Centennial Coal

FINAL

Angus Place Mine Extension Project

Soil and Land Capability Assessment

January 2014

CCC07-010

SLR

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

SLR Consulting Australia
10 Kings Road
New Lambton NSW 2305

Project Manager: **Clayton Richards**
B. Nat Res, Dip Ed, CPSS 2
Associate

Project Officer: **Rhys Worrall**
BSc (Hons)
Senior Environmental Scientist

Project Officer: **Matt Hemingway**
B Env Mgmt, CPSS 1
Environmental Scientist

Project Officer: **Adam Koppers**
BSc (Hons), PhD
Environmental Scientist

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4	24th January 2014	Soil and Land Capability Assessment_Final v2	AK	AC

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ABBREVIATIONS

Angus Place	Angus Place Colliery
ASC	Australian Soil Classification
AHD	Australian Height Datum
BoM	Bureau of Meteorology
BSAL	Biophysical Strategic Agricultural Land
Ca	calcium
CEC	cation exchange capacity
Cl	clay
Cs	course sand
DGR	Director General's Requirements
DP&I	Department of Planning and Infrastructure
DPI	Department of Primary Industries
EIS	environmental impact statement
dS/m	deci-Siemen per metre
EAT	Emerson aggregate test
EC	electrical conductivity
ECe	saturated electrical conductivity
EIS	environmental impact statement
ESA	environmental study area
ESP	exchange sodium percentage
Fs	fine sand
Interim Protocol for BSAL Verification	*Interim Protocol for Site verification and mapping of biophysical strategic agricultural*
ha	hectare
kg	kilogram
km	kilometre
LSC	Land and Soil Capability
LSC Guideline	*The Land and Soil Capability Assessment Scheme; second approximation*
m	metre
Mg	magnesium
mm	millimetre
MSEC	Mine Subsidence Engineering Consultants

n.a.	not applicable
Na	sodium
NSW	New South Wales
OAS&FS	Office of Agricultural Sustainability and Food Security
OC	Organic Carbon
OEH	Office of Environment and Heritage
%	per cent
pH	measure how acidic or basic a substance is.
PAA	project application area
Policy, the	Strategic Regional Land Use Policy
Project, the	Angus Place Mine Extension Project
PSA	particle size analysis
Si	silt
SDWTS	Springvale Delta Water Transfer Scheme comprising
Springvale Coal	Springvale Coal Pty Ltd
Springvale	Springvale Mine
SRLUP	Strategic Regional Land Use Plan

Executive Summary

SLR (formerly GSS Environmental) was engaged by Centennial Angus Place Pty Limited to undertake a Soil and Land Capability Assessment for the proposed Angus Place Mine Extension Project. It has been prepared as part of the Environmental Impact Statement required to accompany the application to the NSW Department of Planning and Infrastructure for development consent under Part 4 Division 4.1 of the *Environmental Planning and Assessment Act 1979.* This report provides:

- Description of the soil classifications across the Project Application Area in accordance with the Australian Soil Classification System.
- Description of the pre and post disturbance Land and Soil Capability classes across the Project Application Area in accordance with the appropriate NSW technical guidelines, including an assessment of the presence of potential biophysical strategic agricultural land.
- Recommendations on soil stripping depths for soil resources in the Project Application Area, including recommendations for topsoil handling, stockpiling and amelioration for re-use in rehabilitation.

The area subject to the Soil and Land Capability Assessment is the Project Application Area comprising an area of approximately 10,468 hectares. A 1:100,000 mapping scale field survey was undertaken by SLR field staff, and soil samples were analysed for various physical and chemical soil attributes by a NATA accredited laboratory.

The soil classification included a desktop literature review (specifically *The Soil Landscapes of the Wallerawang 1:100,000 Sheet* (King, 1993)), field investigations and laboratory soil testing, and identified 12 soil landscapes and four Australian Soil Classification soil orders. The dominant soil order in the Project Application Area is a Tenosol covering 9,060 hectares (86.6 per cent) and representing the Hassans Walls, Warragambe, Wollangambe, Medlow Bath, Newnes Plateau and Long Swamp Soil Landscape Units. The other minor soil orders are Kandosols, Kurosols and Rudosols.

The land capability assessment applied the eight-class *Land and Soil Capability Assessment Scheme* developed by the NSW Office of Environment and Heritage (2012). The aim of the scheme is to delineate the various classes of rural lands on the basis of their capability to remain stable under particular land uses.

The dominant Land and Soil Capability class across the Project Application Area is Class 6 (37.2 per cent), which is land suitable for limited set of land uses, such as grazing and forestry. The second dominant Land and Soil Capability class in the Project Application Area is Class 8 (29.0 per cent), which is land not capable of sustaining any land use except nature conservation. The most agricultural productive Land and Soil Capability class in the Project Application Area is Class 4 (4.1 per cent), which is land capable of a variety of land uses and is suited to grazing with restricted cultivation. The dominant Land and Soil Capability class in the Proposed Surface Infrastructure assessment area is Class 6 (61.7 per cent).

Potential biophysical strategic agricultural land was also assessed to determine if sensitive land resources were present within the Project Application Area in light of the NSW Government's Strategic Regional Land Use Policy. The strategic regional land use plan for the Project Application Area has not been released at the time of this assessment; therefore, no biophysical strategic agricultural land reference mapping is available and there is no requirement for a verification assessment. Notwithstanding, and adopting a precautionary approach, an assessment of the Project Application Area against the biophysical strategic agricultural land verification criteria has been undertaken. The assessment found that there is no potential biophysical strategic agricultural land in the Project Application Area.

The post-disturbance impact assessment determined that the Project may cause some minor ponding in drainage lines where natural gradients are naturally low upstream of longwall chain pillars, as well as tension cracks at the top and side of steep slopes. These impacts are not anticipated to have any effect on post-disturbance Land and Soil Capability classes across the Project Application Area. Some impact on cliffs and pagodas directly above the proposed longwalls is predicted, but would represent a very minor proportion of the exposed rockface in the area. The only likely impact is associated with surface disturbance; however, as the proposed area to be disturbed is small (23.25 hectares), there will be negligible impact on Land and Soil Capability classes.

Determination of suitable soil to conserve for later use in mine rehabilitation has been conducted in accordance with Elliott and Reynolds (2007). Limitations identified are sodic subsoils, erosion hazard and acidity; however these characteristics can be ameliorated (e.g. with organic matter, gypsum, lime) to overcome these limitations. Soil resources will require standard erosion and sediment controls for any proposed disturbance areas associated with surface infrastructure or surface cracking as a result of subsidence.

1.0 INTRODUCTION

SLR (formerly GSS Environmental) was engaged by the proponent Angus Place Pty Ltd (Angus Place Coal), operator of Angus Place Colliery (Angus Place), to undertake a Soil and Land Capability Assessment for the proposed Angus Place Mine Extension Project (the Project). The assessment report has been prepared as part of the Environmental Impact Statement (EIS) that is required to accompany the project application to the NSW Department of Planning and Infrastructure (DP&I) for development consent under Part 4 of the *Environmental Planning and Assessment Act 1979*.

1.1 Background

Angus Place is managed by Centennial Angus Place under a joint venture arrangement between Centennial Springvale Pty Ltd and Springvale SK Kores Pty Ltd. Centennial Angus Place is 100 per cent owned by Centennial Coal Company Ltd. Centennial Coal Company Ltd is a wholly owned subsidiary of Banpu Public Company Ltd.

Angus Place is an underground coal mine producing thermal coal which is supplied to Wallerawang and Mount Piper power stations for domestic power generation. The Angus Place pit top is located approximately five kilometres north of the village of Lidsdale, eight kilometres northeast of the township of Wallerawang and 15 kilometres northwest of the city of Lithgow (**Figure 1.1**). Angus Place is located within the Lithgow Local Government Area.

1.2 Project Description

The Project is seeking approval for the continuation of mining at Angus Place within its mining ML 1424 lease boundary beyond March 2016, when the current operation is planned to cease. Longwall mining is proposed to extend towards the east of the existing workings (Longwalls 1001 to1019), using current mining methods, as shown in **Figure 1.2**.

Specific objectives of the Project are as follows:

- Continue to extract up to 4 million tonnes per annum of run of mine coal from the Lithgow Seam underlying the Project Application Area.
- Develop underground access headings and roadways from the current mining area to the east to allow access to the proposed mining area.
- Undertake secondary extraction by retreat longwall mining for the proposed longwall panels LW1001 to LW1019.
- Continue to use the existing ancillary surface facilities at the Angus Place pit top.
- Continue to manage the handling of run of mine coal through a crusher and screening plant at the Angus Place pit top, and the subsequent loading of the coal onto the existing road haulage trucks for despatch to offsite locations.
- Continue to operate and maintain the existing ancillary surface infrastructure for ventilation, electricity, water, materials supply, and communications at the Angus Place pit top and on Newnes Plateau.
- Install and operate seven additional dewatering borehole facilities on Newnes Plateau and the associated power and pipeline infrastructure.
- Upgrade and extend the existing access tracks from Sunnyside Ridge Road to the dewatering borehole facilities.

- Install and operate water transfer boreholes and pipeline infrastructure at the existing Ventilation Facility site (APC-VS2).

- Construct and operate a downcast ventilation shaft (APC-VS3) and upgrade the existing access track to the proposed facility from Sunnyside Ridge Road.

- Manage mine inflows using a combination of direct water transfer to the Wallerawang Power Station, via the SDWTS, and discharge through Angus Place Colliery's licensed discharge point LDP001 and Springvale Colliery's LDP009.

- Continue to undertake existing and initiate new environmental monitoring programs.

- Continue to operate 24 hours per day seven days per week.

- Continue to provide employment to a full time workforce of up to 225 persons and 75 contractors.

- Progressively rehabilitate disturbed areas at infrastructure sites no longer required for mining operations.

- Undertake life-of-mine rehabilitation at the Angus Place pit top and the Newnes Plateau infrastructure disturbance areas to create final landforms commensurate with the surrounding areas and the relevant zonings of the respective areas.

- Transfer the operational management of coal processing and distribution infrastructure to the proposed Centennial Western Coal Services Project.

1.3 Project Application Area

The area subject to this Soil and Land Capability Assessment is the entire Project Application Area (PAA) totaling an area of approximately 10,468 hectares (**Figure 1.2**). Of relevance to this assessment are the following major proposed project components:

- Proposed Workings: includes land proposed to be subject to underground mining activities covering an area of 2,275 hectares (**Table 1.1**).

- Proposed Surface Infrastructure: includes multiple infrastructure components including the proposed ventilation site, dewatering facility sites and the proposed infrastructure corridor to link the multiple infrastructure components. The Proposed Surface Infrastructure area covers a total area of 23.25 hectares (RPS, 2013a; Golder, 2013).

1.4 Purpose of the Report

1.4.1 Director-General's Requirements for Environmental Assessment

This Soil and Land Capability Assessment has been prepared in accordance with the Director General Requirements (DGRs) issued for the Project in November 2012. **Table 1.1** provides the relevant DGR's and indicates where specific issues have been addressed in this document.

Table 1.1 – Director-General Requirements

Specific issues	Where addressed in this document
Land Resources – including a detailed assessment of impacts to:	
• soils and land capability	**Section 3** (Soils) **Section 4** (Land Capability)
• landforms and topography, including cliffs, rock formations, steep slopes, etc.; and	**Section 2** (Existing Biophysical Environment)
• land use, including agricultural, forestry, conservation and recreational use.	**Section 2** (Existing Biophysical Environment)

1.4.2 Strategic Regional Land Use Policy

This report has been prepared to address the NSW Strategic Regional Land Use Policy (the Policy) (DP&I, 2012a). The Policy aims 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 agricultural industries. The Policy applies to areas within NSW where there is high value agricultural land and increasing activity in the coal and coal seam gas industries. Seven regions within NSW have been identified as applying under this Policy and each of these regions will progressively have a Strategic Regional Land Use Plan (SRLUP) developed or alternatively a similar plan incorporated into the relevant proposed Regional Growth Plans. The SRLUP and/or Regional Growth Plan covering the PAA has not released at the time of this assessment.

Part of this policy addresses the determination of Biophysical Strategic Agricultural Land (BSAL), which is defined by the Policy as “areas with unique natural resource characteristics highly suited for agriculture”. The SRLUPs provide regional scale BSAL base maps with requirements for project specific BSAL verification to be undertaken by proponents of State Significant Development mining and coal seams gas proposals situated in a SRLUP region.

The SRLUP for the PAA has not been released at the time of this assessment; therefore, no BSAL reference mapping is available. Notwithstanding, and adopting a precautionary approach, an assessment of the PAA for BSAL has been undertaken.

There are currently two documents pertaining to the assessment of BSAL, the *Upper Hunter Strategic Regional Land Use Policy* (DP&I, 2012b; hereafter referred to as the Upper Hunter SRLUP) and the *Interim Protocol for Site verification and mapping of biophysical strategic agricultural* ((NSW Office of Environment & Heritage (OEH) and Department of Primary Industries - Office of Agricultural Sustainability and Food Security (DPI-OASFS), 2013); hereafter referred to as the Interim Protocol for BSAL Verification). Although there is significant overlap between the two documents, there are differing BSAL assessment criteria contained in both and therefore a potential BSAL assessment has been undertaken using both documents.

1.5 Assessment Objectives and Standards

The key objectives of the Soil and Land Capability Assessment and relevant standards/guidelines utilised are listed below.

Objective 1 *Classify and determine the soil profile types within the PAA*

To satisfy Objective 1 the soil taxonomic classification system used was the *Australian Soil Classification* (ASC) system (Isbell, 1996).

Objective 2 *Provide a description of, and figures showing, the land capability within the PAA*

To satisfy Objective 2 the relevant guideline applied was *The Land and Soil Capability Assessment Scheme: Second approximation*. This is the guideline recommended by the OEH and supersedes the

former NSW *Rural Land Capability Classification* (Emery, 1986).

Objective 3 *Provide a description of, and figures showing, the agricultural land suitability within the PAA*

To satisfy Objective 3 the relevant guideline applied was the *Agricultural Suitability Maps – Uses and Limitations* (NSW Agriculture & Fisheries, 1990). This is the guideline approved by the Department of Primary Industries (DPI).

Objective 4 *Provide an assessment of Biophysical Strategic Agricultural Land within the PAA*

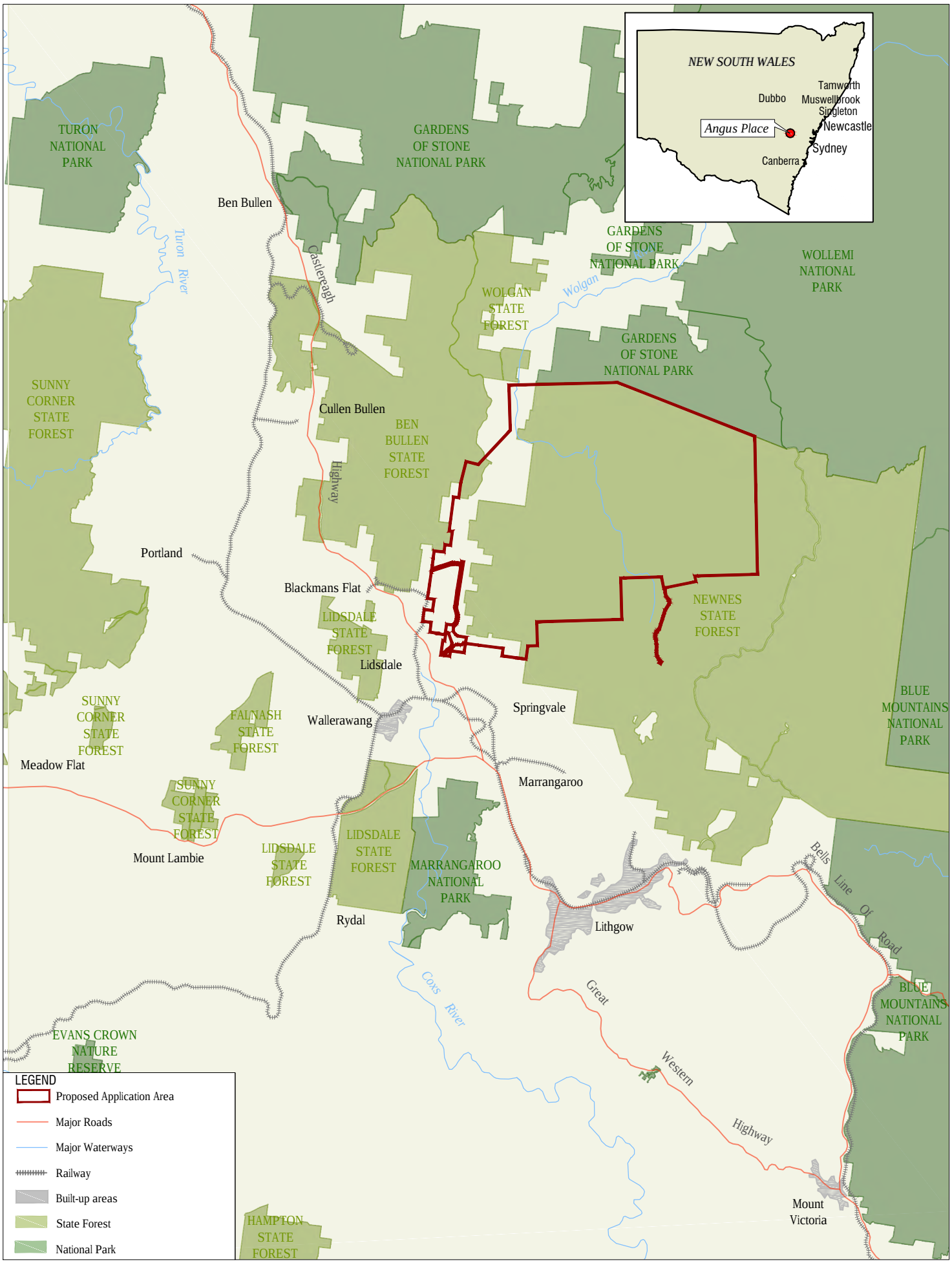
To satisfy Objective 4 the relevant guidelines applied were the Upper Hunter SRLUP and the Interim Protocol for BSAL Verification.

Objective 5 *Provide selective topsoil and subsoil management recommendations*

To satisfy Objective 5 the *Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas* (Elliot and Reynolds, 2007 derived from Elliot and Veness 1981) was utilised to determine which soil types in the PAA are suitable for conserving and reuse in the site rehabilitation program. The approach described in this guideline remains the benchmark for land resource assessment in the Australian mining industry.

Objective 6 *Provide recommendations to mitigate soil erosion and sedimentation associated with the works or soil stockpiles*

To satisfy Objective 6 the guidelines *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Volume 2E Mines and Quarries* (DECC, 2008) were used as a basis for recommendations of soil erosion and sedimentation mitigation associated with the proposed works.



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SLR
LEVEL 1, 14 WATT ST
NEWCASTLE
NEW SOUTH WALES 2300
AUSTRALIA
T: 61 2 4908 4500
F: 61 2 4908 4501
www.slrconsulting.com

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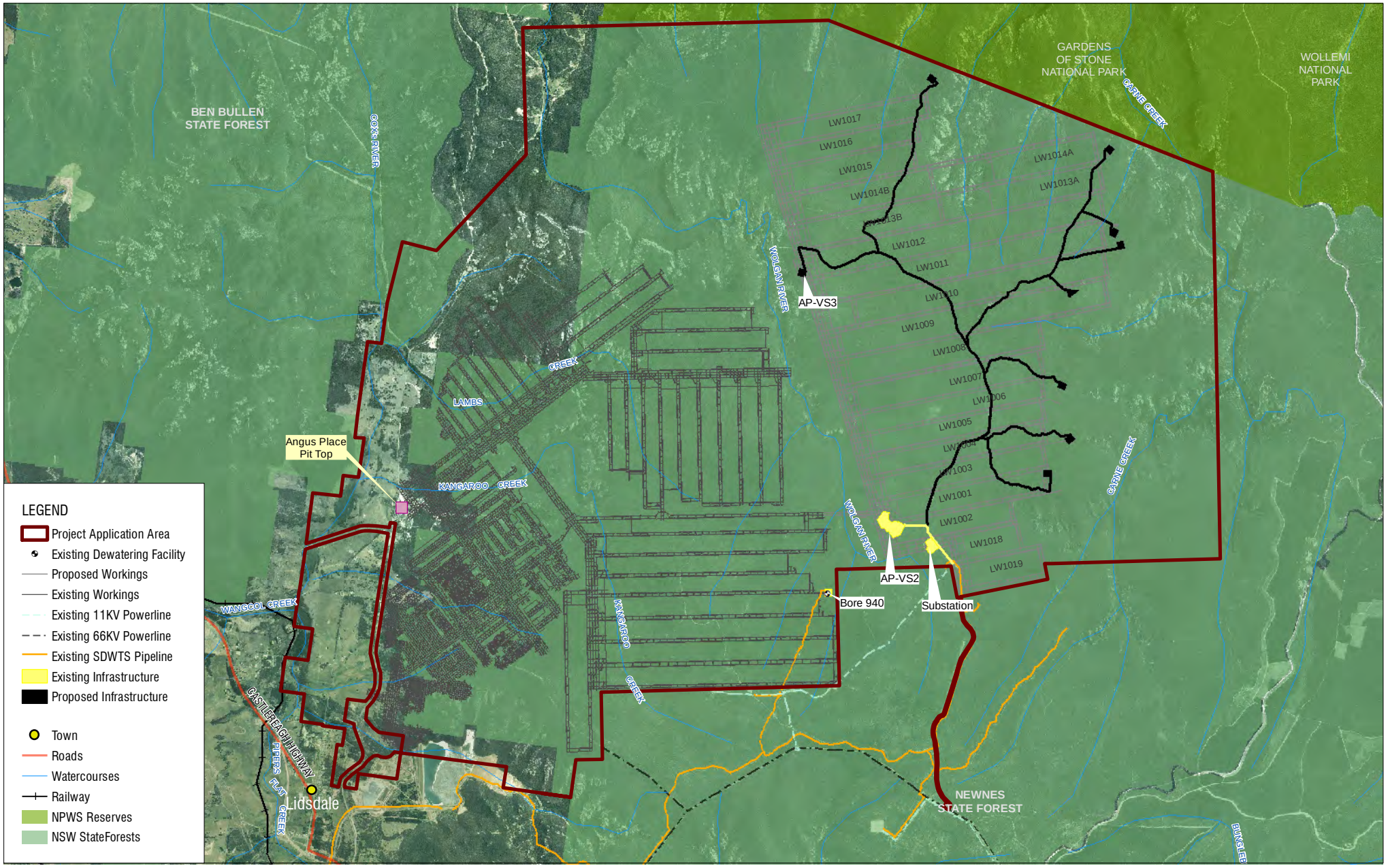
Regional Location

FIGURE 1.1



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F: 61 2 4037 3201
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SITE LAYOUT

FIGURE 1.2

2.0 EXISTING BIOPHYSICAL ENVIRONMENT

2.1 Climate

Representative climate data for the area has been obtained from the nearest Bureau of Meteorology (BoM) weather station located at the Lithgow Newnes Forest Centre, (Station 063062; BoM, 2012). The Newnes Forest Centre ceased operation in 1999; however, it is considered to be a reliable; and representative dataset for the PAA.

Data from the Newnes Forest Centre shows that the PAA experiences a summer dominant rainfall and temperature pattern with an average rainfall of 1,073 millimetres per year and an average maximum temperatures range of 9.4 degrees Celsius in July to 23.5 degrees Celsius in February. The BoM classifies the Lithgow area as having an oceanic climate with warm summers, cool to cold winters and generally steady precipitation year-round.

2.2 Geology

The Project is located in the south of the Western Coalfields. The underlying strata comprise mostly sandstones of the Triassic Narrabeen Group, which are inter-bedded with shale and siltstone bands. The Narrabeen Group rocks are underlain by the Illawarra Coal Measures, which comprise inter-bedded sandstone, siltstone, shale and coal. The general dip of the bedding is to the northeast at about two degrees. Within the PAA, the Narrabeen Group rocks near the surface belong to the Grose Sub-group, and include the Banks Wall Sandstone, the uppermost part of which is deeply weathered and generally very friable. The sandstone, which is up to 200 metres thick in this region, is underlain by the Mt York Claystone, a fine grained stratum, with a thickness in this area ranging from four to 11 metres, that limits vertical infiltration of groundwater from the overlying strata.

The Illawarra Coal measures comprise claystone, siltstone, sandstone and coal seams with a total thickness of about 120 metres in this PAA. The Lithgow Seam is the lowermost seam in the coal measures and is located about 25 metres above the base of the coal measures (Aurecon, 2010).

2.3 Soil Landscape Units

Soil Landscape Units are areas of land that have recognisable and specific topographies and soils that can be presented on maps and described by concise statements. The Soil Landscape Units within the PAA have been mapped by the former NSW Department of Land and Water Conservation, incorporating the NSW Soil Conservation Service (now part of the DPI), at the scale of 1:100,000 (King, 1993).

The PAA contains 12 soil landscape units (**Table 2.1**; **Figure 2.1**). The dominant soil landscape unit is Wollangambe, which is an erosional landscape comprised of rounded convex crests and moderately to steeply inclined sideslopes on sandstone. The second dominant soil landscape unit is Newnes Plateau, which is a residual landscape comprised of level to gently undulating wide crests and ridges on plateau surfaces of sandstone.

Table 2.1 – Soil Landscape Units

Soil Landscape Unit		PAA	
		ha	%
1	Hassans Walls	1,418	13.6
2	Warragamba	1,609	15.4
3	Cullen Bullen	305	2.9
4	Glen Alice	122	1.2
5	Wollangambe	2,672	25.5
6	Lithgow	335	3.2
7	Medlow Bath	1,097	10.5
8	Newnes Plateau	2,036	19.4
9	Deanes Creek (including variant)	131	1.2
10	Long Swamp	236	2.3
11	Mount Sinai	397	3.8
12	Coco	15	0.1
N/A	Disturbed terrain	95	0.9
	Total	**10,468**	**100.0**

These soil landscape units are detailed in the **Section 3.2** where full representative soil type descriptions are presented.

2.4 Topography and Hydrology

The topography of the region consists of rugged mountain ranges and plateaus characterised by sheer and benched cliffs, and steep sided gorges. The rugged topography is dissected by numerous streams and gullies often bordered by discontinuous belts of flat undulating land. The Wolgan, Capertee, Coxs and Macquarie Rivers represent the major permanent water courses in the region; with most other watercourses intermittent. The rivers and streams within the region belong to three major drainage basins: the Capertee River catchment; the Coxs River catchment; and the Turon-Macquarie River catchment.

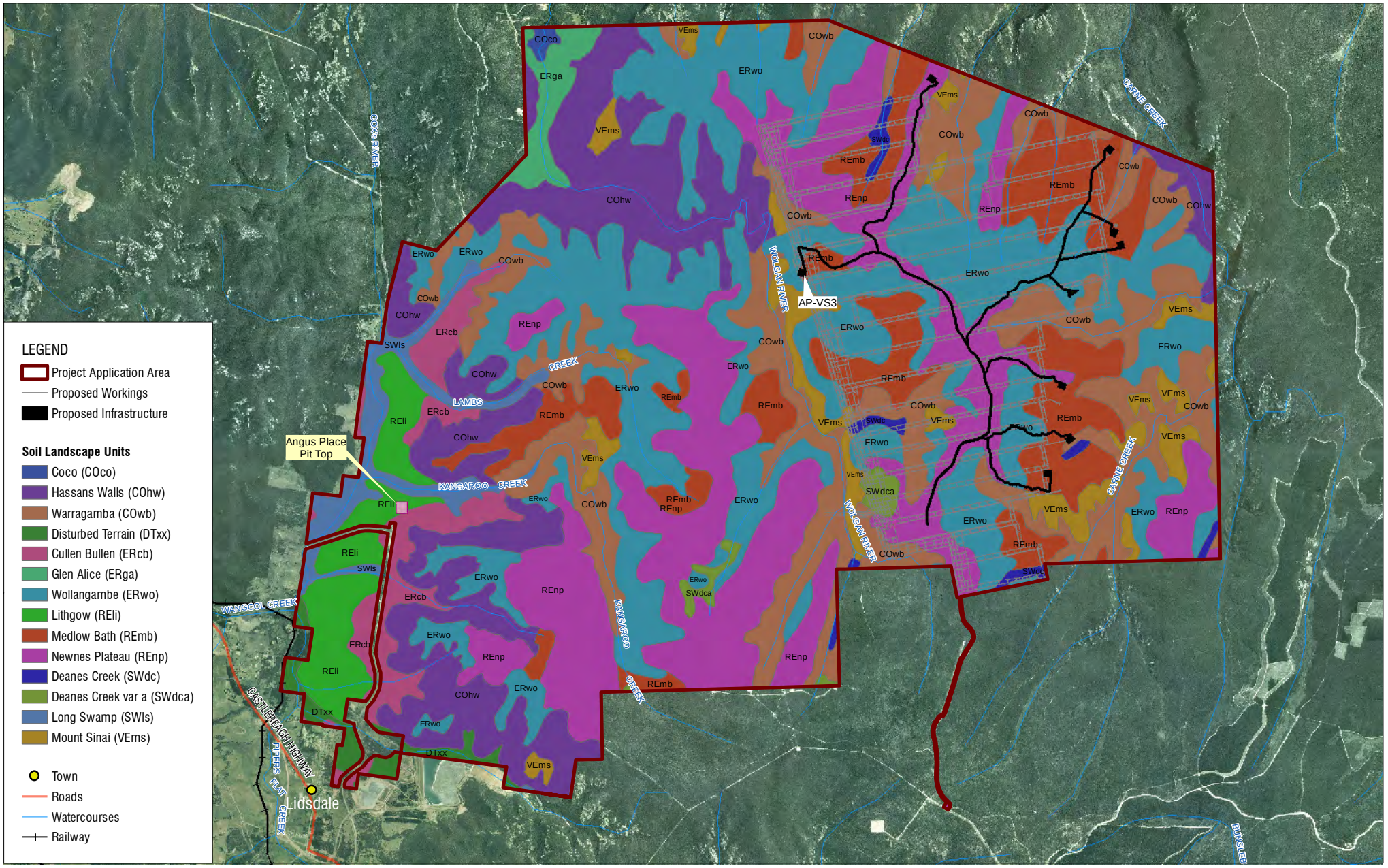
The majority of the PAA lies within the Newnes Plateau, which is a relatively undulating plateau occurring between at an elevation of 1,000 metres and 1,180 metres AHD (**Figure 2.2**). The PAA lies on the boundary between two catchments; the Wolgan-Colo River catchment to the north and the Cox River catchment to the west. The plateau forms part of the divide between the Wolgan and Coxs River valleys and consists of a number of connecting, wide, gently undulating ridges, dissected by relatively steep-sided valleys with the floors of the creeks and gullies occurring between 960 metres and 980 metres AHD (**Figure 2.3**). Sandstone cliffs 40 metres in height can be found in the south western and north eastern corners and along the southern boundary of the lease area. In general, however, the sandstone cliffs range between 10 metres and 40 metres in height throughout the area.

Some swamps occur within the headwater valleys and are controlled by the flat topography and impervious shale layers. These swamps include Sawyers Swamp, and others which are unnamed also occur along the tributaries of both Carne and Marrangaroo Creek.

2.5 Land Use and Vegetation

The PAA is largely covered by the Newnes State Forest (**Figure 1.2**). The Newnes State Forest is located on the Newnes Plateau and contains both native forest and commercial pine plantations. The north-eastern section of the PAA is adjacent to the Wollemi National Park, which is part of the World Heritage listed Greater Blue Mountains area. The *Flora and Fauna Assessment* (RPS, 2013a) undertaken for the Project identified 16 native vegetation communities. Of these, two were listed as endangered ecological communities namely the Newnes Plateau Shrub Swamp and the Temperate Highland Peat Swamp on Sandstone. The Project will not disturb any endangered ecological communities due to clearing activities (RPS, 2013a). Ten threatened flora species were noted to have potential to occur within the PAA, and of these, two were recorded during the RPS survey. These species were *Persoonia hindii* and *Veronica blakelyi Syn. Derwentia blakelyi.*

The *Agricultural Impact Statement* (SLR, 2013a) undertaken for the Project found that only 6 per cent (615 hectares) of the PAA is cleared land and is currently used for agricultural production. The main agricultural land use is cattle, horse and goat grazing.



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NEW SOUTH WALES 2305
AUSTRALIA
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F: 61 2 4037 3201
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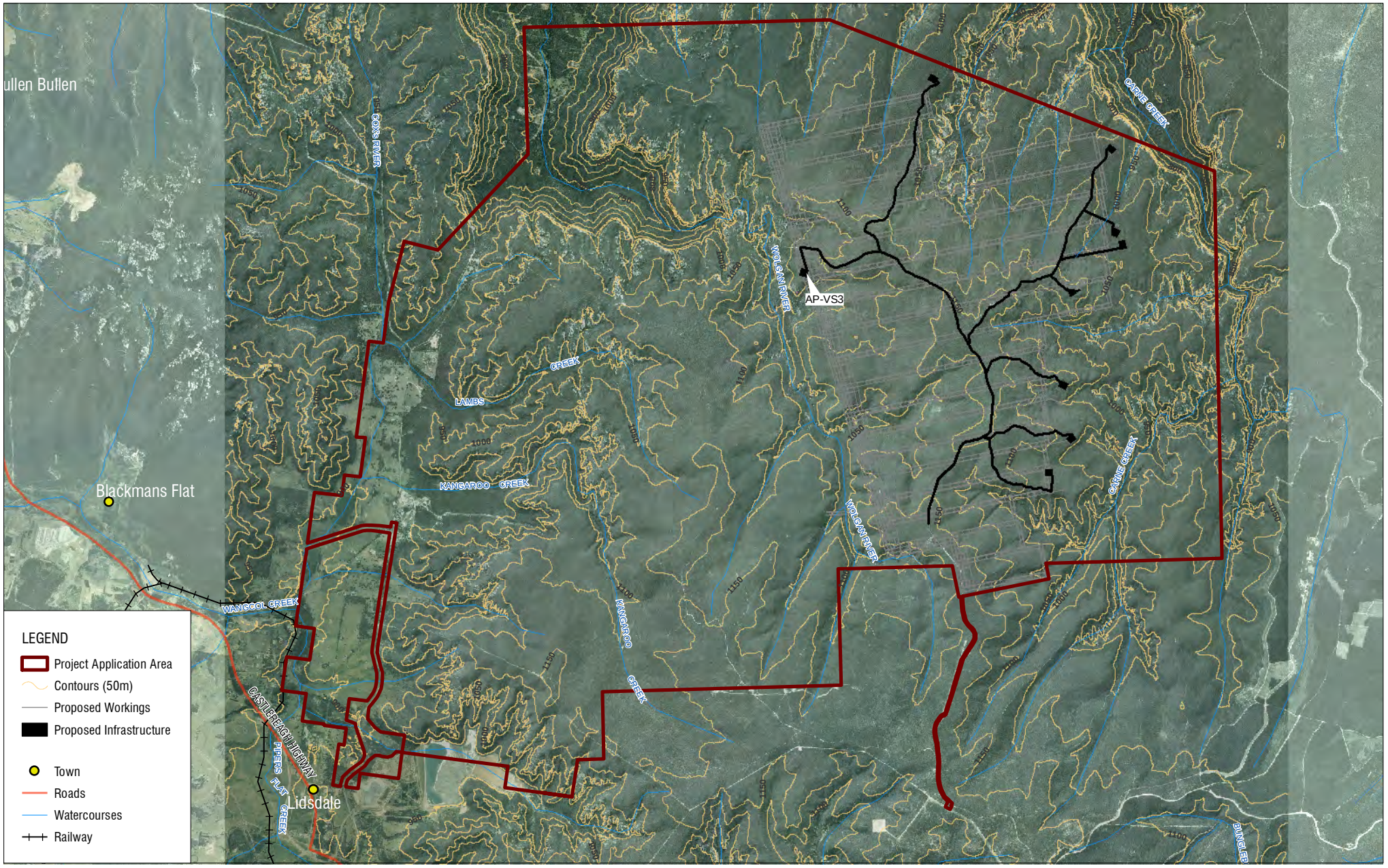
SOIL LANDSCAPE UNITS

FIGURE 2.1



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AUSTRALIA
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F: 61 2 4037 3201
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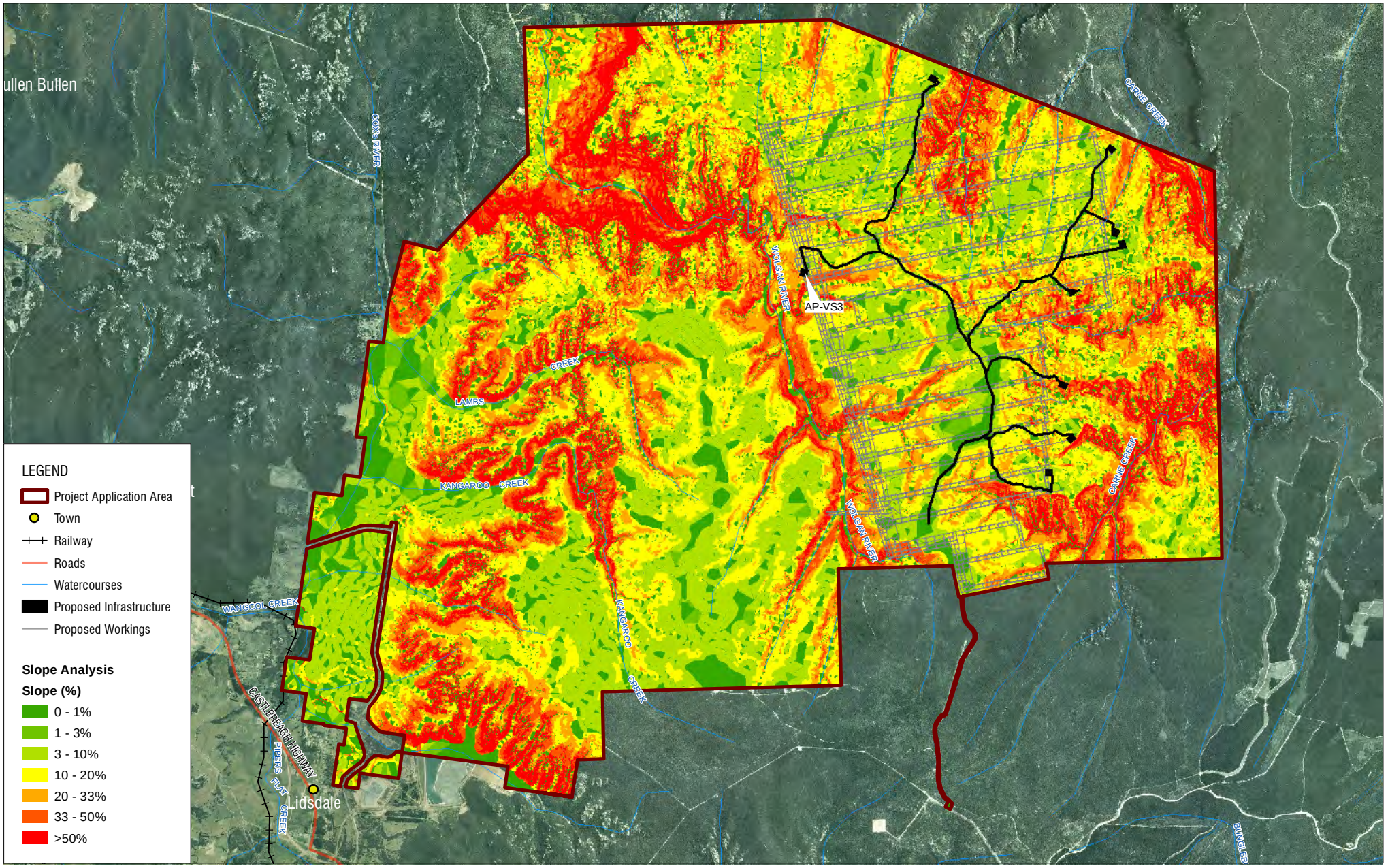
Topography & Hydrology

FIGURE 2.2



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SLOPE ANALYSIS

FIGURE 2.3

3.0 SOIL SURVEY AND ASSESSMENT

3.1 Soil Survey Methodology

A field survey and a desktop study were undertaken to assess the PAA. This process consisted of the components outlined in the sub-sections below. **Appendix 1** contains a general glossary of terms used.

3.1.1 Reference Mapping

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 within the PAA. Aerial photographs and topographical maps were provided by the proponent.
- *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, and water resources studies.
- *Previous reports* - Previous studies were taken into consideration for soils mapping and land assessment. These include the following:
    - *Soil Landscapes of the Wallerawang 1:100,000 Sheet* (King, 1993) and
    - Land and Soil Capability Spatial Data (Department of Natural Resources, 2005).

3.1.2 Field Survey

Scale

Using the Soil Landscapes of the Wallerawang 1:100,000 Sheet as a base reference, further survey work was undertaken to build on this soil data and confirm soil boundaries within the PAA The field survey was undertaken at a medium intensity scale of 1:100,000.

Survey Type

The field survey undertaken was an integrated and qualitative survey. An integrated survey assumes that many land characteristics are interdependent and tend to occur in correlated sets (NCST, 2008). Background reference information derived from sources cited in **Section 3.1.1** were used to predict the distribution of soil attributes in the field. The characteristics evaluated to generate the correlated sets include vegetation type, landform and geology.

The specific type of integrated survey undertaken was a ‘free survey’. A free survey is a conventional form of integrated survey and its strength lies in its ability to assess soil and land at medium scales. Survey points are irregularly located according to the survey teams’ judgement to enable the delineation of soil boundaries. Soil boundaries can be abrupt or gradual, and catena and toposequences are used to aid the description of this variation.

Survey Observations

Survey observations undertaken comply with the 1:100,000 scale survey criteria prescribed in the *Guidelines for Surveying Soil and Land Resources* (NCST, 2008).

The recommended observation density for 1:100,000 scale survey is one observation every 100 hectares. For the PAA of 10,468 hectares this equates to a total of 105 observations required. Generally, a minimum

of 10-30 per cent are to be Detailed Profile Descriptions (also referred to as Class I observations), a minimum of five per cent are to be Laboratory Assessed (also referred to as Class II observations), and the remainder are to be made up by Minor Class Observations (also referred to as Class IV observations).

The total number of observations undertaken was 115, which were comprised of 28 Class I observations, 14 Class II observations and 73 Class IV observations. This meets the observation requirements for a 1:100,000 survey scale (**Figure 3.1**).

Detailed Soil Profile Observation

Soil profiles were assessed in accordance with the *Australian Soil and Land Survey Field Handbook* (NCST, 2009). Information was recorded for the major parameters specified in **Table 3.1** with two to five samples taken from 14 profiles for laboratory analysis (refer **Section 3.1.3**). Each soil profile exposure pit was excavated and placed upon a presentation tray for the profile to be analysed and photographed. The soil pits were backfilled post-analysis.

Table 3.1 – Field Assessment 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 & Size	Soil structure, root penetration, permeability, aeration
Stones – Amount & Size	Water holding capacity, weathering status, erosional / depositional character
Roots – Amount & Size	Effective rooting depth, vegetative sustainability
Ants, Termites, Worms etc.	Biological mixing depth

Global positioning system readings were taken for all sites where detailed soil descriptions were recorded. Vegetation type and land use were also recorded. Soil exposures from cores were photographed during field operations, with photographs being a useful adjunct to description of land attributes.

Soil layers at each profile site were also assessed according to a procedure devised by Elliot and Reynolds (2007) for the recognition of suitable topdressing material in the event surface disturbance occurs in the future. This procedure assesses soils based on grading, texture, structure, consistence, mottling and root presence. A more detailed explanation of the Elliot and Reynolds (2007) procedure is presented in **Section 5** of this report.

3.1.3 Soil Laboratory Assessment

Soil samples from the 14 soil profiles assessed were utilised in the laboratory testing programme. Samples were analysed to:

- classify soil taxonomic classes;
- determine Land and Soil Capability classes; and
- determine suitability of soil as topdressing material.

Soil samples of about 1 – 2 kilograms (kg) were collected from each soil layer. In total, 40 soil samples were sent to the Scone Research Centre for analysis. Certificate of Analyses for these results are contained in **Appendix 2**. The selected physical and chemical laboratory analysis parameters and their relevant application are listed in **Table 3.2**.

Table 3.2 – Laboratory Analysis Parameters

Property	Application
Coarse fragments (>2mm)	Soil workability; root development.
Particle-size distribution(PSA) (<2mm)	Nutrient retention; exchange properties; erodibility; workability; permeability; sealing; drainage; interpretation of most other physical and chemical properties and soil qualities
Aggregate stability (Emerson aggregate test (EAT))	Susceptibility to surface sealing under rainfall or irrigation; effect of raindrop impact and slaking; permeability; infiltration; aeration; seedling emergence; correlation with other properties
Soil acidity/basicity (pH)	Nutrient availability; nutrient fixation; toxicities (especially aluminium and magnesium; liming; sodicity; correlation with other physical, chemical and biological properties
Electrical conductivity (EC)	Appraisal of salinity hazard in soil substrates or groundwater, total soluble salts
Cation Exchange Capacity (CEC) and exchangeable cations	Nutrient status; calculation of exchangeable sodium percentage (ESP); assessment of other physical and chemical properties, especially dispersivity, shrink – swell, water movement, aeration

The laboratory methods used by Scone Research Centre for each physical and chemical parameter are provided below in **Table 3.3**.

Table 3.3 – Laboratory Test Methods

Analyte	Method
PSA	Sieve and hydrometer
pH	1:5 soil/water extract
EC	1:5 soil/water extract
EAT	Emerson Aggregate Test
CEC and exchangeable cations	(AgTU)+ extraction

3.1.4 Soil Type Nomenclature

The applicable technical standard adopted for the Project is the ASC system. The standard is routinely used as the soil classification system in Australia.

3.2 Soil Survey Results

Within the PAA four ASC orders were identified (Tenosols, Kandosols, Kurosols and Rudosols). A summary of the dominant soil types associated with each soil landscape unit is provided in **Table 3.4** and the key findings are:

- The major ASC order in the PAA is a Tenosol covering 9,060 hectares (86.6 per cent) and represents the Hassans Walls, Warragambe, Wollangambe, Medlow Bath, Newnes Plateau and Long Swamp Soil Landscape Units.

- Other minor ASC orders include Kandosols covering 566 hectares (5.4 per cent), Kurosols covering 335 hectares (3.2 per cent) and Rudosols covering 412 hectares (3.9 per cent).

Table 3.4 – Soil Type

Soil Type No.	Soil Landscape Unit	ASC Name	PAA	
			ha	%
1	Hassans Walls	Leptic Tenosol	1,418	13.6
2	Warragamba	Brown-Orthic Tenosol	1,609	15.4
3	Cullen Bullen	Mesotrophic Brown Kandosol	305	2.9
4	Glen Alice	Eutrophic Brown Kandosol	122	1.2
5	Wollangambe	Brown-Orthic Tenosol	2,672	25.5
6	Lithgow	Eutrophic Brown Kurosol	335	3.2
7	Medlow Bath	Red-Orthic Tenosol	1,097	10.5
8a	Newnes Plateau	Brown-Orthic Tenosol	2,028	19.3
8b		Mesotrophic Brown Kandosol	8	0.1
9	Deanes Creek	Mesotrophic Brown Kandosol	131	1.2
10	Long Swamp	Brown-Orthic Tenosol	236	2.3
11	Mount Sinai	Arenic Rudosol	397	3.8
12	Coco	Rudosol	15	0.1
N/A	Disturbed Terrain*	-	95	0.9
		Total	**10,468**	**100.0**

*Disturbed terrain is not discussed further in this report

The Proposed Surface Infrastructure covers 23.25 hectares of land as described in **Section 1.3**. However, the assessment area for the Soil and Land Capability Assessment covers a larger area of 141 hectares to incorporate a number of potential alignment options. This is a conservative approach to ensure due diligence following any required mine plan changes during the EIS process.

The reported results reference the larger assessment area and are therefore considered to be highly conservative as only a small portion of the assessed will be directly impacted upon.

Within the area of land assessed for Proposed Surface Infrastructure four major soil types were identified. An overview of the dominant soil types is provided in **Table 3.5** and the key findings are:

- The major soil types are a Brown-Orthic Tenosol covering 80 hectares (56.8 per cent) and Red-Orthic Tenosol covering 59 hectares (41.8 per cent).

- Other minor soil types include Mesotrophic Brown Kandosol and Arenic Rudosol.

Table 3.5 – Soil Type by Proposed Surface Infrastructure Assessment Area

Soil Type No.	Soil Landscape	ASC Name	Proposed Surface Infrastructure Assessment Area	
			ha	%
2	Warragamba	Brown-Orthic Tenosol	1	0.7
5	Wollangambe	Brown-Orthic Tenosol	27	19.2
7	Medlow Bath	Red-Orthic Tenosol	59	41.8
8a	Newnes Plateau	Brown-Orthic Tenosol	52	36.9
9	Deanes Creek	Mesotrophic Brown Kandosol	1	0.7
11	Mount Sinai	Arenic Rudosol	1	0.7
		Total	**141**	**100.0**

The physical and chemical characteristics of the soil types and management recommendations for each are described in the following sections. **Figure 3.2** shows the distribution of the soil types across the PAA. The disturbed terrain is not a soil type and is not discussed further in this report.

3.2.1 Hassans Walls Soil Landscape

The Hassans Walls Soil Landscape Unit consists of cliffs derived from Narrabeen Group sandstones and steep colluvial talus sideslopes developed over the Illawarra Coal Measures and the Shoalhaven Group (see **Plate 1**). Local relief is to >100 metres, with slopes mostly >40 per cent. Open forest and open woodland is associated with this landscape. Soils are typically dominated by shallow, discontinuous Lithosols (Rudosols) on rocky ledges and cliffs, moderately deep stony Lithosols and Siliceous Sands (Rudosols, Tenosols) on upper slopes, and moderately deep Yellow and Brown Podzolic Soils (Chromosols, Kurosols) on lower slopes.

Limitations to this unit include severe rock-fall hazard, steep slopes, extreme water erosion hazard, mass movement hazard, severe foundation hazard, rock outcrop and localised shallow soils, high run-on, and localised non-cohesive soils. This soil landscape is generally unsuitable for cultivation or grazing due to severe limitations; however some gentler slopes and narrow drainage flats are capable of light grazing.

The Hassans Walls Soil Landscape Unit covers approximately 1,418 hectares (13.6 per cent) of the PAA. For the purpose of this assessment the dominant soil type is represented by a Leptic Tenosol.

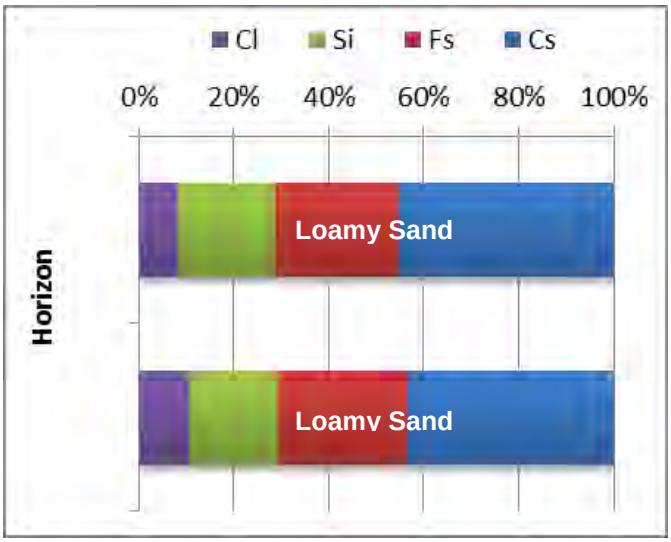
Plate 1: Hassans Walls Soil Landscape

Soil Type 1 – Leptic Tenosol

Soil Type 1 is a Leptic Tenosol. Tenosols are soils that have poorly developed pedological organisation beyond the A horizon (topsoil). In the PAA this soil type is comprised of two major soil horizons and the shallow profile is characterised by a uniform loamy sand soil texture (**Graph 1**). Soil pH is strongly acidic to very strongly acidic, the profile is non-saline (**Graph 2**) and non sodic. CEC is very low and exchangeable calcium is low relative to magnesium (**Graph 3**).

Table 3.6 provides a summary of this soil type.

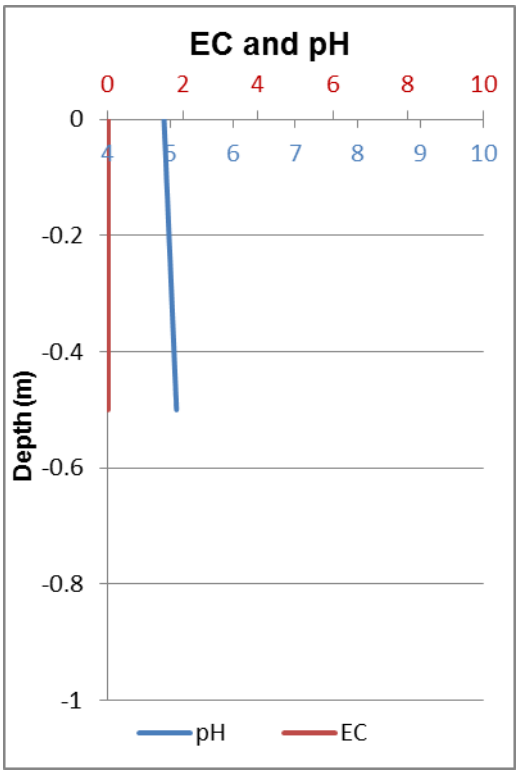
Table 3.6 – Overview: Soil Type 1

Site Description	
	
Plate 2 – Profile (Site 18)	**Plate 3 – Landscape (Site 18)**
	
Graph 1 – Site 18 PSA	

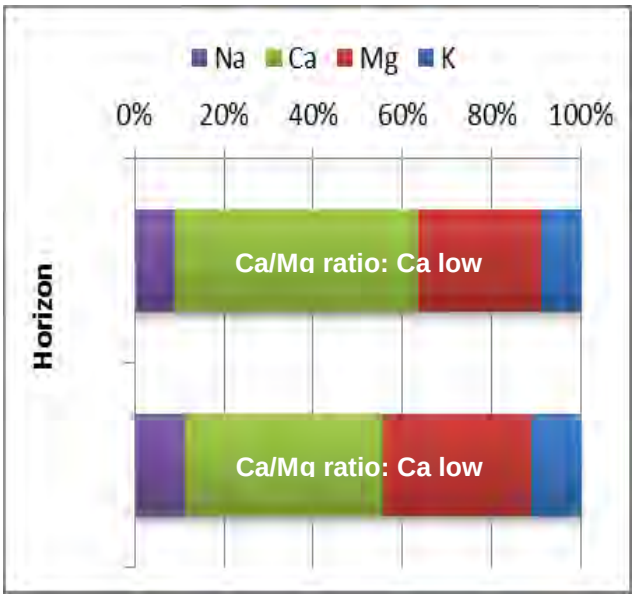
ASC Name	Leptic Tenosol
Representative Site	Site 18
Associated Soil Landscape	Hassans Walls
Dominant Slope Association	Very steeply inclined and precipitous (>35% slopes)
Land Use and Vegetation	Remnant open forest
Land and Soil Capability Limiting Class	8
Soil Stripping Recommendation	0.0 – 0.15 is suitable for stripping and re-use in localised rehabilitation if ameliorated with gypsum or lime for acidity and organic amendments to aid soil structure.

Horizon	Depth (m)	Description
A1	0.0–0.15	Dark greyish brown (10YR4/2) loam to loamy sand, moderate structure grade (organic matter influenced) of 10–20 mm angular blocky peds with a weak consistence. Very strongly acidic (pH 4.9) and very low salinity (EC <0.01 dS/m). Well drained with a clear and wavy boundary and coarse fragments at a 20% presence.
B2w	0.15–0.50	Dark greyish brown (10YR4/2) loamy sand with apedal structure. Strongly acidic (pH 5.1) and very low salinity (EC <0.01 dS/m). Well drained and coarse fragments at 10%.

C	50+	Bedrock						
Horizon	**CEC**		**ESP**		**OC**		**EAT**	
	meq/100g	rating	%	rating	%	rating	class	rating
A1	2.4	Very low	4.2	Non sodic	1.22	Moderate	8	Negligible
B2w	1.7	Very low	5.9	Non sodic	0.77	Moderate	3(1)	Slight



Graph 2 – Site 18 pH and EC



Graph 3 – Site 18 Exchangeable Cations

3.2.2 Warragamba Soil Landscape

The Warragamba Soil Landscape Unit consists of narrow convex crests and ridges and steep colluvial sideslopes on Narrabeen Group sandstones with minor cliffs and scarps on steeper slopes (see **Plate 4**). Local relief is 80 – 1230 metres, and slopes typically >35 per cent. Uncleared open woodland is associated with this landscape. The soils are typically dominated by shallow to deep Lithosols (Rudosols, Tenosols) on crests and ridges, Brown Earths (Kandosols) and Red Podzolic Soils (Kurosols, Chromosols) on upper slopes and Yellow Podzolic Soils (Kurosols, Chromosols) on lower slopes.

Limitations to this unit include mass movement hazard, steep slopes, sever water erosion hazard, rock fall hazard, acidic, stony soils of low fertility and rock outcrop. This soil landscape is generally unsuitable for cultivation or grazing due to severe limitations.

The Warragamba Soil Landscape Unit covers approximately 1,609 hectares (15.4 per cent) of the PAA. For the purpose of this assessment the dominant soil type is represented by a Brown Kandosol.

Plate 4 – Warragamba Soil Landscape

Soil Type 2 – Brown-Orthic Tenosol

Soil Type 2 is a Brown Orthic-Tenosol. In the PAA this soil type is comprised of three major soil horizons and the profile is characterised by loamy sand topsoil grading into sandy loam subsoil (**Graph 4**). Soil pH ranges from strongly acidic to very strongly acidic, the profile is non-saline (**Graph 5**) and the topsoil is non sodic trending to marginally sodic at depth. CEC is very low throughout and the exchangeable calcium is low relative to magnesium (**Graph 6**).

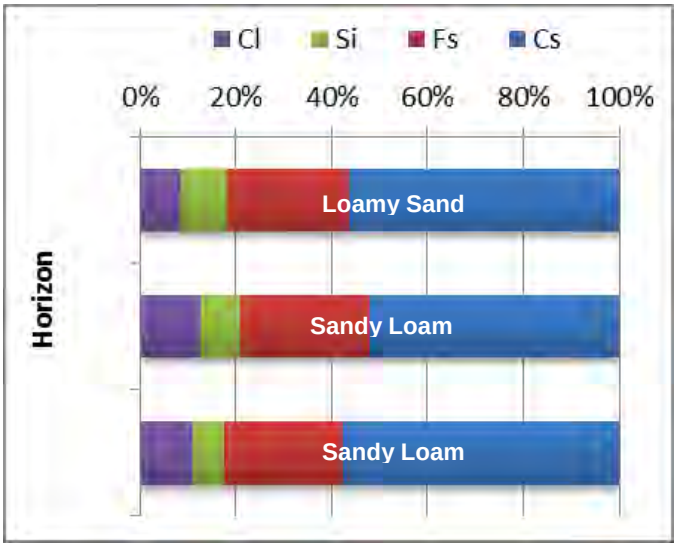
Table 3.7 provides a summary of this soil type.

Table 3.7 – Overview: Soil Type 2

Site Description

Plate 5 – Profile (Site 14)

Plate 6 – Landscape (Site 14)



Graph 4 – Site 14 PSA

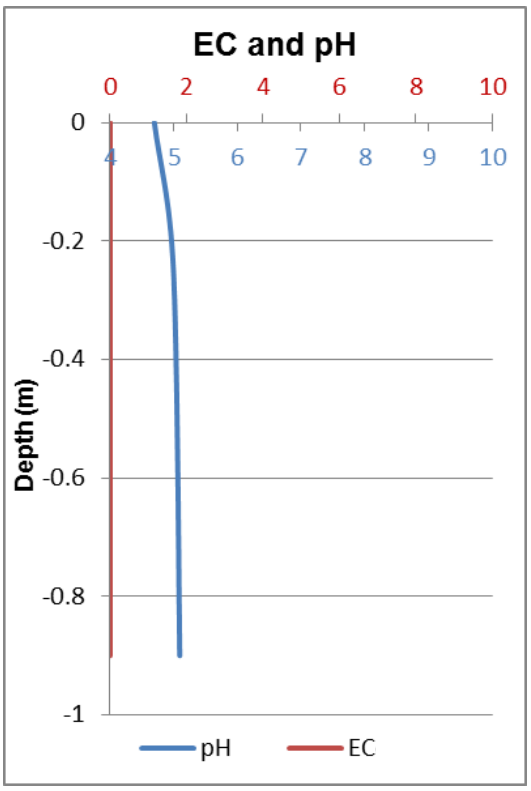
ASC Name	Brown-Orthic Tenosol
Representative Site	Site14
Associated Soil Landscape	Warragamba
Dominant Slope Association	Very steeply inclined and precipitous (>33% slopes)
Land Use and Vegetation	Remnant open forest
Land and Soil Capability Limiting Class	8
Soil Stripping Recommendation	0.0 – 0.25 m is suitable for stripping and re-use in localised rehabilitation if ameliorated with gypsum or lime for acidity and organic amendments to aid soil structure.

Horizon	Depth (m)	Description
A1	0.0–0.25	Very dark brown (10YR2/2) loamy sand, moderate structure grade (organic matter influenced) of 10–40 mm angular blocky peds with a weak consistence. Very strongly acidic (pH 4.7) and very low salinity (EC <0.01 dS/m). Well drained with a gradual boundary and coarse fragments at a 5% presence.
B1	0.25–0.70	Brown (10YR3/2) sandy loam, weak structure grade of 2 – 3 mm crumby peds with weak consistence. Very strongly acidic (pH 5.0) and very low salinity (EC <0.01 dS/m). Well drained with a gradual and wavy boundary.

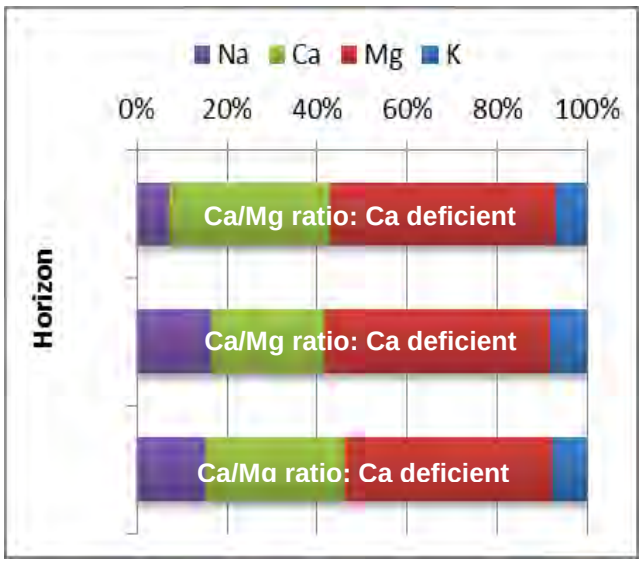
B2	0.70–0.95	Dark brown (10YR3/3) sandy loam, apedal structure. Strongly acidic (pH 5.1) and very low salinity (EC <0.01 dS/m). Well drained.

Horizon	CEC		ESP		OC		EAT	
	meq/100g	rating	%	rating	%	rating	class	rating
A1	4.3	Very low	2.3	Non sodic	3.08	Very high	8	Negligible
B1	2.4	Very low	8.3	Marginally sodic*	1.4	Moderate	5	Slight
B2	1.9	Very low	10.8	Sodic*	0.74	Moderate	6	Negligible

*low clay content; ESP concentration may be skewed



Graph 5 – Site 14 pH and EC



Graph 6 – Site 14 Exchangeable Cations

3.2.3 Cullen Bullen Soil Landscape

The Cullen Bullen Soil Landscape Unit consists of rolling low hills and rises on Illawarra Coal Measures and the Berry Formation (see **Plate 7**). Slopes are typically 10 – 25 per cent and local relief is <50 metres. In the PAA slopes were assessed as being generally <10 per cent. Localised rock outcropping occurs as small isolated low scarps (<5 metres). Extensively cleared open woodland and open forest is associated with this landscape. The soils are typically dominated by shallow to moderately deep Yellow Podzolic Soils (Kurosols, Chromosols) and Yellow Leached Earths on crests; moderately deep Yellow Podzolic Soils (Kurosols, Chromosols), Yellow Leached Earths (Kandosols) and Soloths (Sodosols) on upper and midslopes; and Yellow Podzolic Soils (Kurosols, Chromosols) on lower slopes.

Limitations to this unit include hardsetting topsoils, high water erosion hazard, high run-on, rock outcrop, localised rock fall hazard and localised high foundation hazard. This soil landscape is generally suited to grazing and has moderate limitations for cultivation.

The Cullen Bullen Soil Landscape Unit covers approximately 305 hectares (2.9 per cent) of the PAA. For the purpose of this assessment the dominant soil type is represented by a Brown Kandosol.

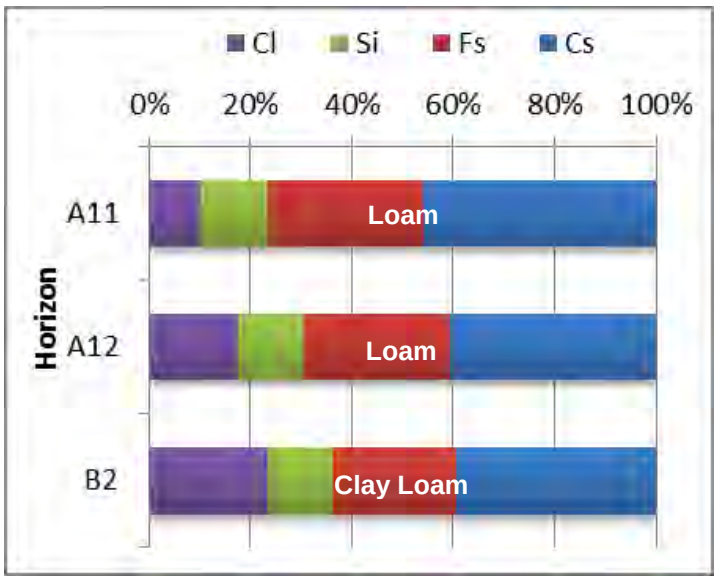
Plate 7 – Cullen Bullen Soil Landscape

Soil Type 3 – Mesotrophic Brown Kandosol

Soil Type 3 is a Mesotrophic Brown Kandosol. In the PAA this soil type is comprised of three major soil horizons and the profile is characterised by loam topsoil grading into clay loam subsoil (**Graph 7**). Soil pH is strongly acidic throughout the profile (**Graph 8**), the profile is non-saline and the topsoil is non sodic trending to marginally sodic at depth. CEC is very low throughout; and exchangeable calcium is low relative to magnesium (**Graph 9**).

Table 3.8 provides a summary of this soil type.

Table 3.8 – Overview: Soil Type 3

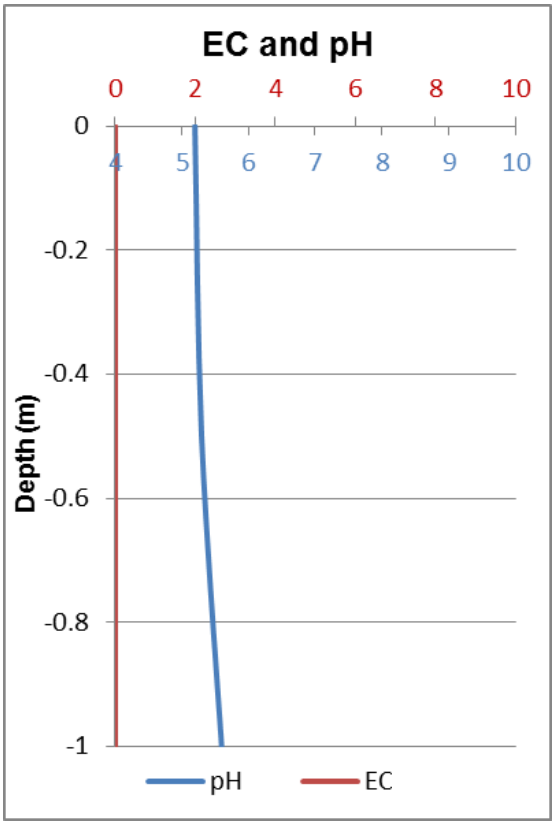
Site Description	
	
Plate 8 – Profile (Site 21)	**Plate 9 – Landscape (Site 21)**
	
Graph 7 – Site 21 PSA	

ASC Name	Mesotrophic Brown Kandosol
Representative Site	Site 21
Associated Soil Landscape	Cullen Bullen
Dominant Slope Association	Gently inclined (3-10% slope)
Land Use and Vegetation	Remnant open forest
Land and Soil Capability Limiting Class	4
Soil Stripping Recommendation	0.0 – 1.0 m is suitable for stripping and re-use in localised rehabilitation. Amelioration of marginal subsoil sodicity required should the subsoil be used in rehabilitation works.

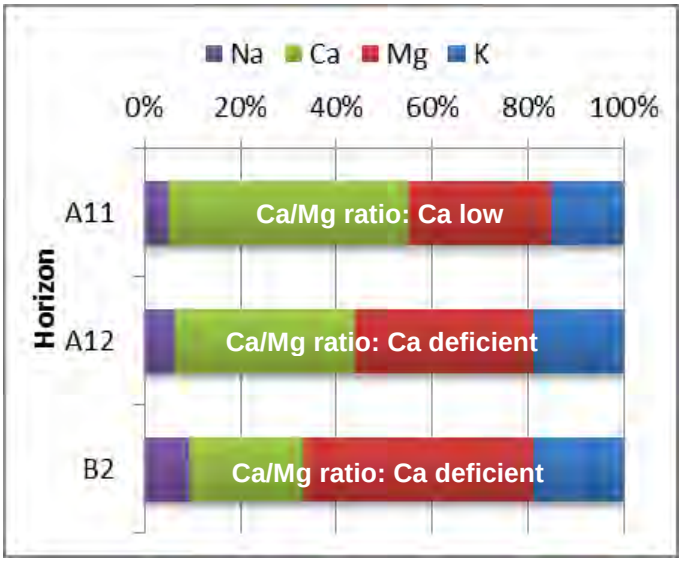
Horizon	Depth (m)	Description
A11	0.0–0.15	Dark yellowish brown (10YR4/4) loam, strong structure of 10 – 20 mm angular blocky peds, with a strong consistence. Strongly acidic (pH 5.2) and very low salinity (EC 0.01 dS/m). Well drained with an abrupt boundary and coarse fragments at a 5% presence.

A12	0.15–0.50	Strong brown (7.5YR4/6) loam, moderately weak structure grade of 10 – 20 mm angular blocky peds with a weak consistence. Strongly acidic (pH 5.3) and very low salinity (EC 0.01 dS/m). Well drained with a gradual boundary.
B2	0.50–1.00	Yellowish red (5YR4/6) clay loam, weak structure grade 5 – 10 mm angular blocky peds with a weak consistence. Strongly acidic (pH 5.6) and very low salinity (EC 0.01 dS/m). Well drained with a gradual boundary.

Horizon	CEC		ESP		OC		EAT	
	meq/100g	rating	%	rating	%	rating	class	rating
A11	2.9	Very low	3.4	Non sodic	1.29	Moderate	8	Negligible
A12	2.3	Very low	4.3	Non sodic	0.59	Very low	5	Slight
B2	3.0	Very low	6.7	Marginally sodic	0.22	Extremely low	5	Slight



Graph 8 – Site 21 pH and EC



Graph 9 – Site 21 Exchangeable Cations

3.2.4 Glen Alice Soil Landscape

The Glen Alice Soil Landscape Unit consists of rolling rises and low hills on Shoalhaven Group sediments in the Wolgan and Capertee Valleys (see **Plate 10**). Local relief is 10 – 30 metres, with slopes of 5 - 20 per cent. Extensively cleared open woodland is associated with this landscape. Soils are typically dominated by shallow to moderately deep Red and Yellow Podzolic Soils (Chromosols, Kurosols) on upper and midslopes, moderately deep Red and Yellow Podzolic Soils (Chromosols, Kurosols, Kandosols) as well as some Yellow Solodic Soils (Sodosols) on lower slopes and in poorly drained positions.

Limitations to this unit include hardsetting topsoils, localised salinity, localised alkalinity, high water erosion hazard, localised steep slopes and occasional localised flooding. This soil landscape is generally suited to grazing and has moderate limitations for cultivation.

The Glen Alice Soil Landscape Unit covers approximately 122 hectares (1.2 per cent) of the PAA. For the purpose of this assessment the dominant soil type is represented by a Brown Kandosol.

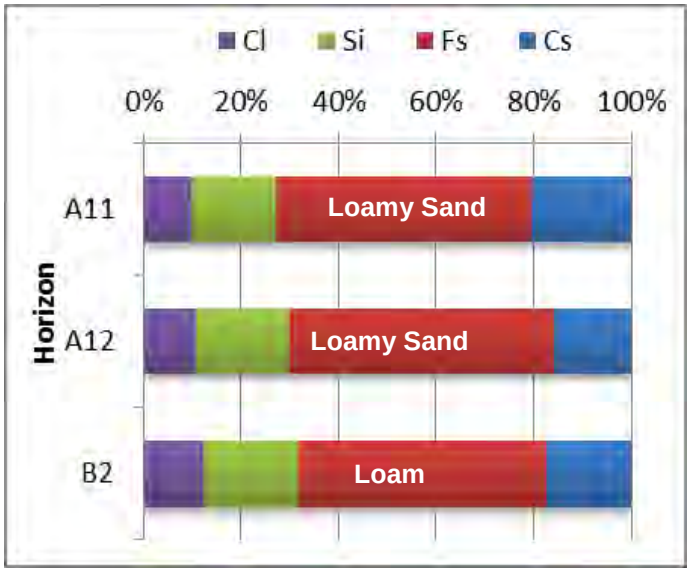
Plate 10 – Glen Alice Soil Landscape

Soil Type 4 – Eutrophic Brown Kandosol

Soil Type 4 is a Eutrophic Brown Kandosol. In the PAA this soil type is comprised of three major soil horizons and the profile is characterised by loamy sand topsoil grading into loam subsoil (**Graph 10**). Soil pH trends from moderately acidic in the topsoil to slightly acidic in the subsoil, the profile is non-saline (**Graph 11**) and non sodic. CEC is low throughout and exchangeable calcium is low relative to magnesium (**Graph 12**).

Table 3.9 provides a summary of this soil type.

Table 3.9 – Overview: Soil Type 4

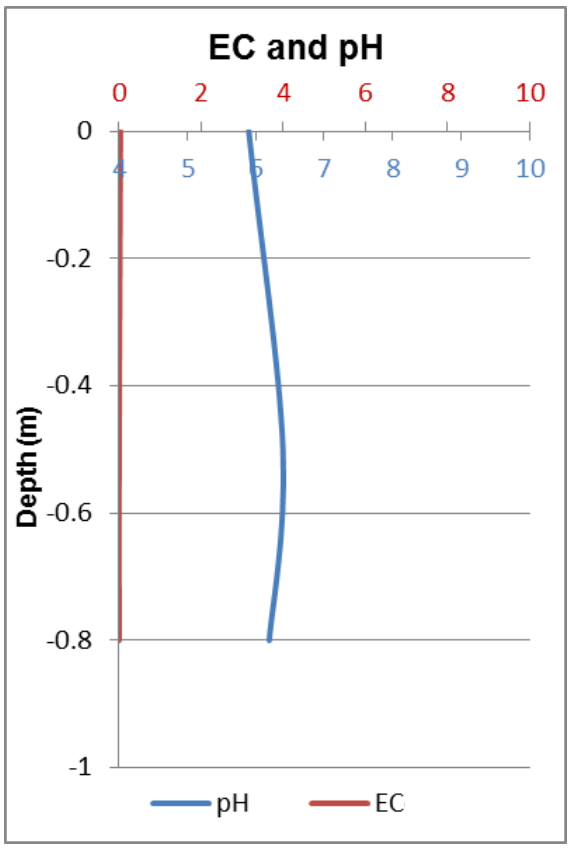
Site Description	
	
Plate 11 – Profile (Site 20)	**Plate 12 – Landscape (Site 20)**
	
Graph 10 – Site 20 PSA	

ASC Name	Eutrophic Brown Kandosol
Representative Site	Site 20
Associated Soil Landscape	Glen Alice
Dominant Slope Association	Moderately inclined; 10-20% slopes
Land Use and Vegetation	Remnant open forest and some regrowth
Land and Soil Capability Limiting Class	4
Soil Stripping Recommendation	0.0 – 0.80 m is suitable for stripping and re-use in localised rehabilitation. Amelioration with organic amendments to improve soil structure required.

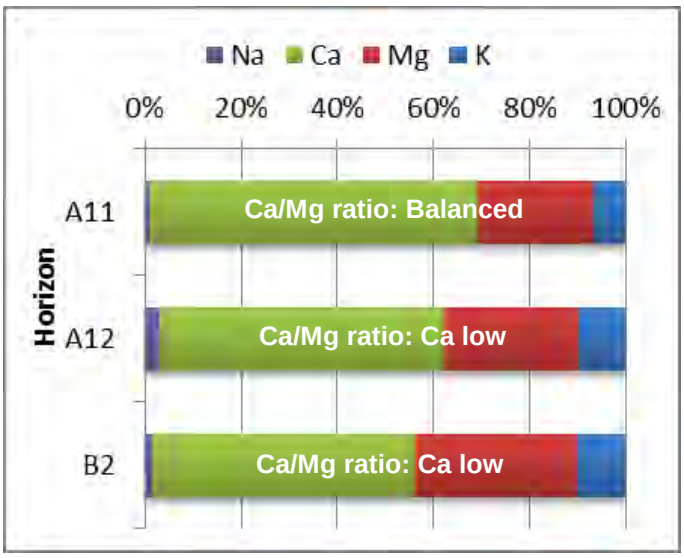
Horizon	Depth (m)	Description
A11	0.0–0.30	Dark brown (10YR3/3) loamy sand, moderate structure of 10 – 30 mm angular blocky peds, with a weak consistence. Moderately acidic (pH 5.9) and very low salinity (EC 0.04 dS/m). Well drained with an abrupt boundary and coarse fragments at a 5% presence.

A12	0.30–0.65	Brown (7.5YR4/3) loamy sand, moderate to weak structure grade of 5 – 10 mm angular blocky peds with a weak consistence. Slightly acidic (pH 6.4) and very low salinity (EC 0.01 dS/m). Moderately drained with a gradual boundary.
B2	0.65–0.80	Brown (7.5YR3/6) loam, weak structure grade 5 – 10 mm angular blocky peds with a weak consistence. Slightly acidic (pH 6.2) and very low salinity (EC 0.01 dS/m). Moderately drained with a gradual boundary.

Horizon	CEC		ESP		OC		EAT	
	meq/100g	rating	%	rating	%	rating	class	rating
A11	9.3	Low	1.1	Non sodic	2.4	High	8	Negligible
A12	6.3	Low	3.2	Non sodic	0.9	Moderate	3(1)	Slight
B2	6.1	Low	1.7	Non sodic	0.9	Moderate	3(1)	Slight



Graph 11 – Site 20 pH and EC



Graph 12 – Site 20 Exchangeable Cations

3.2.5 Wollangambe Soil Landscape

The Wollangambe Soil Landscape Unit consists of rounded convex crests and moderately to steeply inclined sideslopes on Narrabeen Group sandstones (see **Plate 13**). Local relief is to 100 metres, with slopes usually <35 per cent. Localised rock outcrop is common including broken scarps and small rock ledges and cliffs. Largely uncleared, open woodland and open forest is associated with this landscape. Soils are typically dominated by Siliceous Sands (Tenosols), Lithosols (Rudosols) and Yellow and Red Earths (Kandosols) on crests; moderately deep Earthy Sands (Tenosols), Yellow Earths (Kandosols) on sideslopes; moderately deep Yellow Podzolic Soils (Chromosols, Kurosols) and Gleyed Podzolic Soils (Hydrosols) developed over shale lenses, with shallow Siliceous Sands (Tenosols) and Lithosols on small rock ledges and broken scarps.

Limitations to this unit include high to severe water erosion, steep slopes, shallow soils, localised rock fall hazard, localised rock outcrop and low soil fertility. This soil landscape is generally suited to light grazing and has high limitations for cultivation.

The Wollangambe Soil Landscape Unit covers approximately 2,672 hectares (25.5 per cent) of the PAA. For the purpose of this assessment the dominant soil type is represented by an Orthic Tenosol.

Plate 13 – Wollangambe Soil Landscape

Soil Type 5 – Brown-Orthic Tenosol

Soil Type 5 is a Brown-Orthic Tenosol. In the PAA this soil type is comprised of three major soil horizons and the profile is characterised by sandy loam grading into decomposing parent material (**Graph 13**). Soil pH is strongly acidic to very strongly acidic, the profile is non-saline (**Graph 14**) and topsoil is non sodic trending to marginally sodic at depth. CEC is very low and, exchangeable calcium is low relative to magnesium (**Graph 15**).

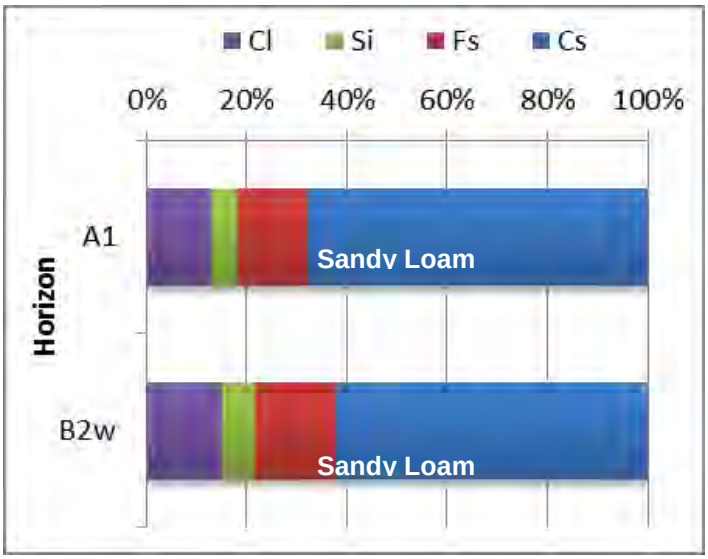
Table 3.10 provides a summary of this soil type.

Table 3.10 – Overview: Soil Type 5

Site Description

Plate 14 – Profile (Site 4)

Plate 15 – Landscape (Site 4)

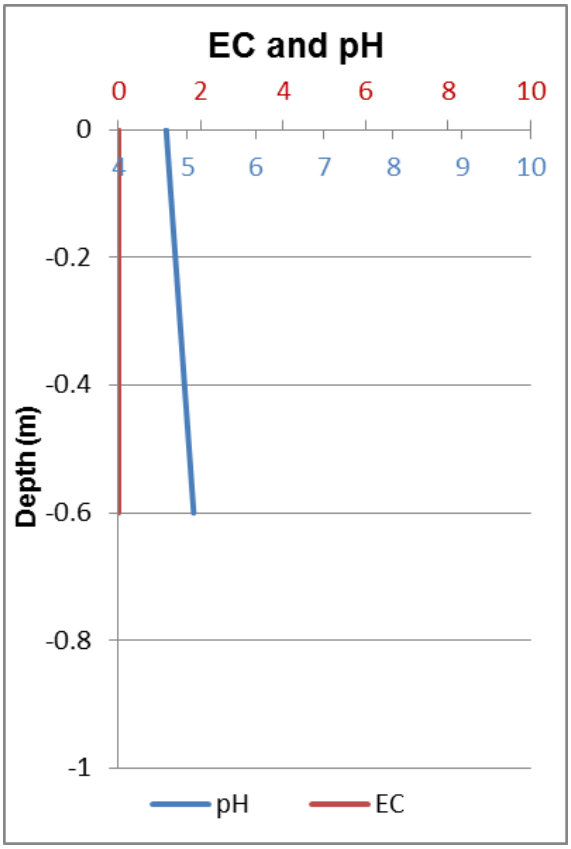


Graph 13 – Site 4 PSA

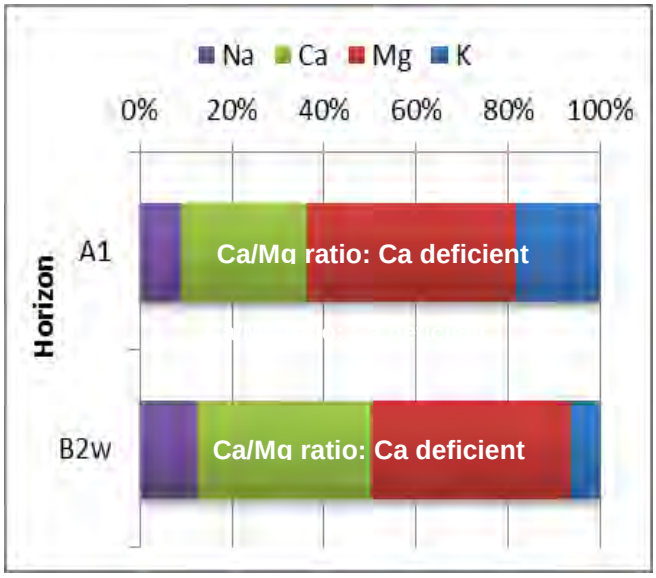
ASC Name	Brown-Orthic Tenosol
Representative Site	Site 4
Associated Soil Landscape	Wollangambe
Dominant Slope Association	Moderately inclined (10-20% with some steep slopes of 20-32%)
Land Use and Vegetation	Remnant open forest
Land and Soil Capability Limiting Class	6
Soil Stripping Recommendation	0.0 – 0.20 m is suitable for stripping and re-use in localised rehabilitation if ameliorated with gypsum or lime for acidity.

Horizon	Depth (m)	Description
A1	0.0–0.20	Dark brown (10YR3/3) sandy loam, moderate structure of 2 – 10 mm round peds, with a weak consistence. Very strongly acidic (pH 4.7) and very low salinity (EC 0.01 dS/m). Well drained with a gradual boundary and coarse fragments at a 10% presence.
B2w	0.20–0.60	Strong brown (7.5YR5/6) sandy loam with apedal structure. Strongly acidic (pH 5.1) and

		very low salinity (EC 0.01 dS/m). Moderately drained with a clear boundary and coarse fragments at 10% presence.						
BC	0.60–0.90	Gravelly (90% presence) quartz based parent material.						
Horizon	**CEC**		**ESP**		**OC**		**EAT**	
	meq/100g	rating	%	rating	%	rating	class	rating
A1	2.6	Very low	3.8	Non sodic	1.9	High	8	Negligible
B2w	2.3	Very low	8.7	Marginally sodic	0.7	Moderate	5	Slight



Graph 14 – Site 4 pH and EC



Graph 15 – Site 4 Exchangeable Cations

3.2.6 Lithgow Soil Landscape

The Lithgow Soil Landscape Unit consists of flat to undulating rises and broad valley floors on Illawarra Coal Measures and the Berry Formation (**Plate 16**). Local relief is to 20 metres, with slopes <10 per cent, with localised rock outcrop. Extensively cleared open forest and open woodland dominate this landscape. Soils are typically dominated by moderately deep Red and Yellow Podzolic Soils (Chromosols, Kurosols) and Yellow Leached Earths (Kandosols) on upper slopes and well drained areas; and moderately deep to deep Soloths/Solodic Soils (Sodosols) are found on lower slopes and in areas of poor drainage.

Limitations to this unit include hardsetting topsoils, high run-on, localised rock fall hazards and localised potential aluminium toxicity. This soil landscape is generally suited to grazing and has moderate to high limitations for cultivation.

The Lithgow Soil Landscape Unit covers approximately 335 hectares (3.2 per cent) of the PAA. For the purpose of this assessment the dominant soil type is represented by a Brown Kurosol.

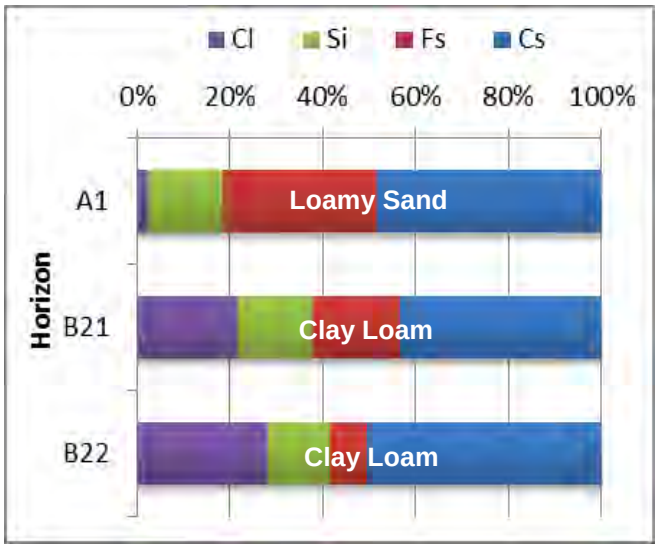
Plate 16 – Lithgow Soil Landscape

Soil Type 6 – Eutrophic Brown Kurosol

Soil Type 6 is a Eutrophic Brown Kurosol; Kurosols are soils with a texture contrast profile, which are strongly acidic in the subsoil. In the PAA this soil type is comprised of three major soil horizons and the profile is characterised by loamy sand topsoil overlying clay loam subsoil (**Graph 16**). Soil pH trends from moderately acidic in the topsoil to strongly acidic at depth. The soil profile in non-saline (**Graph 17**) and non sodic. CEC is very low throughout and exchangeable calcium is low relative to magnesium (**Graph 18**).

Table 3.11 provides a summary of this soil type.

Table 3.11 – Overview: Soil Type 6

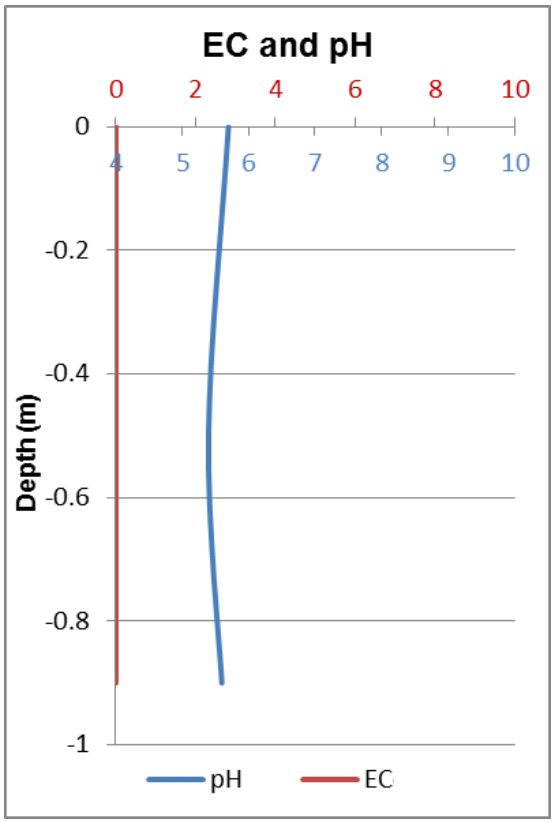
Site Description	
	
Plate 17 – Profile (Site 19)	**Plate 18 – Landscape (Site 19)**
	
Graph 16 – Site 19 PSA	

ASC Name	Eutrophic Brown Kurosol
Representative Site	Site 19
Associated Soil Landscape	Lithgow
Dominant Slope Association	Gently inclined (3-10% slope)
Land Use and Vegetation	Predominantly cleared for grazing, minor remnant vegetation.
Land and Soil Capability Limiting Class	6
Soil Stripping Recommendation	0.0 – 0.60 m is suitable for stripping and re-use in localised rehabilitation. Amelioration to reduce 'clodiness' of subsoil required.

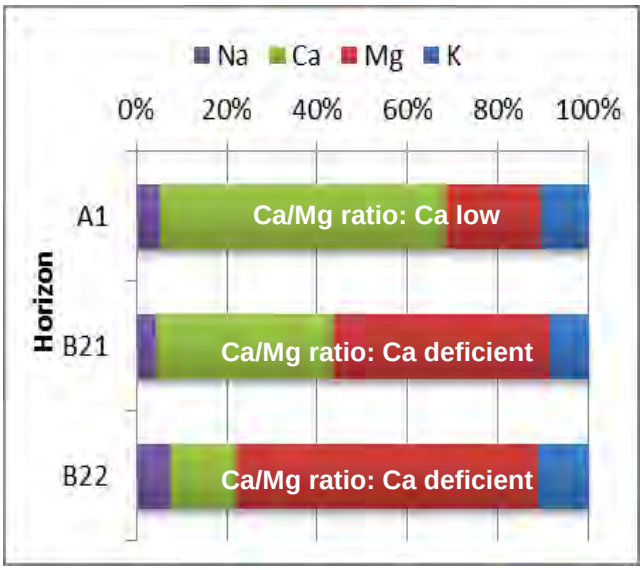
Horizon	Depth (m)	Description
A1	0.0–0.30	Dark greyish brown (10YR4/2) loamy sand, with lightly crusted, apedal structure. Moderately acidic (pH 5.7) and very low salinity (EC 0.01 dS/m). Moderately drained with an abrupt and even boundary and coarse fragments at a 25% presence.
B21	0.30–0.60	Yellowish brown (10YR5/8) clay loam, moderate structure grade of sub angular blocky peds with a strong consistence. Strongly acidic (pH 5.4) and very low salinity (EC 0.01 dS/m). Poorly drained with a gradual and uneven boundary and coarse fragments at 10% presence.

B22	0.60–0.90	Yellowish brown (10YR5/8) clay loam, moderate structure grade of sub angular blocky peds with a strong consistence Moderately acidic (pH 5.6) and very low salinity (EC 0.01 dS/m). Poorly drained with a clear boundary and coarse fragments at 40% presence.
C	0.90+	Parent material.

Horizon	CEC		ESP		OC		EAT	
	meq/100g	rating	%	rating	%	rating	class	rating
A1	2.4	Very low	4.2	Non sodic	1.1	Moderate	8	Negligible
B21	3.5	Very low	2.9	Non sodic	0.1	Extremely low	5	Slight
B22	5.2	Very low	3.8	Non sodic	<0.1	Extremely low	5	Slight



Graph 17 – Site 19 pH and EC



Graph 18 – Site 19 Exchangeable Cations

3.2.7 Medlow Bath Soil Landscape

The Medlow Bath Soil Landscape Unit consists of narrow crests and moderately inclined sideslopes on Narrabeen Group sandstones (**Plate 19**). Local relief is to 20 – 50 metres, with a slope of 10 – 20 per cent, and localised rock outcrop. Partially cleared open forest and open woodland characterises this landscape. Soils are typically dominated by moderately deep Earthy Sands (Tenosols) and Yellow Earths (Kandosols) on crests and sideslopes; and shallow Lithosols/Siliceous Sands (Rudosols/Tenosols) associated with rock outcrop.

Limitations to this unit include shallow, stony, acid soils of low fertility, high potential aluminium toxicity, moderate erodibility and localised rock outcrop. soil landscape is generally suited to grazing and has moderate to high limitations for cultivation.

The Medlow Bath Soil Landscape Unit covers approximately 1,097 hectares (10.5 per cent) of the PAA. For the purpose of this assessment the dominant soil type is represented by a Red Kandosol.

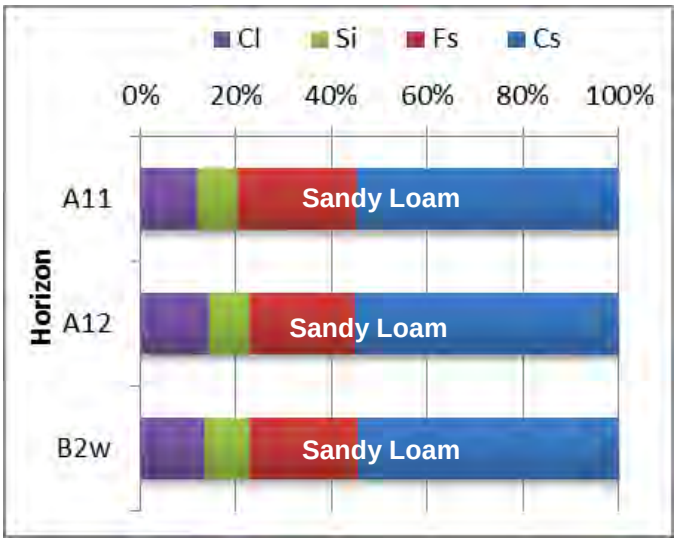
Plate 19 – Medlow Bath Soil Landscape

Soil Type 7 – Red-Orthic Tenosol

Soil Type 7 is a Red-Orthic Tenosol. In the PAA this soil type is comprised of three major soil horizons and the profile is characterised by a uniform sandy loam soil texture (**Graph 19**). Soil pH is strongly acidic to very strongly acidic to, the profile is non-saline (**Graph 20**) and non sodic. CEC is low throughout and exchangeable calcium is low relative to magnesium (**Graph 21**).

Table 3.12 provides a summary of this soil type.

Table 3.12 – Overview: Soil Type 7

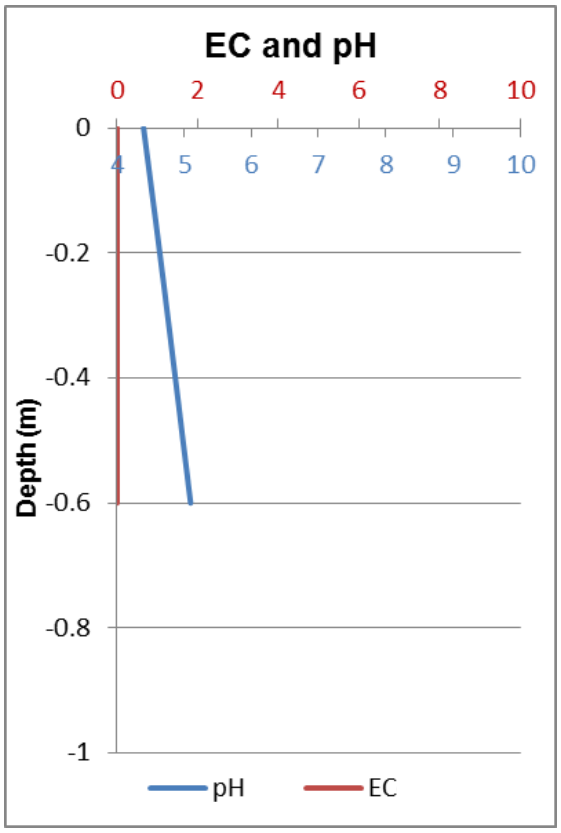
Site Description	
	
Plate 20 – Profile (Site 8)	**Plate 21 – Landscape (Site 8)**
	
Graph 19 – Site 8 PSA	

ASC Name	Red-Orthic Tenosol
Representative Site	Site 8
Associated Soil Landscape	Medlow Bath
Dominant Slope Association	Moderately steep to very steep (10-32% slopes)
Land Use and Vegetation	Remnant open forest
Land and Soil Capability Limiting Class	6
Soil Stripping Recommendation	0.0 – 0.60 m is suitable for stripping and re-use in localised rehabilitation if ameliorated with gypsum or lime for acidity. Ameliorate with organic amendments to improve subsoil structure.

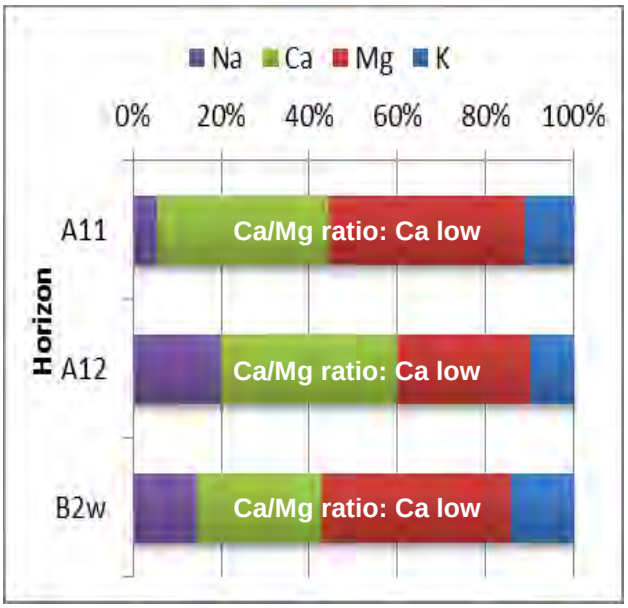
Horizon	Depth (m)	Description
A11	0.0–0.15	Dark brown (5YR4/4) sandy loam, moderate structure of 10 – 30 mm sub angular blocky peds, with a weak consistence. Very strongly acidic (pH 4.4) and very low salinity (EC 0.03 dS/m). Well drained with a gradual boundary and coarse fragments at a 10% presence.

A12	0.15–0.25	Dark Reddish Brown (5YR3/4) sandy loam, moderate structure grade of 10 – 20 mm rounded peds with a weak consistence. Very strongly acidic (pH 4.7) and very low salinity (EC 0.02 dS/m). Well drained with a clear boundary and coarse fragments at 5% presence.
B2w	0.25–0.60	Dark Reddish Brown (5YR3/4) sandy loam, very weak structure grade of 5 - 10 mm rounded peds with a weak consistence. Strongly acidic (pH 5.1) and very low salinity (EC 0.01 dS/m). Well drained with a gradual boundary and coarse fragments at 10% presence.
CB	0.60+	Friable parent material

Horizon	CEC		ESP		OC		EAT	
	meq/100g	rating	%	rating	%	rating	class	rating
A11	5.6	Very low	1.8	Non sodic	4.1	Very high	8	Negligible
A12	4.0	Very low	5.0	Non sodic	2.2	High	8	Negligible
B2w	2.6	Very low	3.8	Non sodic	1.2	Moderate	3(1)	Slight



Graph 20 – Site 8 pH and EC



Graph 21 – Site 8 Exchangeable Cations

3.2.8 Newnes Plateau Soil Landscape

The Newnes Plateau Soil Landscape Unit consists of level to gently undulating low crests and ridges on plateau surfaces of Triassic Grose Sandstone (**Plate 22**). Local relief is to 20 metres, with slopes <10 per cent, and infrequent rock outcrop. Partially cleared low open forest and woodland and pine plantations characterise this landscape. Soils are typically dominated by shallow Sands/Lithosols (Rudosols) on crests and associated with rock outcrop; moderately deep Earthy Sands (Tenosols) on gently inclined sideslopes; and moderately deep Yellow Earths (Kandosols) associated with shale / ironstone lenses; and deep Earthy Sands (Tenosols) on deeply weathered friable sandstones.

Limitations to this unit include acid, highly permeable, stony soils of low fertility, low water holding capacity, high potential aluminium toxicity and localised shallow soils. This soil landscape is generally suited to grazing and has moderate limitations for cultivation.

The Newnes Plateau Soil Landscape Unit covers approximately 2,036 hectares (19.4 per cent) of the PAA. For the purpose of this assessment there are two soil types separated by different soil surveys. Soil Type 8a is represented by a Brown-Orthic Tenosol and is considered to be the dominant soil type for this landscape. Soil Type 8b is a Mesotrophic Brown Kandosol (correlated from *Springvale Mine Extension Project – Soil and Land Capability Assessment* (SLR, 2013b)).

Plate 22 – Newnes Plateau Soil Landscape

Soil Type 8a – Brown-Orthic Tenosol

Soil Type 8a is a Brown-Orthic Tenosol. In the PAA this soil type is comprised of three major soil horizons and the profile is characterised by sandy loam topsoil grading to loamy sand (**Graph 22**). Soil pH trends from very strongly acidic to strongly acidic, the profile is non-saline (**Graph 23**) and the topsoil subsoil is marginally sodic trending to strongly sodic at depth. CEC is very low throughout; and exchangeable calcium is low to deficient relative to magnesium (**Graph 24**).

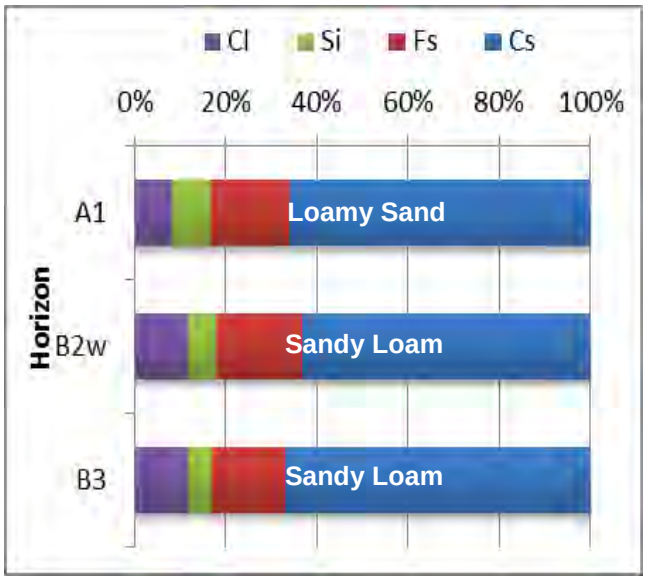
Table 3.13 provides a summary of this soil type. Brown Dermosols are also common.

Table 3.13 – Overview: Soil Type 8a

Site Description

Plate 23 – Profile (Site 9)

Plate 24 – Landscape (Site 9)



Graph 22 – Site 9 PSA

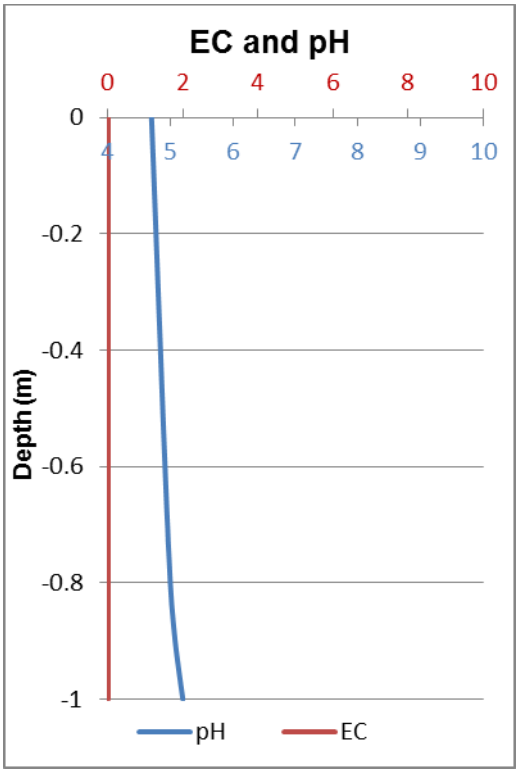
ASC Name	Brown-Orthic Tenosol
Representative Site	Site 9
Associated Soil Landscape	Newnes Plateau
Dominant Slope Association	Flat to gently inclined (<10% slope)
Land Use and Vegetation	Remnant open forest
Land and Soil Capability Limiting Class	5
Soil Stripping Recommendation	0.0 – 0.25 m is suitable for stripping and re-use in localised rehabilitation if ameliorated with gypsum or lime for acidity..

Horizon	Depth (m)	Description
A1	0.0–0.25	Dark brown (10YR3/3) loamy sand, moderate structure of 10 – 30 mm rounded blocky peds, with a weak consistence. Very strongly acidic (pH 4.7) and very low salinity (EC <0.01 dS/m). Well drained with a gradual boundary.
B2w	0.25–0.80	Strong brown (7.5YR4/6) sandy loam, weak structure grade of 5 – 10 mm rounded blocky peds with a weak consistence. Strongly acidic (pH 5.0) and very low salinity (EC <0.01 dS/m). Well drained with a gradual boundary.

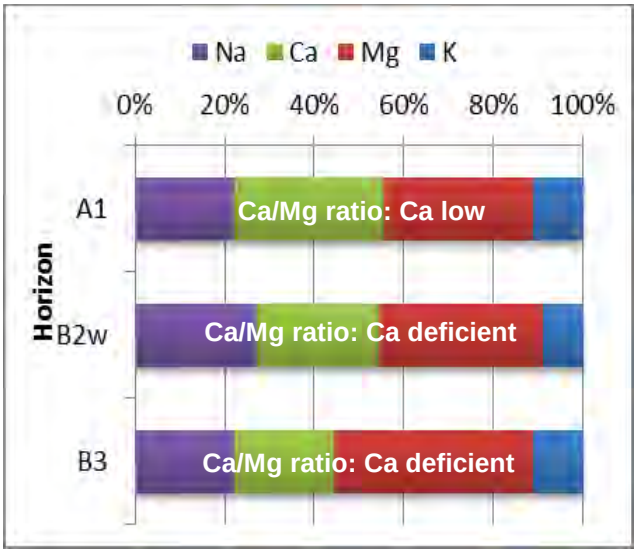
B3	0.80–1.00	Strong brown (7.5YR5/8) sandy loam, apedal structure. Strongly acidic (pH 5.2) and very low salinity (EC <0.01 dS/m). Well drained.

Horizon	CEC		ESP		OC		EAT	
	meq/100g	rating	%	rating	%	rating	class	rating
A1	4.6	Very low	8.3	Marginally sodic*	1.79	Moderate	8	Negligible
B2w	3.1	Very low	16.7	Strongly sodic*	0.38	Extremely low	6	Negligible
B3	3.1	Very low	16.7	Strongly sodic*	0.22	Extremely low	6	Negligible

*low clay content; ESP concentration may be skewed



Graph 23 – Site 9 pH and EC



Graph 24 – Site 9 Exchangeable Cations

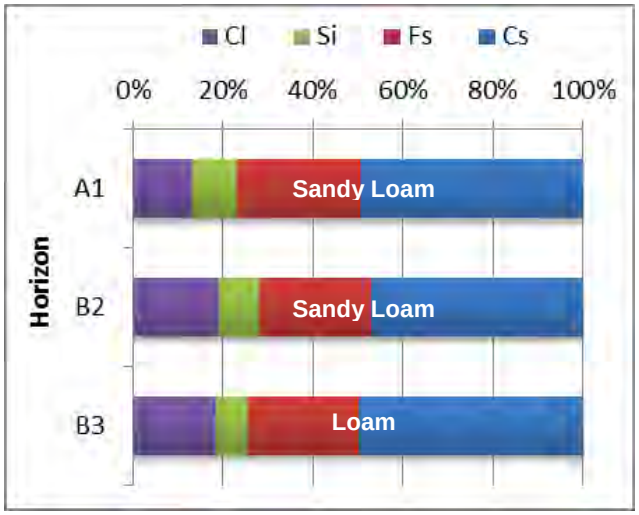
Soil Type 8b – Mesotrophic Brown Kandosol

Soil Type 8b is a Mesotrophic Brown Kandosol. This soil type is comprised of three major soil horizons and the profile is characterised by sandy loam topsoil overlying loam subsoil (**Graph 25**). Soil pH is very strongly acidic; salinity is very low throughout the profile (**Graph 26**); and the profile is non sodic at the surface trending to sodic at depth. CEC is very low throughout and exchangeable calcium is low relative to magnesium (**Graph 27**).

This Soil Type has been correlated with Newnes Plateau from *Springvale Mine Extension Project – Soil and Land Capability Assessment* (SLR, 2013b).

Table 3.14 provides a summary of this soil type.

Table 3.14 – Overview: Soil Type 8b

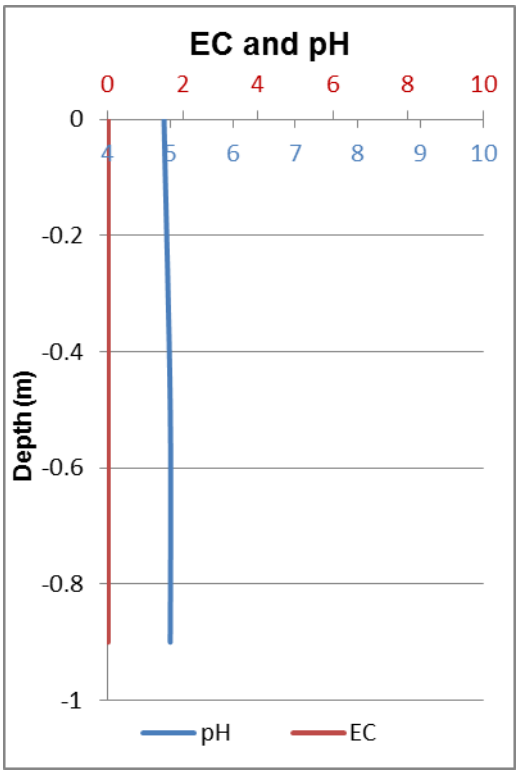
Site Description	
 **Plate 25 – Profile (Site 13) (SLR, 2013b)**	 **Plate 26 – Landscape (Site 13)**  **Graph 25 – Site 13 (SLR, 2013b) PSA**

ASC Name	Mesotrophic Brown Kandosol
Representative Site	Site 13 (SLR, 2013b)
Associated Soil Landscape	Newnes Plateau
Dominant Slope Association	Flat to gently inclined (<10% slope)
Land Use and Vegetation	Forestry (pine)
Land and Soil Capability	Class 5
Within Surface Infrastructure Area	Yes
Soil Stripping Recommendation	0.0 – 0.80 m is suitable for stripping and re-use in localised rehabilitation. Requires amelioration with gypsum/ lime for acidity and organic amendments to aid soil structure. Amelioration of sodic subsoil also required should the subsoil be used in rehabilitation works.

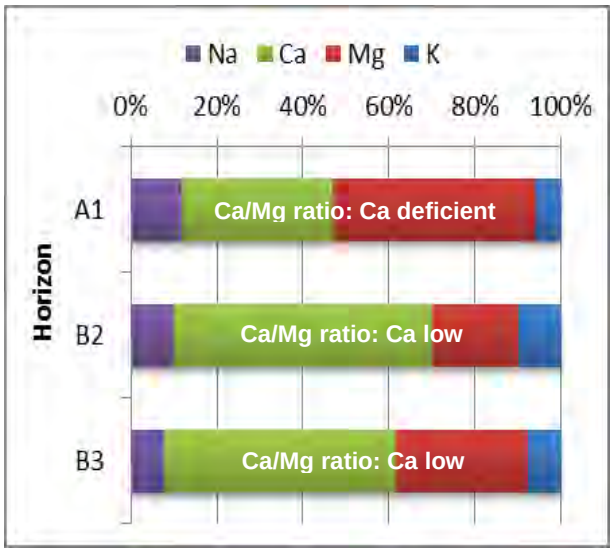
Horizon	Depth (m)	Description
A1	0.0–0.15	Dark brown (10YR3/3) sandy loam, moderate structure grade of 10 – 20 mm angular blocky peds with a weak consistence. Very strongly acidic (pH 4.4) and very low salinity (EC 0.01 dS/m). Well drained with a clear boundary and coarse fragments at 5% presence.

B2	0.15–0.40	Dark brown (10YR3/3) sandy loam, moderate structure grade of 10 mm angular blocky peds with a weak consistence. Very strongly acidic (pH 4.7) and very low salinity (EC 0.01 dS/m). This horizon is well drained with a gradual boundary.
B3	0.40–0.80	Strong brown (7.5YR4/6) loam, weak to moderate structure grade of 10 mm angular blocky peds with a weak consistence. Very strongly acidic (pH 4.8) and very low salinity (EC 0.01 dS/m). This horizon is well drained with coarse fragments at a 10% presence.

Horizon	CEC		ESP		OC		EAT	
	meq/100g	rating	%	rating	%	rating	class	rating
A1	5.8	Very low	3.4	Non sodic	1.7	Moderate	8	Negligible
B2	2	Very low	10.0	Marginally sodic	1.9	High	8	Negligible
B3	1.6	Very low	12.5	Sodic	0.6	Moderate	6	Negligible



Graph 26 – Site 13 (SLR, 2013b) pH and EC



Graph 27 – Site 13 (SLR, 2013b) Exchangeable Cations

3.2.9 Deanes Creek Soil Landscape

The Deanes Creek Soil Landscape Unit consists of narrow, gently inclined elongated valley-side tree swamps along drainage lines on Narrabeen Group Sandstones (**Plate 27**). Local relief is to 30 metres, with slopes 10 - 30 per cent. Vegetation consists of cleared closed heath and closed sedgeland with open woodland on swamp margins. Soils are dominated by moderately deep waterlogged Humic Gley Soils (Hydrosols) and Grey Earths (Kandosols) near and along drainage lines with shallow to moderately deep Peaty Sands (Tenosols) and Earthy Sands (Tenosols) on swamp margins.

Limitations to this unit include permanently high water tables and periodic to permanent waterlogging, acid soils of low fertility, high run-on, and high foundation hazard. This soil landscape is generally unsuitable for cultivation or grazing due to severe limitations.

The Deanes Creek Soil Landscape Unit covers within 68 hectares (0.6 per cent) of the PAA; a variant to this unit is present on steeper slopes and is also present within the PAA (63 hectares, 0.6 per cent). The total for the Deanes Creek Soil Landscape Unit is 131 hectares (1.2 per cent). For the purpose of this assessment it is represented by the dominant soil type is represented by a Brown Kandosol.

Plate 27 – Deanes Creek Soil Landscape

Soil Type 9 – Mesotrophic Brown Kandosol

Soil Type 9 is a Mesotrophic Brown Kandosol. In the PAA this soil type is comprised of three major soil horizons and the profile is characterised by a loam grading to a sandy loam and sandy clay loam. Soil pH is pH trends from very strongly acidic in the topsoil to moderately acidic in the subsoil, salinity is very low throughout the profile (**Graph 28**) and non sodic. CEC is very low throughout and exchangeable calcium is low relative to magnesium (**Graph 29**).

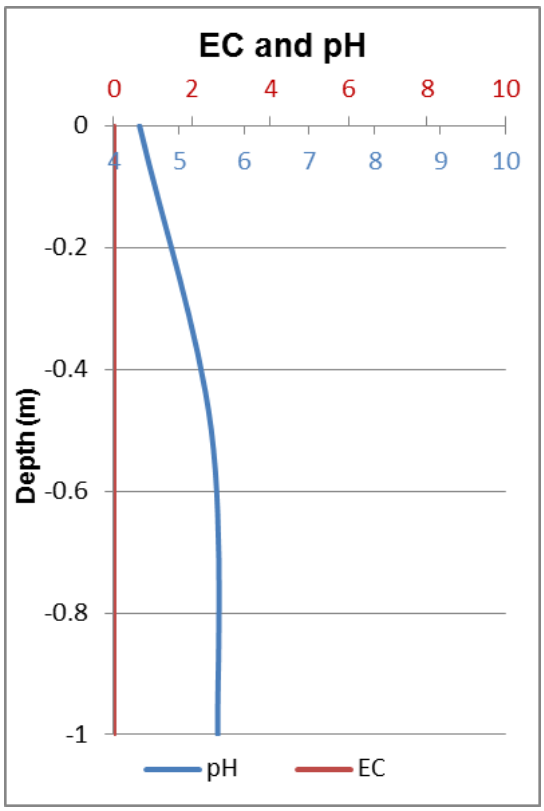
Table 3.15 provides a summary of this soil type.

Table 3.15 – Overview: Soil Type 9

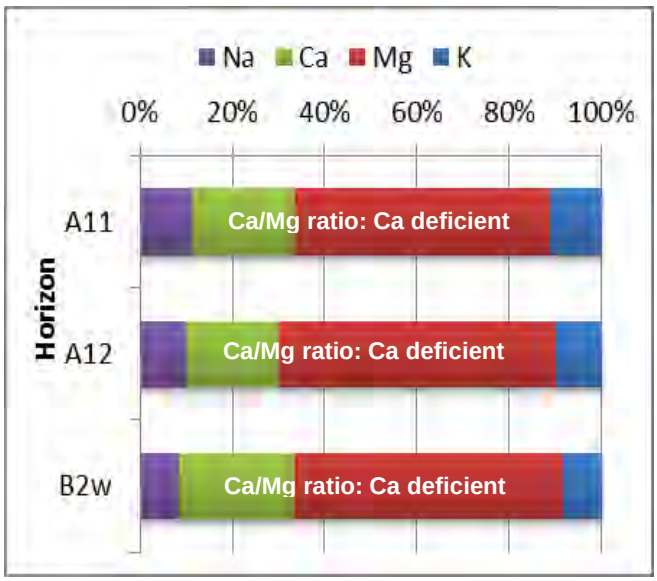
Site Description		
 **Plate 28 – Profile (Site 24)**		 **Plate 29 – Landscape (Site 24)**
ASC Name	Mesotrophic Brown Kandosol	
Representative Site	Site 24	
Associated Soil Landscape	Deanes Creek	
Dominant Slope Association	Gently inclined (3-10% slopes) with some areas up to 33%	
Land Use and Vegetation	Remnant open forest	
Land and Soil Capability Limiting Class	6	
Soil Stripping Recommendation	0.0 – 0.40 m is suitable for stripping and re-use in localised rehabilitation if ameliorated with gypsum or lime for acidity.	
Horizon	**Depth (m)**	**Description**
A11	0.0–0.15	Brown loam, moderate structure of 5 – 10 mm blocky peds, with a weak consistence. Very strongly acidic (pH 4.4)* and very low salinity (EC 0.01 dS/m)*. Well drained with a clear boundary.
A12	0.15–0.40	Greyish-brown sandy loam, weak structure grade of 10 – 20 mm blocky peds with a weak consistence. Strongly acidic (pH 5.5)* and very low salinity (EC 0.01 dS/m)*. Moderately drained with a clear boundary.
B2w	0.40–0.80	Yellowish-brown sandy clay loam, weak structure grade of 10 – 20 mm blocky peds with a weak consistence. Moderately acidic (pH 5.6)* and very low salinity (EC 0.01 dS/m)*. This horizon is well drained.

Horizon	CEC*		ESP*		OC*		EAT*	
	meq/100g	rating	%	rating	%	rating	class	rating
A11	4.3	Very low	2.3	Non sodic	2.9	High	8	Negligible
A12	2.7	Very low	3.7	Non sodic	0.4	Very low	6	Negligible
B2w	3.1	Very low	3.2	Non sodic	0.2	Extremely low	6	Negligible

* Correlated with Deanes Creek Soil Landscape Soil Type from *Springvale Mine Extension Project – Soil and Land Capability Assessment* (SLR, 2013b)



Graph 28 – Site 6 pH and EC (SLR, 2013b)



Graph 29 – Site 6 Exchangeable Cations (SLR, 2013b)

3.2.10 Long Swamp Soil Landscape

The Long Swamp Soil Landscape Unit consists of level to very gently inclined swamps on recent alluvium overlying the Permian Illawarra Coal Measures (**Plate 30**). Local relief is to 20 metres, with slopes mainly <3 per cent. Closed sedgeland and closed heath with open forest on swamp margins characterises this landscape. Soils are dominated by moderately deep wet Peaty Loams (Podzol/Hydrosol), Grey Earths (Kandosols) and Humic Gleys (Hydrosols).

Limitations to this unit include high run-on, permanent high water tables, waterlogging, high foundation hazard, and highly organic acid soils of low fertility. This soil landscape is generally suited to light grazing and has moderate limitations for cultivation.

The Long Swamp Soil Landscape Unit covers approximately 236 hectares (2.3 per cent) of the PAA. For the purpose of this assessment the dominant soil type is represented by an Orthic Tenosol.

Plate 30 – Long Swamp Soil Landscape

Soil Type 10 – Brown-Orthic Tenosol

Soil Type 10 is a Brown-Orthic Tenosol. In the PAA this soil type is comprised of three major soil horizons and the profile is characterised by a uniform loamy sand soil texture (**Graph 30**). Soil pH trends from very strongly acidic to strongly acidic, the profile is non-saline (**Graph 31**) and the topsoil is non-sodic becoming marginally sodic at depth. CEC is very low throughout, and exchangeable calcium is low relative to magnesium (**Graph 32**).

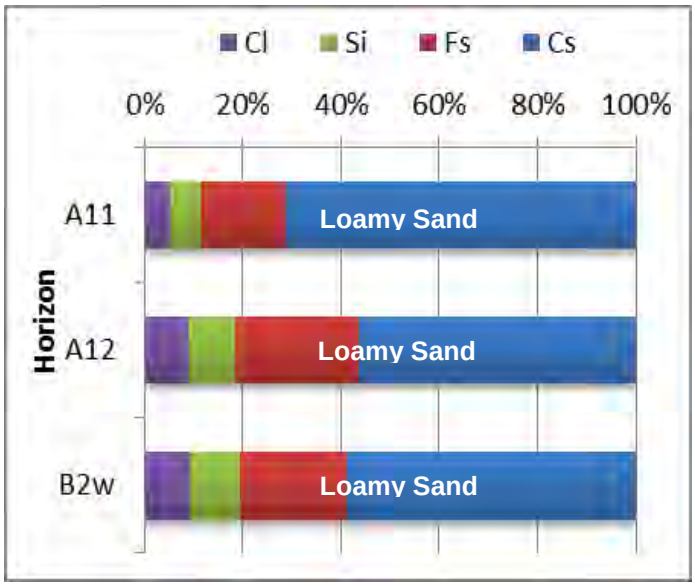
Table 3.16 provides a summary of this soil type.

Table 3.16 – Overview: Soil Type 10

Site Description

Plate 31 – Profile (Site 17)

Plate 32 – Landscape (Site 17)



Graph 30 – Site 17 PSA

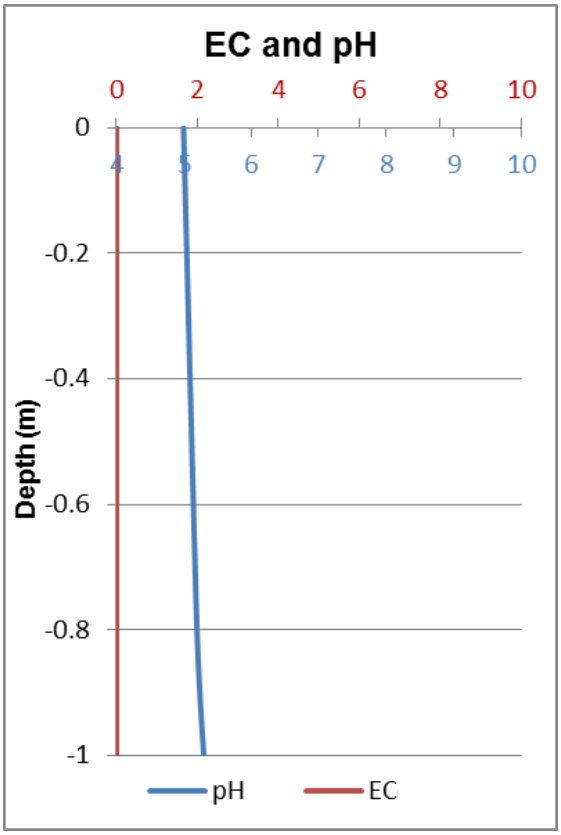
ASC Name	Brown-Orthic Tenosol
Representative Site	Site 17
Associated Soil Landscape	Long Swamp
Dominant Slope Association	Very gently inclined (0-3% slopes)
Land Use and Vegetation	Cleared for grazing; some remnant vegetation
Land and Soil Capability Limiting Class	6
Soil Stripping Recommendation	0.0 – 0.5 m is suitable for stripping and re-use in localised rehabilitation. Organic amendment to improve soil structure is required.

Horizon	Depth (m)	Description
A11	0.0–0.10	Brown (10YR4/3) loamy sand, weak structure of 5 – 20 mm blocky peds with a weak consistence. Very strongly acidic (pH 5.0) and very low salinity (EC 0.03 dS/m). Well drained with a clear boundary and a coarse fragment presence of 25%.

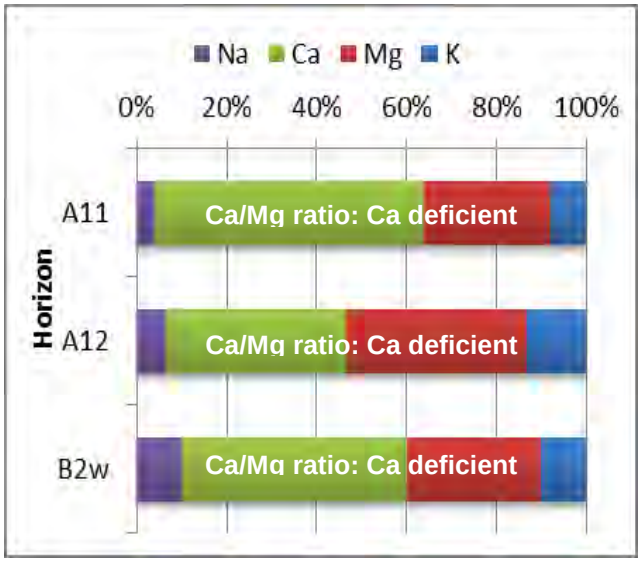
A12	0.10–0.50	Brown (10YR4/3) loamy sand, weak to moderate structure grade of 10 – 20 mm blocky peds with a weak consistence. Strongly acidic (pH 5.2) and very low salinity (EC <0.01 dS/m). Well drained with a gradual boundary and coarse fragments at a 5% presence.
B2w	0.50–1.00	Brown (7.5YR5/4) loamy sand with apedal structure. Strongly acidic (pH 5.3) and very low salinity (EC 0.01 dS/m). This horizon is moderately drained with coarse fragments at 5% presence.

Horizon	CEC		ESP		OC		EAT	
	meq/100g	rating	%	rating	%	rating	class	rating
A11	3.6	Very low	3.6	Non sodic	2.2	High	8	Negligible
A12	2.2	Very low	4.5	Non sodic	0.9	Moderate	3(1)	Slight
B2w	1.6	Very low	6.3	Marginally sodic*	0.3	Extremely low	5	Slight

*low clay content; ESP concentration may be skewed



Graph 31 – Site 17 pH and EC



Graph 32 – Site 17 Exchangeable Cations

3.2.11 Mount Sinai Soil Landscape

The Mount Sinai Soil Landscape Unit consists of narrow, rocky undulating crests and steep sideslopes with many rocky benches and pagoda formations on Narrabeen Group Sandstones (**Plate 33**). Local relief is to 130 metres, with slopes generally >30 per cent, and abundant rock outcrop. Open heath with some open woodland in protected valleys characterises this landscape. Soils are dominated by very shallow, stony sands/Lithosols (Rudosols) on crests and sideslopes with rocky benches; shallow Earthy Sands (Tenosols) and occasional Yellow earths (Kandosols) on insides of benches and in deeply weathered joint lines in the Narrabeen group sandstones; and shallow Earthy Sands (Tenosols) in narrow incised valleys.

Limitations to this unit include extreme water erosion hazard, rock outcrop, steep slopes, rock fall hazard, wind erosion hazard, and stony shallow, acid, non-cohesive highly permeable soils with low fertility. This soil landscape is generally unsuitable for cultivation or grazing due to severe limitations.

The Mount Sinai Soil Landscape Unit covers approximately 397 hectares (3.8 per cent) of the PAA. For the purpose of this assessment the dominant soil type is represented by an Orthic Tenosol.

Plate 33 – Mount Sinai Soil Landscape

Soil Type 11 – Arenic Rudosol

Soil Type 11 is a Arenic Rudosol. In the PAA this soil type is comprised of three major soil horizons and the profile is characterised by a uniform loamy sand soil texture (**Graph 33**). Soil pH is very strongly acidic throughout, the profile is non-saline (**Graph 34**) and the topsoil is marginally sodic becoming strongly sodic at depth. CEC is very low throughout and, exchangeable calcium is low relative to magnesium (**Graph 35**).

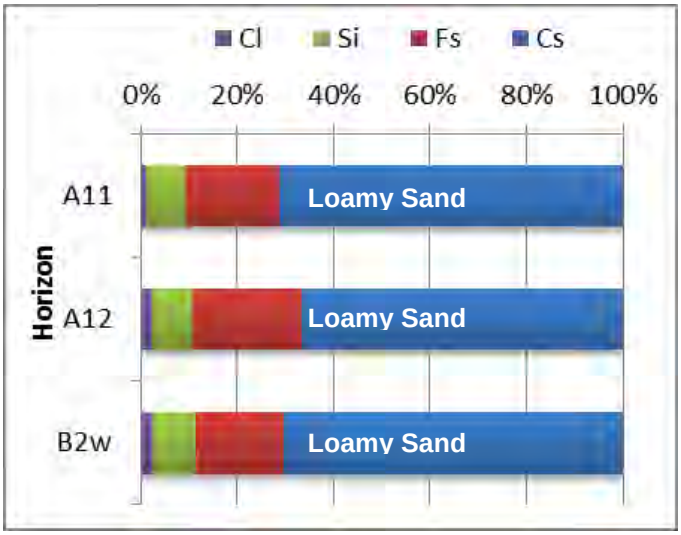
Table 3.17 provides a summary of this soil type.

Table 3.17 – Overview: Soil Type 11

Site Description

Plate 34 – Profile (Site 12)

Plate 35 – Landscape (Site 12)



Graph 33 – Site 12 PSA

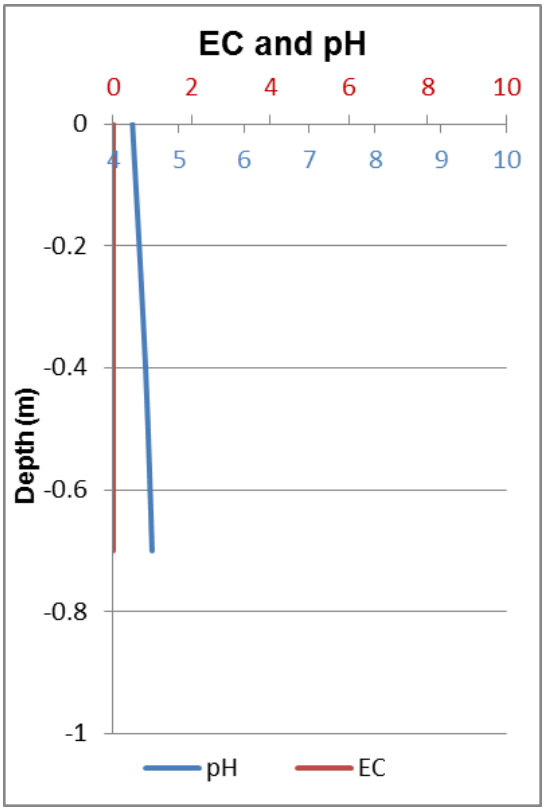
ASC Name	Arenic Rudosol
Representative Site	Site 12
Associated Soil Landscape	Mount Sinai
Dominant Slope Association	Steep to very steeply inclined (>32% slopes)
Land Use and Vegetation	Remnant open forest
Land and Soil Capability Limiting Class	7
Soil Stripping Recommendation	0.0 – 0.10 m is suitable for stripping and re-use in localised rehabilitation if ameliorated with gypsum or lime for acidity. Organic amendment to improve soil structure is required.

Horizon	Depth (m)	Description
A11	0.0–0.10	Very dark grey (10YR3/1) loamy sand, weak structure of 10 – 20 mm blocky peds, with a weak consistence. Very strongly acidic (pH 4.3) and very low salinity (EC 0.03 dS/m). Well drained with a clear boundary and a coarse fragment presence of 5%.
A12	0.10–0.40	Very dark grey (10YR3/1) loamy sand, very weak structure grade of 10 – 30 mm blocky peds with a weak consistence. Very strongly acidic (pH 4.5) and very low salinity (EC 0.02 dS/m). Well drained with an abrupt boundary.

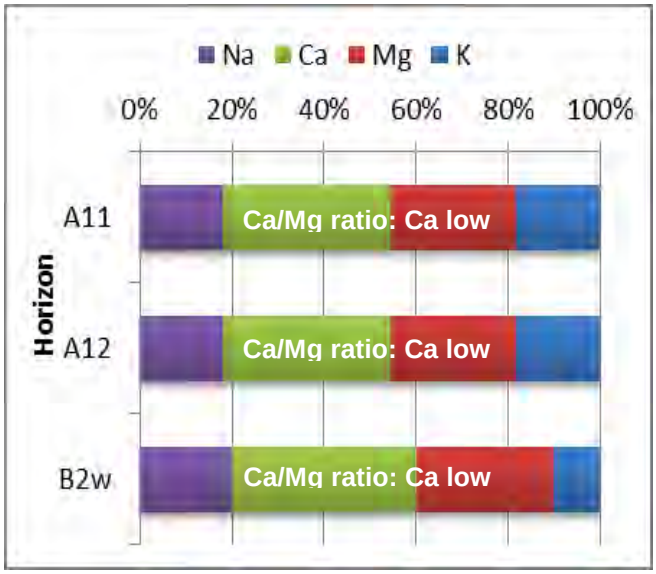
B2w	0.40–0.70	Brown (10YR3/2) loamy sand, with apedal structure. Very strongly acidic (pH 4.6) and very low salinity (EC 0.01 dS/m). This horizon is moderately drained.
C	0.70+	Decomposing parent material

Horizon	CEC		ESP		OC		EAT	
	meq/100g	rating	%	rating	%	rating	class	rating
A11	1.6	Very low	12.5	Marginally sodic*	1.8	High	8	Negligible
A12	1.8	Very low	11.1	Marginally sodic*	1.7	Moderate	8	Negligible
B2w	1.3	Very low	15.4	Strongly sodic*	0.6	Very low	2(1)	High to moderate

*low clay content; ESP concentration may be skewed



Graph 34– Site 12 pH and EC



Graph 35 – Site 12 Exchangeable Cations

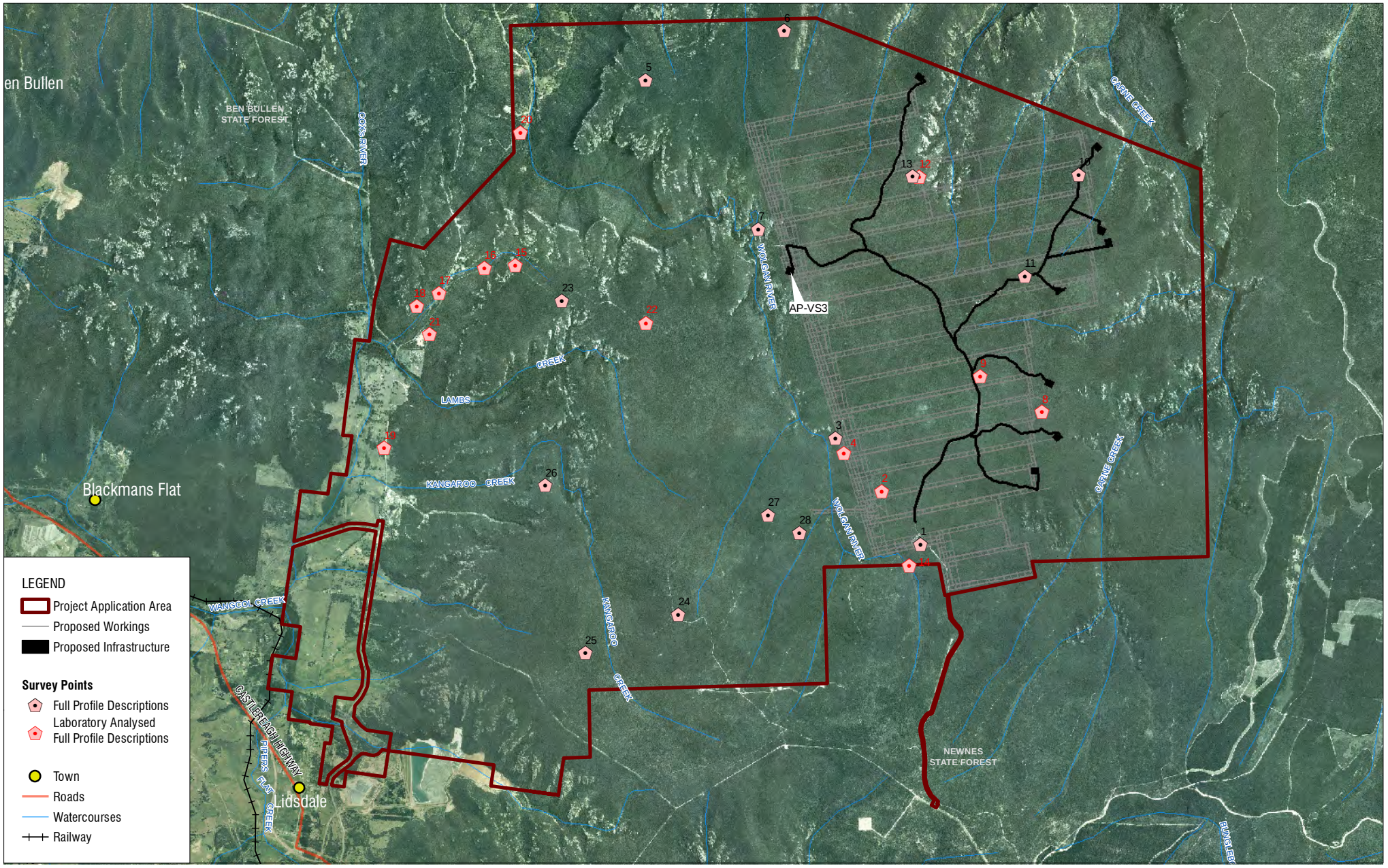
3.2.12 Coco Soil Landscape

The Coco Soil Landscape Unit consists of narrow crests and ridges and steep sideslopes on mixed Devonian sediments. Local relief is to 80 – 180 metres, with slopes mostly >25 per cent. Rock outcrop and surface boulders, cobbles and gravels are common especially on quartzite and porphyry parent materials.

The soils are highly variable; however, are mostly shallow to moderately deep stony Lithosols (Rudosols, Tenosols), Earthy Sands (Tenosols) and Yellow Podzolic Soils (Chromosols, Kurosols) on porphyries and some quartzite; shallow to moderately deep Yellow and Red Podzolic Soils (Chromosols, Kurosols) and Red Earths (Kandosols) on shales, some limestones and sandstones; shallow Terra Rossa/Red Podzolic Soil intergrades (Dermosols, Chromosols, Kandosols/ Chromosols, Kurosols) on some limestones; and shallow Yellow Podzolic Soils (Chromosols, Kurosols) and Lithosols Rudosols) on schist and some quartzites.

Limitations to this unit include shallow stony soils, localised rock outcrop, steep slopes, mass movement hazard, and high foundation hazard. This soil landscape is generally unsuitable for cultivation or grazing due to severe limitations.

The Coco Soil Landscape Unit's dominant soil type is a Rudosol. This Soil Landscape Unit was not ground truthed as it has limited distribution (0.1 per cent of the PAA) and is external to the location of the Proposed Project Components.



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10 KINGS ROAD
NEW LAMBTON
NEW SOUTH WALES 2305
AUSTRALIA
T: 61 2 4037 3200
F: 61 2 4037 3201
www.slrconsulting.com

Project No.:	CCC07-010
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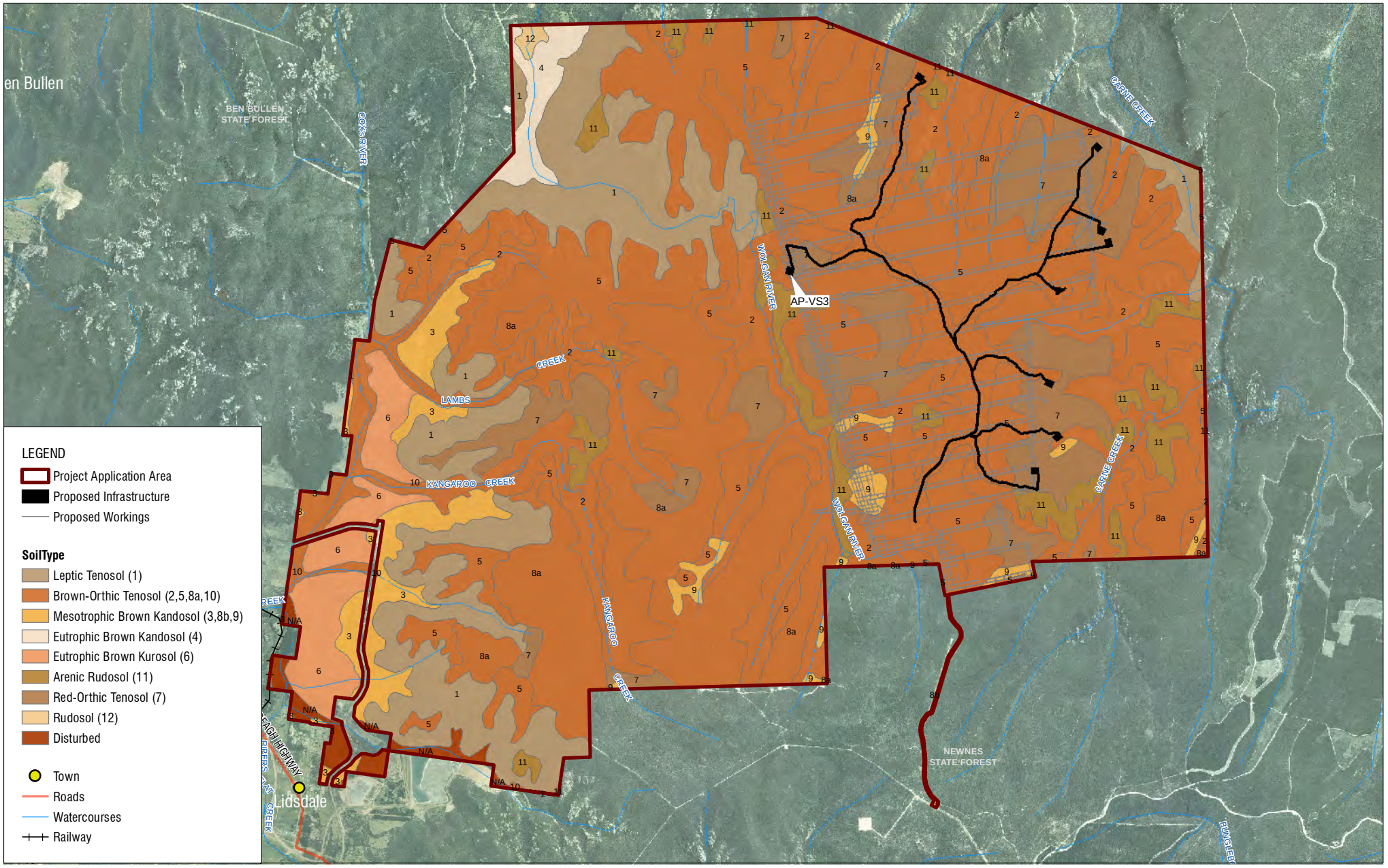
FIELD SURVEY

FIGURE 3.1



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SLR
10 KINGS ROAD
NEW LAMBTON
NEW SOUTH WALES 2305
AUSTRALIA
T: 61 2 4037 3200
F: 61 2 4037 3201
www.slrconsulting.com

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ANGUS PLACE SOILS & LAND RESOURCE

SOIL TYPES

FIGURE 3.2

4.0 LAND ASSESSMENT

In NSW, rural lands are currently being mapped according to two different land classification systems. The first system was developed by the NSW Office of Environment and Heritage and classifies land into eight classes (Classes 1 to 8) known as Land and Soil Capability (LSC) classes. This system has been recently introduced to replace the former Rural Land Capability System (Emery, 1986) that was formerly the benchmark for land capability assessments in NSW. The second system, developed by the former NSW Department of Agriculture (now part of the DPI), classifies land into five classes (Classes 1 to 5) known as Agricultural Suitability classification. The third is system used to identify BSAL (refer **Section 1.4.2**)

The PAA has been assessed for:

- LSC classification;
- Agricultural Suitability classification; and
- BSAL.

4.1 Land and Soil Capability

4.1.1 Methodology

The LSC classification applied to the PAA was in accordance with *The Land and Soil Capability Assessment Scheme; Second approximation* (OEH, 2012) (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 4.1** and their definition has been based on two considerations:

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

Table 4.1 – 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.

Class	Land and Soil Capability
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

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 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; and
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 PAA 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 per cent, which may be designated LSC 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 the wind erosion hazard for each soil unit:

- Wind erosive power - has been mapped in the PAA as ‘High’ (Figure 6 in the LSC Guideline).
- Capacity of the land to maintain surface cover - determined by the average rainfall. For the PAA the average annual rainfall is 1,073 millimetres (refer **Section 3.1**) and therefore the PAA lies within the “greater than 500 millimetres rainfall” (Table 6 of the LSC Guideline).

- Erodibility of the soil to wind - determined by surface texture in accordance with Table 5 of the LSC guideline.

- Exposure of the land to wind - determined by site inspection of location and exposure within the PAA.

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, being soil buffering capacity, pH and mean annual rainfall. In this assessment, soil buffering capacity was based on the Great Soil Groups (Table 9 in the LSC Guideline); surface soil pH and a regional mean annual rainfall range of greater than 900 millimetres.

Hazard 5: Salinity

The salinity hazard is determined through a range of data and criteria. The overall recharge potential for the site was determined based on an average annual rainfall of 1,073 millimetres, with annual evaporation of 1400-1600 millimetres (BOM, 2006). This suggests low recharge potential, however, recharge potential also relates to landform position with elevated sites having a high recharge potential.

The PAA, according to the Salt Store Map of NSW (Figure 7 in the LSC Guideline) is located in area of low salt store. 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 Assessment

The PAA has been assessed and classified into the Land and Soil Capability Classes 4, 5, 6, 7 and 8, as shown in **Table 4.2**.

Table 4.2 – Land and Soil Capability Assessment

Soil Types		Hazard Criteria								
No.	Name	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	Leptic Tenosol	8	5	3	5	1	1	6	8	**8**
2	Brown-Orthic Tenosol	8	5	3	4	1	1	3	8	**8**
3	Mesotrophic Brown Kandosol	**3**	4	3	4	1	1	2	1	**4**
4	Eutrophic Brown Kandosol	4	4	3	3	1	2	1	1	**4**
5	Brown-Orthic Tenosol	6	5	3	5	1	1	4	1	**6**
6	Eutrophic Brown Kurosol	3	5	3	3	1	3	3	1	**5**
7	Red-Orthic Tenosol	4	5	3	6	1	1	4	1	**6**
8a	Brown-Orthic Tenosol	3	5	3	5	1	1	2	1	**5**
8b	Mesotrophic Brown Kandosol	3	4	3	5	1	1	3	1	**5**
9	Mesotrophic Brown Kandosol	2	3	3	6	1	1	1	1	**6**
10	Brown-Orthic Tenosol	1	5	3	5	1	1	1	1	**5**
11	Arenic Rudosol	7	7	3	6	1	1	6	1	**7**
12^	Rudosol									**7**

^ LSC correlated with Soil Landscapes of the Wallerawang 1:100,000 Sheet (King 1993).

A summary of the LSC Classes across the PAA is provided in **Table 4.3** and the key findings are:

- The dominant LSC Class in the PAA is Class 6 (37.2 per cent), which describes land suitable for limited set of land uses, such as grazing and forestry.
- The second dominant LSC Class in the PAA is Class 8 (29.0 per cent), which describes land capable of sustaining any land use except nature conservation.
- The most agricultural productive LSC Class in the PAA is Class 4 (4.1 per cent), which is land capable of a variety of land uses and is suited to grazing restricted cultivation.
- The dominant LSC Class in the Proposed Surface Infrastructure assessment area is Class 6 (61.7 per cent). No Class 4 land is present in the Proposed Surface Infrastructure assessment area.

Table 4.3 – Land and Soil Capability Classes

Land and Soil Capability	PAA		Proposed Surface Infrastructure Assessment Area	
Class	**ha**	**%**	**ha**	**%**
4	427	4.1	Nil	Nil
5	2,607	24.9	52	36.9
6	3,900	37.2	87	61.7
7	412	3.9	1	0.7
8	3,027	29.0	1	0.7
Disturbed Terrain	95	0.9	Nil	Nil
Total	**10,468**	**100.0**	**141**	**100.0**

The limitations associated with each LSC Class are discussed below and their distribution is shown in **Figure 4.1**.

Class 4 Land

Class 4 land is associated with the Cullen Bullen and Glen Alice Soil Landscape Units. This classification indicates that the land is capable of a limited range of land uses, and specialised practices are necessary to overcome very severe limitations. The land should not be cultivated for cropping or for establishing pasture grasses, however, the land can be used for grazing if careful management and stocking practices are implemented.

The primary constraint to these soil types are soil acidification hazard due to the low buffering capacity of the soils and the strongly acidic soil through the profiles and wind erosion hazard.

Class 5 Land

Class 5 land is associated with the Lithgow, Newnes Plateau and Long Swamp Soil Landscape Unit. This classification indicates that the land is capable of a very limited range of land uses, and careful management is required to prevent long-term impact on land use capability. The land should not be cultivated, and used for grazing, horticulture or forestry.

The primary constraint to these soil types are soil acidification hazard due to the low buffering capacity of the soils and the strongly acidic soil through the profiles and wind erosion hazard.

Class 6 Land

Class 6 land is associated with the Wollangambe, Medlow Bath and Deanes Creek Soil Landscape Units. This classification indicates the land has very low capability and is limited to grazing or forestry. Management of limitations is required to prevent significant land and environmental degradation.

The primary constraint to these soil types are soil acidification hazard due to the low buffering capacity of the soils and the strongly acidic soil through the profiles and water erosion hazard.

Class 7 Land

Class 7 land is associated with the Mt Sinai Soil Landscape Unit. This classification indicates the land is incapable of any agricultural land use, however, may be used for forestry. Severe land use limitations must be managed to be prevent on-site and off-site impacts.

The primary constraint to the Mt Sinai soil type is the water erosion hazard due to the steep slope gradients which are typically greater than 30 per cent.

Class 8 Land

Class 8 land is associated with the Hassans Walls and Warragamba Soil Landscape Units. This classification indicates the land is incapable of any agricultural land use and it is recommended that no disturbance of native vegetation occur as the land is incapable of sustaining any land use.

The primary constraint for the Hassans Walls and Warragamba soil type is the water erosion hazard due to steep slope gradients.

4.2 Agricultural Suitability

4.2.1 Methodology

The Agricultural Suitability system was applied to the PAA in accordance with the DPI's guideline *Agricultural Suitability Maps – uses and limitations* (NSW Agricultural & Fisheries 1990). The system consists of five classes (Classes 1 to 5), providing a ranking of rural lands according to their productivity for a wide range of agricultural activities with the objective of determining the potential for crop growth within certain limits. A description of each Agricultural Suitability Class is provided in **Table 4.4**.

Table 4.4 – Agricultural Suitability Classes

Class	Land Use	Management Options
1	Highly productive land suited to both row and field crops.	Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.
2	Highly productive land suited to both row and field crops.	Arable land suitable for regular cultivation for crops but not suited to continuous cultivation.
3	Moderately productive lands suited to improved pasture and to cropping within a pasture rotation.	Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture.
4	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing.	Land suitable for grazing but not for cultivation. Agriculture is based on native or improved pastures established using minimum tillage.
5	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing.	Land unsuitable for agriculture or at best suited only to light grazing.

The main soil properties and other landform characteristics considered significant for the land suitability assessment are topsoil texture, topsoil pH, solum depth, external and internal drainage, topsoil stoniness and slope as well as bio-physical factors such as elevation, rainfall and temperature. The overall suitability classification for each specific soil type is determined by the most severe limitation, or a combination of the varying limitations.

4.2.2 Assessment

Agricultural Suitability has been assessed and classified into Class 3 and 5 for the PAA. The limitations associated with each Agricultural Suitability Class are discussed below and the land area of each Class is shown in **Table 4.5** and **Figure 4.2**.

Table 4.5 – Agricultural Suitability Class Areas

Agricultural Suitability	PAA		Proposed Surface Infrastructure Assessment Area	
Class	**ha**	**%**	**ha**	**%**
3	3,034	29.0	52.0	36.9
4	3,900	37.2	87.0	61.7
5	3,439	32.9	2.0	1.4
Disturbed Terrain	95	0.9	Nil	Nil
Total	**10,468**	**100.0**	**141**	**100.0**

Class 3 Land

Class 3 land consists of Soil Types 3, 4, 6, 8a, 8b and 10. Agricultural activity must be based on improved pastures established using minimum tillage techniques or cropping within a pasture rotation. The production level is low as a result of constraints such as high erodibility associated with slope and the chemical limitation of strong acidity on vegetation growth.

Class 4 Land

Class 4 land consists of Soil Types 5, 7 and 9. This classification indicates the land is suitable for grazing but not cultivation. Agriculture activity must be based on native or improved pastures established using minimum tillage techniques. The production level is low as a result of constraints such as high erodibility associated with slope, and shallow soils. Currently, the Class 4 land is partially cleared for grazing on mid slopes, and protected by green timber of upper slopes. However, no grazing is currently undertaken on the cleared area.

Class 5 Land

Class 5 land is consists of Soil Type 1, 2, 11 and 12. This class of land is best managed by the presence of light green timber due to its highly erodible soils and steep slopes. Partial clearing for grazing can occur, however, significant stands of trees are required to maintain soil cover. This soil type is severely constrained by its terrain, physical and chemical characteristics.

4.3 Biophysical Strategic Agricultural Land

The SRLUP for the PAA has not been released at the time of this assessment; therefore, no BSAL reference mapping is available and there is no requirement for a BSAL verification assessment. Notwithstanding, and adopting a precautionary approach, an assessment of the PAA against the BSAL criteria has been undertaken.

There are currently two documents pertaining to the assessment of BSAL, the Upper Hunter SRLUP and the Interim Protocol for BSAL Verification. The former is used to assess potential BSAL at a regional scale and the latter is used for site specific verification purposes. Although there is significant overlap between the two documents, there are differing BSAL assessment criteria contained in both and therefore a potential BSAL assessment has been undertaken using both documents.

4.3.1 BSAL Assessment Using SRLUP for the Upper Hunter

The values and criteria that relate to BSAL are from the Upper Hunter SRLUP and are reproduced below in **Table 4.6**.

Table 4.6 – BSAL Criteria: SRLUP for the Upper Hunter

Criteria
• Land that falls under soil fertility classes "high", "moderately high" under the Draft Inherent General Fertility of NSW and
• Land capability classes I, II or III under the Land and Soil Capability Mapping of NSW; 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; and
• Land capability classes I or II under the Land and Soil Capability Mapping of NSW; 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.

BSAL Assessment Results: Upper Hunter SRLUP

The minimum requirement for rainfall reliability for the region was met for the PAA (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 types fertility attributes (cross-referenced to the Great Soil Group) to determine if the BSAL criteria, as specified in **Table 4.6**, are met in the PAA. The soil fertility and the outcomes of the BSAL assessment are shown below in **Table 4.7**.

Table 4.7 – Applied BSAL Criteria: SRLUP for the Upper Hunter

Soil Type		Great Soil Group	LSC Class	Fertility*	BSAL	LSC Limitation
1	Leptic Tenosol	Lithosols	**8**	Low	No	LSC class & fertility
2	Brown-Orthic Tenosol	Earthy Sands	**8**	Low	No	LSC class
3	Mesotrophic Brown Kandosol	Brown Earths	**4**	Moderate	No	LSC class
4	Eutrophic Brown Kandosol	Brown Earths	**4**	Moderate	No	LSC class
5	Brown-Orthic Tenosol	Earthy Sands	**6**	Low	No	LSC class & fertility
6	Eutrophic Brown Kurosol	Brown Podzolic Soils	**5**	Moderate	No	LSC class
7	Red-Orthic Tenosol	Earthy Sands	**6**	Low	No	LSC class & fertility
8a	Brown-Orthic Tenosol	Earthy Sands	**5**	Low	No	LSC class & fertility
8b	Mesotrophic Brown Kandosol	Brown Earth	**5**	Moderate	No	LSC class

Soil Type		Great Soil Group	LSC Class	Fertility*	BSAL	LSC Limitation
9	Mesotrophic Brown Kandosol	Brown Earth	**6**	Moderate	No	LSC class
10	Brown-Orthic Tenosol	Earthy Sands	**5**	Low	No	LSC class & fertility
11	Arenic Rudosol	Earthy Sands	**7**	Low	No	LSC class & fertility
12	Rudosol	Lithosol	**7**	Low	No	LSC class & fertility

** Correlated based on Great Soil Group*

Whilst the PAA met the minimum rainfall, the fertility class and LSC classifications for each soil type indicate that the soil resources do not qualify as potential BSAL.

4.3.2 BSAL Assessment Using Interim Protocol

This methodology uses a two phase verification assessment:

- Phase 1 – Confirm access to reliable water supply; and
- Phase 2 - 12 step site verification criteria.

Phase 1 Assessment – Access to Reliable Water Supply

For lands to be classified as BSAL they must have access to reliable water supply which has been defined as:

- greater than 350 millimetres rainfall per annum (9/10 years); or
- within 150 metres of a regulated river; or
- within 150 metres of a 5th order unregulated river; or
- within 150 metres of an unregulated river that flows 95 per cent of the time; or
- access to highly productive groundwater (as defined by NSW Office of Water).

Phase 2 Assessment - Verification Criteria

The 12 step site verification criteria are detailed in Interim Protocol for BSAL Verification and are summarised in **Table 4.8**. If a criterion fails to meet any of the BSAL conditions (except step 5 or step 6), the site is rejected as BSAL and the remaining conditions are not assessed.

Table 4.8 – Twelve Step Site Verification Criteria According to Interim Protocol

Step Number	Criteria	BSAL Definition
1	Slope	Slope of less than or equal to 10%
2	Rock outcrop	Rock outcrop of less than 30%
3	Surface rockiness	Less than 20% of the area has unattached rock fragments greater than 60 mm diameter
4	Gilgai	Less than 50% of the area has gilgai depression that are deeper than 500 mm
5	Slope	Slope of less than 5%
6	Rock outcrop	Nil rock outcrop
7	Soil fertility	Moderate fertility (if < 5 % slope, nil rock outcrop)
		Moderately high or high fertility (if < 5% slope, 5-30% rock outcrop)

		Moderately high or high fertility (if > 5% slope)
8	Physical barrier	Effective rooting depth to a physical barrier is greater than or equal to 750 mm
9	Soil drainage	Soil drainage is better than poor
10	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.
11	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
12	Chemical barrier	Effective rooting depth to a chemical barrier is greater than or equal to 750 mm

BSAL Assessment Results: Interim Protocol

The minimum requirement for Phase 1 was met for all soil types with an average annual rainfall of approximately 1,073 millimetres for the PAA (Section 2.1).

According to the Phase 2 – Site verification assessment, none of the soil types are potential BSAL. A summary of the assessed criteria is provided in **Table 4.7** and the key findings are:

- Most soil types did not meet the first criteria of 'slope' (Soil Types 1, 2, 4, 5, 7, 8b, 11 and 12) with slopes greater than 10 per cent.
- Soil Types 3, 6, 8a and 9 did not meet the fifth criteria of 'slope' with slopes generally greater than 5 per cent, and subsequent criteria for soil fertility.
- Soil Type 10 failed the 'soil fertility' criteria due to an inherent fertility of moderately low.

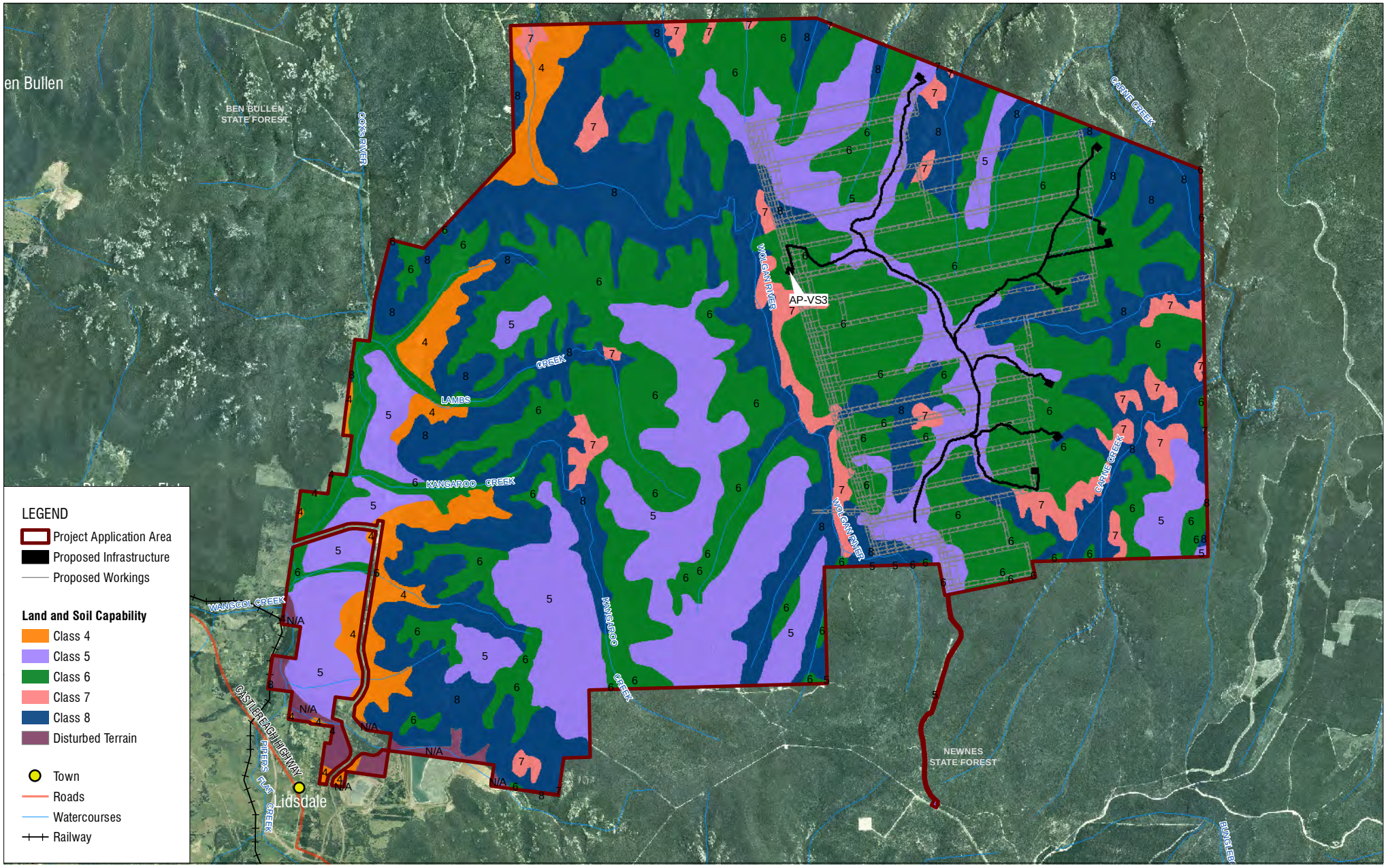
Therefore no soil type is considered potential BSAL within the PAA according to the Interim Protocol for BSAL Verification (**Table 4.9**).

Table 4.9 – Applied BSAL Criteria: Interim Protocol for Site Verification

Soil Type		Site Verification Step							BSAL
No	Name	1	2	3	4	5	6	7	
1	Leptic Tenosol	✘	-	-	-	-	-	-	No
2	Brown-Orthic Tenosol	✘	-	-	-	-	-	-	No
3	Mesotrophic Brown Kandosol	✓	✓	✓	✓	✘	-	✘	No
4	Eutrophic Brown Kandosol	✘	-	-	-	-	-	-	No
5	Brown-Orthic Tenosol	✘	-	-	-	-	-	-	No
6	Eutrophic Brown Kurosol	✓	✓	✓	✓	✘	-	✘	No
7	Red-Orthic Tenosol	✘	-	-	-	-	-	-	No
8a	Brown-Orthic Tenosol	✓	✓	✓	✓	✘	-	✘	No
8b	Mesotrophic Brown Kandosol	✘	-	-	-	-	-	-	No
9	Mesotrophic Brown Kandosol	✓	✓	✓	✓	✘	-	✘	No
10	Brown-Orthic Tenosol	✓	✓	✓	✓	✓	✓	✘	No
11	Arenic Rudosol	✘	-	-	-	-	-	-	No
12	Rudosol	✘	-	-	-	-	-	-	No

4.3.3 Biophysical Strategic Agricultural Land Summary

As discussed two BSAL assessments have been completed due to differing BSAL assessment criteria contained in both the Upper Hunter SRLUP and the Interim Protocol for BSAL Verification. Both assessments determined that no potential BSAL is present within the PAA.



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SLR
10 KINGS ROAD
NEW LAMBTON
NEW SOUTH WALES 2305
AUSTRALIA
T: 61 2 4037 3200
F: 61 2 4037 3201
www.slrconsulting.com

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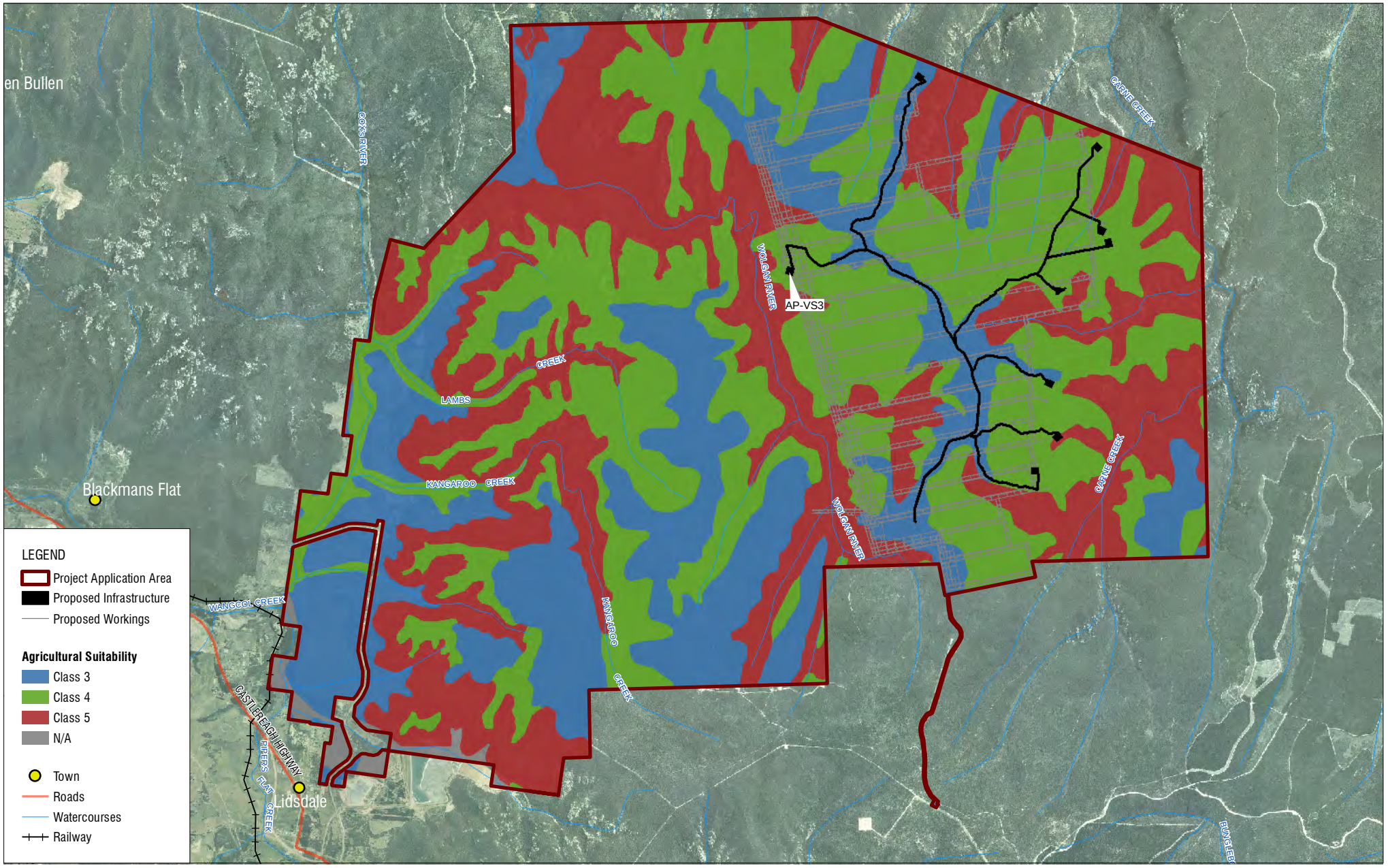
ANGUS PLACE SOILS & LAND RESOURCE

LAND AND SOIL CAPABILITY: PRE-MINING

FIGURE 4.1



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LEVEL 1, 241 DENISON ST
BROADMEADOW
NEW SOUTH WALES 2292
AUSTRALIA
T: 61 2 4920 3000
F: 61 2 4961 3360
www.slrconsulting.com

Project No.:	CCC07-010
Date:	20/01/2014
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ANGUS PLACE SOILS & LAND RESOURCE

AGRICULTURAL SUITABILITY : PRE-MINING

FIGURE 4.2

5.0 IMPACT ASSESSMENT AND DISTURBANCE MANAGEMENT

The development of the Project will disturb land associated with the construction and operation of infrastructure components. Each component of the Project has a construction and operational disturbance footprint with some parts of the disturbance footprint being progressively rehabilitated immediately after construction with the remainder being rehabilitated at the end of operational use.

This assessment of the Project impacts on the proposed footprint includes:

- Impact assessment of LSC classes and BSAL to be impacted upon by the Project.
- Soil resource assessment, which assesses soil suitability for salvage and re-use for rehabilitation works.
- Soil management recommendations of stripped and salvaged soil resources.

5.1 Impact Assessment of LSC Classes and BSAL

There is no potential BSAL contained within the PAA and therefore will not be impacted upon by the Project.

5.1.1 Proposed Workings

The Project is not anticipated to have any significant impact on Land and Soil Capability classes across the PAA from the Proposed Workings as potential ponding and tension cracks have been assessed as being of low risk to the soil and land resources.

According to the *Subsidence Predictions and Impact Assessments for the Angus Place Colliery Mine Extension Project* (MSEC, 2013), the predicted post-disturbance slope gradients are expected to be very similar to the natural grades along drainage lines. Therefore it is not expected that any significant change in ponding or scouring along drainage lines will occur. Where the natural gradients are naturally low upstream of longwall chain pillars, some minor ponding may occur. Surface water ponding can have prohibitive effects on the agricultural ability of the land due to waterlogging of the soils. Due to the location of the potential ponding along drainage lines, there is not anticipated to have any impact on potential Land and Soil Capability within the PAA.

Potential mining subsidence can cause the downslope movement of the soil and therefore result in tension cracks appearing at the tops and along the sides of the steep slopes and compression ridges forming at the bottoms of the steep slopes (MSEC, 2013). These cracks are likely to naturally infill with the surface soils, however, it is possible that remediation will be required through infilling of surface cracks with suitable soil material. Due to the predicted location of tension slopes, it is not anticipated that any tension cracks will affect the distribution of Land and Soil Capability classes across the PAA as the agricultural capability of the steep slopes is inherently very low.

Major topographic features of the PAA are not anticipated to be impacted upon. There are two cliffs and pagoda complexes located within the 26.5 degree angle of draw, whilst they could experience low levels of subsidence and some far-field horizontal movements; it is unlikely that these impacts will be significant (MSEC, 2013). There is also one cliff and some isolated pagodas located adjacent to the proposed LW1014B, which could experience fracturing and some localised spalling of the rockface. It is predicted that the potential impact of the proposed mIning would represent less than 1 per cent of the total rockface (MSEC, 2013).

5.1.2 Proposed Surface Infrastructure

The Proposed Surface Infrastructure covers 23.25 hectares of land and the alignment has been designed to avoid target threatened flora species. The *Decommissioning and Rehabilitation Strategy* (SLR, 2013c) proposes to rehabilitate the disturbed land to create final landforms commensurate with the end land uses in accordance with the proposed land zoning in the draft *Lithgow City Local Environmental Plan* (2013). The final land use for the Proposed Surface Infrastructure assessment area is woodland, which is consistent with the proposed RU3 Forestry for all infrastructure areas on Newnes Plateau. Therefore the Project is not anticipated to have any significant long-term impacts on Land and Soil Capability classes across the PAA from the Proposed Surface Infrastructure.

The overall soil loss balance of the catchment will remain close to neutral according to the *Angus Place Colliery Surface Water Impact Assessment* (RPS, 2013b). The only likely impact on land and soil resources will be due to surface disturbance associated with the Proposed Surface Infrastructure. Clearing of vegetation will result in increased risk of soil erosion; however it will have no impact on the existing LSC if the disturbance management recommendations outlined in **Section 5.0** are implemented.

5.2 Soil Stripping Assessment

The assessment area for the soil stripping assessment for the Soil and Land Capability Assessment covers 141 hectares as this area incorporated a number of potential alignment options and was a performed as a conservative approach to ensure due diligence following any required mine plan changes during the EIS process (refer **Section 3.2**). The actual area subject to surface disturbance is only 23.25 hectares.

While the impacts of the proposed Project on soil resources within the PAA are expected to be negligible (refer **Section 5.1**), soils that may be subject to surface disturbance from infrastructure should be managed in order to minimise impact and ensure appropriate rehabilitation of the disturbed areas can be undertaken.

The soil resources that are likely to be impacted by the surface infrastructure, as outlined on **Figure 3.1**, include the following;

- Soil Type 2 – Brown-Orthic Tenosol;
- Soil Type 5 – Brown-Orthic Tenosol;
- Soil Type 7 – Red-Orthic Tenosol;
- Soil Types 8a – Brown-Orthic Tenosol;
- Soil Type 9 – Mesotrophic Brown Kandosol;
- Soil Type 11 – Arenic Rudosol.

5.2.1 Methodology

Determination of suitable soil to conserve for later use in rehabilitation has been conducted in accordance with Elliot & Reynolds (2007). The approach remains the benchmark for land resource assessment in the Australian mining industry. This procedure involves assessing soils based on a range of physical and chemical parameters. **Table 5.1** lists the key parameters and corresponding desirable selection criteria.

Table 5.1 – Topsoil Stripping Suitability Criteria

Parameter	Desirable criteria
Structure Grade	>30% peds
Coherence	Coherent (wet and dry)
Mottling	Absent
Macrostructure	>10cm
Force to Disrupt Peds	≤ 3 force
Texture	Finer than a Fine Sandy Loam
Gravel & Sand Content	<60%
pH	4.5 to 8.4
Salt Content	<1.5 dS/m

Gravel and sand content, pH and salinity were determined for all samples using the laboratory test results. Texture was determined in the field and cross referenced with laboratory results, specifically particle size analysis. All other physical parameters outlined in Table 5.1 were determined during the field assessment.

5.2.2 Topsoil Stripping Assessment

The topsoil covering the Proposed Surface Infrastructure assessment area is generally stable; however, amelioration to improve soil structure and some inherent sodicity and acidity soil characteristics is required. While the poor structure that characterises the majority of the topsoil is not ideal, this soil is nonetheless able to facilitate germination, and appropriate management of this soil and amelioration (such as treatment with gypsum, lime, etc.) will provide an acceptable and stable media for revegetation. Where practically possible, topsoil resources should be salvaged where they are to be disturbed and stockpiled for respreading at mine closure.

The subsoils throughout the Proposed Surface Infrastructure assessment area range between stable and unstable due to characteristics such as sodicity, salinity and acidity As a result of these factors, stripping the subsoil is not recommended unless required for rehabilitation works.

Table 5.2 summarises the limitations for the soil types situated in the Proposed Surface Infrastructure assessment area and provides recommendation on suitable soil stripping depths.

Table 5.2 – Recommended Soil Stripping Depths

Soil Type		Recommended Soil Stripping Depth (m)	Recommended Amelioration for Stripped Soil	Stripping Depth Limitation	Associated Surface Infrastructure
No.	Name				
2	Brown-Orthic Tenosol	0 – 0.25	Lime or gypsum application to improve acidity. Organic amendments to improve subsoil structure.	Sodic subsoil	- ESA for Dewatering Facility Sites
5	Brown-Orthic Tenosol	0 – 0.20	None	Poor soil structure and coarse fragment content.	- ESA for dewatering facility sites - Infrastructure corridor - Ventilation shaft 3

Soil Type		Recommended Soil Stripping Depth (m)	Recommended Amelioration for Stripped Soil	Stripping Depth Limitation	Associated Surface Infrastructure
No.	Name				
7	Red-Orthic Tenosol	0 – 0.60	Lime or gypsum application to improve acidity. Organic amendments to improve subsoil structure.	Parent material	- ESA for dewatering facility sites - Infrastructure corridor - Ventilation shaft 3
8a	Brown-Orthic Tenosol	0 – 0.25	Lime or gypsum application to improve acidity and sodicity / soil dispersion Organic amendments to improve subsoil structure.	Strongly sodic subsoil	- ESA for dewatering facility sites - Infrastructure corridor - Ventilation shaft 2
9	Mesotrophic Brown Kandosol	0 – 0.40	Lime or gypsum application to improve acidity.	Poor soil structure	- Ventilation shaft 2
11	Arenic Rudosol	0 – 0.10	Lime or gypsum application to improve acidity and sodicity / soil dispersion Organic amendments to improve subsoil structure.	Poor soil structure and strongly sodic subsoil	- ESA for dewatering facility sites

5.2.3 Topdressing Management

Where soil stripping and transportation is required, the following handling techniques are recommended to prevent excessive soil deterioration:

- Strip material to the depths as recommended in **Table 5.2**, subject to further investigation as required.
- Topsoil should be maintained in a slightly moist condition during stripping. Material should not be stripped in either an excessively dry or wet condition.
- Stripping should be timed to take place in unison with any vegetation clearing activity. Removal of groundcover is not necessary; it is appropriate to mix soil with grass during the stripping but first undertake a weed assessment.
- Specific ameliorants for each soil type should be utilised according to those recommended in **Table 5.2**. In summary:
    - All soil types require lime or gypsum application to improve acidity. This application will also improve sodicity and soil dispersion in Soil Types 8a and 11.
    - Soil Type 2, 7, 8a and 11 also require organic amendments to improve soil structure.
- Grading or pushing soil into windrows with graders or dozers for later collection are examples of preferential less aggressive soil handling systems. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material.

- The surface of soil stockpiles should be left in as coarsely structured a condition as possible in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming.

- As a general rule, maintain a maximum stockpile height of 3 metres.

- If long-term stockpiling is planned (that is greater than 3 months), seed and fertilise stockpiles as soon as possible. An annual cover crop species that produce sterile florets or seeds should be sown. A rapid growing and healthy annual pasture sward will provide sufficient competition to minimise the emergence of undesirable weed species. The annual pasture species will not persist in the rehabilitation areas but will provide sufficient competition for emerging weed species and enhance the desirable micro-organism activity in the soil.

- Prior to re-spreading stockpiled topsoil, an assessment of weed infestation on stockpiles should be undertaken to determine if individual stockpiles require herbicide application and / or "scalping" of weed species prior to topsoil spreading.

- An inventory of available soil should be maintained to ensure adequate topsoil materials are kept separate to subsoil materials.

5.2.4 Soil Re-Spreading and Seedbed Preparation

Soil should be re-spread directly onto disturbed areas where practical. Where topsoil resources allow, topsoil should be spread to that which existed pre disturbance. Topsoil should be spread, treated with fertiliser and seeded in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion.

Thorough seedbed preparation should be undertaken to ensure optimum establishment and growth of vegetation. All topsoiled areas should be lightly contour ripped (after topsoil spreading) to create a "key" between the topsoil and subsoil/spoil. Ripping should be undertaken on the contour. Best results will be obtained by ripping when soil is moist and when undertaken immediately prior to sowing. The respread topsoil surface should be scarified prior to, or during seeding, to reduce run-off and increase infiltration. This can be undertaken by contour tilling with a fine-tyned plough or disc harrow.

6.0 CONCLUSION

This Soil and Land Capability Assessment has been conducted based on the findings of a field investigation and a desktop review of reference information. The findings of this assessment include:

- The dominant ASC soil order in the PAA was a poorly developed sandy soil (Tenosols; 86.6 per cent). The second commonly found soil order was a sandy Kandosol (5.4 per cent). All soil types were moderately to strongly acidic throughout the profile.

- Pre-disturbance LSC classes range from Class 4 (moderately capable land) to Class 8 (unsuitable for agriculture) with 37.2 per cent of the PAA classified as Class 6, which describes land suitable for limited set of land uses, such as grazing and forestry. The second dominant LSC Class in the PAA is Class 8 (29.0 per cent), which describes land not capable of sustaining any land use except nature conservation. The most agricultural productive LSC Class in the PAA is Class 4 (4.1 per cent), which is land capable of a variety of land uses and is suited to grazing with restricted cultivation.

- The dominant LSC Class in Proposed Surface Infrastructure assessment Area is Class 6 (61.0 per cent). Class 6 lands are low capability land and restricted to low-impact land uses such as grazing, forestry and nature conservation.

- The LSC classes across the PAA will not affected by the Project as subsidence and associated surface water impacts have been assessed as being of low risk to soil and land resources. LSC classes will also not be affected by the Proposed Surface Infrastructure area as this land will be rehabilitated with a final land use of woodland, which is is consistent with the proposed land use zoning of RU3 Forestry for the Newnes Plateau.

- BSAL was assessed to determine if unique natural resource characteristics highly suitable for agriculture occur within the PAA in accordance with the NSW Government's Strategic Regional Land Use Policy. The assessment determined that no soils within the PAA qualified as potential BSAL.

- Soils within the PAA are recommended to be stripped prior to any significant surface disturbance, and subsequently respread in focused rehabilitation efforts. Subsoils are generally not appropriate for stripping due to a combination of reasons including sodicity, salinity, acidity and structure.

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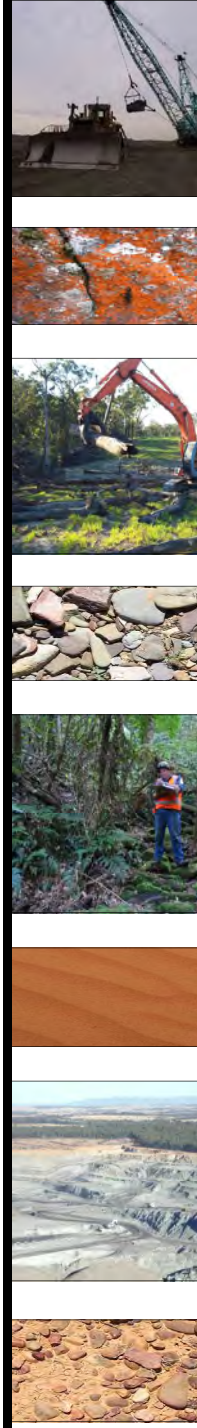
GLOSSARY



APPENDIX 1

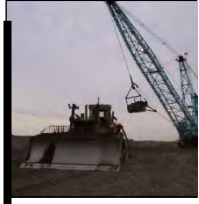
Table A1.1 – List of Glossary Terms and Definitions[1]

Term	Definition
Acidity	A property expressed by the pH value when this is below 7.0 in a soil/water suspension.
Aggregate	A unit of soil structure usually formed by natural processes in contrast with natural processes, and generally <10 mm in diameter.
Aggregate Stability	Refers to the stability of soil structural units (aggregates) when immersed in water.
Aglime	A soil amendment containing calcium carbonate, magnesium carbonate and other materials, used to neutralise soil acidity and furnish calcium and magnesium for plant growth.
Alkalinity	A property expressed by the pH value when this exceeds 7.0 in a soil/water suspension.
Anion	An element with a negative charge.
Availability	General expression referring to the ease with which plants can absorb a particular nutrient form the soil.
Available Water Capacity	The amount of water in the soil, generally available to plants, that can be held between field capacity and the moisture content at which plant growth ceases. Sometimes also known as the *Plant Available Water Capacity*.
Available Phosphorus	The amount of phosphorus in the soil available for plant uptake.
Base Saturation	Percentage of cation exchange capacity that is saturated with potassium, calcium, magnesium and sodium ions.
Bulk Density	The mass of dry soil per unit bulk volume; a measure of soil porosity, with low values meaning a highly porous soil and vice versa. It does not, however, give any indication of the number, sizes, shapes, distribution or continuity of soil pores.
Cation	An element with a positive charge.
Cation Exchange	Process whereby cations interchange between the soil solution and the clay or organic matter complexes in the soil.
Cation Exchange Capacity	The total amount of exchangeable cations that a soil can adsorb, expressed in centimoles of positive charge per kilogram of soil
Clay	A soil separate consisting of particles <0.002 mm in equivalent diameter.
Crumb	A soft, porous, more or less rounded soil aggregate 1 to 5 mm in diameter.
Consistence Force	Consistence force refers to the strength of cohesion and adhesion in the soil.
Course Fragments	Particles greater than 2mm
Electrical Conductivity	A measure of the conduction of electricity through water or a water extract of soil. It can be used to determine the soluble salts in the extract and hence soil salinity. The unit of electrical conductivity is the Siemens and soil salinity is normally expressed as decisiemens per meter at 25˚C (dS/m).
Emerson Aggregate Test	A classification of soil aggregates based on their coherence in water.
Exchangeable Cation	A positively charged ion held on or near the surface of a solid particle by a negative surface charge of a colloid and which may be replaced by other positively charged ions in the soil solution.
Exchangeable Sodium Percentage	Exchangeable sodium fraction expressed as a percentage.
Field Texture Grade	Field texture is a measure of the behaviour of a small handful of soil when moistened and kneaded into a ball and then passes out between thumb and forefinger. The recommended field texture grades are characterised by the behaviour of the moist bolus.

Term	Definition
Field Colour	The colour of soil material is determined by comparison with a standard Munsell colour chart.
Flocculation	The process by which colloidal or very fine clay particles, suspended in water, come together into larger masses or loose 'flocs' which eventually settle out of suspension.
Gravel	A mixture of coarse mineral particles larger than 2mm, but less than 75mm in diameter.
Hydraulic Conductivity	The flow of water through soil per unit of energy gradient. For practical purposes, it may be taken as the steady state of percolation rate of a soil when infiltration and internal drainage are equal, measured as depth per unit time.
Infiltration	The downward entry of water into the soil through the soil surface.
Leaching	The removal of materials in solution from the soil.
Massive	Refers to that condition of a soil layer (horizon) in which the layer appears as a coherent, or solid, mass which is largely devoid of peds, and is more than 6mm thick.
Metals	A metal is a chemical element that is a good conductor of both electricity and heat forms cation and ionic bonds with non metals.
Monitoring Unit	A monitoring and reporting unit is the result of stratification of the study area, it represents a unique combination of soil, climate, land use and land management practices.
Mottles	Spots, blotches or streaks of subdominant colours different from the matrix colour and also different from the colour of the ped surface.
Organic Carbon	Gives an estimate of the amount of organic matter in a soil as a percentage by weight.
Organic Matter	Is the sum of all natural and thermally altered biologically derived organic materials found in the soil. These materials, in various states of decay, include leaf litter, plant roots, branches, living, and dead organism, and excreta.
pH (soil)	A measure of the acidity or alkalinity of a soil. It represents the negative logarithm of the hydrogen ion concentration in a specified soil/water suspension on a scale of 0 to 14.
Parent Material	The unconsolidated and more or less chemically weathered mineral or organic matter form which the solumn of soils is developed by pedogenic processes.
Particle Size Analysis	The laboratory determination of the amounts of the different separates in a soil sample such as clay, silt, fine sand, coarse sand and gravel. The amounts are normally expresses as percentages by weight of dry soil.
Ped	A unit of soil structure such as an aggregate, crumb, prism, block or granule, formed by natural processes (in contrast with a clod which is artificially formed).
Permeability (soil)	The ease with which gases, liquids or plant roots penetrate or pass through a bulk mass of soil or layer of soil.
Physical Properties (soil)	Those characteristics, processes or reactions of a soil which is caused by physical forces and which can be described by, or expressed in, physical terms or equations. These can be difficult to separate from chemical properties; hence terms, physical-chemical or physico-chemical.
Pores	The part of the bulk volume of the soil not occupied by soil particles.
Sampling Site	A georeferenced point within a monitoring unit where one or more samples are taken for analysis.
Sand	A soil particle that in the USDA soil texture system is of size 0.05 mm to 2.0 mm in diameter.
Silt	A soil particle that in the USDA soil texture system is of size 0.002 mm to 0.05 mm in diameter.
Sodicity	A property expressed by the amount of exchangeable sodium present relative to the cation capacity of a soil horizon.

Term	Definition
Soil Classification	The systematic arrangement of soils into groups or categories on the basis of similarities and differences in their characteristics.
Soil Coherence	The degree to which soil material is held together at different moisture levels, If two-thirds or more of the soil material, whether composed of peds or not, remain united at a given moisture level, then the soil is described as coherent.
Soil Consistence	The resistance of soil material to deformation or rupture.
Soil Erodibility	The susceptibility of a soil to the detachment and transportation of soil particles by erosive agents.
Soil Horizon	A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, biological properties such as colour structure, texture, consistency, kinds and number of organisms present, degrees or acidity or alkalinity.
Soil Profile	A vertical section of the soil through all its horizons.
Soil Salinity	The amount of soluble salts in a soil. The convention measure of soil salinity is the electrical conductivity of a saturation extract.
Soil Structure	Refers to the way soil particles are arranged and bound together to form aggregates or peds.
Soil Texture	The relative proportions of the various soil separates in as soil as described by the classes of soil texture. It is the general coarseness or fineness of soil material as it affects the behaviour of a moist ball (bolus) when pressed between the thumb and forefinger.
Solumn	The upper part of a soil profile above the parent material, in which current processes of soil formation are active. The solumn consists of either the A and B horizons or the A horizon alone when no B is present.
Structure Pedality Grade	Is the degree of development and distinction of ped.
Structure Ped and Size	Refers to the distinctness, size and shape of peds.
Subsoil	Refers to B soil horizon
Topsoil	Refers to A1 and A2 soil horizons.

1 Definitions have been sourced from: Charman and Murphy, 1991; Peverill et al., 1999; Mckensie et al., 2004; NCST, 2009.








Certificate of Analysis

Note: Relevant soil samples are highlighted

APPENDIX 2

NSW GOVERNMENT Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO12/388R3
REPORT TO:	M Hemingway GSS Environmental PO Box 907 Hamilton NSW 2303
REPORT ON:	Sixty nine soil samples SV and AP
PRELIMINARY RESULTS ISSUED:	21 November 2012
REPORT STATUS:	Final
DATE REPORTED:	23 November 2012
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED

SR Young
(Laboratory Manager)

Scone Research Centre, PO Box 283 Scone 2337, 709 Gundy Road Scone 2337
Ph: 02 6545 1666 Fax: 02 6545 2520

Report No: SCO12/388R3
Client Reference: M Hemingway
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	C1A/4	C2A/3	C2B/3	C6A/2	C5A/4 CEC & exchangeable cations (me/100g)						P18B/2 AWC	
	Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	OC (%)	CEC	Na	K	Ca	Mg	Al	0.3bar (%)	15bar (%)
1	Site 1 SV 0-25	0.01	4.7	3.9	1.05	1.2	0.2	0.2	0.4	0.6	0.4	9.3	4.5
2	Site 1 SV 25-60	0.01	4.8	4.1	0.64	0.9	0.3	0.1	0.5	0.7	0.3	6.2	4.0
3	Site 1 SV 60-85	<0.01	5.1	4.2	0.17	<0.5	0.1	0.1	0.4	0.2	0.3	6.3	3.6
4	Site 2 AP 0-15	0.03	4.7	3.8	1.84	4.5	0.1	0.4	0.5	0.5	3.0	17.2	9.5
5	Site 2 AP 15-40	0.02	4.7	3.9	0.94	3.9	0.1	0.2	0.3	0.4	2.9	15.2	9.1
6	Site 2 AP 40-80	0.01	4.7	4.0	0.55	3.8	0.2	0.2	0.4	0.6	3.1	14.8	9.3
7	Site 2 SV 0-15	0.01	4.8	4.0	1.59	1.7	0.1	0.2	0.3	0.5	1.1	13.2	6.6
8	Site 2 SV 15-55	0.01	5.0	4.2	0.67	0.7	0.1	0.2	0.7	0.5	0.3	9.9	6.6
9	Site 2 SV 55-80	<0.01	5.4	4.3	0.28	0.9	0.2	0.1	1.0	0.7	0.5	9.7	6.5
10	Site 4 AP 0-20	0.01	4.7	4.0	1.89	2.5	0.1	0.2	0.3	0.5	1.5	12.4	6.5
11	Site 4 AP 20-60	<0.01	5.1	4.2	0.71	0.9	0.2	0.1	0.6	0.7	0.7	10.3	5.8

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Lab No	Method	C1A/4	C2A/3	C2B/3	C6A/2	C5A/4 CEC & exchangeable cations (me/100g)						P18B/2 AWC	
	Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	OC (%)	CEC	Na	K	Ca	Mg	Al	0.3bar (%)	15bar (%)
12	Site 4 SV 0-10	<0.01	5.0	4.1	1.83	1.6	0.1	0.2	0.9	0.7	1.0	12.0	5.9
13	Site 4 SV 10-25	<0.01	5.0	4.2	1.32	1.1	0.1	0.1	0.6	0.2	0.7	10.9	6.0
14	Site 4 SV 25-65	<0.01	5.0	4.3	0.71	0.7	0.1	0.1	0.4	0.2	0.3	9.3	5.3
15	Site 5 SV 0-25	0.01	5.0	4.1	2.16	3.9	0.1	0.2	0.7	0.3	2.0	13.9	6.9
16	Site 5 SV 25-60	<0.01	5.2	4.4	1.23	2.2	0.1	0.1	0.8	0.3	0.6	9.7	5.6
17	Site 5 SV 60-95	<0.01	5.5	4.5	0.77	1.2	0.1	0.1	0.2	0.5	0.5	9.2	6.5
18	Site 6 SV 0-30	0.01	4.4	3.8	2.91	4.3	0.1	0.1	0.2	0.5	3.5	14.6	8.2
19	Site 6 SV 30-80	<0.01	5.5	4.2	0.41	2.7	0.1	<0.1	0.2	0.6	2.2	10.2	6.4
20	Site 6 SV 80-100	<0.01	5.6	4.2	0.21	3.1	0.1	<0.1	0.3	0.7	1.6	10.9	6.9
21	Site 8 AP 0-15	0.03	4.4	3.7	4.06	7.6	0.1	0.2	0.7	0.8	3.8	19.2	9.4
22	Site 8 AP 15-25	0.02	4.7	3.9	2.18	7.4	0.2	0.1	0.4	0.3	3.0	14.8	8.3
23	Site 8 AP 25-60	0.01	5.1	4.1	1.22	5.8	<0.1	0.1	0.2	0.3	1.9	11.6	6.7
24	Site 8 SV 0-8	0.06	4.3	3.7	4.56	6.7	0.2	0.2	0.1	0.3	3.2	15.9	9.1
25	Site 8 SV 8-30	0.02	4.6	4.1	1.79	5.1	0.1	<0.1	0.3	0.3	2.4	16.6	8.4

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Lab No	Method	C1A/4	C2A/3	C2B/3	C6A/2	C5A/4 CEC & exchangeable cations (me/100g)						P18B/2 AWC	
	Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	OC (%)	CEC	Na	K	Ca	Mg	Al	0.3bar (%)	15bar (%)
26	Site 9 AP 0-25	<0.01	4.7	4.0	1.79	4.6	0.2	<0.1	0.3	0.3	1.6	11.8	5.4
27	Site 9 AP 25-80	<0.01	5.0	4.3	0.38	3.1	0.3	<0.1	0.3	0.4	0.8	8.9	4.8
28	Site 9 AP 80-100	<0.01	5.2	4.3	0.22	3.1	0.2	<0.1	0.2	0.4	0.4	9.2	4.8
29	Site 10 SV 0-25	0.01	5.1	4.3	2.31	4.5	0.2	<0.1	0.4	0.4	1.6	17.0	8.7
30	Site 10 SV 25-80	<0.01	5.3	4.5	0.65	2.3	0.1	<0.1	<0.1	0.3	1.4	10.5	6.8
31	Site 10 SV 85-100	<0.01	5.3	4.4	0.18	<0.5	0.2	<0.1	0.3	0.6	2.4	12.2	6.4
32	Site 11 SV 0-20	0.05	5.9	5.0	4.40	16.9	0.4	1.3	9.3	5.9	0.4	43.1	25.4
33	Site 11 SV 20-85	0.03	6.2	5.2	2.98	19.1	0.4	0.8	9.9	7.6	0.3	44.7	26.9
34	Site 11 SV 85-100	0.01	6.3	5.1	0.92	9.5	0.4	0.3	4.1	4.2	0.7	28.3	14.9
35	Site 12 AP 0-10	0.03	4.3	3.3	1.81	2.2	0.2	0.2	0.4	0.3	0.5	10.0	3.5
36	Site 12 AP 10-40	0.02	4.5	3.2	1.66	1.0	0.2	0.2	0.4	0.3	0.7	10.2	3.4
37	Site 12 AP 40-70	<0.01	4.6	3.5	0.55	<0.5	0.2	0.1	0.4	0.3	0.3	8.1	1.9

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Lab No	Method	C1A/4	C2A/3	C2B/3	C6A/2	C5A/4 CEC & exchangeable cations (me/100g)						P18B/2 AWC	
	Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	OC (%)	CEC	Na	K	Ca	Mg	Al	0.3bar (%)	15bar (%)
38	Site 13 SV 0-15	0.01	4.4	3.6	1.78	5.8	0.2	0.1	1.3	0.8	3.2	22.3	9.6
39	Site 13 SV 15-40	<0.01	4.7	4.1	1.92	2.0	0.2	0.1	0.5	0.5	1.4	16.8	8.1
40	Site 13 SV 40-80	<0.01	4.8	4.2	0.63	1.6	0.2	<0.1	0.5	0.5	1.1	13.8	7.0
41	Site 14 AP 0-25	0.01	4.7	3.9	3.08	3.6	0.1	0.1	0.5	0.7	2.9	16.6	7.7
42	Site 14 AP 25-75	0.01	5.0	4.2	1.40	1.2	0.2	0.1	0.3	0.6	1.2	13.6	6.6
43	Site 14 AP 75-90	<0.01	5.1	4.4	0.74	0.8	0.2	<0.1	0.4	0.6	0.6	10.1	5.3
44	Site 14 SV 0-15	0.01	4.9	4.1	2.44	2.8	0.2	0.1	0.6	0.8	1.7	16.6	7.8
45	Site 14 SV 15-60	<0.01	5.0	4.3	0.98	<0.5	0.1	0.1	0.6	0.2	1.0	14.8	7.1
46	Site 14 SV 60-90	<0.01	5.0	4.2	0.33	1.3	0.1	0.1	0.7	0.4	1.2	10.7	6.3
47	Site 15 AP 0-15	0.02	4.8	4.1	2.21	0.5	<0.1	0.2	0.6	0.4	1.3	4.9	2.7
48	Site 15 AP 15-50	<0.01	4.8	4.2	1.52	1.1	<0.1	0.1	0.6	0.4	1.1	12.0	4.8

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Lab No	Method	C1A/4	C2A/3	C2B/3	C6A/2	C5A/4 CEC & exchangeable cations (me/100g)						P18B/2 AWC	
	Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	OC (%)	CEC	Na	K	Ca	Mg	Al	0.3bar (%)	15bar (%)
49	Site 16 AP 0-8	0.02	5.2	4.3	2.30	3.3	<0.1	0.3	2.2	0.7	1.3	12.6	5.4
50	Site 16 AP 8-30	0.01	5.3	4.3	1.30	<0.5	<0.1	0.2	0.7	0.5	0.8	11.4	4.8
51	Site 16 AP 30-80	<0.01	5.4	4.3	0.86	1.2	<0.1	0.2	0.5	0.6	0.6	12.8	6.1
52	Site 16 AP 80-100	<0.01	5.6	4.4	0.41	1.7	0.1	0.2	0.5	0.9	0.9	10.6	5.7
53	Site 17 AP 0-10	0.03	5.0	4.2	2.23	2.2	0.1	0.2	1.5	0.7	1.1	6.2	4.1
54	Site 17 AP 10-50	<0.01	5.2	4.3	0.93	1.5	0.1	0.2	0.6	0.6	0.7	8.7	4.6
55	Site 17 AP 50-100	<0.01	5.3	4.3	0.28	1.6	0.1	0.1	0.5	0.3	0.6	7.1	3.3
56	Site 18 AP 0-15	0.01	4.9	4.1	1.22	3.1	<0.1	0.1	0.6	0.3	1.3	15.6	5.4
57	Site 18 AP 15-50	<0.01	5.1	4.2	0.77	2.3	<0.1	0.1	0.4	0.3	0.8	13.4	5.3
58	Site 19 AP 0-30	0.01	5.7	4.7	1.10	3.9	<0.1	0.2	1.2	0.4	0.5	11.8	2.8
59	Site 19 AP 30-60	<0.01	5.4	4.2	0.12	4.5	0.1	0.2	0.9	1.1	1.2	15.9	7.2
60	Site 19 AP 60-90	<0.01	5.6	4.1	0.06	6.9	0.2	0.3	0.4	1.8	2.5	18.8	10.2

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Lab No	Method	C1A/4	C2A/3	C2B/3	C6A/2	C5A/4 CEC & exchangeable cations (me/100g)						P18B/2 AWC	
	Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	OC (%)	CEC	Na	K	Ca	Mg	Al	0.3bar (%)	15bar (%)
61	Site 20 AP 0-30	0.04	5.9	5.1	2.35	10.0	0.1	0.6	6.2	2.2	<0.3	18.4	8.1
62	Site 20 AP 30-65	0.01	6.4	5.2	0.88	7.0	0.2	0.6	3.6	1.7	<0.3	16.0	6.8
63	Site 20 AP 65-100	0.01	6.2	5.1	0.93	7.2	0.1	0.6	3.2	2.0	<0.3	16.8	6.9
64	Site 21 AP 0-15	<0.01	5.2	4.2	1.29	3.7	0.1	0.3	1.0	0.6	0.9	12.7	6.2
65	Site 21 AP 15-50	0.01	5.3	4.2	0.59	1.6	0.1	0.3	0.6	0.6	0.7	11.6	6.8
66	Site 21 AP 50-100	<0.01	5.6	4.3	0.22	2.7	0.2	0.4	0.5	1.0	0.9	12.4	7.7
67	Site 22 AP 0-15	0.05	4.6	3.9	2.77	4.7	0.2	0.3	0.9	0.6	3.1	19.1	10.5
68	Site 22 AP 15-55	<0.01	5.3	4.2	1.01	3.7	0.2	0.2	0.5	1.4	1.8	15.0	9.0
69	Site 22 AP 55-100	<0.01	5.7	4.2	0.26	4.8	0.3	0.2	0.6	1.4	2.6	14.4	10.0

SOIL CONSERVATION SERVICE
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Lab No	Method	P7B/2 Particle Size Analysis (%)					P7C/2 Particle Size Analysis – mech dis (%)					P9B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	clay	silt	f sand	c sand	gravel	EAT	dry	moist
1	Site 1 SV 0-25	9	4	18	68	1	5	7	19	68	1	8	2.5Y 6/3	2.5Y 4/2
2	Site 1 SV 25-60	9	4	15	70	2	6	7	17	68	2	5	2.5Y 5/4	2.5Y 4/4
3	Site 1 SV 60-85	9	3	16	65	7	na	na	na	64	7	6	10YR 7/6	10YR 6/8
4	Site 2 AP 0-15	24	9	38	26	3	13	10	42	32	3	8	2.5Y 6/4	2.5Y 5/4
5	Site 2 AP 15-40	28	9	35	27	1	16	10	43	30	1	5	2.5Y 6/4	2.5Y 5/6
6	Site 2 AP 40-80	31	8	34	25	2	na	na	na	29	2	6	2.5Y 6/6	2.5Y 5/6
7	Site 2 SV 0-15	13	7	25	53	2	9	8	23	58	2	8	10YR 5/4	10YR 4/4
8	Site 2 SV 15-55	15	7	22	55	1	na	na	na	54	1	6	10YR 5/8	7.5YR 5/6
9	Site 2 SV 55-80	17	5	23	53	2	na	na	na	55	2	6	10YR 5/6	10YR 4/6
10	Site 4 AP 0-20	12	5	13	64	6	6	11	16	61	6	8	10YR 4/6	10YR 3/3
11	Site 4 AP 20-60	14	6	15	58	7	10	11	16	56	7	5	7.5YR 6/6	7.5YR 5/6

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Lab No	Method	P7B/2 Particle Size Analysis (%)					P7C/2 Particle Size Analysis – mech dis (%)					P9B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	clay	silt	f sand	c sand	gravel	EAT	dry	moist
12	Site 4 SV 0-10	11	6	19	57	7	3	10	21	59	7	8	2.5Y 5/4	2.5Y 3/3
13	Site 4 SV 10-25	13	7	22	55	3	9	9	24	55	3	5	10YR 5/4	10YR 4/4
14	Site 4 SV 25-65	13	6	24	56	1	na	na	na	56	1	6	10YR 5/6	10YR 4/6
15	Site 5 SV 0-25	8	9	18	62	3	6	5	22	64	3	8	10YR 4/3	10YR 3/2
16	Site 5 SV 25-60	9	6	15	59	11	na	na	na	58	11	8	10YR 5/4	10YR 3/3
17	Site 5 SV 60-95	13	4	17	61	5	3	11	18	63	5	5	10YR 4/6	10YR 3/6
18	Site 6 SV 0-30	13	8	30	49	<1	3	8	35	54	<1	8	10YR 4/4	10YR3/3
19	Site 6 SV 30-80	18	7	30	45	<1	na	na	na	50	<1	6	7.5YR 5/6	7.5YR 4/6
20	Site 6 SV 80-100	19	7	28	40	6	na	na	na	47	6	6	10YR 6/6	10YR 5/8
21	Site 8 AP 0-15	11	8	23	51	7	5	9	20	59	7	8	7.5YR 4/4	7.5YR 3/4
22	Site 8 AP 15-25	14	8	21	53	4	7	10	23	56	4	8	7.5YR 4/4	7.5YR 3/3
23	Site 8 AP 25-60	12	8	20	48	12	8	8	22	50	12	3(1)	7.5YR 4/6	7.5YR 3/4
24	Site 8 SV 0-8	7	6	14	47	26	6	5	13	50	26	8	2.5Y 5/2	2.5Y 3/2
25	Site 8 SV 8-30	14	9	18	42	17	9	12	21	41	17	5	10YR 6/3	10YR 3/3

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Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P7C/2 Particle Size Analysis – mech dis (%)					P9B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	clay	silt	f sand	c sand	gravel	EAT	dry	moist
26	Site 9 AP 0-25	8	8	17	64	3	6	8	17	66	3	8	10YR 5/4	10YR 3/3
27	Site 9 AP 25-80	11	6	18	60	5	na	na	na	62	5	6	7.5YR 5/6	7.5YR 4/6
28	Site 9 AP 80-100	11	5	15	63	6	na	na	na	63	6	6	7.5YR 6/6	7.5YR 5/8
29	Site 10 SV 0-25	14	6	37	42	1	5	8	36	50	1	8	10YR 5/2	10YR 2/2
30	Site 10 SV 25-80	17	6	32	44	1	na	na	na	45	1	6	10YR 6/3	10YR 4/4
31	Site 10 SV 85-100	18	7	36	38	1	na	na	na	41	1	6	10YR 6/4	10YR 5/8
32	Site 11 SV 0-20	42	33	19	6	0	29	35	24	12	0	8	10YR 5/2	10YR 2/1
33	Site 11 SV 20-85	58	31	9	2	0	31	33	31	5	0	5	10YR 4/1	10YR 2/1
34	Site 11 SV 85-100	44	32	15	9	0	35	38	19	8	0	3(1)	10YR 6/1	10YR 4/1
35	Site 12 AP 0-10	1	7	17	62	13	0	7	16	64	13	8	10YR 5/1	10YR 3/1
36	Site 12 AP 10-40	2	7	19	56	16	0	10	16	58	16	8	10YR 5/1	10YR 3/1
37	Site 12 AP 40-70	2	8	16	62	12	1	9	15	63	12	2(1)	10YR 6/2	10YR 3/2

SOIL CONSERVATION SERVICE
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GSS Environmental
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	Sample Id	clay	silt	f sand	c sand	gravel	clay	silt	f sand	c sand	gravel	EAT	dry	moist
38	Site 13 SV 0-15	11	11	15	58	5	6	11	16	62	5	8	10YR 5/3	10YR 3/3
39	Site 13 SV 15-40	17	10	17	54	2	12	11	19	56	2	8	10YR 5/4	10YR 3/3
40	Site 13 SV 40-80	17	11	14	53	5	na	na	na	53	5	6	7.5YR 5/6	7.5YR 4/6
41	Site 14 AP 0-25	8	9	24	53	6	4	8	24	58	6	8	10YR 4/2	10YR 2/2
42	Site 14 AP 25-75	12	8	26	50	4	8	6	27	55	4	5	10YR 5/3	10YR 3/2
43	Site 14 AP 75-90	10	6	23	53	8	na	na	na	52	8	6	10YR 6/3	10YR 3/3
44	Site 14 SV 0-15	13	10	27	49	1	8	10	30	51	1	8	10YR 5/3	10YR 3/3
45	Site 14 SV 15-60	19	9	25	47	<1	12	10	28	50	<1	5	10YR 6/3	10YR 4/3
46	Site 14 SV 60-90	18	7	24	49	2	na	na	na	50	2	6	7.5YR 6/4	7.5YR 5/6
47	Site 15 AP 0-15	4	4	12	59	21	1	5	17	56	21	8	10YR 6/2	10YR 4/2
48	Site 15 AP 15-50	6	5	12	47	30	2	7	14	47	30	8	10YR 6/3	10YR 4/3

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	Sample Id	clay	silt	f sand	c sand	gravel	clay	silt	f sand	c sand	gravel	EAT	dry	moist
49	Site 16 AP 0-8	4	9	11	54	22	4	7	14	53	22	8	10YR 5/2	10YR 3/2
50	Site 16 AP 8-30	8	10	15	53	14	7	10	16	53	14	3(1)	10YR 6/2	10YR 3/2
51	Site 16 AP 30-80	12	11	19	50	8	10	13	19	50	8	5	10YR 6/2	10YR 4/2
52	Site 16 AP 80-100	15	9	16	48	12	13	7	22	46	12	5	10YR 6/3	10YR 4/3
53	Site 17 AP 0-10	4	5	14	57	20	2	4	10	64	20	8	10YR 5/3	10YR 4/3
54	Site 17 AP 10-50	8	9	23	52	8	7	5	18	62	8	3(1)	10YR 6/3	10YR 4/3
55	Site 17 AP 50-100	8	9	19	52	12	7	7	19	55	12	5	7.5YR 6/4	7.5YR 5/4
56	Site 18 AP 0-15	6	15	19	33	27	6	12	22	33	27	8	10YR 6/2	10YR 4/2
57	Site 18 AP 15-50	9	16	23	37	15	7	14	28	36	15	3(1)	10YR 6/2	10YR 4/2
58	Site 19 AP 0-30	2	14	29	42	13	1	13	30	43	13	8	10YR 6/3	10YR 4/2
59	Site 19 AP 30-60	15	11	13	30	31	14	8	16	31	31	5	10YR 7/4	10YR 5/8
60	Site 19 AP 60-90	21	10	6	38	25	19	9	7	40	25	5	10YR 7/4	10YR 5/8

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	Sample Id	clay	silt	f sand	c sand	gravel	clay	silt	f sand	c sand	gravel	EAT	dry	moist
61	Site 20 AP 0-30	9	16	48	19	8	5	14	52	21	8	8	10YR 4/3	10YR 3/3
62	Site 20 AP 30-65	10	18	51	15	6	8	17	53	16	6	3(1)	7.5YR 5/3	7.5YR 4/3
63	Site 20 AP 65-100	11	18	46	16	9	11	15	51	18	5	3(1)	7.5YR 4/6	7.5YR 3/6
64	Site 21 AP 0-15	10	13	30	45	2	11	10	30	47	2	8	10YR 5/4	10YR 4/4
65	Site 21 AP 15-50	17	13	28	40	2	16	12	30	40	2	5	7.5YR 6/6	7.5YR 4/6
66	Site 21 AP 50-100	22	12	23	37	6	6	23	29	33	9	5	5YR 5/6	5YR 4/6
67	Site 22 AP 0-15	19	11	18	47	5	9	12	21	53	5	8	7.5YR 4/4	7.5YR 3/3
68	Site 22 AP 15-55	26	11	21	41	1	21	14	22	42	1	5	5YR 5/6	5YR 3/4
69	Site 22 AP 55-100	32	10	17	38	3	1	6	39	51	3	5	5YR 5/8	5YR 4/6

na = not applicable

END OF TEST REPORT