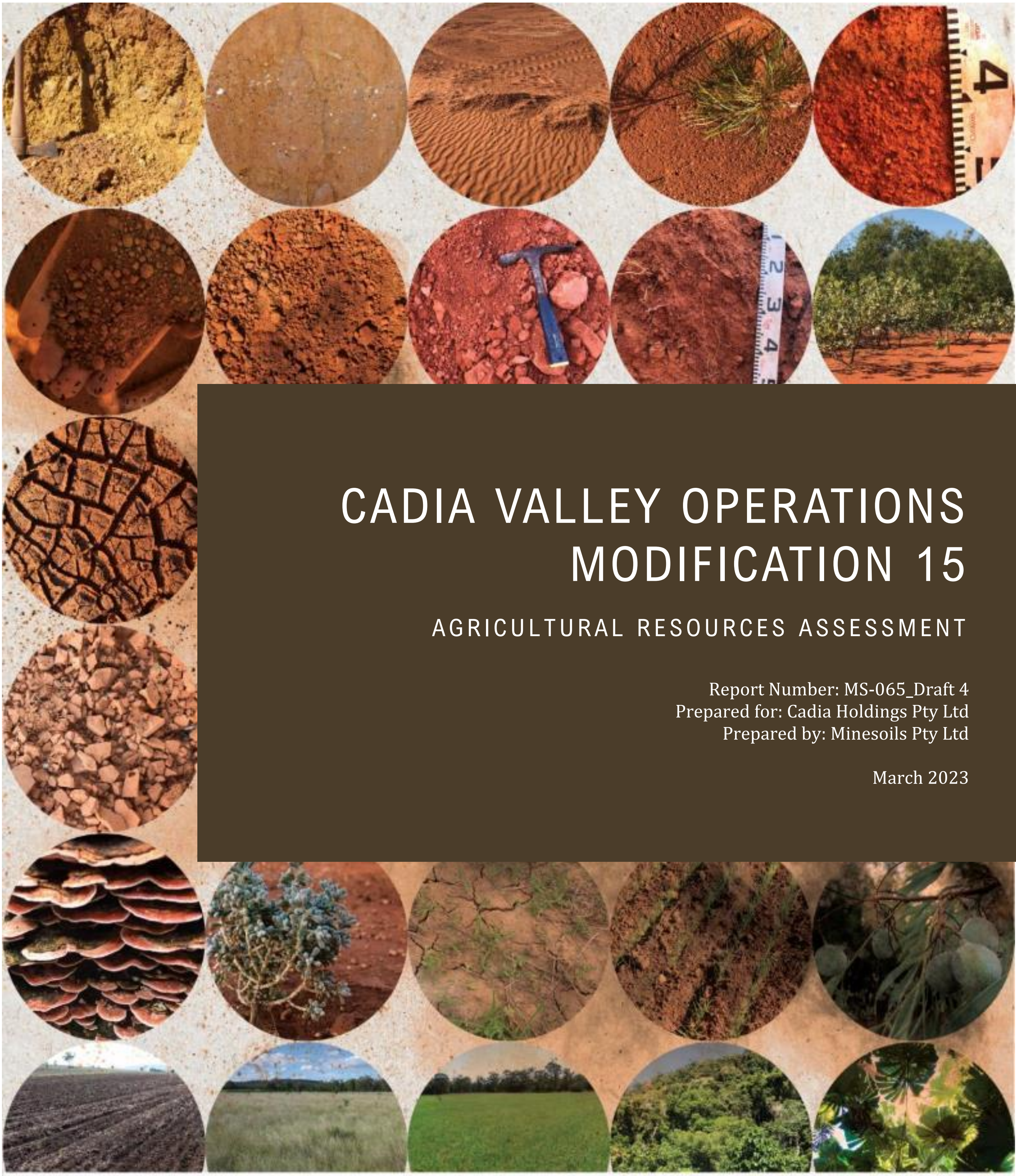

CADIA VALLEY OPERATIONS MODIFICATION 15

AGRICULTURAL RESOURCES ASSESSMENT

Report Number: MS-065_Draft 4
Prepared for: Cadia Holdings Pty Ltd
Prepared by: Minesoils Pty Ltd

March 2023

MINESOILS
LAND & REHABILITATION SPECIALISTS

PREPARED BY

Minesoils Pty Ltd
ABN 84 627 497 509

0408 474 248
clayton@minesoils.com.au
www.minesoils.com.au
PO Box 11034 Tamworth NSW 2340

DISCLAIMER

DOCUMENT CONTROL

Reference	Date	Prepared by	Approved
MS-065_Draft 1	6 July 2022	Matt Hemingway & Clayton Richards	Clayton Richards
MS-065_Draft 2	20 July 2022	Matt Hemingway & Clayton Richards	Clayton Richards
MS-065_Draft 3	5 August 2022	Matt Hemingway & Clayton Richards	Clayton Richards
MS-065_Draft 4	7 October 2022	Matt Hemingway	Clayton Richards
MS-065_Final	20 October 2022	Matt Hemingway	Clayton Richards
MS-065_Final V2	24 March 2023	Matt Hemingway	Clayton Richards

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1. INTRODUCTION

1.1 CADIA VALLEY OPERATIONS BACKGROUND

The Cadia Valley Operations (CVO) are located approximately 25 kilometres (km) south west of Orange, in the Central Tablelands of New South Wales (NSW) (refer to **Figure 1**). Cadia Holdings Pty Limited (CHPL)(the Proponent) is the owner and operator of the CVO and is a wholly owned subsidiary of Newcrest Mining Limited.

Project Approval (PA 06_0295) for the CVO was granted by the NSW Minister for Planning under Part 3A of the *NSW Environmental Planning and Assessment Act*, 1979 (EP&A Act) on 6 January 2010 (PA 06_0295). PA 06_0295 includes all components of the CVO including the Cadia East underground mine (Cadia East), the Cadia Hill Open Pit Tailings Storage Facility (PTSF), the Ridgeway underground mine (Ridgeway), CVO Dewatering Facilities and a wide range of ancillary and supporting infrastructure. These integrated operations are herein referred to as the CVO.

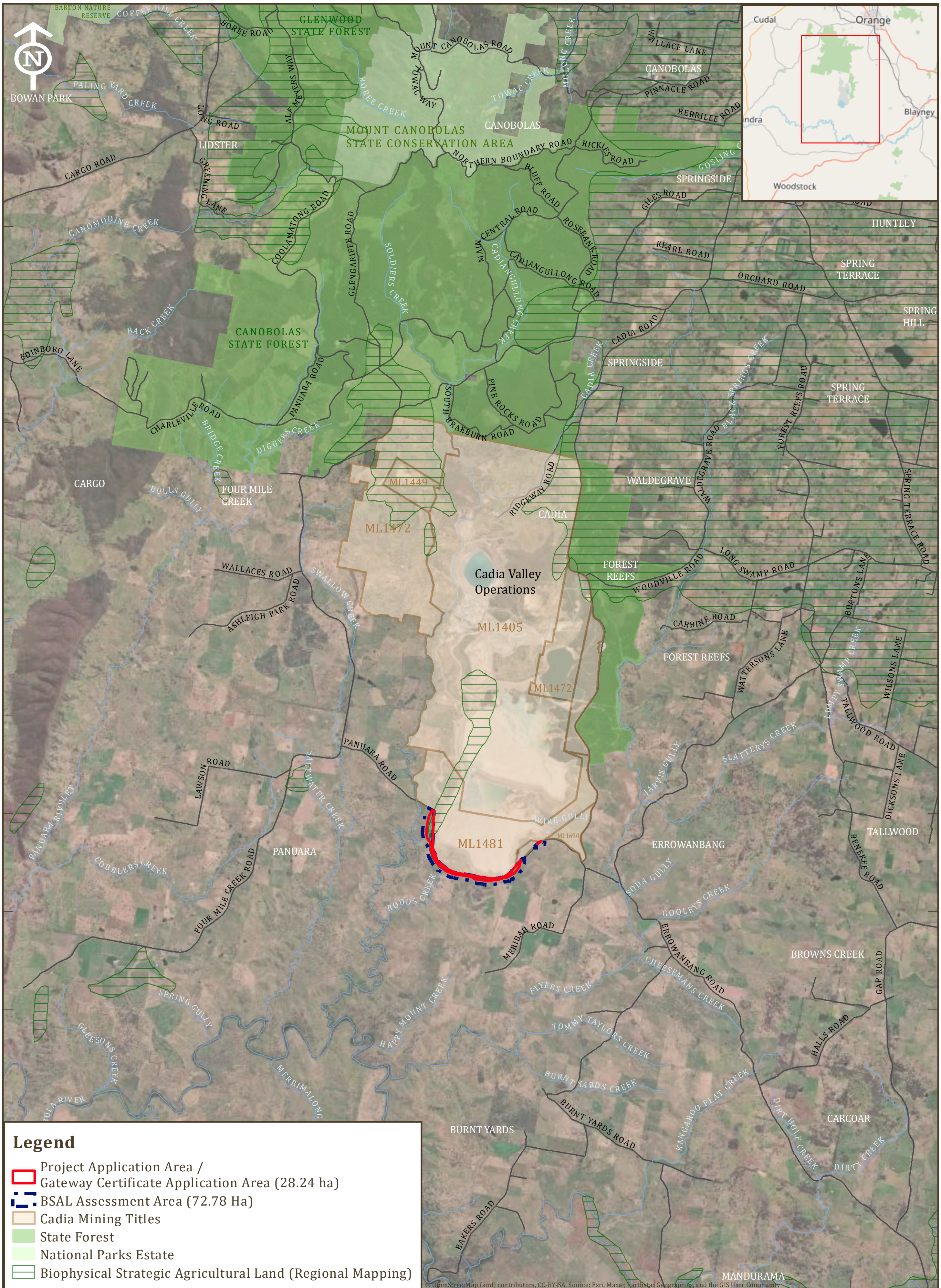
CHPL plans to seek a modification under the State Significant Development provisions of Section 4.55(2) of the EP&A Act. Modification 15 (the Modification) proposes changes to the tailings storage facility (TSF) embankment footprints which are required following further detailed design, consistent with the evolution of an optimised design and construction program of this scope and magnitude.

Accordingly, the Proponent is seeking a Gateway Certificate over an area of 28.2 hectares (ha), herein referred to as the Project Application Area (PAA) of Modification 15. A 100 metre (m) buffer has also been applied to the PAA (excluding areas within a current mining lease) and these areas combined are referred to as the Biophysical Strategic Agricultural Land (BSAL) Assessment Area (72.8 ha) for the purposes of verifying any BSAL within or immediately surrounding the PAA (refer to **Figure 2**).

1.2 REPORT OBJECTIVES AND SCOPE

The objective of this report is to assess the PAA to verify BSAL or Non-BSAL to support the application for a Gateway Certificate. The verification program was undertaken in accordance with the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (Office of Environment & Heritage [OEH] and Department of Primary Industries - Office of Agricultural Sustainability and Food Security [DPI-OAS&FS], 2013); hereafter referred to as the Interim Protocol.

The purpose of this report is to provide the results of the BSAL verification program (conducted in accordance with the *Interim Protocol)* and the findings of a soil and land impact assessment.



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Regional Context

FIGURE 1

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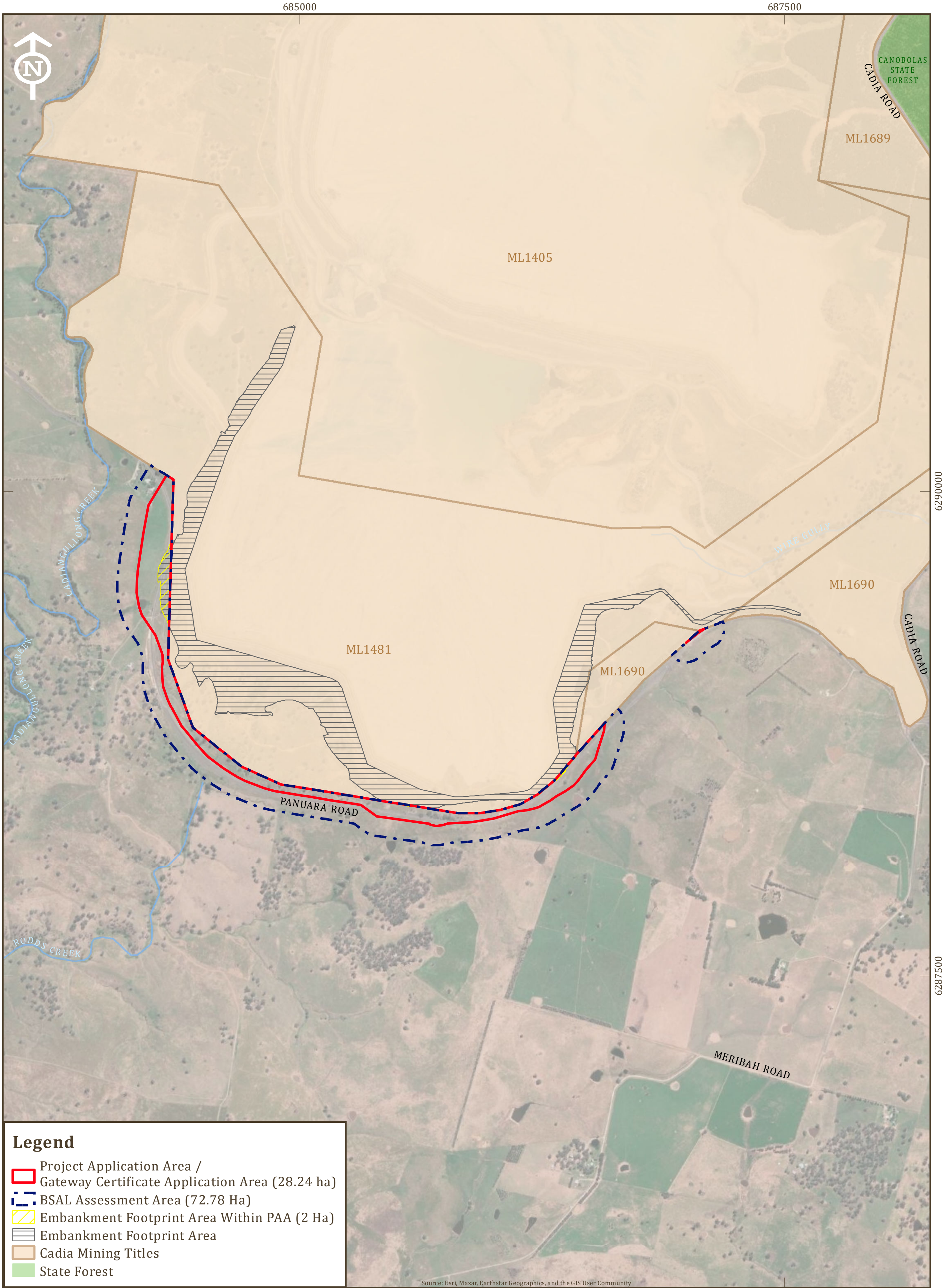

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Project Application Area and BSAL Assessment Area

FIGURE 2

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2 EXISTING ENVIRONMENT

This section is based on regional mapping and soils on a desktop basis. The results of field work are presented in Sections 4 and 5.

2.1 GEOLOGY, HYDROLOGY AND TOPOGRAPHY

The BSAL Assessment Area is located within the eastern Lachlan Fold Belt of NSW. The surficial geology of the region consists of andesite, tuff, limestone, siltstone, shale, feldspathic greywacke, chert and diorite, with coarse-grained intermediate rocks including syenite and monzonite, and in-situ and alluvial/colluvial materials derived from above parent rock less than 1m deep on crests and up to 10–40 m deep on lower slopes and in drainage depressions (Source: Department of Main Roads [DMR] [2002)] in Kovac et al. [2010]) (refer **Figure 3**).

The BSAL Assessment Area is located in the Belubula River Catchment, a tributary of the Lachlan River Catchment. Several unnamed first and second order ephemeral streams occur within the PAA.

The landscape within the BSAL Assessment Area ranges from broad drainage lines into low hills with smooth, undulating slopes rising to crests. Slopes within the BSAL Assessment Area range from 0 - 1% along the open drainage lines and flats up to rocky upper slopes and crest rises. 25.5 ha or 35% of the BSAL Assessment Area lies on slopes >10% (refer **Figure 4**).

2.2 SOIL LANDSCAPES

Soil landscape units for the BSAL Assessment Area are mapped by the Department of Planning, Industry and the Environment (DPIE) and are compiled into 40 published soil landscape maps that cover central and eastern NSW, based on standard 1:100,000 and 1:250,000 topographic sheets (DPIE, 2020). The mapping provides an inventory of soil and landscape properties of the area and identifies major soil and landscape qualities and constraints. It integrates soil and topographic features into single units with relatively uniform land management requirements. In the associated reports, soils are described in terms of soil materials in addition to the Australian Soil Classification (ASC), the Great Soil Groups, and the Northcote systems.

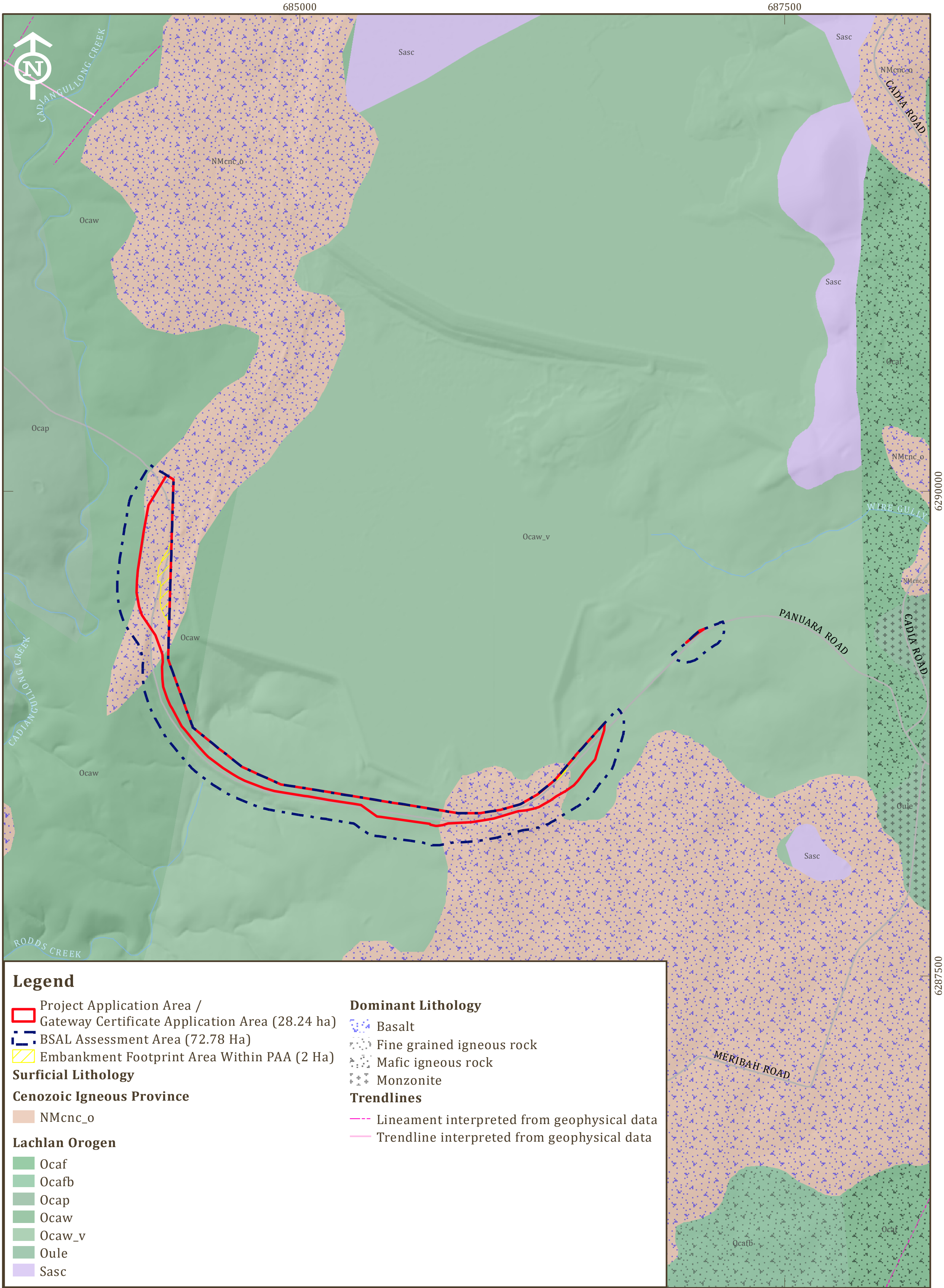
The BSAL Assessment Area primarily consists of the Panuara Soil landscape, with a small portion of the Towac Soil Landscape in the north-western portion of the PAA (refer **Figure 5**), which are described below.

Panuara Soil Landscape

Undulating low hills to rolling hills, 500 – 965 m above sea level. Local relief is usually between 100–120 m, although it can be as low as 60 m for undulating slopes around Panuara. Slopes vary from 5–8% but are up to 15% in the steeper terrain. Slope lengths vary from 500–800 m. Drainage lines run west and are spaced from 500–800 m apart.

Vegetation has been extensively cleared; however, remnant native vegetation consists of dry sclerophyll forest dominated by mountain gum and manna gum.

Soil distribution consists of Red Podzolic Soils on mid to upper slopes, Yellow Solodic Soils occur in drainage lines. Yellow Podzolic Soils occur on lower slopes with Red Earths or Brown/Red Earths. Chocolate Soils or Euchrozems occur on remnants of basaltic mesas.



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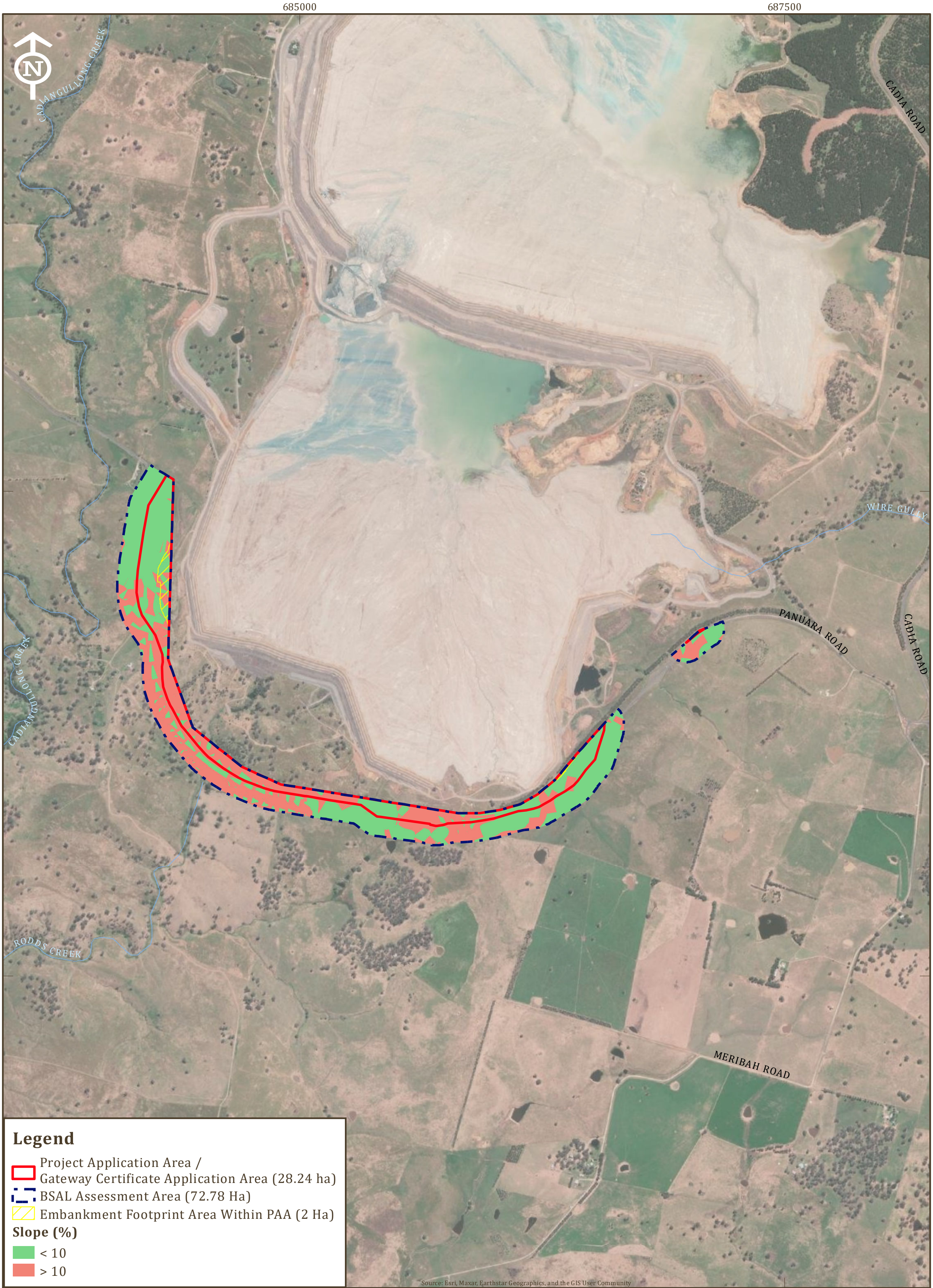
Surficial Geology

FIGURE 3



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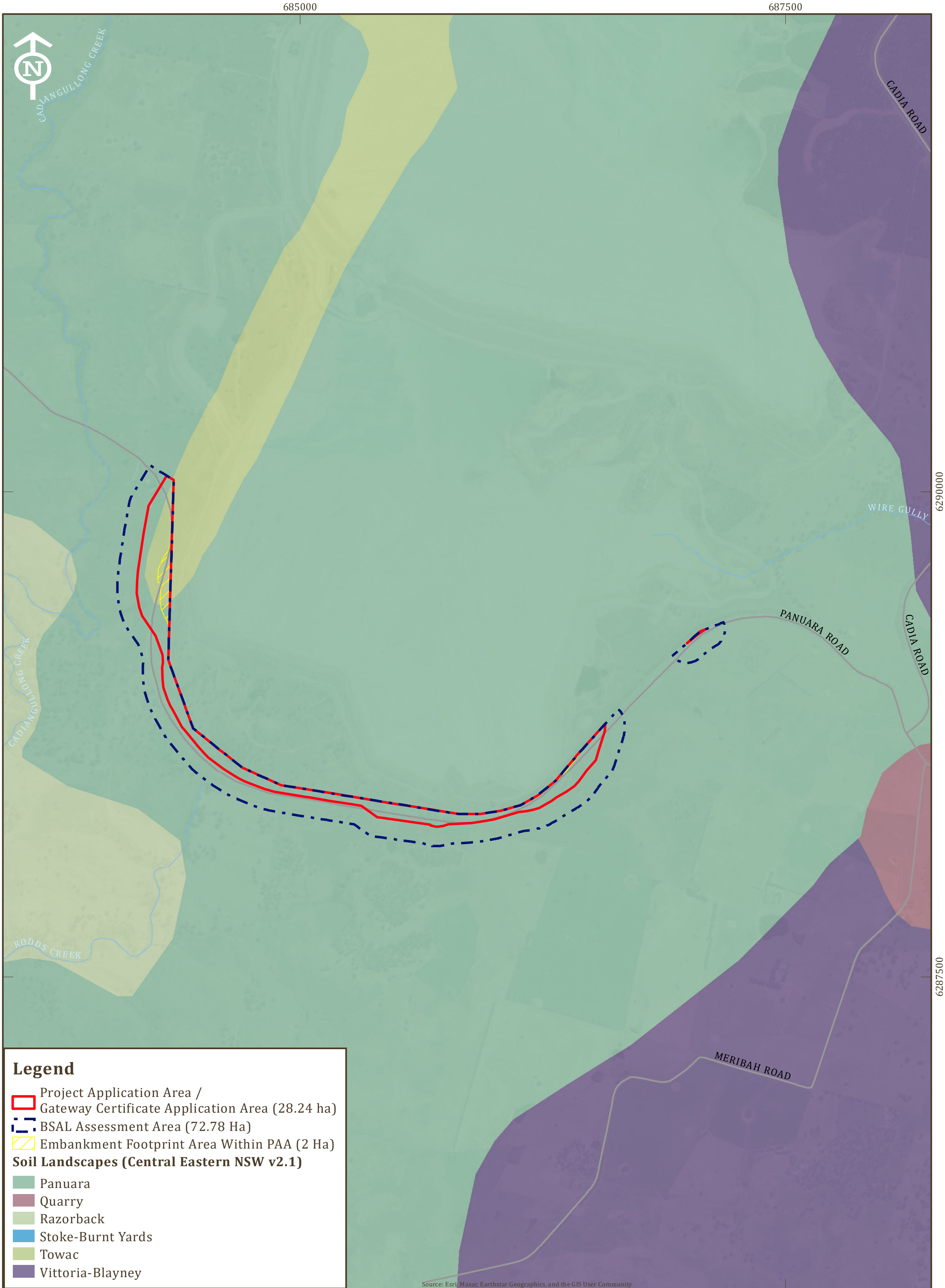
Slope Analysis

FIGURE 4



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Regionally Mapped Soil Landscapes

FIGURE 5

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Towac Soil Landscape

Undulating hills to rolling low hills, from 980 – 1080 m in elevation. Local relief varies from 40–60 m, with some to 100 m. Slopes are between 6–10% but can be up to 20%. Slopes in drainage depressions range from 8% on higher areas to 1–2% in the lower lands.

Remnant native vegetation consists of savannah woodlands with yellow box communities including blakely's red gum, grey box, apple box, bastard box and broad-leaved peppermint on lower areas.

Soil distribution consists of Krasnozems which are dominant and occur on the upper to midslopes are, Red Podzolic/Krasnozem intergrades found on upper slopes, and Yellow Podzolic/Solodic Soils in drainage depressions.

2.3 REGIONALLY MAPPED SOIL TYPES

The NSW regional soil mapping indicates the ASC of soils within the study area is primarily dominated by Kurosols and Ferrosols (refer to **Figure 6**). An overview of these soil types is detailed below.

Kurosols

Kurosols are defined as soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is strongly acidic.

Ferrosols

Ferrosols are defined as soils other than Vertosols, Hydrosols, and Calcarosols that:

- Have B2 horizons in which the major part has a free iron oxide content greater than 5% iron in the fine earth fraction (<2 mm), and
- Do not have a clear or abrupt textural B horizon or a B2 horizon in which at least 0.3 m has vertic properties.

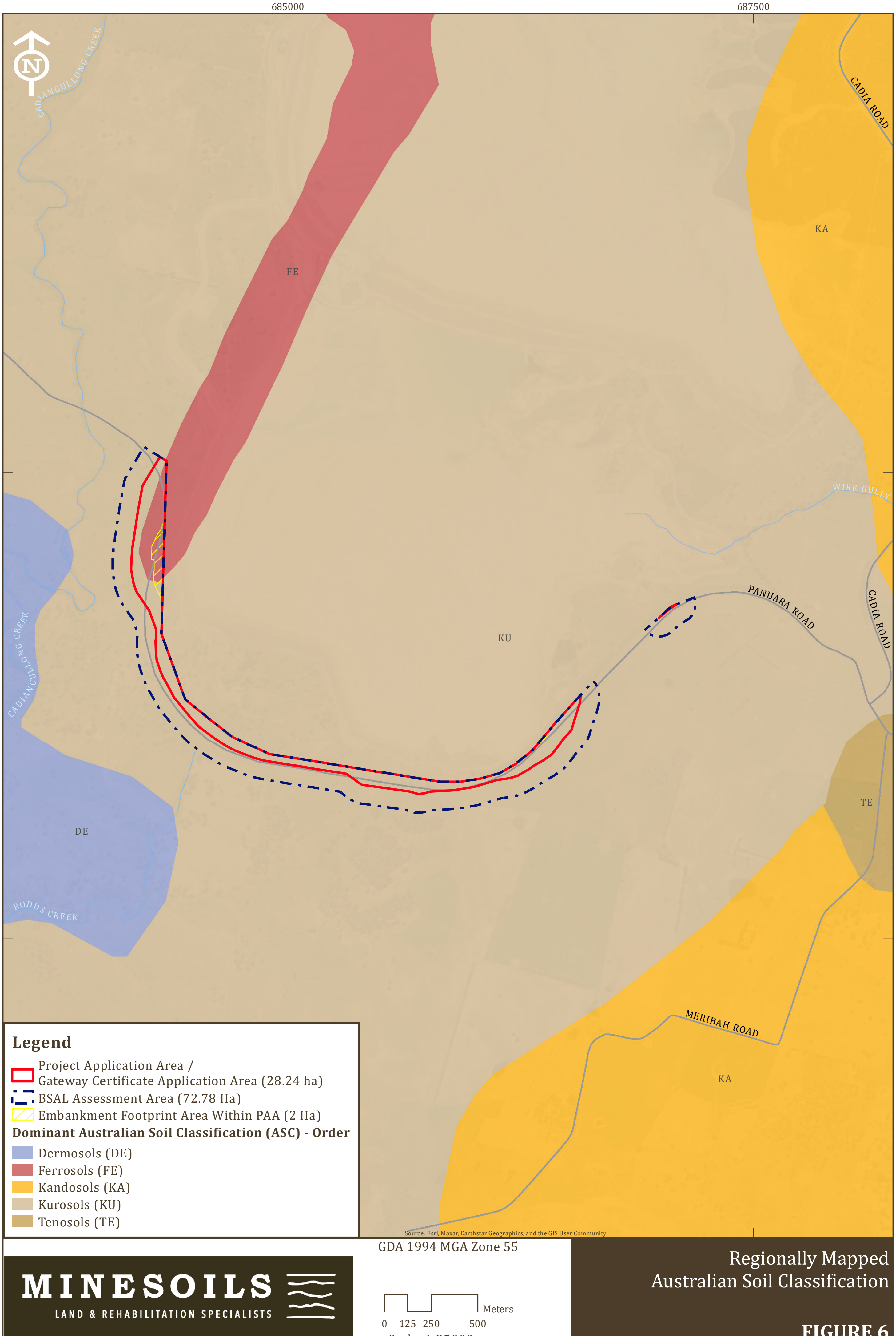
2.4 INHERENT FERTILITY

Inherent fertility is based on the physical and chemical features of soils in their natural, undegraded condition and correlates to ASC mapping. Regional soil inherent fertility has been mapped for the area and indicates the BSAL Assessment Area contains soils with 'Moderate' and 'Moderately High' inherent fertility (refer to **Figure 7**).

Soils with 'Moderate' fertility usually require fertilisers and/or have some physical restrictions for arable use. Soils with 'Moderately High' fertility have a high level of fertility in their virgin state which is significantly reduced after a few years of cultivation (Murphy et al 2007).

2.5 REGIONALLY MAPPED LAND AND SOIL CAPABILITY

Land and Soil Capability (LSC) mapping 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. Regional LSC mapping indicates the PAA contains Class 3 and Class 4 land (refer to **Figure 8**).



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PANUARA ROAD
CADIA ROAD
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DE
RODDS CREEK
MERIBAH ROAD
KA
Legend
Project Application Area / Gateway Certificate Application Area (28.24 ha)
BSAL Assessment Area (72.78 Ha)
Embankment Footprint Area Within PAA (2 Ha)
Dominant Australian Soil Classification (ASC) - Order
Dermosols (DE)
Ferrosols (FE)
Kandosols (KA)
Kurosols (KU)
Tenosols (TE)
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
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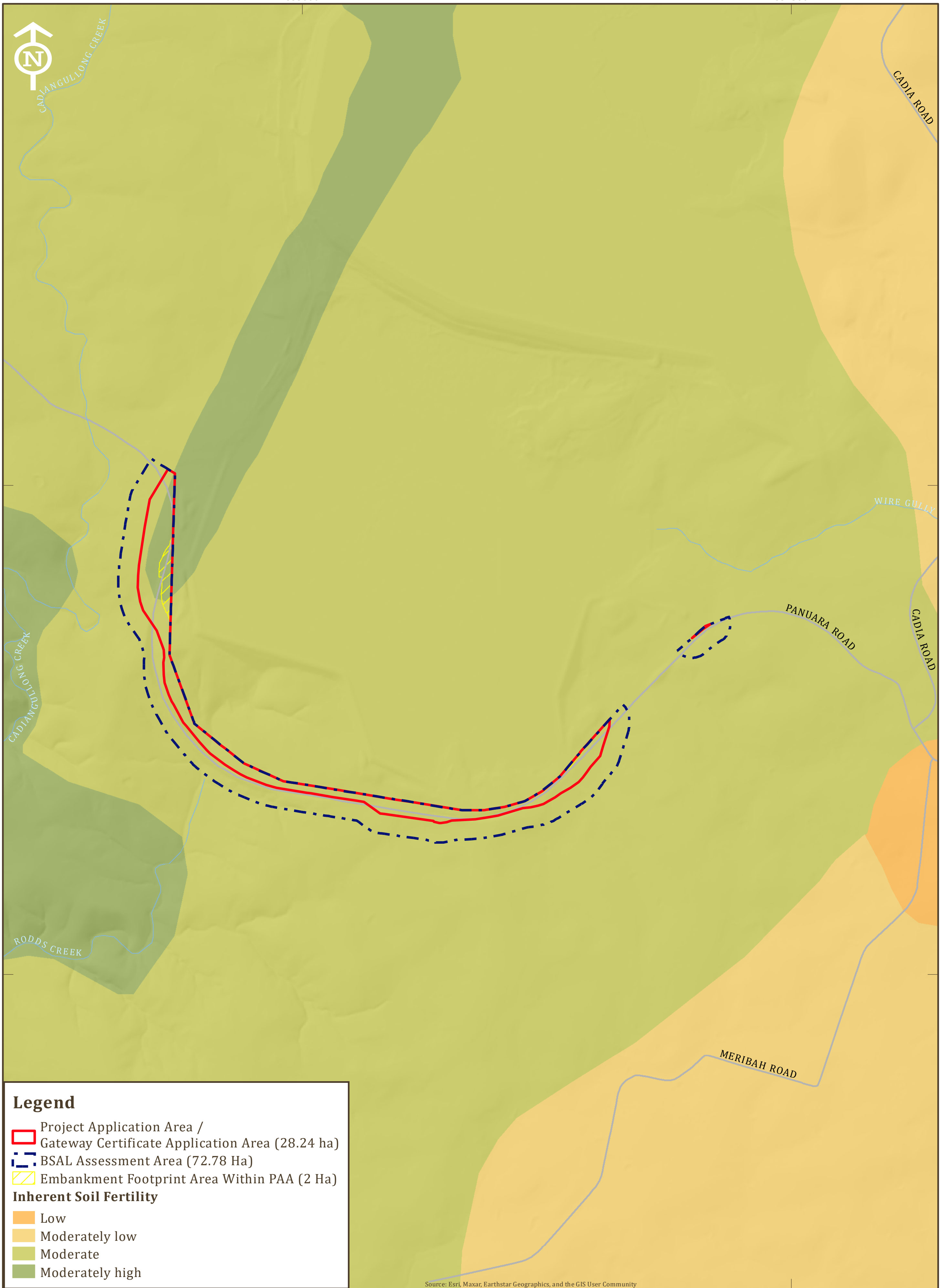

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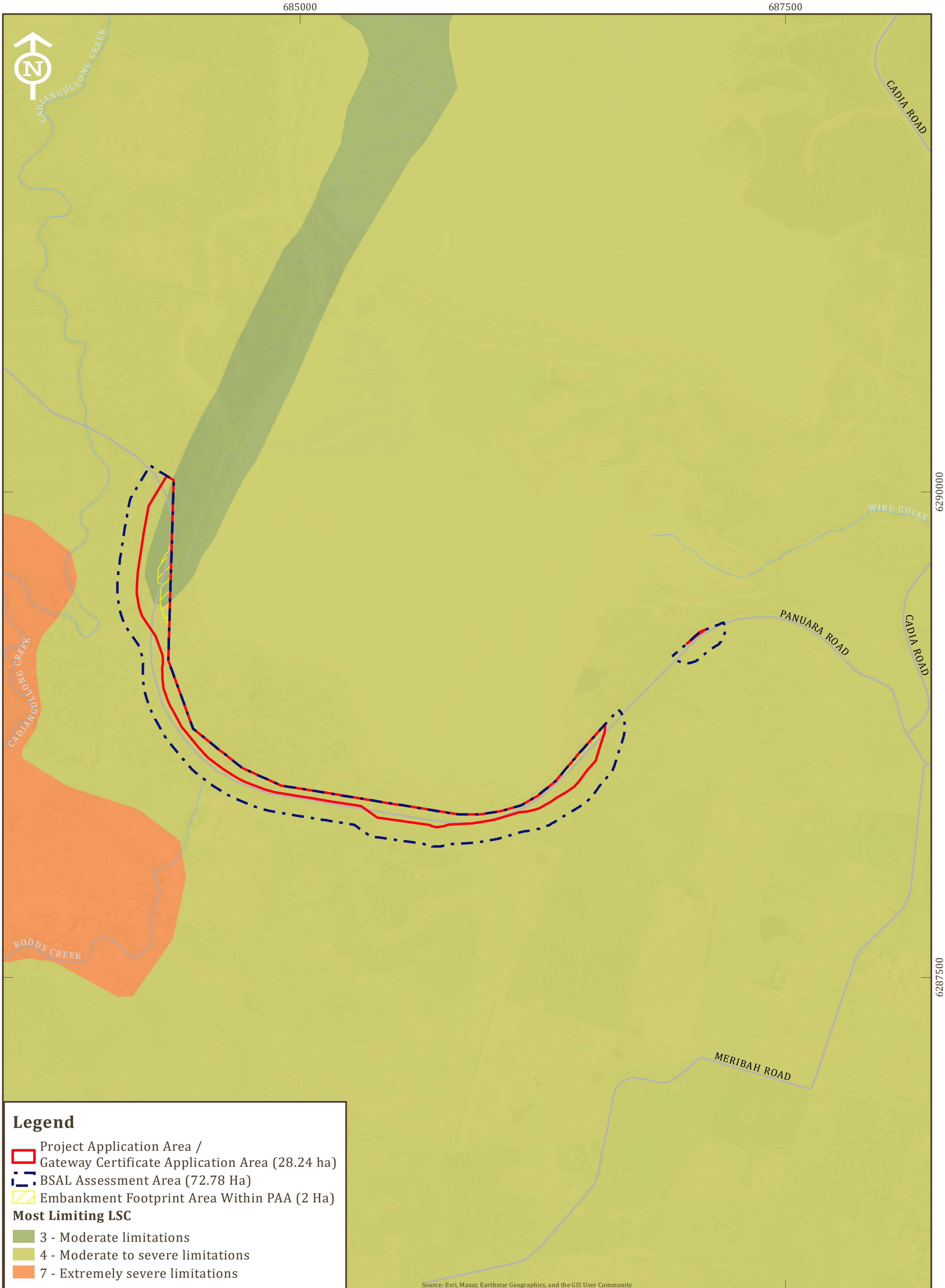
Regionally Mapped
Inherent Soil Fertility

FIGURE 7



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Regionally Mapped
Land and Soil Capability

FIGURE 8

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Class 3

This classification indicates land that 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.

Class 3 lands have been mapped in a small area in the north west of the PAA

Class 4

This classification indicates moderate capability land that has moderate to high limitations for high-impact land uses. This 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, input, investment and technology.

Class 4 lands are the most spatially extensive of the land classes within the PAA.

2.6 LAND USE

The dominant land use in the CVO's locality include mining and agricultural activities in the form of cultivation and grazing on improved/native pastures. An extensive portion of the CVO's locality has designation as State Forest.

The BSAL Assessment Area consists of extensively cleared land used for grazing on native and improved pastures. Scattered paddock trees occur across the land.

3 THE BSAL ASSESSMENT PROCESS

3.1 OVERVIEW

BSAL is land with a rare combination of natural resources highly suitable for agriculture. These lands intrinsically have the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity and require minimal management practices to maintain this high quality (OEH and DPI-OAS&FS, 2013).

The criteria used to measure BSAL under the original Upper Hunter *Strategic Regional Land Use Plan* (SRLUP) (Department of Planning and Infrastructure, 2012b) were based on three regional scale parameters:

1. Soil Fertility – based on the regional scale *Draft Inherent General Fertility of NSW* (Department of Planning and Industry [DP&I], 2012a),
2. Land and Soil Capability – based on the regional scale *Land and Soil Capability Mapping of NSW* (OEH, 2012a), and
3. Access to reliable water supply.

The application of the Strategic Agricultural Land mapping is to 'trigger' the Gateway Process for new project development applications.

The *State Environmental Planning Policy (Resources and Energy) 2021* (Mining SEPP) requires certain types of developments (i.e. mining or petroleum developments) to verify whether the proposed development is on BSAL. The *Interim Protocol* assists proponents and landholders to understand what is required to identify the existence of BSAL and outlines the technical requirements for the on-site identification and mapping of BSAL.

3.2 METHODOLOGY

The methodology reported in the following section has been undertaken based on the *Interim Protocol* (OEH and DPI-OAS&FS, 2013).

Step 1: Identify the project area which will be assessed for BSAL

"The assessment area should include the entire project area and include at least a 100 m buffer to take into account minor changes in design, surrounding disturbance and minor expansion. If BSAL is part of a larger contiguous mass of BSAL then the boundary of this area must also be identified".

The BSAL Assessment Area is 72.8 ha, inclusive of a 100 m buffer surrounding the PAA to account for minor changes in design in accordance with the *Interim Protocol*, as shown in **Figure 2**.

Step 2: Confirm access to a reliable water supply

"BSAL lands must have access to a "reliable water supply".

Representative rainfall data for the area has been obtained from the closest Commonwealth Bureau of Meteorology (BoM) weather stations to the Activity Area (BoM, 2021); the Orange Airport Automatic Weather Station (AWS) (063303) and Orange Agricultural Institute (063254). Mean annual rainfall is approximately 881.9 mm at the Orange Airport AWS and approximately 906.5 mm at the Orange Agricultural Institute. This rainfall is above the criteria threshold of 350 mm per year, and therefore the site has access to a reliable water supply.

Step 3: Choose the appropriate approach to map the soils information

Access to the project area will define the level of investigation that the proponent can undertake. If the proponent has access to the land then the BSAL verification requirements for on-site soils assessment as described in sections 6 and 9 of the Interim Protocol should be met. If the proponent does not have access then the proponent should develop a model of soils distribution guided by sections 6 and 9 based on landscape characteristics using the information below.

…

It is important to note that for either approach, if any criteria indicate that the site is not BSAL, then no further assessment is necessary. The flow chart in Figure 2 is designed to assess the simplest criteria first, to avoid more costly assessments if the site can be easily discounted as BSAL.

The Proponent has access to the site for the purposes of site verification of BSAL.

Step 4: Risk assessment

The proponent should undertake a risk assessment as this will influence the density of soil sampling required as explained in Section 9.6.1. The proposed activity on parts or all of the project area may be of low risk to agriculture and so may only require a sampling density of 1:100 000. Alternatively, other areas may be at higher risk of impact and so should have a sampling density of 1:25 000.

To identify the potential for the PAA to impact on agricultural resources and the appropriate level of soil survey required, an evaluation of risk to agricultural resources and enterprises was undertaken. This risk assessment is taken from the *Guideline for Agricultural Impact Statements at the Exploration Stage* (Department of Trade, Investment, Regional Infrastructure and Services [DTIRIS], 2012) and is based on the probability of occurrence and the consequence of the impact, as described in the *Land Use Conflict Risk Assessment Guide* (NSW DPI, 2011). Depending on the risk, inspection densities can range from 1 site per 25-400 ha for low risk to 1 site per 5-25 ha for high risk (Gallant *et al*., 2008) (refer to **Table 1**, **Table 2** and **Table 3**).

Table 1: Agricultural Impacts Risk Ranking Matrix

Consequence		Probability				
		A Almost Certain	B Likely	C Possible	D Unlikely	E Rare
1	Severe and/or permanent damage. Irreversible impacts.	A1	B1	C1	D1	E1
2	Significant and /or long-term damage. Long term management implications. Impacts difficult or impractical to reverse.	A2	B2	C2	D2	E2
3	Moderate damage and/or medium-term impact to agricultural resources or industries. Some ongoing management implications which may be expensive to implement. Minor damage or impacts over the long term.	A3	B3	C3	D3	E3
4	Minor damage and/or short-term impact to agricultural resources or industries. Can be managed as part of routine operations.	A4	B4	C4	D4	E4
5	Very minor damage and minor impact to agricultural resources or industries. Can be effectively managed as part of normal operations.	A5	B5	C5	D5	E5

Low Risk

Medium Risk

High Risk

Source: Interim Protocol Appendix 3 Risk Assessment (OEH and DPI-OAS&FS, 2013)

Table 2: Agricultural Impact Risk Ranking – Probability Descriptors

Level	Descriptor	Description
A	Almost certain	Common or repeating occurrence
B	Likely	Known to occur or it has happened
C	Possible	Could occur or I've heard of it happening
D	Unlikely	Could occur in some circumstances but not likely to occur
E	Rare	Practically impossible or I've never heard of it happening

Source: Interim Protocol Appendix 3 Risk Assessment (OEH and DPI-OAS&FS, 2013)

Table 3: Agricultural Impact Risk Ranking – Consequence Descriptors

Consequence	Description	Example of Implications
Level: 1 Severe	Severe and/or permanent damage to agricultural resources, or industries Irreversible Severe impact on the community	Long term (e.g. 20 years) damage to soil or water resources Long term impacts (e.g. 20 years) on a cluster of agricultural industries or Important agricultural lands
Level: 2 Major	Significant and/or long-term impact to agricultural resources, or industries Long-term management implications Serious detrimental impact on the community	Water or soil impacted, possibly in the long term (e.g. 20 years) Long term (eg. 20 years) displacement / serious impacts on agricultural industries
Level: 3 Moderate	Moderate and/or medium-term impact to agricultural resources, or industries Some ongoing management implications Minor damage or impacts but over the long term.	Water or soil known to be affected, probably in the short – medium term (e.g. 1-5 years) Management could include significant change of management needed to agricultural enterprises to continue.
Level: 4 Minor	Minor damage and/or short-term impact to agricultural resources, or industries Can be effectively managed as part of normal operations	Theoretically could affect the agricultural resource or industry in short term, but no impacts demonstrated Minor erosion, compaction or water quality impacts that can be mitigated. For example, dust and noise impacts in a 12-month period on extensive grazing enterprises.
Level: 5 Negligible	Very minor damage or impact to agricultural resources, or industries Can be effectively managed as part of normal operations	No measurable or identifiable impact on the agricultural resource or industry

Source: *Interim Protocol* Appendix 3 Risk Assessment (OEH and DPI-OAS&FS, 2013)

The proposed agricultural impacts within the PAA are conservatively considered to be:

a. Consequence: Level 2 – Significant and/or long-term impact to agricultural resources, or industries. Long-term management implications. Serious detrimental impact on the community; and

b. Probability: A – Almost Certain. Common or repeating occurrence.

The risk matrix result is A2 which is considered a high risk to agricultural activities. Therefore, this area is to have an inspection density of 1:25,000, which requires a minimum observation site every 20 ha within the PAA. For the purpose of this survey, the 100 m buffer area is also considered to require an inspection density of 1:25,000.

Site assessment of slope gradients was undertaken using a digital elevation model, which show gradients greater than 10% (as shown in **Figure 4**). This area of 25.5 ha was discounted from BSAL field assessment and verified as Non-BSAL based on a desktop review. Contiguous areas of <20 ha within broader areas of slopes >10% (1.9ha) and land disturbance associated with Panuara Road (13.9 ha), totalling an area of 15.8 ha, was additionally discounted. The remainder of the BSAL Assessment Area, consisting of 31.5 ha, was subject to further BSAL assessment.

Therefore, based on the reached inspection density, the number of inspection sites required is a minimum of 2 sites to verify BSAL or Non-BSAL based on the soil types identified.

Soils and landscape verification criteria

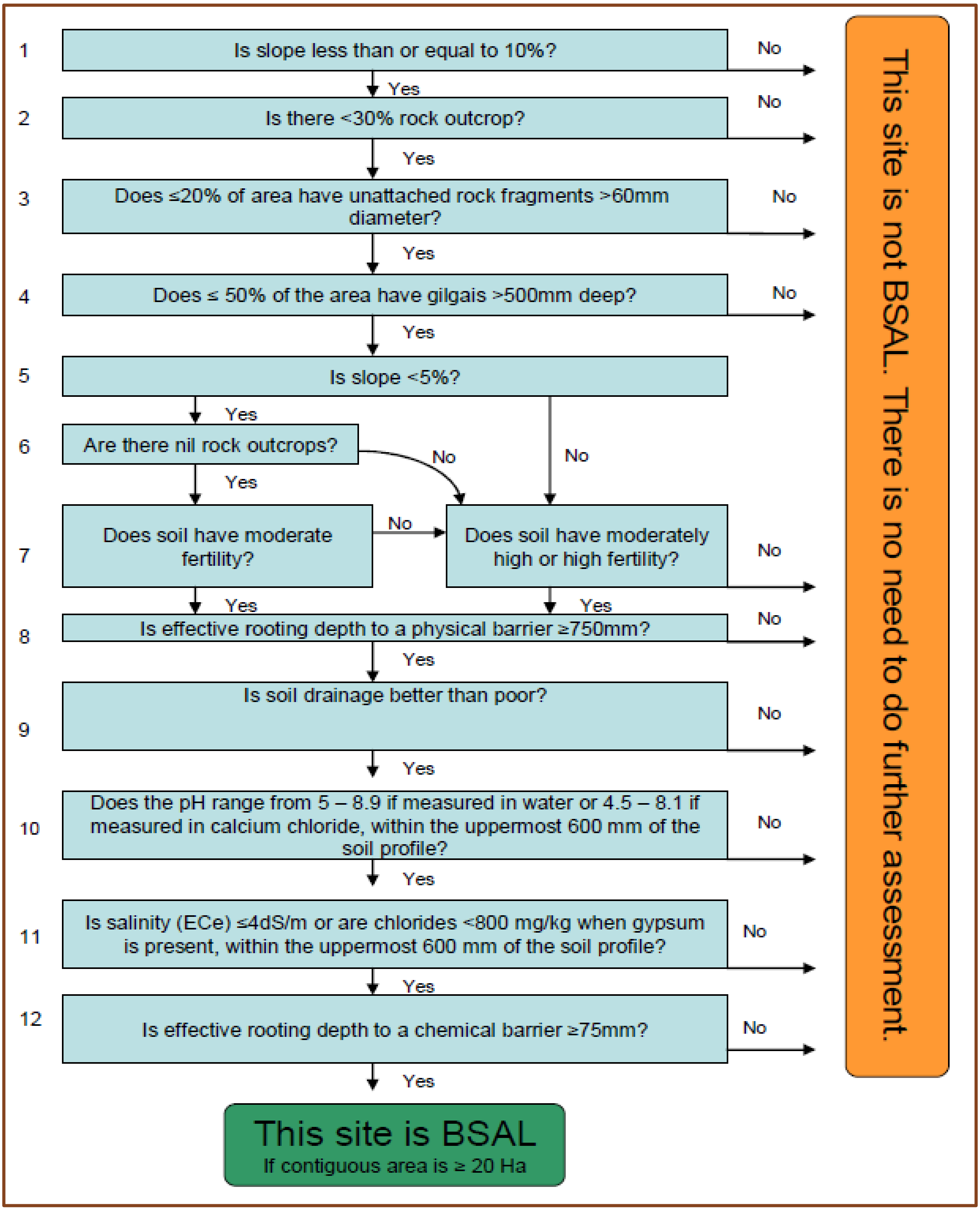
Ten site verification criteria have been identified in the *Interim Protocol*, with the easy-to-measure criteria assessed first (**Figure 9**). Soil samples were collected and assessed in the field and laboratory. Analytical tests undertaken are listed in **Table 4** below. The ten site verification parameters are: slope; rock outcrop; surface rock fragments; gilgai; soil fertility (based on soil type); effective rooting depth to a physical barrier; soil drainage; soil pH; salinity; and effective rooting depth to a chemical barrier. For soil to be classified as BSAL at each representative site, it must meet all the criteria outlined in the flow chart shown in **Figure 9**. If any criteria are not met, the site is not BSAL and there is no need to continue the assessment. The specific requirements for each parameter to be assessed is outlined in the Interim Protocol. Site field assessment of slope gradients was undertaken using a hand-held clinometer to confirm the digital elevation model results. Other exclusion parameters were assessed in the field, including rock outcrops, surface rock and the presence of gilgai. These were considered exclusion sites and no further parameters were recorded.

A field assessment was undertaken by Minesoils in June 2021 and May 2022, with a total of 10 sites inspected, as shown on **Figure 10**. All 10 sites were subjected to test pit assessment and sampling. Samples from 7 sites were submitted for laboratory analysis to confirm soil type and BSAL status, qualifying them as 'detailed' sites. The remaining three sites are presented as 'check' sites.

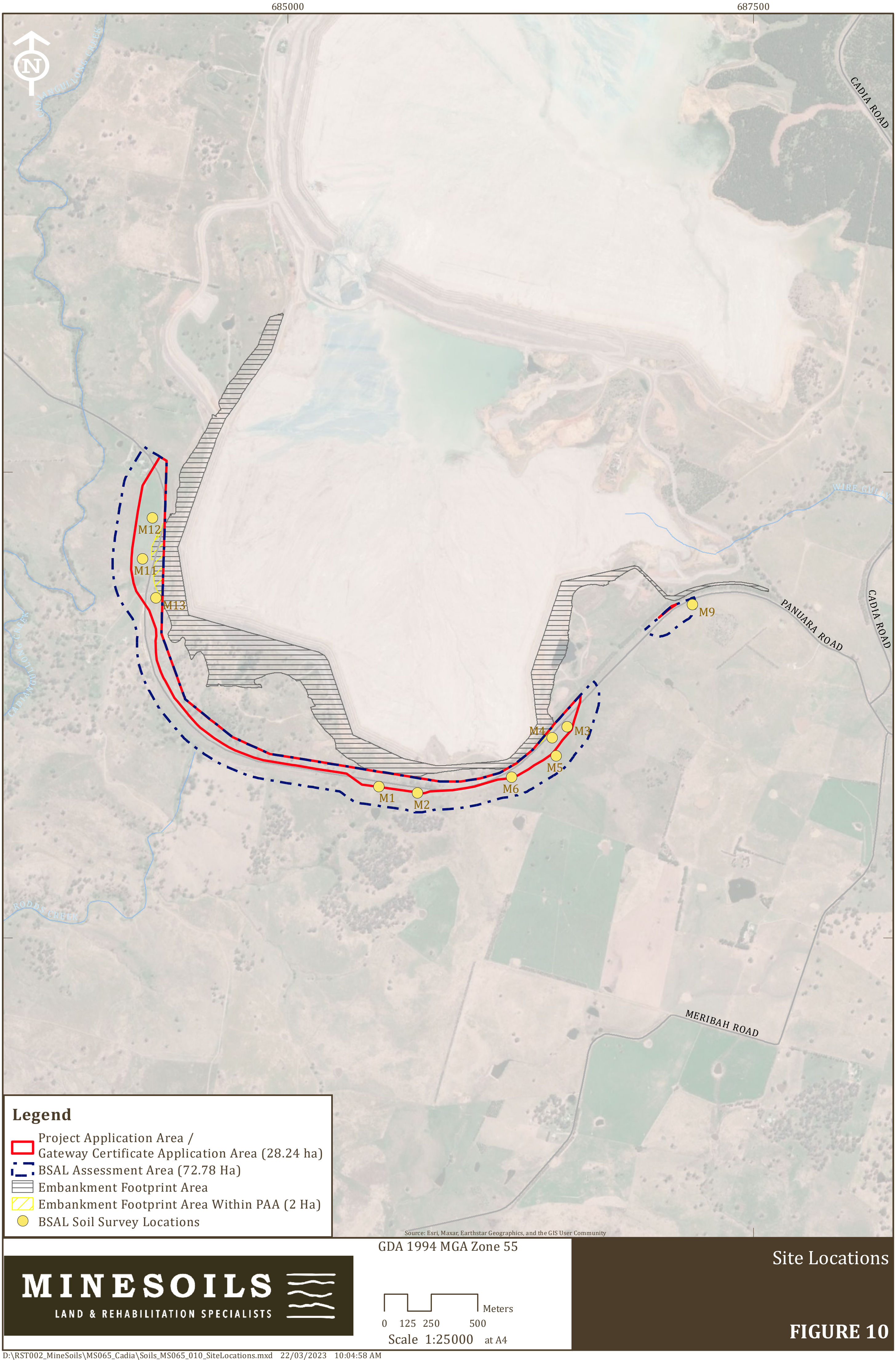
Table 4: Soil Sample Laboratory Analysis

Lab Analysis	
pH (1:5 water & calcium chloride (CaCl))	Rayment & Lyons, 2011-4A1
Electrical Conductivity (EC) and Chloride	Rayment & Lyons 2011-3A1
Cation Exchange Capacity (CEC) & Exchangeable Sodium Percentage (ESP)and Ca:Mg Ratio	Rayment & Lyons 2011-15J1
Particle Size Analysis (PSA) (Selected samples only)	ISSS Hydrometer plus 0.2 and 2.0 mm Sieving (Commonwealth Scientific and Industrial Research Organisation [CSIRO] 'Yellow Book')

Figure 9: Schematic Diagram of BSAL Site Verification Criteria



Source: Interim Protocol (OEH and DPI-OAS&FS, 2013)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M5
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M11
M12
M13
Legend
Project Application Area /
Gateway Certificate Application Area (28.24 ha)
BSAL Assessment Area (72.78 Ha)
Embankment Footprint Area
Embankment Footprint Area Within PAA (2 Ha)
BSAL Soil Survey Locations
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
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Site Locations
FIGURE 10
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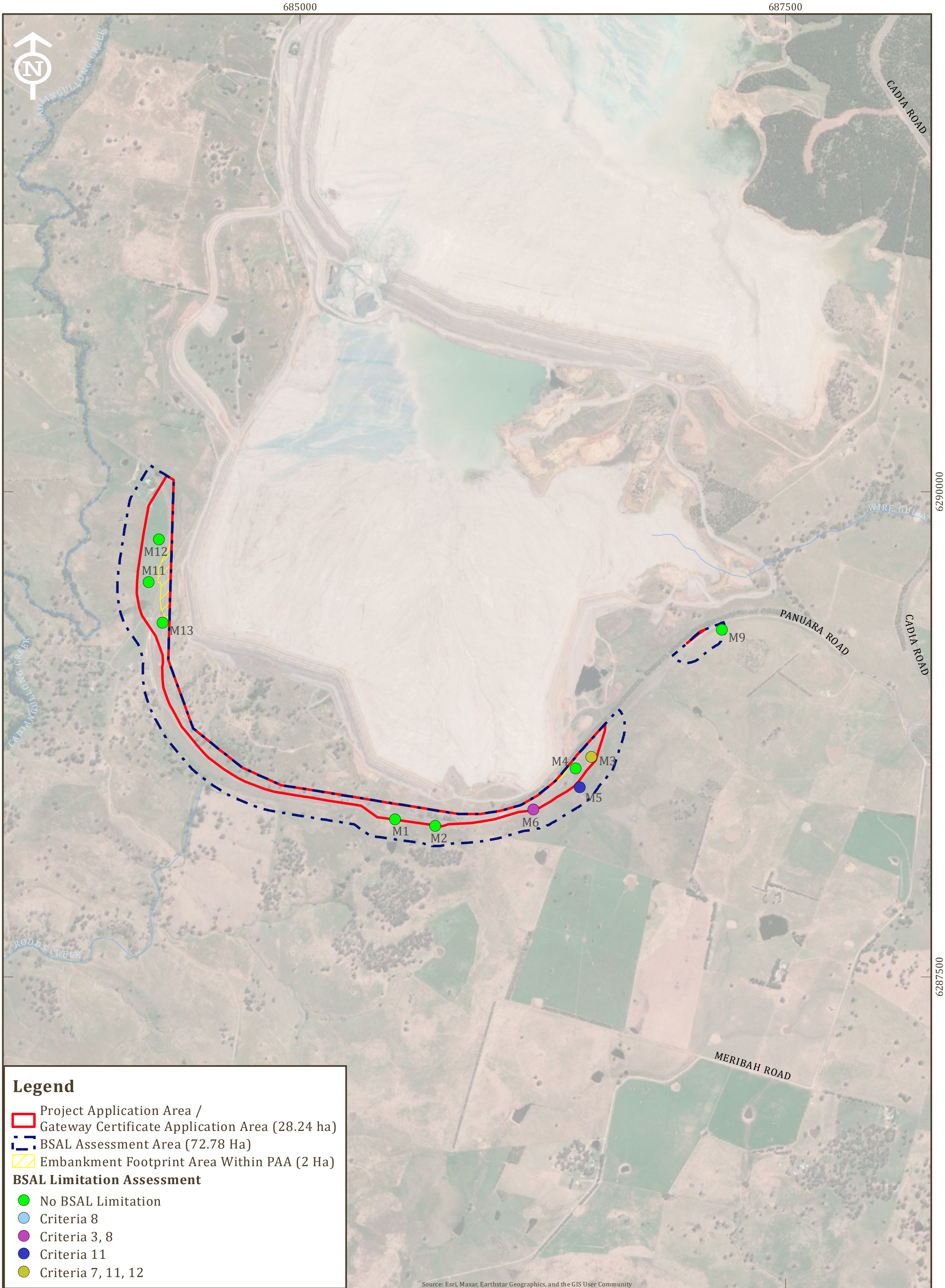
4 BSAL VERIFICATION RESULTS

The BSAL site verification assessment resulted in 7 sites satisfying the BSAL criteria. A further 3 sites failed to satisfy the requirements for BSAL (refer **Figure 11**). Therefore, BSAL is confirmed to be present within the BSAL Assessment Area.

Verified BSAL occurs over an area of 24.9 ha of the BSAL Assessment Area (8.3 ha of the PAA), with distribution shown in **Figure 12**. The remaining 47.9 ha of the BSAL Assessment Area is verified Non-BSAL due to contiguous areas <20 ha, areas of slopes >10% and land disturbance associated with Panuara Road. Additional BSAL limitations in these areas include salinity, depth to physical barrier, depth to chemical barrier and rockiness.

While there are no contiguous areas >20 ha within the BSAL Assessment Area (the largest contiguous mass present is <10 ha), site observations, existing regional mapping, and concurrent studies viewed in the context of the findings of this assessment suggest the areas of BSAL verified likely form part of a larger contiguous mass (i.e. >20 ha).

Table 5 details the BSAL verification assessment process and summaries limiting factors for all eliminated sites.



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BSAL Assessment

FIGURE 11

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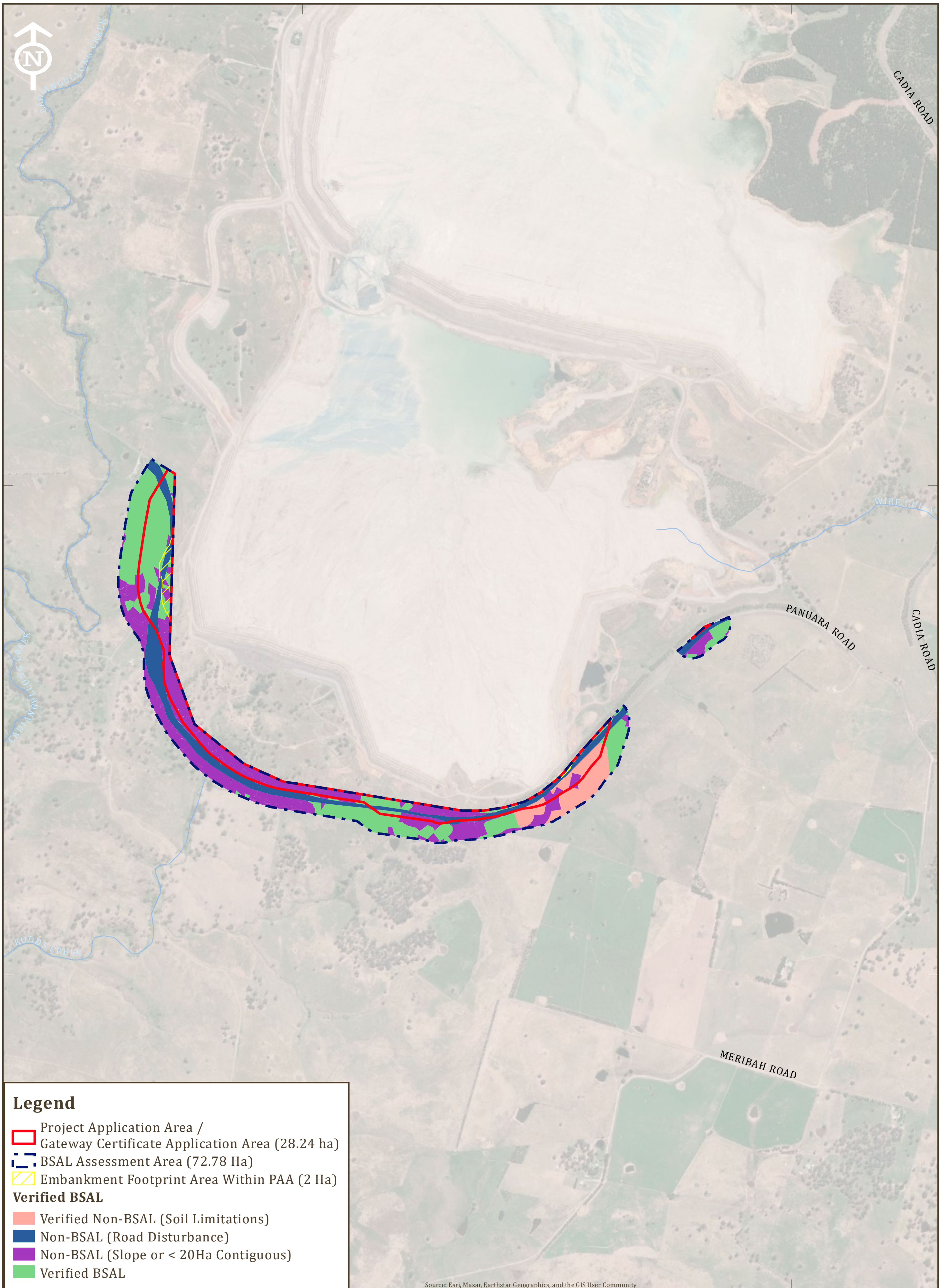

Legend

- Project Application Area / Gateway Certificate Application Area (28.24 ha)
- BSAL Assessment Area (72.78 Ha)
- Embankment Footprint Area Within PAA (2 Ha)

Verified BSAL

- Verified Non-BSAL (Soil Limitations)
- Non-BSAL (Road Disturbance)
- Non-BSAL (Slope or < 20Ha Contiguous)
- Verified BSAL

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Verified BSAL

FIGURE 12

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Table 5: Site BSAL Verification Summary

Site #	Inspection Site Type	Mapping Unit		Soil Profile - Australian Soil Classification (ASC)	ASC Family Criteria	1. Is slope < 10%?	2. Is there < 30% Rock Outcrop?	3. < 20% unattached Rock Fragments > 60mm?	4. Does < 50% have Gilgais >500mm deep?	5. Is Slope <5%?	6. Are there nil rock outcrops?	7a. Does Soil Have Moderate Fertility?	7b. Does soil have moderately high or high fertility?	8. Is ERD to a physical barrier >750mm?	9. Is drainage better than poor?	10. Is pH between 5.0 and 8.9?	11. Is salinity (ECe) < 4 dS/m	12. Is ERD to a chemical barrier >750mm?	Soil Profile BSAL Verification	Limiting Factors
		#	Name																	
M1	Detailed	2	Dermosols	Haplic Eutrophic Brown Dermosol	BEMOW	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	BSAL	-
M2	Check	2	Dermosols	Brown Dermosol	-	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	-	-	-	BSAL	-
M3	Detailed	1	Chromosols	Eutrophic Mesonatric Brown Sodosol	BFLMW	✓	✓	✓	✓	×	✓	×	×	✓	✓	✓	×	×	Non-BSAL	7. Soil fertility 11. Salinity 12. Depth to chemical barrier
M4	Detailed	1	Chromosols	Haplic Eutrophic Brown Chromosol	BFLOW	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	BSAL	-
M5	Detailed	1	Chromosols	Haplic Hypocalcic Brown Chromosol	BEKOW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	Non-BSAL	11. Salinity
M6	Check	2	Dermosols	Brown Dermosol	-	✓	✓	×	✓	✓	×	✓	✓	×	✓	-	-	-	Non-BSAL	3. Rockiness 8. Depth to physical barrier
M9	Check	1	Chromosols	Brown Chromosol	-	✓	✓	✓	✓	×	×	✓	✓	✓	✓	-	-	-	BSAL	-
M11 (D8)	Detailed	1	Chromosols	Haplic Eutrophic Red Chromosol	BEMOW	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	BSAL	-
M12 (D9)	Detailed	1	Chromosols	Haplic Eutrophic Red Chromosol	BEMOW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	BSAL	-
M13 (D12)	Detailed	1	Chromosols	Haplic Eutrophic Red Chromosol	BEMOW	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	BSAL	-

5 SOIL ASSESSMENT

5.1 SOIL SURVEY METHODOLOGY

Minesoils undertook a soil and land resource survey to inform the following tasks to be undertaken for the Gateway Assessment:

- Soil assessment, identifying Soil Units, soil qualities and risks including erosion, Acid Sulphate Soils risk and salinity;
- LSC Assessment and mapping in accordance with *The Land and Soil Capability Assessment Scheme – Second Approximation* (OEH, 2012b).
- Management and mitigation measures for handling soil during construction, operations and decommissioning.

The objective of the Minesoils fieldwork program is to satisfy the field assessment, sampling and testing requirements related to soil and land resources. The fieldwork plan outlined below was designed to satisfy the following requirements:

- Soil survey and mapping of areas outside current mining leases: This was undertaken at greater than a 'detailed' 1:25,000 survey intensity, and required collection of landform pattern and element information, soil profile data, and taxonomic parameters to distinguish Soil Units according to the ASC criteria, within the CVO.
- LSC: The information required for the LSC assessment was collected during both the desktop assessment and verified on the ground during the field program. The LSC system requires data on biophysical features from in situ measurements and regional mapping.
- Soil qualities: Additional information was recorded in the field on erosion and evidence of potentially erosive soils including tunnelling, rill, gully and sheet erosion, which may require specific handling and management techniques during construction or operational activities, and the consequences of this on stripping and rehabilitation. Observations were made on risks of Acid Sulphate Soils and salinity.

The field program was designed as an integrated free survey. An integrated survey assumes that many land characteristics are interdependent and tend to occur in correlated sets (National Committee on Soil and Terrain [NCST], 2008). 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 gradual variation. Soil pits were excavated by a tracked excavator to 1 m. Site clearances and dial before you dig (DBYD) plans were undertaken as part of the excavation planning requirements.

Soil profiles within the PAA (refer to **Figure 10**) were assessed in accordance with the *Australian Soil and Land Survey Field Handbook* (NCST, 2009). Detailed soil profile descriptions were recorded covering the major parameters specified in **Table 6** below. Soil profile logging was undertaken in the field using Minesoils soil data sheets, including Global Positioning System (GPS) recordings and photographs of the landforms and soil profiles. Soils were keyed out in accordance with the *Australian Soil Classification Third Edition* (Isbell, R. F., 2021).

Soil samples were collected at each of the assessment site's soil horizons to a depth of 1 m. A total of 38 samples were collected, 28 of these were considered representative and subject to laboratory testing. The laboratory testing suite for these sites is detailed in the **Table 4**.

Duplicate samples at every site were collected during the fieldwork and would be stored until the Gateway Application is finalised.

Table 6: Detailed Soil Profile Description Parameters

Detailed Field Assessment Parameters	
Horizon depth including distinctiveness and shape	Pan presence and form
Field texture grade	Permeability and drainage
Field colour (Munsell colour chart)	Field pH
Pedality structure, grade and consistence	Field moisture
Soil fabric and stickiness	Surface condition
Stones (abundance and size)	Landform pattern / element
Mottles (amount, size and distinctiveness)	Current land use and previous disturbance
Segregations (abundance, nature, form and size)	Vegetation

5.2 SOIL SURVEY RESULTS

Two soil mapping units were identified within the PAA and the BSAL Assessment Area. The distribution of these soil mapping units is illustrated on **Figure 13**.

The soil mapping units consist of the following:

- Soil Mapping Unit 1: Chromosols; and
- Soil Mapping Unit 2: Dermosols.

An overview of each of the soil mapping units is presented below. Detailed profile descriptions of representative sites are included in **Appendix 1** and summarised in **Table 7**.

Soil Mapping Unit 1: Chromosols

Chromosols are defined as soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is not sodic and not strongly acid. Soils with strongly subplastic upper B2t horizons are also included even if they are sodic.

Representative dominant detailed soil profiles include M4, M5, M9, M11, M12, M13.

A subdominant soil profile exists within this mapping unit. M3 is a Sodosol, which is a duplex soil similar to a Chromosol, however, is defined as a texture contrast soil in which the major part of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is sodic. Profile M3 represents this subdominant soil type occurrence.

This mapping unit is the most spatially extensive within the BSAL Assessment Area, covering 48.0 ha.

Soil Mapping Unit 2: Dermosols

Dermosols are defined as soils other than Vertosols, Hydrosols, Calcarosols and Ferrosols which have B2 horizons that have grade of pedality greater than weak throughout the major part of the horizon, and do not have clear or abrupt textural B horizon.

Site M1 is the representative dominant detailed soil profile. Check sites for this mapping unit include M2 and M6.

This mapping unit covers an area of 24.8 ha.

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Scale 1:25000 at A4

Soil Mapping Units

FIGURE 13

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Table 7: Soil Map Units and Soil Types Summary

Site #	Soil Map Units		Soil Profile - Australian Soil Classification (ASC)	ASC Family Criteria
	#	Name		
M1	2	Dermosols	Haplic Eutrophic Brown Dermosol	BEMOW
M2	2	Dermosols	Brown Dermosol	-
M3	1	Chromosols	Eutrophic Mesonatric Brown Sodosol	BFLMW
M4	1	Chromosols	Haplic Eutrophic Brown Chromosol	BFLOW
M5	1	Chromosols	Haplic Hypocalcic Brown Chromosol	BEKOW
M6	2	Dermosols	Brown Dermosol	-
M9	1	Chromosols	Brown Chromosol	-
M11	1	Chromosols	Haplic Eutrophic Red Chromosol	BEMOW
M12	1	Chromosols	Haplic Eutrophic Red Chromosol	BEMOW
M13	1	Chromosols	Haplic Eutrophic Red Chromosol	BEMOW

6 LAND CAPABILITY IMPACT ASSESSMENT

6.1 OVERVIEW

The LSC classification applied to the PAA was in accordance with the OEH guideline *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 8** 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 8: Land and Soil Capability Classification

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

6.2 METHODOLOGY

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
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 therefore assessed against the appropriate criteria tables in the LSC Guidelines. Assessment of the water erosion hazard is almost solely dependent on the slope percentage of the land, based on each soil landscape unit. The only exception is land which falls within the slope range of 10-20%, which may be designated 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 type: wind erosion power, exposure to wind, average rainfall and soil erodibility. Three criteria were assessed to be consistent for each soil type:

- Wind erosive power for the PAA has been mapped as 'Low';
- Exposure of the land to wind was also determined to range from Low to High depending on the landform pattern and landform element in the proximity of the sites throughout the PAA; and
- The average rainfall for the region is 881.9 mm (BoM, 2021), and therefore the PAA lies within the "greater than 500 mm rainfall" category.

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

Hazard 3: Soil Structure Decline

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

Hazard 4: Soil Acidification

The soil acidification hazard is assessed using three criteria, being soil buffering capacity, pH and mean annual rainfall. In this assessment, soil buffering capacity was based on surface soil texture; surface soil pH and a regional mean annual rainfall range of 550 - 700mm.

Hazard 5: Salinity

The salinity hazard is determined through a range of data and criteria. The recharge potential for the site was determined based on an average annual rainfall of 656.4 mm, with annual evaporation of 50-220 mm (BoM, 2021). This would suggest a high recharge potential and a low discharge potential.

According to the Salt Store Map of NSW, the PAA is located in an area of low salt store. However, due the current available scale of this mapping, laboratory tested EC values were used to determine salt store. The entire study PAA fell within non saline to moderately saline EC results.

Hazard 6: Water Logging

Water logging was determined by the soil 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.

6.3 PRE-DISTURBANCE LSC

The findings of the LSC assessment on each soil type within the CVO are presented in **Table 9**. An overview of the pre-disturbance LSC for the PAA is presented in **Figure 14**, and summarised in **Table 10**.

Table 9: LSC for Soil Survey of the PAA

	Hazard Criteria								
	1	2	3	4	5	6	7	8	Overall
	Water erosion	Wind erosion	Structure	Acidity	Salinity	Water-logging	Soil depth	Movement	Class
M1	3	3	**4**	**3**	3	3	1	1	**4**
M2	3	**3**	**4**	-	3	3	1	1	**4**
M3	3	3	**4**	3	4	6	1	1	**6**
M4	3	3	**4**	**3**	4	3	1	1	**4**
M5	3	3	**4**	**3**	4	3	1	1	**4**
M6	3	3	**6**	**-**	3	1	6	1	**6**
M9	3	**3**	3	-	3	3	1	1	**3**
M11	**3**	**3**	**3**	3	3	2	1	1	**3**
M12	2	**4**	3	**3**	3	2	1	1	**4**
M13	**3**	**3**	**3**	**3**	3	2	1	1	**3**

Table 10: Pre-disturbance LSC of the PAA

LSC	Project Application Area	
	ha	%
3	12.2	43
4	11.6	41
6	4.4	16
Total	28.2	100

6.4 POST-DISTURBANCE LSC

The PAA will largely be subject to minor landform changes resulting in temporary impacts. Temporary impacts will cover 26.2 ha and would consist of ancillary disturbance and infrastructure such as laydown areas, roads, soil stockpiles and water management/seepage dams. These areas will be subject to localised soil stripping and rehabilitation (refer Section 7).

Landform changes will be significant and permanent for a small area consisting of 2.0 ha, where the tailing dam embankment footing encroaches the PAA. Here, the embankment slope will remain as the final landform, which will have a final slope in the order of 1:3 vertical to horizontal and a final land use of native woodland for habitat, with more limited rehabilitation options.

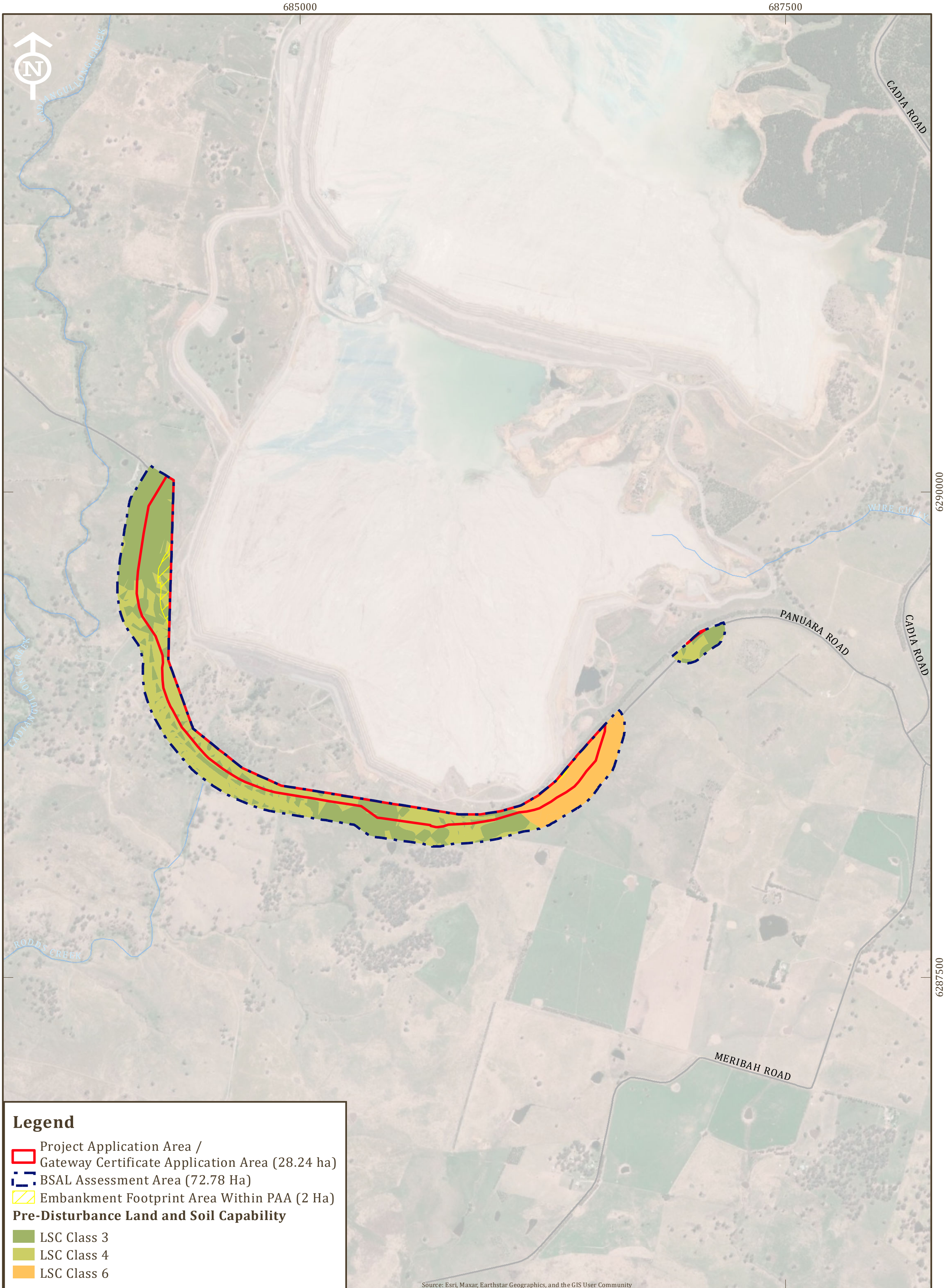
The LSC of the entire PAA would be class 8 during operations, which is considered not suitable for agriculture.

Following the life of the CVO, the areas of the PAA that would be subject to minor, temporary impacts will retain their current LSC class status. Areas subject to significant, permanent changes will become LSC class 7 land, which is considered low capability land generally incapable of agricultural land use.

An overview of the post-disturbance LSC for the PAA is presented in **Figure 15**, and summarised in **Table 11**.

Table 11: Post-disturbance LSC of the PAA

LSC	Project Application Area	
	ha	%
3	11.1	39
4	10.9	39
6	4.2	15
7	2.0	7
Total	28.2	100



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Pre-disturbance
Land and Soil Capability

FIGURE 14

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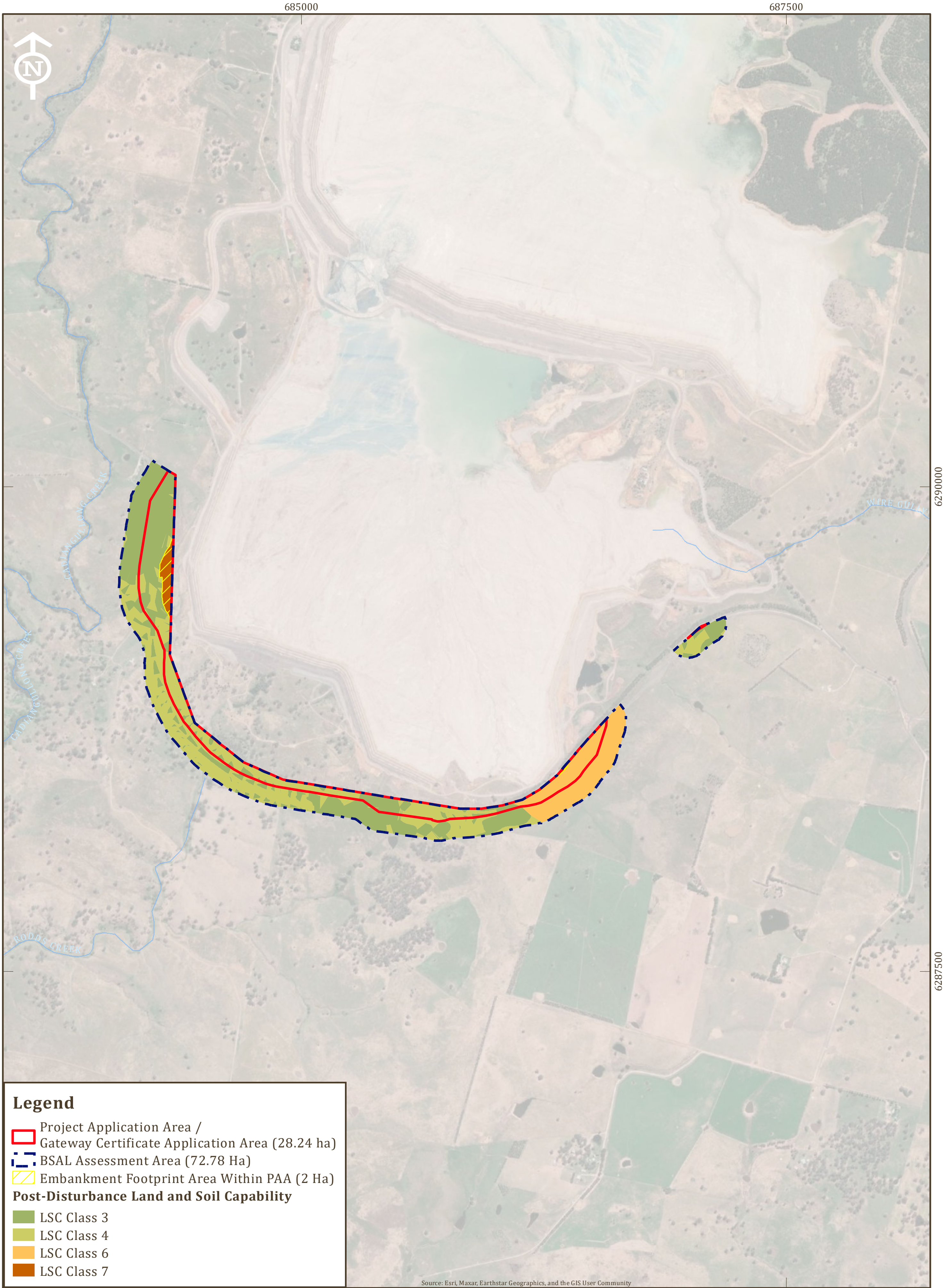

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Post-disturbance
Land and Soil Capability

FIGURE 15

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7 DISTURBANCE MANAGEMENT

Soil that is proposed to be disturbed during the Modification has been assessed to determine suitability for stripping, stockpiling and re-use of soil resources. This assessment is an integral process for successful rehabilitation of the Modification. This section provides information on the following key areas related to the management of the topsoil resources for the area within the PAA.

7.1 SOIL STRIPPING METHODOLOGY

The procedure for determining soil stripping depths involves assessing soils based on a range of physical and chemical parameters. This is combined with an understanding of the nature of disturbance and potential alternative options for suitable material. Determination of suitable soil to conserve for later use in rehabilitation has been conducted. **Table 12** below lists the key parameters and corresponding desirable selection criteria used for the selection of soil material for use as topdressing.

Table 12 Soil Stripping Suitability

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%

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 PSA.

All other physical parameters outlined in the table above were determined during the field assessment. Structural grade is significant in terms of the soil's capability to facilitate water relations and aeration. Good permeability and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade and depends on the proportion of coarse peds in the soil surface. Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils (without pores) are considered unsuitable as topdressing materials. The shearing test is used as a measure of the soil's ability to maintain structure grade. Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the excavation, transportation and spreading of topdressing material. Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both a wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates.

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeability; however, some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reduced soil conditions and poorly aerated soils are unsuitable for revegetation purposes.

7.2 SOIL STRIPPING STRATEGY

Soil that is proposed to be disturbed during the Modification would be stripped and stored for re-use in rehabilitation efforts in order to mitigate long term effects on the LSC of the CVO.

Laboratory soil analytical results (refer **Appendix 2**) were used in conjunction with the field assessment (refer Section 3.2) to determine the suitability of soil resources for recovery and re-use in rehabilitation, following the life of the mine.

Generally, both Soil Mapping Unit 1 and Soil Mapping Unit 2 represent suitable materials for re-use in rehabilitation, These soils are physically desirable and chemically stable, resulting in a low erosion risk. Nonetheless, appropriate erosion and sediment control measures should be implemented during any disturbance of these materials.

One exception is site M3, which represents a dispersion risk due to its sodic nature. Soil amelioration is recommended where these subsoils are exposed to disturbance. This may include deep ripping and application of dry gypsum and organic matter to improve soil structure and dispersity. Additional erosion management will also be required in order to reduce risk. Upon respreading, these soils should be used exclusively as a subsoil, and encapsulated by the loamy topsoils and/or subsoils associated with non-sodic soil types.

Due to the limited nature of the anticipated disturbance outside of the embankment footprint, it is expected that all soil stripping and re-use would be localised; that is, soil would be respread from where it is stripped, reinstating the soil profile to its original condition. Additionally, soils would be stripped only in areas where soil disturbance occurs. The depth of soil salvaged should be as deep as excavations or surface disturbance as required, or to a depth where parent material is encountered. Therefore, instead of an approach that would have broad stripping of soil resources over the entire PAA, site managers will be able to make decisions on targeted soil stripping for re-use when the locations of soil disturbance for surface infrastructure have been finalised.

In areas subject to significant landform disturbance associated with the Southern Tailings Storage Facility (STSF) embankment, a soil stripping operation should be undertaken to a nominated depth of 1 m or until a point at which parent material is reached to maximise the recovery of soil resources prior to disturbance. This material should be stockpiled and re-spread on the final landform embankment slopes and/or used to bolster rehabilitation efforts on returning areas subject to minor impacts to their original LSC.

For rehabilitation efforts being undertaken in the broader CVO at the time of stripping, stripped soils may be directly placed onto rehabilitation lands outside the PAA. This reduces the need for double handling and stockpiling of soil material. If soil resources within the PAA are used for rehabilitation elsewhere at the CVO, CHPL will source supplementary soil materials from elsewhere onsite with suitable physical and chemical characteristics for use in rehabilitation within the PAA in order to meet LSC class and BSAL commitments.

7.3 HIGHER IMPACT AREAS

It is recommended that proposed long term stockpiles in areas associated with the higher impact activities where large amounts of soil will be displaced should be stripped of topsoil. Then the excavated subsoil (if requiring disturbance) should be placed on the exposed subsoil of the stockpile area to create a low-profile landform of subsoil. A thin layer of topsoil material from the stripped areas should be placed as a 'cap' over the subsoil stockpiles to promote vegetation growth. Topsoil materials should otherwise be stockpiled separately to subsoils.

Topsoil and subsoil depths for these areas should be recorded in Geographic Information System (GIS) and rehabilitated with target species to build up the seedbank.

7.4 STRIPPED SOIL MANAGEMENT

The following soil handling techniques are recommended to prevent excessive soil deterioration and dispersion.

- Strip soil material to maximum excavation depths only.
- Soil should ideally be stripped in a slightly moist condition. Material should not be stripped in either an excessively dry or wet condition.
- Push soil into windrows or small stockpiles with graders. This technique is an example of preferential less aggressive soil handling. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material.
- An inventory of available soil should be maintained to ensure adequate materials are available for planned rehabilitation activities when the time comes.

7.5 STOCKPILE MANAGEMENT

Where required, the following management measures should be implemented during the stockpiling/storage of soils for the Modification in accordance with the Land and Biodiversity Management Plan (CHPL, 2016):

- As a general rule, maintain stockpile height to the minimum necessary to fit within the available local footprint. Clayey soils should be stored in lower stockpiles for shorter periods of time compared to coarser textured sandy soils.
- Stockpile topsoils and subsoils materials separately.
- 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.
- Where necessary, a flow diversion bank or catch drain should be placed up-slope of a stockpile to direct surface water flows away. All stockpiles shall remain in a free-draining location to avoid long term soil saturation.
- Where necessary, silt fences or cleared vegetation should be installed around topsoil stockpiles or stripped areas as a form of erosion and sediment control. Mulch or wood chip from cleared vegetation can also be applied as a veneer over topsoil stockpiles to slow erosion, weed establishment and to maintain moisture content.
- Seed and fertilise stockpiles as soon as possible. An annual cover crop species that produce sterile florets or seeds may 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. Final rehabilitation target species should be established on stockpiles to build up a desirable species seed bank in the topsoil.
- Prior to re-spreading stockpiled topsoil onto the disturbance area, 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.

7.6 SOIL RE-SPREADING AND SEEDBED PREPARATION

The following re-spreading and seedbank preparation techniques are recommended to prevent excessive soil deterioration and dispersion.

- Topsoil should be spread to a depth that reflects pre-disturbance soil horizons.
- 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 soil and material below. 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 soil 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.

7.7 ACID SULPHATE SOILS

The potential for acid generation from disturbed material (topsoil and subsoil) within the PAA is very low. Acid Sulphate Soils, which are the main cause of acid generation within the soil mantle, are commonly found less than 5 m above sea level, particularly in low-lying coastal areas such as mangroves, salt marshes, floodplains, swamps, wetlands, estuaries, and brackish or tidal lakes. The CVO is located within the Central Tablelands region of NSW which is approximately 150 km from the coast at >250 metres Australian Height Datum (mAHD). There has been little history of acid generation from disturbed soil or regolith material within this region. Furthermore, laboratory results (refer **Appendix 2**) indicate the soils within the PAA are consistently not strongly acidic and are wholly uncharacteristic of Acid Sulphate Soils. Therefore, the PAA considered to be a negligible risk for Acid Sulphate Soils and no mitigation measures are required.

8 CONCLUSION

The Proponent is seeking a Gateway Certificate over the PAA of 28.2 ha. The Modification's BSAL Site Verification Assessment was undertaken May 2022 by Minesoils. The BSAL Assessment Area was defined as the PAA as well as the required 100 m buffer but excluding areas under a current mining lease, totalling 72.8 ha. A total of 41.3 ha was discounted during desktop analysis by slope >10%, <20 ha contiguous area and/or areas surrounded by slopes >10% and disturbance associated with Panuara Road. These exclusions left 31.5 ha to be assessed.

A total of 10 sites were assessed in accordance with the Interim Protocol to obtain suitable representative soil profiles to determine soil type and characteristics. A total of 7 sites satisfied the BSAL criteria. Therefore, verified BSAL is confirmed to be present over approximately 24.9 ha of the BSAL Assessment Area (8.3 ha of the PAA). The remaining 47.9 ha of the BSAL Assessment Area is verified Non-BSAL.

While there are no contiguous areas >20 ha within the BSAL Assessment Area (the largest contiguous mass present is <10 ha), site observations, existing regional mapping, and concurrent studies viewed in the context of the findings of this assessment suggest the BSAL verified likely forms part of a larger contiguous mass.

As part of the BSAL assessment process, two soil mapping units were identified within the BSAL Assessment Area:

- Soil Mapping Unit 1: Chromosols, covering 48.0 ha or 66 % of the BSAL Assessment Area; and
- Soil Mapping Unit 2: Dermosols, covering 24.8 ha or 34 % of the BSAL Assessment Area.

The pre-disturbance LSC assessment undertaken for the PAA determined the presence of the following classes:

- LSC Class 3, covering 12.2 ha or 43 % of the PAA;
- LSC Class 4, covering 11.6 ha or 41 % of the PAA; and
- LSC Class 6, covering 4.4 ha or 16 % of the PAA.

The PAA will largely be subject to minor landform changes resulting in temporary impacts. Temporary impacts will cover 26.2 ha (or 93%) of the PAA and would consist of ancillary disturbance and infrastructure such as laydown areas, roads, soil stockpiles and water management/seepage dams. Following the end of life for the CVO, minor landform impact areas will be re-graded (where required) and stockpiled topsoil and subsoil be placed over disturbed areas and rehabilitated with either native vegetation or improved pastures depending on the intended final land use. This strategy, along with good soil management practices, will facilitate the rehabilitation in returning this land to an equivalent LSC class.

For the 2.0 ha area, where the STSF embankment encroaches the PAA, the landform changes will be significant and permanent. Here, the embankment slope will remain as the final landform, which will have a landuse of native woodland for habitat, with more limited rehabilitation options.

The LSC of the entire PAA would be class 8 during operations, which is considered not suitable for agriculture.

Following the life of the CVO, the PAA will be subject to minor, temporary impacts. The majority of the PAA would retain its current LSC class status, while the areas subject to significant, permanent changes will become LSC class 7. Therefore, the post-disturbance LSC of the PAA will consist of the following classes:

- LSC Class 3, covering 11.1 ha or 39 % of the PAA;
- LSC Class 4, covering 10.9 ha or 39 % of the PAA;
- LSC Class 6, covering 4.2 ha or 15 % of the PAA; and
- LSC Class 7, covering 2.0 ha or 7 % of the PAA.

All soil that is proposed to be disturbed during the Modification would be stripped and directly placed or stored for re-use in rehabilitation efforts. It is anticipated that for areas subject to minor, temporary changes, soil stripping and re-use would be localised; that is, would be respread from where it is stripped, reinstating the soil profile to its original condition.

In areas subject to significant landform disturbance associated with the STSF embankment, a soil stripping operation will maximise the recovery of soil resources prior to disturbance. This material should be stockpiled and re-spread on the final landform embankment slopes and/or used to bolster rehabilitation efforts on returning areas subject to minor impacts to their original LSC.

For rehabilitation efforts being undertaken in the broader CVO at the time of stripping, stripped soils may be directly placed onto rehabilitation lands outside the PAA. This reduces the need for double handling and stockpiling of soil material. If soil resources within the PAA are used for rehabilitation elsewhere at the CVO, CHPL will source supplementary soil materials elsewhere on site with suitable physical and chemical characteristics for use in rehabilitation within the PAA in order to meet LSC class and BSAL commitments.

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Appendix 1
Soil Profile Descriptions

Site Description – Site M1				
Site Reference	M1	**ASC Name**	Haplic Eutrophic Brown Dermosol (BEMOW)	
Average Slope	5%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Hillslope	**Soil Fertility**	Moderately High	MGA 55
Landform Element	Mid Slope	**BSAL Site Status**	Verified BSAL	X: 685489
Surface Condition	Soft	**Mapped as BSAL**	Yes	Y: 6288313

Plate 1 – Soil Profile (M1)

Plate 2 – Surface (M1)

Plate 3 – Landscape (M1)

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Very dark brown (Munsell 7.5YR 2.5/2) Clay Loam, with moderate pedality. Slightly acidic pH, non-saline. Non-sodic. No coarse fragments. Many roots and well drained. Gradual boundary.
A2	0.15 – 0.35	Dark brown (Munsell 7.5YR 3/3) Light Medium Clay, with moderate pedality. Neutral pH, non-saline. Non-sodic. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.35 – 0.60	Dark yellowish-brown (Munsell 10YR 4/4) Medium Clay, with strong pedality. Moderately alkaline pH, non-saline. Non-sodic. No coarse fragments. Few roots and moderately drained. Gradual boundary.
B22	0.60+	Dark yellowish-brown (Munsell 10YR 4/4) Heavy Clay, with strong pedality. Moderately alkaline pH, non-saline. Non-sodic. No coarse fragments. No roots and moderately drained.

Sample Depth	ECe		pH(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.5	Non-saline	6.2	Slightly Acidic	0.5	Non sodic
0.20-0.30	0.3	Non-saline	6.8	Neutral	1.1	Non sodic
0.40-0.50	0.4	Non-saline	8.0	Moderately Alkaline	2.4	Non sodic
0.65-0.75	0.6	Non-saline	8.3	Moderately Alkaline	3.5	Non sodic

Site Description – Site M2				
Site Reference	2	**ASC Name**	Brown Dermosol	
Average Slope	6%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Hillslope	**Soil Fertility**	Moderately High	MGA 55
Landform Element	Mid Slope	**BSAL Site Status**	Verified BSAL	X: 685697
Surface Condition	Soft	**Mapped as BSAL**	Yes	Y: 6288278

Plate 1 – Soil Profile (M2)

Plate 2 – Surface (M2)

Plate 3 – Landscape (M2)

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Dark brown Clay Loam (field texture), with moderate pedality. No coarse fragments. Many roots and well drained. Gradual boundary.
A2	0.15 – 0.40	Light brown Silty Clay Loam (field texture), with moderate pedality. No coarse fragments. Common roots and well drained. Gradual boundary.
B2	0.40 – 0.75	Dark yellowish brown Medium Clay (field texture), with strong pedality. No coarse fragments. Very few roots and moderately drained.

Site Description – Site M3					
Site Reference	M3	**ASC Name**	Eutrophic Mesonatric Brown Sodosol (BFLMW)		
Average Slope	8%	**Land Use**	Grazing	**Coordinates**	
Landform Pattern	Hillslope	**Soil Fertility**	Moderately Low	MGA 55	
Landform Element	Lower Slope	**BSAL Site Status**	Verified Non-BSAL	X: 686501	
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6288634	

Plate 1 – Soil Profile (M3)

Plate 2 – Surface (M3)

Plate 3 – Landscape (M3)

Horizon	Depth (m)	Description
A1	0.00 – 0.20	Very dark greyish brown (Munsell 10YR 3/2) Silty Loam, with moderate pedality. Strongly acidic pH, moderately saline. Sodic. No coarse fragments. Many roots and moderately drained. Gradual boundary.
A2	0.20 – 0.40	Dark reddish grey (Munsell 2.5YR 4/1) Silty Loam, with weak pedality. Strongly acidic pH, moderately saline. Sodic. No coarse fragments. Very few roots and poorly drained. Clear boundary.
B2	0.40+	Dark yellowish brown to brown (Munsell 10YR 4/4 to 10YR 4/3) Clay Loam, with strong pedality. Mildly alkaline trending to strongly alkaline pH, slightly saline trending to non-saline. Sodic. No coarse fragments. 30% distinct grey mottles. No roots and poorly drained.

Sample Depth	ECe		pH$_{(1-5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	6.6	Moderately saline	5.5	Strongly Acidic	13.5	Sodic
0.20-0.30	6.5	Moderately saline	6.5	Slightly Acidic	19.6	Sodic
0.40-0.50	3.1	Slightly saline	7.6	Mildly Alkaline	16.0	Sodic
0.65-0.75	1.6	Non-saline	8.7	Strongly Alkaline	17.4	Sodic

Site Description – Site M4				
Site Reference	M4	**ASC Name**	Haplic Eutrophic Brown Chromosol (BFLOW)	
Average Slope	5%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Hillslope	**Soil Fertility**	Moderately High	MGA 55
Landform Element	Mid Slope	**BSAL Site Status**	Verified BSAL	X: 686420
Surface Condition	Soft	**Mapped as BSAL**	Yes	Y: 6288574

Plate 2 – Surface (M4)

Plate 1 – Soil Profile (M4)

Plate 3 – Landscape (M4)

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Very dark brown (Munsell 7.5YR 2.5/3) Loam, with strong pedality. Slightly acidic pH, non-saline. Non-sodic. No coarse fragments. Many roots and well drained. Clear boundary.
B21	0.15 – 0.30	Very dark brown (Munsell 7.5YR 2.5/3) Light Medium Clay with moderate pedality. Neutral pH, non-saline. Non-sodic. No coarse fragments. Common roots and moderately drained. Clear boundary.
B22	0.30+	Strong brown (Munsell 7.5YR 4/6) Light Medium Clay to Medium Clay, with strong pedality. Mildly alkaline pH, non-saline. Non-sodic. No coarse fragments. Very few roots and moderately drained.

Sample Depth	ECe		pH$_{(1\text{-}5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.8	Non-saline	6.1	Slightly Acidic	1.3	Non sodic
0.20-0.30	0.4	Non-saline	6.6	Neutral	1.1	Non sodic
0.40-0.50	0.4	Non-saline	7.4	Mildly Alkaline	2.6	Non sodic
0.65-0.75	0.3	Non-saline	7.6	Mildly Alkaline	3.4	Non sodic

Site Description – Site M5				
Site Reference	M5	**ASC Name**	Haplic Hypocalcic Brown Chromosol (BEKOW)	
Average Slope	4%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Hillslope	**Soil Fertility**	Moderately High	MGA 55
Landform Element	Lower Slope	**BSAL Site Status**	Verified Non-BSAL	X: 686442
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6288477

Plate 2 – Surface (M5)

Plate 1 – Soil Profile (M5)

Plate 3 – Landscape (M5)

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Very dark brown (Munsell 10YR 2/2) Silty Loam, with moderate pedality. Moderately acidic pH, non-saline. Non-sodic. No coarse fragments. Many roots and well drained. Clear boundary.
A2	0.15 – 0.25	Very dark greyish brown (Munsell 10YR 3/2) Loam, with weak pedality. Slightly acidic pH, non-saline. Non-sodic. No coarse fragments. Few roots and moderately drained. Clear boundary.
B2	0.25+	Dark yellowish brown to brown (Munsell 10YR 4/4 to 10YR 4/3) Medium Clay to Sandy Clay Loam, with strong pedality. Mildly alkaline trending to moderately alkaline pH, slightly saline trending to moderately saline. Non-sodic. No coarse fragments. No roots and moderately drained.

Sample Depth	ECe		$pH_{(1\text{-}5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	1.2	Non-saline	5.8	Moderately Acidic	0.6	Non sodic
0.15-0.25	1.0	Non-saline	6.4	Slightly Acidic	1.6	Non sodic
0.40-0.50	3.2	Slightly saline	7.6	Mildly Alkaline	1.6	Non sodic
0.65-0.75	5.3	Moderately saline	7.8	Moderately Alkaline	2.8	Non sodic

Site Description – Site M6				
Site Reference	M6	**ASC Name**	Brown Dermosol	
Average Slope	3%	**Land Use**	Road Verge	**Coordinates**
Landform Pattern	Hillcrest	**Soil Fertility**	Moderately High	MGA 55
Landform Element	Upper Slope/Crest	**BSAL Site Status**	Verified Non-BSAL	X: 686202
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6288362

Plate 1 – Soil Profile (M6)

Plate 2 – Surface (M6)

Plate 3 – Landscape (M6)

Horizon	Depth (m)	Description
A	0.00 – 0.15	Dark brown Silty Clay Loam (field assessment), with strong pedality. 30% coarse fragments 60 – 100mm. Many roots and well drained. Gradual boundary.
B	0.15 – 0.30	Dark reddish brown Light Clay (field assessment), with moderate pedality. 50% coarse fragments 60 – 100mm. Many roots and well drained.
C	0.35 – 0.50	Parent material

Site Description – Site M9				
Site Reference	M9	**ASC Name**	Brown Chromosol	
Average Slope	9%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Hillslope	**Soil Fertility**	Moderately High	MGA 55
Landform Element	Mid Slope	**BSAL Site Status**	Verified BSAL	X: 687173
Surface Condition	Soft	**Mapped as BSAL**	Yes	Y: 6289289

Plate 1 – Soil Profile (M9)

Plate 2 – Surface (M9)

Plate 3 – Landscape (M9)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Dark brown Loam (field assessment), with strong pedality. 10% coarse fragments 20 – 200mm. Many roots and well drained. Gradual boundary.
A2	0.10 – 0.25	Light reddish brown Sandy Clay Loam (field assessment), with moderate pedality. No coarse fragments. Many roots and well drained. Clear boundary.
B21	0.25 – 0.50	Yellowish brown Medium Clay (field assessment), with strong pedality. No coarse fragments. Few roots and well drained. Gradual boundary.
B22	0.50+	Yellow Heavy Clay (field assessment), with strong pedality. No coarse fragments. No roots and moderately drained.

Site Description – Site M11 (D8)				
Site Reference	M11	**ASC Name**	Haplic Eutrophic Red Chromosol (BEMOW)	
Average Slope	6%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Hillslope	**Soil Fertility**	Moderately High	MGA 55
Landform Element	Mid Slope	**BSAL Site Status**	Verified BSAL	X: 684220
Surface Condition	Soft	**Mapped as BSAL**	Yes	Y: 6289536

Plate 1 – Soil Profile (M11)

Plate 2 – Surface (M11)

Plate 3 – Landscape (M11)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Very Dark Brown (Munsell 10YR 2/2) Loam, with strong pedality. Moderately acidic pH, non-saline. Non-sodic. No coarse fragments. Many roots and moderately drained. Gradual boundary.
B2	0.10 – 0.80	Dark Reddish Brown to Light Olive Brown (Munsell 5YR 3/4 to 2.5Y 5/6) Heavy Clay with strong pedality. Neutral trending to slightly alkaline pH, non-saline. Non-sodic. No coarse fragments. Common fine roots and moderately drained.

Sample Depth	ECe		$pH_{(1\text{-}5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.4	Non-saline	6.0	Moderately Acidic	1.8	Non sodic
0.20-0.30	0.1	Non-saline	6.8	Neutral	1.0	Non sodic
0.40-0.50	0.3	Non-saline	7.3	Neutral	1.2	Non sodic
0.65-0.75	0.3	Non-saline	7.7	Mildly Alkaline	2.1	Non sodic

Site Description – Site M12 (D9)				
Site Reference	M12	**ASC Name**	Haplic Eutrophic Red Chromosol (BEMOW)	
Average Slope	2%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Hillcrest	**Soil Fertility**	Moderately High	MGA 55
Landform Element	Crest	**BSAL Site Status**	Verified BSAL	X: 683962
Surface Condition	Soft	**Mapped as BSAL**	Yes	Y: 6290230

Plate 2 – Surface (M12)

Plate 1 – Soil Profile (M12)

Plate 3 – Landscape (M12)

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Very Dark Brown (Munsell 7.5YR 2.5/3) Silty Loam with strong pedality. Moderately acidic pH, non-saline. Non-sodic. No coarse fragments. Common fine roots and moderately drained. Clear boundary.
B21	0.15 – 0.40	Dark Reddish Brown (Munsell 5YR 3/4) Heavy Clay with strong pedality. Neutral pH, non-saline. Non-sodic. No coarse fragments. Common fine roots and moderately drained. Gradual boundary.
B22	0.40 – 0.80	Olive to Olive Brown (Munsell 5YR 5/6 to 2.5Y 4/3) Heavy Clay with strong pedality. Moderately alkaline trending to strongly alkaline pH, non-saline. Non-sodic. No coarse fragments. Few roots and moderately drained.

Sample Depth	ECe		$pH_{(1\text{-}5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.4	Non-saline	5.7	Moderately Acidic	1.1	Non sodic
0.20-0.30	0.3	Non-saline	7.2	Neutral	1.2	Non sodic
0.40-0.50	0.3	Non-saline	7.9	Moderately Alkaline	1.6	Non sodic
0.65-0.75	0.5	Non-saline	8.4	Strongly Alkaline	2.6	Non sodic

Site Description – Site M13 (D12)				
Site Reference	M13	**ASC Name**	Haplic Eutrophic Red Chromosol (BEMOW)	
Average Slope	5%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Hillslope	**Soil Fertility**	Moderately High	MGA 55
Landform Element	Mid Slope	**BSAL Site Status**	Verified BSAL	X: 684292
Surface Condition	Soft	**Mapped as BSAL**	Yes	Y: 6289325

Plate 1 – Soil Profile (M13)

Plate 2 – Surface (M13)

Plate 3 – Landscape (M13)

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Dark Brown (Munsell 7.5YR 3/4) Silty Clay Loam with moderate pedality. Moderately acidic pH, non-saline. Non-sodic. No coarse fragments. Common fine roots and moderately drained. Clear boundary.
B21	0.15 – 0.40	Red (Munsell 2.5YR 4/8) Heavy Clay with strong pedality. Slightly acidic pH, non-saline. Non-sodic. No coarse fragments. Common fine roots and moderately drained. Gradual boundary.
B22	0.40 – 0.80	Reddish-yellow to Yellowish-red (Munsell 5YR 6/8 to 5YR 5/8) Silty Clay with strong pedality. Neutral pH, non-saline. Non-sodic. No coarse fragments. Few roots and moderately drained.

Sample Depth	ECe		pH$_{(1\text{-}5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.7	Non-saline	6.0	Moderately Acidic	1.0	Non sodic
0.20-0.30	0.3	Non-saline	6.4	Slightly Acidic	1.0	Non sodic
0.40-0.50	0.5	Non-saline	6.7	Neutral	1.5	Non sodic
0.65-0.75	0.5	Non-saline	6.7	Neutral	1.6	Non sodic

Appendix 2
Laboratory Certificates of Analysis

GRAIN SIZE ANALYSIS (hydrometer and sieving techniques)

28 soil samples supplied by Minesoils Pty. Ltd. on 17 May, 2022 - Lab Job No. M8724
Analysis requested by Clayton Richards. Job Ref. MS-062 Soils
PO BOX 11034 TAMWORTH NSW 2340

SAMPLE ID	Lab Code	MOISTURE CONTENT (% of water in sample)	TOTAL GRAVEL > 2 mm (% of total oven-dry equivalent)	GRAVEL > 4.75 mm (% of total oven-dry equivalent)	GRAVEL 2.00-4.75 mm (% of total oven-dry equivalent)	COARSE SAND 200-2000 µm (0.2-2.0 mm) (% of total oven-dry equivalent)	FINE SAND 20-200 µm (0.02-0.2 mm) (% of total oven-dry equivalent)	SILT 2-20 µm ISSS (% of total oven-dry equivalent)	CLAY < 2 µm (% of total oven-dry equivalent)
1 0 - 10	M8724/1	18.5%	1.2%	0.0%	1.2%	5.4%	55.7%	14.8%	22.9%
1 20 - 30	M8724/2	23.3%	0.7%	0.0%	0.7%	2.3%	43.1%	12.0%	41.9%
1 40 - 50	M8724/3	22.0%	2.5%	1.7%	0.8%	2.4%	27.0%	20.7%	47.3%
1 65 - 75	M8724/4	19.5%	0.9%	0.0%	0.9%	2.1%	36.5%	9.2%	51.3%
3 0 - 10	M8724/5	23.0%	7.9%	2.2%	5.7%	6.6%	34.6%	39.9%	10.8%
3 25 - 35	M8724/6	18.2%	16.1%	3.6%	12.5%	6.3%	52.5%	21.9%	3.2%
3 45 - 55	M8724/7	20.0%	3.9%	0.9%	3.0%	6.9%	36.3%	20.2%	32.8%
3 65 - 75	M8724/8	20.8%	5.1%	2.5%	2.6%	6.5%	45.2%	15.6%	27.6%
4 0 - 10	M8724/9	20.9%	0.2%	0.2%	0.1%	5.1%	63.3%	18.9%	12.5%
4 20 - 30	M8724/10	21.1%	0.2%	0.0%	0.2%	4.3%	31.4%	22.8%	41.4%
4 40 - 50	M8724/11	22.8%	0.0%	0.0%	0.0%	1.3%	36.4%	19.8%	42.5%
4 65 - 75	M8724/12	20.4%	0.2%	0.0%	0.2%	2.4%	25.5%	24.4%	47.5%
5 0 - 10	M8724/13	30.2%	0.8%	0.0%	0.8%	9.2%	52.6%	28.4%	9.0%
5 20 - 30	M8724/14	16.8%	9.7%	1.1%	8.6%	10.9%	47.9%	19.9%	11.6%
5 40 - 50	M8724/15	22.8%	0.4%	0.0%	0.4%	2.6%	34.1%	13.6%	49.3%
5 65 - 75	M8724/16	20.6%	0.1%	0.0%	0.1%	14.0%	51.2%	27.9%	6.8%
7 0 - 10	M8724/17	23.9%	2.1%	0.4%	1.7%	4.5%	63.7%	7.1%	22.6%
7 20 - 30	M8724/18	19.6%	1.9%	1.9%	0.0%	5.3%	57.9%	13.1%	21.8%
7 40 - 50	M8724/19	16.6%	2.4%	0.0%	2.4%	5.6%	52.7%	30.0%	9.3%
7 60 - 70	M8724/20	9.0%	18.1%	12.5%	5.6%	3.4%	45.5%	27.1%	5.9%
8 0 - 10	M8724/21	27.5%	1.7%	1.0%	0.8%	22.9%	57.8%	13.9%	3.6%
8 20 - 30	M8724/22	16.1%	7.4%	1.2%	6.2%	0.2%	66.0%	16.8%	9.5%
8 40 - 50	M8724/23	21.9%	1.0%	0.0%	1.0%	8.6%	42.8%	7.7%	39.9%
8 65 - 75	M8724/24	19.7%	0.6%	0.0%	0.6%	6.5%	43.8%	14.0%	35.1%
10 0 - 10	M8724/25	23.5%	2.1%	0.5%	1.6%	14.1%	48.0%	24.9%	10.8%
10 20 - 30	M8724/26	20.7%	4.4%	0.4%	4.0%	13.4%	44.3%	15.6%	22.3%
10 40 - 50	M8724/27	21.2%	0.8%	0.0%	0.8%	6.2%	37.3%	11.8%	43.9%
10 65 - 75	M8724/28	19.2%	0.9%	0.0%	0.9%	6.1%	38.7%	10.1%	44.3%

Note:
1: The Hydrometer Analysis method was used to determine the percentage sand, silt and clay,
modified from SOP meth004 (California Dept of Pesticide Regulation), using method of Gee & Bauder (1986),
in *Methods of Soil Analysis. Part 1* Agron. Monogr. 9 (2nd Ed). Klute, A., American Soc. of Agronomy Inc., Soil Sci. Soc. America Inc., Madison WI: 383-411.
2: Australian Standard 1289.3.8.1-1997 (see attached)
3. Analysis conducted between sample arrival date and reporting date.
4. This report is not to be reproduced except in full. Results only relate to the item tested.
5. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal).
6. This final report was issued on 14/06/2022 and replaces the report issued on 10/06/2022. The data for M8724/16 and M8724/17 are now correct.

checked: ....
Graham Lancaster (Nata signatory)
Laboratory Manager

Environmental Analysis Laboratory, Southern Cross University,
Tel. 02 6620 3678, website: scu.edu.au/eal

Munsell Colour

28 soil samples supplied by Minesoils Pty. Ltd. on 17 May, 2022 - Lab Job No. M8724
Analysis requested by Clayton Richards. Job Ref. MS-062 Soils
PO BOX 11034 TAMWORTH NSW 2340

SAMPLE ID	Lab Code	MOIST MUNSELL COLOUR		MOTTLE MUNSELL COLOUR		DEGREE OF MOTTLING (%)
		Code	Description	Code	Description	
1 0 - 10	M8724/1	7.5 YR 2.5/2	very dark brown	..	..	..
1 20 - 30	M8724/2	7.5 YR 3/3	dark brown	..	..	..
1 40 - 50	M8724/3	10 YR 4/4	dark yellowish brown	..	..	..
1 65 - 75	M8724/4	10 YR 4/4	dark yellowish brown	..	..	..
3 0 - 10	M8724/5	10 YR 3/2	very dark greyish brown	..	..	..
3 25 - 35	M8724/6	2.5 YR 4/1	dark reddish gray	..	..	..
3 45 - 55	M8724/7	10 YR 4/4	dark yellowish brown	..	..	..
3 65 - 75	M8724/8	10 YR 4/3	brown	..	..	..
4 0 - 10	M8724/9	7.5 YR 2.5/3	very dark brown	..	..	..
4 20 - 30	M8724/10	7.5 YR 2.5/3	very dark brown	..	..	..
4 40 - 50	M8724/11	7.5 YR 4/6	strong brown	..	..	..
4 65 - 75	M8724/12	7.5 YR 4/6	strong brown	..	..	..
5 0 - 10	M8724/13	10 YR 2/2	very dark brown	..	..	..
5 20 - 30	M8724/14	10 YR 3/2	very dark grayish brown	..	..	..
5 40 - 50	M8724/15	10 YR 4/4	dark yellowish brown	..	..	..
5 65 - 75	M8724/16	10 YR 4/3	brown	..	..	..
7 0 - 10	M8724/17	10 YR 3/3	dark brown	..	..	..
7 20 - 30	M8724/18	10 YR 4/4	dark yellowish brown	..	..	..
7 40 - 50	M8724/19	10 YR 3/3	dark brown	..	..	..
7 60 - 70	M8724/20	2.5 Y 7/2	light gray	..	..	..
8 0 - 10	M8724/21	7.5 YR 2.5/3	very dark brown	..	..	..
8 20 - 30	M8724/22	5 YR 3/4	dark reddish brown	..	..	..
8 40 - 50	M8724/23	7.5 YR 4/4	brown	..	..	..
8 65 - 75	M8724/24	7.5 YR 5/6	strong brown	..	..	..
10 0 - 10	M8724/25	7.5 YR 2.5/2	very dark brown	..	..	..
10 20 - 30	M8724/26	7.5 YR 2.5/3	very dark brown	..	..	..
10 40 - 50	M8724/27	10 YR 4/4	dark yellowish brown	..	..	..
10 65 - 75	M8724/28	10 YR 4/4	dark yellowish brown	..	..	..

Note:
1: The Munsell Colour Chart was used to determine the colour.
2. Analysis conducted between sample arrival date and reporting date.
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5. This report was issued on 10/06/2022.

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal

ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

28 samples supplied by Minesoils Pty. Ltd. on 17/05/2022. Lab Job No.M8724
Analysis requested by Clayton Richards. Your Job: Job Ref. MS-065 Soils
PO BOX 11034 TAMWORTH NSW 2340

			Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
		Sample ID:	1 0 - 10	1 20 - 30	1 40 - 50	1 65 - 75	3 0 - 10	3 25 - 35
		Crop:	Soil	Soil	Soil	Soil	Soil	Soil
		Client:						
Parameter		**Method reference**	**M8724/1**	**M8724/2**	**M8724/3**	**M8724/4**	**M8724/5**	**M8724/6**
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.17	6.79	7.98	8.28	5.50	6.48
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.058	0.038	0.057	0.110	0.692	0.689
Exchangeable Calcium	(cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	10	14	16	19	6.9	5.5
	(kg/ha)		4,683	6,455	7,357	8,586	3,118	2,467
	(mg/kg)		2,091	2,882	3,284	3,833	1,392	1,101
Exchangeable Magnesium	(cmol$_+$/kg)		4.4	8.5	13	15	2.9	3.0
	(kg/ha)		1,185	2,310	3,502	4,016	793	817
	(mg/kg)		529	1,031	1,563	1,793	354	365
Exchangeable Potassium	(cmol$_+$/kg)		1.7	1.4	0.91	0.88	0.50	0.15
	(kg/ha)		1,519	1,218	799	774	441	128
	(mg/kg)		678	544	357	346	197	57
Exchangeable Sodium	(cmol$_+$/kg)		0.08	0.28	0.74	1.3	1.6	2.1
	(kg/ha)		41	143	380	646	833	1,084
	(mg/kg)		18	64	170	289	372	484
Exchangeable Aluminium	(cmol$_+$/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		1.5	<1	<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1	<1	<1
Exchangeable Hydrogen	(cmol$_+$/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.04	<0.01	<0.01	<0.01	0.04	<0.01
	(kg/ha)		<1	<1	<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	17	25	31	36	12	11
Calcium (%)		**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	63	59	53	53	58	51
Magnesium (%)			26	35	42	41	24	28
Potassium (%)			10	5.7	3.0	2.5	4.2	1.4
Sodium - ESP (%)			0.48	1.1	2.4	3.5	13	20
Aluminium (%)			0.04	0.01	0.01	0.00	0.03	0.00
Hydrogen (%)			0.24	0.00	0.00	0.00	0.36	0.07
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol$_+$/kg)	2.4	1.7	1.3	1.3	2.4	1.8

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal

ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

28 samples supplied by Minesoils Pty. Ltd. on 17/05/2022. Lab Job No.M8724
Analysis requested by Clayton Richards. Your Job: Job Ref. MS-065 Soils
PO BOX 11034 TAMWORTH NSW 2340

			Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
		Sample ID:	1 0 - 10	1 20 - 30	1 40 - 50	1 65 - 75	3 0 - 10	3 25 - 35
		Crop:	Soil	Soil	Soil	Soil	Soil	Soil
		Client:						
	Parameter	Method reference	M8724/1	M8724/2	M8724/3	M8724/4	M8724/5	M8724/6

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_+/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
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17. This report was issued on 27/05/2022.

WORLD RECOGNISED ACCREDITATION
Accreditation No. 14960
Accredited for compliance with ISO/IEC 17025 - Testing

Quality Checked: Kris Saville
Agricultural Co-Ordinator

KS

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal

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AGRICULTURAL SOIL ANALYSIS REPORT

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Analysis requested by Clayton Richards. Your Job: Job Ref. MS-065 Soils
PO BOX 11034 TAMWORTH NSW 2340

			Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12
		Sample ID:	3 45 - 55	3 65 - 75	4 0 - 10	4 20 - 30	4 40 - 50	4 65 - 75
		Crop:	Soil	Soil	Soil	Soil	Soil	Soil
		Client:						
Parameter		**Method reference**	**M8724/7**	**M8724/8**	**M8724/9**	**M8724/10**	**M8724/11**	**M8724/12**
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.57	8.73	6.07	6.62	7.37	7.57
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.355	0.186	0.083	0.044	0.044	0.044
Exchangeable Calcium	(cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	9.3	8.5	12	16	18	18
	(kg/ha)		4,159	3,800	5,350	7,036	8,210	7,972
	(mg/kg)		1,857	1,696	2,388	3,141	3,665	3,559
Exchangeable Magnesium	(cmol+/kg)		11	10	5.5	9.5	17	19
	(kg/ha)		2,940	2,752	1,509	2,590	4,714	5,043
	(mg/kg)		1,312	1,229	674	1,156	2,105	2,251
Exchangeable Potassium	(cmol+/kg)		0.38	0.31	1.8	0.85	0.55	0.44
	(kg/ha)		336	276	1,537	743	479	385
	(mg/kg)		150	123	686	332	214	172
Exchangeable Sodium	(cmol+/kg)		3.9	4.0	0.25	0.30	0.97	1.3
	(kg/ha)		2,002	2,055	129	155	498	675
	(mg/kg)		894	917	58	69	223	301
Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	1.9	1.7	<1	1.4
	(mg/kg)		<1	<1	<1	<1	<1	<1
Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	0.06	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	1.4	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	24	23	20	26	37	38
Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	38	37	61	59	49	47
Magnesium (%)			44	44	28	36	47	49
Potassium (%)			1.6	1.4	9.0	3.2	1.5	1.2
Sodium - ESP (%)			16	17	1.3	1.1	2.6	3.4
Aluminium (%)			0.01	0.02	0.05	0.03	0.01	0.02
Hydrogen (%)			0.00	0.00	0.31	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	0.86	0.84	2.1	1.6	1.1	0.96

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

28 samples supplied by Minesoils Pty. Ltd. on 17/05/2022. Lab Job No.M8724
Analysis requested by Clayton Richards. Your Job: Job Ref. MS-065 Soils
PO BOX 11034 TAMWORTH NSW 2340

		Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12
	Sample ID:	3 45 - 55	3 65 - 75	4 0 - 10	4 20 - 30	4 40 - 50	4 65 - 75
	Crop:	Soil	Soil	Soil	Soil	Soil	Soil
	Client:						
Parameter	Method reference	M8724/7	M8724/8	M8724/9	M8724/10	M8724/11	M8724/12

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwo
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil res
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11. Conversions to kg/ha = mg/kg x 2.24
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Quality Checked: Kris Saville
Agricultural Co-Ordinator
KS

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal

ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

28 samples supplied by Minesoils Pty. Ltd. on 17/05/2022. Lab Job No.M8724
Analysis requested by Clayton Richards. Your Job: Job Ref. MS-065 Soils
PO BOX 11034 TAMWORTH NSW 2340

			Sample 13	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18
Sample ID:			5 0 - 10	5 20 - 30	5 40 - 50	5 65 - 75	7 0 - 10	7 20 - 30
Crop:			Soil	Soil	Soil	Soil	Soil	Soil
Client:								
Parameter		**Method reference**	**M8724/13**	**M8724/14**	**M8724/15**	**M8724/16**	**M8724/17**	**M8724/18**
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	5.78	6.40	7.55	7.83	6.56	6.73
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.125	0.105	0.433	0.557	0.112	0.033
Exchangeable Calcium	(cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	11	8.3	22	22	14	12
	(kg/ha)		5,074	3,706	9,720	9,674	6,119	5,383
	(mg/kg)		2,265	1,654	4,339	4,319	2,732	2,403
Exchangeable Magnesium	(cmol+/kg)		2.1	2.0	7.6	8.5	2.7	5.5
	(kg/ha)		571	553	2,081	2,315	730	1,503
	(mg/kg)		255	247	929	1,034	326	671
Exchangeable Potassium	(cmol+/kg)		1.4	0.38	0.80	0.55	0.89	0.37
	(kg/ha)		1,267	336	705	484	783	328
	(mg/kg)		565	150	315	216	350	146
Exchangeable Sodium	(cmol+/kg)		0.09	0.17	0.49	0.89	0.08	0.11
	(kg/ha)		45	88	253	460	42	58
	(mg/kg)		20	39	113	205	19	26
Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	0.01	<0.01	<0.01	<0.01	0.01	0.01
	(kg/ha)		2.4	1.9	1.8	2.0	2.4	2.2
	(mg/kg)		1.1	<1	<1	<1	1.1	<1
Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.04	<0.01	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	15	11	31	32	17	18
Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	75	76	71	68	79	67
Magnesium (%)			14	19	25	27	16	31
Potassium (%)			9.6	3.5	2.6	1.8	5.2	2.1
Sodium - ESP (%)			0.58	1.6	1.6	2.8	0.48	0.62
Aluminium (%)			0.08	0.08	0.03	0.03	0.07	0.06
Hydrogen (%)			0.29	0.06	0.00	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	5.4	4.1	2.8	2.5	5.1	2.2

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal

ABN: 41 995 651 524

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Analysis requested by Clayton Richards. Your Job: Job Ref. MS-065 Soils
PO BOX 11034 TAMWORTH NSW 2340

			Sample 13	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18
		Sample ID:	5 0 - 10	5 20 - 30	5 40 - 50	5 65 - 75	7 0 - 10	7 20 - 30
		Crop:	Soil	Soil	Soil	Soil	Soil	Soil
		Client:						
	Parameter	Method reference	M8724/13	M8724/14	M8724/15	M8724/16	M8724/17	M8724/18

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwo
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KS

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PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

28 samples supplied by Minesoils Pty. Ltd. on 17/05/2022. Lab Job No.M8724
Analysis requested by Clayton Richards. Your Job: Job Ref. MS-065 Soils
PO BOX 11034 TAMWORTH NSW 2340

			Sample 19	Sample 20	Sample 21	Sample 22	Sample 23	Sample 24
		Sample ID:	7 40 - 50	7 60 - 70	8 0 - 10	8 20 - 30	8 40 - 50	8 65 - 75
		Crop:	Soil	Soil	Soil	Soil	Soil	Soil
		Client:						
Parameter		**Method reference**	**M8724/19**	**M8724/20**	**M8724/21**	**M8724/22**	**M8724/23**	**M8724/24**
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.14	7.35	6.55	6.56	7.52	7.75
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.031	0.027	0.185	0.141	0.045	0.045
Exchangeable Calcium	(cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	11	4.9	14	6.3	8.6	8.0
	(kg/ha)		4,854	2,222	6,505	2,808	3,860	3,595
	(mg/kg)		2,167	992	2,904	1,254	1,723	1,605
Exchangeable Magnesium	(cmol+/kg)		4.1	2.4	3.6	2.9	12	12
	(kg/ha)		1,129	658	968	789	3,285	3,284
	(mg/kg)		504	294	432	352	1,467	1,466
Exchangeable Potassium	(cmol+/kg)		0.26	0.16	1.9	1.5	0.54	0.44
	(kg/ha)		229	144	1,662	1,353	475	386
	(mg/kg)		102	64	742	604	212	172
Exchangeable Sodium	(cmol+/kg)		0.13	0.13	<0.065	<0.065	0.47	0.54
	(kg/ha)		66	67	<33	<33	240	278
	(mg/kg)		29	30	<15	<15	107	124
Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
	(kg/ha)		1.0	1.1	2.5	1.2	1.3	<1
	(mg/kg)		<1	<1	1.1	<1	<1	<1
Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	15	7.7	20	11	22	21
Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	70	65	72	58	40	38
Magnesium (%)			27	32	18	27	56	57
Potassium (%)			1.7	2.1	9.5	14	2.5	2.1
Sodium - ESP (%)			0.83	1.7	0.16	0.55	2.1	2.6
Aluminium (%)			0.03	0.07	0.06	0.06	0.03	0.02
Hydrogen (%)			0.00	0.00	0.00	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	2.6	2.0	4.1	2.2	0.71	0.66

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		Sample 19	Sample 20	Sample 21	Sample 22	Sample 23	Sample 24
	Sample ID:	7 40 - 50	7 60 - 70	8 0 - 10	8 20 - 30	8 40 - 50	8 65 - 75
	Crop:	Soil	Soil	Soil	Soil	Soil	Soil
	Client:						
Parameter	**Method reference**	M8724/19	M8724/20	M8724/21	M8724/22	M8724/23	M8724/24

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwo
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil res
10. Conversions for 1 $cmol_+/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimat
13. ** NATA accreditation does not cover the performance of this service.
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Agricultural Co-Ordinator KS

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			Sample 25	Sample 26	Sample 27	Sample 28
		Sample ID:	10 0 - 10	10 20 - 30	10 40 - 50	10 65 - 75
		Crop:	Soil	Soil	Soil	Soil
		Client:				
Parameter		**Method reference**	**M8724/25**	**M8724/26**	**M8724/27**	**M8724/28**
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.63	6.90	7.94	8.34
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.108	0.065	0.072	0.066
Exchangeable Calcium	(cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	17	14	19	16
	(kg/ha)		7,849	6,467	8,662	7,101
	(mg/kg)		3,504	2,887	3,867	3,170
Exchangeable Magnesium	(cmol+/kg)		3.7	7.4	16	18
	(kg/ha)		994	2,010	4,328	4,909
	(mg/kg)		444	897	1,932	2,191
Exchangeable Potassium	(cmol+/kg)		2.3	1.2	0.64	0.53
	(kg/ha)		2,045	1,058	561	464
	(mg/kg)		913	472	251	207
Exchangeable Sodium	(cmol+/kg)		0.08	0.11	0.31	0.49
	(kg/ha)		42	55	160	251
	(mg/kg)		19	25	72	112
Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		1.2	1.3	1.1	<1
	(mg/kg)		<1	<1	<1	<1
Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	24	23	36	35
Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	74	62	53	45
Magnesium (%)			15	32	44	52
Potassium (%)			9.9	5.2	1.8	1.5
Sodium - ESP (%)			0.35	0.46	0.86	1.4
Aluminium (%)			0.03	0.03	0.01	0.00
Hydrogen (%)			0.00	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	4.8	2.0	1.2	0.88

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PO BOX 11034 TAMWORTH NSW 2340

		Sample 25	Sample 26	Sample 27	Sample 28
	Sample ID:	10 0 - 10	10 20 - 30	10 40 - 50	10 65 - 75
	Crop:	Soil	Soil	Soil	Soil
	Client:				
Parameter	Method reference	M8724/25	M8724/26	M8724/27	M8724/28

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwo
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
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			Heavy Soil	Medium Soil	Light Soil	Sandy Soil
		Sample ID:				
		Crop:				
		Client:	Clay	Clay Loam	Loam	Loamy Sand
Parameter		**Method reference**	**Indicative guidelines - refer to Notes 6 and 8**			
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.5	6.5	6.3	6.3
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.200	0.150	0.120	0.100
Exchangeable Calcium	**(cmol+/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	15.6	10.8	5.0	1.9
	(kg/ha)		7000	4816	2240	840
	(mg/kg)		3125	2150	1000	375
Exchangeable Magnesium	**(cmol+/kg)**		2.4	1.7	1.2	0.60
	(kg/ha)		650	448	325	168
	(mg/kg)		290	200	145	75
Exchangeable Potassium	**(cmol+/kg)**		0.60	0.50	0.40	0.30
	(kg/ha)		526	426	336	224
	(mg/kg)		235	190	150	100
Exchangeable Sodium	**(cmol+/kg)**		0.3	0.26	0.22	0.11
	(kg/ha)		155	134	113	57
	(mg/kg)		69	60	51	25
Exchangeable Aluminium	**(cmol+/kg)**	**Inhouse S37 (KCl)	0.6	0.5	0.4	0.2
	(kg/ha)		121	101	73	30
	(mg/kg)		54	45	32	14
Exchangeable Hydrogen	**(cmol+/kg)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.6	0.5	0.4	0.2
	(kg/ha)		13	11	8	3
	(mg/kg)		6	5	4	2
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	20.1	14.3	7.8	3.3
Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	77.6	75.7	65.6	57.4
Magnesium (%)			11.9	11.9	15.7	18.1
Potassium (%)			3.0	3.5	5.2	9.1
Sodium - ESP (%)			1.5	1.8	2.9	3.3
Aluminium (%) / **Hydrogen (%)**			6.0	7.1	10.5	12.1
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	6.5	6.4	4.2	3.2

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		Heavy Soil	Medium Soil	Light Soil	Sandy Soil
	Sample ID:				
	Crop:				
	Client:	Clay	Clay Loam	Loam	Loamy Sand
Parameter	Method reference	Indicative guidelines - refer to Notes 6 and 8			

Notes:

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