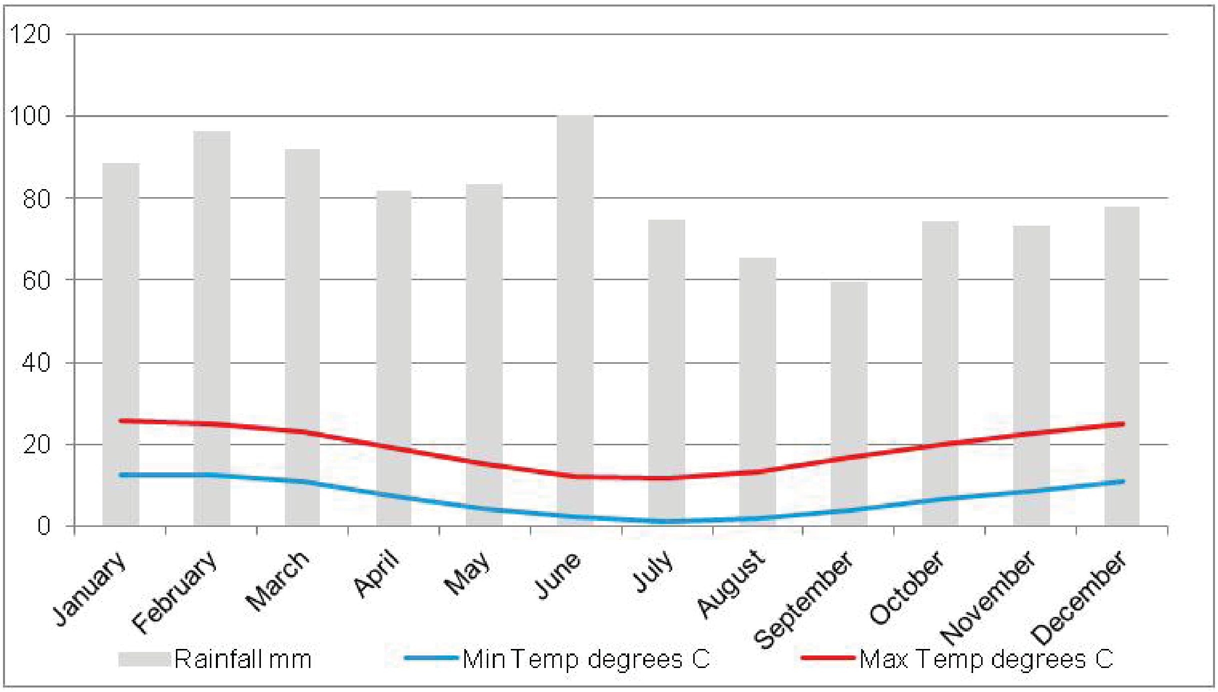
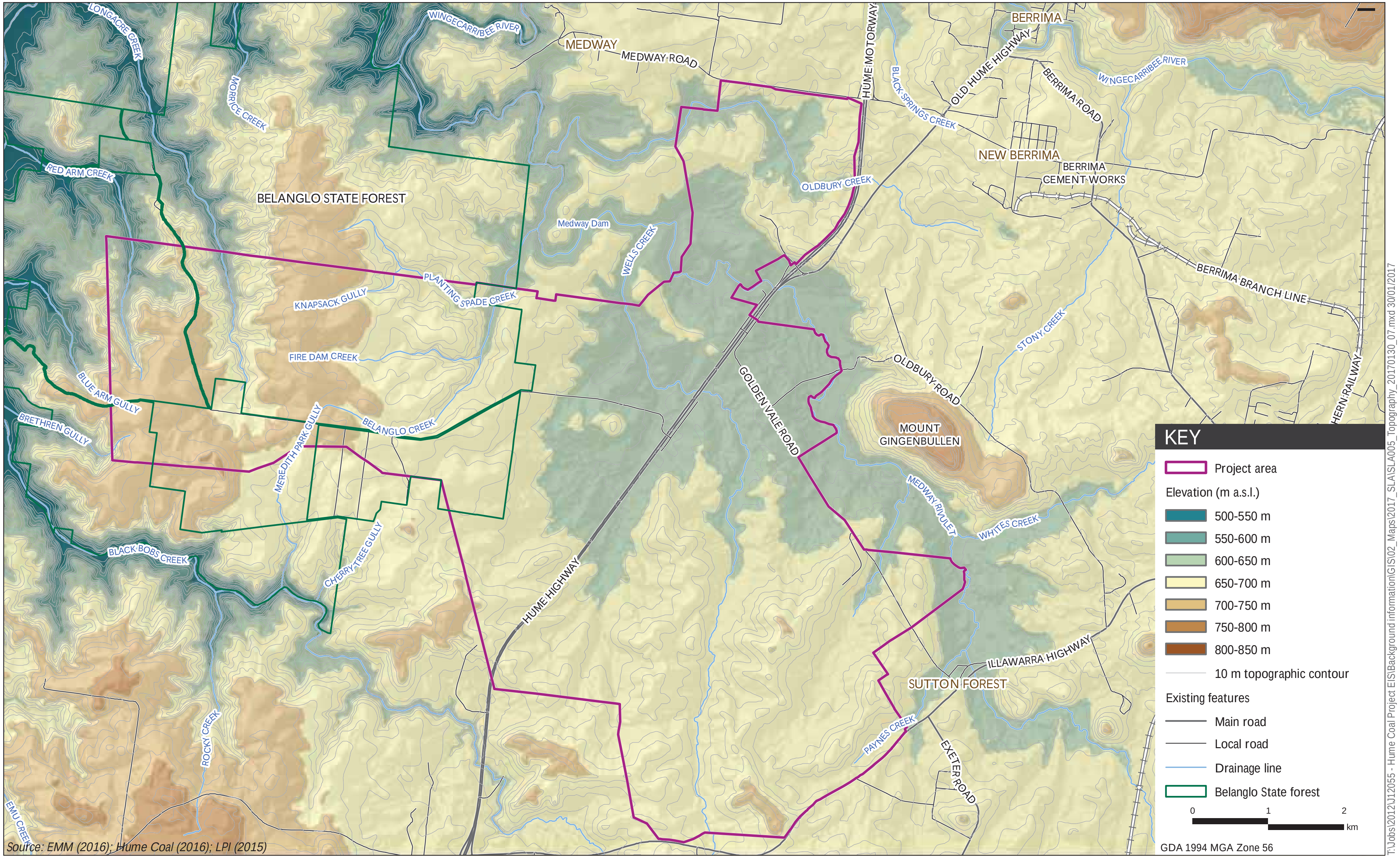


Figure 3.1 Mean rainfall and temperature in Moss Vale (Station 68045) 1914 - 2014

3.2 Topography

The project area is situated on the elevated, relatively flat Woronora-Nattai Plateau of the Southern Highlands. Elevations typically range from approximately 550 to 735 metres (m) above Australian Height Datum (AHD). Most of the central and eastern parts of the project area have very low rolling hills with occasional elevated ridge lines (Figure 3.2). There are steeper slopes and deep gorges in the west of the project area, in Belanglo State Forest, associated with steeply incised valleys, gorges and drainage lines.



Topography and landform
Hume Coal Project
Environmental Impact Statement
Figure 3.2

EMM HUMECOAL PROJECT

3.2.1 Slopes

A digital elevation model (DEM) was developed to detail the slope categories across the project area for the BSAL asessment. The topography of the project area and surrounds is diverse with slopes varying from 2 to > 50%.The DEM was split into two categories; slopes greater then (>) and less than (<) 10%. Figure 3.3 shows that the majority of the project area has slopes of 10% or less. There are steeper slopes above 10%, associated with the deeply incised drainage lines in the west of the project area and the elevated ridge lines through the central and eastern parts of the project area.

3.2.2 Surface hydrology

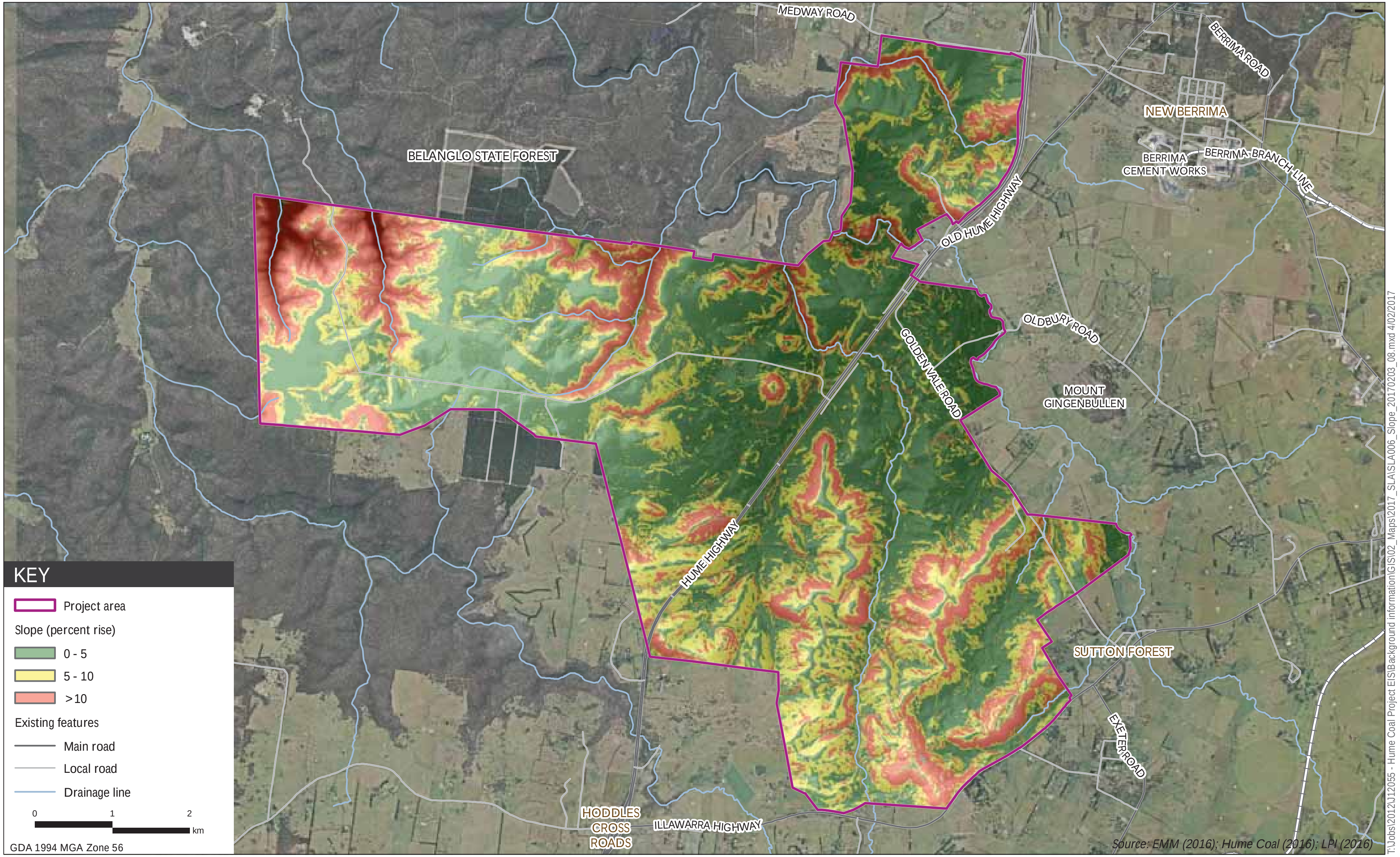
The project area is in the Wingecarribee River catchment, part of the wider catchment of the Hawkesbury-Nepean catchment. It is traversed by several drainage lines, all of which ultimately discharge to the Wingecarribee River, at least 5 km downstream from the project area.

The main surface water bodies within the project area are Oldbury Creek, Wells Creek, Longacre Creek and Medway Rivulet. Other water bodies in the immediate vicinity of the project area are Black Bobs Creek, and Wingecarribee River. These surface water features are within the Wells Creek and Medway Rivulet sub-catchment (shown in Figure 3.2).

Black Bobs Creek is a rocky channel with dense riparian vegetation and Medway Rivulet is a sandy, grassy channel with rocky banks. The upper reaches of Black Bobs Creek and Medway Rivulet are ephemeral (that is flow in response to rainfall) with isolated, stagnant pools while the lower reaches in the vicinity of the project area comprise gullies with steep banks. Both creeks flow north-west. Wells Creek is ephemeral, joining Medway Rivulet north of the project area upstream of Medway Dam.

3.3 Ecology

The majority of the project area, including the surface infrastructure areas, has been cleared and contains exotic grassland. Native vegetation is mainly restricted to the north-west of the project area, in parts of Belanglo State Forest. However, some remnant native vegetation patches occur in the central northern part of the project area, associated with creeks and there are scattered remnant paddock trees in places. There are also scattered patches of poorer condition native vegetation in the centre of the project area.



Slope in the project area

Hume Coal Project

Soil and Land Assessment Report

Figure 3.3

EMM HUMECOAL

3.4 Geology

3.4.1 Regional geological mapping

The project area is in the Southern Coalfield, on the south-western edge of the Permo-Triassic Sydney Basin. The Sydney Basin primarily consists of sediments deposited in a 'basin' environment, which were deposited between two major 'fold belts'; the Lachlan Fold Belt to the north-east and the New England Fold Belt to the west. Initially, sediments were deposited into the basin from the north and interspersed with several sequences of coal seams. One of these coal sequences is the Illawarra Coal Measures which contains some 10 recognised coals, some of which are of economic importance, in particular the Bulli and Wongawilli Seams. These seams were deposited during the Permian period.

The basal sedimentary units of the Permian are contained in the Talaterang Group which also includes the Clyde Coal Measures. This in turn is overlain by the marine sedimentary rocks of the Shoalhaven Group, which form the immediate base of the Illawarra Coal Measures. The target coal measure of the project (Wongawilli Seam) is the thickest and most widespread seam in these coal measures. Overlying the Permian rocks are Triassic deposits, namely the Hawkesbury Sandstone and the Wianamatta Shale Group. During the late Triassic to early Jurassic period, the region experienced episodes of volcanic activity. As a result, there are also igneous necks, sills, basalt flows, diatremes, dykes and faults in the project area.

The Wianamatta Group - Ashfield Shale outcrops over much of the eastern and southern project areas, while the Hawkesbury Sandstone outcrops in the north-west. The hills in the southern part of the project area are capped by Tertiary basalt.

The *Moss Vale 1:100,000 Geological Sheet* (Trigg and Campbell 2009) shows Hawkesbury Sandstone to be dominant on the western side of the project area. The majority of the central and eastern parts are covered by Quaternary deposits, interspersed with Bringelly Shale, Ashfield Shale, and Cenozoic tertiary basalts. Table 3.1 summarises the descriptions of each geological unit mapped in the project area and Figure 3.4 is a zoomed in section of the Moss Vale 1:100,000 geological map sheet.

Table 3.1 Geological units mapped in project area

Age	Code	Name	Description
Cenozoic Quaternary	Qa	Alluvium	Sand and silt, deposited in stream and river channels
	Qap	Alluvium	Flood plain deposits of silt and clay with variable soil development
	Qas	Alluvium	Lake and swamp deposits; dark grey silty clay and clay
	Qc	Residual Deposits	Talus slope deposits and poorly sorted, weakly cemented to unconsolidated colluvial lenses of polymictic conglomerate, interspersed with unconsolidated clay and silty sand layers and modified by pedogenesis.
	Qr	Residual Deposits	Residual deposits of unconsolidated clayey course- to fine-grained sands to weakly consolidated sandy clay layers; some podzolic soil profiles.
Cenozoic Tertiary	Czb	Basalt	Alkaline olivine basalt. Typically deeply weathered with extensive soil development.
	Czbr	Autobrecciated Basalt	
	Czeb	Analcine basanite	Olivine bearing basalt with analcite

Table 3.1 Geological units mapped in project area

Age	Code	Name	Description
Mesozoic Triassic (Wianamatta Group)	Rwb	Bringelly Shale	Bringelly Shale - Light to dark grey, sideritic claystone to siltstone, dark grey carbonaceous claystone, laminite, sandstone to siltstone, quartz-lithic very fine-to medium-grained sandstone, coal. Plant fragments and fossil roots abundant.
	Rwa	Ashfield Shale	Ashfield Shale - Dark grey to black, sideritic claystone to siltstone and sandstone/siltstone laminite. Plant fossils rare.
Mesozoic Triassic	Rh	Hawkesbury Sandstone	Off-white to yellow, very quartzose: fine- to very coarse-grained sandstone, pebbly sandstone, conglomerate, siltstone. Cross bedding.

Notes: 1.Map Unit Descriptions (Moss Vale 1:100,000 Geological Sheet).