Appendix 5

Agricultural Impact Statement

AGRICULTURAL IMPACT STATEMENT

Bulga Optimisation Project

April 2013

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Bulga Optimisation Project

April 2013

Prepared by

Umwelt (Australia) Pty Limited

on behalf of

Bulga Coal Management Pty Ltd

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Report No.	**2869/R08/FINAL**
Date:	**April 2013**

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1.0 Introduction

Bulga Coal Management (BCM) currently operates the Bulga Surface Operations which, together with the Bulga Underground Operations, comprise the Bulga Coal Complex (BCC). The Bulga Surface Operations development consent expires in 2025, however, the coal reserves approved to be mined are expected to be exhausted by 2018/2019. BCM propose to extend the operating life of the Bulga Surface Operations through the Bulga Optimisation Project (the Project). The Project will extend the life of extraction for the existing Bulga Surface Operations from the current approved consent expiry date by approximately 10 years and will recover an additional approximately 200 million tonnes (Mt) of run of mine (ROM) coal. Apart from the relocation of surface facilities, the Project does not alter the approved underground mining operations which are due to be completed around 2032.

This Agricultural Impact Statement (AIS) has been prepared to assess the potential impacts of the Project on agricultural resources and industries in the areas in and around the Project area and, where relevant, the broader Hunter Valley region.

The location and boundaries of the Project area are shown in **Figures 1.1** and **1.2**. Further information about Project is provided in **Section 1.2**.

Figure 1.3 shows the parts of the Project area that have previously been directly impacted by mining or other significant surface disturbance and includes areas which are in the process of rehabilitation under the requirements of existing consents and management plans. Due to the low (or zero) agricultural potential of theses existing disturbed the AIS, has largely excluded these areas from the assessment of impact on agricultural productivity. The potential for these areas to be rehabilitated to a standard capable of supporting future agricultural production has been considered.

Consistent with the Director-General's Requirements for the Project, this AIS has been prepared in accordance with the *Guideline for Agricultural Impact Statements* (Department of Planning and Infrastructure March 2012). The AIS has also taken into account the recently released *Upper Hunter Strategic Rural Land Use Policy* (Upper Hunter SRLUP).

In particular, the AIS evaluates the potential for the Project to impact on:

- agricultural land that is mapped (in the Upper Hunter SRLUP) as Biophysical Strategic Agricultural Land (BSAL) (or could be mapped as BSAL), within or in close proximity (within 2km) to the Project area;
- agricultural land that is within a Critical Industry Cluster (in this case, the wine industry and associated agricultural tourism based on areas at Pokolbin, Broke-Fordwich, Belford, Lovedale, Mount View and Denman), within or in close proximity to the Project area; and
- other agricultural land uses, resources and infrastructure, within or in close proximity to the Project area, or where relevant, more broadly in the region.

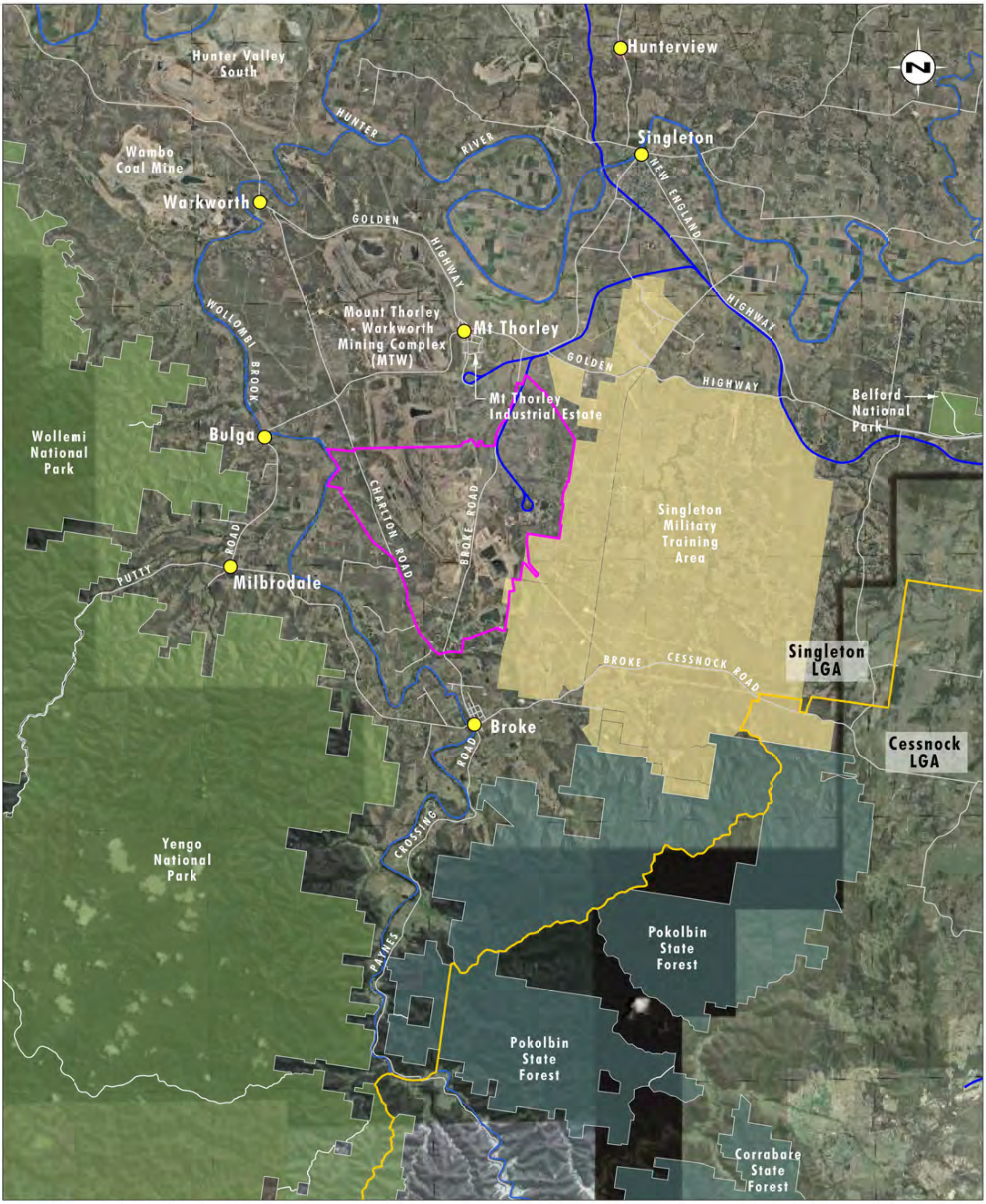
The assessment:

- provides information about sources of knowledge used in the assessment process, including consultation with landholders, businesses, community organisations and agencies, as well as published data on agricultural production and economic values, and published and new data about the land and soil assets of the Project area and its local region. This information is in **Sections 1.0** and **2.0**;

FIGURE 1.1

Locality Plan

Umwelt
Environmental Consultants



Source: Google Earth (2010), LPMA

Legend

- Project Area
- Local Government Area
- National Park
- State Forest
- Singleton Military Training Area
- Towns/Villages

FIGURE 1.2

Surrounding Environment - Greater Bulga Area

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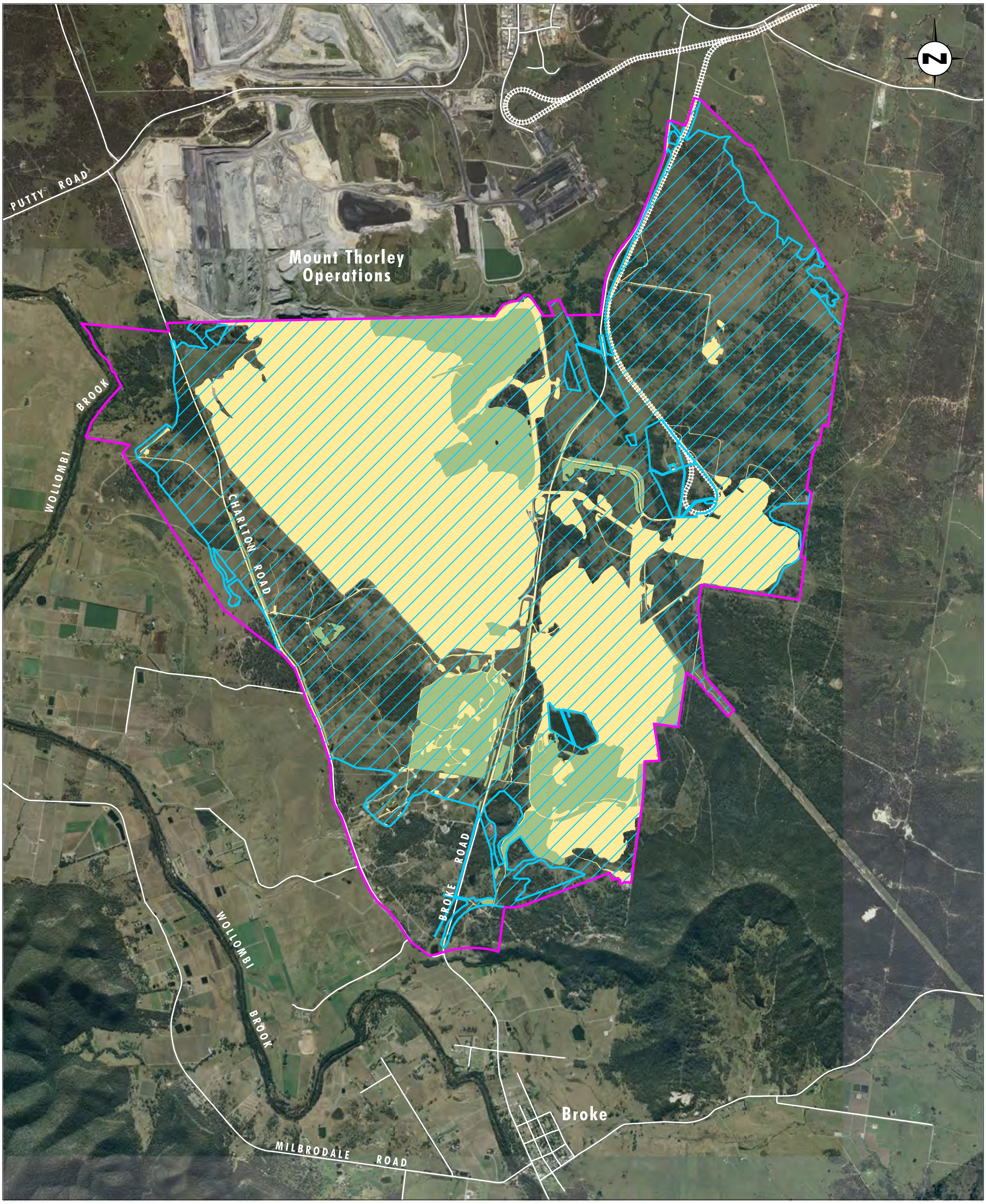


Source: AAM Pty Limited (March 2012), Xstrata Coal (NSW) Pty Ltd

0 1 2 3km

Legend

- Project Area
- Project Disturbance Footprint
- Existing Disturbance
- Current Mine Rehabilitation

FIGURE 1.3

Existing Disturbed Areas within Project Area

- describes and maps the soils, terrain and land characteristics, water resources and agricultural land use history of the Project area and its local context, with particular attention to areas that have been mapped in regional scale maps as being Strategic Agricultural Land (SAL), because of biophysical characteristics (BSAL) or socio-economic values (Critical Industry Clusters or CIC). This information is in **Sections 2.0** and **4.0**.

  The AIS provides baseline data of the agricultural enterprises and resources on the Project area and in the surrounding region at an appropriate scale and notes the existing constraints to and opportunities for agricultural land uses. This information is in **Section 3.0**;

- describes and maps areas to be temporarily and permanently removed from agricultural uses, including land transferred to environmental or biodiversity uses. Land that could be returned to agricultural uses is also identified and measures to achieve suitable land and soil capability after mining (during the mine rehabilitation process) are discussed. This information is in **Section 5.0**;

- analyses and evaluates the risks that the Project presents to agricultural land resources and uses. This is based on identification of potential impacts of the Project on agricultural resources and industries and a risk based approach to identify potentially significant impacts. Potential impacts considered include removal or reduction in the quality of agricultural resources (such as soil, suitable terrain, water and infrastructure); and potential socio- economic impacts such as reduction in visual amenity, and reduced or lost access to transport infrastructure, agricultural support services or value adding agricultural industries. The AIS also identifies potential benefits of the Project for agricultural and rural industries. The evaluation considers both operational and post mining land use contexts and Project specific and cumulative impacts. This information is in **Section 5.0**. Additional assessment of potential impacts on the broader social values of agricultural land use in the locality of the Project area is presented in the Social Impact and Opportunities Assessment that accompanies the EIS for the Project;

- identifies options for minimising any adverse impacts on agricultural resources (**Section 6.0**); and

- provides an overview of the comparative cost benefit ratios of agriculture (including agriculture related tourism in the Broke Fordwich wine tourism area) and mining in the Project area (**Section 5.2.5**). This is further discussed in the Economic Impact Statement that accompanies the Environmental Impact Statement (EIS) for the Project.

The focus of this assessment is on the potential impacts of the Project on agricultural land capability and agricultural production/productivity.

The analysis and impact evaluation indicate the following outcomes for agricultural land use:

- mining, grazing, viticulture and rural tourism land uses have coexisted in this area for more than 30 years and all these uses have changed or expanded over that time;

- soil landscapes and land and soil capability in the Project area and its local context are diverse, but a common theme is that the area is characterised by relatively poor, texture contrast soils, with low fertility, poor structure, high erodibility, high erosion hazard, and limited access to permanent or quality water. The exception is the lower western slopes of the Fordwich Sill and some parts of the alluvial terrain along Wollombi Brook. Specific information about the land and soil capability of these areas is provided in **Section 2.0**;

- the Project will have negligible direct impact on BSAL, as defined in the Upper Hunter SRLUP. Additional soil survey and mapping at 1:25,000 scale demonstrates that no land meeting the BSAL criteria lies within the Project area however there is potential for land on the western slopes of the Fordwich Sill located within 2 kilometres of the Project area to meet BSAL criteria. The Project will have a negligible impact on any land located outside the Project area that may qualify as BSAL;

- the Project will have minimal direct impact on the agricultural lands within the Broke-Fordwich subregion of the Viticulture Critical Industry Cluster, as defined in the Upper Hunter SRLUP. The construction of the new Noise and Visual Bund, which will screen properties within the Broke-Fordwich viticulture subregion from the mining landscape, has the potential to improve conditions for the small boutique wineries and tourism facilities in the subregion; and

- within the footprint of the Project, agricultural land is currently of land and soil capability classes 5 (non mined areas) to 8 (previously mined areas) (refer to **Section 2.0**) and has historically been used for low intensity cattle grazing. BCM currently manage some of the 'buffer land' within the Project area for grazing purposes along with a vineyard and an olive grove. Post mining land rehabilitation will primarily be targeted to restoring native ecosystems. This is consistent with regional priorities for restoring and enhancing biodiversity connectivity. However, some areas of the indicative final landform identified for the Project have been identified as being potentially suitable for grazing and other agricultural production with appropriate soil remediation action after mining. There is also scope for other agriculture related businesses/industries to use the Project area following closure.

1.1 Location

This report considers the potential impacts of the Project on the Project disturbance area and also considers potential impacts on the general locality, which is the context for the current and proposed mining land use. This broader locality is referred to as the 'Study Area'.

The Project is located approximately 12 kilometres south-west of Singleton in the Hunter Valley, NSW (refer to **Figure 1.1**), approximately 4 kilometres north of the village of Broke and 4 kilometres east of the village of Bulga (refer to **Figure 1.2**).

Land use within and to the north of Project area is dominated by coal mining. **Figure 1.3** highlights the parts of the Project area which are currently directly impacted by mining. Within the proposed 4116 hectare Project disturbance footprint, these heavily disturbed areas total approximately 2115 hectares (approximately 51%). This area includes approximately 432 hectares of previously mined and disturbed land which is currently undergoing rehabilitation. The approved final land use of areas currently undergoing rehabilitation is native vegetation.

The Project area is adjoined to the north by the Mount Thorley/Warkworth Operations open cut coal mine and to the east by the Singleton Military Training Area (SMTA) which occupies over 13,750 hectares. The SMTA is used for defence training purposes and has not been considered further in the AIS due to the long term non-agricultural nature of the land use.

The Project area is predominately to the east and north of the Broke-Fordwich Wine Sub-Region which is based around the Wollombi Brook alluvial floodplain and the fertile Fordwich Sill between Broke and Bulga. A small section of the Project area associated with the construction of the Noise and Visual Bund and realignment of Charlton Road (refer to **Section 1.2**), west of the existing alignment of Charlton Road, is located within the Broke Fordwich Wine Sub-Region (as mapped in the Upper Hunter SRLUP). Charlton Road currently forms the eastern boundary of the Wine Sub-Region in the vicinity of the Project area). The Broke-Fordwich Wine Sub-Region has been identified as a Critical Industry Cluster (CIC) in the Upper Hunter Strategic Regional Land Use Plan (NSW Government 2012). The CIC is discussed further in **Section 4.2**.

Approximately 150 hectares of land mapped within the CIC will be disturbed by the Project. The section of the CIC within the Project area does not have any vineyards located on it but it does contain one olive grove, currently owned and managed by BCM, which is proposed to be removed. A pipeline supplying irrigation water to rural properties in the CIC will be realigned as part of the Project. One vineyard, known as The Vere, and owned by BCM will be directly impacted by the Project. This vineyard is located to the east of the current alignment of Broke Road and is not part of the CIC.

The broader context of the Study area extends from the Monkey Place Creek catchment to the south-east of the Project area, to the Hunter River in the north and is bounded to the west by the Wollemi escarpment. This broader context includes parts of the Wollombi Brook catchment and the Loders Creek catchment.

Figure 1.4 identifies the area that is considered in the AIS. As discussed in **Section 4.0**, this area includes part of the Broke Fordwich Wine Sub Region CIC and an area identified in the Upper Hunter SRLUP as being BSAL.

1.2 The Project

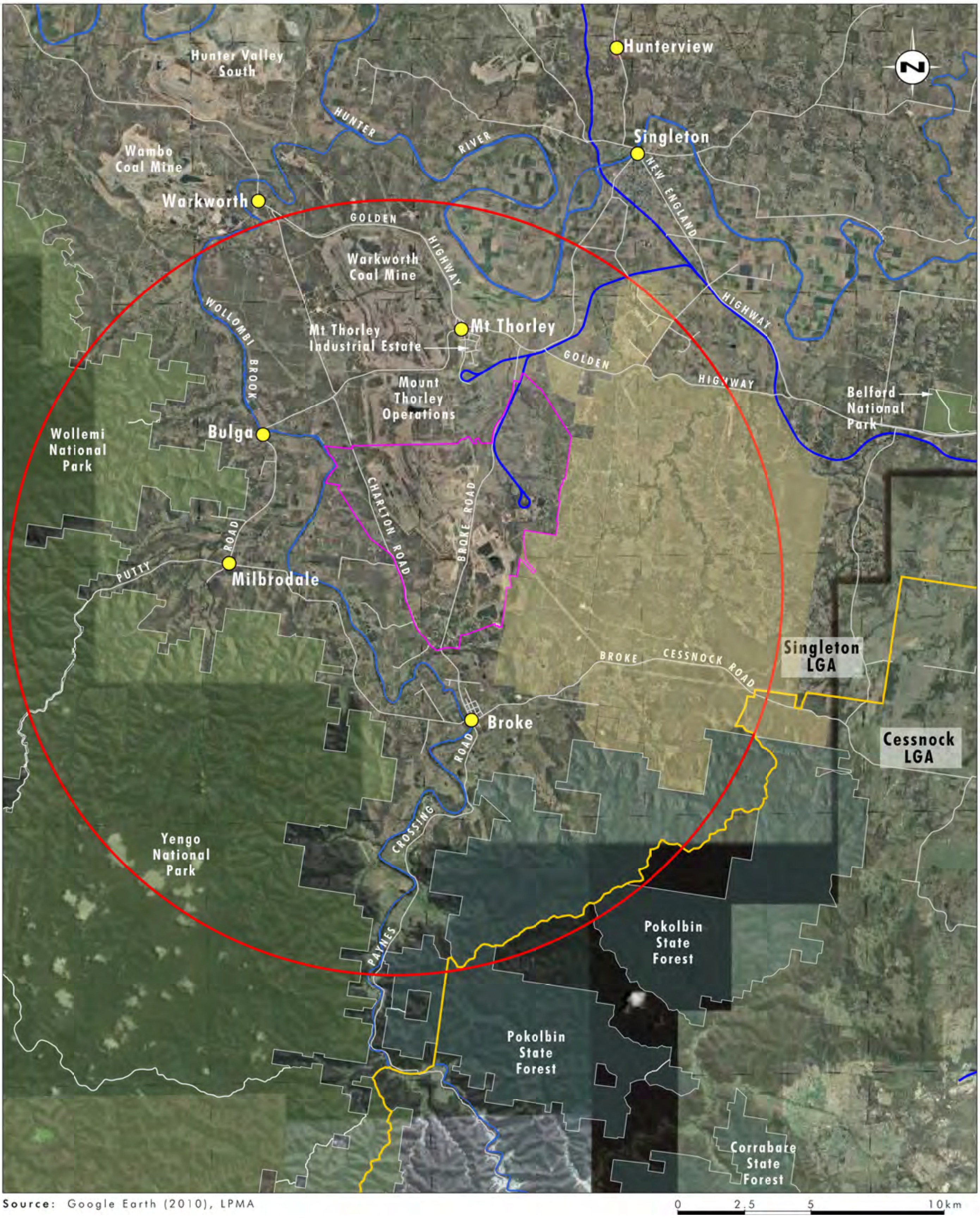
The Project is a proposed continuation of the existing Bulga Surface Operations at BCC. The BCC also includes the Bulga Underground Operations, an approved multi-seam longwall mining operation. The Project does not change the approved longwall mining operations. The Project will enable mining to continue for a further approximately 22 years (approximately 10 years beyond the existing Bulga Surface Operations' development consent expiry date) extracting approximately 200 million tonnes of additional run of mine (ROM) coal by open cut methods. Further activities within the Project area associated with the rehabilitation of the areas impacted by BCC activities will occur for several years after mining has ceased.

The Project will optimise utilisation of existing infrastructure at the complex. No change is proposed to either the maximum approved production rate from the open cut operations or the coal handling and preparation plant (CHPP) throughput.

The key features of the Project are summarised in **Table 1.1**. The location of these key features is shown in **Figure 1.5**.

Table 1.1 – Overview of the Project

Major Project Components	Proposed Operations
Total Production	Approximately 230 Mt ROM Coal over the life of the Project including approximately 30 Mt of existing approved ROM coal reserves.
Annual Production Limit	No changes from current approved annual limits. Up to 12.2 Mtpa ROM coal from the Bulga Surface Operations and up to 20 Mtpa ROM coal through the CHPP.
Mine Life (Production)	Approximately 22 years with further rehabilitation and closure works being carried out after the end of this period.
Operating Hours	24 hours per day, 7 days per week.
Number of Employees	Continued employment of approximately 700 full time employees, decreasing towards the end of the Project. Approximately 300 construction employees, predominately during the first 3 to 4 years of the Project.



Source: Google Earth (2010), LPMA

Legend
- Project Area
- AIS Study Area
- Local Government Area
- National Park
- State Forest
- Singleton Military Training Area
- Towns/Villages

FIGURE 1.4

AIS Study Area

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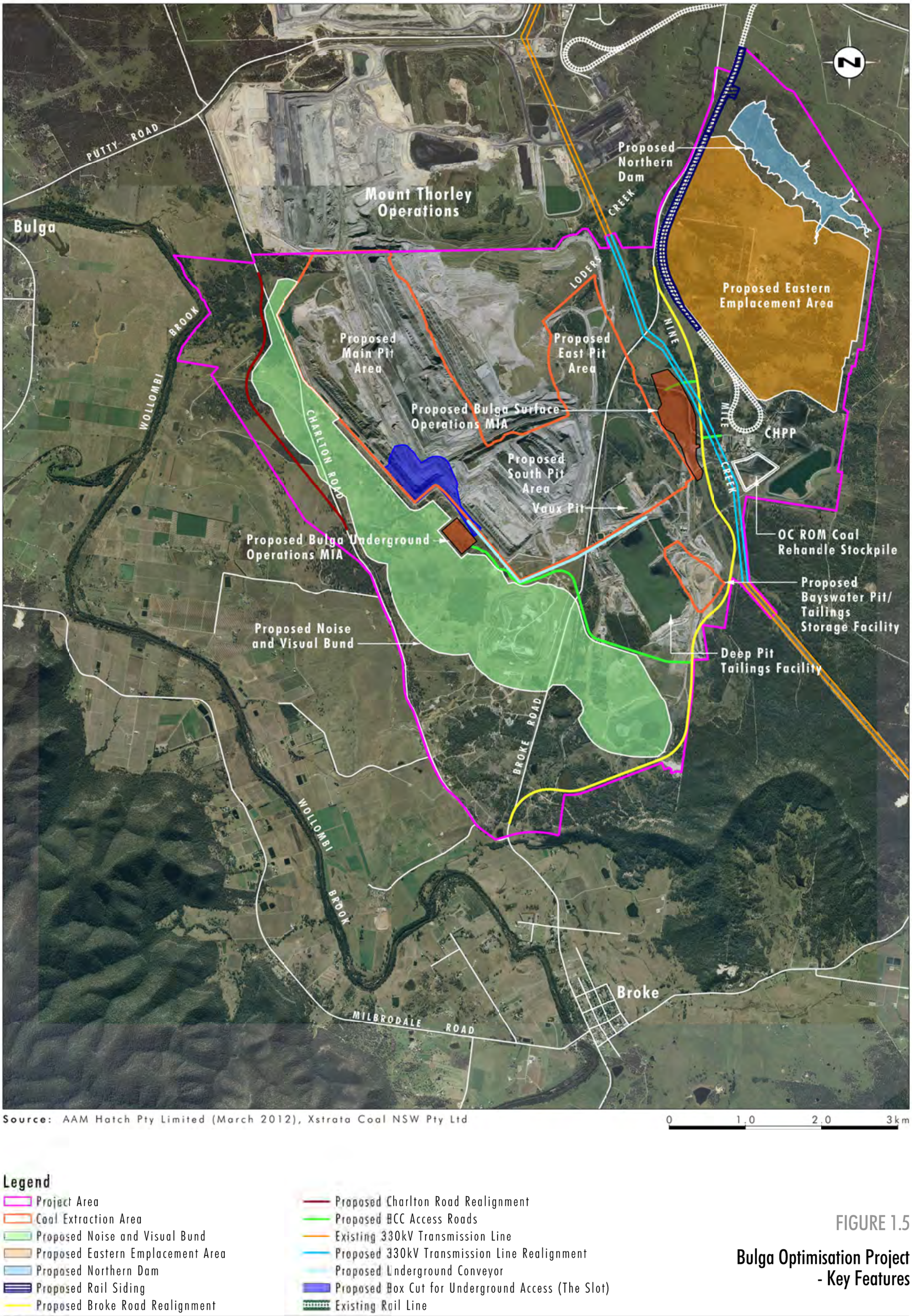

FIGURE 1.5

Bulga Optimisation Project - Key Features

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Table 1.1 – Overview of the Project (cont.)

Major Project Components	Proposed Operations
Mining Methods	Open cut mining (including some highwall mining).
Mining Areas	Mining in three contiguous pit areas: • a western extension of the existing Bulga Pit and extraction of coal to the base of the Woodlands Hill seam (the Main Pit area); • an eastern extension of the Bulga Pit to mine the deeply dipping seems in the Wittingham Coal Measures (the East Pit area); and • deeper mining down to and including the Broonie seam series (South Pit area). A new pit area, known as the Bayswater Pit, mining shallow coal reserves will also be developed to the northeast of the former Deep Pit. This pit will ultimately be used for wet tailings storage. The Project will also develop a new box cut in the highwall for accessing existing approved underground mining areas.
Mine Infrastructure	• A new open cut mine infrastructure area (MIA). • A new underground MIA as its currently approved location will be affected by the proposed open cut mining. • Upgrades to the existing CHPP to improve throughput efficiency and increase product yield. • Changes to some Bulga Underground Operations infrastructure, including conveyor location, where it will be affected by the proposed open cut mining. • Development of new haul roads to out-of-pit emplacement areas including 2 new bridges over the realigned section of Broke Road. • Enlargement of ROM and product coal stockpile areas. • Construction and use of new approximately 3000 ML water storage dam (Northern Dam) as part of the mine water system. • Changes to mine and clean water diversion, management and reticulation systems. • Changes to ancillary infrastructure, including access roads and the development of construction laydown areas.
Emplacement Areas	Construction of two out-of-pit emplacement areas. The proposed Noise and Visual Bund has been designed to minimise the noise and visual impacts of the ongoing mining operations while the proposed Eastern Emplacement Area enables overburden from the eastern side of the open cut operations to be handled in a manner that minimises noise and air quality impacts to the majority of residents around the Project area. Overburden will also be emplaced in-pit.
Tailings and Rejects Strategy	Tailings will be disposed of in the Deep Pit and Bayswater Pits with tailings also potentially disposed of in the underground workings. Coarse rejects and paste thickened tailings will be co disposed with overburden.
External Coal Transport Infrastructure	No change to approved annual maximum product transported by train. Continued use of Saxonvale Rail Spur. Construction and use of a rail siding adjacent to the existing rail easement capable of parking two coal trains awaiting loading at the BCC.
Electricity Infrastructure	Realignment of sections of two 330 kV transmissions lines and other 66 kV and 11 kV powerlines and other changes to associated electricity infrastructure.
Public Roads	Realignment of sections of Broke Road and Charlton Road and the construction of haul road bridges over the realigned section of Broke Road.

Table 1.1 – Overview of the Project (cont.)

Major Project Components	Proposed Operations
Pipelines and Other Services Infrastructure	The relocation of the Broke Fordwich Private Irrigation District (PID) water pipeline, Singleton Council Broke potable water supply pipeline and other services (such as telecommunications infrastructure) which are associated with the existing public road alignments.
Resource Definition Exploration	Ongoing borehole drilling and sampling in and adjacent to mining areas to better understand the coal resource, coal quality, geological conditions and geotechnical constraints.
Rehabilitation	Rehabilitation of areas disturbed by BCC operations, infrastructure and construction.

A more detailed Project description is provided in the EIS which this AIS accompanies.

The footprint of the open cut mining area is largely within the existing BCC disturbance footprint. Additional areas of disturbance are:

- Two out-of-pit emplacement areas associated with the Project will extend the disturbance footprint of the Project onto land that is currently or has historically been used for grazing and other agricultural activities.
- The proposed Noise and Visual Bund will be located largely over land that will be subsided by the approved longwall mining operations carried out as part of the Bulga Underground Operations.
- Construction of the new Northern Dam.
- Realignment of sections of the Broke and Charlton Roads (refer to **Figure 1.5**).
- The diversion of the Broke-Fordwich Private Irrigation District (PID) pipeline which supplies water from the Hunter River to the Broke-Fordwich area also forms part of the Project. To avoid impacts on irrigators relying on the pipeline, the diversion of the PID pipeline will be fully constructed before the existing pipeline is decommissioned.

The disturbance footprint of the proposed Project is shown in **Figure 1.3**.

1.3 Director-General's Environmental Assessment Requirements (DGRs)

The NSW Department of Planning and Infrastructure (DP&I) issued DGRs for the Project on 14 December 2011 and supplementary DGRs on 30 April 2012. The DGRs outline the specific requirements to be addressed in the Environmental Impact Statement (EIS). Whilst the 14 December 2011 DGRs do not contain specific requirements for the assessment of impacts on agricultural production, the supplementary DGRs were primarily focussed on the assessment of impacts on agriculture and potential land use conflicts generally. Specifically, the Supplementary DGRs require:

> the preparation of an Agriculture Impact Statement that includes specific focused assessment of the impacts of the proposal on strategic agricultural land, having regard to the draft gateway criteria in the draft Upper Hunter Strategic Regional Land Use Plan.

As confirmed by the DP&I in November 2012, the AIS has been prepared having regard to the Upper Hunter SRLUP which was finalised in late September 2012 (replacing the earlier draft referred to in the DGRs). As DGRs had been issued for the EIS prior to the finalisation of the Upper Hunter SRLUP, the Gateway process under the Upper Hunter SRLUP does not apply to the Project. However the DGRs require the AIS and EIS to address the criteria. Gateway criteria for strategic agricultural land and where they have been addressed in the AIS are provided in **Table 1.2**.

Table 1.2 – Checklist of Gateway Criteria for Upper Hunter SRLUP

Gateway Criteria	Relevant AIS Section
Project area Verification – whether the applicant's Gateway Certificate Application demonstrates that the mapped land does or does not meet the criteria for biophysical strategic agricultural land and/or the critical industry cluster (note: as the maps that identify strategic agricultural land are regional in scale, the applicant would be required at the gateway stage to verify that the Project area does meet the criteria of the relevant category/s of strategic agricultural land).	**Section 4.0**

Biophysical Strategic Agricultural Land – Whether the proposal would significantly reduce the agricultural productivity of the land based on a consideration of:
• Impacts on the land through surface area disturbance and subsidence;
• Impacts on:
  ▪ Soil fertility
  ▪ Rooting depth, or
  ▪ Soil profile materials and thickness;
• Increases in land surface microrelief or soil salinity, or significant changes to soil PH, and
• Impacts on Highly Productive Groundwater, including the provisions of the Aquifer Interference Policy and the advice of the Minister for Primary Industries (note that the Minister for Primary Industries will be required take into account the advice of the Commonwealth Independent Expert Scientific Committee in providing advice at this stage).
	Section 4.1

Critical Industry Clusters – Whether the proposal would lead to significant impacts on the critical industry cluster through: • surface area disturbance, • subsidence, • reduced access to agricultural resources, • reduced access to support services and infrastructure, • reduced access to transport routes, or • loss of scenic and landscape values.	**Section 4.2**
Consultation – Any advice received from the Commonwealth Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development.	**N/A**

1.3.1 Agricultural Impact Statement Guidelines

The DP&I has issued guidelines for the preparation of agricultural impact statements (DP&I 2012). The guidelines are outlined in **Table 1.3** which also identifies the relevant section of the AIS where the required information is provided.

Table 1.3 – Summary of Agricultural Impacts Statement Guidelines

Assessment Requirement	Relevant Section of AIS
The Project area (detailed assessment of the agricultural resources and agricultural production of the Project area).	**Sections 2.0** and **3.0**
The Surrounding Locality (Identification of the agricultural resources and current agricultural enterprises within the surrounding locality of the Project area). (The AIS must contain maps/information of the locality surrounding the Project, which describes existing agricultural resources).	**Sections 2.0** and **3.0**
Current agricultural enterprises	**Sections 2.0** and **3.0**
Identification and assessment of the impacts of the Project on agricultural resources or industries	**Sections 4.0** and **5.0**
Identification/Assessment of physical movement of water away from agriculture	**Sections 4.0** and **5.0**
Assessment of Socio Economic Impacts	**Sections 4.0** and **5.0**
Identification of options for minimising adverse impacts on agricultural resources, including agricultural lands, enterprises and infrastructure at the local and regional level.	**Sections 5.0** and **6.0**
Document consultation with adjoining land-users and government departments	**Section 1.5**

A full economic impact assessment for the Project has been prepared and is contained in the EIS prepared for the Project. Socio-economic impacts are also considered in **Sections 4.0** and **5.0** of this AIS. Section 4 of the EIS also identifies the consultation that has been undertaken for the Project. A full response to submissions from agencies, local councils and the community and other stakeholders will be provided following public exhibition of the EIS and considerations of any submissions that may be made.

1.3.2 Consultation

The AIS Guideline (2012) requires information about engagement with stakeholders, including landholders and government departments.

Various local landholders, agricultural support industries and government agencies were consulted during the preparation of this AIS to obtain an understanding of the nature of the agricultural industry in the area. The people and organisations consulted, and the nature of the consultation is set out in **Table 1.4**.

Table 1.4 – Consultation Undertaken for Agricultural Impacts Statement

Organisation	Nature of Consultation
Jurd's Real Estate, Cessnock	Impact of mining on rural property values.
EC Throsby Pty Ltd, Wittingham (Stock and station agent)	Throughput of livestock.
Primo Australia (Abattoir), Scone	Size of business in terms of cattle throughput and no. of employees. Difficulty in sourcing cattle locally.
Kurri Meats, Kurri Kurri	Throughput of livestock.
Hunterstay Accommodation, Property Manager	Demand for tourist accommodation as well as mine worker accommodation.
Margan Wines, Broke	Irrigation water use/source/techniques. Viticulture productivity and expansion opportunities.

Table 1.4 – Consultation Undertaken for Agricultural Impacts Statement (cont.)

Organisation	Nature of Consultation
Catherine Vale Wines	The wine industry and impact of mining on the Broke area.
Broke Fordwich Private Irrigation District	The Private Irrigation District, how it functions, the size and the resources such as the pipelines etc, prospects for expansion.
NSW Office of Water, Newcastle	Availability/access to Hunter Water sharing plans and general agricultural water use data.
Department of Primary Industries (DPI), Agronomist, Scone	Carrying capacities of agricultural land around Broke-Singleton.
DPI Horticulturalist, Tocal	General information on the grape/wine industry in the Hunter region.
DPI, Agronomists and Policy Officers	On-site meeting and site inspection to discuss approach to AIS.

2.0 Land and Soil Capability and Physical Resources within the Study Area

This section describes and maps the soils, slopes, land characteristics and water availability of the Project area and surrounds. These are key physical resources to support agricultural land uses.

Information about existing and proposed future agricultural land uses, including type of use and area of proposed uses, is provided in **Section 3.0**.

2.1 Slope and Topography

Slopes and terrain units within the Project area and the surrounding landscape have been determined from a detailed Digital Terrain Model (DTM), which was derived from LiDAR data (aerial laser scanning) flown in 2011. The DTM enables rapid calculation of slope angle and slope form. By considering the DTM in conjunction with aerial photography and field observations, associations between slope and particular landforms can be confirmed.

Figure 2.1 shows areas of different slope classes in the Project area. Slope classes are aligned with the slope classes used in the BSAL verification criteria (DPI 2012) and in the NSW Land and Soil Capability Scheme (Second Approximation), 2012. The different slope classes represent the maximum slope for the different Land and Soil Capability classes used to determine the presence of BSAL.

2.1.1 Slope Classes

The general locations in which different slope classes within the Project area (excluding land disturbed by existing mining activities) are located are summarised in **Table 2.1**.

Table 2.1 – General Locations of Slope Classes in the Project Area

Slope Class*	Where are these slopes generally located?
</=2%, (Class 1)	Floodplain and terraces of the Wollombi Brook
2-5% (Class 2	Floodplain and terraces of the Wollombi Brook
5-12% (Class 3)	Alluvial/windblown sands draped over bedrock terrain Lower slopes of the Fordwich Sill Some undisturbed lands east of Charlton Road
12-20%land (Class 4)	Some undisturbed lands east of Charlton Road
20-33% (Class 5)	Upper slopes of Fordwich Sill.
33-50%, equivalent to class 7 land	Upper slopes of the Fordwich Sill, Slopes of the Sandstone hinterland/ranges, including 'The Vere'
>50%, equivalent to class 8 land	Slopes of the Sandstone hinterland/ranges, including 'The Vere'
Water	

*Corresponding Land and Soil Classification Class shown in brackets.

FIGURE 2.1

Landforms and Slopes

2.1.2 Landform

Terrain descriptors used in this section follow the terminology in McKenzie *et al* 2008 and McDonald *et al* 1990.

The study area is defined by three distinct land forms that influence historical and modern agricultural land uses. These land forms are generally indicative of the associated soil types. The locations of these landforms and slopes in the study area are shown in **Figure 2.1**.

Alluvial landforms

Alluvial floodplains and terraces along the Hunter River and Wollombi Brook are flat, mostly fertile and well drained landforms, with direct access to shallow aquifer and river water for irrigation. These alluvial plains are defined by the meander pattern of the watercourses and are inset within the surrounding steep sandstone hills, ranging to mountains and cliffs upstream of Broke. Downstream of Broke, the floodplain widens but is still set within a steep bedrock valley form. The Hunter River floodplain within the study area, upstream of Singleton, is very broad. This land form supports a range of high value agricultural enterprises within the study area.

Fordwich Sill ridge crest and slopes

The Fordwich Sill is an igneous intrusion which underlies a long, low hill to the north-west of the village of Broke, between the BCC and Wollombi Brook (refer to **Figure 2.1**). The Fordwich Sill has weathered to a rolling hill form, with a flat crest, steep upper slopes and side slopes generally between 5 and 10^{o}. The soils associated with the Fordwich Sill are moderately well drained, fertile and have a low erosion risk. The soils are reasonably deep on the lower slopes however they become shallow and stoney on the steeper slopes and at the hill top. The soil types are discussed further in **Section 2.2**.

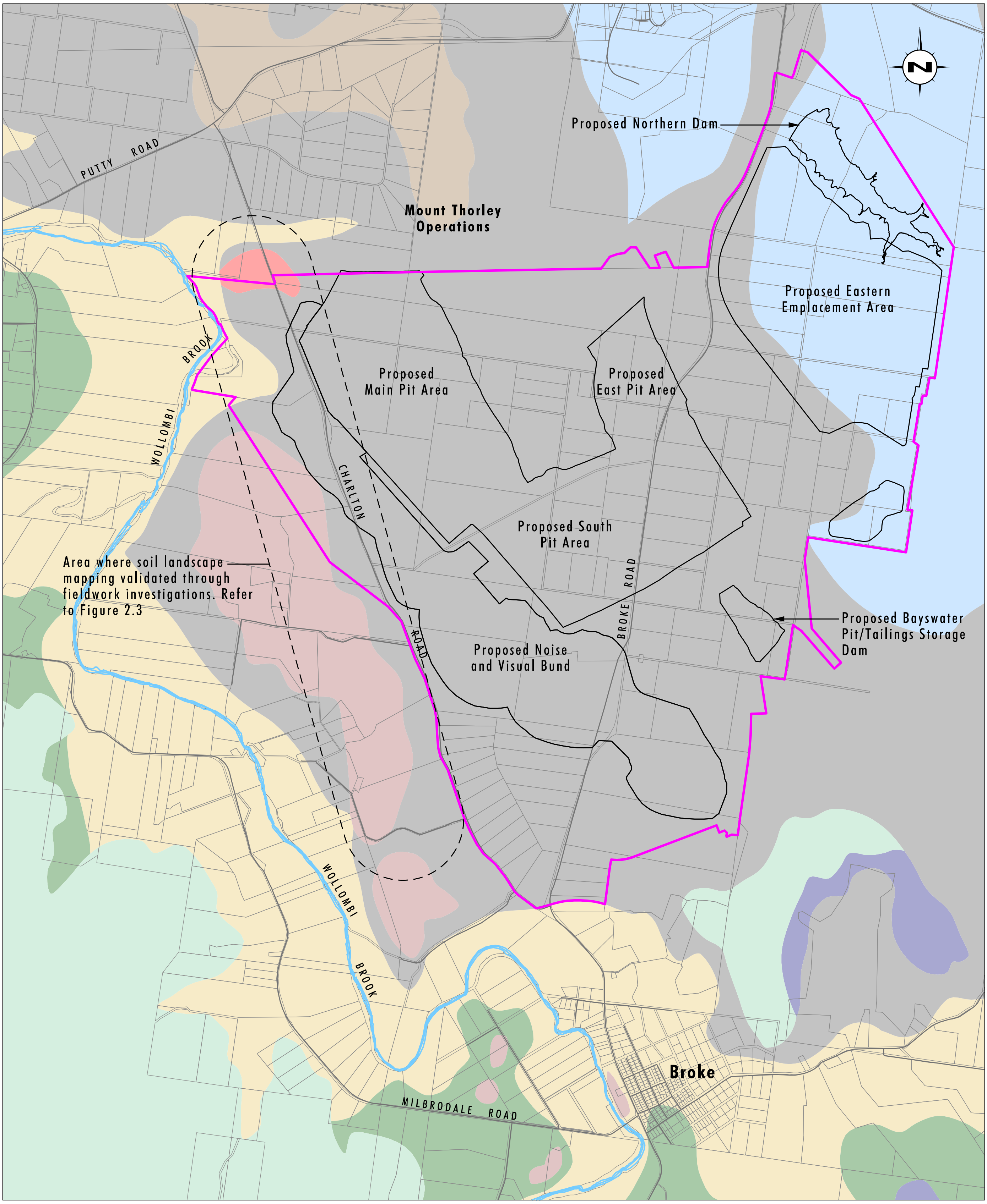
Undulating terrain

The remaining terrain in the region is gently undulating country with low crests and convex/concave side slopes, that cover the Project area and the land towards Singleton. The slopes typically vary from >2° to about 10° with restricted steeper areas associated with gully lines.

There are significant areas to the south, southeast and west of the study area that are dominated by steep and heavily timbered country that are not considered in this report due to the non- agricultural nature of the country. This land is included in National Park, State Forest and parts of the SMTA (see **Figures 1.2** and **2.1**)

2.2 Soil Landscapes in the Study Area (context of the Project area)

Soil Landscapes are defined by distinctive associations of terrain, soil and vegetation at the landscape scale. For the Upper Hunter region, soil landscape mapping was completed by Kovac and Lawrie (1991). These soil landscapes, as described by Kovac and Lawrie (1991), are detailed below (**Table 2.2**). **Figure 2.2** shows the location of these soil landscapes as mapped by Kovac and Lawrie (1991) within and in the vicinity of the Project area.



Source: BCM (2012), LPMA, Kovac and Lawrie (1991)

0 1 2 3km

Legend

- Project Area
- Saxonvale Soil Landscape
- Rothbury Soil Landscape
- Lees Pinch Soil Landscape
- Bulga Soil Landscape
- Branxton Soil Landscape
- Jerrys Plains Soil Landscape
- Ogilvie Soil Landscape
- Warkworth Soil Landscape
- Wollombi Soil Landscape

FIGURE 2.2

Soil Landscapes (Kovac & Laurie 1991)

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20130422 10.13

Table 2.2 – Soil Landscape Characteristics

Soil Landscape	Terrain	Soil Profile Types	Other Characteristics	Hazards
Wollombi Soil Landscape	Wollombi Brook floodplains	Alluvial soils (deep alluvially derived sands and Earthy Sands). Topsoils may include: brown to brownish-black or yellowish-brown loamy sand; brown to brownish-black sandy loam; brown sand; and dark reddish-brown loam-fine sand. Subsoils may include: dark reddish-brown loamy sand, brown fine sandy-loam, and sandy to medium clay	Profile depth greater than 100 cm, but poorly differentiated. pH 6.0-6.5 Low to moderate fertility Low water holding capacity	Susceptible to moderate stream bank erosion along watercourses. The erodibility and soil salinity risk is low.
Saxonvale Soil Landscape	Elongated ridge and steep to moderate side slopes associated with the Fordwich Sill. Lower gradient undulating terrain on footslopes of the ridge.	Predominantly comprised of gradational, medium textured and well structured soil profiles (Chocolate Soils). Brown Soloths occur on some upper slopes. Topsoils may include: brownish-black loam, dark brown sandy-loam, and brown loamy sand. Subsoils may include: dull to dark reddish-brown light/medium clay and brown sandy-clay.	Profile depth 70-100 cm pH 6.0 Low (Brown Soloths) to high (Chocolate Soils) fertility Moderately well drained Moderate to high available water-holding capacity	Susceptible to minor sheet and rill erosion on slopes, particularly where there is significant run-on potential. The erodibility and soil salinity risks of both the topsoils and subsoils are low.
Branxton Soil Landscape	Moderate to low slopes, with long side slopes. Drainage lies have eroded valley fills, many would formerly have had chain of ponds form.	Yellow podzolic soils on mid slopes and red podzolic soils on crests and upper slopes. Yellow soloths on lower slopes and drainage lines. Siliceous sands may occur on drainage flats in larger valleys.	Acid topsoil Low fertility Rapidly to poorly drained, low to moderate water holding capacity. pH 5.5-6.5	High erosion hazard on long slopes with high run-on. Yellow soloths subject to tunnel and gully erosion and may have high salinity. Siliceous sands affected by gullying.

Table 2.2 – Soil Landscape Characteristics (cont.)

Soil Landscape	Terrain	Soil Profile Types	Other Characteristics	Hazards
Rothbury Soil Landscape	The duplex soils in the north-east of the Project area are associated with the Rothbury Soil Landscape. Undulating country, including upper, mid and lower slopes.	Strong texture contrast Red Podzolic Soils on upper slopes and Yellow Podzolic Soils on midslopes. On lower slopes Yellow Solodic Soils and brown Soloths occur, while in the drainage lines Prairie Soils occur. Topsoils may include: dull brown to dark brown sandy-loam; dark brown sandy-loam or loam; brown sandy-loam to clay loam; yellowish-brown sandy-clay loam; brownish-black silty-clay loam; dark brown silt loam; and yellowish-brown loamy sand. Subsoils may include: yellow-orange, yellowish-grey, bright brown to reddish brown medium clay; yellowish brown light/medium clay; and dark brown light clay. The depth to bedrock typically ranges from 60 cm to over 200 cm.	Low to moderate fertility, Poorly to moderately well drained Moderate to high available water-holding capacity. Typical soil pH varies between 5.5 and 7.0.	The soils of Rothbury are susceptible to minor sheet erosion on slopes with moderate sheet and gully erosion on the lower slopes. The erodibility of the topsoils ranges from moderate (Red and Yellow Podzolic Soils, Brown Soloths and Prairie Soils) to high (Yellow Solodic Soils). The erodibility of subsoils ranges between low (Red Podzolic Soils), low to moderate (Yellow Podzolic Soils), moderate (Prairie Soils and Yellow Solodic Soils) and high (Brown Soloths). The soil salinity ranges from low (Red and Yellow Podzolic Soils, and Prairie Soils) to high (Yellow Solidic Soils and Brown Soloths).
Warkworth Soil Landscape	Predominantly comprised of Siliceous Sands. Occurs on the remnant sand dunes located in the north-west of the Project area.	Topsoil is bright brown to orange loamy-sand. Sand deposits are more than 100 cm deep, thinning towards the margins where the sand overlies bedrock terrain.	These sandy soils have a low fertility, is rapidly drained and has a low available water-holding capacity. Typical pH is 6.0 and mass movement hazard is nil.	Susceptible to minor sheet erosion where disturbed. The erodibility and soil salinity of both the topsoil and subsoil are low.

2.2.1 Soil Sampling and Mapping Program in the Project Area

Significant soil sampling in and around the Project area has been undertaken since the early 1990s as the site has been progressively developed as an expanding coal mining area. In addition to soil studies undertaken within and adjacent to the Project area by GSSE (2013), McInnes (1996), Mitchell McCotter (1992), Umwelt (2003) and Global Systems (2003), broad scale soil landscape validation sampling was undertaken for the purposes of the Project. The location of this sampling is shown in **Figure 2.3**.

For the current Project, the combined data available from these surveys and profile descriptions refines the distribution of soils types and hazards that have previously been mapped at a regional scale. This information allows clarification of the boundary of potential Land and Soil Capability Classes (as mapped by OEH at 1:250,000 scale), and qualification of the information about land and soil capability relevant to the identification BSAL. Further information about Land and Soil Capability classes is contained in **Section 2.5**.

2.2.1.1 Validation of Soil Mapping in the Project area

Risk based approach to validation

From a risk based approach, the potential loss/deterioration of land capability and agricultural suitability was assessed as being of low-moderate risk in the risk assessment undertaken for the Project (refer to **Appendix 4** of the EIS). The primary reason for the rating not being higher was the recognition that the vast majority of the Project area is located on poor quality soils that have low-moderate soil fertility and are generally affected by both sheet and gully erosion. With the possible exception of some lower gradient slopes and chocolate soils associated with the Saxonvale Soil Landscape, the land and soils within the Project area are typically suited only to low intensity grazing or conservation. The loss (even on a permanent basis) of the lower quality land and soil resources from future agricultural production is not considered to be a significant impact at a local or broader regional scale.

Accordingly, a risk based approach to validation of soil mapping was undertaken with greater intensity of soil mapping and sampling focussed on the potentially higher quality and/or alluvial aquifer associated soil landscapes. The approach to sampling and mapping of each of the soil landscapes is shown in **Table 2.3**. This level of validation of soil landscapes is designed to enable an informed assessment of the potential impacts of the Project on environmental and social factors dependant on key soil resources.

Table 2.3 – Risk Based Approach to Validation of Soil Types

Soil Landscape	Broad Suitability for Agriculture	Approach to Soil Sampling and Mapping
Branxton	Low-moderate fertility soils generally suited only to low-intensity grazing.	Low density soil samples in key areas proposed to be impacted to confirm location and ascertain fertility and usefulness in rehabilitation. Visual observations also used to confirm location.
Rothbury	Low-moderate fertility soils generally suited only to low-intensity grazing.	Low density soil samples in key areas proposed to be impacted to confirm location and ascertain fertility and usefulness in rehabilitation. Visual observations also used to confirm location.

Table 2.3 – Risk Based Approach to Validation of Soil Types (cont.)

Soil Landscape	Broad Suitability for Agriculture	Approach to Soil Sampling and Mapping
Saxonvale	Moderate to High fertility soils with lower slopes being suitable for cropping and horticulture/viticulture. Steeper slopes have shallow, rocky soils, generally better suited to low intensity grazing or native vegetation.	Higher density soil sampling and observations, particularly around the margins mapped by Kovac and Lawrie (1991), to confirm the extent of the soil landscape in the Project area and the fertility of soil types within the soil landscape. This work was largely done by GSSE as part of the Blakefield North Modification (refer to **Section 2.1.3**) which will also impact on this soil landscape.
Warkworth	Sandy soils generally not suitable for agriculture due to erodibility and poor fertility. The Warkworth Sands Woodland EEC is strongly associated with this soil landscape and conservation of this EEC is considered a better use of this land than agriculture.	No soil samples but location of aeolian sands mapped using visual inspection as part of detailed Warkworth Sands woodland EEC mapping (refer to **Section 5.6**).
Wollombi*	Low to moderate fertility sandy alluvial soils associated with the Wollombi Brook and Monkey Place Creek. Loamier variants have greater potential for pasture and rotational cropping.	The location of this soil landscape within the Project Area was mapped in detail as part of the Aboriginal Archaeological Assessment (Umwelt 2003a) forming part of the Bulga Coal Continued Underground Operations EIS (Umwelt 2003b). No additional mapping or validation of this soil landscape was undertaken for this Project.

*Using the detailed soil mapping undertaken by Umwelt (2003a), the Project has been designed to avoid any surface disturbance in this soil landscape due to its potential association with alluvial aquifers.

2.2.1.2 Mapping Undertaken for Blakefield North Project

Detailed soil mapping and assessment was prepared for BCM's Blakefield North project (GSSE 2013, see **Appendix A** for full profile descriptions and photos). The Blakefield North project area overlaps at the surface with the current Project area. Mapping carried out by GSSE (2013), conducted at a 1:25,000 scale, identified 10 specific Australian Soil Classification soil types (Isobel, 2002) across the slopes within the area identified as being BSAL in the Upper Hunter SRLUP (an area broadly aligning with the Saxonvale Soil Landscape mapped by Kovac and Lawrie (1991)), refining the available information about soil types and hazards. The purpose of this mapping was to validate the mapping of BSAL contained in the Upper Hunter SRLUP.

The soil types described during this survey fell within the following Great Soil Groups:

- Brown, red and yellow podsolic – on hillslopes of varying steepness;
- Chocolate soils – mid to lower slopes, on the Fordwich Sill;
- Lithosols – on ridge crests and steep upper slopes of the Fordwich Sill; and
- Yellow soloth – on low gradient footslopes and some valley fills.

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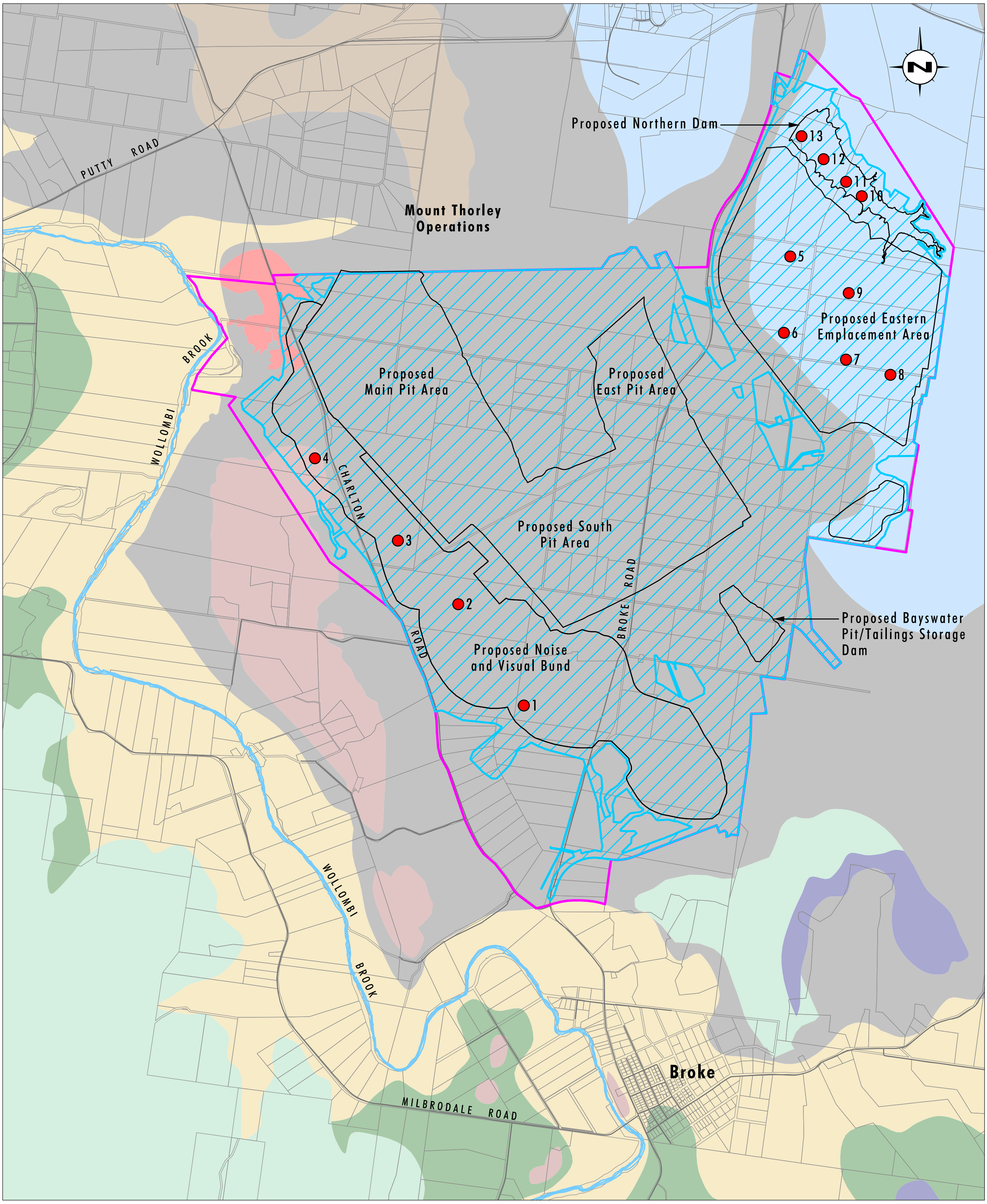

Source: BCM (2012), LPMA, Kovac and Lawrie (1991), Umwelt (2003a), Umwelt (2003b), GCSE (2013)

Legend

- Project Area
- Project Disturbance Footprint
- Approximate Soil Sampling Location
- Saxonvale Soil Landscape
- Rothbury Soil Landscape
- Lees Pinch Soil Landscape
- Bulga Soil Landscape
- Branxton Soil Landscape
- Jerrys Plains Soil Landscape
- Ogilvie Soil Landscape
- Warkworth Soil Landscape
- Wollombi Soil Landscape

FIGURE 2.3

Validated Soil Landscape Mapping in Project Area

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2.2.1.3 Soil Landscape validation of Lower Quality Soil Landscapes

Soil sampling associated with the Rothbury and Branxton soil landscapes was undertaken within the Project area in December 2011 and February 2012, to confirm existing information and provide more information in the north-eastern portion of the Project area where previous sampling has not been undertaken. Extensive observations of the Project site were also taken to confirm the uniformity of the landscapes as they have been mapped by Kovac and Laurie (1991). As illustrated on **Figure 2.3**, sampling was undertaken within the footprints of the proposed Noise and Visual bund, the Eastern Emplacement Area and the Northern Dam site.

The topsoils and subsoils were sampled and tested to assist in determining their current land and soil capability and to assess the suitability of soils for topsoil stripping and rehabilitation. The topsoils were tested for:

- electrical conductivity (EC);
- pH;
- Total Cation Exchange Capacity;
- calcium, magnesium, potassium, sodium and aluminium;
- available phosphorus;
- soil stability (using the Emerson Aggregate Test (EAT)); and
- texture.

The subsoils were tested for EC, pH, EAT and texture. The results of this soil sampling are contained in **Appendix B**.

The extent of the aeolian sands associated with the Warkworth Sands Woodland Endangered Ecological Community (EEC) was also assessed as part of the mapping exercise associated with defining the extent of the Warkworth Sands Woodland EEC (discussed further in the EIS and the *Ecological Impact Assessment: Bulga Optimisation Project* (Umwelt 2013)).

A small area of the Wollombi Soil Landscape is represented within north-west of the Project area however it is not within the disturbance footprint of the Project (refer to **Figure 2.3**) and therefore was not sampled as part of the AIS. Most of the high intensity/high value agricultural activity within the wider study area is undertaken on this soil landscape.

2.2.1.4 Results of soil testing and mapping

Details of soil profiles and soil characteristics in the Project area are presented below, for each Soil Landscape.

The mapped location of the soil landscapes and their relationship to the key features of the Project are shown on **Figure 2.3**. This mapping is a composite of the soil landscaping mapping undertaken by Kovac and Lawrie (1991), soil mapping undertaken for the *Bulga Coal Continued Underground Operations EIS* (Umwelt 2003b), soil mapping undertaken for the Blakefield North project (GSSE, 2013) and the soil sampling undertaken for this Project.

As can be seen from **Figure 2.3**, the Branxton soil landscape dominates the Project area, with a smaller area of the Rothbury soil landscape in the north-east of the Project area. The remaining soil landscapes, Saxonvale, Wollombi and Warkworth, located in the west of the Project area, only occupy a very small area.

The results of the soil sampling undertaken generally confirm the mapping undertaken of Kovac and Lawrie (1991) (refer to **Figure 2.2**), however, the westernmost soil sample (Soil Sampling Location 4 in **Figure 2.3**) indicates that the Saxonvale soil landscape extends slightly further north than was mapped by Kovac and Lawrie (1991). Soil mapping undertaken by Umwelt (2003) and GSSE (2013) suggests that the south-eastern extent of the Saxonvale soil landscape is also less than mapped by Kovac and Lawrie (1991). The mapping of the extent of the aeolian sands associated with the Warkworth Sands Woodland EEC also shows that the extent of the Warkworth Soil Landscape in the Project area is larger than identified by Kovac and Lawrie (1991).

The soils within the Project area which conform with the Branxton and Rothbury soil landscapes generally have low to moderate fertility and are moderately to highly erodible. These soils are generally not suitable for cropping. The soils associated with the Saxonvale soil landscape are of low to high fertility and the higher fertility chocolate soils located on low slopes are generally suitable for cropping. The sands associated with the Warkworth soil landscape have low fertility and are highly erodible.

Branxton Soil Landscape

The soils have previously been identified as Yellow Duplex and Podsolics that are slightly acidic, non-saline and with a clear textural boundary at a depth of up to 40 centimetres (Umwelt 2003). Recent sampling at Sites 1, 2 and 3 identified the soils as moderately acidic, non-saline and with Exchangeable Sodium Percentages of 6 to 8 per cent indicating the soils are likely to be lower fertility Soloths (Yellow Solodics). The texture contrast boundary was sharp at sites 1 and 2 and recorded at depths of 12 to 15 centimetres.

Branxton Soil Landscape	
Sites 1, 2, 3	
Great Soil Group/ASC Classification	Yellow Solodic/Yellow Soloth
Soil Landscape	Branxton
Slope Class	3 to < 10%
Landscape Position	Midslope to lower slope
Land and Soil Capability Class	4 to 5 Main limitation – soil acidification
Physical Description	
A1 Horizon	Sandy-clay, apedal, moderately acid (pH 4.7), medium CEC, non-saline, moderately dispersible with elevated sodium (exchangeable sodium percentage 6.25 to 8.5%). Sharp texture contrast boundary at 12 to 15 cm.
B Horizon	Medium clay, moderately dispersible and prone to tunnel erosion, orange/iron mottling evident, moderate pH (4.6).

Rothbury Soil Landscape

Soil landscape mapping identified these soils as red to yellow podzolics on the upper to mid slopes ranging to yellow solodics on the lower slopes. Sampling at Sites 5 to 9 were undertaken in the disturbance foot print of the Eastern Emplacement Area while Sites 10 to 13 were taken along the gully that will become the Northern Dam.

The soils of the Eastern Emplacement Area are moderately fertile and stable however the subsoils are prone to erosion, particularly on the lower slopes (refer to **Plate 2.1**).

	Sites 5, 7 and 9	Site 6	Site 8
Great Soil Group/ASC Classification	Yellow to Brown podzolic/Podzol	Yellow Solodic	Site shows evidence of having been previously disturbed
Soil Landscape	Rothbury	Rothbury	Rothbury
Slope Class	3 to < 10%	3 to < 10%	<3%
Landscape Position	Upper slope – Site 7; midslopes – Sites 5, 9	Lower slope	Upper slope
Land and Soil Capability Class	4 to 5 Main limitations: Soil acidification	5 Main limitations: Subsurface (tunnel) water erosion	4 Main limitation: soil acidification
Physical Description			
A1 Horizon	Loamy-sand, highly aggregated, moderately acidic (pH 4.9), non-saline, medium-good CEC, non sodic, sharp texture contrast at 20 to 25 cm.	Silty loam, highly aggregated, moderately acidic (pH 4.9), non-saline, medium-good CEC, sharp texture contrast at 20 to 25 cm.	Loamy sand, acidic (pH 4.3), non-saline, low CEC, moderate exchangeable sodium percentage (6%), slightly dispersible, no texture contrast boundary, evidence of charcoal at 20 cm.
B Horizon	Medium clay, slightly acidic (pH5.5 to 6.5), non saline,	Dispersive medium clay, slightly alkaline (pH7.8), moderately saline	Stable loamy sand, non-saline, slightly acidic (pH 6.4)

The soil sites sampled along the drainage line of the Northern Dam were uniform and low to moderately fertile, well drained, non-saline, moderately acidic gradational soils. There was no textural contrast in the B horizon.

Sites 10 to 13	
Great Soil Group/ASC Classification	Alluvial
Soil Landscape	Rothbury
Slope Class	<3%
Landscape Position	Drainage line

Sites 10 to 13	
Land and Soil Capability Class	4 to 5 Main limitation: Water erosion
Physical Description	
A1 Horizon	Sandy loam, moderately acidic (pH 4.5), non-saline, moderately low CEC, stable and not prone to slaking or dispersion, gradational boundary at 10 to 15 cm.
B Horizon	Loamy-sand, moderately acidic (pH 4.8), non-saline, stable and not prone to slaking or dispersion.

Saxonvale Soil Landscape

The one site sampled in the Saxonvale Soil Landscape confirmed the results of recent soil survey and testing undertaken as part of the Blakefield North project (GSSE 2013). The soil is a well structured, fertile clay soil with good soil depth. The soil is moderately acidic and non-saline. The topsoil is slightly dispersive and the subsoil moderately dispersible. The soil has elevated sodium levels with an Exchangeable Sodium Percentage of 9.5 per cent.

Site 4	
Great Soil Group/ASC Classification	Chocolate soil/Brown Dermosol
Soil Landscape	Saxonvale
Slope Class	<3%
Landscape Position	Lower slope
Land and Soil Capability Class	4 Main limitation: Water erosion, soil structure decline (sodic)
Physical Description	
A1 Horizon	Stongly structured dark brown medium clay, non-saline, moderately acidic. High CEC with high Magnesium levels. Gradational boundary to B horizon at 30 cm.
B Horizon	Well structured heavy clay, slightly acidic and non-saline.

Wollombi Soil Landscape

This landscape was not sampled as the disturbance footprint of the Project will not impact on the soil landscape which occurs along the Wollombi Brook in the north-west of the Project area.

PLATE 2.1
Gully Erosion in Proposed Location of Eastern Emplacement Area

Warkworth Soil Landscape

While not specifically sampled, the soils associated with the Warkworth Sands Woodland EEC and derived grassland variant was visually inspected by ecologists as part of a detailed vegetation mapping exercise (Umwelt 2012a). This sampling indicated a strong correlation between the Warkworth sands community and Aeolian sands consistent with the Warkworth Soil Landscape. This vegetation and associated Warkworth sands mapping indicates that the Warkworth Soil Landscape is more extensive than was previously mapped by Kovac and Lawrie (1991). The depth sampling undertaken by the ecologists indicated that the depth of these sands varied from several centimetres to over a metre.

2.3 Climate

Climate measurements including monthly rainfall distribution, evaporation, as well as maximum and minimum temperatures provide a key determinant of the agricultural potential of a district. The Bureau of Meteorology (BoM) maintain a number of weather recording stations in the vicinity of the BCC.

The Jerrys Plains Station (BoM Station 61086) has been used to characterise the rainfall and temperature data for the region. The Scone SCS Station (BoM Station 61089) has been used to characterise the monthly evaporation. These records, shown in **Table 2.4**, have been selected as they are long term (recorded for over 100 years) and they provide consistency between data used for components of the EIS.

Table 2.4 – Mean Monthly Rainfall, Maximum and Minimum Temperatures at Jerrys Plains and Mean Monthly Evaporation at Scone SCS

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall (mm)	76.7	72.8	58.4	44.5	40.9	48.1	43.5	36.5	42	52.2	61.1	67.9	645.2
Max temp (ºC)	31.7	30.9	28.9	25.3	21.3	18	17.4	19.4	22.9	26.2	29.1	31.3	25.2
Min temp (ºC)	17.1	17.1	15	11	7.5	5.3	3.8	4.4	7	10.3	13.2	15.7	10.6
Monthly Evaporation (mm)	220	174	155	105	68	48	56	84	117	155	183	220	1584

Source: Rainfall, Bureau of Meteorology, Jerrys Plains BOM, Station 61086.
Evaporation, Bureau of Meteorology, Scone SCS, BOM Station 61089.

The Broke district has a mild climate with few frosts and reasonably evenly distributed monthly rainfall. The rainfall is slightly summer dominant with 60 per cent of rain falling from October to March inclusive. The monthly evaporation exceeds rainfall in every month except June where evaporation is equal to rainfall.

The climate is suitable for a range of agricultural enterprises including permanent and annual horticulture, cropping enterprises as well as improved perennial and native pastures. The climate would support temperate to sub-tropical plants so long as there is a degree of frost tolerance or dormancy over winter. The growing season length would depend on the crop however it would be reasonable to expect that temperate species would have suitable conditions for growth from September through to May inclusive and possibly over the winter. Sub-tropical species could be expected to have a growing season of October through to March or April.

Permanent horticultural plantings and improved pastures would rely on irrigation to provide consistent productivity in this climate where there can be significant gaps between rainfall events and the evaporation rate is high.

2.4 Vegetation Patterns in the study area

The native vegetation in the study area is currently a mixture of grasslands, woody regrowth vegetation of varying densities from woodland through to forest and natural woodlands and forest areas. The grasslands within the Project area are derived following the widespread clearing of land for agricultural development since European settlement. Woody regrowth vegetation tends to dominate areas where agriculture is less profitable and corresponds with lower capability land. Naturally forested areas are confined to the steeper land that has always been considered unsuitable for agriculture. These areas have uses other than agriculture, including forestry, conservation, tourism and military training.

Further details regarding vegetation in the study area can be found in the *Ecological Impact Assessment: Bulga Optimisation Project* (Umwelt 2013).

2.5 Land and Soil Capability

Land and soil capability is the ability of the land to sustain a range of land uses and land management practices in the long term without degradation of soil, land, air and water resources (OEH 2012, drawing on Dent and Young 1981, Emery 1986 and Sonter and Lawrie 2007). Biophysical characteristics and hazards considered in determining land and soil capability are shown in **Table 2.5**:

Table 2.5 – Land and Soil Capability Classification: Biophysical Characteristics and Hazards

Soil and Landscape Characteristics	Hazards
• Soil type • Slope • Landform position • Acidity • Salinity • Drainage • Rockiness • Climate	• Water erosion, including sheet, rill and gully erosion • Wind erosion • Soil structure decline • Soil acidification • Salinity • Water logging • Shallow soils and rockiness • Mass movement

The Land and Soil Capability assessment scheme for NSW (OEH 2012) utilises concepts introduced in both natural resources literature and policy (such as the NSW natural resources targets, Natural Resources commission 2005), previous land capability assessments and mapping (Emery 1986) and in agricultural suitability classification schemes, such as Department of Agriculture 1983, SOILpak 1998, 2001 and FAO 1976, 1983.

The Land and Soil Capability scheme (OEH 2012) is designed to provide regional scale information about land capability as applied to broad scale, dry-land agricultural uses.

Table 2.6 presents the rationale and definitions for the eight land and soil capability classes currently used in NSW and their presence in the Project area based on broad scale (1:250,000 scale) mapping undertaken for the Upper Hunter SRLUP (refer to **Figure 2.4**).

Table 2.6 – Land and soil capability classes (OEH 2012)

LSC Class	General Definition	Present in Project area (based on regional scale mapping)?
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. Land capable of all rural land uses and land management practices	No
2	**Very high capability land**: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.	No
3	**High capability land**: Land has moderate limitations and is capable of sustaining high impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.	Yes (very small area, west of Charlton Road)
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)		
4	**Moderate capability land**: Land has moderate to high limitations for high impact land uses. Will restrict land management options for regular, high impact land uses such as cropping, high intensity grazing and horticulture. These limitations can only be managed by specialized management practices with a high level of knowledge , expertise, inputs, investment and technology.	Yes
5	**Moderate- low capability land**: Land has high limitations for high impact 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.	Yes
Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)		
6	**Low capability land**: Land has very high limitations for high impact land uses. Land use restricted to low impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environment degradation	Yes
Land generally incapable of agricultural land use (selective forestry and nature conservation)		
7	**Very low capability land**: Land has severe limitations that restrict most land uses and generally cannot be overcome. On site and off site impacts of land management practices can be extremely severe if limitations are not managed. There should be minimal disturbance of native vegetation	Yes (predominantly land previously disturbed by mining)
8	Extremely low capability land: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation	Yes (land previously disturbed by mining)

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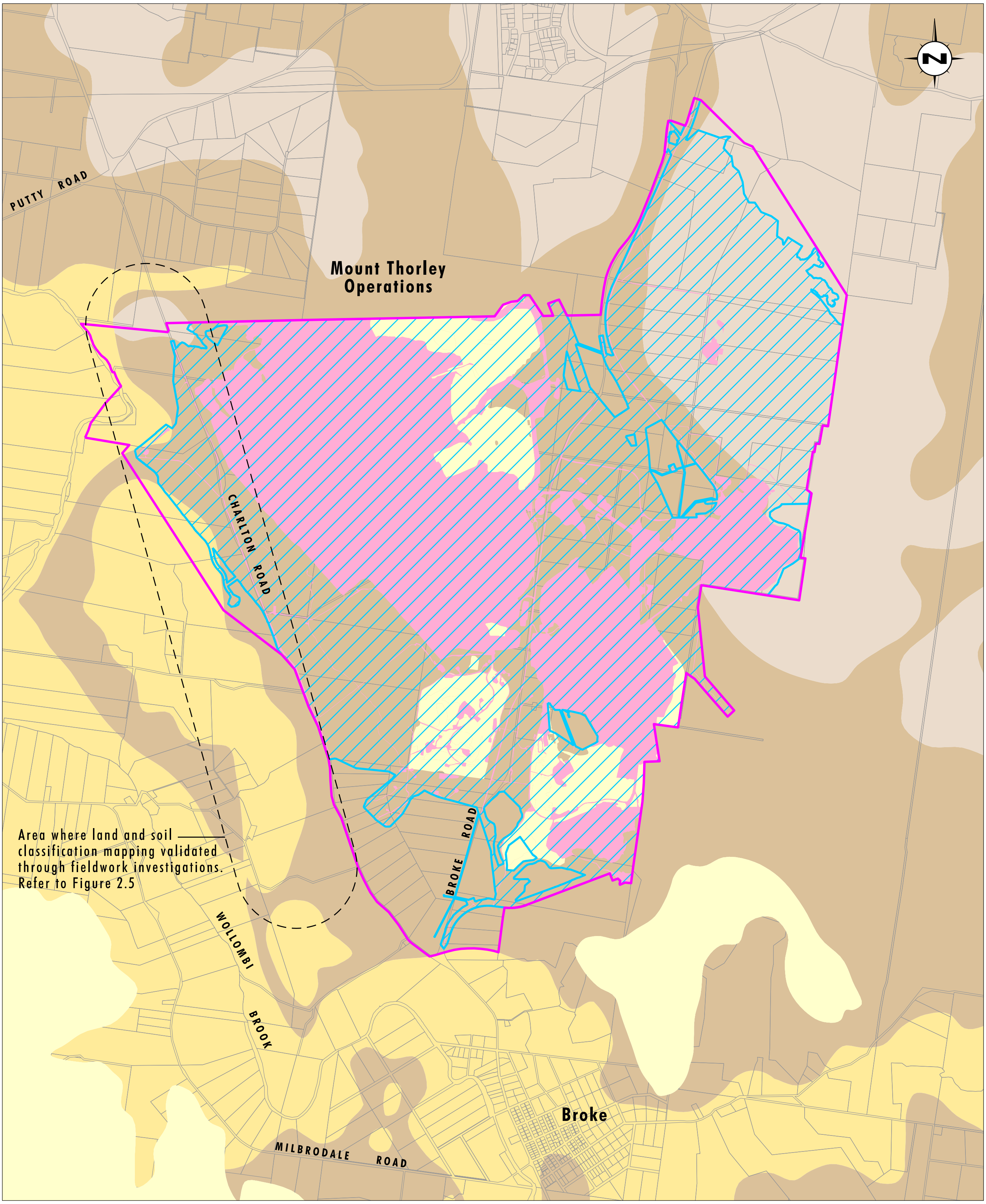

Source: Office of Environment and Heritage (OEH) SRLUP Mapping (2012), Department of Lands (2009)

0 1 2 3km

Legend

- Project Area
- Project Disturbance Footprint
- 3 - High Capability Land
- 4 - Moderate Capability Land
- 5 - Moderate-Low Capability Land
- 6 - Low Capability Land
- 7 - Very Low Capability Land
- 8 - Extremely Low Capability Land

FIGURE 2.4

Existing Land and Soil Capability (OEH 2012)

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The classes identify limitations on the type and intensity of use as a result of the severity of constraints related to the physical attributes of the soil and the extent to which intensive management is required to prevent on and off site degradation under varying land uses. The LSC Guideline requires each tract of similar land be assessed for each of the hazards and ranked from 1 to 8 where Class 1 represents the least hazard and Class 8 the highest hazard. From this the overall LSC Class is determined by the ranking of the most limiting hazard.

The classification does not necessarily reflect existing land uses; rather, it indicates the potential of the land for different agricultural purposes, while maintaining the quality of natural assets.

2.6 Water Resources

There are a number of small ephemeral creeks draining the Project area including the Northern Drainage Line, the Southern Drainage Line, and drainage lines that drain into Loders Creek or Nine Mile Creek (refer to **Figure 2.5**). Aspects of the Project including the construction of the Noise and Visual bund, the Eastern Emplacement area, the Northern Dam and the re-alignment of the Broke and Charlton Roads will have an impact on the localised water flow patterns and will be subject to water management plans.

The groundwater resources within Project area are limited to hardrock coal measures that have poor storage and transmission capabilities. Groundwater from these aquifers is saline and low quality (Mackie Environmental Research 2013).

The Wollombi Brook is a highly connected surface and alluvial groundwater source. The water is generally high quality however it is underlain by saline water associated with Permian coal measures which can leak into the alluvium under natural pressure gradients. (Mackie Environmental Research 2013). During dry times or following long periods of pumping the water quality in the aquifer can deteriorate due to increased EC levels.

Wollombi Brook is divided into two irrigation districts, the Upper and Lower Wollombi Brook. The Lower Wollombi Brook, in which the Project area is partly situated, has a total surface water entitlement of 6663 ML/year comprising 110 surface licenses with 88 per cent of the water used for agriculture. The groundwater entitlement is 5071 ML/year comprising 38 licenses. Fifty-five per cent of this water is used for irrigation purposes. The Upper Wollombi Brook has a much lower water entitlement with 2713 ML/year comprising 79 surface licenses and 2 groundwater licenses with 99 per cent used for agriculture. In total the Wollombi Brook accounts for 8.35 per cent of the total Hunter Extraction Management Unit (NSW Department Water and Energy 2009).

The Lower Wollombi Brook is considered as having high economic dependence on commercial extraction of water. It has medium instream values and high hydrological stress as peak extraction exceeds inflow in summer. The Upper Wollombi Brook has high instream values and high hydrological stress (NSW Dept Water and Energy 2009).

There are no new extraction licenses being issued for the Wollombi Brook.

The Broke-Fordwich Private Irrigation District (PID) is a community based irrigation scheme that pipes irrigation water from the Hunter River. The PID has a total annual extraction limit of 3000 ML and services over 240 individual shareholders in the Broke, Fordwich, Milbrodale and Bulga districts. The shareholders don't hold individual irrigation licenses and the entitlement is attached to the land and can only be transferred by direct application to the PID Board of Management. Currently there is approximately 200 ML of entitlement available for subscribers to increase their allocation. The PID pipeline currently runs through the

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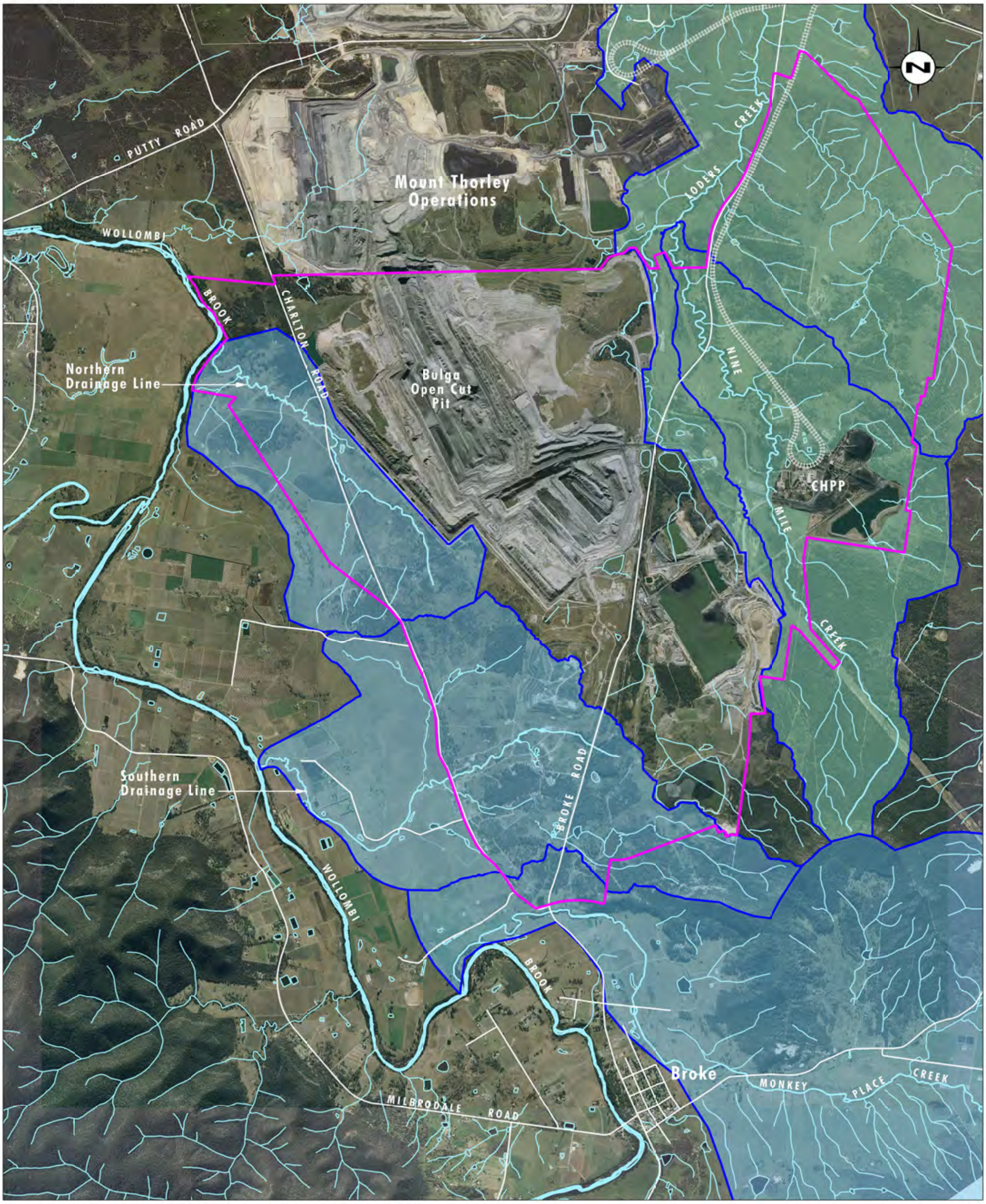

Source: AAM Pty Limited (March 2012), Xstrata Coal (NSW) Pty Ltd, LPMA

0 1.0 2.0 3km

Legend

- Project Area
- Catchment Boundary
- Wollombi Brook Sub Catchments within Project Area
- Loders Creek Catchment
- Railway Line
- Drainage Line

FIGURE 2.5

Water Resources and Catchments

Project area and will be relocated with the Broke Road realignment as part of the Project. The realignment route and process has been discussed and agreed with the PID Board of Management.

The Project area currently has a small level of irrigation development associated with the Vere Vineyard and BCM owned olive grove (refer to **Section 3.2**), however, there is extensive existing and proposed infrastructure development as part of the mine water management system which could potentially be used for irrigation purposes following closure of the mine.

There are only limited opportunities to expand the irrigation area within the Broke-Fordwich region. There may be opportunities in the future for the Broke-Fordwich PID or individuals to purchase more entitlement from the Hunter River if demand for water increases, however, the value of this water would be high due to limited trading and high demand generally within the Hunter Extraction Management Unit.

The majority of irrigation is used for vineyards and other horticulture. It is generally applied by efficient drip irrigation techniques. Irrigation water is also applied to pastures and crops using a combination of techniques including low pressure centre pivot and travelling irrigators and high pressure sprays. The dairy farm at the junction of the Charlton and Broke Roads is a significant agricultural water user in the Broke-Fordwich PID.

2.7 Land and Soil Capability and Physical Description of the Project Area

The Project area was assessed in greater detail and ranges from Land and Soil Capability Class 4 to 8. The assessment process is described in detail in **Section 2.7.5**.

While the Project has been designed to maximise the use of previously disturbed areas, some aspects of the Project will involve direct impact on areas of land that are not currently disturbed by mining or on areas that have previously been mined and are under various stages of rehabilitation. The physical resources and land capability of these areas have been examined in detail to provide baseline information from which the impacts of the Project on the agricultural activities and potential of the Project area can be determined. **Figure 1.3** shows the proposed disturbance footprint for the Project.

Components of the Project that will impact directly on land currently not extensively disturbed by direct mine surface impacts include the:

- Noise and Visual Bund;
- Eastern Emplacement Area;
- proposed Northern Dam; and
- realignment of the Charlton and Broke Roads.

The Noise and Visual Bund, southern section of the Broke Road realignment and the Charlton Road realignment are all largely located over areas that have been, or will be, undermined and subsided by the approved Bulga Underground Operations.

2.7.1 Topography and Landform

The proposed location of the Noise and Visual Bund currently has low slopes, mostly less than 5 degrees (refer to **Figure 2.2**). The relatively undisturbed parts of this area are generally free of significant erosion; however, some of the steeper slopes associated with current rehabilitation activities are eroding actively. These areas will be covered by overburden emplacement forming the Noise and Visual Bund and will be vegetated and actively managed to minimise erosion risks.

The proposed location of the Eastern Emplacement Area currently has about 50 per cent of the area with slopes less than 5 degrees and 50 per cent with slopes between 5 and 12 degrees. Currently the proposed site of the Eastern Emplacement Area has some active gully erosion associated with exposed subsoils on the lower slopes (refer to **Plate 2.1**).

The proposed Northern Dam is located in an area that has low slopes on the south-western side of the drainage line and slopes between 5 and 12 degrees on the north-eastern side of the creek line. The creek line itself is deeply incised. The drainage line on which the Northern Dam is proposed to be constructed has a history of gully erosion with some areas currently active and other areas stabilising with vegetation.

Slopes of 5 and 12 degrees contribute to potential erosion hazard of the Project area due to the concentration of overland water flow. The lower gradient slopes also have an elevated erosion risk due to the impeded drainage of the medium to heavy clay B horizon of duplex soils and the generally thin A horizon as a result of past sheet erosion, probably associated with early clearing and grazing activities.

2.7.2 Water Resources

There are a number of small ephemeral creeks draining the Project area including the Northern Drainage Line, the Southern Drainage Line, and drainage lines that drain into Loders Creek or Nine Mile Creek (refer to **Figure 2.5**).

The groundwater resources within Project area are limited to hard rock coal measures and weathered shallow coal measures. Groundwater from the hard rock coal aquifers is saline and low quality while the groundwater in the weathered shallow coal measures varies from fresh to slightly saline (Mackie Environmental Research 2013).

The Project area currently has a small level of irrigation development associated with the Vere Vineyard and BCM owned olive grove (refer to **Section 3.2**), however, there is extensive existing and proposed infrastructure development as part of the mine water management system which could potentially be used for irrigation purposes following closure of the mine should this be deemed appropriate as part of the detailed mine closure process

2.7.3 Vegetation Types

The Project area is characterised by regrowth of native vegetation including Ironbark, Bulloak and Grey Box. The regenerating tree cover is often thick enough to inhibit grass growth, leaving the ground bare of vegetation but with litter particularly in areas where Bulloak is dominant. Native woody vegetation covers approximately 10 per cent of the Noise and Visual Bund area, 50 per cent of the Eastern Emplacement Area, and 30 to 40 per cent of the area impacted by the new Northern Dam. The Noise and Visual Bund area also has an area of previously rehabilitated overburden that has been planted with native vegetation. The remaining areas are a mixture of native pastures and introduced perennial and annual grasses and weeds including, Rhodes Grass, lantana, blackberry and saffron thistles.

2.7.4 Soil Types

Effective local scale soil sampling, description and analysis is necessary to verify soil type, Soil Landscape and whether or not the land meets the criteria for BSAL. The soil mapping shown in **Figure 2.3** is a composite of the mapping undertaken by Kovac and Lawrie (1991), Umwelt 2003a, Umwelt 2003b, GSSE 2013 and soil sampling undertaken for the AIS (refer to **Section 2.2**).

The Branxton Soil Landscape dominates the Project area, with a smaller area of the Rothbury Soil Landscape in the north-east of the Project area where the Eastern Emplacement Area and the Northern Dam are proposed to be developed. A small section of the Project area associated with the realignment of Charlton Road is located within the Saxonvale Soil Landscape.

Noise and Visual Bund

The area of the proposed Noise and Visual Bund has a range of soil types. Sampling sites 1 and 2 (refer to **Figure 2.3**) contain duplex soils. Sampling site 3 (refer to **Figure 2.3**) is a uniform fine sandy loam.

Sampling sites 1 and 2 are sandy clay loams overlying medium to heavy clay subsoils. They are non-saline and moderately acid throughout the depth sampled. The Cation Exchange Capacities (CEC) are moderately good however the calcium is low, magnesium is high, sodium is high, and potassium and aluminium are moderate. The available phosphorus is very low. At sampling site 1 the topsoil and subsoil are moderately prone to slaking and have low dispersion; this area has a moderate tunnel erosion hazard. Sampling site 2 has a topsoil and subsoil that are more stable but the subsoil in particular is more dispersive which will inhibit drainage. The topsoil depths are around 12 to 15 centimetres. The subsoils in sampling site 2 show signs of waterlogging (mottling). Overall, these soils have low-moderate fertility and are highly erodible. These soils are not suitable for cropping without considerable organic matter and chemical inputs.

Sampling site 3 is located in an area of regenerating native vegetation and has a uniform texture profile. The soil is fine sandy clay loam. The soil is non-saline. The topsoil is moderately acid while the subsoil is neutral to slightly alkaline. CEC is moderate. The calcium is very low, magnesium is high, potassium is moderate, sodium and aluminium are moderate. The available phosphorus is very low. The topsoil is moderately susceptible to slaking while the subsoil is more stable. Topsoil depth is very shallow at 5 centimetres. Overall, the soil at this location is of low-moderate fertility and is moderately erodible. These soils are not suitable for cropping without considerable organic matter and chemical inputs.

The soils at sampling sites 1, 2, and 3 are consistent with the Branxton Soil Landscape and the soil landscape mapping in these areas is accurate.

Sampling site 4 (refer to **Figure 2.3**), near the western most extent of the proposed bund and located on the western side of the Charlton Road, reflects a soil type with a deep heavy clay topsoil associated with the volcanic Fordwich Sill and the Saxonvale Soil Landscape. The soil at sampling site 4 is a uniform clay soil. It is moderately saline, slightly acidic, becoming more alkaline with depth. The CEC is high. Actual calcium is high, however, calcium is low compared with magnesium which is very high. Potassium is moderate, sodium is moderately high and aluminium is low. The available phosphorus is very low. The topsoil is not prone to slaking however it is dispersive. The subsoil has less stable aggregates but is not dispersive. The soil in this location is associated with the Saxonvale Soil Landscape and extended the north-eastern extent of this soil landscape from that previously mapped by Kovac and Lawrie (1991) and Umwelt (2003). This soil is of moderate to high fertility and is suitable for low intensity, occasional cropping, however, application of phosphate fertiliser would be required.

While not specifically sampled, the soils associated with the Warkworth Sands Woodland EEC and derived grassland variant was visually inspected by ecologists as part of a detailed vegetation mapping exercise (Umwelt 2012a). This sampling indicated a strong correlation between the Warkworth sands community and Aeolian sands consistent with the Warkworth Soil Landscape. This vegetation and associated Warkworth sands mapping indicates that the Warkworth Soil Landscape is more extensive than was previously mapped by Kovac and Lawrie (1991). The depth sampling undertaken by the ecologists indicated that the depth of these sands varied from several centimetres to over a metre.

Eastern Emplacement Area

The soils of the Eastern Emplacement Area are associated with the Rothbury Soil Landscape and the Branxton Soil Landscape.

The soils at sampling sites 5, 6, 7 and 9 (refer to **Figure 2.3**) are duplex with loamy topsoils 20 to 25 centimetres deep and medium clay subsoils. They are non-saline, moderately acidic becoming slightly less acidic with depth. The CEC is moderately good with low calcium, adequate magnesium and potassium, low sodium and very low aluminium. The available phosphorus is very low. The topsoils are stable and highly aggregated. The subsoils are slightly to moderately dispersive and have some degree of susceptibility to tunnel erosion and gully erosion when exposed (refer to **Plate 2.1**). Overall, the soil at this location is of low- moderate fertility and is moderately to highly erodible. It is generally not suitable for cropping without considerable chemical inputs.

The soil at Sampling site 8 (refer to **Figure 2.3**) is a loamy sand with topsoil greater than 25 centimetres deep. The soil is non-saline, acidic in the topsoil and becoming less acidic with depth. The CEC is low. The calcium, magnesium and potassium are low. The sodium and aluminium are also low. The available phosphorus is very low. Both the topsoil and subsoil are slightly dispersive. Overall, the soil at this location is of low fertility and is moderately erodible. It is generally not suitable for cropping without considerable chemical and probably organic matter inputs.

Northern Dam Area

The proposed Northern Dam is located in an area mapped as being part of the Rothbury Soil Landscape. The soils were sampled in four locations (Sites 10 to 13 – refer to **Figure 2.3**) and profile characteristics are consistent along the length of the creek. They are generally fine sandy loams over-lying sandy loams. The soils are non-saline, moderately acidic soils with the subsoil becoming slightly less acid. The CEC is moderate with adequate calcium, magnesium and potassium. The aluminium level is low and the sodium level is slightly elevated. The available phosphorus is very low. The topsoils are stable and not prone to slaking or dispersion. The subsoils are also stable and not prone to dispersion. The subsoil at sampling site 14, nearest the proposed dam wall, is highly aggregated. These soils are prone to stream bank erosion along the stream channel; however, would not be prone to erosion from overland flow. Overall, the soil at this location is of moderate fertility and is moderately erodible and is generally not suitable for cropping without considerable chemical inputs.

2.7.5 Land and Soil Capability of the Project Area

The Land and Soil Capability Classes are determined by assessing the hazards associated with individual areas of land. Assessment of the hazards has been undertaken for each soil type and is based on the 2012 Land and Soil Capability guidelines.

Factors taken into account when assessing the Land and Soil Capability Classes is based on the Project area are as follows:

Hazard 1 – Water Erosion

The Project area is within the Eastern and Central divisions and slope class has the most influence on the potential for water erosion.

Hazard 2 – Wind Erosion

The Project area is mapped as being in an area of low wind erosivity and the average annual rainfall is >500 millimetres indicating the land is capable of maintaining high levels of ground cover. Surface soil texture and exposure of the area to wind were considered.

Hazard 3 – Soil Structure Decline

The texture of surface soil and the exchangeable sodium percentage influence the potential for soil structure decline as well as the ability to recover in the future.

Hazard 4 – Soil Acidification

The estimated buffering capacity of the soil is considered in conjunction with the existing pH and annual rainfall.

Hazard 5 – Salinity

Three inputs are combined and include the recharge potential, the discharge potential and the actual salt store of the soil. The Project area is mapped as having a low salt store.

Hazard 6 – Waterlogging hazard

This hazard is assessed on the typical soil drainage characteristics of the soil, the duration of waterlogging and the return period.

Hazard 7 – Shallow soils and rockiness

Assessment is based on the percentage of rock outcropping and the average soil depth.

Hazard 8 – Mass movement

This is assessed largely on the presence of existing mass movement and average annual rainfall being > 500 millimetres.

The results are presented in **Table 2.7**.

Table 2.7 – Land and Soil Capability classes in the Project area, based on field evidence

Soil Type	Water erosion	Wind erosion	Soil structure decline	Soil acidific-ation	Salinity	Water logging	Shallow soils and rockiness	Mass movemen t	Overall LSC Class
Yellow solodic	3	3	4 (subsoil)	**5**	1	3	3	1	**5**
Yellow podzolic	3	4	3	**5**	1	3	4	1	**5**

Table 2.7 – Land and Soil Capability classes in the Project area, based on field evidence (cont.)

Soil Type	Water erosion	Wind erosion	Soil structure decline	Soil acidific-ation	Salinity	Water logging	Shallow soils and rockiness	Mass movement	Overall LSC Class
Brown podzolic	3	2	**4**	**4**	1	2	**4**	1	**4**
Alluvial	2	2	3	**5**	1	1	2	1	**5**
Chocolate	3	1	**6**	3	1	2	2	1	**6**

2.7.5.1 Land and Soil Capability Mapping in the Project Area

The Land and Soil Capability classes (as described by OEH (2012)) of the Project Area are mapped on **Figure 2.4**.

Land and Soil Capability in the wider landscape context of the Project area was assessed using general observations of the district, remote sensing techniques and information on soil landscapes. Land and Soil Capability Class 3 land was identified on the alluvial river and creek floodplains and the lower slopes of the eastern face of the Fordwich Sill. The majority of the Study are falls into Land and Soil Capability Classes 3 to 6. This land capability broadly corresponds to the soil landscapes. **Table 2.8** details the Land and Soil Capability Classes of the soil landscapes within the Study area.

Table 2.8 – General land and soil capability of soil landscapes

Soil Landscape	Limiting Hazard	Land & Soil Capability Classes	
		Study Area	Project Disturbance Footprint
Wollombi	Water erosion	3	N/A
Saxonvale – upper slopes	Shallow soils/rockiness	6 to 7	N/A
Saxonvale – lower slopes	Soil structure decline	3 to 6	4
Branxton	Water erosion, soil structure decline, acidification	4 to 6	4 to 6
Rothbury	Water erosion, shallow soils/rockiness, soil acidification	3 to 7	4 to 7
Warkworth	Wind erosion, soil structure decline	5	5

The Land and Soil Capability mapping of the Project area contained in **Figure 2.6** has conservatively mapped the soil landscapes against the better of the classifications except in the southwest and western areas of the Project area and around the Fordwich Sill where additional biophysical data was available (refer to **Section 2.2**).

Based on local scale data, the Project area is dominated by Class 4, 5, 6, 7 and 8 land. Small areas within each soil type may have a different Land and Soil Capability Class ranking as shown in **Table 2.8**; however, as an overall assessment, the soil types represented in the Project area are of low to moderate capability only.

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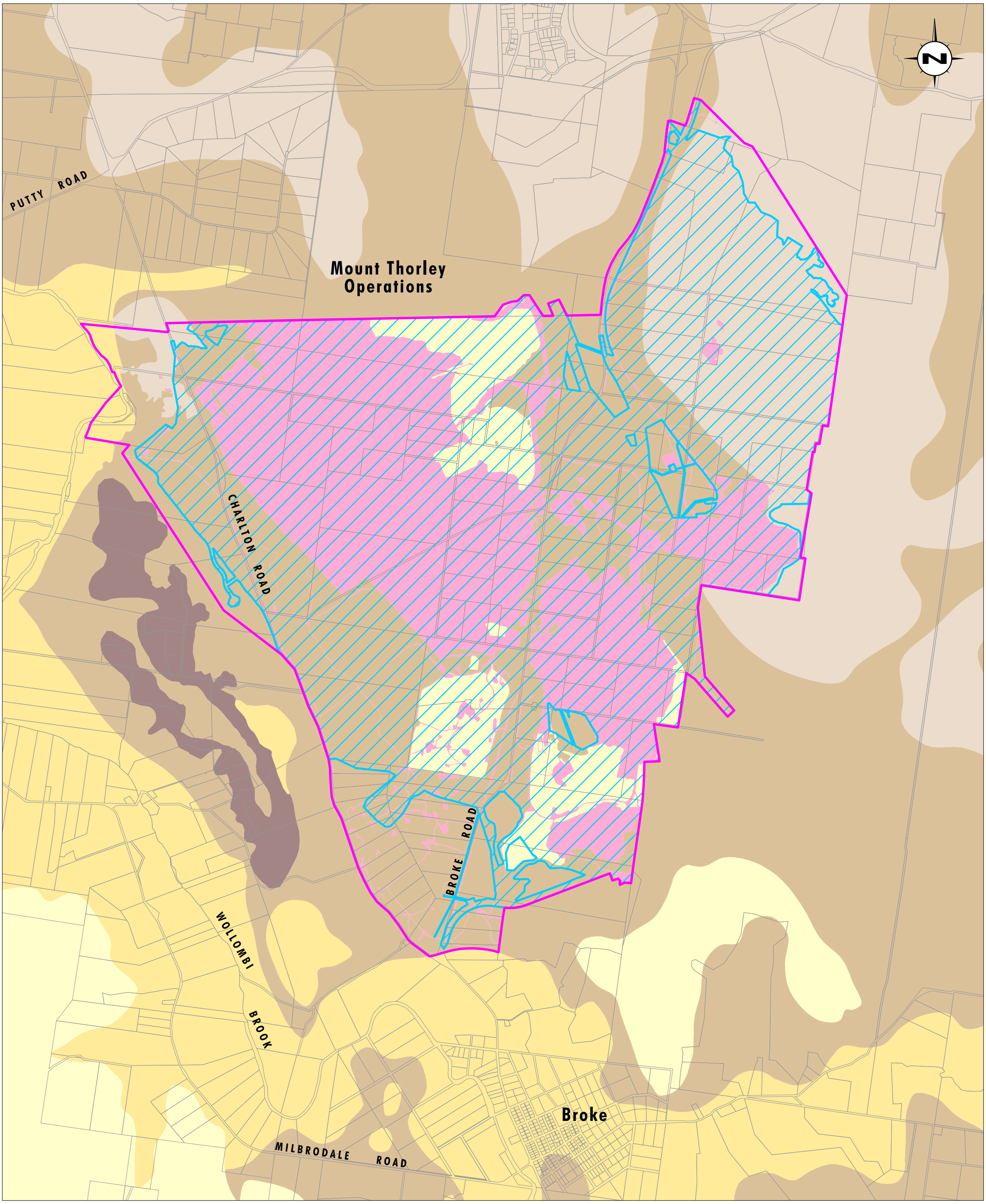

Source: Office of Environment and Heritage (OEH) SRLUP Mapping (2012), Department of Lands (2009)

0 1 2 3km

Legend

- Project Area
- Project Disturbance Footprint
- 3 - High Capability Land
- 4 - Moderate Capability Land
- 5 - Moderate-Low Capability Land
- 6 - Low Capability Land
- 7 - Very Low Capability Land
- 8 - Extremely Low Capability Land

FIGURE 2.6

Existing Land and Soil Capability

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Figure 2.6 also shows the areas where the Soil and Land Capability (as mapped regionally) has been modified as a result of existing mining and other activities within the Project area. This land is mapped by OEH (2012) as Class 4 and 5 land, but in its current condition (disturbed, open cut pit or early stages of rehabilitation) is actually Class 7 and 8 land.

Areas directly impacted by mining, through haul roads, overburden emplacement areas, mining pit areas and mining related infrastructure are presently unsuitable for agriculture because of erosion hazards that are difficult to manage such as steep slopes, shallow erodible soils, high run-on potential and low nutrient status. Some of these areas have potential to be returned to Class 5 and 6 land through the implementation of appropriate rehabilitation techniques and there are significant examples of remediated landforms in the Hunter Valley which are used for low intensity grazing.

The chocolate soil associated with the Saxonvale soil landscape was mapped at the regional scale by OEH (2012) as Class 3 land. The more detailed investigations found that most of this soil landscape does not met Class 3 Land and Soil Capability criteria and is actually Class 4 or higher due to slope and soil structure decline issues (the soil had a high exchangeable sodium percentage (refer to **Appendix A**)). This limitation can be overcome with management inputs (gypsum) to reduce the sodium levels and then the productive capability would improve significantly. The best quality land and soil resources recorded by GSSE (2013) lie on the western footslopes of the Fordwich Sill, towards the Wollombi Brook. This area is outside the footprint of the current Project and the fertility of the soil in this area is unlikely to be high enough to satisfy the criteria as BSAL. It is possible that there are small, discontinuous areas of land and soil resource within the Project disturbance footprint that would meet the criteria for both Class 3 land and fertility requirements of BSAL however any areas would be smaller than the contiguous 20 hectares required to meet the criteria of BSAL. There alluvial soils associated with the Wollombi Soil Landscape have been identified by OEH as being Land and Soil Capability Class 3. These soils can be found in the northwest of the Project area but are located outside the proposed Project disturbance footprint. The soils within this soil landscape are only of low to moderate fertility and are therefore not considered to be BSAL.

The remainder of the Project area is mapped as Class 4 - 8 land, which has high limitations if used for agricultural land uses more intensive than grazing with limited or no cultivation. Horticulture or viticultural uses may also be practiced on Class 4 and 5 land, with appropriate controls and this is evidenced by the existing Vere Vineyard located within the Project area.

Soil acidification is the major hazard for the most common soils that will be affected by the Project. Lime can be applied to ameliorate surface soil acidity and hence manage this limitation however erosion risk and soil structural decline are also significant constraints and the low to moderate fertility of these soils will generally preclude them from higher intensity cropping even if acidification is treated.

From an agricultural point of view, the vegetation currently on the areas proposed for the Noise and Visual Bund, the Eastern Emplacement Area and the Northern Dam is low quality and in its current condition would only be capable of supporting low density beef or sheep grazing.

Significant investment in removing the regrowth timber, weed control, improved pasture species and fertiliser would be required to improve the livestock carrying capacity of the land. The relatively poor Land and Soil Capability rating over the majority of the Project area indicates the majority of the Project area, if used for agriculture, is more suited to lower intensity grazing applications and, at the current time, economic returns are not likely to cover input costs to improve the quality of the grazing resource.

3.0 Agricultural Enterprises and Resources in the Broke Fordwich Region

3.1 Agricultural History

The Hunter Valley was initially developed from the mouth of the Coal (Hunter) River. Exploration from Windsor to the land west of Singleton occurred around 1817 and the first overland route was cleared as an access roadway from Windsor to Singleton in about 1823. This route is now known as the Putty Road. Large agricultural/pastoral runs were granted from the early 1820s and agricultural development began in earnest.

The Broke area was first settled in the 1820s when John Blaxland received a land grant of 8000 acres centred around the Wollombi Brook for discovering the route into the Hunter Valley from Windsor. He named the property Fordwich after his birth place.

The Great North Road was built to become the main route for livestock and people to travel overland between Sydney and the Hunter Valley, crossing the Hawkesbury River at Wisemans Ferry. The road branched at Wollombi with one route heading to Cessnock and the other to Jerrys Plains. Broke flourished with this passing trade in the late 1800s but when the use of the Great North Road declined, so did the village.

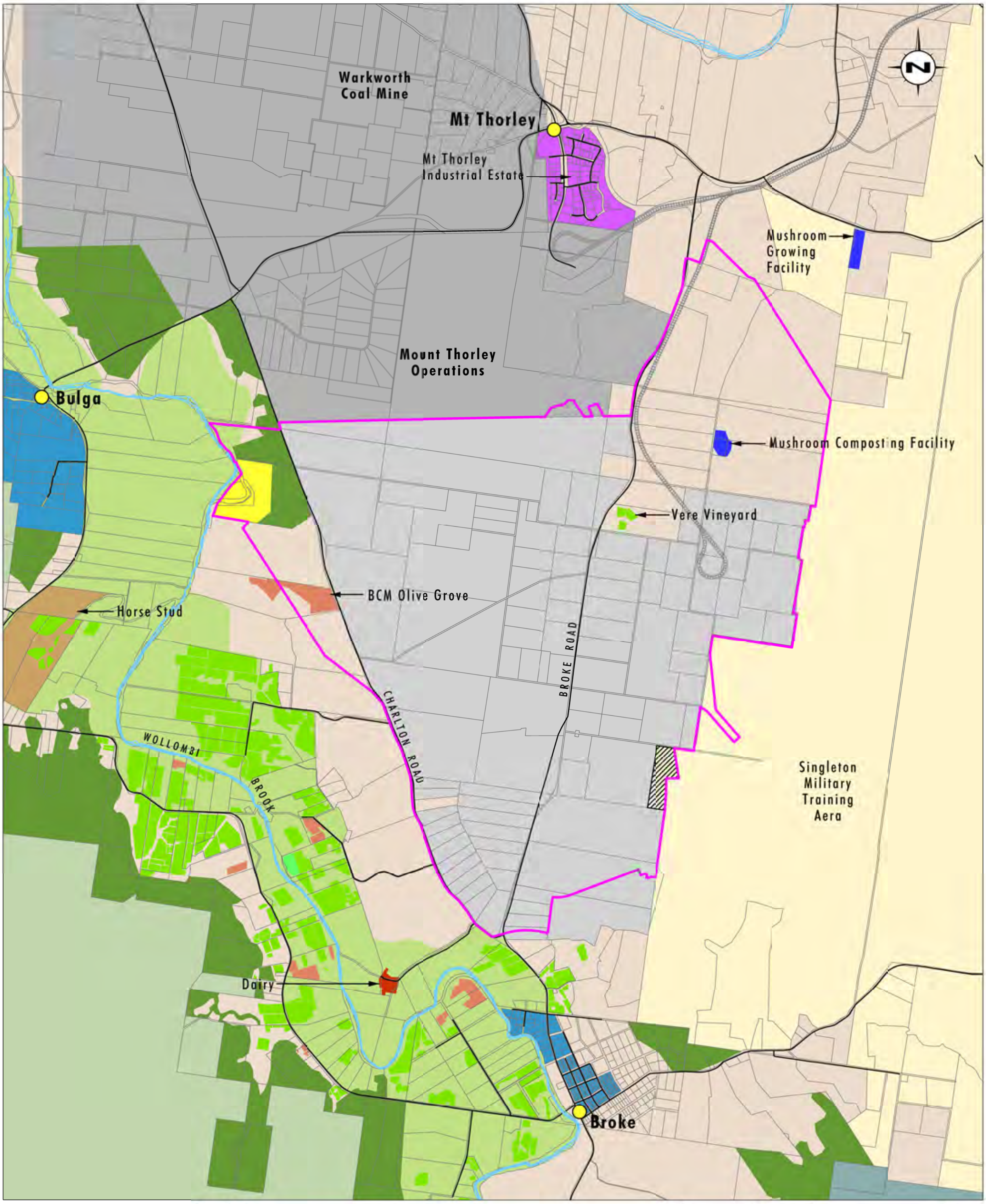
The district was developed for cropping along the Wollombi Brook floodplains and grazing on the undulating country towards Singleton. Dairying was an important industry in the Upper Hunter from the late nineteenth century, due to suitable land and the introduction of rail transport and refrigeration. The region is one of the original wine grape growing areas in NSW. Agricultural development was restricted to the south and west of the Broke village by the rugged sandstone terrain.

Coal mining and timber were also major industries associated with the early development of the Hunter Valley. A more detailed discussion on the history of the region and the Project area is included in the Historical Heritage Assessment prepared as part of the EIS for the Project.

3.2 Current Agricultural Enterprises

The region is characterised by the vineyard/boutique winery and cellar door enterprises that comprise the Broke-Fordwich Wine Sub-Region (**Plate 3.1**). In addition there are a range of other small permanent horticultural enterprises including olive groves (**Plate 3.2**), oranges and macadamias. These horticultural industries are concentrated around the higher quality soil landscapes along the Wollombi Brook and the Fordwich Sill and are reliant on irrigation. **Figure 3.1** shows the locations of horticultural and viticulture land uses, as well as broad acre grazing, fodder and other crops. There are currently estimated to be 50 – 60 rural properties in the Study Area.

The individual vineyards are mostly small enterprises often supported by off-farm income that either includes tourist accommodation and cafe or restaurant style food outlets or unrelated income. At the current time, wine grapes are suffering from over production issues and many of the small vineyards/wineries are unlikely to be viable stand-alone agricultural enterprises.



Source: Google Earth (2010), LPMA

Legend

- Project Area
- National Park
- State Forest
- Singleton Military Training Area
- SMTA Licensed to BCM
- Bulga Mining and Buffer Area
- MTW Operations
- Conservation - Private
- Forest/Woodland Area - Private Management
- Olive Grove
- Vineyards
- Mixed, Grazing and Cropping Land
- Grazing
- Industrial
- Village/Small Holdings
- Town/Village Centres

FIGURE 3.1

Surrounding Land Use

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20121205 10.02

PLATE 3.1
Vineyards in Broke_Fordwich Viticulture Sub-Region

PLATE 3.2
Olive Grove in Study Area

There is one vineyard, known as the Vere Vineyard located within the Project area (refer to **Figure 3.1**). The Vere Vineyard is predominately cabernet sauvignon. The genetic value of the cabernet grapes in the Vere Vineyard has been recognised and vines propagated from the Vere Vineyard vines are being planted in a vineyard at Halkin Estate on the western side of Fordwich Sill. The Vineyard is owned by BCM but is currently leased to a local winemaker.

BCM also own and operate an olive grove which is located in the west of the Project area (refer to **Figure 3.1**). The olives are used for olive oil production. As with grapes, there is currently an oversupply of olive oil in the market and the olive grove is not considered to be financially viable as a stand-alone enterprise.

Grazing enterprises, including a large cattle dairy, beef cattle, horses (refer to **Plate 3.3**) and alpacas also feature in the district. The higher value enterprises often have fodder cropping including lucerne and oats/ryegrass/clover for hay and silage production associated with them (refer to **Plate 3.4**). The cropping largely occurs on the better class agricultural land on the Wollombi Brook floodplain and is usually supported with irrigation. The dairy is located on the Fordwich Sill and has extensive access to irrigation for pastures and crops on higher quality soils from the Saxonvale soil landscape (refer to **Figure 3.1**).

More extensive beef cattle grazing enterprises are undertaken on the lower class land associated with the largely duplex, lower fertility Branxton and Rothbury soil landscapes. Irrigation is generally not available and not viable in these enterprises. Many of these enterprises are marginal due to the lack of investment in improved pastures and fertilisers reflecting the lower returns resulting from lack of scale.

The region is noted for its agri-tourism including accommodation, dining and wine tasting rather than broadscale agricultural enterprises.

A Stage 1 mushroom composting facility (refer to **Figure 3.1**) is located on a portion of the proposed site of the Eastern Emplacement Area. A Stage 1 facility involves preparing the compost that is then used as a growing medium for mushroom farming. This operation is associated with a large mushroom farm located on the Mitchell Line of Road (refer to **Figure 3.1**).

Despite areas of quality soils around the Fordwich Sill and alluvial flood plains and access to irrigation water, the majority of agriculture in the region is considered to be economically marginal (Economics Consulting Services 2012), and rural property income is generally supplemented by off farm income generated from other industries including mining, tourism, public sector, and professional services.

BCM and related entities (collectively referred to as BCM in this report) own and manage significant agricultural land resources surrounding the BCC, particularly to the south-west and the north-east of the BCC. BCM maintain the majority of this land in productive agricultural enterprises, usually reflecting the existing land uses when it was purchased, except where proximity to active mining operations precludes agricultural activities due to human and animal safety issues.

PLATE 3.3
Horse Stud east of Putty Road

PLATE 3.4
Fodder crops and silage on Wollombi Brook Alluvial Flats

3.3 Agricultural Industry Support Infrastructure

Support infrastructure for the agricultural industries in the Hunter Valley is well established. There are milk processing factories, abattoirs and regional saleyards as well as retailers of agricultural equipment and providers of specialist services such as agronomic advice or management services. A brief overview of regional infrastructure and services for agriculture is provided below:

- Abattoirs located in Singleton, Scone and Kurri Kurri process up to 1300 head of cattle per day, for both the export and domestic markets. Cattle are sourced from around the eastern seaboard, including into Queensland. Cattle are supplied from both on-property sales and from sale yards. Employment is significant with up to about 600 fulltime employees.

- Regional sale yards are located at Scone, Singleton and Maitland. Anecdotally, numbers of cattle sold at Singleton and Maitland have declined by about one third to a half over the past 10 to 15 years. While some of this is undoubtedly linked to the expansion of mining in the region which has removed significant areas of potential grazing land from agricultural production, declining yard numbers are typical across the State as producers use other forums for selling stock.

- Milk processing is undertaken at Hexham.

- Wine grapes are either processed directly on the vineyard or sold on to other wineries in the region including around the Cessnock/Pokolbin district. The grape growing industry is well supported by a vine management industry that undertakes contract pruning, fertilising and spraying.

- A pipeline servicing the Broke-Fordwich Private Irrigation District runs adjacent to Broke Road through the Project area. This pipeline draws water from the Hunter River and supplies vineyards and other farming operations in the Broke Fordwich area.

These specialised ancillary agricultural industries are in turn supported by regional businesses supplying equipment and services.

The region is close to major transport links and population centres including Sydney and Newcastle.

3.4 Economic Value

The economic output of the agricultural sector in the Broke-Fordwich Region is difficult to quantify exactly however there are a number of sources of indirect information available including employment and business output statistics as well as gross margin budgets.

Information collected by the Bureau of Statistics based on the Singleton Local Government Area (LGA) indicates that approximately 5 per cent of the working population is employed in the agricultural sector. This compares with approximately 19.5 per cent employed in the mining industry. Wages in the agricultural sector are generally about half the wages in the mining sector.

Business output statistics from 2009 indicate that in the Singleton LGA 64 per cent of agricultural businesses turned over less than $50,000 per annum indicating these businesses are part time only, and typically supported by another form of income

(Economics Consulting Services 2012). It is estimated there are 50 – 60 rural properties in the Broke/Bulga area.

Gross margin budgets identify the difference between the gross income and the variable costs associated with an enterprise. They can be used to provide a comparison of the relative profitability of different enterprises and to identify the funds available to meet the fixed costs of a business. The Department of Primary Industries (DPI) publishes gross margin budgets for a range of livestock enterprises (Department of Primary Industries 2011). Typically the cattle enterprises undertaken in the Hunter Valley are cow-calf operations where the calves are born in spring and sold as they are weaned prior to the following winter. About 20 per cent of the calves would be retained to join the breeding herd. This system fits well with the productive capacity and climate of the land within the area as the highest feed demand coincides with the spring/summer/autumn period of highest pasture growth, particularly where the pasture base is unimproved or semi improved natural pastures.

The economic value of these enterprises is relatively low, with gross margin analysis indicating that returns may be in the order of $130 per hectare (Department of Primary Industries 2011). Trading livestock that includes buying, growing and selling cattle over a 12 month period is a higher value grazing enterprise. Gross margins may be up to $180 per hectare (DPI 2011) but the disadvantages of having to expend a large amount of capital each year to purchase new livestock and higher management inputs including better pastures mean these enterprises are not as popular or don't suit a system where the operator also works off farm.

The gross margins for enterprises such as lucerne or vegetables that require access to high quality flat alluvial land, irrigation and well drained soils indicate that potential returns are much higher than livestock grazing. Irrigated lucerne hay production for example may have returns in the order of $830 per hectare (Department of Primary Industries 2011) while vegetables such as lettuces may return up to $5000 per hectare (Department of Primary Industries 2011). These enterprises require high value Class I land and have high to very high management inputs.

While gross margins are helpful in comparing the relative viability of different industries on a given piece of land, they do not necessarily indicate the profitability of businesses, which may have high fixed costs such as repayments and interest on capital.

The wine industry is divided into a number of sectors, the wine retailers, wine makers and grape growers. The wine retailers deal with selling wine to consumers, wine makers produce and bottle wine from grapes sourced from grape growers. The Broke Fordwich Region is based around mainly small scale grape growers. The district is also characterised by various levels of vertical integration where many grape growers are also producing their own wines, or contracting a winery to produce their own wines, and then selling their own products through cellar door outlets or restaurants.

The Australian wine industry is strongly focused on export markets as well as a domestic market that competes with imported wine. Currently there are significant pressures on all sectors of the wine industry caused by oversupply of grapes, strong foreign exchange rates and increasing competition from other countries. This has resulted in low returns from the industry (Economics Consulting Services 2012).

At the small grape grower/wine maker end of the industry, which best describes the industry around the Broke Fordwich Region, vertical integration and development of a specialist local market in conjunction with tourism (for example, wine tasting, accommodation, relaxation and small festivals) has been encouraged through the Broke Fordwich Wine Sub-Region. This approach to develop a regional 'brand' has been a long term strategy to overcome the market pressures of low grape prices and insufficient scale to cover the fixed costs associated with any business, including interest on capital and tax (Economics Consulting Services 2012). As a general rule, the wholesale and retail distribution costs make up over 35 per cent of the retail price of a bottle of wine. Selling a bottle of wine at a premium price has a significant positive impact on the returns. Balancing this however, are the increased costs associated with running a winery, marketing the finished product, developing a recognised brand name and maintaining consistent supply and quality.

It is hard to determine if this strategy of combining vertical integration with tourism has been completely successful at this stage however the industry and the region strongly promotes itself within the tourism sector as the 'tranquil side of the Hunter Valley' (Broke Fordwich Wine and Tourism Association 2012). Income from many of the small vineyards is supplemented by income from other sources, with many of the grape growers in the region currently not living full time on farm, or being involved full time in vine management and grape production.

3.5 Agricultural Potential of Lands Surrounding the Project

The region enjoys a mild climate, has medium quality alluvial soils along the Wollombi Brook, high fertility soils associated with the Fordwich Sill, access to irrigation water and is reasonably close to the markets and support services of the Hunter Valley, Newcastle and Sydney. It is reasonable to expect that high value horticulture (both permanent plantings and annual cropping) will continue to be developed along Wollombi Brook.

Moving away from Wollombi Brook towards Singleton, the land is lower in quality and agricultural potential. These class 5, 6 and 7 areas are more suited to extensive land uses such as grazing. Soil types prone to sheet, rill and gully or stream bank erosion are common in the region and limit the potential for intensification of the agricultural enterprises.

The long term sustainability of extensive agricultural enterprises such as beef cattle grazing on such land, requires investment in high input grazing management techniques including fertiliser, improved long term perennial pastures established using direct drilling techniques and rotational grazing. These management inputs would be required to maintain high groundcover levels and improve soil organic matter levels to reduce the risk of erosion, particularly on steeper areas. It is likely that many agricultural holdings on Class 5, 6 or 7l land would be unsustainable as single small rural properties without significant investment in fertiliser and long term pasture establishment and it is possible that the investment required for these inputs would outweigh the additional income that would flow from these productivity improvements.

As outlined in the main text of the EIS, the currently proposed final land use of the Project area is primarily native vegetation, with some areas having future potential for ongoing agricultural use if desirable (refer to **Section 6.0**). These potential agricultural areas will be prioritised for better topsoil material where possible as part of the mine rehabilitation program.

It is noted that where reestablishment of land suitable for agriculture is both viable (e.g. soils are of sufficient quality) and desirable (i.e. is the preferred final land use), this can be achieved on much of the rehabilitated areas, however, due to the presence of final mining voids and some steeper slope areas, this is typically not achievable for all of the mined area.

On the former grazing areas on Class 5 to 7 lands, rehabilitation after mining activities may reduce the long term availability of lower quality agricultural land, as rehabilitation may involve creating landscapes which have higher slope classes and poorer soil types and hence lower land capability. This may encourage a long term change in land use from generally low value agriculture to environmental conservation or forestry to maintain stable landforms.

3.6 Agricultural use of the Project area

The majority of the Project area is currently owned by BCM and is managed as buffer land and for mine operation purposes. The proposed locations of the Eastern Emplacement Area and Northern Dam are managed for agricultural/rural industrial purposes as well as limited grazing. A Stage 1 mushroom composting facility is located on part of the area proposed for the Eastern Emplacement Area (refer to **Figure 3.1**).

The overall economic value of the enterprises located within the Project area, with the exception of the Stage 1 mushroom composting facility which is linked to a mushroom growing operation on the Mitchell Line of Road, is low.

There is a small area of the moderate to high fertility Saxonvale soil landscape on the Fordwich Sill supporting a BCM owned olive grove that is within the Project area (refer to **Figure 3.1**). The Vere Vineyard, also owned by BCM and leased to a private wine maker, is located within the Project area along the Broke Road (refer to **Figure 3.1**).

Approximately 325 hectares of land owned by BCM along Wollombi Brook and on Fordwich Sill is leased out as grazing land for beef and dairy cattle and fodder production. Vineyards on Fordwich Sill, as well the Vere Vineyard on the Broke Road, are leased to local winemakers. The olive groves on Fordwich Sill are managed by BCM and harvested commercially. Colinta, an Xstrata subsidiary, manages grazing operations on over 1000 hectares of BCM owned land adjoining Wollombi Brook and along the Broke Road to the north of the BCC. There are currently over 500 hectares of buffer land which is undisturbed by the Bulga Surface Operations that is not actively managed for agricultural uses, largely due to its proximity to active mining or rehabilitation areas and due to prioritisation of much of this land for biodiversity management. A small area of this land occurs on the Fordwich Sill and could possibly be used for agricultural development in the future.

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4.0 Assessment against Gateway Criteria

The Project area occupies land within the region subject to the Upper Hunter SRLUP. Although the Project is not required to go through the Gateway process under the Upper Hunter SRLUP, the DGRs for the Project require that the EIS has regard to the Gateway criteria. Assessment against the Gateway criteria is provided in this section.

4.1 Potential Impact on Biophysical Strategic Agricultural Land

The Gateway process requires the assessment of the Project's potential impacts on Biophysical Strategic Agricultural Land (BSAL) land located within the Project area. The high level strategic mapping undertaken for the Upper Hunter SRLUP has identified an area of BSAL in close proximity to the Project area. An examination of this mapping indicates that this area correlates well with the Saxonvale soil landscape (refer to **Figure 4.1**).

4.1.1 Site Verification Process

For land to qualify as BSAL in the Upper Hunter SRLUP, it must be land with a Land and Soil Capability Class of either 1 or 2 and have moderate to high soil fertility. Access to quality agricultural water supply is also considered. Class 3 land may as also qualify as BSAL if it has a high soil fertility.

A site verification assessment has been undertaken for the Project and this has identified that there is no Class 1, 2 or 3 land within the Project disturbance footprint. As discussed in **Section 2.7**, the soils associated with the Wollombi Soil Landscape located in the northeast of the Project area are identified as being Class 3 land, however the low to moderate soil fertility of these soils precludes this land from being BSAL.

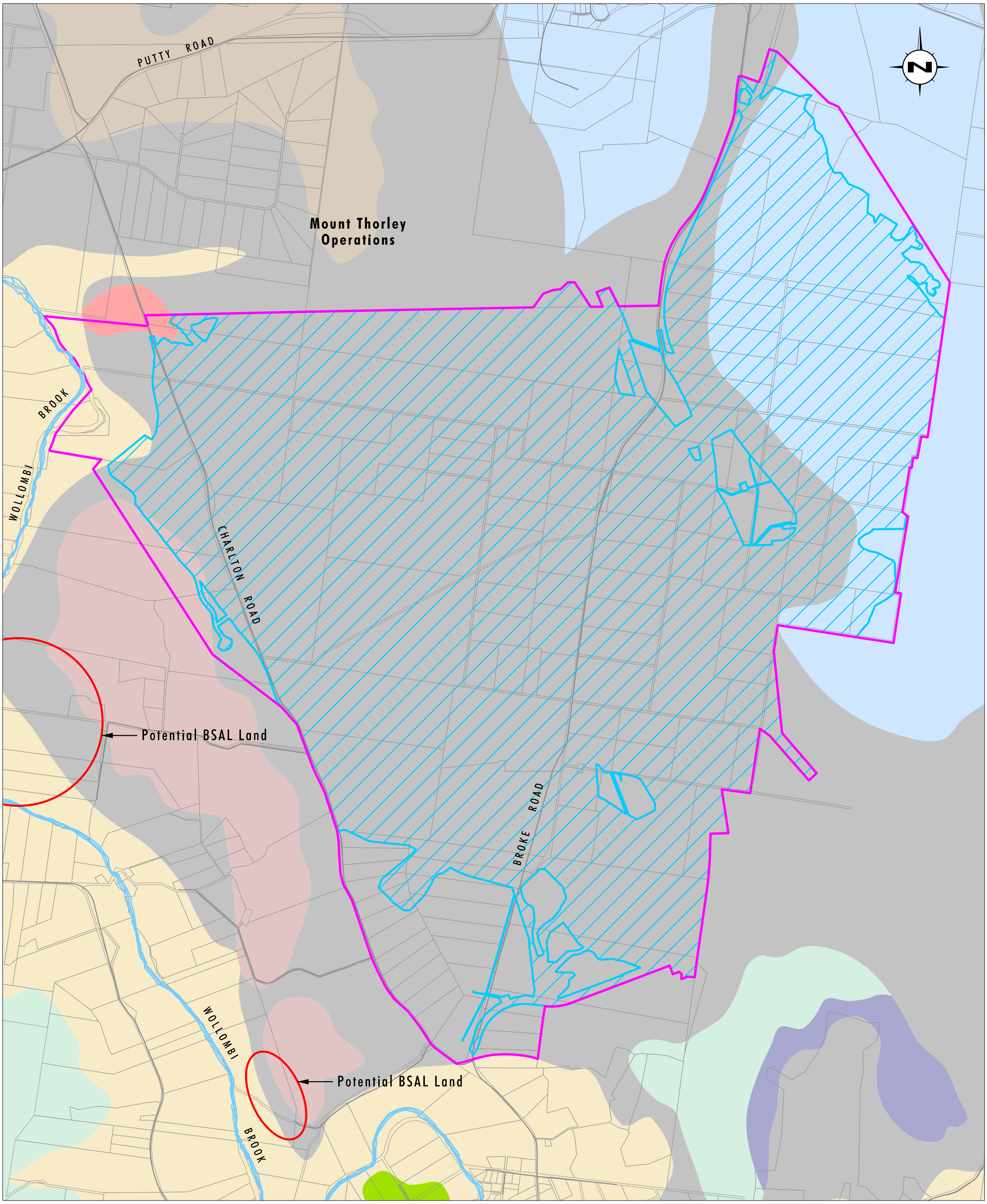
It is recognised that the footslopes on the western side of Fordwich Sill (refer to **Figure 2.1**) may qualify as BSAL (refer to **Figure 4.1**) however soil fertility may not be high enough. Further field work including Land and Soil Capability mapping and soils sampling would be required to confirm this, however given that these areas are located outside the Project area, will not be impacted by the Project and the Gateway Process does not apply to the Project, this additional field work is not considered to be warranted.

As there is no Class 1, 2 land within the Project area and the only Class 3 land is on soils that are of low to moderate fertility, there is no BSAL land located within the Project area. Notwithstanding the fact that the Gateway criteria do not apply to the Project, given the proximity of the Project to land on the western side of Fordwich Sill which has the potential to meet the BSAL criteria, the following sections assess the Project's potential impacts on BSAL land.

4.1.2 Potential Impact on Off-site BSAL Productivity

The Upper Hunter SRLUP Gateway Criteria require an assessment of whether a proposal would significantly reduce the agricultural productivity of the land based on a consideration of:

- Impacts on the land through surface area disturbance and subsidence;
- Impacts on:
  - Soil fertility;



Source: BCM (2012), LPMA, Upper Hunter SRLUP (2012), Umwelt (2003), Kovac and Lawrie (1991)

Legend

- Project Area
- Proposed Disturbance Area

Soil Landscapes:

- Wollombi Soil Landscape
- Saxonvale Soil Landscape
- Rothbury Soil Landscape
- Jerrys Plains Soil Landscape
- Lees Pinch Soil Landscape
- Ogilvie Soil Landscape
- Warkworth Soil Landscape
- Branxton Soil Landscape

FIGURE 4.1

Potential Biophysical Strategic Agricultural Land

  - Rooting depth, or
  - Soil profile materials and thickness;
- Increases in land surface microrelief or soil salinity, or significant changes to soil PH, and
- Impacts on highly productive groundwater systems.

There is no BSAL located within the Project's disturbance footprint. The Project will not impact on the chemical or physical properties of the soils in off-site areas that may meet the BSAL criteria.

4.1.2.1 Potential Impacts on Aquifers

The alluvial aquifer of Wollombi Brook is a significant agricultural water resource in the area. Groundwater modelling indicates that the existing approved underground operations may have a small impact on the alluvial aquifer (Mackie Environmental Research 2003, Mackie Environmental Research 2013), however monitoring of the aquifers indicates that any actual impact is undetectable (Mackie Environmental Research 2013). The current Project is not predicted to result in any discernible impact on the alluvial aquifer of Wollombi Brook (Mackie Environmental Research 2013).

Consistent with the Aquifer Interference Policy and licensing requirements under the *Water Management Act 2000*, BCM currently hold sufficient licence allocations to account for the predicted take from the alluvial aquifer associated with Wollombi Brook due to depressurisation associated with the Bulga Underground Operations.

The deeper open cut pit developed by the Project will have an impact on low productivity and poor quality aquifers associated with coal seams (Mackie Environmental Research 2012). These systems are not considered to be highly productive, nor are they used for agricultural or domestic purposes.

4.1.3 Predicted Impact on BSAL

Assessed against the Gateway criteria, the Project will have a negligible impact on the physical characteristics and water supply for potential BSAL land located on the western footslopes of the Fordwich Sill. Other potential impacts on agricultural operations that may be associated with the potential BSAL land are discussed further in **Section 5.0**.

4.2 Potential Impact on Critical Industry Clusters

In addition to high quality agricultural land identified because of its biophysical characteristics, the Upper Hunter SRLUP identifies important, high income earning and distinctive regional agricultural land use clusters (Critical Industry Clusters or CIC). The viticulture related activities of the Pokolbin and Broke-Fordwich areas are identified as part of the broader Hunter Valley Viticulture CIC. The Gateway process of the SRLUP requires an assessment of whether a proposal would lead to significant impacts on a critical industry cluster (CIC) through consideration of the following criteria:

- surface area disturbance,
- subsidence,
- reduced access to agricultural resources,
- reduced access to support services and infrastructure,

- reduced access to transport routes, or
- loss of scenic and landscape values.

As identified in **Section 2.0**, a small part of the Project is located within the Hunter Valley Viticulture CIC by virtue of being within the Broke-Fordwich Geographical Indicator Sub-region (refer to **Figure 4.2**). The geographical boundary of the sub-region is Charlton Road.

The Project components which will directly impact on the CIC (refer to **Figure 4.2**) are:

- construction of realigned section of Charlton Road;
- parts of the northern section of the Noise and Visual Bund; and
- surface water management works associated with managing run-off from the Noise and Visual Bund.

A conservation area is also proposed to be located within the CIC.

The assessment of impacts on the CIC is discussed in the sections below.

4.2.1 Surface Area Disturbance

Approximately 314 hectares of the Project area is located within the Hunter Valley Viticulture CIC of which approximately 128 hectares is proposed to be disturbed as part of the Project. A further 115 hectares will be set aside for permanent conservation purposes (approximately 55 hectares of which is already identified as a conservation area).

The Project will not cause the removal of any vineyards located within the CIC.

Approximately 13 hectares of olive groves owned by BCM will be removed to enable the development of the Noise and Visual Bund and Charlton Road realignment. At present, this olive grove is not commercially viable and the removal of this grove will slightly reduce the supply of olives for olive oil in a market in which supply well outstrips demand.

The areas being set aside for conservation purposes are not presently considered suitable for viticulture or other purposes, largely due to the soil types present. This includes the Warkworth Sands Woodland, which is present in this area and restricted to the Warkworth Sands Soil Landscape. This vegetation community is listed as being an endangered ecological community under the NSW *Threatened Species Conservation Act 1995* and is poorly conserved and the area is therefore a high priority for conservation and is considered to be unsuitable for future agricultural purposes.

4.2.1.1 Disturbance of Agriculture outside the Viticulture CIC

The Vere vineyard is outside the area of the Hunter Valley Viticulture CIC. It is currently owned by BCM and managed for grape wine production. The vineyard will be removed during the Project. Vines propagated from genetic material from the Vere Vineyard (which is not located within the CIC) are currently being planted in the Halkin Estate vineyard located on the Western Side of the Fordwich Sill within the CIC area. The preservation of this genetic material will effectively mitigate the removal of the existing established Vere Vineyard.

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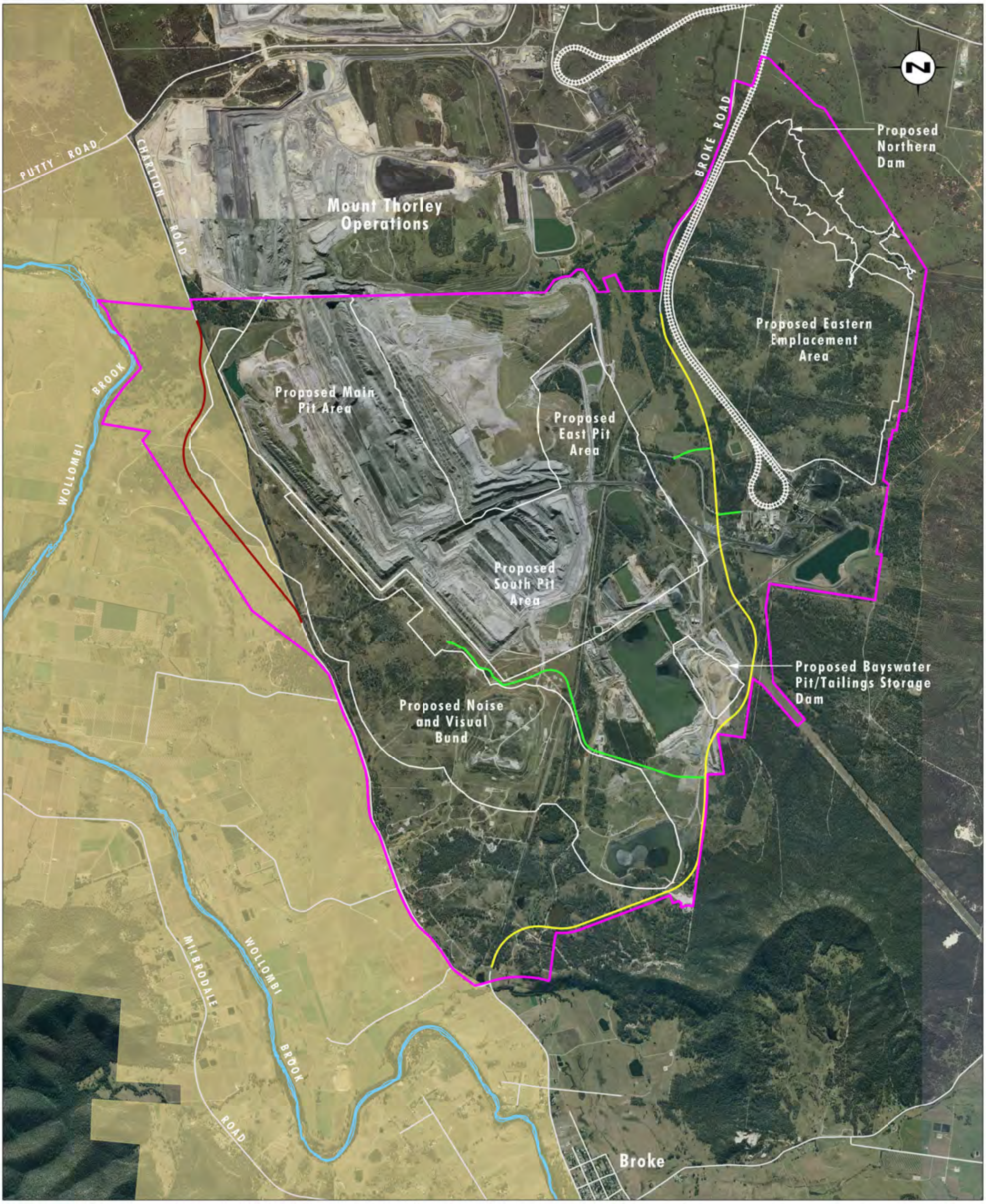

Source: AAM Pty Limited (March 2012), Xstrata Coal (NSW) Pty Ltd, LPMA Upper Hunter SRLUP (2012)

0 1 2 3km

Legend

- Project Area
- Proposed Broke Road Realignment
- Proposed Charlton Road Realignment
- Proposed BCC Access Roads
- Viticulture Critical Industry Cluster

FIGURE 4.2

Hunter Valley Vitculture Critical Industry Cluster

File Name (A4): R08/2869_601.dgn
20121217 16.19

4.2.2 Subsidence

The Project will not have any subsidence impacts.

4.2.3 Reduced Access to Agricultural Resources

The Project will not remove any vineyards from the CIC. The Project will remove some land from being available for viticulture. The portion of this land that is potentially availability for viticulture is considered to be less suitable for viticulture than other areas in the CIC that remain available for viticulture. The removal of land that is potentially available for viticulture will not impact on the viability of the viticulture in the Broke-Fordwich Viticulture Sub-Region or the CIC generally.

The Project will reduce the overall production of olives in the region, however, this impact is likely to be of benefit to other producers as the supply of olives for oil production in the Hunter Valley currently meets or exceeds demand. The loss of this production will not be of detriment to the commercial viability of the viticulture (or olive oil) industry located within the CIC.

The Project is not considered to have a significant impact on access to agricultural resources within the CIC.

4.2.4 Reduced Access to Support Services and Infrastructure

The Project will not impact on access to agricultural infrastructure and support services. The Project will require the realignment of the existing pipeline servicing the Broke-Fordwich Private Irrigation District. The construction of this pipeline will occur prior to the decommissioning of the existing pipeline meaning any disruption to service will be minimal and only associated with the actual commissioning process. BCM will meet all costs of realignment including any studies required.

4.2.5 Reduced Access to Transport Routes

The Project will not reduce access to transport routes.

The realignment of Broke and Charlton Roads will result in a small increase in travel times along these roads The realigned sections will be fully constructed prior to the closure of the existing roads, so there will be only a minor disruption to traffic using these roads during the process of joining the realigned sections with the current road alignment; such disruptions will be similar to those experienced during general maintenance operations on the roads.

As identified in the Upper Hunter SRLUP, the rail transport system retains sufficient capacity to handle current and projected volumes of agricultural produce moved by rail. The continued production of coal at the BCC and transport by rail will not reduce the availability of capacity for agricultural or passenger movement by rail which is built into the rail system design.

4.2.6 Loss of Scenic and Landscape Values

The Bulga Surface Operations are currently visible from a number of locations within the Broke-Fordwich Viticulture Sub-Region and the unrehabilitated overburden areas (particularly the spoil associated with the Whybrow Highwall) is considered by many to detract from the visual amenity of the area (refer to **Sections 4.0** and **5.9** of the EIS, which discuss stakeholder engagement and visual impacts). This has been recognised in the Project design. The proposed Noise and Visual Bund around the western and southern perimeters of the open cut pit has been designed to act as a visual screen and reduce the noise impacts for residents on rural properties and in the villages of Broke, Milbrodale and Bulga to the south and west of the Project.

The external face of the Noise and Visual Bund is pivotal to the mitigation of visual impacts. Coupled with the bund's noise shielding effects, it is proposed that the external face of the bund is in place as quickly as practicable to maximise the benefits of the Noise and Visual Bund over the life of the Project.

The external face of the Noise and Visual Bund is planned to be completed within the first approximately three years of the Project with some sections completed earlier than others. The external face will be shaped and vegetated as soon as practicable to create an external screen for the mining operations that is in keeping with natural terrain features in the area (undulating low hills with woodland vegetation of variable density). A landscape architect was engaged by BCM to facilitate community input workshops in relation to the design of the outer face of this bund. Community workshops were also held to obtain community input on the final bund landform. Based on this input, the Noise and Visual Bund will be landscaped to be broadly consistent with the shape and character of surrounding natural landscapes.

The initial development of the Noise and Visual Bund will result in a visually intrusive feature in the landscape that is visible from a number of areas within the Broke-Fordwich Viticulture Sub-Region. Until vegetated, the external face of the Noise and Visual Bund will be similar to the existing Whybrow Highwall spoil area. The early shaping and vegetation of the external face will significantly ameliorate the visual impact of the bund. Once fully vegetated, the bund will be similar in shape and landform to other vegetated hills in the surrounding landscape. From approximately Year 4 of the Project onwards, the visual impact of the Project will be significantly less than that of the existing operation for vantage points to the west of the Project area. The improvement for vantage points to the south is less so as the existing operations are less visually intrusive than is the case to the west, however, there will be some improvement in visual amenity relative the existing operations as the vegetation on the Noise and Visual Bund develops (refer to main text of EIS).

Plates 4.1, **4.2**, **4.3** and **4.4** show the progressive development and vegetation of the Noise and Visual Bund and provide a good indication of the visual impact of this feature in selected areas around within the Broke-Fordwich Viticulture Sub-Region (refer to **Figure 4.3**). As can be seen from these Plates, the visual intrusion associated with mining operations is all but eliminated as the vegetation on the Bund becomes more developed.

The noise bunding properties of the Noise and Visual Bund will also improve the amenity in the Broke-Fordwich Viticulture Sub-Region with predicted noise levels from the operations being below existing operating levels for much of the mines operating life despite similar levels of production.

4.2.7 Predicted Impact on Hunter Valley Viticulture CIC

Coal mining has been carried out at the BCC for over 30 years and currently coexists with the viticulture and related industries located in the CIC. BCM has undertaken significant research on the impact of underground mining on viticulture to demonstrate this coexistence. There is no evidence to suggest that the existing BCC operations are having an adverse impact on the agricultural productivity of the area.

Assessed against the Gateway criteria of the Upper Hunter SRLUP, the Project will have a minimal impact on the Broke-Fordwich Viticulture Sub-Region and a negligible impact on the Hunter Valley Viticulture CIC overall. Whilst the development of the Noise and Visual Bund will be visible and result in some visual impacts, these impacts are largely similar to those of the existing operations, will be short term and be mitigated through progressive rehabilitation.

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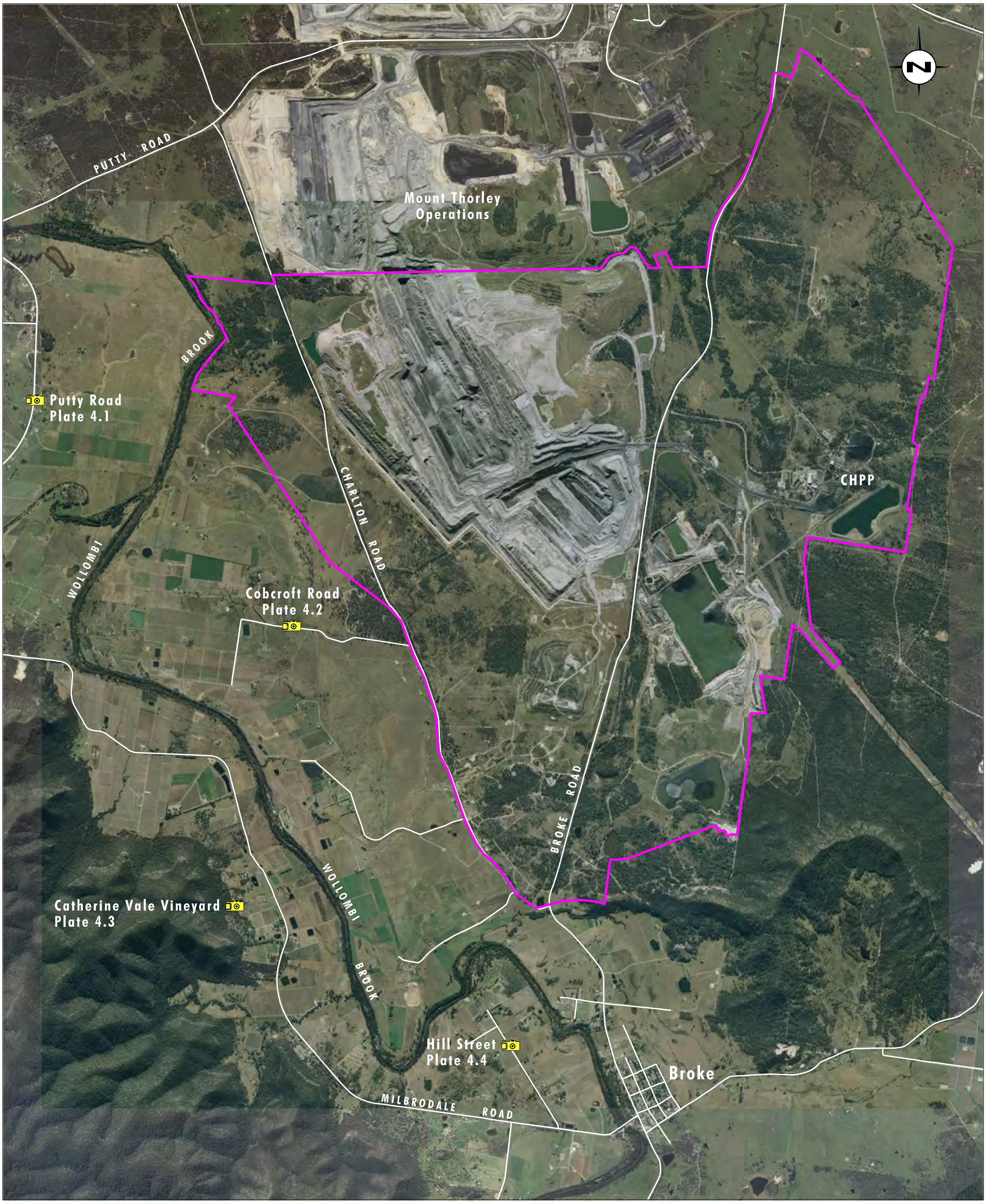

Source: AAM Pty Limited (March 2012), Xstrata Coal (NSW) Pty Ltd

0 1 2 3km

Legend

Project Area

Camera Location

FIGURE 4.3

Vantage Points for Visual Analysis of Noise and Visual Bund

PLATE 4.1

Putty Road Visual Montage

PLATE 4.2

Cobcroft Road Visual Montage

PLATE 4.3

Catherine Vale Vineyard Visual Montage

PLATE 4.4

Hill Street Visual Montage

As outlined in the EIS, there is generally predicted to be minimal changes in existing dust, noise, water and other impacts when compared to the existing situation, with some impacts such as noise predicted to decline over the life of the Project. The Noise and Visual Bund has been designed to provide medium to long term mitigation improvements to the noise and visual amenity in the surrounding area relative to the existing situation are likely to be of benefit to the local tourism industry which supports much of the viticulture industry in the Broke-Fordwich Viticulture subregion. With the implementation of the Noise and Visual Bund along with the extensive regime of environmental and social management and mitigation measures proposed as part of the Project, it is anticipated that the Project will continue to be a good example of the coexistence of mining and agriculture.

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5.0 Assessment of Projects Potential Impacts on Agricultural Production

The following sections discuss the potential impact of the Project on existing agricultural enterprises and potential agricultural productivity in the study area generally and expand on the assessment of Gateway criteria contained in **Section 4.0**.

5.1 Impacts on the Project Area

The majority of land that is within the Project disturbance area is either not currently used for agriculture or used for low intensity cattle grazing. Approximately 51 per cent of the Proposed disturbance area is land that is already disturbed by mining activities roads or other surface disturbing activities, is in the process of being rehabilitated from such uses or is planted to non-indigenous (and non agricultural) tree species. A further 18 per cent of the proposed disturbance area is woodland or other native forest vegetation which is generally unsuitable for agriculture other than very low intensity grazing. Approximately 1220 hectares of the proposed Project disturbance area (30 per cent) is grassland. The vast majority of this is native grassland derived following the clearing of woodland communities and is generally of poor pasture quality.

The majority of the undisturbed land within the proposed Project disturbance area is owned and managed by BCM as buffer land and has been destocked for management reasons. There is some privately owned land within the Project area used for the production of mushroom compost.

Two potentially higher value agricultural enterprises which will be affected by the Project are the Vere Vineyard (approximately 5 hectares), located along the Broke Road, and the olive plantations (approximately 13 hectares) located on Fordwich Sill along the Charlton Road. Both of these enterprises are owned by BCM and are currently managed for production. Impacts on these enterprises are discussed in **Section 5.1.1.2**.

5.1.1 Impact on Productivity of Land in the Project Area

Approximately 1220 hectares of potential grazing land, which is largely Class 4, 5 and 6 land located on the Branxton and Rothbury soil landscapes, will be affected by the Project. Some of this land will have a lower land capability post mining due to the increased slope of some of the land and is proposed to be rehabilitated for conservation landuses.

Approximately 26 hectares of Class 4 land in the Saxonvale soil landscape on the fringes of the Fordwich Sill will be impacted by the construction of the Charlton Road realignment, Noise and Visual Bund and associated water management infrastructure. The soils in this area are of higher value from an agricultural perspective than those in the rest of the Project area due to their higher fertility. This area is currently used for grazing and the BCM owned olive grove is also located on this soil landscape.

A further approximately 5 hectares currently planted to vineyards (the Vere Vineyard) will also be removed as a result of the Project.

5.1.1.1 Use of Project Area as Grazing Land

This land, at its current capability, could be expected to carry a self replacing beef cattle herd of approximately 400 cows, calving in August and with calves sold into the weaner market in April/May. (Blackwood *et al* 2006). This size herd would require fertiliser to be applied on a regular basis and some areas of improved perennial pastures to be established to grow the replacement heifers.

The value of this enterprise in terms of gross margin would be approximately $130 per hectare including pasture maintenance costs which equates to $158,860 per year (Department of Primary Industries 2011).

With higher management inputs, a more valuable steer trading and growing enterprise could return closer to $180 per hectare or $220,000 per annum. This enterprise has greater returns due to the lower overall feed requirements over a 12 month period, however, it would require some fodder cropping, high quality perennial pastures or grain feeding to reach feedlot market requirements. It may also involve higher risks from price fluctuations (Department of Primary Industries 2011).

The Project would have a long term and potentially permanent impact on the ability of this land to be run as a grazing enterprise returning these sorts of returns.

5.1.1.2 Other Agricultural Land Uses within the Project area

The relocation of the genetic stock of the Vere vineyard has an upfront cost but will mitigate the long term loss of this historical and agricultural asset.

The relocation of the Charlton Road will result in the loss of an olive grove but due to the small scale of the grove the impact of the removal on the broader industry is likely to be negligible or, as discussed in **Section 4.2.1**, slightly positive.

The sterilisation of approximately 26 hectares of the Saxonvale soil landscape on the fringe of the Fordwich Sill has a higher loss value than the other agricultural land loss due to the better soil type and condition in this location than elsewhere in the Project area. This area will be impacted by the development of the Visual and Noise Bund and Charlton Road realignment. Extending the Visual and Noise Bund will reduce noise and visual impacts on the village of Bulga and nearby rural properties that contribute to the agriculture and tourism lifestyle landscape. The benefits of these amenity improvements are expected to outweigh the loss of agricultural land along Charlton Road. The soils from this area will also be stripped and reused in rehabilitation.

A mushroom composting facility is located on a portion of the proposed site of the Eastern Emplacement area. This is a Stage 1 composting facility which generates compost material for use as mushroom growing medium. Secondary and tertiary treatment of the compost is undertaken at a nearby mushroom growing operation located on the Mitchell Line of Road. BCM is currently in negotiations with the owner of this facility regarding the relocation or purchase of the Stage 1 composting facility and associated land. This impact is minimal as the facility is not site dependant and is capable of being relocated to an alternative site. The facility will not be affected by the Project until approximately Year 4 of the Project and there are a number of years to construct a replacement facility to which the Stage 1 mushroom composting operation can relocate, with no impact to the ongoing viability of the composting enterprise. A replacement, upgraded, facility could be constructed prior to the decommissioning of the existing facility meaning continuity of production could be maintained.

5.1.2 Post-Mining Impacts

The conceptual closure plan for the existing operations is to return disturbed areas to woodland communities for biodiversity purposes. Given the existing generally poor quality soils in the Project area and the lower land capability following mining, the conceptual closure plan for the Project is also to rehabilitate disturbed areas to native vegetation for biodiversity purposes. The conceptual final landform and closure plan for the Project is shown in **Figure 5.1**. Several flatter areas in the conceptual rehabilitated final landform have been identified as having potential for agriculture due to their landform, and proximity to access roads and water (refer to **Figure 5.1**). The feasibility of rehabilitating these areas to a standard that would facilitate sustainable grazing and limited cropping or other agricultural industries that are not soil and land capability dependent will be assessed during the detailed rehabilitation and closure planning process.

Final closure of the mine may provide some potential for agricultural and or rural industrial development in areas where existing mining infrastructure, such as the rail loop, can be utilised. The feasibility of these options will be considered during the detailed mine closure process which will commence at least 5 years prior to the cessation of mining.

5.2 Impacts on Broke Fordwich Region

5.2.1 Long Term Impacts

The largest long term impact on agricultural productivity as a result of the Project will be the direct impact of removing largely low class grazing land from production and changing the land use to conservation. This impact is long term, if not permanent. On some lower capability lands, a long term change from low intensity grazing to conservation management will mean that the land is being managed more closely in accordance with its limitations and capability.

The removal of the five hectare Vere Vineyard and 13 hectares of olive groves are also permanent impacts, however, the higher value genetic grape vine stock from the Vere Vineyard will be preserved by grafting into a new vineyard on the Fordwich Sill area.

5.2.2 Short Term Impacts

The Project will have noise, air quality and lighting impacts, however, the levels of these impacts will be similar to those of the existing BCC operations and design features of the Project will result in these impacts reducing over time. These issues do not directly affect the productivity of agricultural enterprises in the surrounding region and are manageable with appropriate work schedules and care to rehabilitate the Project area on an ongoing basis.

It is likely that the proposed Project will have a similar impact on ongoing agricultural productivity in the region to that of the existing Bulga Surface Operation. The level of impact will be minimal and manageable. For instance there may be changes to intermittent flows in ephemeral drainage lines due to the management of runoff water from the out of pit emplacement areas (refer to **Section 5.2.3.2**).

The Project is unlikely to impact on the grape growing/wine making industries of the region. The Visual and Noise Bund is designed to mitigate the effects of future mining on the villages of Broke and Bulga and the associated agricultural land along Wollombi Brook and the Fordwich Sill. As the Bund becomes revegetated, the visual, noise, dust and light impacts of the Project should be significantly reduced, potentially improving the marketability of the

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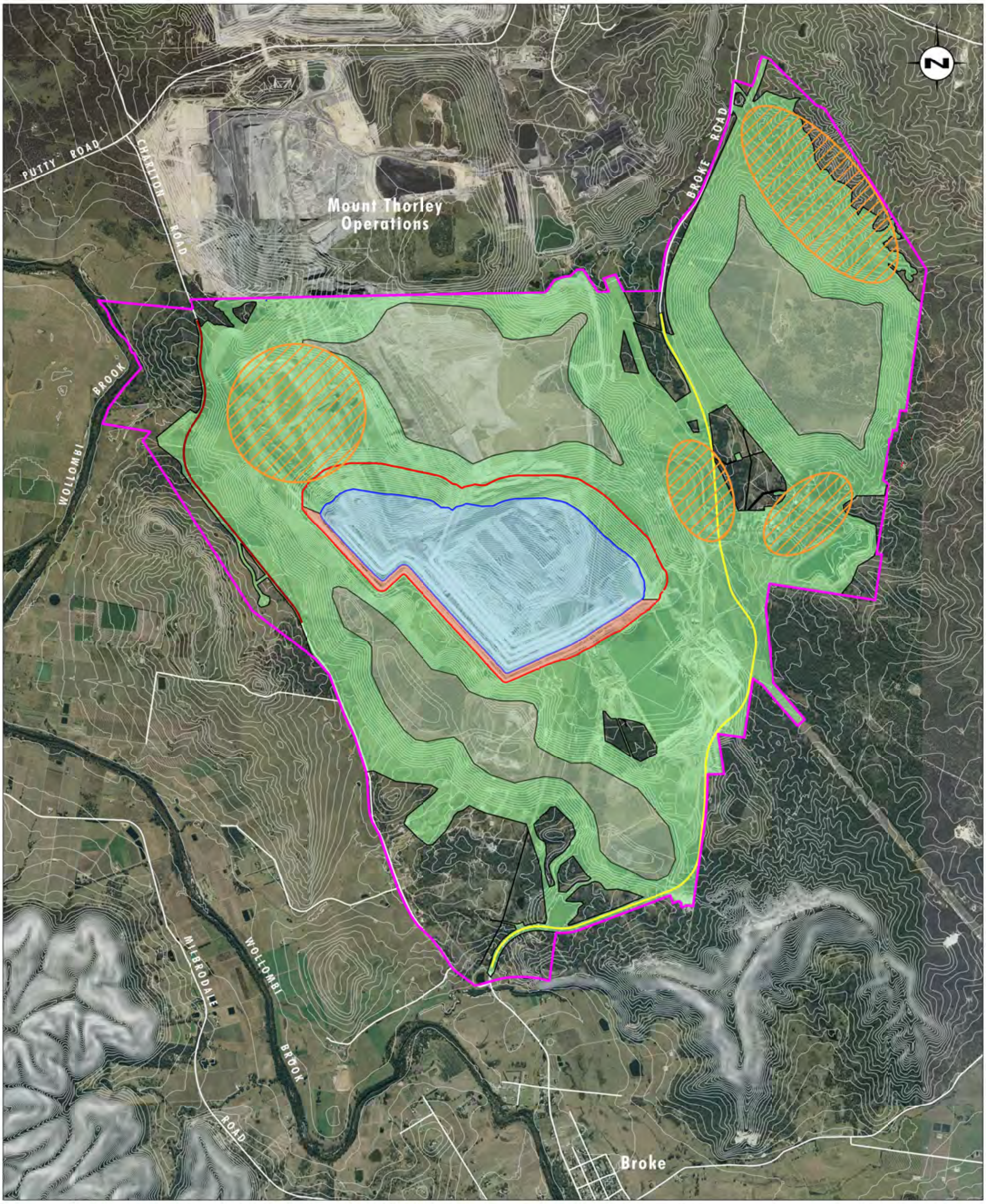

Source: AAM Pty Limited (March 2012), Xstrata Coal (NSW) Pty Ltd

0 1 2 3km

Legend

- Project Area
- Lower Density Woodland
- Higher Density Woodland
- Water
- Highwall
- Final Void
- Proposed Broke Road Realignment
- Proposed Cahrlton Road Alignment
- Areas with Potential for Agricultural Production Post Closure

FIGURE 5.1

Post Closure - Areas with Potential for Agricultural Use

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20121123 10.24

region by better shielding the specialised agri-tourism industries from the mining operations and improving the visual amenity of the locality.

Consultation with local real estate agents indicates that the capital value of agricultural land in the Region is distorted by the presence of a successful mining industry and the large demand for semi retired and rural lifestyle blocks. However, anecdotally, land values are impacted both negatively and positively by the mining industry. Agricultural land can be elevated in value if it is located in an area where a mine is to be developed and the mining company increases the demand for land due to increased population and average incomes. In contrast, agricultural land adjacent to a mine may be negatively impacted due to an unwillingness on the part of some potential buyers to purchase land close to an operating mine. Lifestyle blocks may also be devalued by the proximity of coal mines, noting also that demand for land close to mines may also increase due to increased employment demand. Low value agricultural land with significant areas of remnant vegetation present may be of value to mining companies (and other developers) as an ecological offset for other onsite impacts; the purchase price for such properties is generally more than would be the case if the land was sold for its agricultural values alone. An accurate quantification of the impact of mining on property prices is therefore difficult, if not impossible, due to complexities of the property market generally and also the variable nature of potential impacts that mining can have on property prices.

Anecdotally, it is generally perceived by the community that the demands for rural lifestyle blocks has also increased the cost of agricultural land in the Hunter Valley and Broke-Fordwich area by creating demand for smaller sized blocks. These blocks are often created through the subdivision of larger blocks previously used for various agricultural activities. While this increase in demand for lifestyle blocks is having a cumulative impact on the availability of agricultural land, it may also be contributing to keeping the value of land higher than may otherwise be based on agricultural productive capacity alone.

While the Project has the potential to have short term impacts on the surrounding community, this is unlikely to directly affect agricultural production and based on the impact assessment findings, the predicted impacts will be no higher than that of the present BCC operations. Following the construction of the Noise and Visual Bund, the Project's impacts on the local areas are predicted to decrease. This reduction in noise and visual impacts in particular will improve the amenity in the area and potentially improve the marketability of the area for agri-tourism. Any impacts on agricultural land values will be difficult to quantify, however, it is expected that the improved amenity in the area due to the Noise and Visual Bund will at least partially offset any negative impact associated with the prolonged life of the open cut operations at the BCC.

5.2.3 Impact on Water Resources

5.2.3.1 Groundwater Impacts

The potential impact of the Project on groundwater resources is covered in **Section 4.1.3**. As discussed in that section, the Project is not predicted to have an increased impact on higher quality alluvial aquifers or any other groundwater resource utilised for agricultural production relative to the existing approved BCC operations. The existing operations have had no observable impact on groundwater levels of the Wollombi Brook alluvial aquifer which is a key source of agricultural water for the local area.

The Project will result in the depressurisation of aquifers associated with coal seams extracted by the Project. The water quality in these aquifers is generally poor (Mackie Environmental Research 2012). The depressurisation of these aquifers is predicted to reduce inflows to the Loders Creek surface system by approximately 0.001 ML per day. This level of impact is considered to be negligible. It is also worth noting that these inflows are generally highly saline and the reduction in these inflows may result in a marginal improvement in water quality in the Loders Creek system.

5.2.3.2 Surface Water Impacts

Catchment Impacts

The Project will impact on annual flow volumes within downstream catchment areas due to the need to contain runoff from disturbed areas, including mining areas and overburden emplacement areas, during the operational and rehabilitation phases of the Project. The predicted change in catchment areas for impacted catchments (refer to **Figure 2.5**) relative to pre-mining levels is set out in **Table 5.1** (Umwelt 2012b).

Table 5.1 – Predicted Impacts on Catchment Areas

Catchment	Pre-Mining (ha)	Approved Final Landform (ha)	Project	
			Year 6 (ha)	Indicative Final Landform (ha)
Wollombi Brook	200,000	199,961	198,940	199,931
Northern Drainage Line	839	753	309	752
Southern Drainage Line	1,345	1,392	815	1,363
Loders Creek (at confluence with Hunter River)[1]	5,958	5,447	2,588	5,071
Loders Creek (immediately downstream of confluence with Nine Mile Creek)	3,643	3,236	1,120	2,893
Nine Mile Creek	1,327	1,327	1,067	2,079

Notes: 1) Excluding Doctors Creek as it is not impacted by the Project.
2) Final Landform is when both decommissioning of infrastructure and the rehabilitation of the post mining landform are completed.
3) The catchment areas of Wollombi Brook and Loders Creek include sub-catchments for separate drainage lines listed within the above table.

The reductions in annual flow volumes during the operational phase of the Project are in the order of 40 - 55 per cent in the ephemeral drainage lines leaving the Project area. Riparian use of water in these systems for agricultural purposes is considered to be minimal due to the inherent unpredictability of flows in these largely ephemeral systems. Flow volumes in these systems will return to close to pre-mining levels at the completion of mining with some catchments returning to these levels earlier as the quality of runoff from rehabilitated areas improves and is returned to the catchments. It is important to note that the changes in annual flow volumes with the proposed final landform are considered to be small within the context of ephemeral streams, with the change in flows being less than the seasonal and annual variations in flow volumes comparing dry years to wet years. The Project is consequently considered likely to have limited impact on ecosystems and downstream users as the predicted impact is within the natural variation of the existing creek systems (Umwelt 2012b).

Water Use and Discharge

The modelled overall site water balance is summarised in **Table 5.2**. The modelling indicates that the Project can continue to maintain a neutral site water balance with management of water surplus and deficits via the Hunter River Salinity Trading Scheme (HRSTS) and licensed abstractions from the Hunter River (Umwelt 2013b).

Table 5.2 – Forecast Mine Water Balance[1]

Component	Existing Approved (ML/year)	Project (ML/year)
Inflows		
Site Rainfall Runoff	2,848	3,980
Tailings Water Reclaim	1,335	1008
Underground Groundwater Inflow	907	1,069
Pit Groundwater Inflow	58	74
Hunter River Licensed Extraction	50	383
Total inflows	***5,198***	***6,514***
Outflows		
Evaporation	997	831
HRSTS Release	4	778
External Spill from sediment dams	89	23
CHPP Supply	3,379	2,487
Underground Supply	394	559
Haul Road Supply	623	1,815
Total outflows	***5,466***	***6,493***

1. For a median rainfall sequence.

Water is supplied to BCC from the Hunter River via the Mount Thorley Water Supply Scheme. The water balance model indicates that the need for water via the Mount Thorley Water Supply Scheme will be approximately 383 ML/year for median rainfall averaged over the life of mine. This predicted volume is within the current High Security Entitlement held by BCM of 867 ML/year based on 100 per cent allocation (Umwelt 2013b).

The Project will not significantly alter water quality or ecology of downstream systems. It is also considered that the Project will not significantly impact on the potential use of water for downstream users on the local creek systems (Umwelt 2013b). The licensed water extractions required to meet the demands of the Project are similar to those of the existing operations. BCM currently hold sufficient water extraction entitlements to meet the projected water demands of the Project.

5.2.4 Cumulative Impacts of Coal Mining on Agricultural Output

The value of temporary or permanently lost agricultural production on an individual mine basis may not be significant, however, on a cumulative basis, across the scale of the Hunter Valley, this permanent loss of agricultural land has the potential to impact on the ability of the region to sustain some agricultural industries and enterprises as the available land becomes more disjointed. Low intensity grazing is the main such industry directly affected. The ongoing reduction of production in the grazing industry across the region is likely to impact negatively on transport, marketing and access to processing services.

Any negative changes in water quality and quantity may also have an impact on the ability of the region to sustain agricultural outputs that are sensitive to quality water access.

A further impact of continued coal mining on the region is the need for mines to purchase increasing environmental offsets. This invariably removes areas of land from agricultural production that are generally larger than the actual mine footprint. Effectively this is a permanent loss to agriculture and, in the long term, places more pressure on remaining agricultural land to be more productive, requiring greater investment in best agricultural practices to sustain viable land and water resources into the future.

Given the generally marginal nature of the agricultural land being impacted by the Project, the Project's overall contribution to the cumulative reduction in agricultural productivity in the region is considered to be minimal. The Project also limits the magnitude of the potential cumulative impact from mining by maximising the use of the existing BCC disturbance footprint to extract additional resources rather than developing a greenfield project to extract similar amounts of resource which may have a higher impact on agricultural productivity in the area.

BCM is committed to maintaining agricultural production on land currently owned and managed by it where this is appropriate from an environmental, safety and operational perspective, and this also mitigates against the potential contribution of this Project to cumulative impacts.

Consistent with Xstrata Coal policy, the biodiversity offsets proposed for the Project have focussed on areas which have lower agricultural potential, thus reducing the amount of land removed from productivity through environmental offsets. The proposed biodiversity offset areas for the Project are located within an area identified by the Upper Hunter SRLUP for conservation. The properties in question are currently operated by Colinta but include both high value grazing and cropping land (including land mapped in the Upper Hunter SRLUP as BSAL) as well as wooded areas of with little or no agricultural value. All of the land mapped as BSAL is excluded from the proposed biodiversity offset area, as is the vast majority of cleared land, despite the ability of much of this land to be regenerated to high quality ecological communities.

Improved documentation and mapping of offset areas is one of the priority actions in the Upper Hunter SRLUP. As information about offset areas, management approach and management impacts is compiled and analysed, understanding of the real costs and benefits of a long term shift to conservation land management will improve.

It is noted that that the proposed biodiversity offset areas for this Project occur in an area that has been identified as a priority for biodiversity conservation in regional strategies (e.g. the Upper Hunter SRLUP and the Great Eastern Ranges Initiative) supporting the use of the low productivity grazing land in this area for biodiversity offsets. The proposed offset area identified for the Project excludes higher quality grazing and cropping land (including land mapped as being BSAL in the Upper Hunter SRLUP located on the proposed offset property. This is discussed further in Ecological Assessment that forms part of the EIS for the Project.

As noted above, the Project is not predicted to significantly alter the quality of water downstream from the Project. Cumulative impact of saline discharges from mines and other sources is managed in the Hunter River catchment through the Hunter River Salinity Trading Scheme which is mandated on mines (including the BCC) through conditions imposed on Environment Protection Licences under the *Protection of the Environment Operations Act 1997*.

6.0 Mitigation of Potential Impacts

A number of environmental management and mitigation strategies will be employed to minimise the potential noise, air quality. visual, water, traffic and other impacts during the life of the Project. The Project also includes specific design features, such as the Noise and Visual Bund, to mitigate the impact of the Project on the local community. These measures reduce the potential of the Project to impact on surrounding agricultural land uses.

The construction of the Noise and Visual Bund in particular, will assist the Project in managing noise and visual impacts from the Project which will mitigate the potential impact of the Project on agri-tourism related industries in the Broke, Fordwich and Bulga areas. The early vegetation of the Noise and Visual Bund will significantly mitigate the visual impact of the mining operations carried out at the BCC which will also benefit the agri-tourism related industries in the Broke, Fordwich and Bulga areas.

The inclusion of areas of rehabilitated land in the final landform that have potential for future agricultural uses will mitigate the potential loss of agricultural productivity resulting from the mining activities being undertaken (refer to **Figure 5.1**). Given the generally poor quality of the land being impacted by the project, the potential uses of any land returned to agricultural production is likely to be limited to low intensity grazing. Some of these areas may also be suitable for intensive agricultural industries that are not soil and land capability dependent. The extent of rehabilitated land made available for use for agricultural purposes following cessation of mining will be determined as part of the detailed mine closure process.

Where appropriate from an environmental, safety and operational perspective, buffer lands owned by BCM will continue to be maintained as operating agricultural enterprises.

The genetic stock of the Cabernet grapes grown in the Vere Vineyard is being maintained through the planting of vines propagated from the Vere Vineyard vines on the western side of the Fordwich Sill.

The Stage 1 mushroom composting facility presently operating in a portion of the proposed location of the Eastern Emplacement Area will need to be relocated. Overburden emplacement which would directly impact on this site will not occur until approximately Year 4 of the Project providing sufficient time to relocate this facility to an alternate location. BCM is currently in commercial negotiations with the operator of the Stage 1 mushroom composting facility in relation to the possible acquisition of this property. The acquisition will also include compensation for the costs associated with the relocation of the facility to an alternate location. If an agreement cannot be reached with the operator of the composting facility, an alternate, smaller Eastern Emplacement Area design has been identified which can coexist with the facility. With these mitigation measures in place, the Project will not result in a negative impact on this agricultural industry.

Further details on these and other environmental management and mitigation measures that will minimise the impacts of the Project on the surrounding land uses are outlined in the EIS.

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7.0 Conclusions

The Project will result in the medium to long term removal of agriculture production over an area of approximately 1200 hectares. This area has historically been used for low intensity cattle grazing. The value of a cow-calf operation on this land in gross margin terms is in the order of $130 per hectare including pasture maintenance costs which equates to $156,000 per year (Department of Primary Industries 2011). With higher management inputs, a more valuable steer trading and growing enterprise could return closer to $180 per hectare or $215,000 per annum. The profitability of such an operation is low when fixed costs, taxation and interest on capital is taken into consideration. Other than potential rural industrial uses, there are few other viable agricultural uses of this land due to the poor quality of the soil, particularly given the oversupply of grapes and olives which are the main recognised horticultural enterprises in the areas.

Whilst the Stage 1 mushroom composting facility located on a portion of the proposed Eastern Emplacement Area is a high value use of this land, the value of this land for coal mining purposes is considered to be significantly higher. The relocation of this facility is commercially and technically feasible without any adverse impact on production and therefore the Project can be managed to not adversely affect the contribution of this agricultural enterprise to the economy. BCM is currently in commercial negotiations with the operator of the Stage 1 mushroom composting facility in relation to the possible acquisition of this property. The acquisition will also include compensation for the costs associated with the relocation of the facility to an alternate location. If an agreement cannot be reached with the operator of the composting facility, an alternate, smaller Eastern Emplacement Area design has been identified which can coexist with the facility.

The Project is predicted to have minimal impacts on the agricultural productivity of the surrounding region. While the Project will contribute to the further reduction of grazing land resulting from coal mining operations in the Hunter Valley, the relative contribution of the Project is considered to be small, particularly when compared to 'greenfield' projects which might be developed to meet the demand for coal should the Project not be developed.

The economic benefits and value of coal mining in the Project area will significantly outweigh the value of agricultural production in the area directly impacted by the mine. The value of the proposed mining operations at both a private and public level exceeds the value of the land for agricultural uses by several orders of magnitude.

The construction and vegetation of the Noise and Visual Bund will improve the visual and noise amenity of the area to the south and west of the Project area relative to the existing operations and this is likely to improve the viability of agri-tourism industries which are developing in this area. This positive impact is likely to improve the overall viability of tourism related industries in the area.

Whilst the existing BCC has some level of impact on the surrounding community, it has been able to demonstrate coexistence with agriculture in the area for over 30 years. During this time, the community and agricultural production in the area has changed with more lifestyle blocks and agri-toursim developing in recent years. The design of the Project, including the development of the Noise and Visual Bund will significantly mitigate the impact of operations at the BCC on the neighbouring Broke-Fordwich Viticulture Subregion (part of the Hunter Valley Viticulture CIC) and lessen any adverse impact the proximity of the mine to this area may have had on the tourism industry in the area. Despite the loss of generally low quality grazing land and the removal of a vineyard and olive grove, overall, the Project represents a good example of the coexistence that is achievable between agriculture and mining in New South Wales.

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APPENDIX A

Previous Soil Survey and Soil Test Results

Our Ref: Lt_633.10067_Soil Survey_Final

20th February 2013

Ralph Northey
Environment and Community Manager
Bulga Coal Complex
PMB 8 (567 Broke Road)
Singleton NSW 2330

Sent Via: Email Transmission

Dear Ralph,

RE: BULGA UNDERGROUND OPERATIONS – MODIFICATION PROJECT: SOIL SURVEY AND LAND CAPABILITY ASSESSMENT

1.0 INTRODUCTION

GSS Environmental (GSSE) was engaged by Bulga Coal Management Pty Ltd (BCM) in June 2012, on behalf of Bulga Joint Venture (BJV), to undertake a Land Capability Assessment for the Bulga Underground Operations (BUO) modification Project (the Project).

The Project is a modification to the approved Blakefield North Mine located approximately 12 kilometres (km) south-west of Singleton, in the Upper Hunter Valley of New South Wales (NSW). BCM is seeking to modify Development Consent DA 376-8-2003 pursuant to Section 75W of the Environmental Planning and Assessment Act, 1979 (EP&A Act) to allow for a revised longwall underground mine layout and associated infrastructure. The proposed Project modification area (Project Area) is approximately 710 ha (**Figure 1**). The Strategic Regional Land Use Plan (SRLUP) for the Upper Hunter (DPI, 2012) has mapped 252 hectares (ha) of land within the Project Area as potential Biophysical Strategic Agricultural Land (BSAL). The area under assessment is termed the Study Area and is 252 ha (**Figure 1**).

GSSE was commissioned to undertake an assessment to 'ground truth' the mapped BSAL within the Project Area according to Upper Hunter SRLUP. The assessment was comissioned prior to the release of the *Land and Soil Capability Assessment Scheme; Second approximation* (OEH, 2012a) and the *Interim Protocol for Site verification and Mapping of Biophysical Strategic Agriclural Land* (OEH, 2012b).

2.0 SOIL SURVEY ASSESSMENT: METHODOLOGY

2.1 Reference Map

An initial soil map (reference map) was developed using the following resources and techniques.

Aerial photographs and topographic maps

Aerial photo and topographic map interpretation was used as a remote sensing technique allowing detailed analysis of the landscape, and mapping of features expected to be related to the distribution of soils.

Reference information

Source materials were used to obtain correlations between pattern elements and soil properties that may be observable in the field. These materials included Cadastral data, prior and current physiographic, geological, vegetation, water resources studies, and the *Soil Landscapes of the Singleton 1:250,000 Sheet* (Kovac & Lawrie, 1991). A slope analysis of the Project Area was assessed to assist with soil distribution and Land and Soil Capability classification (**Figure 2**).

2.2 Field Survey Plan

The field survey was an integrated qualitative survey conducted in accordance with the *Guidelines for Surveying Soil and Land Resources* (NCST, 2008) and comprised of the following three survey observation types:

- Detailed profile descriptions (Class I observations);
- Laboratory assessed profiles (Class II observations); and
- Mapping observations (Class IV observations).

The type and density of survey observations across the Project Area that were utilised in this assessment are listed are shown in **Figure 3** and summarised in **Table 1**.

Table 1 – Soil Survey Observation Type and Density

Area	Survey Scale	Number and Types of Observation			
Description		**Class I (cores)**	**Class II (laboratory)**	**Class IV (mapping)**	**Total**
Soil Survey	1:25,000	20	11	20	**42**

Detailed Profile Description (Class I Observations)

Soil profiles were assessed in accordance with the *Australian Soil and Land Survey Field Handbook* (NCST, 2009). Each soil-profile exposure will be excavated by a soil corer to approximately 1.2 m, or to bedrock. After assessment, soil cores will be backfilled with the remaining soil. Detailed soil profile morphological descriptions recorded information that covered the parameters specified in **Table 2**.

Table 2 – Detailed Soil Profile Description Parameters

Descriptor	Application
Horizon depth	Weathering characteristics, soil development
Field colour	Permeability, susceptibility to dispersion/erosion
Field texture grade	Erodibility, hydraulic conductivity, moisture retention, root penetration
Boundary distinctness and shape	Erosional/dispositional status, textural grade
Consistence force	Structural stability, dispersion, ped formation
Structure pedality grade	Soil structure, root penetration, permeability, aeration
Structure ped and size	Soil structure, root penetration, permeability, aeration
Stones – amount and size	Water holding capacity, weathering status, erosional/depositional character
Roots – amount and size	Effective rooting depth, vegetative sustainability
Ants, termites, worms, etc.	Biological mixing depth

Soil Laboratory Assessment (Class II Observations)

The topsoil samples (0-10 cm) from 18 soil cores and 1 soil mapping observation were sent to the ALS Environmental Division (Brisbane Laboratory) for analysis. All samples were laboratory tested for the parameters in **Table 3**; the accompanying certificates of analysis are provided in **Attachment A**. The guide *Interpreting Soil Test Results* (Hazelton & Murphy, 2007) was used to interpret soil test results.

Table 3 – Detailed Soil Profile Description Parameters

Laboratory Analysis
• Electrical conductivity (EC) • pH • Cation Exchange Capacity (CEC) and exchangeable cations • Total Organic Carbon (TOC) • Nitrite plus Nitrate as N (NOx) • Total Nitrogen as N (TKN + NOx) • Total Sulfur Fluoride Extractable Phosphorus

Mapping Observations (Class IV Observations)

Mapping observations consisted of exposed cuttings (such as cut slopes), topsoil exposure of up to 0.3 m using a spade, vegetation cover associations, and rock outcrops. These were utilised to confirm mapping boundaries, soil type distributions and any other characteristics being mapped in the survey.

2.3 Soil Classification Nomenclature

The applicable technical standard for naming the types of soil identified is the *Australian Soil Classification* (ASC) system (Isbell, 1996).

Ref: **Figure 1**

Title:

Site Plan

Project: Bulga UG AIS

Client: Bulga Underground Operations Pty Ltd

Legend:

- Project Area
- Study Area
- SAL Biophysical

N

Source:
This map contains the Bing Maps aerial imagery web mapping service, which provides worldwide orthographic aerial and satellite imagery. Coverage varies by region.
(c) 2010 Microsoft Corporation and its data suppliers

Drawing No: 633.10067_Fg1_SitePlan_130220

Date: 20/02/2013 Drawing size: A4

Drawn by: NT Reviewed by: AC

Scale: 1:20,000

0 165 330 660
Meters

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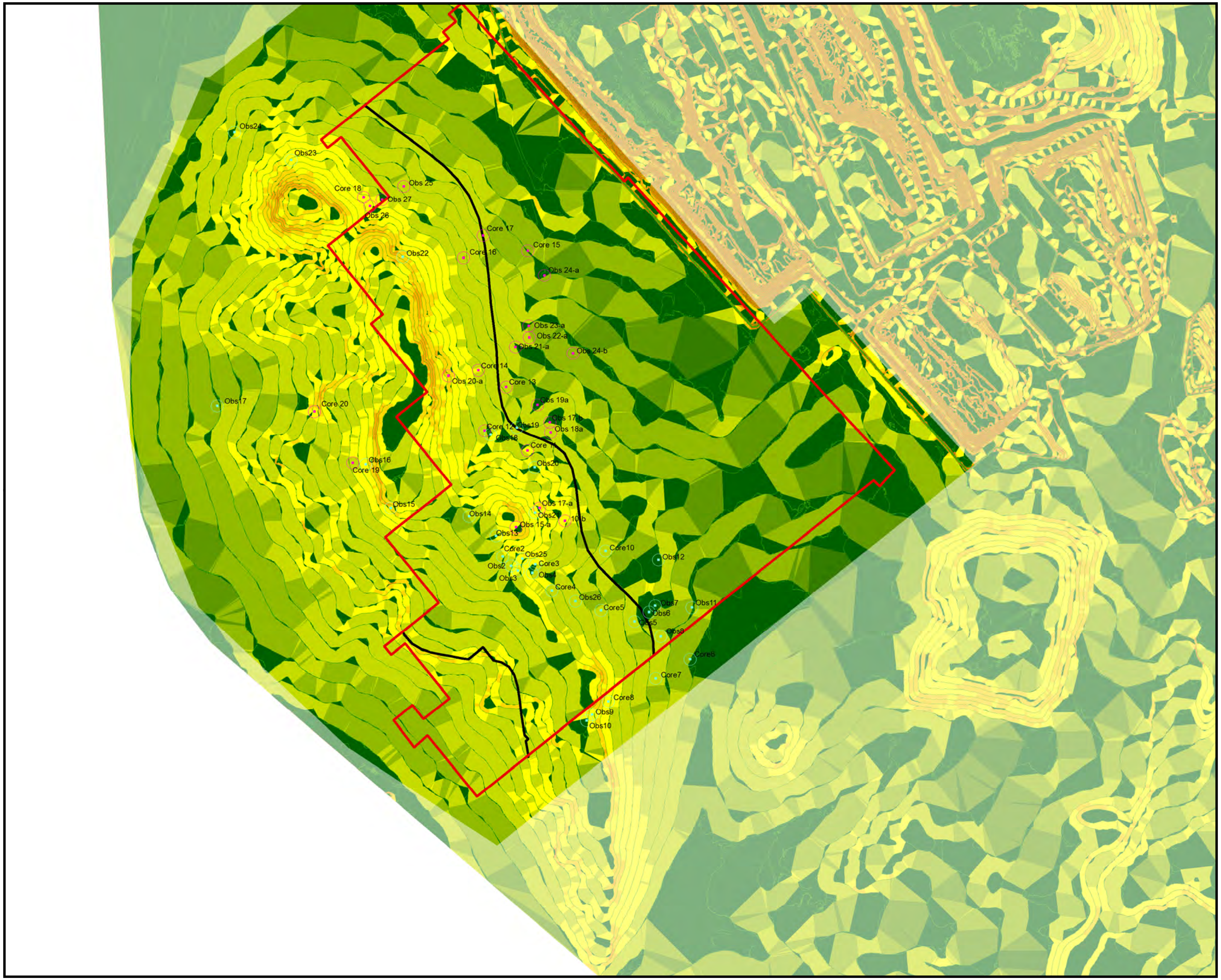
Ref: **Figure 2**

Title: Slope Analysis

Project: Bulga UG AIS

Client: Bulga Undergorund Operation Pty Ltd



Legend:

- Extra Sampling Points
- Sampling Points
- Project Area
- Study Area
- Major Contours

Slope (%)

- 1
- 2
- 3
- 5
- 10
- 18
- 32
- 50
- 100
- 1000
- 1001

N

Source:
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Drawing No: 633.10067_Fg2_SlopeAnalysis_130220

Date: 20/02/2013 Drawing size: A4

Drawn by: NT/LH Reviewed by: AC

Scale: 1:20,000

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Ref: **Figure 3**

Title: Field Survey Map

Project: Bulga UG AIS

Client: Bulga Underground Operations Pty Ltd

Legend:

- Extra Sampling Points
- Sampling Points
- Project Area
- SAL Biophysical

Source:
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Drawing No: 633.10067_Fg3_FieldSurveyMap_130220

Date: 20/02/2013 | Drawing size: A4

Drawn by: NT | Reviewed by: AC

Scale: 1:20,000

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Meters

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3.0 SOIL SURVEY RESULTS

A total of 9 soil types were identified within the Study Area (**Figure 4**). Chromosols (54.9%) and Dermosols (24.5%) were the dominant soil types in the Study Area (**Table 4**). Representative soil samples for each soil type are described below.

Table 4 – Study Area: Soil Types Overview

Soil Type		Land Area	
		ha	%
1	Brown Chromosol	28	11.1
2	Yellowish-brown Chromosol / Sodosol	48	19.1
3	Reddish-brown Chromosol	8	3.2
4	Yellowish-brown Chromosol; shallow	44	17.5
5	Strong Brown Dermosol	18	7.1
6	Yellowish-red Chromosol	10	4.0
7	Reddish-brown Dermosol; moderate	22	8.7
8	Reddish-brown Dermosol; deep	22	8.7
9	Rudosol; Leptic	44	17.5
10	Tenosol; Leptic	8	3.2
Sub-total		**252**	**100.0**

3.1 Soil Type 1: Brown Chromosol

Brown Chromosols cover 28 ha (11.1%) of the Study Area. This representative soil profile is characterised by moderately structured sandy clay loam overlying strongly structured medium to heavy clay subsoil. Topsoil pH is neutral, non-sodic, non-saline and cation exchange capacity is moderate.

Table 5: Overview of Soil Type 1: Brown Chromosol

Plate 1: Profile (Core 5)

Plate 2: Landscape (Core 5)

Site Description		
ASC Name	Brown Chromosol	
Great Soil Group	Brown Podzolic	
Landscape Unit Association	Branxton	
Slope Association	5-10%	
Field Sites	2, 5, 6, 8 and 15	
LSC Capability	Class 3; Main limitations – slope, soil acidity	
Physical Characteristics		
Horizon	**Depth (m)**	**Description**
A1	0-0.2	Brown sandy clay loam; moderate structure and 5-10 mm sub angular peds with moderate consistence; neutral pH (6.6). Rapidly drained with clear boundary.
B21	0.2-0.5	Brown medium to heavy clay; strong structure and blocky peds with very strong consistence. Nil segregations and stones; nil mottles. Gradual boundary.
B22	0.5-0.75+	Brown heavy clay; strong structure and blocky peds with very strong consistence. Ten percent small calcium carbonate nodules. Nil stones and nil mottles.

3.2 Soil Type 2: Yellowish-brown Chromosol / Sodosol

Yellowish-brown Chromosols / Sodosols cover 48 ha (19.1%) of the Study Area. This representative soil profile is characterised by apedal sandy loam overlying strongly structured heavy clay subsoil. Topsoil pH is slightly, non-sodic, slightly saline and cation exchange capacity is low.

Table 6: Overview of Soil Type 2: Yellowish-Brown Chromosol / Sodosol

Plate 3: Profile (Core 10b)

Plate 4: Landscape (Core 10b)

Site Description	
ASC Name	Yellowish-brown Chromosol / Sodosol
Great Soil Group	Yellow Soloth
Landscape Unit Association	Branxton
Slope Association	3-5%
Sampled Site(s)	9, 10a and 10b
LSC Capability	Class 4; Main limitations – soil acidity, soil depth

Physical Characteristics		
Description		
Horizon	**Depth (m)**	**Description**
A1	0-0.2	Very dark grayish-brown sandy loam; apedal structure and 5 mm granular peds with weak consistence. Slightly acidic (pH 6.1). Nil stones; nil mottles. Well drained with a clear and even boundary.
A2	0.2-0.3	Brown sandy clay loam; strong structure and 20 mm sub angular peds with moderate consistence. Nil stones; nil mottles. Well drained with an abrupt and even boundary.
B21	0.3-0.7	Yellowish-brown heavy clay; strong structure with strong consistence. Strongly acidic (pH 5.5*). Nil stones; some orange (20%) and grey (10%) mottling. Poorly drained with a gradual boundary.
BC	0.7+	Weathering rock.

** Correlated with Soil Landscapes of Singleton 1:250,000 Sheet (Kovac & Lawrie, 1991)*

3.3 Soil Type 3: Reddish-brown Chromosol

Reddish-brown Chromosols cover 8 ha (3.2%) of the Study Area. This representative soil profile is characterised by strong structured loam overlying strongly structured heavy clay subsoil. Topsoil pH is neutral, non-sodic, non-saline and cation exchange capacity is moderate.

Table 7: Overview of Soil Type 3: Reddish-brown Chromosol

Plate 5: Profile (Core 13)

Plate 6: Landscape (Core 13)

Site Description	
ASC Name	Reddish-brown Chromosol
Great Soil Group	Red Podzolic
Landscape Unit Association	Branxton
Slope Association	5-10%
Sampled Site(s)	13
LSC Capability	Class 4; Main limitations – soil acidity

Physical Characteristics		
Horizon	**Depth (m)**	**Description**
A1	0-0.2	Dark brown loam; moderate structure and 5 mm granular peds with moderate consistence. Neutral (pH 6.6). Nil stones; nil mottles. Well drained with an abrupt and even boundary.
B1	0.2-0.3	Dark reddish-brown light-medium clay; strong structure and 10-20 mm peds with moderate consistence. Nil stones; nil mottles. Well drained with a clear and even boundary.
B2	0.3-0.6	Reddish-brown heavy clay; strong structure and 100 mm peds with strong consistence. Moderately acidic (pH 6.0*). Some (10%) stones less than 20 mm; nil mottles. Well drained with a gradual boundary.
B3	60-80	Weathering bedrock.

** Correlated with Soil Landscapes of Singleton 1:250,000 Sheet (Kovac & Lawrie, 1991)*

3.4 Soil Type 4: Yellowish-brown Chromosol; Shallow

Yellowish-brown Chromosols (Shallow) cover 44 ha (17.5%) of the Study Area. This representative soil profile is characterised by strong structured loam overlying moderately structured medium clay subsoil. Topsoil pH is moderately alkaline, non-sodic, moderately saline and cation exchange capacity is high.

Table 8: Overview of Soil Type 3: Reddish-brown Chromosol

Plate 7: Profile (Core 14)

Plate 8: Landscape (Core 14)

Site Description	
ASC Name	Yellowish-brown Chromosol; Shallow
Great Soil Group	Yellow Podzolic
Landscape Unit Association	Branxton
Slope Association	10-18%
Sampled Site(s)	14
LSC Capability	Class 4; Main limitations – slope, soil acidity, soil depth

Physical Characteristics

Horizon	**Depth (m)**	**Description**
A1	0-0.2	Brown loam; strong structure and 5 mm granular peds with moderate consistence. Well drained with an abrupt and even boundary and moderately alkaline (pH 7.9). Nil stones; nil mottles.
B2	0.2-0.5	Yellowish-brown medium clay; moderate structure and 20 mm angular peds with moderate consistence. Strongly acidic to neutral (pH 5.5*). Some (20%) stones 20-50 mm; nil mottles. Poorly drained with an abrupt boundary.
BC	0.5-0.6	Bedrock.

** Correlated with Soil Landscapes of Singleton 1:250,000 Sheet (Kovac & Lawrie, 1991)*

3.5 Soil Type 5: Strong Brown Dermosol

Strong Brown Dermosols cover 18 ha (7.1%) of the Study Area. This representative soil profile is characterised by strong structured light clay overlying strongly structured medium clay subsoil. Topsoil pH is neutral, non-sodic, slightly saline and cation exchange capacity is moderate.

Table 9: Overview of Soil Type 5: Strong Brown Dermosol

Plate 9: Profile (Core 17)

Plate 10: Landscape (Core 17)

Site Description	
ASC Name	Strong Brown Dermosol
Great Soil Group	Chocolate Soils
Landscape Unit Association	Saxonvale influenced
Slope Association	5-10%
Sampled Site(s)	16 and 17
LSC Capability	Class 4; Main limitations – soil depth

Physical Characteristics		
Horizon	**Depth (m)**	**Description**
A1	0-0.2	Dark grayish-brown light clay; strong structure and 10-20 mm sub angular peds with moderate consistence. Neutral (pH 6.9). Nil stones; nil mottles. Well drained with a clear boundary.
B2	0.2-0.5	Strong Brown medium clay; strong structure and 100 mm blocky peds with strong consistence. Moderately acidic to neutral (pH 6.0-7.0*). Some (5%) stones less than 5mm; some orange (20%) mottling. Gradual boundary
B3	0.5+	Weathering bedrock.

** Correlated with Soil Landscapes of Singleton 1:250,000 Sheet (Kovac & Lawrie, 1991)*

3.6 Soil Type 6: Yellowish-red Chromosol

Yellowish-red Chromosols cover 140 ha (4.0%) of the Study Area. This representative soil profile is characterised by strongly structured clay loam overlying strongly structured medium clay subsoil. Topsoil pH is neutral, non-sodic, non-saline and cation exchange capacity is moderate.

Table 10: Overview of Soil Type 6: Yellowish-red Chromosol

Plate 11: Profile (Core 18)

Plate 12: Landscape (Core 18)

Site Description	
ASC Name	Yellowish-red Chromosol
Great Soil Group	Red Podzolic
Landscape Unit Association	Branxton
Slope Association	5-10%
Sampled Site(s)	18
LSC Capability	Class 4; Main limitations – soil acidity

Physical Characteristics

Horizon	Depth (m)	Description
A1	0-0.1	Dark reddish-brown clay loam; strong structure and 20 mm sub angular peds with moderate consistence. Neutral (pH 6.6). Some stones (5%); nil mottles. Moderately drained with a clear boundary.
B1	0.1-0.3	Reddish-brown light clay; strong structure and 20-50 mm angular peds with strong consistence. Moderately acidic (pH 6.0*). Nil stones; Some (50%) orange / brown mottling. Moderate to poorly drained with a gradual boundary.
B2	0.3-0.5+	Yellowish-brown medium to heavy clay; strong structure and 20-50 mm angular peds with strong consistence. Moderately acidic (pH 6.0*). Nil stones; Some (20%) grey mottling. Poorly drained.

** Correlated with Soil Landscapes of Singleton 1:250,000 Sheet (Kovac & Lawrie, 1991)*

3.7 Soil Type 7: Reddish-brown Dermosol; moderate

Reddish-brown Dermosols; moderate cover 22 ha (8.7%) of the Study Area. This representative soil profile is characterised by strongly structured sandy loam to sandy clay loam overlying strongly structured sandy clay subsoil. Topsoil pH is neutral, non-sodic, moderately non-saline and cation exchange capacity is moderate.

Table 11: Overview of Soil Type 7: Reddish-brown Dermosol; moderate

Plate 13: Profile (Core 19)

Plate 14: Landscape (Core 19)

Site Description			
ASC Name		Reddish-brown Dermosol; moderate	
Great Soil Group		Red Podzolic	
Landscape Unit Association		Branxton	
Slope Association		5-10%	
Sampled Site(s)		19	
LSC Capability		Class 4; Main limitations – soil acidity, soil depth	
Physical Characteristics			
Horizon	**Depth (m)**	**Description**	
A1	0-0.2	Dark reddish-brown sandy loam to sandy clay loam; strong structure and 20 mm sub angular peds with moderate consistence. Neutral (pH 6.7). Nil stones; nil mottles. Well drained.	
B1	0.2-0.6	Reddish-brown sandy clay; strong structure and 20-50 mm sub angular peds with strong consistence. Moderately acidic (pH 6.0*). Nil stones; nil mottles. Poorly drained.	
B3	0.6+	Weathering bedrock.	

** Correlated with Soil Landscapes of Singleton 1:250,000 Sheet (Kovac & Lawrie, 1991)*

3.8 Soil Type 8: Reddish-brown Dermosol; deep

Reddish-brown Dermosols; deep cover 22 ha (8.7%) of the Study Area. This representative soil profile is characterised by strongly structured clay loam overlaying a light-medium clay. Topsoil has a neutral pH, moderate to high salinity, non-sodic and cation exchange capacity is moderate.

Table 12: Overview of Soil Type 8: Reddish-brown Dermosol; deep

Plate 15: Profile (Core 20)

Plate 16: Landscape (Core 20)

Site Description		
ASC Name	Reddish-brown Dermosol; deep	
Great Soil Group	Red Podzolic	
Landscape Unit Association	Branxton	
Slope Association	5-10%	
Sampled Site(s)	20	
LSC Capability	Class 4; Main limitations – soil acidity	
Physical Characteristics		
Horizon	**Depth (m)**	**Description**
A1	0-0.2	Dark reddish-brown clay loam; strong structure. Neutral (pH 7.1). Nil stones; nil mottles. Well drained.
B1	0.2-1.0+	Reddish-brown light-medium clay. Moderately acidic (pH 6.0*). Nil stones; nil mottles.

** Correlated with Soil Landscapes of Singleton 1:250,000 Sheet (Kovac & Lawrie, 1991)*

3.9 Soil Type 9: Rudosol; Leptic

Rudosols; Leptic cover 44 ha (17.5%) of the Study Area. This representative soil type is associated with sedimentary sandstone outcrops.

Table 13: Overview of Soil Type 9: Rudosol; Leptic

Plate 17: Profile (Obs 15)

Plate 18: Landscape (Obs 15)

Site Description	
ASC Name	Rudosol; Leptic
Great Soil Group	Lithosol
Slope Association	10-18%
Sampled Site(s)	Obs 15
LSC Capability	Class 6; Main limitations - rock outcrop, soil depth

3.10 Soil Type 10: Tenosol; Leptic

Tenosols; Leptic cover 8 ha (3.2%) of the Study Area. This representative soil type is associated with crest of the dolerite sill.

Table 14: Overview of Soil Type 10: Tenosol; Leptic

Plate 19: Surface Rock

Plate 20: Landscape

Site Description	
ASC Name	Tenosol; Leptic
Great Soil Group	Lithosol
Slope Association	0-10%
LSC Capability	Class 6; Main limitations - rock outcrop, soil depth

Ref:

Figure 4

Title: Bulga Study Area - Soil Map

Project: Soils Classifications

Client: Bulga Underground Operations Pty Ltd

Legend

- Extra Sampling Points
- Sampling Points
- Project Area
- Study Area

Study Area Soil Types

- Brown Chromasol
- Reddish-Brown Chromasol
- Yellowish-Brown Chromasol/Sodasol
- Yellowish-Red Chromosol
- Reddish-Brown Dermosol; Deep
- Reddish-Brown Dermosol; Moderate
- Yellowish-Brown Chromosol; Shallow
- Strong-Brown Dermosol
- Rudosol; Leptic
- Tenosol; Leptic

Source:
This map contains the Bing Maps aerial imagery web mapping service, which provides worldwide orthographic aerial and satellite imagery. Coverage varies by region.
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Drawing No: 633.10067_Fg4_Soil Map_130220

Date: 20/02/2013 Drawing size: A4

Drawn by: NT/LH Reviewed by: AC

Scale: 1:20,000

0 165 330 660 Meters

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4.0 Land Assessment

In NSW, rural lands are currently being mapped according the NSW Office of Environment and Heritage (OEH) *Land and Soil Capability Assessment Scheme; Second approximation* (OEH, 2012a) and classifies land into eight classes (Classes 1 to 8) known as LSC classes. The LSC classification then forms an integral part of BSAL Assessment. Therefore the Study Area has been assessed for both:

- Land and Soil Capability (LSC); and
- Biophysical Strategic Agricultural Land (BSAL).

4.1 Land and Soil Capability

4.1.1 Land and Soil Capability Methodology

The LSC classification applied to the Study Area was in accordance with the OEH guideline *The Land and Soil Capability Assessment Scheme; Second approximation* (OEH, 2012a) (referred to as the LSC Guideline). This scheme uses the biophysical features of the land and soil to derive detailed rating tables for a range of land and soil hazards. The scheme consists of eight classes, which classify the land based on the severity of long-term limitations. The LSC classes are described in **Table 15** and their definition has been based on two considerations:

- The biophysical features of the land to derive the LSC classes associated with various hazards; and
- The management of the hazards including the level of inputs, expertise and investment required to manage the land sustainably.

Table 15 – Land and Soil Capability Classes

Class	Land and Soil Capability
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. Land capable of all rural land uses and land management practices.
2	**Very high capability land**: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	**High capability land**: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
4	**Moderate capability land**: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.
5	**Moderate–low capability land**: Land has 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.
Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)	
6	**Low capability land**: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
7	**Very low capability land**: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	**Extremely low capability land**: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation

Source: The Land and Soil Capability Assessment Scheme; second approximation (OEH, 2012a)

Calculating LSC Classes

The biophysical features of the land that are associated with various hazards are broadly soil, climate and landform and more specifically: slope, landform position, acidity, salinity, drainage, rockiness; and climate.

The eight (8) hazards associated with these biophysical features that are assessed by the scheme are:

1. Water erosion
2. Wind erosion
3. Soil structure decline
4. Soil acidification
5. Salinity
6. Water logging
7. Shallow soils and rockiness
8. Mass movement

Each hazard is assessed against set criteria tables, as described in the LSC Guideline; each hazard for the land is ranked from 1 through to 8 with the overall ranking of the land determined by its most significant limitation.

Hazard 1: Water Erosion

The Study Area lies within the Eastern and Central NSW Division, and the appropriate criteria for this division were used in the assessment. Assessment of water erosion hazard is almost solely dependent on the slope percentage of the land , based on each soil landscape unit. The only exception is land which falls within the slope range of 10-20%, which may be designated Class 4 or 5 depending on the presence of gully erosion and/or sodic/dispersible soils.

Hazard 2: Wind Erosion

There are four factors used to assess wind erosion hazard for each soil type. Three criteria were assessed to be consistent for each soil type:

- Wind erosive power for the Study Area has been mapped as ‘low’ (NSW Department of Trade and Investment);
- Exposure of the land to wind was also determined to be “Moderate” throughout the Study Area; and
- The average rainfall for the region is 655 mm (BOM, 2013), and therefore the Study Area lies within the “greater than 500 mm rainfall” category.

The determining factor with regard to wind erosion hazard was therefore the erodibility of each soil type as determined by soil texture according the LSC Guideline.

Hazard 3: Soil Structure Decline

Soil structure decline is assessed on soil characteristics, including surface soil texture, sodicity (laboratory tested) and degree of self-mulching (field tested). These parameters assess the soil structure, stability and resilience of the soil.

Hazard 4: Soil Acidification

The soil acidification hazard is assessed using three criteria, soil buffering capacity, pH and mean annual rainfall. In this assessment, soil buffering capacity was based on soil Great Soil Group; surface soil pH and a regional mean annual rainfall range of 700-900 mm.

Hazard 5: Salinity

The salinity hazard is determined through a range of data and criteria. The recharge potential for the site was determined based on an average annual rainfall of 655 mm, with annual evaporation of 1400-1600 mm (BOM, 2013). This would suggest a low recharge potential.

Based on the annual rainfall data (655 mm) and an average annual evapotranspiration of 800-900 mm, a moderate discharge potential for the site due to a likely balanced rate of water flow.

The Study Area according to the Salt Store Map of NSW, is located in area of low salt store. However, due the current available scale of this mapping, laboratory tested EC values were used to determine salt store.

Hazard 6: Water Logging

Water logging was determined by the soils drainage characteristics, specifically field sample evidence of mottling, soil texture attributes as well as slope and climate.

Hazard 7: Shallow Soils and Rockiness

The shallow soils and rockiness hazard is determined by an estimated exposure of rocky outcrops and average soil depth.

Hazard 8: Mass Movement

The mass movement hazard is assessed through a combination of three criteria; mean annual rainfall, presence of mass movement and slope class.

4.1.2 Land and Soil Capability Assessment

As listed in **Table 16**, the Study Area has been assessed and classified into the LSC Classes of 4 and 6. The limitations associated with each land Class are discussed below and shown in **Figure 5**.

Table 16 – Land and Soil Capability Assessment

Soil Types		Hazard Criteria								
		1	2	3	4	5	6	7	8	Overall
		Water erosion	Wind erosion	Struct -ure	Acidity	Salinity	Water-logging	Soil depth	Move -ment	Class
1	Brown Chromosol	3	1	3	3	1	2	1^	1	**3**
2	Yellowish-brown Chromosol / Sodosol	3	2	3	4	1	2	4	1	**4**
3	Reddish-brown Chromosol	3	1	3	4	1	2	3	1	**4**
4	Yellowish-brown Chromosol; shallow	4	1	3	4	3	2	4	1	**4**
5	Strong Brown Dermosol	3	1	3	3	1	2	4	1	**4**
6	Yellowish-red Chromosol	3	1	3	4	1	2	1^	1	**4**
7	Reddish-brown Dermosol; moderate	3	1	3	4	3	2	4	1	**4**
8	Reddish-brown Dermosol; deep	3	2	3	4	3	2	1	1	**4**
9	Rudosol; Leptic	4	2	3	*	*	2	6	1	**6**
10	Tenosol; Leptic	3	2	3	*	*	2	6	1	**6**

* *Insufficient information to assess.*

^ *Depth to bedrock not known assumed best case scenario*

Class 3 Land

This classification indicates that the land is highly capable of high-impact land uses, such as cultivation and grazing. Careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation. The primary constraints to this land class are slope and soil acidity.

Class 4 Land

This classification indicates that the land is moderately capable for a range of land uses, and specialised practices are necessary to overcome very severe limitations. The primary constraints to this land class are soil acidity and soil depth.

Class 6 Land

This classification indicates that the land has low capability for a most land uses, and is limited to grazing, forestry and nature conservation. The primary constraint to this land class is rock outcrop and soil depth.

4.2 Biophysical Strategic Agricultural Land

The NSW Government recently released the Strategic Regional Land Use Policy to assist the development of a long-term strategy for continued progress of the mining industry that also ensures local community sustainability and on-going viability of existing industries. Part of this policy is the development of Strategic Regional Land Use Plans, which includes the determination of Biophysical Strategic Agricultural Land (BSAL), defined as areas with unique natural resource characteristics.

As discussed earlier, the *Strategic Regional Land Use Plan (SRLUP) for the Upper Hunter* (DP&I, 2012) has mapped 252 ha within the Project Area as being "Biophysical Strategic Agricultural Land (BSAL)".

There are currently two documents pertaining to the assessment of BSAL, the Upper Hunter SRLUP (DP&I 2012) and the *Interim Protocol for Site verification and mapping of biophysical strategic agricultural land* (OEH, 2012b). Although there is significant overlap between the two documents, there is differing BSAL assessment criteria contained in both, therefore a BSAL assessment has been undertaken using both documents.

4.2.1 BSAL Assessment Using SRLUP for the Upper Hunter

The values and criteria that relate to BSAL are outlined in **Table 17**. This assessment used these criteria to assess BSAL in the Study Area according to the *SRLUP for the Upper Hunter* (DP&I, 2012).

Table 17 – BSAL Values and Criteria: SRLUP for Upper Hunter

	Criteria
•	Land that falls under soil fertility classes "high", "moderately high" under the Draft Inherent General Fertility of NSW (OEH, 2011a); and
•	Land capability classes I, II or III under the Land and Soil Capability Mapping of NSW (OEH); and
•	Reliable water of suitable quality, characterised by land having rainfall of greater than 350 mm per annum (9 out of 10 years) or land within 150 m of the following surface or groundwater resource: a regulated river; or unregulated rivers where there are flows for at least 95% of the time (i.e. the 95th percentile flow of each month of the year is greater than zero) or 5th order and higher rivers, or groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5 L/s and total dissolved solids of less than 1,500 mg/L.
	Or
•	Land that falls under soil fertility classes "moderate" under the Draft Inherent General Fertility of NSW (OEH, 2011a); and
•	Land capability classes I or II under the Land and Soil Capability Mapping of NSW (OEH); and
•	Reliable water of suitable quality, characterised by land having rainfall of greater than 350 mm per annum (9 out of 10 years) or land within 150 m of the following surface or groundwater resource: a regulated river; or unregulated rivers where there are flows for at least 95% of the time (i.e. the 95th percentile flow of each month of the year is greater than zero) or 5th order and higher rivers, or groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5 L/s and total dissolved solids of less than 1,500 mg/L.

Source: DP&I, 2012

BSAL Assessment Results

The minimum requirement for rainfall reliability for the region was met for the Study Area (refer **Section 2.1**); therefore, the LSC and fertility class were further assessed in this section. To do this, this assessment compares the LSC Classes against the soil units fertility attributes to determine if the BSAL criteria, as specified in **Table 17**, are met in the Study Area. The soil fertility and the outcomes of the BSAL assessment are shown below in **Table 18**.

Table 18 – Applied BSAL Criteria: SRLUP for the Upper Hunter

Soil Type		Great Soil Group	LSC	Fertility*	BSAL	BSAL Limitation
1	Brown Chromosol	Brown Podzolic	**3**	Moderate	No	Fertility
2	Yellowish-brown Chromosol / Sodosol	Yellow Soloth	**4**	Moderately low	No	LSC class & fertility
3	Reddish-brown Chromosol	Red Podzolic	**4**	Moderately low	No	LSC class & fertility
4	Yellowish-brown Chromosol; shallow	Yellow Podzolic	**4**	Moderately low	No	LSC class & fertility
5	Strong Brown Dermosol	Chocolate soils	**4**	Moderately High	No	LSC class
6	Yellowish-red Chromosol	Red Podzolic	**4**	Moderately low	No	LSC class & fertility
7	Reddish-brown Dermosol; moderate	Red Podzolic	**4**	Moderately low	No	LSC class & fertility
8	Reddish-brown Dermosol; deep	Red Podzolic	**4**	Moderately low	No	LSC class & fertility
9	Rudosol; Leptic	Lithosol	**6**	Low	No	LSC class & fertility
10	Tenosol; Leptic	Lithosol	**6**	Low	No	LSC class & fertility

** Correlated based on Great Soil Group*

Whilst the Study Area both meet the minimum rainfall, the fertility class and LSC classifications for each soil type indicate that the soil resources do not qualify as BSAL.

4.2.2 BSAL Assessment Using Interim Protocol for Site Verification

This methodology used the twelve step site verification criteria listed within the Interim Protocol for Site Verification, which are summarised in **Table 19**. If a criterion fails to meet any of the BSAL conditions, the site is rejected as BSAL and the remaining conditions are not assessed.

Table 19 – Twelve Step Site Verification Criteria According to Interim Protocol

Step Number	Criteria	BSAL Definition
1	Reliable Water Supply	Greater than 350 mm annual rainfall (9 out of 10 years), or underlain by ground water acquifer with yield greater than 5L/s and total dissolved solids less than 1,500 mg/L
2a	Slope	Slope of less than or equal to 12%
2b	Slope	Slope of less than 5% (if yes, go to 3a – if no, go to 3b)
3a	Rock Outcrop	Are there nil rock outcrops (if yes, go to 4a – if no, go to 3b)
3b	Rock Outcrop	Rock outcrop of less than 30% (if yes, go to 4b)
4a	Soil Type	Soil which has naturally moderate fertility (if yes, go to 5 – if no, go to 4b)
4b	Soil Type	Soil which has naturally high or moderately high fertility
5	Surface Rockiness	Less than 20% of the area has unattached rock fragments greater than 60 mm diameter
6	Gilgai	Less than 50% of the area has gilgai depression that are deeper than 500 mm
7	Soil Depth	Soil depth greater than 750 mm
8	Drainage	Soil must not be poorly or very poorly drained soils
9	pH	pH within range of 5.0 to 8.9 when measured in water or pH within range of 4.2 to 8.1 when measured in calcium chloride.
10	Soil Salinity	Electrical conductivity in a saturated extract (ECe) less than or equal to 4 dSm/m or if gypsum is present, chlorides less than 800 mg/kg
11	Soil Water Storage	Soil must be able to store more than or equal to 75 mm of water to effective soil depth of 1 metre or less
12	Minimum Area	Soil must have a contiguous area of greater or equal to 20 Ha

Source: OEH, 2012b

BSAL Assessment Results

All Soil Types were rejected as BSAL at various steps of the *Interim Protocol for Site verification and mapping of biophysical strategic agricultural land* (OEH, 2012b); the limiting step(s) for each Soil Type is shown in **Table 20**.

Table 20 – Applied BSAL Criteria: Interim Protocol for Site Verification

Soil Type		Limiting Site Verification Criteria		BSAL
		Step	Reason(s)	
1	Brown Chromosol	4b	Slope greater than 5% Soil fertility is less than moderately high	No
2	Yellowish-brown Chromosol / Sodosol	4b	Soil fertility is less than moderate	No
3	Reddish-brown Chromosol	4b	Slope greater than 5% Soil fertility is less than moderately high	No
4	Yellowish-brown Chromosol; shallow	2a	Slope greater than 12%	No
5	Strong Brown Dermosol	7	Slope greater than 5% Soil depth is less than 750 mm	No
6	Yellowish-red Chromosol	4b	Slope greater than 5% Soil fertility is less than moderately high	No
7	Reddish-brown Dermosol; moderate	4b	Slope greater than 5% Soil fertility is less than moderately high	No
8	Reddish-brown Dermosol; deep	4b	Slope greater than 5% Soil fertility is less than moderately high	No
9	Rudosol; Leptic	3b	Rock outcrop greater than 30%	No
10	Tenosol; Leptic	3b	Rock outcrop greater than 30%	No

4.2.3 Biophysical Strategic Agricultural Land Summary

As discussed two BSAL assessments have been completed due to differing BSAL assessment criteria contained in both the *Strategic Regional Land Use Plan for the Upper Hunter* (DP&I, 2012) and the *Interim Protocol for Site verification and mapping of biophysical strategic agricultural land* (OEH, 2012b). Both assessments determined that no BSAL is present within the Study Area.

Ref:

Figure 5

Title: Bulga Study Area - Land and Soil Capability

Project: Soils Classifications

Client: Bulga Underground Operations Pty Ltd

Legend:

- Extra Sampling Points
- Sampling Points
- Project Area
- Study Area

Land and Soil Capability

- Class 3
- Class 4
- Class 6

Source:
This map contains the Bing Maps aerial imagery web mapping service, which provides worldwide orthographic aerial and satellite imagery. Coverage varies by region.
(c) 2010 Microsoft Corporation and its data suppliers

Drawing No: 633.10067_Fg5_Land & Soil Capability_130220

Date: 20/02/2013	Drawing size: A4
Drawn by: NT/LH	Reviewed by: AC
Scale: 1:20,000	

0 165 330 660
Meters

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. GSSE does not warrant the accuracy of any such maps or figures.

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Path: V:\633.10067-Bulga UG AIS\Figures\GIS\ArcGIS\Map Documents\633.10067_Fg5_Land & Soil Capability_130220.mxd

5.0 SUMMARY

This Soil Survey and Land Capability Assessment has been prepared in accordance with the *Guidelines for Surveying Soil and Land Resources* (NCST, 2008). The key findings of this assessment are listed below.

- The Study Area is 252 ha of land within the Bulga Underground Operations Modification Project Area that has been mapped as Biophysical Strategic Agricultural Land according to the *Strategic Regional Land Use Plan for the Upper Hunter* (DPI, 2012).

- The Study Area is covered by 8 different soil types, with Chromosols (54.9%) and Dermosols (24.5%) the most dominant.

- The Land and Soil Capability Assessment determined that the majority of the Study Area is Class 4 (172 ha, 68.3%), which is moderately capable land which has high limitations for high-impact land use such as cropping or high intensity grazing. The remaining land is Class 3 (28 ha, 11.1%), which has high capability for managed cultivation and grazing, and Class 6 (52 ha, 20.7%), which has low capability and only suitable for low-impact grazing, forestry or nature conservation.

- Using both the *Strategic Regional Land Use Plan for the Upper Hunter* (DPI, 2012) and *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH, 2012b), the Study Area was determined not to be Biophysical Strategic Agricultural Land.

Yours Faithfully,
GSS ENVIRONMENTAL

Adele Calandra
Senior Environmental Scientist

6.0 REFERENCES

Bureau of Meteorology (BOM) (2013) Broke, BOM Station No. 06611.

Department of Planning and Infrastructure (DP&I) (2012) *Strategic Regional Land Use Plan for the Upper Hunter*.

Isbell R.F. (1996) *Australian Soil Classification* (CSIRO Publishing, Australia)

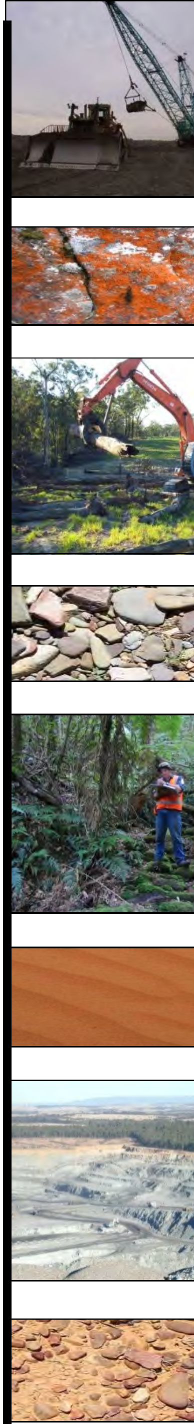
Kovac, M. and Lawrie, J.M. (1991). *Soil Landscapes of the Singleton 1:250 000 Sheet*. Soil Conservation Service of NSW, Sydney.

Office of Environment and Heritage (OEH) (2012a) *The Land and Soil Capability Assessment Scheme; Second Approximation.*

Office of Environment and Heritage (OEH) (2012b) *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land.*

The National Committee on Soil and Terrain (NCST) (2008) *Guidelines for Surveying Soil and Land Resources* (CSIRO, Australia)

The National Committee on Soil and Terrain (NCST) (2009) *Australian Soil and Land Survey Field Handbook*, 3rd edition (CSIRO, Australia).



Certificate of Analysis: Soil Laboratory Assessment

ATTACHMENT A

ALS Group

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1216794**	Page	: 1 of 6
Client	: **GSS ENVIRONMENTAL**	Laboratory	: Environmental Division Brisbane
Contact	: MS ADELE CALANDRA	Contact	: Customer Services
Address	: LEVEL 1, 241 DENISON ST BROADMEADOW NSW, AUSTRALIA 2292	Address	: 32 Shand Street Stafford QLD Australia 4053
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Telephone	: +61 02 4920 3062	Telephone	: +61 7 3243 7222
Facsimile	: +61 02 4961 3360	Facsimile	: +61 7 3243 7218
Project	: XCN06-043	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 26-JUN-2012
Sampler	: AC & MH	Issue Date	: 11-JUL-2012
Site	: ----		
		No. of samples received	: 19
Quote number	: BN/039/12 V2	No. of samples analysed	: 19

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Metals Production Chemist	Brisbane Inorganics
Andrew Epps	Metals Production Chemist	Stafford Minerals - AY
Jonathon Angell	Inorganic Coordinator	Brisbane Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			Client sample ID	Obs -25 0-10cm	C-02 0-10cm	C-03 0-10cm	C-04 0-10cm	C-05 0-10cm
			Client sampling date / time	14-JUN-2012 15:00	14-JUN-2012 15:00	14-JUN-2012 15:00	14-JUN-2012 15:00	14-JUN-2012 15:00
Compound	*CAS Number*	*LOR*	*Unit*	EB1216794-001	EB1216794-002	EB1216794-003	EB1216794-004	EB1216794-005
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.6	6.5	5.9	6.0	6.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	49	15	38	28	19
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	20.3	16.4	24.8	19.1	19.8
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	12.5	3.7	5.7	10.5	7.7
Exchangeable Magnesium	----	0.1	meq/100g	8.8	2.2	3.6	3.2	5.3
Exchangeable Potassium	----	0.1	meq/100g	1.4	0.9	1.0	0.8	1.1
Exchangeable Sodium	----	0.1	meq/100g	0.1	<0.1	<0.1	<0.1	0.1
Cation Exchange Capacity	----	0.1	meq/100g	22.8	6.9	10.5	14.6	14.2
Exchangeable Sodium Percent	----	0.1	%	0.6	0.7	0.6	0.3	0.9
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.01	0.01	0.03	0.02	0.02
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.4	0.5	7.4	7.1	0.5
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1290	1820	3170	4340	1910
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	1290	1820	3180	4350	1910
EK074: Fluoride Extractable Phosphorus (Bray)								
Fluoride Extractable P (Bray)	----	1.0	mg/kg	<1.0	2.6	4.8	6.7	1.0
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	1.46	2.31	2.75	2.37	2.63

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)

			Client sample ID	C-06 0-10cm	C-08 0-10cm	C-09 0-10cm	C-10a 0-10cm	C-10b 0-10cm
			Client sampling date / time	14-JUN-2012 15:00	14-JUN-2012 15:00	14-JUN-2012 15:00	21-JUN-2012 15:00	21-JUN-2012 15:00
Compound	*CAS Number*	*LOR*	*Unit*	**EB1216794-006**	**EB1216794-007**	**EB1216794-008**	**EB1216794-009**	**EB1216794-010**
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**6.5**	**6.1**	**6.4**	**6.1**	**6.1**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**19**	**48**	**22**	**27**	**23**
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	**16.4**	**17.9**	**17.2**	**16.7**	**11.8**
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**5.3**	**7.0**	**3.2**	**3.2**	**4.6**
Exchangeable Magnesium	----	0.1	meq/100g	**4.2**	**3.0**	**3.2**	**2.3**	**2.9**
Exchangeable Potassium	----	0.1	meq/100g	**0.8**	**1.3**	**0.6**	**0.7**	**0.7**
Exchangeable Sodium	----	0.1	meq/100g	<0.1	**0.1**	<0.1	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	**10.3**	**11.4**	**7.1**	**6.3**	**8.2**
Exchangeable Sodium Percent	----	0.1	%	**0.7**	**1.0**	**1.1**	**0.9**	**0.9**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	**0.3**	**15.8**	**0.6**	**1.8**	**3.5**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	**1340**	**3980**	**1840**	**1750**	**2450**
EK062: Total Nitrogen as N (TKN + NOx)								
^ **Total Nitrogen as N**	----	20	mg/kg	**1340**	**4000**	**1840**	**1750**	**2450**
EK074: Fluoride Extractable Phosphorus (Bray)								
Fluoride Extractable P (Bray)	----	1.0	mg/kg	**1.1**	**6.4**	**1.6**	**1.4**	**3.8**
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**1.82**	**2.23**	**2.80**	**2.38**	**2.68**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			Client sample ID	C-11 0-10cm	C-12 0-10cm	C-13 0-10cm	C-14 0-10cm	C-15 0-10cm
			Client sampling date / time	21-JUN-2012 15:00	21-JUN-2012 15:00	21-JUN-2012 15:00	21-JUN-2012 15:00	21-JUN-2012 15:00
Compound	*CAS Number*	*LOR*	*Unit*	EB1216794-011	EB1216794-012	EB1216794-013	EB1216794-014	EB1216794-015
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.4	5.6	6.6	7.9	6.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	35	19	17	79	31
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	12.1	16.8	18.9	17.5	12.4
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	5.9	12.1	7.6	31.3	5.5
Exchangeable Magnesium	----	0.1	meq/100g	5.3	2.4	7.2	4.7	5.6
Exchangeable Potassium	----	0.1	meq/100g	0.8	0.6	1.0	0.9	0.6
Exchangeable Sodium	----	0.1	meq/100g	0.1	<0.1	0.4	<0.1	0.4
Cation Exchange Capacity	----	0.1	meq/100g	12.1	15.2	16.2	37.0	12.0
Exchangeable Sodium Percent	----	0.1	%	0.9	0.4	2.2	0.2	3.0
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	<0.01	0.01	0.01	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.5	1.1	1.3	2.7	<0.1
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1820	1320	1920	2300	1400
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	1820	1320	1920	2300	1400
EK074: Fluoride Extractable Phosphorus (Bray)								
Fluoride Extractable P (Bray)	----	1.0	mg/kg	<1.0	3.5	<1.0	<1.0	1.1
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	2.14	1.60	2.33	1.67	1.72

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL)**

			Client sample ID	C-17 0-10cm	C-18 0-10cm	C-19 0-10cm	C-20 0-10cm	----
			Client sampling date / time	21-JUN-2012 15:00	21-JUN-2012 15:00	21-JUN-2012 15:00	21-JUN-2012 15:00	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1216794-016**	**EB1216794-017**	**EB1216794-018**	**EB1216794-019**	**----**
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**6.9**	**6.6**	**6.7**	**7.1**	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**39**	**23**	**41**	**80**	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	**17.4**	**17.6**	**14.0**	**6.6**	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**14.9**	**9.2**	**11.4**	**10.1**	----
Exchangeable Magnesium	----	0.1	meq/100g	**5.9**	**3.3**	**1.9**	**2.5**	----
Exchangeable Potassium	----	0.1	meq/100g	**1.1**	**0.9**	**1.5**	**1.4**	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	----
Cation Exchange Capacity	----	0.1	meq/100g	**22.0**	**13.4**	**14.9**	**14.0**	----
Exchangeable Sodium Percent	----	0.1	%	**0.3**	**0.4**	**0.3**	**0.5**	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	**0.01**	**0.01**	**0.01**	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	**0.2**	**1.0**	**9.0**	**11.4**	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	**1590**	**1960**	**3880**	**1510**	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ **Total Nitrogen as N**	----	20	mg/kg	**1590**	**1960**	**3890**	**1520**	----
EK074: Fluoride Extractable Phosphorus (Bray)								
Fluoride Extractable P (Bray)	----	1.0	mg/kg	<1.0	**1.5**	**153**	**40.4**	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**1.56**	**2.03**	**1.85**	**1.68**	----

APPENDIX B

Soil Test Results

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO12/020R1
Client Reference: R Rummery
Umwelt Australia
PO Box 768
Bendemeer NSW 2355

SITE No.	Lab No	Method	C1A/4	C2A/3	C2B/3	C5A/3 CEC & exchangeable cations (me/100g)						C8A/2	P9B/2	
		Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	EAT	Texture
5	1	Mushroom Site 1 10cm	0.02	5.9	4.9	12.5	0.4	0.5	6.2	1.9	<0.1	1	8	silty clay loam
6	2	Mushroom Site 2 10cm	0.08	5.8	4.8	11.1	0.7	0.3	3.8	2.0	0.1	1	8	silty loam
7	3	Mushroom Site 3 10cm	0.03	5.6	4.8	8.4	0.4	0.3	3.7	0.2	0.1	3	8	loamy sand
8	4	Mushroom Site 4 10cm	0.02	5.2	4.3	6.6	0.4	0.1	1.8	0.5	0.2	2	3(1)	loamy sand
9	5	Mushroom Site 5 10cm	0.03	6.0	4.9	11.7	0.4	0.5	5.7	1.2	0.3	1	8	silty loam
1	6	Noise Bund Site 1 10cm	0.09	5.7	4.7	14.2	1.2	0.7	2.7	6.0	0.4	2	2(1)	sandy clay
2	7	Noise Bund Site 2 10cm	0.03	6.2	4.8	9.8	0.6	0.5	3.8	2.0	0.4	2	3(1)	fine sandy clay loam
3	8	Noise Bund Site 3 10cm	0.03	5.9	4.6	8.0	0.6	0.4	1.7	2.9	0.4	2	2(1)	fine sandy clay loam
4	9	Noise Bund Site 4 10cm	0.19	6.6	5.4	27.3	2.6	1.0	8.2	11.4	0.3	1	3(3)	medium clay

END OF TEST REPORT

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO12/019R1
Client Reference: R Rummery
Umwelt Australia
PO Box 768
Bendemeer NSW 2355

SITE No.	Lab No	Method	C1A/4	C2A/3	C2B/3	P9B/2	
		Sample Id + Depth	EC (dS/m)	pH	pH ($CaCl_2$)	EAT	Texture
5	1	Mushroom Site 1 subsoil 15cm	0.03	5.8	4.7	3(4)	medium clay
6	2	Mushroom Site 2 subsoil 25cm	1.16	7.8	6.4	2(1)	medium clay
7	3	Mushroom Site 3 subsoil 25cm	0.05	6.6	5.7	2(1)	medium clay
8	4	Mushroom Site 4 subsoil 25cm	0.01	6.4	5.5	3(1)	loamy sand
9	5	Mushroom Site 5 subsoil 30cm	0.18	5.4	4.8	3(3)	medium clay
1	6	Noise Bund Site 1 subsoil 15cm	0.08	5.7	4.6	2(1)	medium clay
2	7	Noise Bund Site 2 subsoil 20cm	0.02	6.2	5.1	3(2)	heavy clay
3	8	Noise Bund Site 3 subsoil 15cm	0.04	8.5	7.2	3(1)	fine sandy loam
4	9	Noise Bund Site 4 30cm	0.12	8.1	6.6	2(1)	heavy clay

S R Young

END OF TEST REPORT

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO12/046R1
Client Reference: Rachel Rummery
Umwelt Australia
PO Box 768
Bendemeer NSW 2355

SITE No.	Lab No	Method	C1A/4	C2A/3	C2B/3	C5A/3 CEC & exchangeable cations (me/100g)						C8A/2	P9B/2	
		Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	EAT	Texture
10	1	Dam Site 1 10cm	0.01	5.8	4.8	7.6	0.4	0.2	3.9	0.9	<0.1	3	3(1)	fine sandy loam
11	2	Dam Site 2 10cm	<0.01	5.9	4.6	5.7	0.3	0.3	2.6	0.8	<0.1	1	3(1)	loamy sand
12	3	Dam Site 3 10cm	0.01	5.7	4.4	7.2	0.4	0.3	3.9	1.0	<0.1	1	3(1)	fine sandy loam
13	4	Dam Site 4 10cm	<0.01	5.6	4.4	7.6	0.4	0.4	3.5	0.9	<0.1	1	3(1)	fine sandy loam

SITE No.	Lab No	Method	C1A/4	C2A/3	C2B/3	P9B/2	
		Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	EAT	Texture
10	5	Dam Site 1 >15cm	<0.01	6.4	5.0	3(1)	loamy sand
11	6	Dam Site 2 >10cm	<0.01	6.2	4.8	3(1)	loamy sand
12	7	Dam Site 3 >10cm	<0.01	6.0	4.6	3(1)	loamy sand
13	8	Dam Site 4 >10cm	<0.01	5.8	4.6	7	loamy sand

S R Young

END OF TEST REPORT

Umwelt (Australia) Pty Limited
75 York Street
Teralba NSW 2284

ph. 02 4950 5322

www.umwelt.com.au