APPENDIX P
Soils and Land Impact Assessment

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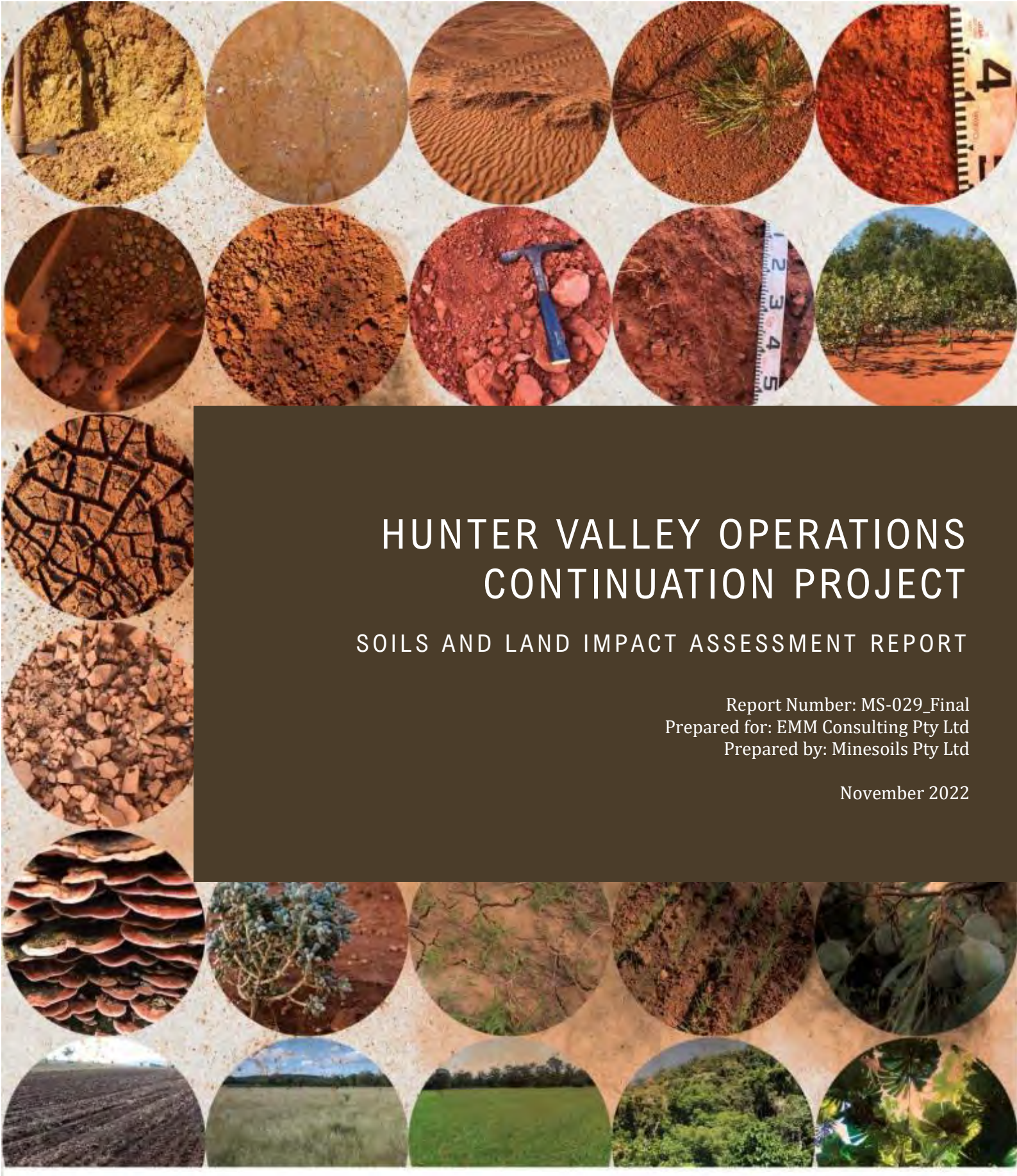

HUNTER VALLEY OPERATIONS CONTINUATION PROJECT

SOILS AND LAND IMPACT ASSESSMENT REPORT

Report Number: MS-029_Final
Prepared for: EMM Consulting Pty Ltd
Prepared by: Minesoils Pty Ltd

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TABLE OF CONTENTS

List of Figures

1. INTRODUCTION

1.1 PROJECT BACKGROUND

Hunter Valley Operations (HVO) is a multi-pit open cut mining complex approximately 24 kilometres (km) north-west of Singleton in the Hunter Valley of New South Wales (NSW) (**Figure 1**). HVO comprises two mine sites separated by the Hunter River, HVO North and HVO South. While the two mine sites are approved under separate development consents, they are operated as one complex with fully integrated environmental management systems.

The existing HVO North operation comprises the approved mining areas of West Pit, Mitchell Pit and Carrington Pit. It operates under development consent DA 450-10-2003 which allows extraction of up to 22 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal until 12 June 2025.

HVO South operates under Project Approval (PA) 06_0261 and comprises the approved mining areas of Riverview Pit and Cheshunt Pit, where mining activities currently take place, and the Riverview South East Extension and South Lemington Pits 1 and 2. PA 06_0261 allows the extraction of up to 20 Mtpa of ROM coal until 24 March 2030.

Mining across HVO is undertaken using dragline and truck and shovel methods. ROM coal from HVO North and South is currently processed at the Hunter Valley (HV) Coal Preparation Plant (CPP) and/or the Howick CPP (both at HVO North), from which product coal is predominantly transported via overland conveyor to the HV load point (HVLP) or Newdell LP and via rail to the Port of Newcastle for export. The Lemington CPP (LCPP) and associated rail loop, which is approved under PA 06_0261 and would process and rail coal from HVO South, is yet to be constructed.

HVO is owned by subsidiary companies of Yancoal and Glencore, as participants in the unincorporated HVO Joint Venture (JV). HV Operations Pty Ltd is the appointed manager of the JV.

1.2 PROJECT OVERVIEW

The HVO Continuation Project (the Project) broadly comprises the continuation of the life of HVO North and HVO South, from the current approved mining completion dates of 2025 and 2030 respectively, to the end of 2050 at HVO North and 2045 at HVO South. The continuation of mining across the HVO Complex will increase resource recovery from the existing operation, predominantly by mining through previously mined areas and to the extent of existing mining tenements and extracting coal from deeper seams at HVO North.

At HVO South an extension to the life of the mine is proposed to facilitate improved mine sequencing outcomes and reduction in mining rate. The Project proposes a reduced mining footprint at HVO South compared to what is approved for extraction, with the previously approved coal extraction in the Riverview South East Extension area and South Lemington Pits 1 and 2 proposed to be removed from mine plan (and future approvals) for the Project. However, some rehabilitation works will be required to be undertaken in the South Lemington Pit 1 area, as part of the mine closure process. The approved shorter rail loop option associated with the LCPP has also been removed from the Project.

A number of infrastructure upgrades and changes are also required to facilitate the Project (and are included as part of it), including the realignment of part of Lemington Road, relocation of transmission and telecommunication lines, and an upgrade of the Newdell Load Point (LP) and including construction of a new product stockpile and train loading bin at the facility, or an extension upgrade of the Hunter Valley HVLP product stockpile including an extension to the existing coal stockpile, and improvements to Lake James and Parnells Dam.

To enable the Project to proceed, two new State significant development (SSD) consents are required; one for HVO North and one for HVO South, under Part 4, Division 4.1 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act). The Project will seek to maintain separate development consents for HVO North and South, as is currently the case. Given that the two mine sites operate as one complex, one Environmental Impact Statement (EIS) has been prepared to support the two development applications required for the Project.

This soil and land impact assessment forms part of the EIS and provides an assessment of the potential soil and land impacts of the Project. It also assesses the potential incremental impacts of the continuation of HVO North and HVO South given separate development consents are being sought for each operation. It documents the soil survey and land and soil capability classification methods and results, initiatives to avoid and minimise land and soil capability impacts, and additional mitigation and soil management measures proposed to address residual impacts not able to be avoided.

The project description is provided in Chapter 4 of the EIS (EMM 2022). The key components of the Project as they relate to HVO North and HVO South are individually listed below.

HVO North

The key changes proposed by the Project to the approved HVO North operations include:

- an extension to the life of the mine until the end of 2050;
- extraction of coal to the base of the Barrett seam across the HVO North mining area. Existing operations are approved to extract coal to the base of the Barrett seam in the West Pit; however, are only approved to the base of the shallower Bayswater seam in Carrington Pit;
- extraction of an additional approximate 400 Million tonnes (Mt) of run of mine (ROM) coal through the extraction of coal from deeper seams and a small increase in the mining extent (between the existing West and Mitchell Pits and Carrington Pit);
- infrastructure upgrades, as listed below:
    - realignment of Lemington Road and new bridge over the Hunter River. While the proposed realigned corridor is partly within the HVO South development consent boundary, the realignment is required to enable the progression of mining from the Mitchell and West pits into the Carrington area at HVO North. The works associated with the road realignment therefore form part of the HVO North Project;
    - HVO North site access road relocation off the existing Lemington Road;
    - an increase in the capacity of Parnells Dam from approximately 1 gigalitres (GL) to 4 GL;
    - realignment of transmission and telecommunication lines that are currently within the proposed mining footprint;
    - HVO North Mine Infrastructure Area upgrade;
    - ancillary activities as required to facilitate operations;
    - access roads to facilitate service provider access;
    - use of demountable/temporary buildings in construction compounds as required;
    - upgrade of the existing Newdell Load Point (LP) train loading facility and construction of a new product stockpile; or
    - extension of the HVLP product coal stockpile, including the closure of a section of Liddell Station Road.
- coal haulage from the HVCPP to the Ravensworth ROM pad, via internal haul roads;
- revised tailings management strategy;
- amendments to the approved final landform;
- progressive rehabilitation throughout the mine life; and
- changes to the development consent boundary to incorporate the changes listed above.

Other than as set out above, all activities that are currently approved under the existing HVO North approval are intended to continue. Key aspects and outcomes of the approved development at HVO North that will remain the same under the Project include the following:

- the maximum allowable annual coal extraction and processing rate;
- annual operational workforce numbers and associated traffic generation;
- approved heights of overburden emplacement areas;
- receipt of ROM coal from HVO South via internal haul roads for processing at all CPP facilities approved for HVO North;
- continued avoidance of the Aboriginal heritage site known as Carrington Mine - Colluvial Deposit 1 (CM-CD1); and
- the ridge between Jerrys Plains and HVO North will remain, continuing to provide an effective amenity barrier.

HVO South

The key changes proposed by the Project to the existing approved operations at HVO South include:

- an extension of the life of the mine until the end of 2045;
- a reduction in the approved maximum ROM coal extraction rate from 20 Mtpa to 18 Mtpa;
- changes to the approved mine sequencing (although noting that mining within the two primary open cut pits; Riverview and Cheshunt, will remain generally within the same footprint as approved);
- removal of coal extraction from the mine plan from the Riverview South East Extension, South Lemington Pit 1 and South Lemington Pit 2 mining areas;
- infrastructure upgrades and changes to that currently approved, as listed below:
    - removal of the LCPP short rail loop option;
    - removal of the approved conveyor from HVO South to the HVCPP at HVO North (the conveyor has not been constructed);
    - construction of the Cheshunt and Riverview flood protection levees;
    - realignment of transmission lines;
    - enlargement of Lake James from approximately 0.7 GL to 2 GL;
    - additional tailings pipelines and pumps;
    - ancillary activities as required to facilitate operations;
    - access roads to facilitate service provider access; and
    - use of demountable/temporary buildings in construction compounds as required.
- revision and implementation of the tailings strategy; and
- amendments to final landform due to rescheduling and or infrastructure relocations, progressive rehabilitation will be undertaken throughout the mine life.

Other than as set out above, all activities that are currently approved under the existing HVO South approval are intended to continue. Key aspects of the approved development at HVO South that will remain the same for the Project include:

- the coal seams to be extracted (ie no increase in the depth of mining);
- the extent of approved mining areas within the Riverview and Cheshunt Pits;
- approved heights of overburden emplacement areas;
- construction of the LCPP and associated rail loop (long rail loop option only);
- transfer of coal from HVO South to HVO North for processing; and
- annual operational workforce numbers and associated traffic generation.

1.3 PROJECT TERMINOLOGY

The following key terms are used throughout this assessment to describe the Project:

- **HVO Complex** – comprises both HVO North and HVO South operations.
- **The Project** – the Project in its entirety; encompassing the continuation of the life of the complex, ie, both HVO North and HVO South, within their respective proposed development consent boundaries, as illustrated in **Figure 1**.
- **Project Area** – The area that is the subject of the two development applications, ie, the proposed development consent boundary for HVO North and the proposed development consent boundary for HVO South.
- **Existing and approved disturbance area** – Areas that are disturbed and/or approved to be disturbed under the current development consents that apply to the HVO Complex.
- **Approved mining area** – The areas within the approved disturbance area that have been previously assessed and approved under the NSW EP&A Act for mining operations.
- **Additional disturbance area** – The areas that will be disturbed by the Project that are outside of the existing and approved disturbance area.
- **Proposed mining area, HVO North** – Areas where coal extraction will take place for the Project at HVO North and includes:
    - areas already disturbed by mining that will be re-disturbed to facilitate coal extraction in the deeper Barrett seam;
    - areas not previously approved for mining (eg the area between the Mitchell Pit and Carrington Pit); and
    - areas approved but not yet disturbed (eg the Carrington West Wing area).
- **Proposed mining area, HVO South** – Comprises the Riverview Pit and Cheshunt Pit, where coal extraction will continue under the Project, down to the Bayswater seam.
- **Previously approved areas not retained** – Areas that are disturbed and/or approved to be disturbed under the current development consents that apply to the HVO Complex, that will no longer be disturbed by the Project, such as the LCPP short rail loop, the Riverview South East Extension and South Lemington Pit 2 mining areas, and the approved temporary crossing across the Hunter River between HVO North and South.
- **Transmission line corridors** – Two categories of transmission line corridors have been defined for the purpose of quantifying the extent of disturbance for the Project:
    - realigned transmission lines (ie new transmission line easements) – the extent of disturbance will be limited to transmission line poles/towers and an access road for maintenance along the alignment, as well as vegetation management to maintain safe powerline clearance; and
    - existing transmission line easements to be decommissioned – disturbance will be confined to existing access tracks and cleared areas.
- **Realigned Lemington Road corridor** – The corridor extends from the Comleroi Road intersection with the Golden Highway at the southern end of the new alignment, along the Comleroi Road alignment around the south-eastern side of HVO South, and then extends in a northerly direction to join the existing Lemington Road at a point approximately 2.3 km south of the New England Highway/Lemington Road intersection. The corridor also allows for two options with respect to the connection to the Golden Highway; one assuming that the Golden Highway is realigned by United Wambo as approved under SSD 7142, and a second option that connects with the current alignment of the Golden Highway.
- **Project disturbance area** – this area is a combination of the additional disturbance area and the existing and approved disturbance area, minus the areas not being retained by the Project.

1.4 SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

This assessment has been prepared in accordance with requirements of the NSW Department of Planning and Environment (DPE). These were set out in the Secretary's Environmental Assessment Requirements (SEARs) for the Project, issued on 11 March 2021. The SEARs for the Project that are addressed in this report are as follows:

> *- an assessment of the likely impacts of the development on the soils and land capability of the site and surrounds, paying particular attention to strategic agricultural land.*

To inform the preparation of the SEARs, DPE invited other government agencies to recommend matters to be addressed in the EIS. The NSW Biodiversity and Conservation Division (BCD) and the NSW Environmental Protection Authority (EPA) raised matters relevant to the soils and land impact assessment. The matters raised are listed below and have been taken into account in preparing this assessment.

> *- The EIS must map the following features relevant to water and soils including: acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Planning Map)* (BCD).

> *- Identify potential impacts to soils and land resources as a result of the proposed development and identify best practice mitigation measures and strategies that will be required/undertaken if applicable in accordance with relevant guidance/standards* (EPA).

1.5 STUDY AREA

The proposed development consent boundaries of the HVO North and HVO South elements of the Project are shown in **Figure 2**. Due to the mining history within these boundaries, land previously disturbed for mining activity or approved for disturbance by mining activity, as well as land not previously approved to be disturbed will be subject to disturbance as a result of the Project. These areas are referred to as the redisturbance area and additional disturbance area respectively.

The study area for this assessment will consist of areas within the redisturbance area and additional disturbance area that will be subject to impacts from mining activities and rehabilitation efforts associated with the Project, excluding the establishment or modification of infrastructure areas such as powerline and road corridors or areas approved for disturbance under current development consents that apply to other neighbouring mines (Ravensworth Operations, United Wambo and Liddell Coal Operations). The study area covers a total area of approximately 6,777 ha, and is comprised of the following elements:

- Current Disturbance – lands disturbed due to mining activity at the commencement of the Project.
- Current Rehabilitation – lands rehabilitated following previous mining activity at the commencement of the Project.
- Undisturbed Areas – lands that have not been disturbed by mining activity. Undisturbed areas include lands approved for disturbance and lands that are not currently approved for disturbance.

Land approved to be, but not yet disturbed at the commencement of the Project has been included within the study area as to accurately reflect disturbance at the commencement of the Project. Noting this, Current Disturbance as displayed in **Figure 2** reflects areas currently disturbed and those proposed to be disturbed by the commencement of the Project being 2023 or Year 1 of the Project.

A breakdown of the study area components for HVO North and HVO South is presented in **Table 1**.

Table 1: Study Area Components

Study Area Component		Area (ha)	
		HVO North	HVO South
Current Disturbance		2,497	1,603
Current Rehabilitation		941	574
Undisturbed Areas	Lands approved for disturbance	554	186
	Lands not approved for disturbance	374	48
Total		4,366	2,411
Overall Total		6,777	

In order to consider the entire Project Area for post-mining landform and land use purposes, rehabilitated areas within the Project Area but not subject to the Project (approximately 1,400 ha) are also shown on **Figure 2**. However, these are not included in the study area for this assessment.

1.6 REPORT STRUCTURE

This report is structured as follows:

Section 1 Introduction – outlines the Project, defines the study area, and presents the purpose of this report.

Section 2 Existing Environment – overview of existing information on soil resources in the study area.

Section 3 Soil Assessment – describes the methodology of the field survey, its results, and an overview of soil resources over the wider study area.

Section 4 Land Capability Impact Assessment – describes the methodology of the land capability impact assessment of the study area

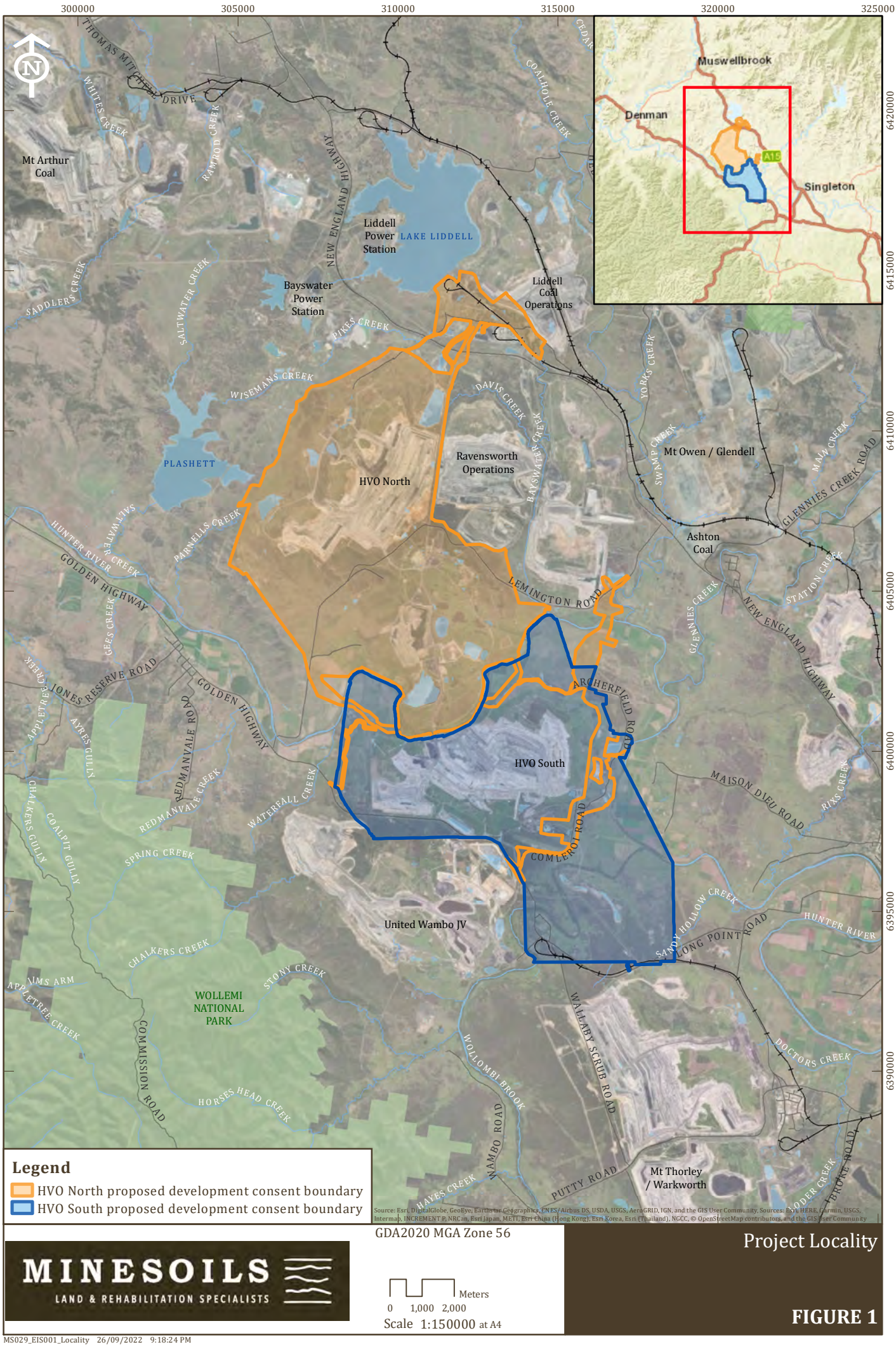
Section 5 Disturbance Management – provides a summary of the environmental mitigation and management recommendations, including calculation of total soil material available for stripping and re-use.

Section 6 Summary

Section 7 References

Appendix A Soil Survey Profile Descriptions

Appendix B Certificate of Analyses – Results of soil analysis from NATA accredited laboratory



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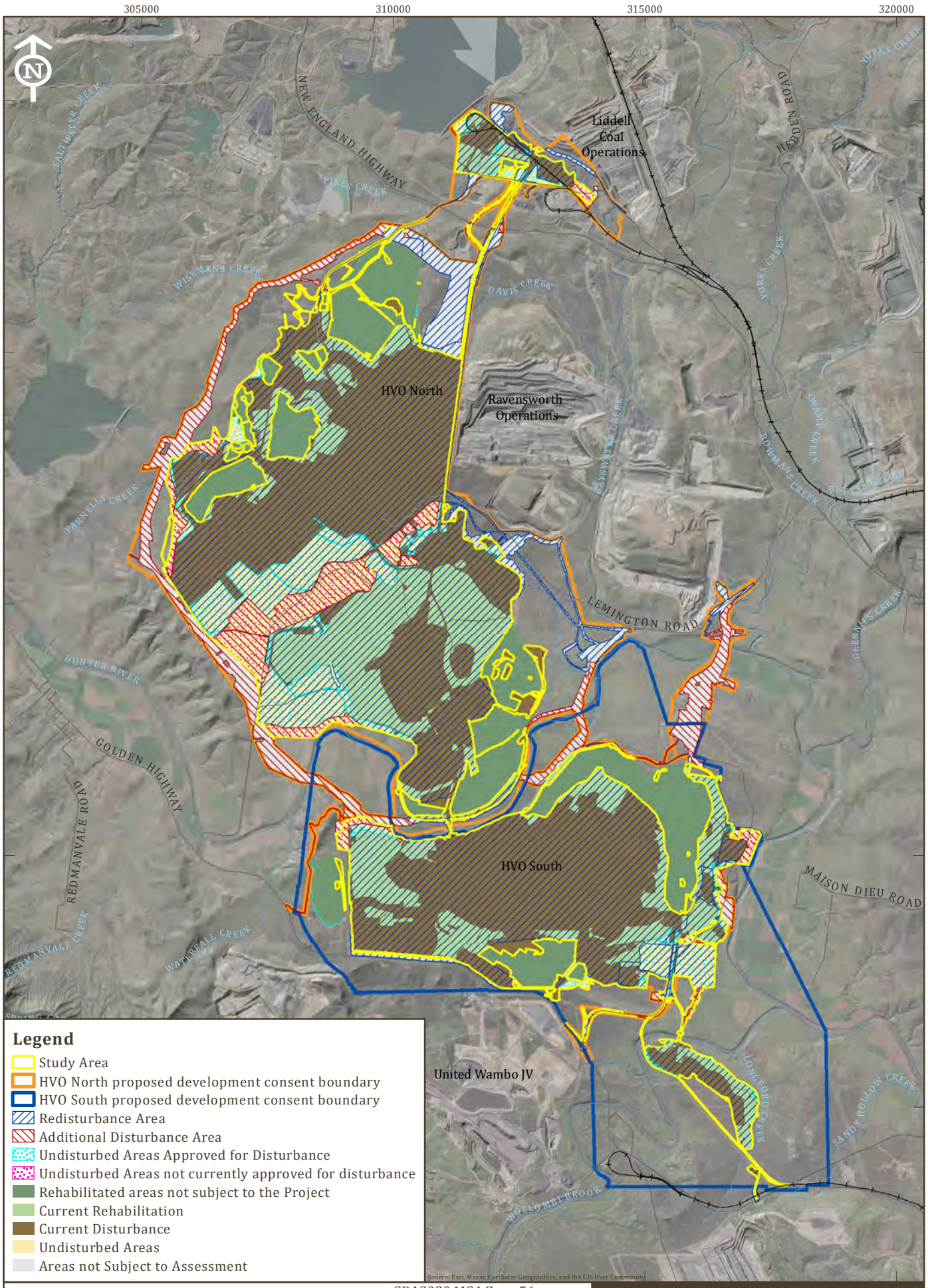

GDA2020 MGA Zone 56

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0 500 1,000 2,000 Meters

Scale 1:100000 at A4

Study Area

FIGURE 2

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2 EXISTING ENVIRONMENT

2.1 CLIMATE

The regional climate of the Project Area is characterised by hot summers and mild dry winters. Rainfall is relatively consistent throughout the year, although slightly lower in winter than in summer. Evaporation exceeds rainfall throughout the year and a soil moisture deficit is likely (especially in the summer months). The annual rainfall averages 656 mm, while the annual evaporation is 1,544 mm.

Temperatures range from a maximum average of 32.1˚C in January, down to a minimum average of 4.3 ˚C in July and August (Singleton STP Bureau of Meteorology (BOM) station No. 061397, 2022).

2.2 LAND USE

Land use within the study area consists of mining activity for current disturbance areas, with some low intensity cattle grazing on rehabilitation areas. Undisturbed areas are largely cleared for agriculture, with some areas subject to cattle grazing and cropping activities.

2.3 GEOLOGY TOPOGRAPHY & SLOPE

The Project Area is within the Sydney Basin which formed in the Late Carboniferous – Early Permian due to igneous rifting and crustal thinning, which resulted in the deposition of Permian and Triassic aged sedimentary sequences. HVO extracts coal seams within the Permian aged Jerrys Plains Subgroup of the Hunter Coalfields. The Jerrys Plains Subgroup comprise coal seams, along with overburden and interburden consisting of sandstone, siltstone, tuffaceous mudstone and conglomerate.

The Project Area is located in the Hunter River catchment, with the Hunter River entering the site at numerous locations (refer **Figure 2**). Tributaries of the Hunter River that exist within the Project Area include Bayswater Creek, Wollombi Brook, Parnells Creek, Farrells Creek, Bowmans Creek and several unnamed ephemeral streams.

Large areas of the Project locality and Project Area have been disturbed by mining operations, creating artificial low points associated with voids and high points relating to overburden dumps. The topography of the Project Area is characterised by an undulating hillslope, gently sloping alluvial plains associated with stream floodplains and large areas of manmade disturbance to the natural topography due to coal mining. Natural local relief typically ranges from 60-150 m Australian Height Datum (AHD), and down to approximately 50 m AHD along the Hunter River.

Within the study area, slope on rehabilitated areas and previously undisturbed areas alike ranges from very gently undulating to steep, with significant expanses greater than 10% slope (refer **Figure 3**). Elevation of emplacement areas are up to approximately 240 m AHD and pit voids extend down to depths of approximately -130 m AHD (refer **Figure 4**).

2.4 SOIL LANDSCAPES

HVO is located within the Soil and Land Resources of the Hunter Region 1:100,000 Sheet (Office of Environment and Heritage, 2018). 460 soil landscape map units have been described within the Hunter Region. Each unit is an inventory of soil and landscape information with relatively uniform land management requirements, allowing major soil and landscape qualities and constraints to be identified. Many representative type profiles are supported by laboratory analysis and soils are described using the Australian Soil Classification and the Great Soil Groups systems.

The soil landscape units that occur within the undisturbed areas of the study area are shown on **Figure 5**, and described below.

Donalds Gully Soil Landscape

The landscape is characterised by gently undulating plain to undulating rises comprising footslopes, drainage plains and alluvial fans on Permian Wittingham Coal Measures in the central north of the Hunter Region (refer Plate 1). Slopes 1 - 5%, local relief <30 m, elevation 250 - 510 m. Extensively cleared woodland and open-woodland.

Soils include moderately deep to deep (50 - <150 cm), imperfectly to poorly drained Brown, Yellow and Grey Sodosols and Natric Kurosols (Solodic Soils and Soloths); moderately deep to very deep (50 - 500 cm), imperfectly drained Chromosols (Grey Brown and Yellow Podzolic Soils and Non-calcic Brown Soils); and moderately deep to deep (50 - <150 cm), moderately well-drained to imperfectly drained Red Dermosols and Chromosols (Red Brown Earths), Hypocalcic Calcarosols (Terra Rossa Soils), Red and Brown Vertosols (Red and Brown Clays) and Black Dermosols (Redzinas and Prairie Soils).

Qualities and limitations include localised foundation hazard, localised productive arable land, localised recharge zone, localised discharge zone, localised salinity hazard, localised gully erosion hazard, widespread sheet erosion hazard, widespread high run-on, localised poor drainage, widespread seasonal waterlogging, localised flood hazard.

Plate 1: Representative landform of the Donalds Gully soil landscape (EOH, 2018)

Ravensworth Soil Landscape

The landscape is characterised by undulating rises to undulating low hills on Permian Wittingham Coal Measures in the central area of the Hunter Region (refer Plate 2). Slopes 3 - 10% (locally to 20%), local relief 20 - 90 m, elevation 30 - 280 m. Extensively cleared woodlands and open woodlands. Areas of widespread land degradation present.

Soils consist of moderately deep to deep (50 - <150 cm), well-drained to imperfectly drained Red, Brown and Yellow Kurosols (Red and Yellow Podzolic Soils) and Chromosols (Red Brown Earths and Non-calcic Brown Soils).

Qualities and limitations include widespread complex soils, localised foundation hazard, widespread recharge zone, localised discharge zone, localised salinity hazard, localised gully erosion hazard, widespread sheet erosion hazard.

Plate 2: Representative landform of the Ravensworth soil landscape (EOH, 2018)

Singleton Soil Landscape

The landscape is characterised by level plain to gently undulating plains on Quaternary alluvium in the central part of the Hunter Region (refer Plate 3). Slopes <3%, local relief <10 m, elevation 10 - 200 m. Extensively cleared woodland, dominated by improved pastures.

Soils consist of deep (100 - <150 cm), moderately well-drained Brown and Black Dermosols (Prairie Soils and Chernozems) and deep (100 - <150 cm), well-drained Red and Brown Kandosols (Red Earths and Brown Earths); deep (100 - <150 cm), imperfectly drained Haplic Epipedal Black Vertosols (Black Earths); deep (100 - <150 cm), well-drained Bleached Red Chromosols (Red Podzolic Soils and Red Soloths); and deep (100 - <150 cm), imperfectly to well-drained Stratic Rudosols (Alluvial Soils).

Qualities and limitations include localised complex soils, localised non-cohesive soils, widespread foundation hazard, widespread productive arable land, widespread recharge zone, localised wind erosion hazard, localised gully erosion hazard, localised sheet erosion hazard, widespread streambank erosion hazard, localised high run-on, localised poor drainage, localised permanently high watertables, localised permanent waterlogging, localised seasonal waterlogging, widespread flood hazard.

Plate 3: Representative landform of the Singleton soil landscape (EOH, 2018)

Branxton Soil Landscape

The landscape is characterised by gently undulating rises to undulating low hills comprising footslopes and drainage plains on mixed Permian sedimentary rock in the central south of the Hunter Region (refer Plate 4). Slopes 1 - 5%, local relief 20 - 50 m and elevation 40 - 130 m. Partial to extensively cleared woodlands for viticulture and grazing on native pastures.

Soils consist of moderately deep (50 - 100 cm), moderately well-drained to imperfectly drained Red, Brown and Yellow Kurosols (Red and Yellow Podzolic Soils) and Brown and Yellow Sodosols (Solodic Soils); deep (100 - <150 cm), imperfectly to poorly drained Grey and Yellow Sodosols (Grey and Yellow Solodic Soils); and deep (100 - <150 cm), poorly drained Black and Grey Kurosols (Grey and Brown Podzolic Soils).

Qualities and limitations include localised foundation hazard, widespread recharge zone, localised discharge zone, localised salinity hazard, localised gully erosion hazard, localised sheet erosion hazard, localised high run-on, localised poor drainage, localised seasonal waterlogging.

Plate 4: Representative landform of the Branxton soil landscape (EOH, 2018)

Foy Brook Soil Landscape

The landscape is characterised by level plain to gently undulating plain on Quaternary alluvium in the central area of the Hunter Region (refer Plate 5). Slopes 0 - 3%, local relief <5 m, elevation 30 - 330 m. Extensively cleared riparian forests.

Soils are characterised by moderately deep to deep (50 - <150 cm), moderately well-drained to well-drained Brown Kandosols (Brown Earths and Alluvial Soils) and Brown Dermosols (Brown Earths); deep to very deep (100 - 500 cm), moderately-well drained Brown Dermosols and Kandosols (Brown Earths); and deep to very deep (100 - 500 cm), poorly drained Brown Sodosols (Solodic Soils) and imperfectly drained Brown Kurosols (Yellow Podzolic Soils).

Qualities and limitations include localised non-cohesive soils, localised foundation hazard, widespread recharge zone, localised discharge zone, widespread streambank erosion hazard, widespread high run-on, localised poor drainage, localised seasonal waterlogging, localised flood hazard.

Plate 5: Representative landform of the Foy Brook soil landscape (EOH, 2018)

Dochra Soil Landscape

The landscape is characterised by undulating low hills on Permian siltstones and mudstones in the central part of the Hunter Region (refer Plate 6). Slopes 5 - 10% (occasionally up to 15%), local relief 30 - 70 m, elevation 40 - 170 m. Includes areas of made land (rehabilitated mine spoil). Extensively cleared open-forest.

Soils consist of moderately deep (50 - <100 cm), moderately well-drained Eutrophic Subnatric Brown Sodosols (Solodic Soils); moderately deep (50 - <100 cm), well drained Acidic-Sodic Magnesic Brown Dermosols (Soloths); moderately deep (50 - <100 cm), imperfectly drained Eutrophic Subnatric Red and Brown Sodosols (Solodic Soils); and moderately deep (50 - <100 cm), imperfectly drained Haplic Natric Red Kurosols (Soloths).

Qualities and limitations include localised complex soils, localised mass movement hazard, localised foundation hazard, localised complex terrain, localised recharge zone, localised discharge zone, localised salinity hazard, widespread gully erosion hazard, widespread sheet erosion hazard, localised streambank erosion hazard, localised high run-on, localised poor drainage, localised seasonal waterlogging.

Plate 6: Representative landform of the Dochra soil landscape (EOH, 2018)

Granbalang Soil Landscape

The landscape is characterised by rolling low hills to rolling hills on Permian Wittingham Coal Measures in the central area of the Hunter Region (refer Plate 7). Slopes 10 - 20% (locally to 32%), local relief 30 - 120 m, elevation 30 - 350 m. Partially cleared woodlands and open woodlands. Contains extensive areas of land degradation.

Soils consist of shallow to deep (25 - <150 cm), well to moderately well-drained Brown Kurosols (Yellow Podzolic Soils) and Red and Brown Chromosols (Red Brown Earths and Non-calcic Brown Soils).

Qualities and limitations include localised shallow soils, widespread complex soils, localised foundation hazard, widespread recharge zone, localised gully erosion hazard, widespread sheet erosion hazard.

Plate 7: Representative landform of the Granbalang soil landscape (EOH, 2018)

Disturbed Terrain

Disturbed Terrain consists of landscape has been extensively disturbed by human activity and the features of the original landscape have been extensively modified. Includes extensive areas of coal mining in the Hunter Valley and past coastal sand mined areas. Also occurs as numerous quarries and garbage tips, industrial sites and other areas where excavation and deposition of material has occurred.

Soils are often absent or extensively disturbed.

2.5 LAND AND SOIL CAPABILITY

Land capability, as detailed in the OEH guideline *The Land and Soil Capability Assessment Scheme; Second approximation* (OEH 2012) (referred to as the LSC Guideline), 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, as further detailed in Section 4.1. The LSC classes that occur within the study area are shown in **Figure 6** and detailed below. Note all regional mapping that occurs over land that is currently disturbed or rehabilitated has been removed from the figure to make it more reflective of the current environment

LSC Class 3

This LSC class occurs over a limited extent in the study area. It is mapped on the alluvial plains of the Hunter River and its tributaries. 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.

LSC Class 4

This LSC class has a limited occurrence within study areas of HVO North and HVO South. This classification indicates land has moderate to high limitations for high-impact land uses and 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.

LSC Class 5

This classification occurs extensively throughout the study area of HVO North and South, recurring extensively in the wider Project locality. This classification indicates moderate–low capability land that 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.

LSC Class 6

This classification occurs extensively throughout the study areas of HVO North and HVO South. It otherwise occurs sporadically throughout the Project Area outside the study area. This classification indicates low capability land that 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.

Disturbed Terrain, Current Disturbance and Current Rehabilitation

Lands subject to significant landform disturbance are identified on regional mapping as disturbed terrain and do not have a regionally mapped LSC classification. The current disturbance and rehabilitation areas of the study area have been separated from regional LSC mapping to reflect this.

2.6 EXISTING SOIL SURVEYS

Two key existing soil surveys describe soils within the study area. The DA 9/96 Proposed Expansion of Howick Coal Mine Environmental Impact Statement (EIS) (Novacoal Australia Pty Ltd 1996) soil survey covered approximately 880 ha. The DA 450-10-2003 Modification 3 (MOD 3) - Carrington West Wing Soil Survey and Land Resource Assessment (GSSE, 2010) soil survey covered approximately 137 ha. The study area boundaries for these assessments are included on **Figure 7**.

Previous approvals information for the additional soil impact area not covered by these assessments is either absent or unreliable due to poor quality.

The findings of the existing soils surveys are presented below and are considered further in the soil resource assessment section (refer Section 3).

DA 9/96 Proposed Expansion of Howick Coal Mine Environmental Impact Statement

This assessment divided its study area into five different soil mapping units. The soils of the area, apart from some small pockets of alluvial soils, are predominantly hilltop soils with a high fine sand content in the topsoils with few gravels, and consist of the following:

- Soil Mapping Unit A – hillslope having an A2 horizon;
- Soil Mapping Unit B – hillslopes having no A2 horizon;
- Soil Mapping Unit C – dark lower slope/foot slope soils;
- Soil Mapping Unit D – buried hillslope soils; and
- Soil Mapping Unit E – alluvial soils.

Soil Mapping Unit A occurs more frequently than any other, covering approximately 468 ha of the study area for the assessment. The soils within the unit are consistent, with little variation across the study area. The soil surface is mainly degraded, usually hard-setting but sometimes crusting with some scattered ironstone gravels. Only small areas are grassed with a thin organic mulch. The topsoil averages 7 cm thick and is a dark brown, acid, moderately structured, porous clay loam or fine sandy clay loam. It grades abruptly to a lower topsoil or bleached A2 Horizon, average thickness 7 cm of a brown to dull reddish brown, porous, earthy, stony clay loam or fine sandy clay loam. This layer grades over a 2-5 cm boundary to the subsoil.

Soil Mapping Unit B consist of a degraded, thin, average depth 9 cm topsoil, or A Horizon, of dark reddish brown, slightly acid, sometimes stony, moderately pedal, porous, soft clay loam or fine sandy clay loam over a sharp boundary to an upper subsoil layer or B1 Horizon, average thickness 15 cm.

Soil Mapping Unit C occurs over an area mainly in the south-west corner of the study area under the Howick Ridge and extends to the southern boundary, west of the major flow line. The surface soil is blacker and more friable than the soils of adjacent unit because of the hillslope influence of that part of the Howick Ridge directly uphill from the unit. It reflects a different geology and is attributed to dark claystone bands. The unit is characterised by a friable brown-black to dark brown clay loam topsoils which are slightly acid, moderately structured, porous and slightly sticky with small amounts of ironstone gravel. This layer changes abruptly to an upper subsoil, or 81 Horizon, of dark reddish brown, moderately structured, very tough, dense, somewhat gravelly, alkaline light medium clay over a lower subsoil or A2 Horizon, of reddish brown moderately structured, tough, dense, a little gravelly, alkaline light to light medium clay. Total soil depth is 145 cm plus.

Soil Mapping Unit D occurs in two separate places, both of which are located directly downslope of the steep hillside at those points where the Mitchells Line of Road cuts under the hillside. The hillside, at these points, is very badly eroded with deep gullies both above the roads and along the carriageway in former roadside table drains. The soil which is being removed from the hills has been deposited below the road in the shape of loaves, on very gentle lower slope and footslope topography. A thin (5 cm average depth) topsoil of dull reddish brown, weakly pedal clay loam is underlain by a number of depositional layers. The number of layers varies from three directly under the steep ridge line off the severely graded hill to one furthest from the hill influence. The greatest thickness of depositional layering occurs where a small lobe of recent colluvium has been deposited immediately below the road. The original soil was noted to have been truncated by the deposited colluvium through either the A1 or the A2 Horizon. There was likely some erosion of these topsoil layers before the depositional phase, as is evidenced over most of the hillslopes in the study area, especially in the west towards the active mining, where ribbing and sheeting of the surface soil has caused the loss of all the topsoil Horizon in some areas.

Soil Mapping Unit E soils occupy a limited extent of the assessment study area in four isolated deposits. The topsoil is a brownish black to darkish reddish brown, slightly acid, friable clay loam with weak to moderate consistence and no stones. The top depositional layer is a dull reddish brown to reddish brown, slightly acid clay loam or light clay with moderate to strong pedality, moderate consistence and coherence, rough faced blocky peds, and little stone. It grades into a second depositional layer of dark reddish brown to reddish brown, moderately alkaline light clay with weakly to moderately pedal blocky peds, moderate consistence and coherence and some gravel bands. This layer grades over 2 - 5 cm to a third depositional layer of reddish brown moderately alkaline-sandy clay with weak to moderate pedality, earthy to rough faced, porous peds and some gravel bands.

The assessment notes that from a dispersion percentage perspective and from Emerson Aggregate Test results, the soils all have stable topsoils but moderately dispersible A2 Horizons, and slightly to highly dispersible and subsoils. During the course of stripping, stockpiling and respreading, consideration will need to be given to protecting these soils from erosion. From a chemical perspective, all soils have acceptable pH for agronomic purposes, although there is an increase in pH with depth and some deeper layers are considered too high to support vegetation. From electrical conductivity determinations it is concluded that none of the topsoils are too saline to be used for mine rehabilitation. However high values are recorded in some sub-soils.

DA 450-10-2003 Modification 3 - Carrington West Wing Soil Survey and Land Resource Assessment

A soil survey was undertaken in September 2009 by GSSE to classify and determine the soil profile types of the proposed extension area and assess the suitability of the current topsoil material for future rehabilitation. Ten (10) soil profiles were assessed at selected sites throughout the assessments study area to identify the following soil units:

- Brown Uniform Silty Clay Loam (43.9 ha);
- Brown Uniform Silty Clay (56.8 ha); and
- Red Brown Duplex Loam (36.1 ha).

The Brown Uniform Silty Clay Loam soil unit generally consists of yellowish brown and brown silty clay loams throughout the profile. These moderately structured soils range from slightly alkaline to moderately alkaline at depth. The soils are generally non-saline and have moderate fertility. The topsoil and subsoil are non-sodic. The top 1.20 m of this soil is suitable for stripping and reuse as a topsoiling medium in rehabilitation. Soil at further depths may be suitable; however restrictions on pit depth prevented further investigation. This soil requires only the standard erosion and sediment control measures if disturbed.

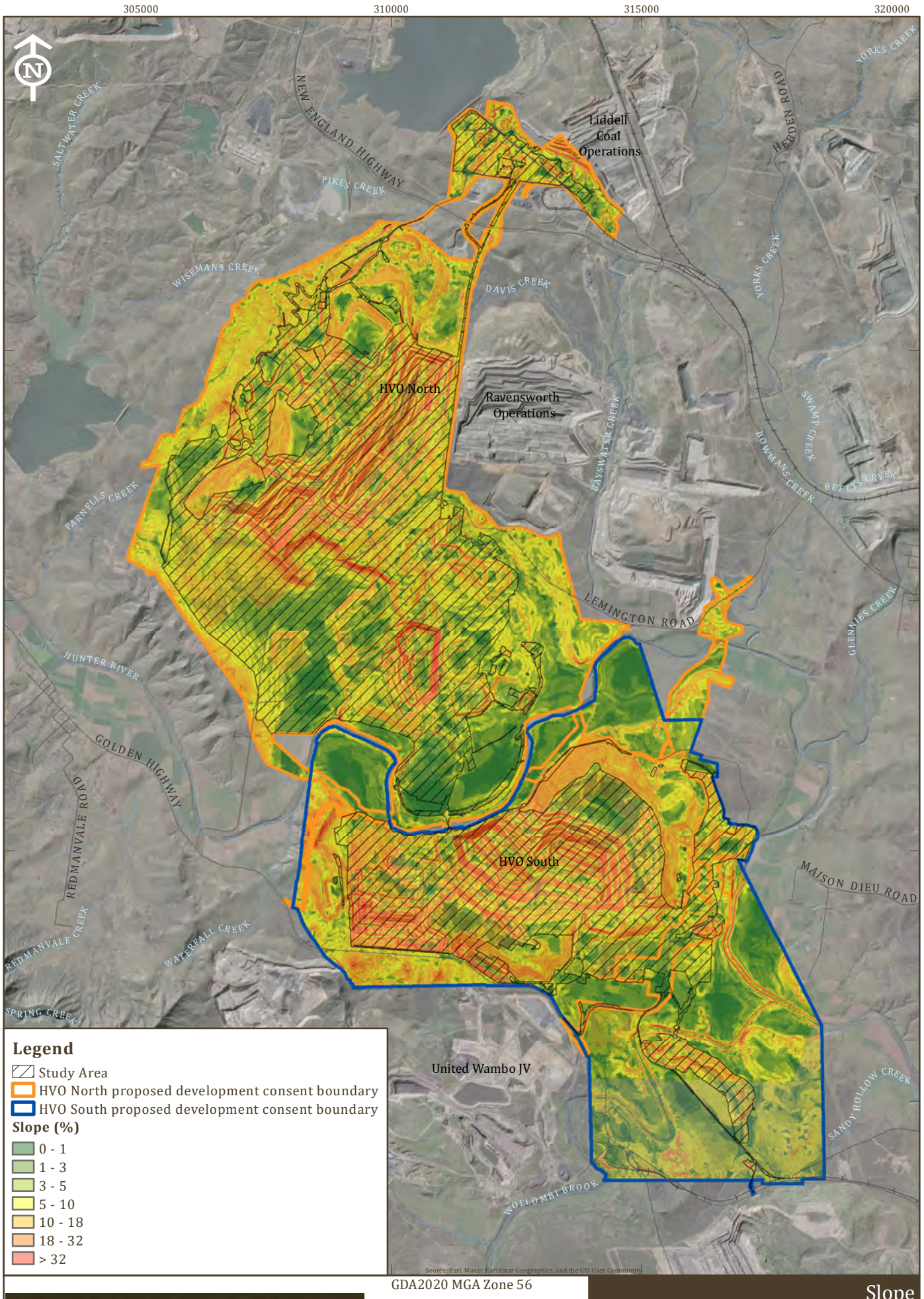
The Brown Uniform Silty Clay soil unit generally consists of brown to dark greyish brown silty clays to medium clays throughout the profile. These moderately drained soils range from neutral to moderately alkaline at depth. The soils are generally non-saline with moderate fertility. The topsoil and subsoil are non-sodic to moderately sodic. The top of this 0.20 m of soil is suitable for stripping and reuse as a topsoiling medium in rehabilitation. The subsoil is generally not suitable for stripping and re-use during rehabilitation operations due to very high clay content, massive structure and moderate salinity. Whilst this subsoil is unsuitable for use as a topsoiling material, consideration may be given to selectively stripping and conserving this material for use as an intermediate layer between reshaped overburden and the final topsoiling layer.

The Red Brown Duplex Loam soil unit generally consists of reddish brown to brown loams and silty clay loams which overlie a texture contrast to brown to reddish brown clay subsoil. These moderately drained soils range from moderately acidic to neutral in the upper layers, to moderately and strongly alkaline at depth. The soils are non-saline in the upper layers, ranging to saline at depth. The topsoil and subsoils are non-sodic. The top 0.10 m of soil is suitable for stripping and reuse as a topsoiling medium in rehabilitation. The lower layers are generally unsuitable due to the limiting factors of massive structure, moderate potential for dispersion and high alkalinity. Whilst this subsoil is unsuitable for use as a topsoiling material, consideration may be given to selectively stripping and conserving this material for use as an intermediate layer between reshaped overburden and the final topsoiling layer.

Table 2 highlights the soil mapping units for each field point locations. Fieldpoints are presented on **Figure 7**.

Table 2: Mapping Units and Associated Reference Field Points

Mapping Unit	Sites #
Brown Uniform Silty Clay Loam	1, 2, 3, 8
Brown Uniform Silty Clay	4, 5, 6, 7
Red Brown Duplex Loam	9, 10



Legend

- Study Area
- HVO North proposed development consent boundary
- HVO South proposed development consent boundary

Slope (%)

- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 18
- 18 - 32
- > 32

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0 500 1,000 2,000 Meters

Scale 1:100000 at A4

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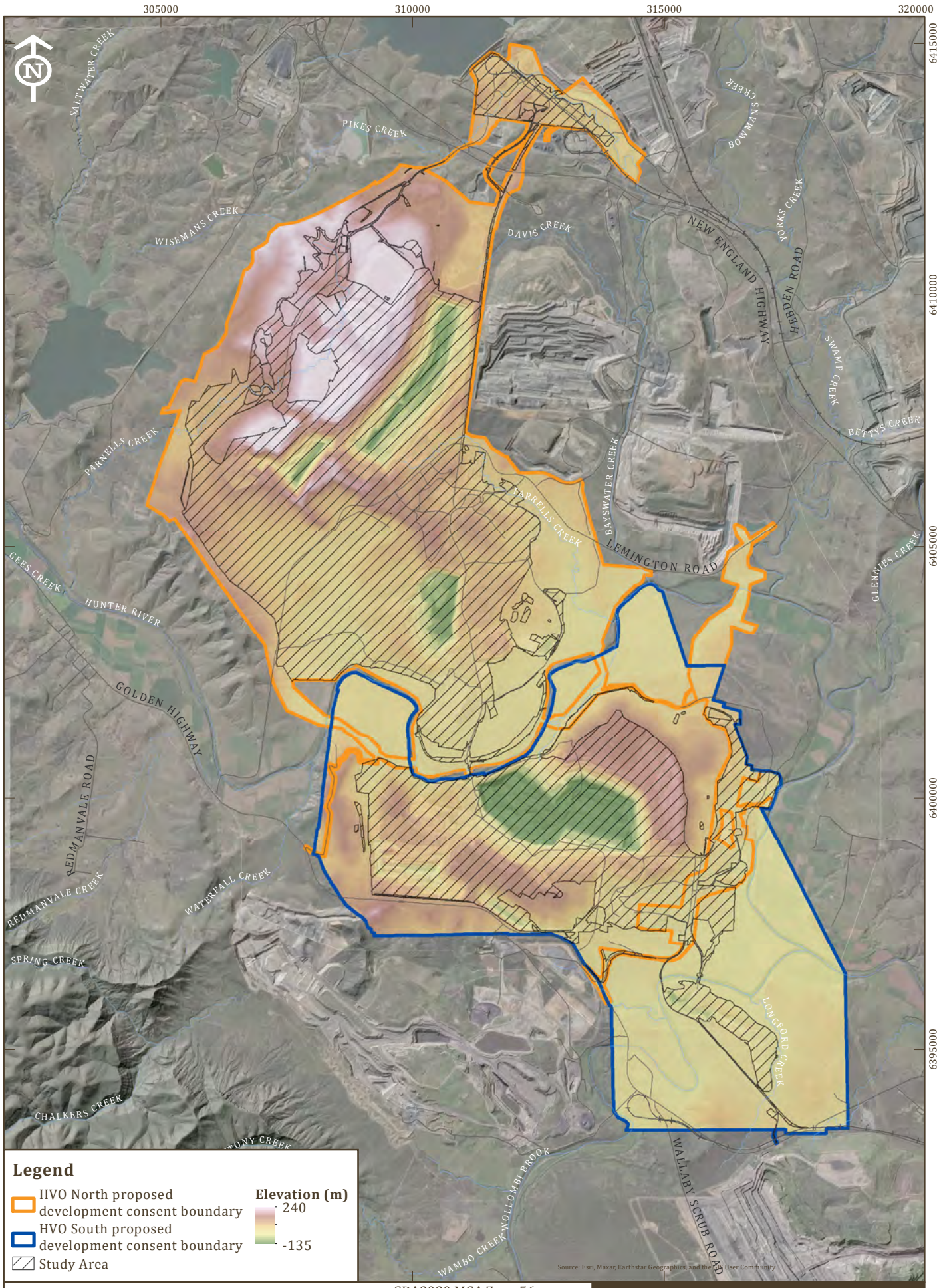
Slope

FIGURE 3

MS029_EIS003_Slope 28/11/2022 11:30:42 AM



Legend

- HVO North proposed development consent boundary
- HVO South proposed development consent boundary
- Study Area

Elevation (m)

240

-135

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Meters
0 500 1,000 2,000

Scale 1:100000 at A4

Topography

FIGURE 4

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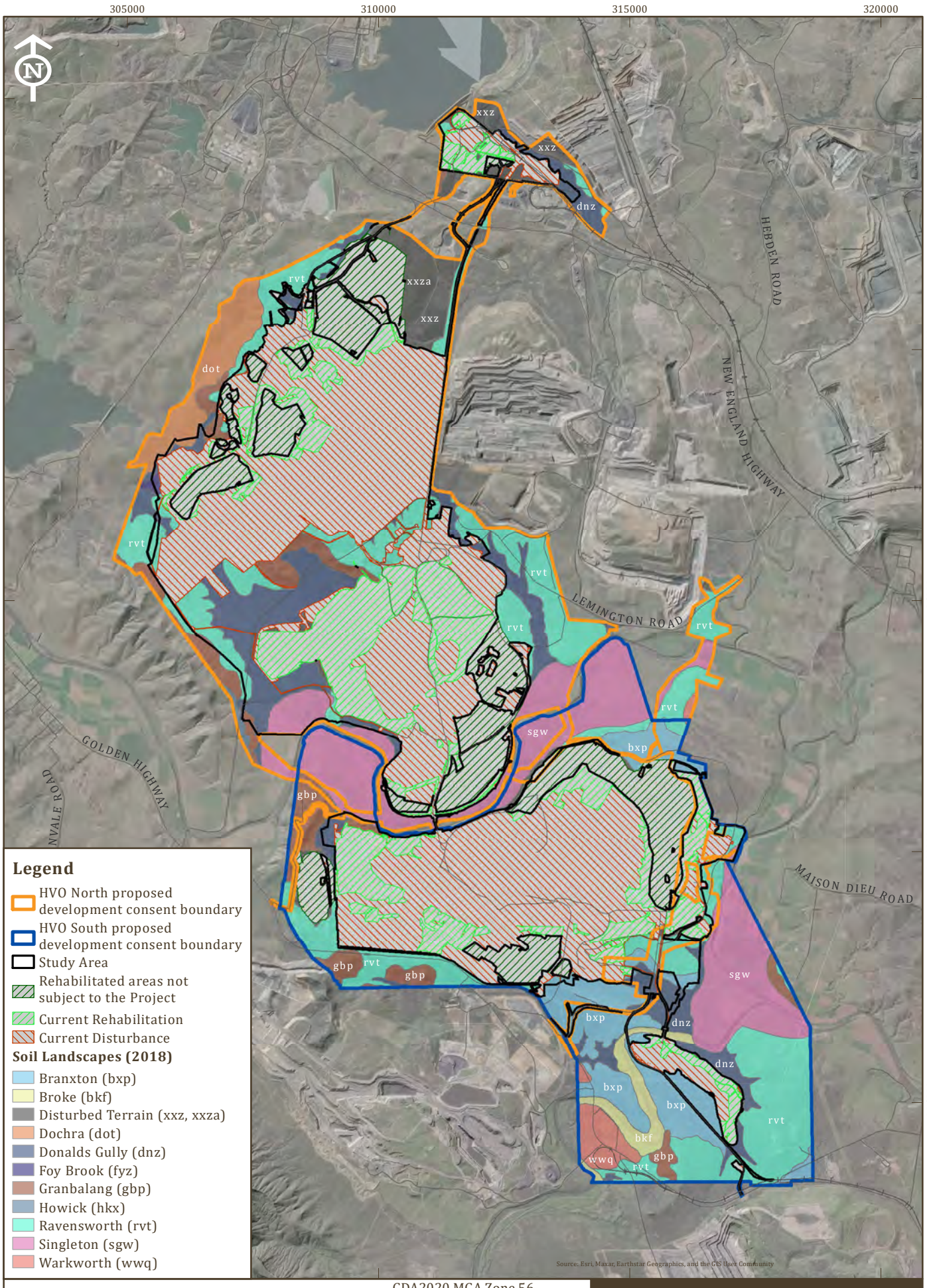

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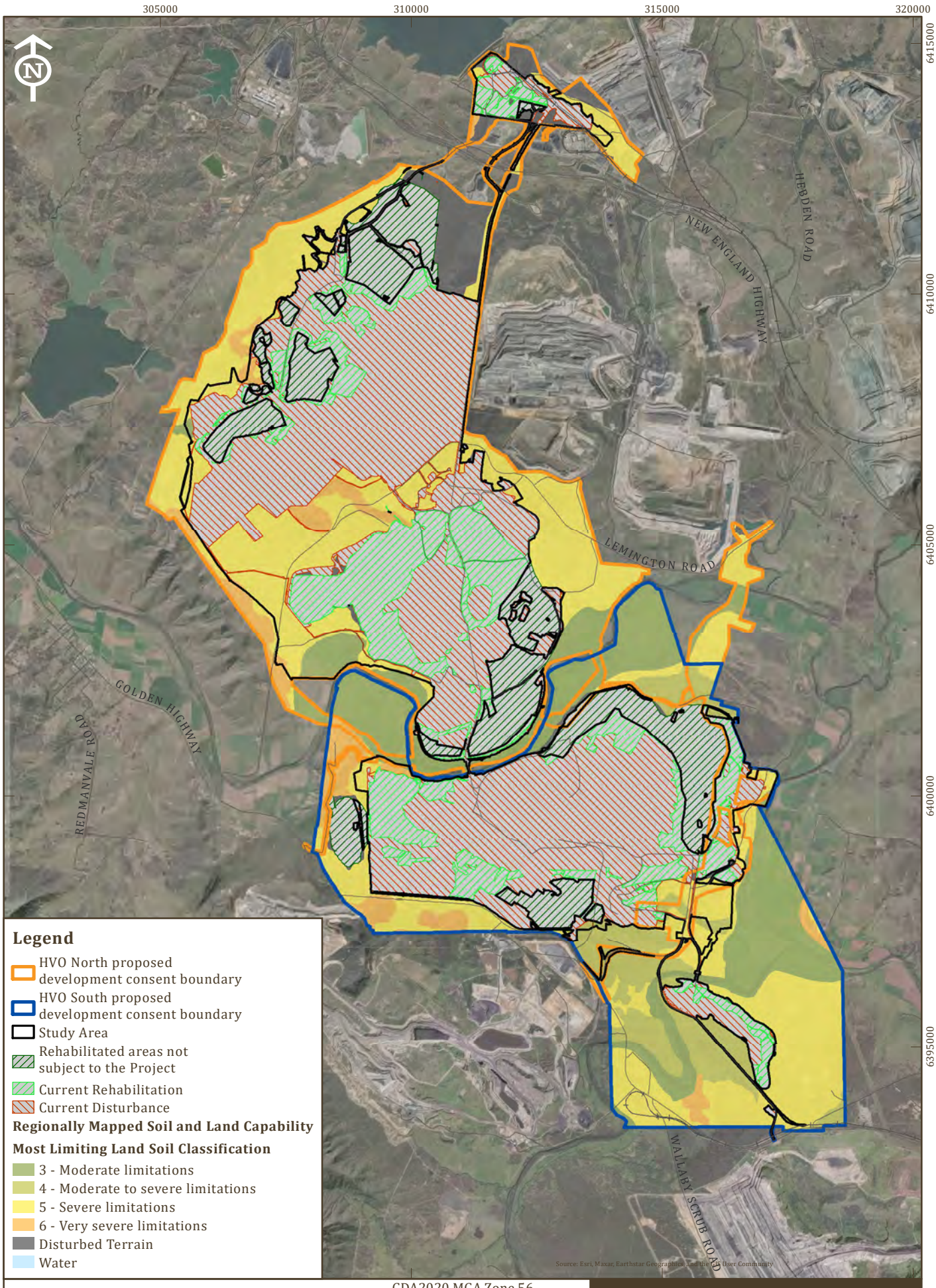
Meters
0 500 1,000 2,000
Scale 1:100000 at A4

Regionally Mapped Soil Landscapes

FIGURE 5

MS029_EIS005_RegionalSoilLandscapes 28/11/2022 11:42:14 AM



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0 500 1,000 2,000 Meters

Scale 1:100000 at A4

Regionally Mapped Soil and Land Capability

FIGURE 6

MS029_EIS006_RegionalLSC 28/11/2022 11:44:07 AM

3 SOIL RESOURCE ASSESSMENT

Minesoils undertook a soil and land resource assessment of soil resources to satisfy the following tasks to be undertaken throughout the EIS process:

- Soil survey and assessment, identifying soil types, soil qualities and risks including erosion, acid sulfate soils risk and salinity;
- Land and soil capability (LSC) assessment;
- Acid Sulfate Soils assessment; and
- Management and mitigation measures for handling soil during construction, operations, and rehabilitation.

The soil resources that will be subject to stripping and re-use in rehabilitation efforts include the following:

- Soils in the Undisturbed Areas that are not approved for disturbance;
- Soils in the Undisturbed Areas that are currently approved for disturbance; and
- Soils on Current Rehabilitation within the study area.

A soil survey of the Undisturbed Areas that are not approved for disturbance was undertaken to inform the soil and land assessment. Undisturbed Areas not covered by this soils survey were assessed using previous soil survey information, or where previous soil survey information was unavailable, regional mapping. The methodology and results are presented in Section 3.1.

An overview of recoverable resources from rehabilitation areas is addressed in Section 3.3.

3.1 SOIL RESOURCE ASSESSMENT METHODOLOGY

The objective of Minesoils proposed fieldwork program is to inform the soil and land resources assessment. The fieldwork plan outlined below was designed to satisfy the following requirements:

- Soil survey and mapping: collection of landform pattern and element information, soil profile data, and taxonomic parameters to distinguish soil types according to the Australian Soil Classification criteria, within a portion of the study area.
- EIS land and soil capability (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 required data on biophysical features from in situ measurements and regional mapping.
- EIS 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 stripping and rehabilitation. Observations were made on risks of acid sulphate soils (ASS) 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 (NSCT, 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. Works were completed in accordance with the HVO Ground Disturbance Permit Procedure.

There were 14 soil investigation sites in the soil survey study area and samples were collected and tested at all sites. Two to four samples were collected from each site and depths were typically at 0-10 cm, 20-30 cm, 40-50 cm and 65-75 cm. The laboratory testing suite for these sites is detailed in the **Table 3** below.

Soil profiles within the soil survey study area were assessed in general accordance with the Australian Soil and Land Survey Field Handbook soil classification procedures (NCST, 2009). Detailed soil profile descriptions were recorded covering the major parameters specified in **Table 4** below. Soil profile logging was undertaken in the

field using Minesoils soil data sheets, including GPS recordings and photographs of the landforms and soil profiles. Soils were keyed out in accordance with the Australian Soil Classification (ASC) Third Edition (2021).

Table 3: 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

Table 4: Soil Sample Laboratory Analysis

Lab Analysis	
Analyte	**Methodology**
pH (1:5 water & CaCl)	Rayment & Lyons 2011-4A1
Electrical Conductivity (EC) and Chloride	Rayment & Lyons 2011-3A1
Cation Exchange Capacity (CEC) & 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 (CSIRO 'Yellow Book')

The soils survey covered approximately 250 ha of HVO North study area, and points were located in the largest contiguous portion of the Undisturbed Area component of the study area. This information was used to accurately map soils and land resources for the area of field site location coverage (refer **Figure 7**), and adjacent undisturbed areas.

Other areas within the Undisturbed Area component of the HVO North study area were assessed using existing soils survey information. Detailed soils information for the Carrington West Wing Area MOD3 Soil Survey and Land Resource Assessment (GSSE, 2010), which included 10 fieldpoints (G – G10) (refer **Figure 7**), was used to inform the soil and land resource assessment for the area covered by the previous soil survey. Additionally, and although the information was less reliable, DA 9/96 EIS (Novacoal Australia Pty Ltd 1996) reference information was also used to support Minesoils assessment. The coverage of the existing soil investigations within the study area is presented on **Figure 7**.

For all remaining Undisturbed Areas within the study area, regional mapping was used for the assessment where no ground truthed soil investigation findings or existing data was available for use. As per HVO Topsoil Management Plan and the Rehabilitation Management Plan (RMP) (ERR 2022), additional soil investigations as part of soil characterisation to inform stripping activities is standard practice at HVO and will be undertaken in these areas prior to disturbance.

3.2 SOIL SURVEY RESULTS

A summary of the soil survey findings is shown in **Table 5** with soil profile locations shown on **Figure 7**. Full soil profile descriptions are included in **Appendix 1**.

Table 5: Soil Survey Summary

Site #	Soil Map Units		Soil Profile – Australian Soil Classification (ASC)	ASC Family Criteria
	#	Name		
E1	1	Sodosol	Vertic Subnatric Black Sodosol	BEMOW
E2	2	Vertosol/Dermosol Complex	Episodic-Endocalcareous Epipedal Brown Vertosol	EQRW
E3	1	Sodosol	Vertic Subnatric Brown Sodosol	BEMOW
E4	1	Sodosol	Bleached-Sodic Eutrophic Red Chromosol	BEOOW
E5	1	Sodosol	Eutrophic Mottled-Subnatric Brown Sodosol	BEMOW
E6	2	Vertosol/Dermosol Complex	Sodic Eutrophic Brown Dermosol	BEMOW
E7	1	Sodosol	Eutrophic Mesonatric Brown Sodosol	BEOOW
E8	2	Vertosol/Dermosol Complex	Haplic Epipedal Brown Vertosol	EQSW
E9	2	Vertosol/Dermosol Complex	Haplic Eutrophic Brown Dermosol	BEMOW
E10	2	Vertosol/Dermosol Complex	Haplic Eutrophic Brown Dermosol	BEOOW
E11	2	Vertosol/Dermosol Complex	Endocalcareous-Endohypersodic Epipedal Black Vertosol	FQRW
E12	2	Vertosol/Dermosol Complex	Endocalcareous Epipedal Black Vertosol	EQSW
E13	2	Vertosol/Dermosol Complex	Endohypersodic Epipedal Black Vertosol	EQSW
E14	2	Vertosol/Dermosol Complex	Endocalcareous-Endohypersodic Epipedal Black Vertosol	FQRW

3.3 SOIL MAPPING UNITS

The soil mapping units of the Undisturbed Areas of the study area consist of the following:

- Soil Unit 1: Sodosol;
- Soil Unit 2: Vertosol/ Dermosol Complex;
- Soil Unit 3: Alluvial Soils; and
- Soil Unit 4: Natric Kurosols.

These soil mapping units are presented on **Figure 7.** An overview of each mapping unit is presented below.

Soil Unit 1 – Sodosol

The Sodosol unit is represented by 5 soil survey sites and consists of clear or abrupt texture contrast soils with varying degrees of sodicity in the subsoils. Sodosols are characterised by a clear or abrupt textural B horizon and 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 and not strongly acid. Chromosols are soils with a clear or abrupt textural B horizon

and 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 not sodic and not strongly acidic.

Typically, more sodic soils were present throughout this soil unit, with four representative Sodosol soil types encountered. The Chromosol soil type is a sub-dominant.

This soil unit covers approximately 625 ha or 54% of the Undisturbed Areas portion of the study area.

Soil Unit 2 – Vertosol/ Dermosol Complex

The Vertosol/ Dermosol complex is represented by 9 soil survey sites and consists of clay textured soil profiles with no texture contrast horizons. Vertosols are soils with a clay field texture of 35% or more clay throughout the solum except for thin, surface crusty horizons 30 mm or less thick, and with shrink-swell properties that exhibit strong cracking when dry, and at depth have slickensides and/or lenticular peds. Dermosols are soils that have B2 horizons that have a grade of pedality greater than weak throughout the major part of the horizon, and do not have clear or abrupt textural B horizon. Soils within this unit are typically sodic at depth.

This soil unit covers approximately 366 ha or 31% of the Undisturbed Areas portion of the study area.

Soil Unit 3 – Alluvial Soils

The Alluvial Soils unit accounts for deep, depositional soils on the floodplains of the hunter river and its tributaries. This soil unit contains a range of non-texture contrast soils including Rudosols, Tenosols and Dermosols soil types (depending on the level of structure grade), and is mapped according to regionally mapped soil types and information included in the Carrington West Wing Area MOD3 Soil Survey and Land Resource Assessment (GSSE, 2010).

Rudosols are soils with little, if any, (rudimentary) pedologic organisation apart from (a) minimal development of an Al horizon or (b) the presence of less than 10% of B horizon material (including pedogenic carbonate) in fissures in the parent rock or saprolite. The soils are apedal or only weakly structured in the A1 horizon and show no pedological colour changes apart from the darkening of an A1 horizon. There is little or no texture or colour change with depth unless stratified or buried soils are present.

Tenosols are soils that do not fit the requirements of any other soil orders and generally with one or more of the following:

1. A peaty horizon.
2. A humose, melacic or melanic horizon, or conspicuously bleached A2 horizon, which overlies a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials.
3. A horizons which meet all the conditions for a peaty, humose, melacic or melanic horizon except the depth requirement, and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials.
4. A1 horizons which have more than a weak development of structure and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials.
5. An A2 horizon which overlies a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials.
6. B2 horizon with 15% clay (SL) or less1 , or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite which contains between 10 and 50% of B horizon material (including pedogenic carbonate).
7. A ferric or bauxitic horizon >0.2 m thick.
8. A calcareous horizon >0.2 m thick

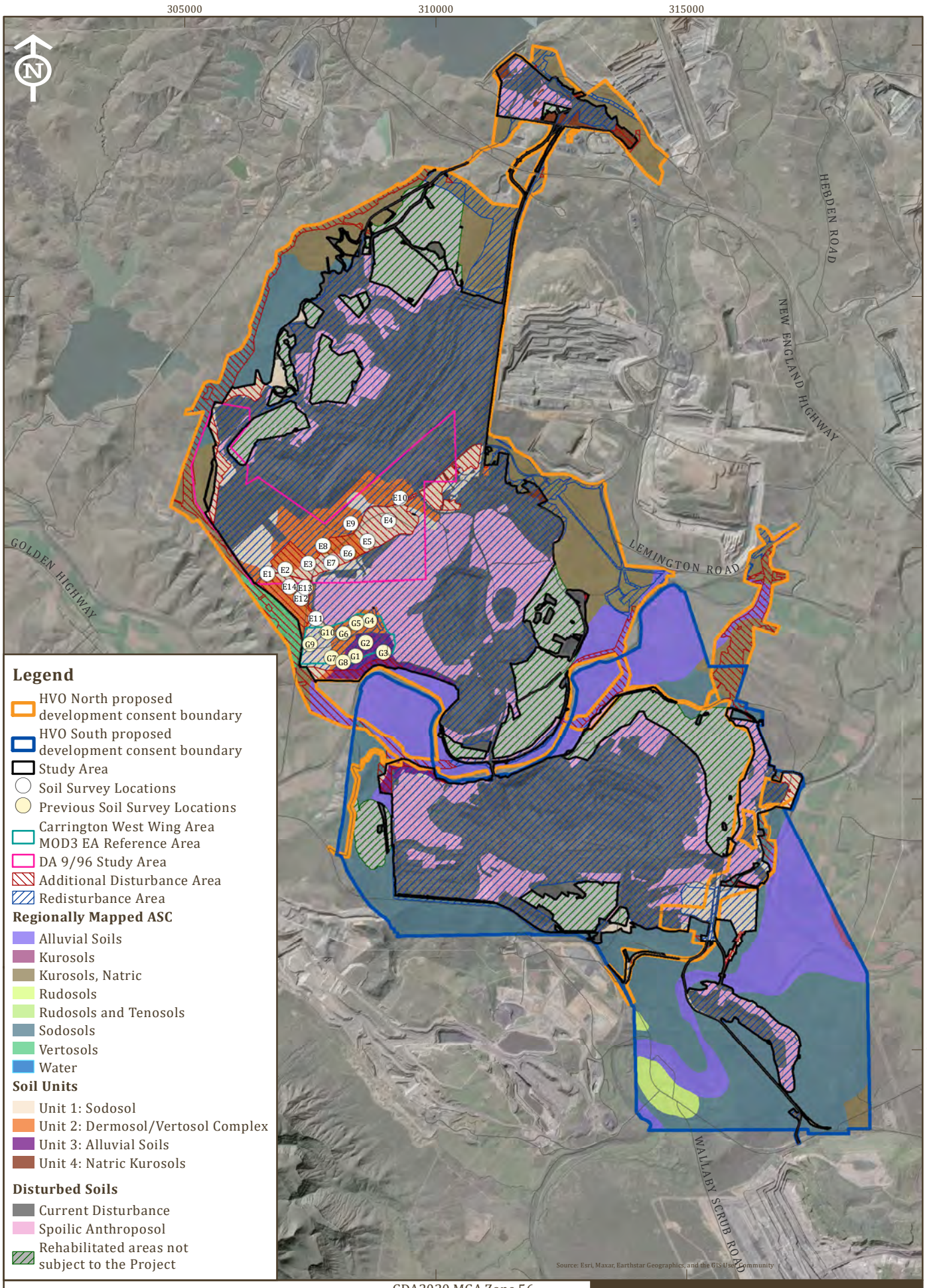
This soil unit covers approximately 124 ha or 11% of the Undisturbed Areas portion of the study area.

Soil Unit 4 – Natric Kurosols

The Natric Kurosols unit is mapped for areas according to regionally mapped soil types for areas where no ground truthed soils investigations were undertaken or previous soil survey data is available.

Natric Kurosols are 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 acid and in which the major part of the upper 0.2 m of the B2t horizon is sodic.

This soil unit covers approximately 46 ha or 4% of the Undisturbed Areas portion of the study area.



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0 500 1,000 2,000 Meters

Scale 1:100000 at A4

Australian Soil Classification Units

FIGURE 7

MS029_EIS007_SoilMapUnits 28/11/2022 11:49:05 AM

3.4 SOIL RESOURCES WITHIN CURRENT REHABILITION

Soil resources that will have been respread on rehabilitated lands within the study area prior to the commencement of the Project will be re-stripped and used for the subsequent rehabilitation associated with the Project. Recoverable resources from rehabilitation areas are classified as Spoilic Anthroposols, which are defined as soils that have formed or are forming on mineral materials that have been moved by earthmoving equipment in mining, highway construction, dam building etc (Isbell, R. F., 2021). Landscapes are human-formed, and hence may present an 'unnatural' geomorphic expression. As a result, these soils are expected to have a wide range of physical and chemical attributes and variable depths, although within the soil parameters for the region.

Based on the HVO Topsoil Management Plan and the RMP, the soil resources that have been allocated to established rehabilitated lands within the redisturbance area are expected to be erosionally stable and in appropriate condition for stripping and/or re-use. Therefore, for the purposes of this report, all soil resources on rehabilitated lands within the redisturbance area are assumed to be physically and chemically suitable and available for utilisation as part of the Project.

Additional assessment of these resources will be required to inform management controls prior to stripping and re-use.

Soil resources that were stripped and stockpiled but not yet used in rehabilitation activities at the commencement of the Project will amount to approximately 1,893,370 m^3 as per information provided by HVO in accordance with the approved RMP. These materials are also assumed to be physically and chemically suitable and available for utilisation as part of the Project.

3.5 SOIL RESOURCE AREAS SUMMARY

Table 6 outlines the areas of recoverable soil resources for HVO North and HVO South respectively.

Table 6: Soil Resources within the Study Area

Study Area		Total Area (ha)	
		HVO North	HVO South
Undisturbed Areas	Soil Mapping Unit 1: Sodosols	423	202
	Soil Mapping Unit 2: Vertosol/Dermosol Complex	366	0
	Soil Mapping Unit 3: Alluvial Soils	93	31
	Soil Mapping Unit 4: Natric Kurosols	46	0
Current Rehabilitation		941	574
Total		1,869	807

3.6 ACID SULPHATE SOILS FINDINGS

Acid sulfate soils (ASS) have been classified into 5 different classes based on the likelihood of the acid sulfate soils being present in particular areas and at certain depths (NSW Department of Planning and Environment, 2018):

- Class 1: ASS in a class 1 area are likely to be found on and below the natural ground surface.
- Class 2: ASS in a class 2 area are likely to be found below the natural ground surface.
- Class 3: ASS in a class 3 area are likely to be found beyond 1 m below the natural ground surface.
- Class 4: ASS in a class 4 area are likely to be found beyond 2 m below the natural ground surface.
- Class 5: ASS are not typically found in Class 5 areas. Areas classified as Class 5 are located within 500 m on adjacent class 1, 2, 3 or 4 land.

The study area does not contain any of the above classes on the NSW Acid Sulfate Soil Planning Map.

Assessing land elevation and distance from the coast, in conjunction with existing ASS mapping for NSW, the potential for ASS is considered a very low risk.

Further, there was no evidence of ASS indicators such as soil gleying, odour, marine sediments and organic materials recorded as part of the soils survey.

4 LAND CAPABILITY IMPACT ASSESSMENT

4.1 LAND AND SOIL CAPABILITY ASSESSMENT

The LSC classification applied to the study area was in accordance with the OEH guideline *The Land and Soil Capability Assessment Scheme; Second approximation* (OEH 2012a) (referred to as the LSC Guideline). This scheme uses the biophysical features of the land and soil to derive detailed rating tables for a range of land and soil hazards. The scheme consists of eight classes, which classify the land based on the severity of long-term limitations. The LSC classes are described in **Table 7** 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 7: 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.

4.1.1 ASSESSMENT APPROACH

The following summarised the assessment approach for LSC within the separate components of the study area:

- For Undisturbed Areas within the study area that were subject to the soil survey, a full site verification of LSC was undertaken in accordance with the methodology outlined in Section 4.1.2.
- For all remaining Undisturbed Areas within the study area, regional mapping was used where no ground truthed soil investigation findings were undertaken.
- For Current Rehabilitation areas of the study area, the commitments of the currently approved final landform were used to determine LSC.
- Current Disturbance areas of the study area were presumed to default to LSC class 8.

4.1.2 SITE VERIFICATION 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 Project Area lies within the Eastern and Central NSW Division, and the appropriate criteria for this division were used in the assessment. Assessment of water erosion hazard is almost solely dependent on the slope percentage of the land, based on each soil landscape unit. The only exception is land which falls within the slope range of 10-20%, which may be designated 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 wind erosion hazard for each soil type. Three criteria were assessed to be consistent for each soil type:

- Wind erosive power for the Project Area has been mapped as 'Low' (NSW Department of Trade and Investment);
- 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 Project Area; and
- The average rainfall for the region is 656 mm (BOM 2022), and therefore the Project Area lies within the "greater than 500 mm rainfall" category.

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

Hazard 3: Soil Structure Decline

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

Hazard 4: Soil Acidification

The soil acidification hazard is assessed using three criteria, 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 – 700 mm.

Hazard 5: Salinity

The salinity hazard is determined through a range of data and criteria. The recharge potential for the site was determined based on an average annual rainfall of 656 mm, with annual evaporation of 1,544 mm (BOM 2022). This would suggest a high recharge potential and a low discharge potential.

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

The LSC assessment was based on the above methodology for areas subject to soil survey.

4.1.3 RESULTS OF SITE VERIFICATION

The findings of the LSC assessment on the soil survey area are presented in **Table 8**, which shows a range of LSC classes from 3 to 6.

Table 8: Site Verified LSC

		Hazard Criteria								
		1	2	3	4	5	6	7	8	Overall
Site	Soil Unit	Water erosion	Wind erosion	Structure	Acidity	Salinity	Water-logging	Soil depth	Movement	Class
1	Sodosol	3	1	3	3	4	3	1	1	**4**
2	Vertosol/Dermosol Complex	1	1	4	3	4	3	1	1	**4**
3	Sodosol	1	1	4	3	4	3	1	1	**4**
4	Sodosol	3	1	3	3	1	2	1	1	**3**
5	Sodosol	2	1	4	3	4	6	1	1	**6**
6	Vertosol/Dermosol Complex	1	2	3	3	1	6	1	1	**6**
7	Sodosol	1	1	3	3	4	6	1	1	**6**
8	Vertosol/Dermosol Complex	3	1	3	2	1	2	1	1	**3**
9	Vertosol/Dermosol Complex	4	2	3	3	1	1	1	1	**4**
10	Vertosol/Dermosol Complex	1	2	3	2	1	1	1	1	**3**
11	Vertosol/Dermosol Complex	3	2	3	3	4	4	1	1	**4**
12	Vertosol/Dermosol Complex	3	2	3	2	3	3	1	1	**3**
13	Vertosol/Dermosol Complex	2	2	3	3	3	3	1	1	**3**
14	Vertosol/Dermosol Complex	3	2	3	3	3	3	1	1	**3**

4.2 PROJECT COMMENCEMENT LSC OF STUDY AREA

The LSC classes for the study areas of HVO North and South as of Project commencement are presented in **Table 9** and shown in **Figure 8**. A description of the LSC classes and the associated limitations for the soil survey study area are provided below.

Table 9: Project Commencement of LSC

Study Area	LSC Class	Area (ha)		
		HVO North	HVO South	Overall Total
Undisturbed Areas	3	261	10	271
	4	146	56	202
	5	392	158	550
	6	118	9	127
Current Rehabilitation	4/5/6	618	299	917
	6/7	335	210	545
Current Disturbance	8	2,497	1,668	4,165
	Total	4,367	2,410	6,777

A description of the LSC classes and the associated limitations for the soil survey study area are provided below:

Class 3 Land

Class 3 land covers a significant portion of the Undisturbed Areas, primarily in the area subject to site verification of LSC, but also in association with the alluvial soils of the Carrington West Wing area. This classification indicates land has slight to moderate limitations. Where only slight limitations are present, these lands 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. Where more moderate limitations occur, land 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 4 Land

Class 4 land includes a portion of the Undisturbed Areas, primarily in the area subject to site verification of LSC. This classification indicates land has moderate to high limitations for high-impact land uses and 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. The primary constraints to this land class are soil structure decline hazard and salinity.

Class 5 Land

Class 5 land has been delineated over the largest portion of the Undisturbed Areas, primarily based on regional mapping where no ground truthed soil investigations were undertaken. This classification indicates 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.

Class 6 Land

Class 6 land has been delineated over a small portions of the Undisturbed Areas. This classification indicates land that 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. The primary constraints to this land class include water-logging, salinity and soil structure decline.

Class 4/5/6 Land

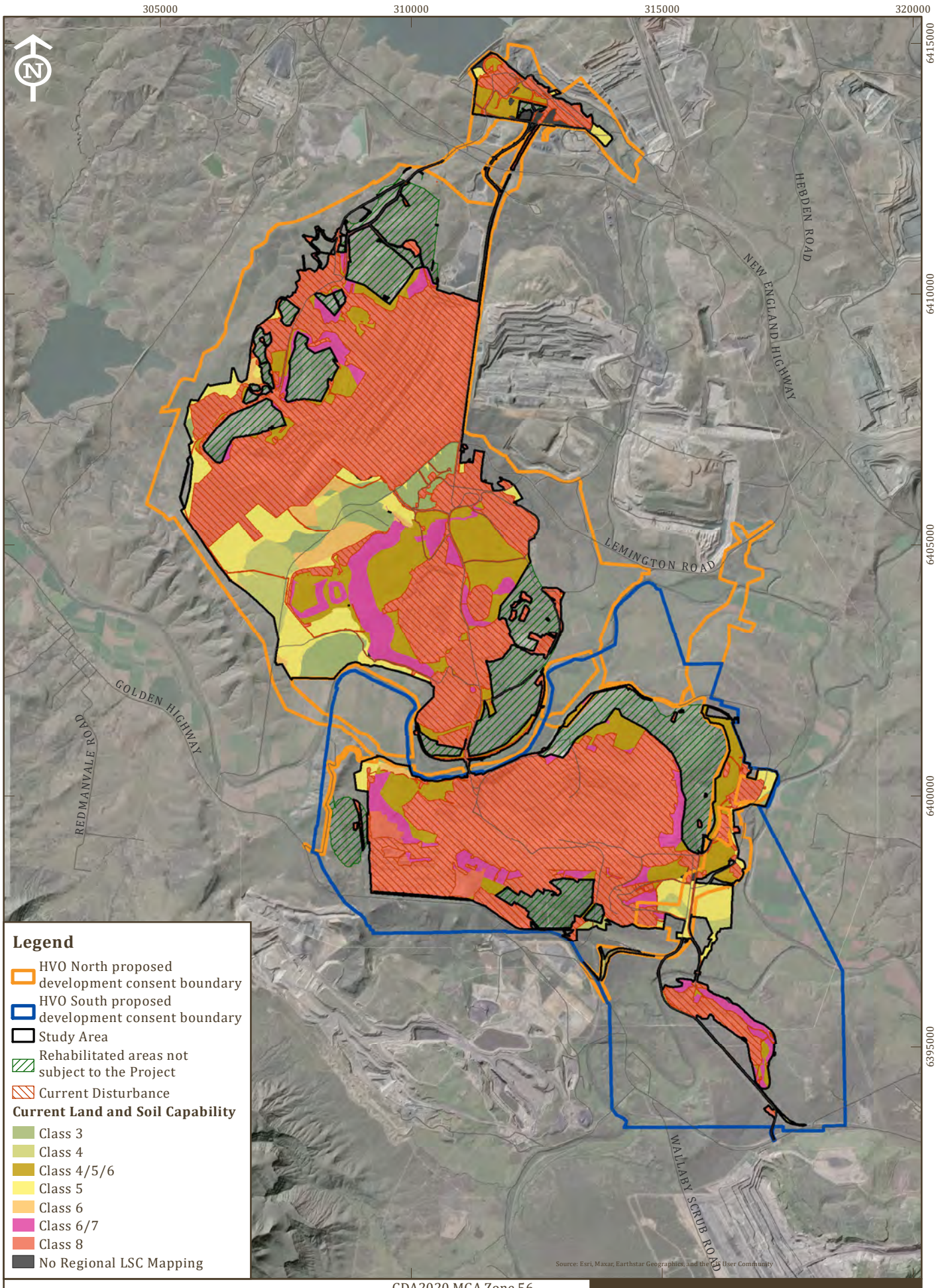
Class 4/5/6 Land incorporates Current Rehabilitation areas that are currently approved for a final land use of grazing on pasture. These classes of land are considered suitable for this activity and indicate land that has moderate to very high limitations. At best this means land management options are restricted for regular high-impact land uses such as cropping, high-intensity grazing and horticulture and are best suited to grazing, nature conservation or forestry. In areas with greater limitations, careful management of limitations is required to prevent severe land and environmental degradation.

Class 6/7 Land

Class 6/7 Land incorporates Current Rehabilitation areas that are currently approved for a final land use of woodland. This classification indicates land that has very high limitations for high-impact land uses to severe limitations that restrict most agricultural land uses and generally cannot be overcome. Careful management of limitations is required to prevent severe land and environmental degradation.

Class 8 Land

Class 8 land is designated to Current Disturbance areas and final pit voids and water management areas. This is a default classification for land that represents no agricultural capability. Note the water management areas are only indicative and subject to change as closure works are undertaken. Remaining dams will be confirmed via the RMP closer to mine closure.



Legend

- HVO North proposed development consent boundary
- HVO South proposed development consent boundary
- Study Area
- Rehabilitated areas not subject to the Project
- Current Disturbance

Current Land and Soil Capability

- Class 3
- Class 4
- Class 4/5/6
- Class 5
- Class 6
- Class 6/7
- Class 8
- No Regional LSC Mapping

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0 500 1,000 2,000 Meters

Scale 1:100000 at A4

Current Land and Soil Capability

FIGURE 8

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4.3 IMPACT ASSESSMENT ON LSC

Due to the open cut nature of the Project which will require major landform modification (leveling) and soil stripping, impacts on all current LSC classes within the study area would be high during operations.

Final land use domains are defined as land management units characterised by similar final land use objectives. Each final land use domain will require specific decommissioning and rehabilitation methods. The final land use domains for the Project Area have been selected to be consistent with those specified in *Form and Way: Rehabilitation management plan for large mines* (RR, 2021), and are listed with their descriptions in **Table 10**.

Table 10: Final Land Use Domains

Domain	Name	Description
A	Native Ecosystem	Areas to be rehabilitated with woodland species commensurate with adjacent remnant vegetation. This will also include a network of tree corridors to ensure connectivity of woodland community areas
B	Agricultural – Grazing	Areas to be rehabilitated with selected native and exotic grasses and pasture species to facilitate grazing.
G	Water Storage Area	A network of dams and surface water management structures are planned to be retained to assist in ongoing water and land management (e.g. stock watering).
J	Pit Lake	Pit lakes, commonly referred to as final voids, will create permanent water bodies. Landforms above pit water level will be vegetated where practical with woodland vegetation communities.
Ka	Other – Native Ecosystem – partial vegetation on highwall benches	Areas of highwall benches are to be partially revegetated with native vegetation. Areas (ha) included in Domain A, shown on figures for clarity due to different objectives and completion criteria will apply.
Kb	Other – Agriculture- Grazing alluvial areas	Includes 65 ha of Rural Land Capability Class II and 65 ha of Class III land* subject to proposed mining occurring in the Carrington West Wing area in accordance with previous management commitment. Area (ha) included in Domain B for analysis purposes, delineated as a separate Domain as different completion criteria and management commitments apply.

* Note: commitments to Rural Land Capability Classes are as per the now outdated Rural Land Capability classification scheme (NSW Office of Environment and Heritage, 1988). For the purpose of this assessment, a conversion has been applied to identify these areas LSC classes 2 and 3 respectively.

Domains are to be rehabilitated to a suitable LSC to facilitate the proposed final land uses. Rehabilitation will be undertaken in accordance with the Hunter Valley Operations Mine Closure and Rehabilitation Strategy (EMM 2022a). Alternate final land uses for these areas will be investigated and confirmed via the RMP closer to mine closure.

Post mining land use of final pit lakes or water management domains will retain a LSC class of 8. The remaining domains will be re-graded (where required) and topsoil or suitable growth medium (combination of topsoil, subsoil, mulch etc) be placed over the area and revegetated with either native vegetation or pastures. This strategy, along with good soil management practices as outlined in Section 5 and the Mine Closure and Rehabilitation Strategy (EMM 2022a) will facilitate the rehabilitation of land in these domains to an appropriate LSC for the final land use.

As outlined in Section 4.2, the LSC classes for the study area as of Project commencement are as follows:

- Undisturbed Areas: LSC Class 3 – covering approximately 271 ha, LSC Class 4 – covering approximately 202 ha, LSC Class 5 – covering approximately 550 ha, LSC Class 6 – covering approximately 127 ha.
- Current Rehabilitation: LSC Class 4/5/6 – covering approximately 917 ha, LSC Class 6/7 – covering approximately 545 ha.
- Current Disturbance: LSC Class 8 – covering approximately 4,165 ha.

The proposed post mining LSC for the Project is as follows:

- Domain A (inclusive for Domain Ka): LSC Class 5/6/7 – covering approximately 2,823 ha;
- Domain B: LSC Class 4/5/6 – covering approximately 3,408 ha;
    - Domain Kb: LSC Class 2 – covering approximately 65 ha;
    - Domain Kb: LSC Class 3 – covering approximately 65 ha;
- Domains G and J: LSC Class 8 – covering approximately 416 ha.

The proposed conceptual post-mining LSC is shown on **Figure 9** and presented in **Table 11** below.

Table 11: Post-mining LSC of the Study Area

Domain	LSC Range	Area (ha)		
		HVO North	HVO South	Overall
A and Ka	5/6/7	1,691	1,132	2,823
B	4/5/6	2,336	1,072	3,408
	(Domain Kb) 2	65	0	65
	(Domain Kb) 3	65	0	65
G	8	15	17	32
J	8	202	182	384
	Total	4,374	2,403	6,777

4.4 DOMAIN B LSC

As outlined in Section 4.3, the final land use Domain B: Agricultural - Grazing (excluding Domain kb) has been presented as a post-mining LSC class range of 4/5/6. This classification directly aligns with the classes of the LSC scheme that are generally considered the most suitable for a grazing land use.

The LSC 4/5/6 classification considers final landform and soil characteristics but has primarily been applied based on the intended final land use of grazing.

As outlined in Section 5.4, a soil respread depth of 0.1m will be applied to these areas during rehabilitation. Soil depth is considered for LSC as shallow soil means less volume of soil available for storing nutrients and water. In accordance with the LSC scheme, a soil depth of 0.1m would typically default land to a LSC class of 7.

By definition LSC class 7 land has extremely severe limitations for most land uses and is not capable of any cultivation or grazing by stock. Use of LSC class 7 land for these purposes may result in severe erosion and degradation.

Minesoils have chosen not to apply a post mining LSC of class 7, as this classification is not considered a true representation of the intended land use and agricultural capability of mined land rehabilitation of Domain B, based on local experience with grazing on rehabilitated land and grazing trials evidence.

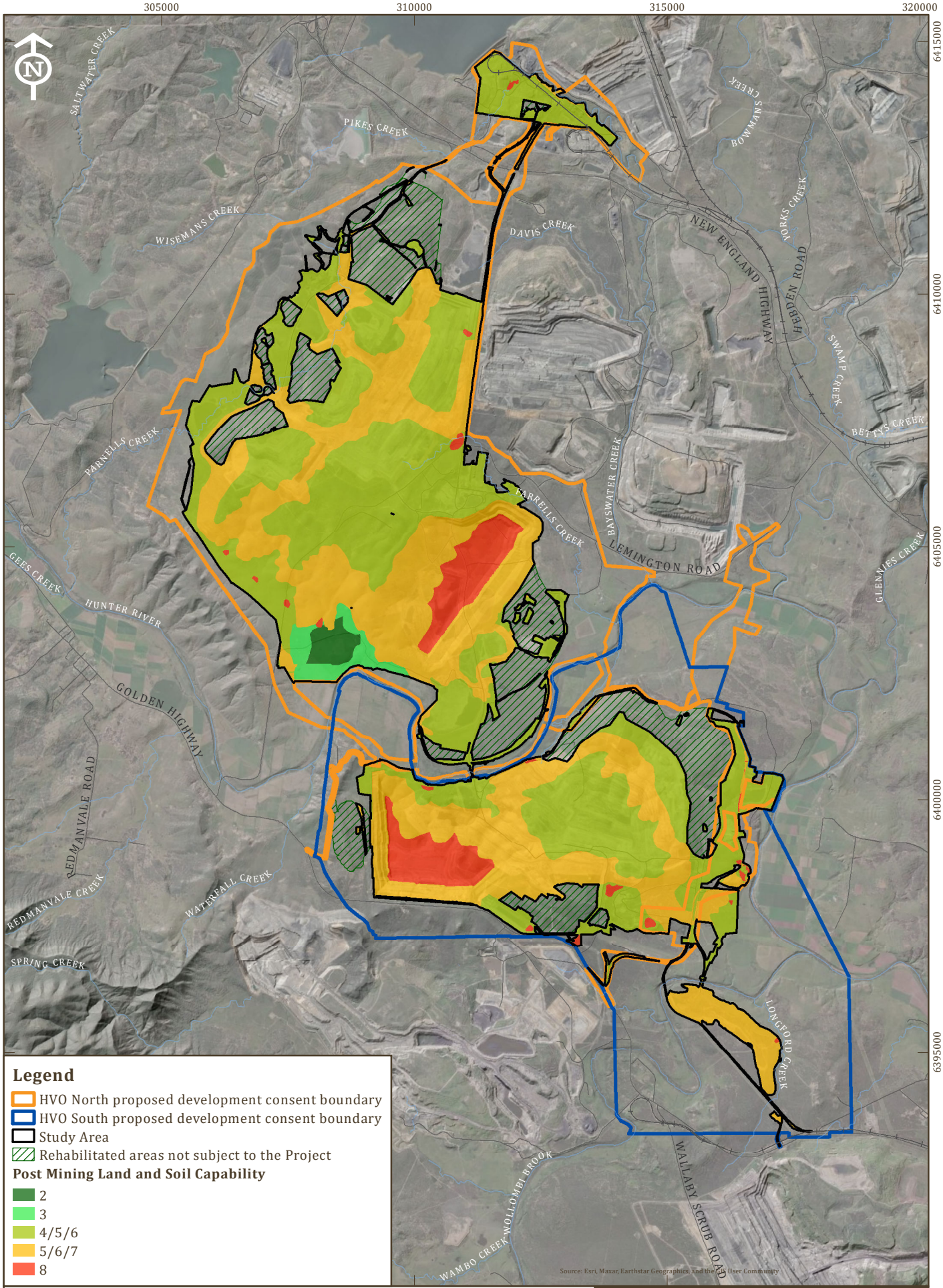
HVO currently undertakes grazing on rehabilitated land within the re-disturbance area. The rehabilitated landform has demonstrated capacity to facilitate grazing at an intensity and productivity equivalent to that of unmined analogue sites and areas within the additional disturbance area that are currently subject to grazing activity. Soil respread depths on overburden in these areas at the time of rehabilitation was 0.1m.

HVO rehabilitated lands subject to cattle grazing were included Upper Hunter Dialogue's grazing trials, a four-year grazing study started in June 2014 to evaluate how beef cattle would fare on rehabilitated mined land and whether the land would offer a commercially sustainable option for grazing livestock. The study was designed and is monitored by the Department of Primary Industries in collaboration with the Upper Hunter Mining Dialogue Joint Working Group – Land Management, including representatives from agricultural groups, local farmers, environmental groups, state and local government and the mining industry. In both trial sites (HVO and Mt Arthur), the livestock's weight gain have outperformed the cattle grazing on the unmined analogue sites, indicating sustainable use of mined lands as commercially productive pasture after mining has ended.

In addition, due to the sedimentary nature of the sites overburden materials, as this material weathers and is impacted by bioturbation, what could be considered the soil depth for the purpose as growth media, rootzone and water holding capacity will exceed the 0.1m topdressing material.

Finally, the NSW LSC scheme (2012) was heavily based on the Central West CMA LSC Scheme and was designed for undisturbed, naturally occurring landforms and soil characteristics. Land capability is based on an assessment of the biophysical characteristics of the land, the extent to which this will limit a particular type of land use, and the current technology that is available for the management of the land. Its application was not intended for rehabilitated landforms with specific land use objectives. Landform and soil characteristics that may be considered prohibitive in a natural setting, such as shallow soil depth over solid bedrock limiting rooting depth, are not necessarily applicable to weathered overburden material and may be overcome by the application of new technology and productivity improvement strategies that are relied upon in the context of the statutory commitments of mine owned lands. That is, Domain B must be returned to sustainable grazing land – regardless of its LSC classification.

Based on the above considerations, the nominated LSC class range 4/5/6 is considered to be practically more applicable than LSC class 7, despite the soil respread depths over this area of 0.10m.



Legend

- HVO North proposed development consent boundary
- HVO South proposed development consent boundary
- Study Area
- Rehabilitated areas not subject to the Project

Post Mining Land and Soil Capability

- 2
- 3
- 4/5/6
- 5/6/7
- 8

GDA2020 MGA Zone 56

Meters
0 500 1,000 2,000

Scale 1:100000 at A4

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Post-Mining Land and Soil Capability

FIGURE 9

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5 DISTURBANCE MANAGEMENT

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

- soil stripping strategy;
- soil stripping depths and volume;
- soil respread depths and balance;
- stripped soil management; and
- soil respreading and seedbed preparation.

5.1 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 as a guide for the selection of soil material for use as topsoiling. Given the pre-mining soils present on site, consideration and weight is also given to existing soil material appropriate for establishing similar woodland in the area.

Table 12: Soil Stripping Suitability

Parameter	Desirable criteria
Structure Grade	>30% peds
Coherence	Coherent (wet and dry)
Mottling	Absent
Macrostructure	>10 cm
Force to Disrupt Peds	≤3 force
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 particle size analysis.

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 topsoiling 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 topsoiling

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 the 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. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.

5.2 SOIL STRIPPING STRATEGY

For Undisturbed Areas within the study area that were subject to soil survey, laboratory soil analytical results (refer **Appendix 2**) were used in conjunction with the field assessment (refer Section 3.2) to determine the depth of soil material suitable for recovery and re-use in rehabilitation. Structural and textural properties of soils, along with dispersion potential and sodicity were the most common and significant limiting factors in determining depth of soil suitability for re-use.

The topsoil of Soil Unit 1 is considered marginally suitable, however all subsoil associated with this unit would typically be inappropriate for stripping and rehabilitation purposes due to its highly sodic and dispersive nature. This soil unit should be stripped to a depth of approximately 0.2 m.

Should further stripping be required, targeted controls must be implemented to mitigate the risk associated with sodic clay subsoils. This may include the application of gypsum, lime (for non-alkaline soils) and/or organic matter such as compost/mulch, which can increase the humus content further reducing the impacts of sodicity. Further, any ameliorated sodic soils should be prioritised to be placed on flatter landforms to reduce the risks of rill and gully erosion on slopes. Where practical, a topsoiling of non-sodic coarser textured materials would reduce the surface crusting, common to sodic minesoils, and allow better water infiltration and seed germination.

Soil Unit 2 also exhibits sodicity, however, there is a reduced dispersion risk due to other physical and chemical attributes of this soil unit such as structure and salinity. These soils should be salvaged to a depth of approximately 0.3 m or greater, given controls are implemented to manage the risk of surface water erosion likely to occur once excavated, exposed and stored. Amelioration must be to a level that this material is suitable for use as topsoiling.

The variability of salinity is noted for this soil and should be subject to standard soil characterisation investigations prior to re-use. No high or extreme saline material should be used for topsoiling.

For all remaining Undisturbed Areas within the study area, assumptions based on regional mapping were made where no ground truthed soil investigation findings were undertaken. For Soil Unit 3, it is assumed that a minimum of approximately 1.2 m of soil will be available for recovery. For Soil Units 4 and 5, it is assumed that a minimum of approximately 0.1 m of soil topsoiling material will be available for recovery. As per HVO Topsoil Management Plan and the RMP (ERR 2022), additional soil investigations as part of soil characterisation to inform stripping activities is standard practice at HVO and will be undertaken in these areas prior to disturbance and also accommodate any change in soil parameters encountered during stripping.

It is conservatively assumed that as a minimum, 0.1 m of suitable topsoiling material will be available for stripping and re-use from the Current Rehabilitation areas.

Existing soil stockpiles are currently incorporated into the Current Disturbance area. Characterisation sampling is being progressively undertaken across existing site stockpiles to improve the knowledge base of the soil

resource, and updated characterisation data linked to the registered stockpiles. Key data is maintained within the sites topsoil register.

Visual observations should be undertaken during stripping activities to determine if greater depths of desirable salvageable soil material (such as that of Soil Unit 2 or soils on rehabilitated lands) can be recovered.

It is recommended that proposed long term subsoil stockpile areas should be stripped of topsoil. Then the excavated subsoil 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 where required to promote vegetation growth.

5.3 SOIL STRIPPING DEPTHS AND BANK

The stripping depths determined in section 5.2 have used as a reference to model calculations for a soil bank volume scenario, as presented in **Table 13**.

Table 13: Soil Stripping Depths and Soil Bank

Study Area		Area (ha)		Total Area (ha)	Recommended Stripping Depth (m)	Soil Volume (m^3)
		HVO North	HVO South			
Undisturbed Areas	Soil Mapping Unit 1: Sodosols	423	202	625	0.2	1,250,000
	Soil Mapping Unit 2: Vertosol/Dermosol Complex	366	0	366	0.3	1,098,000
	Soil Mapping Unit 3: Alluvial Soils	94	30	124	1.2	1,488,000
	Soil Mapping Unit 4: Natric Kurosols	46	0	46	0.2	92,000
Current Rehabilitation		941	574	1,515	0.1	1,515,000
Stockpiled Soil at the Commencement of the Project						1,893,370
					Total Volume	7,336,370

The soil bank volume modelling indicates approximately 7,336,370 m^3 of suitable soil is available for rehabilitation.

5.4 SOIL RESPREAD DEPTHS AND BALANCE

The re-spread soil depths to ensure the objectives of the final land use domains and their associated LSC classes are achieved is modelled for the purpose of a soil balance scenario, and shown in **Table 14**.

Table 14: Respread Depths and Required Volume

Domain	Name	Total Area (ha)	Minimum Respread Depth (m)	Required Soil Volume (m^3)
A and Ka	Native Ecosystem	2,823	0.1	2,823,000
B	Agricultural – Grazing	3408	0.1	3,408,000
	(Domains Kb) CWW Class 2	65	1.4	650,000
	(Domains Kb) CWW Class 3	65	1.4	910,000
G	Water Management Area	32	0.0	0
J	Pit Lake	384	0.0	0
			Total Volume	7,791,000

The total volume of material required to meet the final land use and LSC objectives is calculated to be approximately 7,791,000 m^3. Based on a soil bank of approximately 7,336,370 m^3, there will be a soil deficit of approximately 454,630 m^3 or approximately 6% of the soil bank.

Additional suitable alternate growth medium enhancement strategies as outlined below may be employed to mitigate this deficit.

5.5 ADDITIONAL SOIL VOLUME OPTION 1: MULCH FACTOR

In order to increase the balance of available growth media for rehabilitation, the application of mulch to topsoiling was modelled. The primary function of using mulch is to increase rootzone, however additional benefits will include the reduction of soil evaporation, conservation of moisture, control of soil temperature, and improvement of soil microbial activities. Over time the mulch with compost down to a much reduced volume, but will likely provide additional benefits of improved soil biology. This reduction in volume is estimated at 50-75% in short term bulking factor but long term soil biology benefits will be retained.

HVO have identified suitable areas covering a total of 859 ha whereby vegetation growth indicates the likelihood mulch can be recovered during stripping activities. Minesoils estimates a mulch factor of 0.02 m for these areas, resulting in a long term total volume of approximately 171,800 m^3.

5.6 ADDITIONAL SOIL VOLUME OPTION 2: SOIL UNIT 1 SUBSOILS

The sodic subsoils of Soil Unit 1: Sodosols may be stripped given the potential soil deficiency. This will present a risk to the rehabilitation efforts of the Project and require specialised management inputs as outlined in Section 5.2. Stripping should be prioritised based on further assessment of sodicity levels in order to identify areas of non-sodic patches, such as the Chromosol sub-dominant soil type, and lower levels of sodicity (that is, target soils with lower ESP to reduce input requirements and overall risk).

Based on a stripping depth of approximately 0.2 m – 1.0 m, subsoil recovery will provide an additional approximately 5,008,000 m^3 of soil volume.

5.7 ADDITIONAL SOIL VOLUME OPTION 3: IMPORTED ORGANICS

In the native ecosystem and agriculture rehabilitation domains, soil may be respread at depths shallower than the recommended respread depths where a rootzone depth is achieved through supplementing soil with imported organic material. This would be most effective for the native ecosystem rehabilitation domain where topsoil weed load can be an inhibitor of rehabilitation success.

5.8 STRIPPED SOIL MANAGEMENT

The following soil handling techniques are recommended to prevent excessive soil deterioration and dispersion. Final soil handling methods will be included in the RMP for the site and may include alternate methods to manage soil deterioration.

- Prior to stripping of soil, appropriate sediment controls should be installed to prevent off-site loss of soil sediments.
- Strip desirable soil material to maximum excavation depths, subject to further investigation as required.
- Stripping of saturated soils should be avoided.
- Grade or push soil into windrows with graders or dozers for later collection by open bowl scrapers or for loading into rear dump trucks by front-end loaders. These techniques are examples of preferential less aggressive soil handling systems. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material.
- Soil transported by dump trucks may be placed directly onto rehabilitation areas or into storage. Soil transported by scrapers is best pushed to form stockpiles by other equipment (e.g. dozer) to avoid tracking over previously laid soil resulting in compaction of the stockpile.

Where feasible, soil is transferred directly from stripping to re-spreading operations, eliminating the need for storage. However, mine scheduling dictates that soil storage will be necessary on occasion for extended periods. Where stockpiling is required, the following HVO site practices will be implemented:

- The surface of soil stockpiles should be stored less than 3 m in height or ripped in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming.
- Stockpiles should be preferentially located away from active mining areas, watercourses and are placed on areas of flat topography or along the contour to minimise erosion.
- Where necessary, a flow diversion bank or catch drain should be placed up-slope of a stockpile to direct surface water flows away and stockpiles placed 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.
- Seed stockpiles as soon as possible if required for long term storage. 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. Final rehabilitation target pasture or native grass and woodland species should be established on stockpiles to build up a desirable species seed bank in the topsoil.
- A register of available soil should be maintained to ensure adequate materials are available for planned rehabilitation activities when the time comes. As stockpiles are constructed, added to or drawn upon, relocated, or removed the register should be maintained to provide a current account of stockpiled soil materials. The register should be updated periodically and reviewed annually in association with annual reporting processes.
- Inspections of stockpiled soils should be undertaken to inform ongoing management of the resource and to assist in limiting potential degradation of soil quality while held in storage.

- 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 weed control.
- The RMP will consider where additional assessment of soil resources that are currently used on rehabilitated lands will be required to inform management controls prior to re-use.

5.9 SOIL CHARACTERISATION AND TREATMENT

In the absence of existing data, where possible, characterisation of soils is undertaken prior to the commencement of soil stripping or prior to relocation. Characterisation occurs to inform use and/or stockpiling based upon the quality of the topsoil source and to inform amelioration where this is to occur.

Characterisation will generally include quantitative assessment of soil physical and chemical properties by way of laboratory analysis in addition to qualitative considerations such as historic land use, observed vegetation covers, and an assessment of overall soil quality.

Characterisation informs targeted placement decisions to particular rehabilitation areas depending upon their location within the landform and the identified future land use. Where stockpiling is to occur, characterisation informs segregation into stockpiles based upon quality and historic vegetation cover (i.e. native vs. exotic).

Soil ameliorants, such as gypsum, compost, and fertilisers will be applied where required to improve soil condition. The ameliorant type and application rate are confirmed by characterisation testing of soils at appropriate times during the stripping and reuse cycle and, generally, reference to specialist agronomic advice.

Appropriate ameliorants such as organics may be used in place of chemical fertilisers to enhance soil nutrient and organic levels and improve soil or growth medium structure.

5.10 SOIL RE-SPREADING AND SEEDBANK PREPARATION

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

- Following ground preparation and growth medium development works, revegetation activities should commence as soon as possible.
- Soils to be placed to a rehabilitation areas are identified for use based on the soil quality and vegetation history, with consideration to the planned final land use of the rehabilitation area, and with consideration to the mine plan and operational factors.
- Topsoil should be spread to the minimum depths listed in **Table 14** or alternative methods used to create a similar growth medium.
- Topsoil should be spread, treated with ameliorants if required and seeded in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion. Seedbed preparation should be undertaken to ensure optimum establishment and growth of vegetation.
- All topsoiled areas should be lightly contour ripped or cultivated (after topsoil spreading) to create a "key" between the soil and material below. Ripping/cultivating should be undertaken on the contour. Best results will be obtained by ripping/cultivating immediately prior to sowing.
- HVO has developed an inspection and testing process, which records methods of topsoil treatment and application including depth and cultivation.
- The need for maintenance fertilising will be assessed during regular rehabilitation monitoring programs, particularly in agricultural final land use areas where grazing is occurring or planned to occur. The application method (e.g. tractor spreader or aerial spreading) will be determined based on the existing vegetation, landform and timing of application.

Soil management measures will be included in the RMP for the site and may include alternate measures to manage soil deterioration.

5.11 SOIL DEFICIENCY STRATEGY

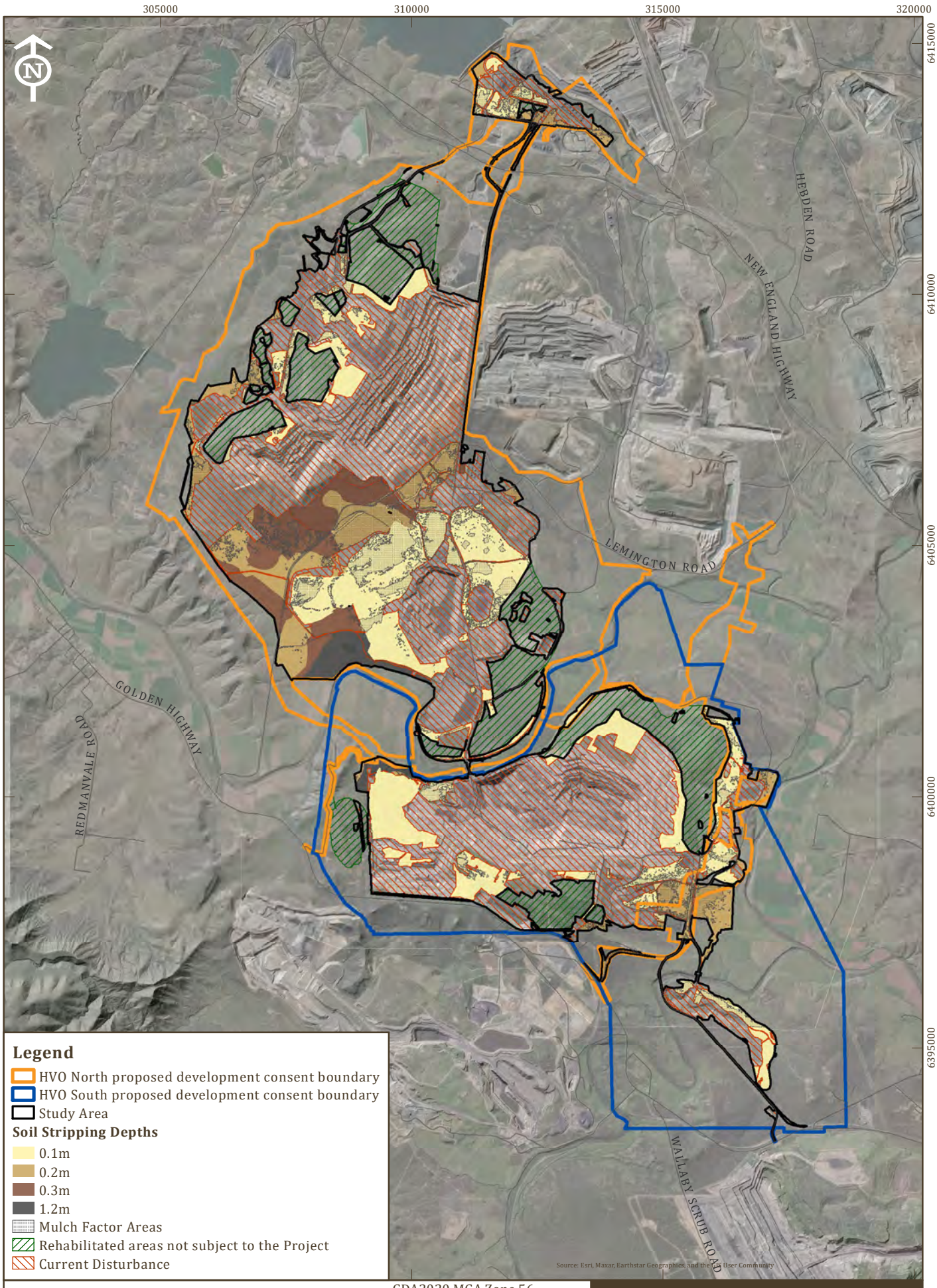
Soil bank and balance information presented in sections 5.3 – 5.7 is partially based on recoverable soil assumptions due to site investigation limitations and the large volume of rehabilitated soils to be recovered, in addition to broad assumptions based on regional mapping for Undisturbed Areas not covered by soil surveys. As per the HVO Topsoil Management Plan and the RMP (ERR 2022), additional soil investigations as part of soil characterisation to inform stripping activities is standard practice at HVO and will be undertaken in these areas prior to disturbance to more accurately determine a soil balance for the Project and the site.

Soil deficiency should remain as a key potential risk in the RMP, which should consider management options including the following:

- Source suitable growth medium for use in rehabilitation.
- Investigate options and alternatives (e.g. organic ameliorants including vegetation mulch)
- Trial methods of rehabilitation that are more topsoil efficient such as the use of compost on overburden: HVO has previously successfully established woodland rehabilitation on areas of mine spoil augmented with compost products.

Where appropriate topsoil resources are not available, alternate growth mediums such as subsoils and mine spoil may be used, typically in association with amelioration and informed by characterisation of the planned growth medium. Revegetation can then be undertaken progressively as surface preparation and amelioration is completed.

Potential solutions for the treatment of soil on mined land should be considered and trialled during the rehabilitation program, to determine suitability on the HVO site.



Legend

- HVO North proposed development consent boundary
- HVO South proposed development consent boundary
- Study Area

Soil Stripping Depths

- 0.1m
- 0.2m
- 0.3m
- 1.2m
- Mulch Factor Areas
- Rehabilitated areas not subject to the Project
- Current Disturbance

GDA2020 MGA Zone 56

MINESOILS
LAND & REHABILITATION SPECIALISTS

0 500 1,000 2,000 Meters

Scale 1:100000 at A4

Soil Stripping Depths

FIGURE 10

MS029_EIS010_Stripping 28/11/2022 12:08:50 PM

6 SUMMARY

The Project was assessed by Minesoils to determine impacts on soil and land resources. The findings have been detailed in this report. The study area covers areas subject to mining impacts as a result of the Project and consists of a total area of approximately 4,366 ha for HVO North and approximately 2,411 ha for HVO South. The study area is comprised of the following elements:

- Current Disturbance – lands disturbed due to mining activity at the commencement of the Project.
- Current Rehabilitation – lands rehabilitated following previous mining activity at the commencement of the Project.
- Undisturbed Areas – lands that have not been disturbed by mining activity. Undisturbed areas includes lands approved for disturbance and lands that are not currently approved for disturbance.

A soils survey was undertaken over approximately 250 ha of the HVO North study area, and field assessment points were located in the largest contiguous portion of the Undisturbed Area component of the study area. Information obtained during the field assessment was used to accurately map soils and land resources of this area and adjacent Undisturbed Areas. Other areas within the Undisturbed Area component of the HVO North study area were assessed using existing soils survey information. For all remaining Undisturbed Areas within the study area, regional mapping was used for the assessment where no ground truthed soil investigation findings or existing data was available for use.

The soil mapping units of the Undisturbed Areas of the study area consist of the following:

- Soil Unit 1: Sodosol – covering approximately 625 ha;
- Soil Unit 2: Vertosol/ Dermosol Complex – covering approximately 366 ha;
- Soil Unit 3: Alluvial Soils – covering approximately 124 ha; and
- Soil Unit 4: Natric Kurosols – covering approximately 46 ha.

The soil resources of the Current Rehabilitation areas are expected to have a wide range of physical and chemical attributes and variable depths, although within the soil parameters for the region. Based on the HVO Topsoil Management Plan and the RMP (ERR, 2022), the soil resources that have been allocated to established rehabilitated lands are expected to be erosionally stable and in suitable condition for stripping and/or re-use.

As per the HVO Topsoil Management Plan and the RMP (ERR 2022), additional soil investigations as part of soil characterisation to inform stripping activities is standard practice at HVO and will be undertaken for both the Undisturbed Areas and the Current Rehabilitation areas prior to disturbance.

The Land and Soil Capability assessment was undertaken for the study area, which consisted of a site verification of LSC undertaken in accordance with the LSC Guideline (OEH 2012) for Undisturbed Areas subject to site investigations. For all remaining Undisturbed Areas within the study area, regional mapping was used where no ground truthed soil investigations were undertaken. The commitments of the currently approved final landform were used to assess LSC for the Current Rehabilitation areas of the study area. Further, Current Disturbance areas of the study area were presumed to default to LSC class 8.

The LSC classes for the study areas of HVO North and South as of Project commencement are as follows:

- Undisturbed Areas: LSC Class 3 – covering approximately 271 ha, LSC Class 4 – covering approximately 202 ha, LSC Class 5 – covering approximately 550 ha, LSC Class 6 – covering approximately 127 ha;
- Current Rehabilitation: LSC Class 4/5/6 – covering approximately 917 ha, LSC Class 6/7 – covering approximately 545 ha; and
- Current Disturbance: LSC Class 8 – covering approximately 4,165 ha.

The proposed post-mining LSC for the Project is based on the application of available soil materials on a rehabilitated landform according to final land use domains. These domains are to be rehabilitated to a suitable LSC to facilitate the final land uses. The post-mining LSC is as follows:

- Domain A and Ka Native Ecosystem: LSC Class 5/6/7 – covering approximately 2,823 ha;
- Domain B Agricultural - Grazing: LSC Class 4/5/6 – covering approximately 3,408 ha;
    - Domain Kb Agricultural – Grazing alluvial areas – LSC Class 2 – covering approximately 65 ha;
    - Domain Kb Agricultural – Grazing alluvial areas – LSC Class 3 – covering approximately 65 ha; and
- Domains G Water Storage Area and J Pit Lake: LSC Class 8 – covering approximately 416 ha.

Soil disturbance mitigation measures and management recommendations have been provided as controls to manage and reduce temporary and long term risk of the Project on land and soil resources. Soil resources have been assessed for suitability in post mining landforms for intended land uses, with a total estimated volume of material available being approximately 7,336,370 m^3. The total volume of material required to meet the final land use and LSC objectives is calculated to be approximately 7,791,000 m^3. Therefore, there will be a soil deficiency of approximately 454,630 m^3 or approximately 6% of the soil bank.

Additional alternate growth medium enhancement strategies may be employed to mitigate this deficit. This includes a mulch recovery factor which would result in an additional approximately 171,800 m^3 of material volume, as well as the recovery sodic subsoils of Soil Unit 1: Sodosols which would require specialised management inputs to provide up to approximately 5,008,000 m^3 of additional soil volume.

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Appendix A
Soil Survey Profile Descriptions

Site Description – Site 1				
Site Reference	E1	**ASC Name**	Vertic Subnatric Black Sodosol (BEMOW)	
Average Slope	3%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Hillslope	**Soil Fertility**	Moderately Low	GDA20z56
Landform Element	Midslope	**ERD**	0.6 m	X: 306651
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6404474

Plate 1 – Soil Profile (E1)

Plate 2 – Surface (E1)

Plate 3 – Landscape (E1)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Very Dark Grey (Munsell 7.5YR 3/1) Clay Loam, with moderate pedality. Slightly acidic pH, non-saline. Non-sodic. No coarse fragments. Many roots and moderately drained. Clear boundary.
B21	0.10 – 0.50	Very Dark Grey to Very Dark Greyish Brown (Munsell 7.5YR 3/1 to 10YR 3/2) Heavy Clay, with strong pedality. Moderately alkaline trending to strongly alkaline pH, non-saline. Sodic. No coarse fragments. Common fine roots and moderately drained. Gradual boundary.
B22	0.50 – 0.80	Brown (Munsell 10YR 4/3) Medium Clay with moderate pedality. Very strongly alkaline pH, moderately saline, sodic. No coarse fragments. No roots and moderately drained.

Sample Depth (m)	ECe		$pH_{(1-5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.5	Non-saline	6.5	Slightly Acidic	2.7	Non sodic
0.20-0.30	0.7	Non-saline	7.8	Moderately Alkaline	6.4	Sodic
0.40-0.50	0.7	Non-saline	8.9	Strongly Alkaline	12.2	Sodic
0.65-0.75	5.4	Moderately saline	9.2	Very Strongly Alkaline	12.6	Sodic

Site Description – Site 2				
Site Reference	E2	**ASC Name**	Episodic-Endocalcareous Epipedal Brown Vertosol (EQRW)	
Average Slope	0%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Footslopes	**Soil Fertility**	Moderately High	GDA20z56
Landform Element	Lower Slope	**ERD**	0.6 m	X: 307009
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6404553

Plate 1 – Soil Profile (E2)

Plate 2 – Surface (E2)

Plate 3 – Landscape (E2)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Dark Brown (Munsell 7.5YR 3/2) Clay Loam, with moderate pedality. Neutral pH, non-saline. Sodic. No coarse fragments. Many roots and moderately drained. Gradual boundary.
B21	0.10 – 0.35	Dark Brown (Munsell 7.5YR 3/3) Heavy Clay, with moderate pedality. Strongly alkaline pH, slightly saline. Strongly sodic. No coarse fragments. Common fine roots and moderately drained. Gradual boundary.
B22	0.35 – 0.80+	Dark Brown to Brown (Munsell 7.5YR 3/4 to 7.5YR 4/4) Silty Clay, with moderate pedality. Strongly alkaline trending to very strongly alkaline pH. Moderately saline to highly saline. Strongly sodic. No coarse fragments. Few roots and moderately drained.

Sample Depth (m)	ECe		$pH_{(1-5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	1.2	Non-saline	7.2	Neutral	8.5	Sodic
0.20-0.30	2.2	Slightly saline	8.5	Strongly Alkaline	16.4	Sodic
0.40-0.50	5.4	Moderately saline	8.9	Strongly Alkaline	23.6	Sodic
0.65-0.75	10.9	Highly saline	9.1	Very Strongly Alkaline	21.3	Sodic

Site Description – Site 3				
Site Reference	E3	**ASC Name**	Vertic Subnatric Brown Sodosol (BEMOW)	
Average Slope	0%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Plain	**Soil Fertility**	Moderately Poor	GDA20z56
Landform Element	Open Depression	**ERD**	0.6 m	X: 307462
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6404678

Plate 1 – Soil Profile (E3)

Plate 2 – Surface (E3)

Plate 3 – Landscape (E3)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Brown (Munsell 7.5YR 4/3) Silty Loam, with moderate pedality. Neutral pH, non-saline. Non-sodic. No coarse fragments. Many roots and moderately drained. Clear boundary.
B21	0.10 – 0.40	Brown (Munsell 7.5YR 4/4) Medium Clay, with moderate pedality. Moderately alkaline pH, non-saline. Sodic. No coarse fragments. Few fine roots and moderately drained. Diffuse boundary.
B22	0.40 – 0.80	Strong Brown (Munsell 7.5YR 4/6 to 7.5YR 4/6) Heavy Clay to Silty Clay, with moderate pedality. Strongly alkaline trending to very strongly alkaline pH, non-saline trending to moderately saline, sodic. No coarse fragments. No roots and moderately drained.

Sample Depth (m)	ECe		$pH_{(1-5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.6	Non-saline	6.7	Neutral	2.5	Non sodic
0.20-0.30	1.1	Non-saline	8.2	Moderately Alkaline	7.3	Sodic
0.40-0.50	0.9	Non-saline	9.0	Strongly Alkaline	11.6	Sodic
0.65-0.75	6.8	Moderately saline	9.1	Very Strongly Alkaline	13.5	Sodic

Site Description – Site 4				
Site Reference	E4	**ASC Name**	Bleached-Sodic Eutrophic Red Chromosol (BEOOW)	
Average Slope	4%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Footslopes	**Soil Fertility**	Moderately High	GDA20z56
Landform Element	Mid Slope	**ERD**	0.8 m+	X: 309060
Surface Condition	Hard Set	**Mapped as BSAL**	No	Y: 6405538

Plate 1 – Soil Profile (E4)

Plate 2 – Surface (E4)

Plate 3 – Landscape (E4)

Horizon	Depth (m)	Description
A1	0.00 – 0.20	Brown (Munsell 7.5YR 4/3) Silty Clay Loam, with moderate pedality. Mildly alkaline pH, non-saline. Non-sodic. No coarse fragments. Many roots and moderately drained. Clear boundary.
A2	0.20 – 0.30	Brown (Munsell 7.5YR 4/3) Clay Loam, with weak pedality. Strongly alkaline pH, non-saline. Non-sodic. No coarse fragments. Few fine roots and moderately drained. Clear boundary.
B2	0.30 – 0.80	Yellowish-Red (Munsell 5YR 4/6) Heavy Clay to Medium Clay with moderate pedality. Strongly alkaline pH, non-saline. Non-sodic trending to sodic at depth. No coarse fragments. Few roots and moderately drained.

Sample Depth (m)	ECe		$pH_{(1-5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.9	Non-saline	7.6	Mildly Alkaline	0.7	Non sodic
0.20-0.30	0.7	Non-saline	8.5	Strongly Alkaline	0.7	Non sodic
0.40-0.50	0.5	Non-saline	8.6	Strongly Alkaline	2.5	Non sodic
0.65-0.75	0.8	Non-saline	8.9	Strongly Alkaline	6.8	Sodic

Site Description – Site 5				
Site Reference	E5	**ASC Name**	Eutrophic Mottled-Subnatric Brown Sodosol (BEMOW)	
Average Slope	1%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Plain	**Soil Fertility**	Moderately Poor	GDA20z56
Landform Element	Lower Slope	**ERD**	0.8 m	X: 308642
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6405118

Plate 1 – Soil Profile (E5)

Plate 2 – Surface (E5)

Plate 3 – Landscape (E5)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Dark Brown (Munsell 7.5YR 3/2) Silty Clay Loam, with moderate pedality. Slightly acidic pH, non-saline. Non-sodic. No coarse fragments. Many roots and poorly drained. Clear boundary.
A2	0.10 – 0.20	Brown (Munsell 7.5YR 4/2) Silty Clay Loam, apedal. Neutral pH, non-saline. Non-sodic. No coarse fragments. Common fine roots and poorly drained. Clear boundary.
B21	0.20 – 0.40	Dark Yellowish-Brown to Strong Brown (Munsell 10YR 4/4) Silty Clay, with moderate pedality. Mildly alkaline pH, non-saline. Sodic. No coarse fragments. Very few fine roots, poorly drained. Gradual boundary.
B22	0.40 – 0.80	Strong Brown (Munsell 7.5YR 4/6) Silty Clay, with moderate pedality. Strongly alkaline pH. Moderately saline. Sodic. No coarse fragments. No roots and poorly drained.

Sample Depth (m)	ECe		$pH_{(1-5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.4	Non-saline	6.1	Slightly Acidic	1.1	Non sodic
0.10-0.20	0.3	Non-saline	6.7	Neutral	2.9	Non sodic
0.30-0.40	0.8	Non-saline	7.8	Mildly Alkaline	10.2	Sodic
0.65-0.75	5.3	Moderately saline	8.7	Strongly Alkaline	22.9	Sodic

Site Description – Site 6				
Site Reference	E6	**ASC Name**	Sodic Eutrophic Brown Dermosol (BEMOW)	
Average Slope	0%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Plain	**Soil Fertility**	Moderately High	GDA20z56
Landform Element	Plain	**ERD**	0.8 m	X: 308247
Surface Condition	Hard Set	**Mapped as BSAL**	No	Y: 6404884

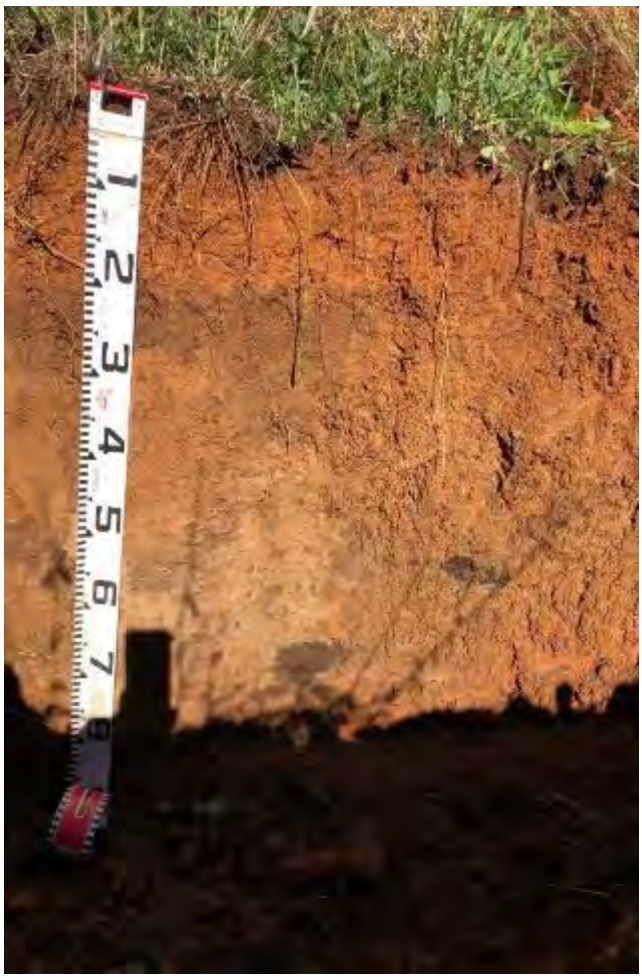

Plate 1 – Soil Profile (E6)

Plate 2 – Surface (E6)

Plate 3 – Landscape (E6)

Horizon	Depth (m)	Description
A1	0.00 – 0.20	Brown (Munsell 7.5YR 4/4) Sandy Clay Loam, with weak pedality. Neutral pH, non-saline. Non-sodic. <10% coarse fragments 5 – 20mm. Many roots and poorly drained. Abrupt boundary.
B21	0.20 – 0.40	Brown (Munsell 7.5YR 4/3) Sandy Clay Loam, with moderate pedality. Strongly alkaline pH, non-saline. Non-sodic. No coarse fragments. Common fine roots and poorly drained. Gradual boundary.
B22	0.40 – 0.80	Brown (Munsell 7.5YR 5/4) Silty Clay, with moderate pedality. Strongly alkaline pH, non-saline trending to moderately saline at depth. Sodic. No coarse fragments. Very few roots and poorly drained.

Sample Depth (m)	ECe		$pH_{(1-5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00-0.10	0.4	Non-saline	7.1	Neutral	1.4	Non sodic
0.20-0.30	0.6	Non-saline	8.5	Strongly Alkaline	1.3	Non sodic
0.40-0.50	1.1	Non-saline	8.8	Strongly Alkaline	6.1	Sodic
0.65-0.75	5.1	Moderately saline	8.9	Strongly Alkaline	21.8	Sodic

Site Description – Site 7				
Site Reference	E7	**ASC Name**	Eutrophic Mesonatric Brown Sodosol (BEOOW)	
Average Slope	0%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Alluvial Plain	**Soil Fertility**	Moderately Poor	GDA20z56
Landform Element	Plain	**ERD**	0.6 m	X: 307917
Surface Condition	Hard Set	**Mapped as BSAL**	No	Y: 6404691

Plate 1 – Soil Profile (E7)

Plate 2 – Surface (E7)

Plate 3 – Landscape (E7)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Brown (Munsell 7.5YR 4/2) Silty Clay Loam, with weak pedality. Slightly acidic pH, non-saline. Non sodic. No coarse fragments. Many roots and poorly drained. Abrupt boundary.
B21	0.10 – 0.40	Brown (Munsell 7.5YR 5/4) Medium Clay, with moderate pedality. Neutral pH, non-saline. Sodic. 10% coarse fragments <10mm. Common fine roots and poorly drained. Gradual boundary.
B22	0.40 – 0.80	Yellowish-Brown (Munsell 10YR 5/4) Light-Medium Clay to Heavy Clay, with moderate pedality. Slightly acidic trending to mildly alkaline pH, moderately saline. Sodic. No coarse fragments. No roots and poorly drained.

Sample Depth (m)	ECe		$pH_{(1-5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.5	Non-saline	6.2	Slightly Acidic	3.9	Non sodic
0.20-0.30	0.4	Non-saline	7.2	Neutral	15.9	Sodic
0.40-0.50	5.3	Moderately saline	6.0	Slightly Acidic	27.9	Sodic
0.65-0.75	5.7	Moderately saline	7.3	Mildly Alkaline	29.6	Sodic

Site Description – Site 8				
Site Reference	E8	**ASC Name**	Haplic Epipedal Brown Vertosol (EQSW)	
Average Slope	3%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Footslopes	**Soil Fertility**	Moderately High	GDA20z56
Landform Element	Mid Slope	**ERD**	0.8 m	X: 307763
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6405032

Plate 1 – Soil Profile (E8)

Plate 2 – Surface (E8)

Plate 3 – Landscape (E8)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Dark Brown (Munsell 10YR 3/3) Silty Clay, with moderate pedality. Slightly acidic pH, non-saline. Non-sodic. 20% coarse fragments <10mm. Many roots and moderately drained. Abrupt boundary.
B21	0.10 – 0.30	Brown (Munsell 7.5YR 4/4) Silty Clay, with moderate pedality. Strongly alkaline pH, non-saline. Non-sodic. No coarse fragments. Common fine roots and moderately drained. Gradual boundary.
B22	0.30 – 0.80	Brown to Strong Brown (Munsell 7.5YR 4/4 to 7.5YR 4/6) Heavy Clay, with moderate pedality. Strongly alkaline pH, non-saline. Non-sodic trending to sodic. No coarse fragments. Very few roots and moderately drained.

Sample Depth (m)	ECe		pH(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.7	Non-saline	6.3	Slightly Acidic	0.9	Non sodic
0.20-0.30	1.0	Non-saline	8.5	Strongly Alkaline	1.0	Non sodic
0.40-0.50	1.0	Non-saline	8.8	Strongly Alkaline	5.2	Non sodic
0.65-0.75	2.0	Non-saline	8.9	Strongly Alkaline	11.1	Sodic

Site Description – Site 9				
Site Reference	E9	**ASC Name**	Haplic Eutrophic Brown Dermosol (BEMOW)	
Average Slope	10%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Hillslope	**Soil Fertility**	Moderately High	GDA20z56
Landform Element	Midslope	**ERD**	0.6 m+	X: 308306
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6405483

Plate 1 – Soil Profile (E9)

Plate 2 – Surface (E9)

Plate 3 – Landscape (E9)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Brown (Munsell 7.5YR 4/3) Clay Loam, with moderate pedality. Neutral pH, non-saline. Non-sodic. No coarse fragments. Many roots and moderately drained. Clear boundary.
B2	0.10 – 0.40+	Brown (Munsell 7.5YR 4/3) Silty Loam, with strong pedality. Neutral pH, non-saline. Non-sodic. No coarse fragments. Many fine roots and moderately drained. Gradual boundary.

Sample Depth	ECe		$pH_{(1\text{-}5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.5	Non-saline	6.5	Neutral	0.6	Non sodic
0.20-0.30	0.6	Non-saline	7.0	Neutral	1.6	Non sodic

Site Description – Site 10				
Site Reference	E10	**ASC Name**	Haplic Eutrophic Brown Dermosol (BEMOW)	
Average Slope	0%	**Land Use**	Grazing	**Coordinates**
Landform Pattern	Alluvial Plain	**Soil Fertility**	Moderate	GDA20z56
Landform Element	Plain Depression	**ERD**	0.6 m+	X: 309290
Surface Condition	Hard Set	**Mapped as BSAL**	No	Y: 6405990

Plate 1 – Soil Profile (E10)

Plate 2 – Surface (E10)

Plate 3 – Landscape (E10)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Very Dark Grey (Munsell 7.5YR 3/1) Light Clay, with moderate pedality. Moderately acidic pH, non-saline. Non-sodic. No coarse fragments. Many roots and moderately drained. Clear boundary.
B2	0.10 – 0.30+	Brown (Munsell 10YR 5/3) Heavy Clay, with moderate pedality. Neutral trending to strongly alkaline pH, non-saline. Non-sodic trending to marginally sodic at depth. No coarse fragments. Many fine roots decreasing to nil at depth and moderately drained.

Sample Depth	ECe		pH(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	1.4	Non-saline	5.7	Moderately Acidic	0.7	Non sodic
0.20-0.30	0.9	Non-saline	7.6	Mildly Alkaline	5.0	Non sodic

Site Description – Site 11				
Site Reference	E11	**ASC Name**	Endocalcareous-Endohypersodic Epipedal Black Vertosol (FQRV)	
Average Slope	4%	**Land Use**	Grazing	**Coordinates**
Site Morphology	Maximal Mid Slope	**Soil Fertility**	High	GDA20z56
Landform Element	Footslope	**ERD**	0.8 m	X: 307620
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6403591

Plate 1 – Soil Profile (E11)

Plate 2 – Surface (E11)

Plate 3 – Landscape (E11)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Very Dark Greyish Brown (Munsell 10YR 3/2) Clay Loam with strong structure and moderate consistence. Moderately acidic pH, non-saline and non-sodic. Nil coarse fragments. Many fine roots and moderately drained. Gradual boundary.
B21	0.10 – 0.35	Dark Greyish Brown (Munsell 10YR 4/2) Heavy Clay with moderate structure and firm consistence. Neutral pH, slightly-saline and marginally-sodic. Nil coarse fragments, few fine roots and moderately drained. Gradual boundary.
B22	0.35-0.80	Very Dark Greyish Brown (Munsell 10YR 3/2) Heavy Clay to light medium clay with moderate structure and firm consistence. Strongly Alkaline pH, moderate to highly-saline and sodic to strongly sodic. Nil coarse fragments, few fine roots and moderately drained. Gradual boundary to B/C horizon.

Sample Depth	ECe		$pH_{(1-5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.7	Non-saline	5.9	Moderately Acidic	2.5	Non sodic
0.20-0.30	2.3	Slightly saline	6.7	Neutral	9.4	Sodic
0.40-0.50	6.5	Moderately saline	8.4	Strongly Alkaline	13.8	Sodic
0.65-0.75	12.3	Highly saline	8.8	Strongly Alkaline	18.9	Sodic

Site Description – Site 12				
Site Reference	E12	**ASC Name**	Endocalcareous Epipedal Black Vertosol (EQSW)	
Average Slope	3%	**Land Use**	Grazing	**Coordinates**
Site Morphology	Lower Slope	**Soil Fertility**	High	GDA20z56
Landform Element	Footslope	**ERD**	1.1 m	X: 307324
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6403992

Plate 1 – Soil Profile (E12)

Plate 2 – Surface (E12)

Plate 3 – Landscape (E12)

Horizon	Depth (m)	Description
A1	0.00 – 0.20	Very Dark Greyish Brown (Munsell 10YR 3/2) Light Clay with strong structure and moderate consistence. Neutral pH, non-saline and non-sodic. Nil coarse fragments. Many fine roots and moderately drained. Gradual boundary.
B21	0.20 – 0.60	Dark Brown to Brown (Munsell 7.5YR 3/2 – 4/3) Heavy Clay with moderate structure and firm consistence. Very strongly alkaline pH, non-saline to slightly saline and sodic. Nil coarse fragments, few fine roots and moderately drained. Gradual boundary.
B22	0.60-1.00	Brown (Munsell 7.5YR 4/4) Medium Clay with massive structure and firm consistence. Very strongly alkaline pH, moderately-saline and strongly sodic. Nil coarse fragments, few fine roots and moderately drained. Layer continues.

Sample Depth	ECe		$pH_{(1-5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.6	Non-saline	6.8	Neutral	2.7	Non sodic
0.20-0.30	1.6	Non-saline	9.0	Very Strongly Alkaline	6.0	Sodic
0.40-0.50	3.1	Slightly saline	9.2	Very Strongly Alkaline	10	Sodic
0.65-0.75	6.3	Moderately saline	9.3	Very Strongly Alkaline	14	Sodic

Site Description – Site 13				
Site Reference	E13	**ASC Name**	Endohypersodic Epipedal Black Vertosol (EQSW)	
Average Slope	2%	**Land Use**	Grazing	**Coordinates**
Site Morphology	Lower Slope	**Soil Fertility**	High	GDA20z56
Landform Element	Footslope	**ERD**	0.8 m+	X: 307403
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6404199

Plate 1 – Soil Profile (E13)

Plate 2 – Surface (E13)

Plate 3 – Landscape (E13)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Very Dark Grey (Munsell 7.5YR 3/1) Clay Loam with strong structure and moderate consistence. Neutral pH, non-saline and non-sodic. Nil coarse fragments. Many fine roots and moderately drained. Gradual boundary.
B21	0.10 – 0.40	Dark Brown (Munsell 7.5YR 3/2) Heavy Clay with moderate structure and firm consistence. Moderately alkaline pH, slightly-saline and sodic. Nil coarse fragments, few fine roots and moderately drained. Gradual boundary.
B22	0.40-0.80	Dark Brown to Dark Reddish Brown (Munsell 7.5YR 3/3 to 5YR 4/3) Heavy Clay with moderate structure and firm consistence. Very strongly alkaline pH, moderately-saline and strongly sodic. Nil coarse fragments, few fine roots and moderately drained. Layer continues.

Sample Depth	ECe		$pH_{(1\text{-}5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	0.9	Non-saline	6.9	Neutral	5.0	Non sodic
0.20-0.30	2.1	Slightly saline	8.1	Moderately Alkaline	13	Sodic
0.40-0.50	5.9	Moderately saline	9.1	Very Strongly Alkaline	17	Sodic
0.65-0.75	6.8	Moderately saline	9.2	Very Strongly Alkaline	18	Sodic

Site Description – Site 14				
Site Reference	E14	**ASC Name**	Endocalcareous-Endohypersodic Epipedal Black Vertosol (FQRW)	
Average Slope	3%	**Land Use**	Grazing	**Coordinates**
Site Morphology	Lower Slope	**Soil Fertility**	High	GDA20z56
Landform Element	Footslope	**ERD**	0.9 m+	X: 307093
Surface Condition	Soft	**Mapped as BSAL**	No	Y: 6404220

Plate 1 – Soil Profile (E14)

Plate 2 – Surface (E14)

Plate 3 – Landscape (E14)

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Very Dark Grey (Munsell 7.5YR 3/1) Clay Loam with strong structure and moderate consistence. Neutral pH, non-saline and non-sodic. Nil coarse fragments. Many fine roots and moderately drained. Gradual boundary.
B21	0.10 – 0.50	Black to Very Dark Grey (Munsell 7.5YR 2.5/1 – 3/1) Heavy Clay to Light Medium Clay with moderate structure and firm consistence. Moderate to very strongly alkaline pH, non-saline to slightly saline and sodic. Nil coarse fragments, few fine roots and moderately drained. Gradual boundary.
B22	0.50-0.80	Dark Brown (Munsell 7.5YR 3/2) Light-Medium Clay with moderate structure and firm consistence. Very strongly alkaline pH, moderately-saline and strongly sodic. Nil coarse fragments, few fine roots and moderately drained. Layer continues.

Sample Depth	ECe		$pH_{(1\text{-}5water)}$		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0-0.10	1.2	Non-saline	6.9	Neutral	2.2	Non sodic
0.20-0.30	0.7	Non-saline	8.4	Moderately Alkaline	6.9	Sodic
0.40-0.50	3.8	Slightly saline	9.2	Very Strongly Alkaline	12	Sodic
0.65-0.75	6.2	Moderately saline	9.3	Very Strongly Alkaline	16	Sodic

Appendix B
Laboratory Results

GRAIN SIZE ANALYSIS (hydrometer and sieving techniques)

36 soil samples supplied by Minesoils Pty. Ltd. on 3 August, 2020 - Lab Job No. J6662.
Analysis requested by Clayton Richards. Your project: MS-029 EIS.
PO Box 11034 TAMWORTH NSW 2340

SAMPLE ID	Lab Code	MOISTURE CONTENT (% of water in oven-dry sample)	TOTAL GRAVEL > 2 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)	Total soil fractions (incl. Gravel)
E1 0-10	J6662/1	19.7%	0.3%	8.6%	35.4%	23.8%	31.9%	100.0%
E1 20-30	J6662/2	24.5%	0.2%	5.2%	29.9%	8.1%	56.6%	100.0%
E1 40-50	J6662/3	21.2%	0.4%	7.4%	25.7%	11.0%	55.5%	100.0%
E1 65-75	J6662/4	14.2%	1.4%	7.7%	26.6%	18.7%	45.5%	100.0%
E2 0-10	J6662/5	19.7%	0.4%	8.8%	40.3%	16.1%	34.3%	100.0%
E2 20-30	J6662/6	25.2%	0.0%	5.7%	24.2%	11.6%	58.5%	100.0%
E2 40-50	J6662/7	20.9%	0.0%	6.8%	22.6%	15.3%	55.4%	100.0%
E2 65-75	J6662/8	17.4%	5.1%	12.2%	10.6%	24.0%	48.1%	100.0%
E3 0-10	J6662/9	12.9%	0.9%	9.4%	39.4%	25.2%	25.1%	100.0%
E3 20-30	J6662/10	15.4%	0.2%	5.4%	24.4%	20.2%	49.9%	100.0%
E3 40-50	J6662/11	14.6%	1.1%	5.5%	17.2%	21.1%	55.1%	100.0%
E3 65-75	J6662/12	13.5%	0.6%	8.8%	21.6%	26.6%	42.5%	100.0%
E4 0-10	J6662/13	19.9%	0.0%	8.9%	21.6%	29.6%	39.9%	100.0%
E4 20-30	J6662/14	13.7%	3.3%	19.2%	32.7%	16.3%	28.5%	100.0%
E4 40-50	J6662/15	14.1%	0.4%	14.3%	24.2%	5.3%	55.8%	100.0%
E4 65-75	J6662/16	13.7%	0.3%	13.8%	23.2%	13.2%	49.5%	100.0%
E5 0-10	J6662/17	22.1%	0.5%	6.0%	32.3%	29.3%	31.9%	100.0%
E5 10-20	J6662/18	17.6%	0.7%	9.1%	25.0%	29.9%	35.3%	100.0%
E5 30-40	J6662/19	14.4%	0.6%	8.1%	19.7%	26.1%	45.5%	100.0%
E5 60-70	J6662/20	14.0%	0.3%	3.8%	7.4%	26.9%	61.6%	100.0%
E6 0-10	J6662/21	11.3%	0.3%	36.4%	33.4%	7.1%	22.8%	100.0%
E6 20-30	J6662/22	15.1%	0.5%	9.8%	19.6%	33.1%	37.0%	100.0%
E6 40-50	J6662/23	14.4%	0.1%	5.3%	13.1%	29.1%	52.5%	100.0%
E6 65-75	J6662/24	15.0%	0.0%	3.3%	6.8%	27.2%	62.6%	100.0%
E7 0-10	J6662/25	19.8%	0.7%	3.4%	27.1%	32.3%	36.4%	100.0%
E7 20-30	J6662/26	13.6%	0.0%	3.1%	26.7%	23.9%	46.3%	100.0%
E7 40-50	J6662/27	12.4%	0.4%	7.9%	32.0%	16.3%	43.3%	100.0%
E7 65-75	J6662/28	13.8%	0.0%	3.4%	25.3%	15.8%	55.5%	100.0%
E8 0-10	J6662/29	17.9%	1.0%	1.2%	18.8%	35.1%	43.8%	100.0%
E8 20-30	J6662/30	14.5%	0.0%	0.4%	21.1%	28.5%	50.1%	100.0%
E8 40-50	J6662/31	14.0%	0.4%	5.7%	16.9%	23.0%	54.0%	100.0%
E8 65-75	J6662/32	15.4%	0.3%	3.6%	10.1%	19.4%	66.7%	100.0%
E9 0-10	J6662/33	17.1%	12.2%	13.1%	27.6%	17.4%	29.7%	100.0%
E9 20-30	J6662/34	12.8%	0.1%	1.7%	14.5%	26.6%	57.1%	100.0%
E10 0-10	J6662/35	24.8%	9.7%	12.4%	22.7%	19.2%	36.0%	100.0%
E10 20-30	J6662/36	17.5%	1.9%	5.3%	4.5%	18.5%	69.9%	100.0%

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. The texture classification was based on the hydrometer results and the appropriate texture triangle.

3. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (see EAL website: scu.edu.au/eal).

4. This report is not to be reproduced except in full.

5. This report was issued on 14/08/2020

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AGRICULTURAL SOIL ANALYSIS REPORT

36 samples supplied by Minesoils Pty. Ltd. on 3/08/2020 . Lab Job No.J6662
Analysis requested by Clayton Richards. Your Job: MS-029 EIS
PO BOX 11034 TAMWORTH NSW 2340

			Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
		Sample ID:	E1 0-10	E1 20-30	E1 40-50	E1 65-75	E2 0-10
		Crop:	N/G	N/G	N/G	N/G	N/G
		Client:	EMM	EMM	EMM	EMM	EMM
	Parameter	Method reference	J6662/1	J6662/2	J6662/3	J6662/4	J6662/5
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.48	7.81	8.92	9.23	7.15
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.060	0.114	0.115	0.717	0.137
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	9.0	14	12	20	6.0
	Exchangeable Calcium (kg/ha)		4,050	6,110	5,483	9,168	2,674
	Exchangeable Calcium (mg/kg)		1,808	2,728	2,448	4,093	1,194
	Exchangeable Magnesium (cmol+/kg)		10	21	24	20	14
	Exchangeable Magnesium (kg/ha)		2,730	5,806	6,592	5,483	3,678
	Exchangeable Magnesium (mg/kg)		1,219	2,592	2,943	2,448	1,642
	Exchangeable Potassium (cmol+/kg)		0.78	1.0	0.69	0.47	0.80
	Exchangeable Potassium (kg/ha)		685	882	606	408	702
	Exchangeable Potassium (mg/kg)		306	394	271	182	313
	Exchangeable Sodium (cmol+/kg)		0.55	2.4	5.2	5.9	1.9
	Exchangeable Sodium (kg/ha)		285	1,257	2,666	3,043	966
	Exchangeable Sodium (mg/kg)		127	561	1,190	1,358	431
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Aluminium (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Aluminium (mg/kg)		<1	<1	<1	<1	<1
	Exchangeable Hydrogen (cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.14	<0.01	<0.01	<0.01	<0.01
	Exchangeable Hydrogen (kg/ha)		3.2	<1	<1	<1	<1
	Exchangeable Hydrogen (mg/kg)		1.4	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	21	38	42	47	22
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	44	35	29	44	27
	Magnesium (%)		49	56	57	43	61
	Potassium (%)		3.8	2.6	1.6	0.99	3.6
	Sodium - ESP (%)		2.7	6.4	12	13	8.5
	Aluminium (%)		0.01	0.00	0.00	0.00	0.01
	Hydrogen (%)		0.69	0.00	0.00	0.00	0.00
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	0.90	0.64	0.50	1.0	0.44
	Emerson Aggregate Test (EAT)	**AS1289.3.8.1-2017	..	..	..	..	2
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	7.5YR3/1 Very dark grey	7.5YR3/1 Very dark grey	10YR3/2 Very dark greyish brown	10YR4/3 Brown	7.5YR3/2 Dark brown
	Mottles Munsell Colour		..	..	..	..	..
			..	..	..	..	..
	Degree of Mottling (%)		..	..	..	..	..

GRAIN SIZE ANALYSIS (hydrometer and sieving techniques)

16 soil samples supplied by Minesoils Pty. Ltd. on the 3rd of August, 2020 - Lab Job No. J6671
Analysis requested by Clayton Richards
PO Box 11034 TAMWORTH NSW 2340

SAMPLE ID	Lab Code	MOISTURE CONTENT (% of water in oven-dry sample)	TOTAL GRAVEL > 2 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)	Total soil fractions (incl. Gravel)
B1 0-10	J6671/1	13.2%	3.8%	16.9%	40.0%	12.8%	26.4%	100.0%
B1 20-30	J6671/2	19.8%	10.1%	8.7%	15.0%	10.5%	55.8%	100.0%
B1 40-50	J6671/3	16.6%	7.2%	8.5%	28.0%	9.3%	47.0%	100.0%
B1 65-75	J6671/4	13.6%	0.3%	5.6%	35.6%	16.2%	42.2%	100.0%
B2 0-10	J6671/5	16.8%	1.9%	11.1%	40.7%	10.2%	36.1%	100.0%
B2 20-30	J6671/6	20.9%	0.4%	8.1%	29.1%	1.2%	61.1%	100.0%
B2 40-50	J6671/7	17.9%	1.1%	8.6%	22.3%	12.5%	55.6%	100.0%
B2 65-75	J6671/8	17.5%	0.7%	8.5%	21.3%	21.3%	48.2%	100.0%
B3 0-10	J6671/9	18.9%	1.0%	7.8%	33.4%	22.4%	35.3%	100.0%
B3 20-30	J6671/10	22.9%	0.1%	6.8%	16.7%	11.3%	65.1%	100.0%
B3 40-50	J6671/11	19.9%	0.5%	7.6%	20.4%	9.3%	62.1%	100.0%
B3 65-75	J6671/12	18.4%	0.4%	8.5%	14.0%	11.0%	66.1%	100.0%
B4 0-10	J6671/13	16.3%	2.2%	10.8%	34.2%	18.8%	34.0%	100.0%
B4 20-30	J6671/14	20.6%	0.4%	8.9%	29.3%	9.3%	52.1%	100.0%
B4 40-50	J6671/15	16.4%	0.4%	11.6%	33.3%	10.1%	44.6%	100.0%
B4 65-75	J6671/16	12.4%	0.6%	11.2%	28.7%	18.6%	40.8%	100.0%

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. The texture classification was based on the hydrometer results and the appropriate texture triangle.

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5. This report was issued on 12/08/2020

checked: .....
Graham Lancaster (Nata signatory)
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AGRICULTURAL SOIL ANALYSIS REPORT

16 samples supplied by Minesoils Pty. Ltd. on 3/08/2020 . Lab Job No.J6671
Analysis requested by Clayton Richards. Your Job: MS-029 BSAL
PO BOX 11034 TAMWORTH NSW 2340

			Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
		Sample ID:	B1 0-10	B1 20-30	B1 40-50	B1 65-75	B2 0-10
		Crop:	soil	soil	soil	soil	soil
		Client:	EMM	EMM	EMM	EMM	EMM
	Parameter	Method reference	J6671/1	J6671/2	J6671/3	J6671/4	J6671/5
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	5.92	6.76	8.45	8.88	6.86
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.087	0.394	1.129	1.428	0.068
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	6.4	7.5	20	18	13
	Exchangeable Calcium (kg/ha)		2,858	3,355	8,904	8,017	5,761
	Exchangeable Calcium (mg/kg)		1,276	1,498	3,975	3,579	2,572
	Exchangeable Magnesium (cmol+/kg)		4.9	7.7	14	15	10
	Exchangeable Magnesium (kg/ha)		1,322	2,091	3,725	4,119	2,842
	Exchangeable Magnesium (mg/kg)		590	934	1,663	1,839	1,269
	Exchangeable Potassium (cmol+/kg)		1.2	0.65	0.60	0.38	1.2
	Exchangeable Potassium (kg/ha)		1,059	567	527	335	1,041
	Exchangeable Potassium (mg/kg)		473	253	235	150	465
	Exchangeable Sodium (cmol+/kg)		0.32	1.6	5.5	7.8	0.69
	Exchangeable Sodium (kg/ha)		165	844	2,807	3,996	354
	Exchangeable Sodium (mg/kg)		74	377	1,253	1,784	158
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Aluminium (kg/ha)		3.0	1.3	1.6	<1	<1
	Exchangeable Aluminium (mg/kg)		1.3	<1	<1	<1	<1
	Exchangeable Hydrogen (cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.20	<0.01	<0.01	<0.01	<0.01
	Exchangeable Hydrogen (kg/ha)		4.5	<1	<1	<1	<1
	Exchangeable Hydrogen (mg/kg)		2.0	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	13	17	40	41	25
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	49	43	50	43	51
	Magnesium (%)		37	44	35	37	42
	Potassium (%)		9.3	3.7	1.5	0.93	4.7
	Sodium - ESP (%)		2.5	9.4	14	19	2.7
	Aluminium (%)		0.11	0.04	0.02	0.01	0.01
	Hydrogen (%)		1.5	0.00	0.00	0.00	0.00
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	1.3	0.97	1.4	1.2	1.2
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	10 YR 3/2 Very Dark Greyish Brown	10YR4/2 Dark greyish brown	10YR3/2 Very dark greyish brown	10YR5/4 yellowish brown	10YR3/2 Very dark grey
	Mottles Munsell Colour		..	..	..	..	..
	Degree of Mottling (%)		..	..	..	..	..

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PO BOX 11034 TAMWORTH NSW 2340

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Sample ID:	B1 0-10	B1 20-30	B1 40-50	B1 65-75	B2 0-10
Crop:	soil	soil	soil	soil	soil
Client:	EMM	EMM	EMM	EMM	EMM
Parameter / Method reference	J6671/1	J6671/2	J6671/3	J6671/4	J6671/5

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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PO BOX 11034 TAMWORTH NSW 2340

			Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
		Sample ID:	B2 20-30	B2 40-50	B2 65-75	B3 0-10	B3 20-30
		Crop:	soil	soil	soil	soil	soil
		Client:	EMM	EMM	EMM	EMM	EMM
	Parameter	Method reference	J6671/6	J6671/7	J6671/8	J6671/9	J6671/10
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	9.03	9.25	9.29	6.88	8.13
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.274	0.535	0.846	0.099	0.362
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	26	23	20	10	13
	Exchangeable Calcium (kg/ha)		11,764	10,185	8,917	4,533	5,812
	Exchangeable Calcium (mg/kg)		5,252	4,547	3,981	2,024	2,595
	Exchangeable Magnesium (cmol+/kg)		20	23	24	13	23
	Exchangeable Magnesium (kg/ha)		5,344	6,254	6,570	3,492	6,142
	Exchangeable Magnesium (mg/kg)		2,386	2,792	2,933	1,559	2,742
	Exchangeable Potassium (cmol+/kg)		0.59	0.49	0.51	0.96	0.69
	Exchangeable Potassium (kg/ha)		513	426	449	841	608
	Exchangeable Potassium (mg/kg)		229	190	200	375	272
	Exchangeable Sodium (cmol+/kg)		3.0	5.3	7.3	1.3	5.3
	Exchangeable Sodium (kg/ha)		1,535	2,708	3,779	651	2,730
	Exchangeable Sodium (mg/kg)		685	1,209	1,687	291	1,219
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Aluminium (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Aluminium (mg/kg)		<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
	Exchangeable Hydrogen (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Hydrogen (mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	49	51	52	25	42
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	53	44	38	40	31
	Magnesium (%)		40	45	47	51	54
	Potassium (%)		1.2	0.95	0.99	3.8	1.7
	Sodium - ESP (%)		6.0	10	14	5.0	13
	Aluminium (%)		0.01	0.01	0.00	0.01	0.00
	Hydrogen (%)		0.00	0.00	0.00	0.00	0.00
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	1.3	0.99	0.82	0.79	0.57
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	7.5YR3/2 Dark brown	7.5YR4/3 Brown	4.5YR4/4 Brown	7.5YR3/1 Brown very dark grey	7.5YR3/2 Dark brown
	Mottles Munsell Colour		..	..	..	..	..
	Degree of Mottling (%)		..	..	..	..	..

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AGRICULTURAL SOIL ANALYSIS REPORT

16 samples supplied by Minesoils Pty. Ltd. on 3/08/2020 . Lab Job No.J6671
Analysis requested by Clayton Richards. Your Job: MS-029 BSAL
PO BOX 11034 TAMWORTH NSW 2340

		Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
	Sample ID:	B2 20-30	B2 40-50	B2 65-75	B3 0-10	B3 20-30
	Crop:	soil	soil	soil	soil	soil
	Client:	EMM	EMM	EMM	EMM	EMM
Parameter	Method reference	J6671/6	J6671/7	J6671/8	J6671/9	J6671/10

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
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			Sample 11	Sample 12	Sample 13	Sample 14	Sample 15
		Sample ID:	B3 40-50	B3 65-75	B4 0-10	B4 20-30	B4 40-50
		Crop:	soil	soil	soil	soil	soil
		Client:	EMM	EMM	EMM	EMM	EMM
	Parameter	Method reference	J6671/11	J6671/12	J6671/13	J6671/14	J6671/15
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	9.09	9.15	6.94	8.35	9.15
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	1.023	1.166	0.137	0.128	0.438
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	20	19	14	17	16
	Exchangeable Calcium (kg/ha)		8,933	8,615	6,334	7,490	7,083
	Exchangeable Calcium (mg/kg)		3,988	3,846	2,828	3,344	3,162
	Exchangeable Magnesium (cmol+/kg)		24	23	9.9	19	22
	Exchangeable Magnesium (kg/ha)		6,408	6,216	2,683	5,284	5,887
	Exchangeable Magnesium (mg/kg)		2,861	2,775	1,198	2,359	2,628
	Exchangeable Potassium (cmol+/kg)		0.54	0.53	1.1	0.65	0.54
	Exchangeable Potassium (kg/ha)		469	464	997	569	477
	Exchangeable Potassium (mg/kg)		209	207	445	254	213
	Exchangeable Sodium (cmol+/kg)		9.0	9.6	0.57	2.7	4.9
	Exchangeable Sodium (kg/ha)		4,652	4,924	295	1,408	2,547
	Exchangeable Sodium (mg/kg)		2,077	2,198	132	629	1,137
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Aluminium (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Aluminium (mg/kg)		<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
	Exchangeable Hydrogen (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Hydrogen (mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	53	52	26	39	43
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	38	37	55	42	37
	Magnesium (%)		44	44	38	49	50
	Potassium (%)		1.0	1.0	4.4	1.6	1.3
	Sodium - ESP (%)		17	18	2.2	6.9	12
	Aluminium (%)		0.01	0.00	0.01	0.01	0.01
	Hydrogen (%)		0.00	0.00	0.00	0.00	0.00
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	0.85	0.84	1.4	0.86	0.73
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	7.5YR3/3 Dark brown	5YR3/4 Dark reddish brown	7.5YR3/1 Very dark grey	7.5YR2.5/1 Black	7.5YR3/1 Very dark grey
	Mottles Munsell Colour		..	..	..	..	..
	Degree of Mottling (%)		..	..	..	..	..

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Analysis requested by Clayton Richards. Your Job: MS-029 BSAL
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	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15
Sample ID:	B3 40-50	B3 65-75	B4 0-10	B4 20-30	B4 40-50
Crop:	soil	soil	soil	soil	soil
Client:	EMM	EMM	EMM	EMM	EMM
Parameter / Method reference	J6671/11	J6671/12	J6671/13	J6671/14	J6671/15

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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			Sample 16	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
		Sample ID:	**B4 65-75**				
		Crop:	**soil**				
		Client:	**EMM**	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
	Parameter	**Method reference**	**J6671/16**	**Indicative guidelines - refer to Notes 6 and 8**			
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	9.25	*6.5*	*6.5*	*6.3*	*6.3*
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.723	*0.200*	*0.150*	*0.120*	*0.100*
	Exchangeable Calcium (cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	14	*15.6*	*10.8*	*5.0*	*1.9*
	Exchangeable Calcium (kg/ha)		6,366	*7000*	*4816*	*2240*	*840*
	Exchangeable Calcium (mg/kg)		2,842	*3125*	*2150*	*1000*	*375*
	Exchangeable Magnesium (cmol$_+$/kg)		21	*2.4*	*1.7*	*1.2*	*0.60*
	Exchangeable Magnesium (kg/ha)		5,714	*650*	*448*	*325*	*168*
	Exchangeable Magnesium (mg/kg)		2,551	*290*	*200*	*145*	*75*
	Exchangeable Potassium (cmol$_+$/kg)		0.48	*0.60*	*0.50*	*0.40*	*0.30*
	Exchangeable Potassium (kg/ha)		421	*526*	*426*	*336*	*224*
	Exchangeable Potassium (mg/kg)		188	*235*	*190*	*150*	*100*
	Exchangeable Sodium (cmol$_+$/kg)		6.9	*0.3*	*0.26*	*0.22*	*0.11*
	Exchangeable Sodium (kg/ha)		3,555	*155*	*134*	*113*	*57*
	Exchangeable Sodium (mg/kg)		1,587	*69*	*60*	*51*	*25*
	Exchangeable Aluminium (cmol$_+$/kg)	**Inhouse S37 (KCl)	<0.01	*0.6*	*0.5*	*0.4*	*0.2*
	Exchangeable Aluminium (kg/ha)		<1	*121*	*101*	*73*	*30*
	Exchangeable Aluminium (mg/kg)		<1	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen (cmol$_+$/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	*0.6*	*0.5*	*0.4*	*0.2*
	Exchangeable Hydrogen (kg/ha)		<1	*13*	*11*	*8*	*3*
	Exchangeable Hydrogen (mg/kg)		<1	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	43	*20.1*	*14.3*	*7.8*	*3.3*
	Calcium (%)	**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	33	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium (%)		49	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium (%)		1.1	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP (%)		16	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium (%)		0.00	*6.0*	*7.1*	*10.5*	*12.1*
	Hydrogen (%)		0.00				
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol$_+$/kg)	0.68	*6.5*	*6.4*	*4.2*	*3.2*
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	7.5YR3/2	..			
			Dark brown	..			
	Mottles Munsell Colour		..	..			
			..	..			
	Degree of Mottling (%)		..	..			

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AGRICULTURAL SOIL ANALYSIS REPORT

16 samples supplied by Minesoils Pty. Ltd. on 3/08/2020 . Lab Job No.J6671
Analysis requested by Clayton Richards. Your Job: MS-029 BSAL
PO BOX 11034 TAMWORTH NSW 2340

		Sample 16	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
	Sample ID:	B4 65-75				
	Crop:	soil				
	Client:	EMM	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
	Parameter	**Method reference**	**J6671/16**	**Indicative guidelines - refer to Notes 6 and 8**		

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 SOIL ANALYSIS REPORT

36 samples supplied by Minesoils Pty. Ltd. on 3/08/2020 . Lab Job No.J6662
Analysis requested by Clayton Richards. Your Job: MS-029 EIS
PO BOX 11034 TAMWORTH NSW 2340

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Sample ID:	E1 0-10	E1 20-30	E1 40-50	E1 65-75	E2 0-10
Crop:	N/G	N/G	N/G	N/G	N/G
Client:	EMM	EMM	EMM	EMM	EMM
Parameter / Method reference	J6662/1	J6662/2	J6662/3	J6662/4	J6662/5

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
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Analysis requested by Clayton Richards. Your Job: MS-029 EIS
PO BOX 11034 TAMWORTH NSW 2340

			Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
		Sample ID:	E2 20-30	E2 40-50	E2 65-75	E3 0-10	E3 20-30
		Crop:	N/G	N/G	N/G	N/G	N/G
		Client:	EMM	EMM	EMM	EMM	EMM
	Parameter	Method reference	J6662/6	J6662/7	J6662/8	J6662/9	J6662/10
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.53	8.88	9.08	6.69	8.17
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.387	0.930	1.269	0.059	0.146
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	8.2	7.3	15	7.4	9.6
	Exchangeable Calcium (kg/ha)		3,684	3,290	6,807	3,328	4,305
	Exchangeable Calcium (mg/kg)		1,645	1,469	3,039	1,486	1,922
	Exchangeable Magnesium (cmol+/kg)		24	24	22	6.1	12
	Exchangeable Magnesium (kg/ha)		6,482	6,653	5,983	1,655	3,281
	Exchangeable Magnesium (mg/kg)		2,894	2,970	2,671	739	1,465
	Exchangeable Potassium (cmol+/kg)		0.53	0.50	0.62	0.90	0.65
	Exchangeable Potassium (kg/ha)		468	440	542	787	573
	Exchangeable Potassium (mg/kg)		209	197	242	352	256
	Exchangeable Sodium (cmol+/kg)		6.4	10.0	10	0.37	1.8
	Exchangeable Sodium (kg/ha)		3,281	5,127	5,252	189	902
	Exchangeable Sodium (mg/kg)		1,465	2,289	2,345	84	403
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Aluminium (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Aluminium (mg/kg)		<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
	Exchangeable Hydrogen (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Hydrogen (mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	39	42	48	15	24
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	21	17	32	50	40
	Magnesium (%)		61	58	46	41	50
	Potassium (%)		1.4	1.2	1.3	6.1	2.7
	Sodium - ESP (%)		16	24	21	2.5	7.3
	Aluminium (%)		0.00	0.00	0.00	0.01	0.01
	Hydrogen (%)		0.00	0.00	0.00	0.00	0.00
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	0.34	0.30	0.69	1.2	0.80
	Emerson Aggregate Test (EAT)	**AS1289.3.8.1-2017	2	2	2	..	..
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	7.5YR3/3 Dark brown	7.5YR3/4 Dark brown	7.5YR4/4 Brown	7.5YR4/3 Brown	7.5YR4/4 Brown
	Mottles Munsell Colour		..	..	..	..	..
	Degree of Mottling (%)		..	..	..	..	..

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AGRICULTURAL SOIL ANALYSIS REPORT

36 samples supplied by Minesoils Pty. Ltd. on 3/08/2020 . Lab Job No.J6662
Analysis requested by Clayton Richards. Your Job: MS-029 EIS
PO BOX 11034 TAMWORTH NSW 2340

		Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
	Sample ID:	E2 20-30	E2 40-50	E2 65-75	E3 0-10	E3 20-30
	Crop:	N/G	N/G	N/G	N/G	N/G
	Client:	EMM	EMM	EMM	EMM	EMM
Parameter	Method reference	J6662/6	J6662/7	J6662/8	J6662/9	J6662/10

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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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.
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   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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    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
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			Sample 11	Sample 12	Sample 13	Sample 14	Sample 15
		Sample ID:	E3 40-50	E3 65-75	E4 0-10	E4 20-30	E4 40-50
		Crop:	N/G	N/G	N/G	N/G	N/G
		Client:	EMM	EMM	EMM	EMM	EMM
	Parameter	Method reference	J6662/11	J6662/12	J6662/13	J6662/14	J6662/15
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.99	9.08	7.64	8.54	8.64
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.147	0.790	0.105	0.086	0.088
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	11	19	14	9.0	8.3
	Exchangeable Calcium (kg/ha)		4,764	8,514	6,216	4,045	3,714
	Exchangeable Calcium (mg/kg)		2,127	3,801	2,775	1,806	1,658
	Exchangeable Magnesium (cmol+/kg)		14	16	4.4	2.0	6.4
	Exchangeable Magnesium (kg/ha)		3,792	4,319	1,202	554	1,745
	Exchangeable Magnesium (mg/kg)		1,693	1,928	537	247	779
	Exchangeable Potassium (cmol+/kg)		0.40	0.39	0.97	0.16	0.26
	Exchangeable Potassium (kg/ha)		346	341	848	142	226
	Exchangeable Potassium (mg/kg)		155	152	378	63	101
	Exchangeable Sodium (cmol+/kg)		3.3	5.5	0.14	0.07	0.39
	Exchangeable Sodium (kg/ha)		1,685	2,841	74	38	201
	Exchangeable Sodium (mg/kg)		752	1,268	33	17	90
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Aluminium (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Aluminium (mg/kg)		<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
	Exchangeable Hydrogen (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Hydrogen (mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	28	41	19	11	15
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	38	47	71	80	54
	Magnesium (%)		49	39	23	18	42
	Potassium (%)		1.4	0.96	5.0	1.4	1.7
	Sodium - ESP (%)		12	14	0.74	0.65	2.5
	Aluminium (%)		0.01	0.00	0.01	0.01	0.01
	Hydrogen (%)		0.00	0.00	0.00	0.00	0.00
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	0.76	1.2	3.1	4.4	1.3
	Emerson Aggregate Test (EAT)	**AS1289.3.8.1-2017	..	..	..	2	..
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	7.5YR4/6 Strong Brown	7.5YR4/6 Strong brown	7.5YR4/3 Brown	7.5YR4/3 Brown	5YR4/6 Yellowish red
	Mottles Munsell Colour		..	..	..	..	..
			..	..	..	..	..
	Degree of Mottling (%)		..	..	..	..	..

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AGRICULTURAL SOIL ANALYSIS REPORT

36 samples supplied by Minesoils Pty. Ltd. on 3/08/2020 . Lab Job No.J6662
Analysis requested by Clayton Richards. Your Job: MS-029 EIS
PO BOX 11034 TAMWORTH NSW 2340

		Sample 11	Sample 12	Sample 13	Sample 14	Sample 15
	Sample ID:	E3 40-50	E3 65-75	E4 0-10	E4 20-30	E4 40-50
	Crop:	N/G	N/G	N/G	N/G	N/G
	Client:	EMM	EMM	EMM	EMM	EMM
Parameter	Method reference	J6662/11	J6662/12	J6662/13	J6662/14	J6662/15

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,
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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
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PO BOX 11034 TAMWORTH NSW 2340

			Sample 16	Sample 17	Sample 18	Sample 19	Sample 20
		Sample ID:	E4 65-75	E5 0-10	E5 10-20	E5 30-40	E5 60-70
		Crop:	N/G	N/G	N/G	N/G	N/G
		Client:	EMM	EMM	EMM	EMM	EMM
	Parameter	Method reference	J6662/16	J6662/17	J6662/18	J6662/19	J6662/20
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.91	6.14	6.72	7.77	8.73
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.106	0.043	0.030	0.097	0.621
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	5.6	6.7	6.1	6.8	7.6
	Exchangeable Calcium (kg/ha)		2,500	2,995	2,753	3,039	3,429
	Exchangeable Calcium (mg/kg)		1,116	1,337	1,229	1,357	1,531
	Exchangeable Magnesium (cmol+/kg)		8.1	3.3	3.0	5.5	9.2
	Exchangeable Magnesium (kg/ha)		2,206	888	805	1,510	2,513
	Exchangeable Magnesium (mg/kg)		985	396	359	674	1,122
	Exchangeable Potassium (cmol+/kg)		0.25	0.93	0.41	0.32	0.31
	Exchangeable Potassium (kg/ha)		218	817	361	284	268
	Exchangeable Potassium (mg/kg)		97	365	161	127	120
	Exchangeable Sodium (cmol+/kg)		1.0	0.12	0.28	1.4	5.1
	Exchangeable Sodium (kg/ha)		520	64	146	739	2,624
	Exchangeable Sodium (mg/kg)		232	28	65	330	1,171
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Aluminium (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Aluminium (mg/kg)		<1	<1	<1	<1	<1
	Exchangeable Hydrogen (cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	0.15	<0.01	<0.01	<0.01
	Exchangeable Hydrogen (kg/ha)		<1	3.4	<1	<1	<1
	Exchangeable Hydrogen (mg/kg)		<1	1.5	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	15	11	9.8	14	22
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	37	60	63	48	34
	Magnesium (%)		54	29	30	39	41
	Potassium (%)		1.7	8.4	4.2	2.3	1.4
	Sodium - ESP (%)		6.8	1.1	2.9	10	23
	Aluminium (%)		0.01	0.03	0.02	0.01	0.01
	Hydrogen (%)		0.00	1.4	0.00	0.00	0.00
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	0.69	2.0	2.1	1.2	0.83
	Emerson Aggregate Test (EAT)	**AS1289.3.8.1-2017	..	..	3	..	..
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	5YR4/6 Yellowish red	7.5YR3/2 Dark Brown	7.5YR4/2 Brown	10YR4/4 Dark yellowish brown	7.5YR4/6 Strong brown
	Mottles Munsell Colour		..	..	..	..	..
			..	..	..	..	..
	Degree of Mottling (%)		..	..	..	..	..

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AGRICULTURAL SOIL ANALYSIS REPORT

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Analysis requested by Clayton Richards. Your Job: MS-029 EIS
PO BOX 11034 TAMWORTH NSW 2340

	Sample 16	Sample 17	Sample 18	Sample 19	Sample 20
Sample ID:	E4 65-75	E5 0-10	E5 10-20	E5 30-40	E5 60-70
Crop:	N/G	N/G	N/G	N/G	N/G
Client:	EMM	EMM	EMM	EMM	EMM
Parameter / Method reference	J6662/16	J6662/17	J6662/18	J6662/19	J6662/20

Notes:

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3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
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AGRICULTURAL SOIL ANALYSIS REPORT

36 samples supplied by Minesoils Pty. Ltd. on 3/08/2020 . Lab Job No.J6662
Analysis requested by Clayton Richards. Your Job: MS-029 EIS
PO BOX 11034 TAMWORTH NSW 2340

			Sample 21	Sample 22	Sample 23	Sample 24	Sample 25
		Sample ID:	E6 0-10	E6 20-30	E6 40-50	E6 65-75	E7 0-10
		Crop:	N/G	N/G	N/G	N/G	N/G
		Client:	EMM	EMM	EMM	EMM	EMM
	Parameter	Method reference	J6662/21	J6662/22	J6662/23	J6662/24	J6662/25
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.09	8.53	8.77	8.93	6.22
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.044	0.066	0.127	0.595	0.054
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	6.1	10	9.0	6.0	4.1
	Exchangeable Calcium (kg/ha)		2,746	4,536	4,018	2,706	1,848
	Exchangeable Calcium (mg/kg)		1,226	2,025	1,794	1,208	825
	Exchangeable Magnesium (cmol+/kg)		2.4	4.0	9.5	13	4.4
	Exchangeable Magnesium (kg/ha)		640	1,084	2,583	3,566	1,197
	Exchangeable Magnesium (mg/kg)		286	484	1,153	1,592	534
	Exchangeable Potassium (cmol+/kg)		0.55	0.54	0.33	0.35	0.71
	Exchangeable Potassium (kg/ha)		483	470	293	307	624
	Exchangeable Potassium (mg/kg)		216	210	131	137	278
	Exchangeable Sodium (cmol+/kg)		0.12	0.20	1.2	5.4	0.37
	Exchangeable Sodium (kg/ha)		64	102	628	2,797	192
	Exchangeable Sodium (mg/kg)		29	45	280	1,249	86
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Aluminium (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Aluminium (mg/kg)		<1	<1	<1	<1	<1
	Exchangeable Hydrogen (cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01	0.14
	Exchangeable Hydrogen (kg/ha)		<1	<1	<1	<1	3.1
	Exchangeable Hydrogen (mg/kg)		<1	<1	<1	<1	1.4
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	9.1	15	20	25	9.7
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	67	68	45	24	42
	Magnesium (%)		26	27	47	53	45
	Potassium (%)		6.0	3.6	1.7	1.4	7.3
	Sodium - ESP (%)		1.4	1.3	6.1	22	3.8
	Aluminium (%)		0.01	0.02	0.01	0.01	0.05
	Hydrogen (%)		0.00	0.00	0.00	0.00	1.4
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	2.6	2.5	0.94	0.46	0.94
	Emerson Aggregate Test (EAT)	**AS1289.3.8.1-2017	..	3	..	..	..
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	7.5YR4/4 Brown	7.5YR4/3 Brown	7.5YR5/4 Brown	7.5YR4/4 Brown	7.5YR4/2 Brown
	Mottles Munsell Colour		..	..	..	..	..
			..	..	..	..	..
	Degree of Mottling (%)		..	..	..	..	..

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Analysis requested by Clayton Richards. Your Job: MS-029 EIS
PO BOX 11034 TAMWORTH NSW 2340

	Sample 21	Sample 22	Sample 23	Sample 24	Sample 25
Sample ID:	E6 0-10	E6 20-30	E6 40-50	E6 65-75	E7 0-10
Crop:	N/G	N/G	N/G	N/G	N/G
Client:	EMM	EMM	EMM	EMM	EMM

Parameter	Method reference	J6662/21	J6662/22	J6662/23	J6662/24	J6662/25

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
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			Sample 26	Sample 27	Sample 28	Sample 29	Sample 30
		Sample ID:	E7 20-30	E7 40-50	E7 65-75	E8 0-10	E8 20-30
		Crop:	N/G	N/G	N/G	N/G	N/G
		Client:	EMM	EMM	EMM	EMM	EMM
	Parameter	Method reference	J6662/26	J6662/27	J6662/28	J6662/29	J6662/30
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.17	6.03	7.31	6.26	8.50
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.053	0.613	0.986	0.084	0.118
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	4.2	3.0	3.9	11	12
	Exchangeable Calcium (kg/ha)		1,900	1,326	1,771	5,114	5,362
	Exchangeable Calcium (mg/kg)		848	592	791	2,283	2,394
	Exchangeable Magnesium (cmol+/kg)		8.0	8.0	13	6.2	6.7
	Exchangeable Magnesium (kg/ha)		2,189	2,181	3,452	1,674	1,831
	Exchangeable Magnesium (mg/kg)		977	974	1,541	748	817
	Exchangeable Potassium (cmol+/kg)		0.29	0.27	0.37	1.5	0.67
	Exchangeable Potassium (kg/ha)		255	235	324	1,321	586
	Exchangeable Potassium (mg/kg)		114	105	145	590	261
	Exchangeable Sodium (cmol+/kg)		2.4	4.4	7.2	0.18	0.19
	Exchangeable Sodium (kg/ha)		1,220	2,243	3,688	92	98
	Exchangeable Sodium (mg/kg)		545	1,001	1,646	41	44
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	<0.01	0.03	<0.01	<0.01	<0.01
	Exchangeable Aluminium (kg/ha)		<1	5.4	<1	<1	<1
	Exchangeable Aluminium (mg/kg)		<1	2.4	<1	<1	<1
	Exchangeable Hydrogen (cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	0.13	<0.01	0.25	<0.01
	Exchangeable Hydrogen (kg/ha)		<1	2.9	<1	5.5	<1
	Exchangeable Hydrogen (mg/kg)		<1	1.3	<1	2.5	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	15	16	24	19	20
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	28	19	16	58	61
	Magnesium (%)		54	51	52	32	34
	Potassium (%)		2.0	1.7	1.5	7.7	3.4
	Sodium - ESP (%)		16	28	30	0.92	0.98
	Aluminium (%)		0.01	0.17	0.01	0.02	0.01
	Hydrogen (%)		0.00	0.83	0.00	1.3	0.00
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	0.53	0.37	0.31	1.9	1.8
	Emerson Aggregate Test (EAT)	**AS1289.3.8.1-2017	2	..	..	..	3
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	7.5YR5/4 Brown	10YR5/4 Yellowish brown	10YR5/4 Yellowish brown	10YR3/3 Dark brown	7.5YR4/4 Brown
	Mottles Munsell Colour		..	..	..	..	..
			..	..	..	..	..
	Degree of Mottling (%)		..	..	..	..	..

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PO BOX 11034 TAMWORTH NSW 2340

	Parameter	Method reference	Sample 26	Sample 27	Sample 28	Sample 29	Sample 30
	Sample ID:		E7 20-30	E7 40-50	E7 65-75	E8 0-10	E8 20-30
	Crop:		N/G	N/G	N/G	N/G	N/G
	Client:		EMM	EMM	EMM	EMM	EMM
			J6662/26	J6662/27	J6662/28	J6662/29	J6662/30

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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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.
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			Sample 31	Sample 32	Sample 33	Sample 34	Sample 35
		Sample ID:	E8 40-50	E8 65-75	E9 0-10	E9 20-30	E10 0-10
		Crop:	N/G	N/G	N/G	N/G	N/G
		Client:	EMM	EMM	EMM	EMM	EMM
	Parameter	Method reference	J6662/31	J6662/32	J6662/33	J6662/34	J6662/35
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.84	8.88	6.53	7.00	5.73
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.168	0.338	0.053	0.073	0.158
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	10	9.4	7.3	10	14
	Exchangeable Calcium (kg/ha)		4,616	4,211	3,299	4,572	6,092
	Exchangeable Calcium (mg/kg)		2,061	1,880	1,473	2,041	2,720
	Exchangeable Magnesium (cmol+/kg)		11	13	2.5	4.6	5.9
	Exchangeable Magnesium (kg/ha)		2,925	3,629	681	1,239	1,600
	Exchangeable Magnesium (mg/kg)		1,306	1,620	304	553	714
	Exchangeable Potassium (cmol+/kg)		0.38	0.36	1.0	0.61	1.2
	Exchangeable Potassium (kg/ha)		337	317	888	532	1,018
	Exchangeable Potassium (mg/kg)		150	141	397	237	454
	Exchangeable Sodium (cmol+/kg)		1.2	2.9	0.07	0.24	0.14
	Exchangeable Sodium (kg/ha)		600	1,478	34	125	74
	Exchangeable Sodium (mg/kg)		268	660	15	56	33
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	<0.01	<0.01	<0.01	<0.01	0.02
	Exchangeable Aluminium (kg/ha)		<1	<1	<1	<1	3.1
	Exchangeable Aluminium (mg/kg)		<1	<1	<1	<1	1.4
	Exchangeable Hydrogen (cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01	0.57
	Exchangeable Hydrogen (kg/ha)		<1	<1	<1	<1	13
	Exchangeable Hydrogen (mg/kg)		<1	<1	<1	<1	5.7
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	23	26	11	16	21
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	46	36	67	65	64
	Magnesium (%)		48	51	23	29	28
	Potassium (%)		1.7	1.4	9.3	3.9	5.4
	Sodium - ESP (%)		5.2	11	0.61	1.6	0.67
	Aluminium (%)		0.01	0.01	0.04	0.03	0.07
	Hydrogen (%)		0.00	0.00	0.00	0.00	2.7
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	0.96	0.70	2.9	2.2	2.3
	Emerson Aggregate Test (EAT)	**AS1289.3.8.1-2017	..	..	..	3	..
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	7.5YR4/4 Brown	7.5YR4/6 Strong brown	7.5YR4/3 Brown	7.5YR4/3 Brown	7.5YR3/1 Very dark grey
	Mottles Munsell Colour		..	..	..	..	..
			..	..	..	..	..
	Degree of Mottling (%)		..	..	..	..	..

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		Sample 31	Sample 32	Sample 33	Sample 34	Sample 35
	Sample ID:	E8 40-50	E8 65-75	E9 0-10	E9 20-30	E10 0-10
	Crop:	N/G	N/G	N/G	N/G	N/G
	Client:	EMM	EMM	EMM	EMM	EMM
Parameter	Method reference	J6662/31	J6662/32	J6662/33	J6662/34	J6662/35

Notes:

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11. Conversions to kg/ha = mg/kg x 2.24
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			Sample 36	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
		Sample ID:	E10 20-30				
		Crop:	N/G				
		Client:	EMM	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
	Parameter	Method reference	J6662/36	Indicative guidelines - refer to Notes 6 and 8			
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.61	*6.5*	*6.5*	*6.3*	*6.3*
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.157	*0.200*	*0.150*	*0.120*	*0.100*
	Exchangeable Calcium (cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	7.1	*15.6*	*10.8*	*5.0*	*1.9*
	Exchangeable Calcium (kg/ha)		3,165	*7000*	*4816*	*2240*	*840*
	Exchangeable Calcium (mg/kg)		1,413	*3125*	*2150*	*1000*	*375*
	Exchangeable Magnesium (cmol$_+$/kg)		13	*2.4*	*1.7*	*1.2*	*0.60*
	Exchangeable Magnesium (kg/ha)		3,539	*650*	*448*	*325*	*168*
	Exchangeable Magnesium (mg/kg)		1,580	*290*	*200*	*145*	*75*
	Exchangeable Potassium (cmol$_+$/kg)		1.1	*0.60*	*0.50*	*0.40*	*0.30*
	Exchangeable Potassium (kg/ha)		924	*526*	*426*	*336*	*224*
	Exchangeable Potassium (mg/kg)		413	*235*	*190*	*150*	*100*
	Exchangeable Sodium (cmol$_+$/kg)		1.1	*0.3*	*0.26*	*0.22*	*0.11*
	Exchangeable Sodium (kg/ha)		578	*155*	*134*	*113*	*57*
	Exchangeable Sodium (mg/kg)		258	*69*	*60*	*51*	*25*
	Exchangeable Aluminium (cmol$_+$/kg)	**Inhouse S37 (KCl)	<0.01	*0.6*	*0.5*	*0.4*	*0.2*
	Exchangeable Aluminium (kg/ha)		1.4	*121*	*101*	*73*	*30*
	Exchangeable Aluminium (mg/kg)		<1	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen (cmol$_+$/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	*0.6*	*0.5*	*0.4*	*0.2*
	Exchangeable Hydrogen (kg/ha)		<1	*13*	*11*	*8*	*3*
	Exchangeable Hydrogen (mg/kg)		<1	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	22	*20.1*	*14.3*	*7.8*	*3.3*
	Calcium (%)	**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	32	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium (%)		58	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium (%)		4.7	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP (%)		5.0	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium (%)		0.03	*6.0*	*7.1*	*10.5*	*12.1*
	Hydrogen (%)		0.00				
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol$_+$/kg)	0.54	*6.5*	*6.4*	*4.2*	*3.2*
	Emerson Aggregate Test (EAT)	**AS1289.3.8.1-2017	3	*Class 3–8*			
	Moist Munsell Colour	**Inhouse Munsell Soil Colour Classification	10YR5/3	..			
			Brown	..			
	Mottles Munsell Colour		..	..			
			..	..			
	Degree of Mottling (%)		..	..			

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		Sample 36	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
	Sample ID:	E10 20-30				
	Crop:	N/G				
	Client:	EMM	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
	Parameter	**Method reference**	**J6662/36**	**Indicative guidelines - refer to Notes 6 and 8**		

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.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer sc
17. This report was issued on 11/08/2020.

Quality Checked: Kris Saville
Agricultural Co-Ordinator KS