# FINAL

## Soil and Land Suitability Assessment

*Red Hill Mining Lease*

*Environmental Impact Statement*

URS03-029

**September 2013**

GSS ENVIRONMENTAL

Environmental, Land and Project Management Consultants

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# *Red Hill Mining Lease Environmental Impact Statement;*

# *Soil and Land Suitability Assessment*

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*Date of Issue* 18 September 2013

*GSSE Ref* URS03-029

**ISSUE AND AMENDMENT CONTROL HISTORY**

| Issue | Date | Description | Author | QA/QC |
|---|---|---|---|---|
| 1 | 6 December 2011 | Draft V1 Document | Matt Hemingway, Andrew Regan | Clayton Richards |
| 2 | 10 February 2012 | Draft V2 Document | Matt Hemingway, Andrew Regan | Clayton Richards |
| 3 | 21 June 2013 | Final | Adam Koppers | Adele Calandra |
| 4 | 27 August 2013 | Final V2 | Clayton Richards | Clayton Richards |
| 5 | 18 September 2013 | Final V3 | Clayton Richards | Clayton Richards |

Distribution List

**Master:** GSS Environmental

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# EXECUTIVE SUMMARY

BM Alliance Coal Operations Pty Ltd proposes to convert the existing Red Hill Mining Lease Application (MLA 70421) to enable the continuation of mining operations associated with the existing GRB mine complex. Specifically, the mining lease conversion will allow for:

- An incremental expansion of the existing Goonyella Riverside Mine;
- An extension of three longwall panels (14, 15 and 16) of the existing Broadmeadow underground mine ;and
- A future incremental underground expansion option on the Red Hill Mining Lease (Red Hill Mine)

These three elements are collectively referred to as the project.

URS Australia Pty Ltd (URS) commissioned GSS Environmental (GSSE) to undertake a soil and land suitability assessment for the project for inclusion in the project's environmental impact statement (EIS). This report involves the compilation of two previous soil surveys undertaken on site, GJR Holdings 2007 and GSSE 2009, with an additional fieldwork and assessment component undertaken by GSSE in 2011. Based on the information from these three studies, this soil and land suitability assessment report provides:

- A description of the soil and land suitability classification across the EIS study area in accordance with the Australian Soil Classification system (ASC) and the Queensland technical guidelines for assessing land suitability;
- Recommendations on soil stripping depths for all soil types in the EIS study area, including recommendations for topsoil handling, stockpiling and amelioration for reuse in rehabilitation;
- Identification of unfavourable materials, which require specific management and handling practices; and
- A description of the Agricultural Land Classes across the EIS study area.

The soil and land suitability field survey was undertaken at a scale of 1:50,000 for the entire EIS study area and 1:25,000 for disturbance areas, in accordance with the *Guidelines for Surveying Soil and Land Resources* (2008). Soil samples were analysed for various physical and chemical soil attributes by a National Association of Testing Authorities accredited laboratory. Results of the analysed field and laboratory data showed that eight major soil units occurred throughout the EIS study area, which consist of 11 soil types, as listed below:

| | | |
|---|---|---|
| 1. Lithic Rudosol | 4. Brown Kurosol | 8a. Shallow Vertosol |
| 2. Tenosol | 5. Brown Chromosol | 8b. Deep Vertosol |
| 3a. Red Kandosol | 6. Brown Sodosol | 8c. Deep Salic Vertosol |
| 3b. Brown Kandosol | 7. Brown Dermosol | |

The majority of these soils are considered appropriate for stripping for reuse in rehabilitation, if required. The soils were also tested for erodibility parameters to determine erosion rates for various disturbances. The results indicate that the construction phase of infrastructure associated with gas drainage and following subsidence of longwall panels are the highest erosion hazard during which time material is unprotected by vegetation, potentially cracked upon the surface and highly exposed to the rainfall and runoff water.

The EIS study area was also assessed for its suitability for agricultural activities and its agricultural importance for the region. Land suitability classification ranges from Class 2 to Class 5 land for rainfed broadacre cropping, and Class 2 to Class 5 land for beef cattle grazing. The EIS study area is dominated by the Sodosol, Kandosol and Vertosol soil types, which are currently used for grazing enterprises. The strategic cropping land (SCL) trigger maps released by the Department of Natural Resources and Mines (formerly Queensland Department of Environment and Resource Management) indicate that there is potential SCL in areas in the north eastern section of the EIS study area.

Based on the assessment of the existing site conditions and soil types, and the proposed mining associated activities to be undertaken, this report has recommended management strategies to be implemented to minimise the impacts on soil and land suitability.

# 1.0 INTRODUCTION

## 1.1 Project Background

GSS Environmental (GSSE) was commissioned by URS Australia Pty Ltd (URS) on behalf of BHP Billiton Mitsubishi Alliance (BMA) to undertake a soil survey and strategic land cropping (SLC) assessment for the Red Hill Mining Lease (the project). This is to form part of an environmental impact statement (EIS) to support the development application for the project. The proposed project will include the following:

1. The extension of BRM longwall panels 14, 15, and 16 into MLA70421. Key elements include;
    - No new mining infrastructure is proposed other than infrastructure required for drainage of incidental mine gas (IMG) to enable safe and efficient mining.
    - Management of waste and water produced from drainage of IMG will be integrated with the existing BRM waste and water management systems.
    - The mining of the BRM panel extensions is to sustain existing production rates of the BRM mine and will extend the life of mine (LOM) by approximately one year.
    - The existing BRM workforce will complete all work associated with the extensions.
2. The incremental expansion of the Goonyella Riverside Mine including
    - Underground mining associated with the RHM underground expansion option to target the GMS;
    - a new mine industrial area (MIA);
    - a CHPP adjacent to the Riverside MIA on MLA 1764 and ML 1900 − the Red Hill CHPP will consist of up to three 1,200 tonne per hour (tph) modules;
    - construction of a drift for mine access;
    - a conveyor system linking RHM to the Red Hill CHPP;
    - associated coal handling infrastructure and stockpiles;
    - a new conveyor linking product coal stockpiles to a new rail load-out facility located on ML 1900;
    - means for providing flood protection to the mine access and MIA, potentially requiring a levee along the west bank of the Isaac River.
3. A potential new Red Hill underground mine expansion option to the east of the GRB mine complex, to target the GMS on MLA 70421. The proposed mine layout consists of a main drive extending approximately west to east with longwall panels ranging to the north and south;
    - A network of bores and associated surface infrastructure over the underground mine footprint for mine gas pre-drainage (IMG) and management of goaf methane drainage to enable the safe extraction of coal;
    - a ventilation system for the underground workings;
    - a bridge across the Isaac River for all-weather access. This will be located above the main headings, and will also provide a crossing point for other mine related infrastructure including water pipelines and power supply;
    - a new accommodation village (Red Hill accommodation village) for the up to 100 per cent remote construction and operational workforces with capacity for up to 3,000 workers;
    - potential production capacity of 14mtpa of high quality hard coking coal over a life of 20 to 25 years

This report involves the compilation of two previous soil surveys undertaken on site: GJR Holdings 2007 and GSSE 2009. An additional fieldwork and assessment component was also undertaken in 2011 to satisfy the Department of Natural Resources and Mines (formerly Queensland Department of Environment and Resource Management) requirements. The purpose of bringing these studies together and finalising the additional requirements is to characterise the terrain conditions in the proposed mine expansion areas in order to facilitate mine and infrastructure planning, as well as undertake an environmental impact assessment for the expansion programme.

As the BRM panel extensions and the RHM footprint will be developed within a previously undisturbed (by mining) area to the east of GRB mine complex, soil resources will be impacted by mining operations. The proposed greenfield underground mining activities, service roads, and drains will result in ground disturbance within the existing GRB mine on ML1763 and on MLA70421. To ensure sufficient topsoil resources are available for post-mining rehabilitation, it is important that all suitable natural topsoil reserves are identified and recovered ahead of this disturbance. Topsoil management and erosion controls are required during both construction and operation phases to manage potential impacts on watercourses. Disturbance to the ground surface and landscape character may also reduce the agricultural suitability of land within the EIS study area or downstream.

## 1.2 Project Location

The project is located within the Belyando Shire, in the northern part of the Bowen Basin, approximately 135 kilometres southwest of Mackay and approximately 30 kilometres north of Moranbah. A locality map, showing the EIS study area in a regional context, is provided in **Figure 1**. The proposed project is shown in **Figure 2**.

The region contains rich thermal and metallurgical coal resources at depth, and several open-cut and underground coal mines operating nearby supply both domestic and export markets. BMA mines, including Peak Downs (some 40 kilometres to the south), have been operating since 1968. Other regional industries include beef cattle grazing and limited cropping.

## 1.3 EIS Study Area

The EIS study area includes underground mining, gas drainage infrastructure and buffer land with nil disturbance, totalling **12,327.38** hectares. The EIS study area has been divided into key areas of disturbance for assessment purposes, as shown in **Figure 2**. The key disturbance areas are described as follows:

- **Subsidence Disturbance** (subsided land from underground mining): This area consists of 3,600.4 hectares or 29.2 per cent of the EIS study area for the Red Hill Mine expansion footprint, and 121.35 hectares for the Broadmeadow panel extensions 14, 15 and 16. These areas include land to be subsided by longwall mining on average three to five metres and up to six metres. Soil stripping will also occur on this land for gas drainage infrastructure, apart from 100 metre buffer around the Isaac River. Given the predicted subsidence profiles surface water drainage, ponding and erosion issues are also considered.
- **Infrastructure Areas:** This area consists of approximately 247.8 hectares or two per cent of the EIS study area. The breakdown of the infrastructure areas are listed below:
    - Red Hill MIA – 30.2ha
    - Red Hill CHPP – 53.9ha
    - Red Hill Conveyor – 55.0ha
    - Red Hill Accommodation Village – 108.7ha


| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | **FIGURE 1**<br>Red Hill Mining Lease<br>Locality Plan | Project: Red Hill Mining Lease EIS<br>Client: URS Australia Pty Ltd |
| Version<br>1<br>2 | Date:<br>06/12/11<br>12/06/13 | Author:<br>KC/LH<br>LF | Checked:<br>CR<br>AK | Approved:<br>CR<br>CR | GSS ENVIRONMENTAL<br>Environmental, Land and Project Management Consultants | File: Fg1_URS03-029_LocationPlan_130613<br>Projection: MGA 94 Zone 55 |

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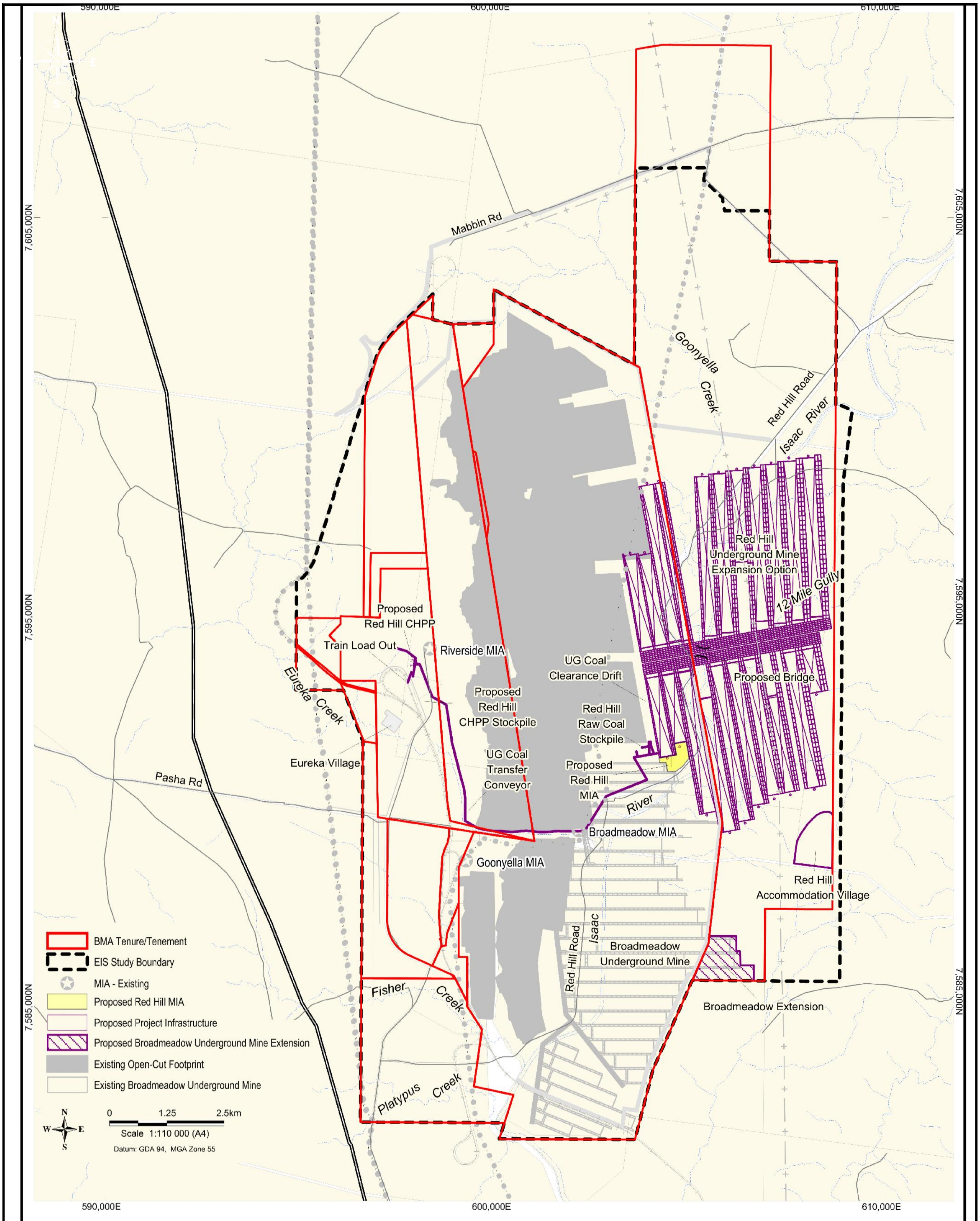


# FIGURE 2

Red Hill Mining Lease Layout

Project: Red Hill Mining Lease EIS

Client: URS Australia Pty Ltd

File: Fg2_URS03-029_ProjectLayout_130823

Projection: MGA 94 Zone 55

| Version | Date: | Author: | Checked: | Approved: |
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| 1 | 02/05/12 | KC | CR | CR |
| 2 | 12/06/13 | LF | AK | CR |

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## 1.4 Study Objectives

To assist BMA with operational topsoil and land management, a survey of soil resources and pre-mining assessment of agricultural land suitability was undertaken. The major objectives of the Soil and Land Suitability Assessment, according to the project's terms of reference (ToR), were to:

**Objective 1** **Classify and determine the soil types within the EIS study area;**

To satisfy Objective 1, the soil taxonomic classification system used was the Australian Soil Classification (ASC) system. This system is routinely used as the soil classification system in Australia. The scale of mapping used for this project was 1:25,000 for disturbance areas and 1:50,000 across the overall site.

**Objective 2** **Assess the pre-mining and post-mining Land Suitability (LS) classes within the EIS study area;**

To satisfy Objective 2, the *Guidelines for Agricultural Land Evaluation in Queensland* (DPI 1990) were used. This includes a standard list of limitations for assessing agricultural land suitability in Queensland.

**Objective 3** **Assess the pre-mining and post-mining Agricultural Land Classes (ALC) within the EIS study area;**

To satisfy Objective 3, the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI 1993) was used. This guideline defines four classes of agricultural land.

**Objective 4** **Assess the pre-mining and post-mining Good Quality Agricultural Land (GQAL) classes within the EIS study area;**

To satisfy Objective 4, the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI 1993) was used. This guideline sets conditions for land in terms of limitations, rating the ability of the land to maintain a sustainable level of agricultural productivity.

**Objective 5** **Assess the pre-mining and post-mining SCL within the EIS study area and provide soil management recommendations for the topsoil management;**

To satisfy Objective 5, the relevant guideline applied was the *Protecting Queensland's strategic cropping land; Guidelines for applying the proposed strategic cropping land criteria* (DERM 2011). The guideline provides guidance on assessing SCL in terms of preliminary assessment, field mapping, criteria and next steps for validation.

**Objective 6** **Assess the suitability of the current topsoil for future rehabilitation including the identification of unfavourable materials in the EIS study area**;

To satisfy Objective 6, the *Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas* (Elliot & Veness 1981) was utilised to determine the soils that are suitable for conserving and utilising in the EIS study area's rehabilitation program. The approach described in this guideline remains the benchmark for land resource assessment in the Australian mining industry.

**Objective 7** **Assess the potential erosion rates for various scenarios during the construction, operational and post mining phases of the project;**

To satisfy Objective 7, the Revised Universal Soil Loss Equation was used to calculate erosion rates and potential erosion hazards, as sourced from Landcom (2004) *Managing Urban Storm Water - Appendix 1A, NSW Government*.

# 2.0 EXISTING ENVIRONMENT

## 2.1 Climate

The EIS study area experiences a semi-arid climate, with local climatic conditions characterised by erratic rainfall and extremes of temperature.

Data for long term climate statistics of the EIS study area have been sourced from the Bureau of Meteorology (BoM) climate statistics for the Moranbah water treatment plant (WTP) which is located in Moranbah, to the southeast of the EIS study area. This data indicates the mean annual rainfall is approximately 600 millimetres and is received primarily between the months of November through March with approximately 50 per cent of rainfall occurring during summer

Long term ambient air temperature statistics suggest that the maximum daily temperatures in summer average between 33.1°C and 34°C with overnight minimums averaging between 21.1°C and 21.9°C. During winter, the maximum daily temperatures average between 23.8°C and 25.5°C with overnight minimums averaging between 9.9°C and 11.2°C

The wind directions in the vicinity of the project are predominantly from the east-northeast through to the east-southeast. The plot highlights that the site generally experiences low to moderate winds reaching a maximum of c. 7.5 metres per second (m/s) and an average speed over all hours of c. 2.7 m/s. The study is characterised by very infrequent winds from the west.

## 2.2 Geology

The geological regimes that outcrop, or occur as surface exposures within the EIS study area, are as listed below (GJR Holdings 2007). These are based on geological mapping data for 1:100,000 scale Harrybrandt (8554) and Wyena (8454) map sheets by the Geological Survey of Queensland (GSQ) (2004).

### 2.2.1 Quaternary Alluvium (Qa)

- River and Floodplain Deposits; clay, silt, sand, gravel.

The Quaternary Alluvial Deposits (Qa) are largely confined to the floodplain and alluvial plains adjacent to the Isaac River and its tributaries in the central eastern, north eastern and central southern sectors of the RHM area.

### 2.2.2 Tertiary-Quaternary Older Alluvial Deposits (TQa)

- Somewhat dissected high-level alluvial deposits in re-entrant valley floors and footslopes; clay, silt, sand, gravel.

Older Alluvial Deposits (TQa) occur as gently inclined mildly dissected high level alluvial deposits on footslopes and in higher parts of valley floors, mainly in the central sector of the RHM. They also occur in the north western and to a limited extent in the central and south western sectors to the west of the GRB mine complex.

### 2.2.3 Tertiary-Quaternary Residual Soils and Colluvium (TQr)

- Siliceous and ferruginous gravely residual soils and colluvium; locally occurring as (TQr\Qf) mainly siliceous gravelly alluvial fan deposits (bajadas) or (TQr\f) highly ferruginous (lateritic) residual soils and/or colluviums.

Residual Soils and Colluvial Deposits (TQr) have been mapped in various locations within the EIS study area. As mapped, they occur associated with various substrate lithological types mainly in the central eastern, south eastern and central western sectors of the EIS study area. In the central eastern sector of the EIS study area terrain units in the (TQr) geological regime locally includes (undifferentiated) occurrences of Quaternary alluvial fan deposits (Qf). They occur as depositional plains (bajadas) of fan-shaped debris deposited by sheet floods. In the south eastern, central western and south western sectors of the EIS study area the TQr sediments occur in association with or are underlain mainly by the Tertiary Suttor Formation (Ts) and locally by occurrences of Tertiary Basalt (Tb). Terrain units identified in these areas have mainly ferruginous (lateritic) gravelly residual soils and/or colluvium and have been designated by the symbol (TQr\f).

### 2.2.4 Tertiary Basalt Flows and Plugs (Tb)

Tertiary Basalt (Tb) remnants of flows and plugs occur mainly in the north eastern sector and locally along the western margin of the EIS study area. These comprise extensive outflows of basalt lava that occurred during the Tertiary Era with consequent infilling of valleys in the Pre-Tertiary landscape.

### 2.2.5 Tertiary Suttor Formation (Ts)

- ➔ Fluvial and lacustrine sediments; quartz sandstone, clayey sandstone, mudstone, conglomerate and minor interbedded basalt.

The Tertiary Suttor Formation (Ts) occurs as low broadly rounded rises and interfluves and remnant low plateau-like areas or elevated plains locally bounded by dissected and eroded low scarps in the central eastern and central western sectors and also in the south eastern and south western sectors of the EIS study area. Terrain units identified in these areas have mainly sandy surface red earths and ferruginous (lateritic) gravelly residual soils underlain by ferruginous sandstone.

### 2.2.6 Late Permian Fort Cooper Coal Measures (Pwt)

- ➔ Lithic sandstone, conglomerate, mudstone carbonaceous shale, coal, tuff and tuffaceous (cherty) mudstone.

The Late Permian Fort Cooper Coal Measures conformably overlie the Moranbah Coal Measures, and are present across the eastern portion of the EIS study area. A number of coal seams are contained within the Fort Cooper Coal Measures. The seams are typically thick (up to 70 metres in the case of the GF2 seam), highly stone-banded and contain high inherent ash coal and are, therefore, not considered economic for the project. The lower boundary of the Fort Cooper Coal Measures is taken as the base of the GF0 seam, a thick and widespread sequence of interbedded dull and stony coal, carbonaceous mudstone and tuff. This unit lies approximately 60 to 70 metres above the Goonyella Upper Seam.

### 2.2.7 Rangal Coal Measures

- ➔ Light grey, cross-bedded, fine to medium grained sandstone, grey siltstone, mudstone, and coal seams. Cemented sections are common in the sandstone.

The Rangal Coal Measures only outcrop/subcrop in the north-east of the EIS study area. The transition between the Fort Cooper Coal Measures and the Rangal Coal Measures is generally clearly marked by the Yarrabee Tuff; a basin-wide marker bed comprising weak, brown tuffaceous claystone.

The conformably overlying Triassic Rewan Group does not occur within the EIS study area.

## 2.3 Topography and Hydrology

The designated sites involved with the proposed project exhibit topographical features consistent with the regional landscape of the Bowen Basin. The topography is dominated by flat to gently sloping landforms and low rolling hills. There are five creeks that exist within the EIS study area; Goonyella Creek, Eureka Creek, Fisher Creek, Platypus Creek and 12 Mile Gully. These are all tributaries of the Isaac River, which runs to the east of the current operations within the site boundary, forming part of the Isaac River Catchment.

The groundwater regime in the area of the proposed project comprises Quaternary alluvial aquifers associated with the creeks and river in the area, Tertiary sediment and basalt aquifers, and Permian sedimentary fractured rock and coal seam aquifers.

## 2.4 Land Use

The proposed EIS study area and areas adjoining the current operations are used for beef cattle grazing and coal mining which is consistent with the predominant land uses in Belyando Shire and Nebo Shire. Grazing activity occurs to the north, east and west of the site on partially cleared land of native and buffel grass pastures. The adjoining properties are predominantly large rural holdings used for grazing cattle on freehold and leasehold land. Denham Park, Riverside, Broadmeadow and Red Hill properties are to be directly affected by the project. Coal mining is undertaken to the north, west and south of the EIS study area with North Goonyella underground and open cut mine (Eaglefield Pit) to the north, the GRB mine complex to the west, and the Moranbah North underground coal mine to the south.

The town of Moranbah is located 30 kilometres south of the project. Moranbah is a purpose-built mining town in the northern part of the Belyando Shire, with a population of nearly 8000 people. Belyando Shire Planning Scheme and Nebo Shire Planning Scheme are the two planning schemes that cover the project's footprint. The EIS study area is to occur on land designated as rural and extractive industry in the local planning schemes and the proposed RHM is compatible with the land's zoning and designations in the local planning schemes.

There are no identified environmentally sensitive areas in the immediate vicinity of the project. Homevale National Park and Resource Reserve are the nearest environmentally sensitive areas to the project. Homevale National Park is approximately 45 kilometres north-east of the project.

## 2.5 Land Systems

The 1:500,000 scale Isaac-Comet Land Systems report by Galloway *et al* (1967) showed the EIS study area contains the following land system units:

### Durrandella Land System

The Durrandella Land System is characterised by hills with lancewood and narrow-leaved ironbark on weathered Tertiary and Permian rocks. The land system is comprised of six land units. Landforms are most commonly Tabular hills and breakaways/ small stony hills. This land system also includes footslopes and alluvial flats. Rocky outcrops are widespread and sheet erosion and gullying have been observed to be active in steeper margins.

Soil types are mainly shallow and rocky soils, which include loamy red and yellow earths and texture contrasts. A variety of vegetation assemblages exist characterise this land system, including Savannah woodland, Lancewood or Bendee, Mixed scrub and Brigalow.

### Connors Land System

The Connors Land System is characterised by alluvial plains with box on texture contrast soils. This land system is comprised of seven land units. Common landforms include alluvial plains, terraces and levees. Additionally back swamps and channels are present throughout the landscape. Large areas of land are subject to flooding and there are some permanent water holes.

Soil types are predominantly texture contrast soils with sandy surface soils. There are also uniform, medium to fine textured alluvial soils and cracking clay soils. Vegetation assemblages consist primarily of Savannah woodland, and to a lesser extent mixed shrub woodland and brigalow.

### Monteagle Land System

The Monteagle Land System is characterised by lowlands with box and texture contrast soils on un-dissected Tertiary land surface. This land system is comprised of six land units. Land forms are most commonly plains, lowlands and colluvial footslopes. Also present are rises and interfluves, depressions and shallow valleys, and alluvial flats. Throughout the landscape there are occasional gilgai and gravels, and gullying has been observed.

Soil types include texture contrast soils of thin sandy or loamy surface soils with strongly alkaline subsoils, and to a lesser extent cracking clay soils and sandy red earths. Vegetation assemblages consist primarily of savannah woodland, with brigalow and mixed shrub woodland also present. The details of this study were used as a source of reference for soil types encountered in the field.

# 3.0 SOIL SURVEY

This soil survey provides an analysis of the main soil types located within the EIS study area. This section outlines the methodology and results for the soil survey.

## 3.1 Soil Survey Methodology

### 3.1.1 Background Reference Information

An initial broad scale reconnaissance soil map for the portion of the EIS study area, which has not been previously approved, was developed using the following background information, resources and techniques:

#### *3.1.1.1 Aerial photographs and topographic maps*

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

#### *3.1.1.2 Reference information*

Source materials were used to obtain correlations between pattern elements and soil properties that may be observable in the field. These materials included cadastral data, prior and current physiographic, geological, vegetation and water resources studies. Source materials included reports which detail previous soil and land suitability mapping for the EIS study area and its surrounds. These reports are listed in date order below:

i. Colour aerial photography – BMA Goonyella Project (AAMH 3155-2c) flown 25 July 2005 by AAM Hatch, Runs 1 and 2 at a nominal scale 1:36,000;

ii. Colour aerial photography – BMA Goonyella Project (AAMH 3102-3c), flown 22 March 2005, Run 1 at nominal scale 1:40,000;

These source materials were used to gain an understanding of the area in terms of vegetation characteristics and distribution, topographic features and the presence of visible colour of surface soils. Vegetation is influenced largely by soil type and topography often dictates soil type, therefore these characteristics were important to analyse as a preliminary stage of assessment. Topography dictates soil development and soil type and is therefore an important factor at the initial assessment stage, and later during the soil mapping stage. Soil colour gives a basic understanding of the prevalence and distribution of similar soils within the EIS study area.

iii. Project topographic data provided by BMA with 0.5 and 2 metre contour intervals;

As aforementioned regarding topography, areas that are flat have greater development capacity than those on steep slopes where erosive processes act quicker than the soil can develop. Topography can also be an important influence on the drainage characteristics of soils.

iv. GSQ Geoscience Data 1:100,000 Sheet areas Harrybrandt (8554) and Wyena (8454), compiled by Natural Resource Sciences – GSQ (2004);

The geology of the area was analysed in order to gain an understanding of the parent material of the soil types throughout the site. Geology has an important influence on the early development of a soil, especially in areas where there is little deposition.

v. CSIRO Australia Land Research Series No.19 – Lands of the Isaac-Comet Area Queensland by Story *et al* (1967);

Such background information was obtained and used as a reference to the land characteristics of the site, aiding the process of identification and justification of soil types and land assessments.

vi. Land Suitability Study of the Collinsville-Nebo-Moranbah Region, Department of Natural Resources and Mines, Land Resources Bulletin QB 84010 ISSN 0155-221X, by P.G. Shields, DPI (1984);

Reference information used as a consultation tool during the process of land suitability assessments. This study was undertaken to determine the cropping potential of the Collinsville-Nebo-Moranbah region. Initial documentation provided a foundation from which the land assessment could be based and supported.

vii. Land Reclamation Services Pty Ltd (January 1993) Report on Soil Survey of Future Open Cut Mining Areas of the Goonyella Riverside Mine;

Such background information was obtained and used as a reference to the land characteristics of the site, aiding the process of identification and justification of soil types and land assessments.

viii. Galloway *et al* (1967) 1:500,000 Isaac-Comet Land Systems;

This survey was originally requested by the Queensland Government to cover part of an area of central Queensland experiencing new activity in pastoral and agricultural pursuits. The aim was to provide a broad inventory of the natural features of an area by subdividing it into *land systems,* each with its own capacity for agricultural use. The area covered was over 40,000 square kilometres and was mapped and described in terms of 28 land systems.

Within the land systems four major soil groups were recognised; Cracking clay soils; Texture-contrast soils; Red and yellow earths; and Shallow rocky soils. In addition to these there were small areas of alluvial soils and uniform coarse textured soils too small to map separately.

Furthermore, the survey outlined that the dominant land use at the time was beef cattle raising and outlined this was due to restrictions imposed by climate, soil and topography. It was noted that there was considerable scope for pasture improvement and some scope for cultivation and irrigation.

ix. GJR Holdings 2007; and

This study was used as a reference for Geology, Terrain and Soils information within a significant portion of the study area. Laboratory test results and field profile descriptions from this report were used as a baseline for soil type descriptions.

x. GSSE 2009.

The purpose of the GJR Holdings 2007 and the GSSE 2009 studies was to characterise the soil conditions in the proposed mine expansion areas, to facilitate mine and infrastructure planning as well as environmental impact assessment that may result from the expansion programme. The GJR Holdings 2007 and the GSSE 2009 studies were the foundation from which this final report has been produced.

### 3.1.2 Field Survey Methodology

GSSE used a qualitative integrated free survey for the project. An integrated survey assumes that many land characteristics are interdependent and tend to occur in correlated sets (NCST 2008). Background reference information derived from sources cited in **Section 3.1.1** (including observable air photography) were used to predict the distribution of soil attributes in the field. Characteristics evaluated include geology, landform and vegetation. A free survey is a conventional form of integrated survey and its strength lies in its ability to assess soil and land at medium to detailed-scales. Survey points are located irregularly, according to the survey teams' expertise and judgement, to enable the delineation of soil boundaries.

The soil mapping was undertaken at a high intensity survey scale of 1:25,000 for all areas to be impacted by the project, whilst the overall area was surveyed at a medium scale of 1:50,000. This survey scale offers an adequate dataset of soil types within the study area and appropriate detail to assess the potential impact on these soils following the proposed operations. To satisfy this scale in accordance with the *Guidelines for Surveying Soil and Land Resources* (NCSR 2008), the number of observations per unit area required was: one observation per 6.25 hectares for the 1:25,000 scale area, and one observation per 25 hectares for 1:50,000 scale. The majority of these observations were considered 'minor' observations, such as exposed cuttings, 0.30 metres auger holes and rock outcrops.

The soil profiles were assessed in accordance with the Australian Soil and Land Survey Field Handbook soil classification procedures. Detailed soil profile descriptions were logged using GSSE soil data sheets. The information recorded consisted of the parameters specified in **Table 1**. Photographs and GPS locations were taken at each site and all soil test pits were backfilled immediately following field assessment.

**Table 1 – Detailed Profile Description Parameters**

| Descriptor | Application |
|---|---|
| Horizon Depth | Weathering characteristics, soil development |
| Field Colour | Soil naming convention, permeability, susceptibility to dispersion /erosion |
| Field Texture Grade | Erodibility, hydraulic conductivity, moisture retention, root penetration |
| Boundary Distinctness and Shape | Erosional / dispositional status, textural grade |
| Consistence Force | Structural stability, dispersion, ped formation |
| Structure Pedality Grade | Soil structure, root penetration, permeability, aeration |
| Structure Ped & Size | Soil structure, root penetration, permeability, aeration |
| Stones – Amount & Size | Water holding capacity, weathering status, erosional / depositional character |
| Roots – Amount & Size | Effective rooting depth, vegetative sustainability |
| Ants, Termites, Worms etc | Biological mixing depth |

Soil layers at each profile site were also assessed according to a procedure devised by Elliot and Veness (1981) and Elliot and Reynolds (2000) for the recognition of suitable topdressing material. This procedure assesses soils based on grading, texture, structure, consistency, mottling and root presence.

### 3.1.1 Laboratory Soil Assessment

Laboratory results from the three latest surveys have been used to distinguish physical and chemical properties of 11 soil units across the EIS study area. Given the variability in testing undertaken over the past five years by the three different surveys, the results were amalgamated to gain an overall thorough understanding of the chemical properties of each soil type. A total of 23 sites were laboratory tested as outlined in **Table 2** below. Majority of sites were analysed in accordance with *Guidelines for Agricultural Land Evaluation in Queensland* (DPI 1990), and were analysed for the following parameters at National Australian Testing Authorities (NATA) accredited laboratories:

Every sample:

- ECe, pH and Chloride.

Every major soil horizon:

- Exchangeable Cations;
- Cation Exchange Capacity (CEC);
- Particle Size Analysis (PSA); and
- Total Phosphorus, Potassium, Sulphur.

Surface soil horizon:

- Micronutrients;
- Aluminium;
- Free and total iron;
- Sulphate;
- Total Nitrogen; and
- Organic Carbon;

Representative samples were also analysed for the following parameters in order to satisfy other components of the TOR's:

- Colour;
- Gravimetric Water Content; and
- K-factor.

**Table 2 – Observation Points per Study**

| **Soil Type** | **URS 2007** (denoted with an 'A') | **GSSE 2009** (denoted with a 'B') | **GSSE 2011** (denoted with a 'C') |
|---|---|---|---|
| 1. Lithic Rudosol | None | B12, B42 | C67 |
| 2. Tenosol | A26 | None | C119, C120 |
| 3a. Red Kandosol | A33, A34, A35, A38, A54, A55, A56, A57, A58, A59, A69, A71, A75, **A76** | **B37, B39** | C68, C91, C92 |
| 3b. Brown Kandosol | A22, A28, A31 | None | C104, C105, C106 |
| 4. Brown Kurosol | **A77** | None | None |
| 5. Brown Chromosol | **A18**, **A20**, A23, A40, A43, A44, A109, A110 ,A111 | B36 | C66, **C82**, C95, C96, C97, C115, C116, C117, C118, C119, C121 |
| 6. Brown Sodosol | A24, A27, A29, A37, A41, A42, A105, A108 | **B38, B40, B41** | C77, C79, **C80**, C87, C88, C93, C94, C102, C107, C109, C110, C114, **C122**, C123 |
| 7. Brown Dermosol | A32, A36**A70**, A73, A78, A79, A81, A83, A68 | **B21, B22** | C72, **C76** |
| 8a. Shallow Vertosol | A3, A5, A7, A8, A11, A106, A107 | None | **C54,**C55, C61,C62, C63, C69, C108 |
| 8b. Deep Vertosol | **A10**, A12, A15 | None | None |

| Soil Type | URS 2007 (denoted with an 'A') | GSSE 2009 (denoted with a 'B') | GSSE 2011 (denoted with a 'C') |
|---|---|---|---|
| 8c. Deep Salic Vertosol | **A2**, **A4**, A6, A9, A13, A14, **A16**, A17, **A21**, A30, A39, A45, A112 | **B34,** B35 | C51, C52, C53, C56, C57, C58, C59, C60, C64,C71, C73, C74, C75, C78, C81, C83, C84, C85, C89, C90, C98, C99, C100, C101, C103, C111, C112, C113, C124 |

*(Note: **Bold** indicates laboratory analysis)*

Laboratory results from all three surveys can be found in **Appendix 3**. These soil types are detailed in the following sections, with **Tables 4–12** and **Plates 1–22** presenting the physical and chemical characteristics of each.

### 3.1.2 Soil Classification

GSSE adopted the Australian Soil Classification system nomenclature to identify and label soil units within the EIS study area, as required by the ToR. The standard is routinely used as the soil classification system in Australia and will form the key descriptor throughout this report. In this system, soil layers are termed horizons and the A and B horizons are together referred to as the Solum.

## 3.2 SOIL SURVEY RESULTS

### 3.2.1 Soil Types Overview

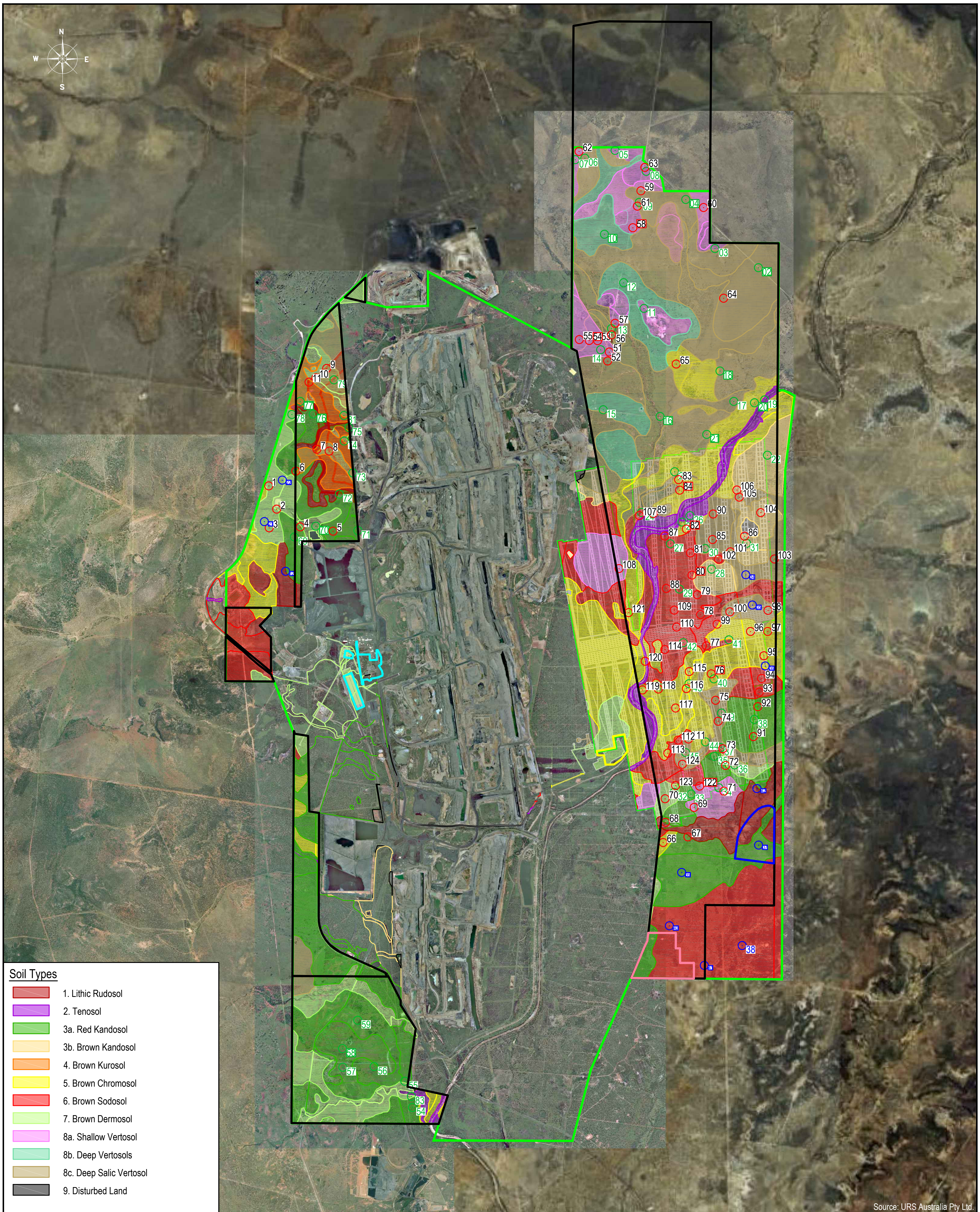
Within the EIS study area 11 soil types were identified. **Table 3** provides an overview of each soil type and their quantitative distribution within the EIS study area. **Figure 3** illustrates their spatial distribution.

**Table 3 – Soil Types**

| Soil Type Number | Soil Types | EIS study area within proposed mining lease | EIS study area within current mining lease | Area (%) |
|---|---|---|---|---|
| | | Area (ha) | Area (ha) | |
| 1 | Lithic Rudosol | 426.0 | 2.8 | 3.5 |
| 2 | Tenosol | 269.51 | 25.18 | 2.4 |
| 3a | Red Kandosol | 2,051.8 | 0.35 | 16.6 |
| 3b | Brown Kandosol | 386.0 | 16.7 | 3.3 |
| 4 | Brown Kurosol | 186.7 | nil | 1.5 |
| 5 | Brown Chromosol | 1,444.53 | 416.7 | 15.1 |
| 6 | Brown Sodosol | 1,757.31 | 176.4 | 15.7 |
| 7 | Brown Dermosol | 816.6 | 168 | 8.0 |
| 8a | Shallow Vertosol | 692.1 | 154.6 | 6.8 |
| 8b | Deep Vertosol | 589.2 | nil | 4.8 |
| 8c | Deep Salic Vertosol | 2674.8 | 36.8 | 22 |

| Soil Type Number | Soil Types | EIS study area within proposed mining lease | EIS study area within current mining lease | Area (%) |
|---|---|---|---|---|
| | | Area (ha) | Area (ha) | |
| n/a | Disturbed Terrain | 1.83 | 35.3 | 0.3 |
| **Total** | | **11,294.55** | **1,032.83** | **100%** |

These soils types have been derived from the current survey (2011) as well as previous field surveys of the site (GJR Holdings 2007; GSSE 2009). The observation points from each of these surveys and the associated soil types are shown on **Figure 3**.




## LEGEND

- Sampling Locations - 2007
- Soil Test Pits - 2009
- Soil Test Pits - 2011
- Tested Sampling Locations - 2007
- Tested Soil Test Pits - 2009
- Tested Soil Test Pits - 2011
- Proposed Mining Lease
- MIA (30.2)
- Broadmeadow Extension (131.35 ha)
- CHPP (53.9 ha)
- Accommodation Village (108.7 ha)

0 2.0 4.0km

Scale 1:90000

Base Plan Data Source: RWC & Geo-spectrum (Australia) Pty Ltd.

| Version | Date: | Author: | Checked: | Approved: |
|---|---|---|---|---|
| 1 | 31/10/11 | ZJ | MH | CR |
| 2 | 18/11/11 | LH | MH | CR |
| 3 | 1/12/11 | LH | MH | CR |
| 4 | 6/12/11 | LF | AR | CR |
| 5 | 02/02/12 | RH | RH | CR |
| 6 | 12/06/13 | RH | RH | CR |

# FIGURE 3

Soil Units and Soil Test Pit Locations

**GSS ENVIRONMENTAL**
Environmental, Land and Project Management Consultants

Project: Red Hill Mining Lease EIS

Client: URS Australia Pty Ltd

File: Fg3_URS03-029_SoilUnits-PitLocation_130823

Projection: MGA 94 Zone 55

V:\URS03-029\Figures\Final\CAD\August 2013 Update\Fg3_URS03-029_SoilUnits-PitLocation_130823.dwg

*To be printed A3*

### 3.2.2 Soil Type 1 – Lithic Rudosols

*Description:* The Lithic Rudosols are of limited extent throughout the EIS study area, and are characterised by shallow rocky (skeletal) soils with a clay loam or clayey soil matrix associated with, or underlain by shallow bedrock or gravelly colluvium. They are mainly shallow (<0.5 metres) and exhibit minimal profile development apart from some darkening near the surface due to the influence of organic matter. The topsoil is structurally stable with low potential for dispersion, and is generally of moderate salinity and is strongly acidic. Similarly, the subsoil has a low potential for dispersion, is generally moderately saline and is strongly acidic. In places the Lithic Rudosols comprise ferruginous gravel and gravelly colluvium derived from weathering of the Permian and Tertiary sedimentary rocks in the area. No samples of this soil type within the EIS study area were collected for laboratory analysis, however descriptions were used from the 2007 at sites adjacent the EIS study area. The rocky nature of this soil type restricted excavation within the EIS study area.

*Location:* These soils occur on the low hills and on lower escarpment slopes of sections throughout the eastern and western portion of the EIS study area. They also occur in association with somewhat deeper uniform and gravelly clay soils (Soil Type 7: Brown Dermosols) on low hilly lands and rises, encompassing an area of 428.8 hectares, or 3.5 per cent of the EIS study area, as shown in **Figure 3**. This soil type is represented by site B12.

*Landuse:* The land overlying these soils is currently used for extensive grazing; however clearing has been limited to the flatter areas where this soil type occurs. The steeper slopes and crests of the small hills are covered by native tree species with some native and introduced grass species.

*Management:* This soil type is generally shallow with coarse rocky topsoil. The topsoil is considered generally unsuitable for use as surface cover in rehabilitation due to its shallow, gravelly, and strongly acidic nature.

**Plate 1: Lithic Rudosol Soil Profile**

**Plate 2: Lithic Rudosol Landscape Setting**

### 3.2.3 Soil Type 2 – Tenosol

*Description:* The Tenosol soils are characterised by poor structure and loose sandy texture. They comprise deep (>1 metre) sand or silty sand grading to loamy or light clayey sand subsoils, usually with some ferruginous concretions associated with mottled sandy clay-clayey sand substrate soils. The topsoil is generally non-dispersive, and has low levels of salinity, with a neutral pH. The subsoil is slightly to moderately dispersive, low in salinity and generally neutral pH. There were no samples of this soil type collected for laboratory analysis within the EIS study area, however descriptions were used based on samples taken adjacent the EIS study area from the 2007 survey. This soil type includes unconsolidated uniform sand, silty sand or gravelly sand deposits in the channel floor in the Isaac River or its main tributaries.

*Location:* This soil type occurs on flat lower area of the catchment, within drainage lines or on the immediate floodplain of the Isaac River, on the eastern side of the EIS study area, encompassing an area of 294.7 hectares, or 2.4 per cent of the EIS study area, as shown in **Figure 3**. This soil type is represented by site C120.

*Landuse:* The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species. However, on the immediate banks of the Isaac River riparian vegetation is largely intact.

*Management:* These soils are considered suitable for use in rehabilitation. The silty sand topsoil does not display any specific management risk related to potential disturbance during stripping. The loamy sand subsoil also displays characteristics beneficial for use in rehabilitation. It is recommended that the topsoil be stripped to a depth of 0.4 metres, and that the subsoil be stripped to a depth of 0.8 metres; however the subsoil is moderately dispersive and should only be used as an intermediate layer in rehabilitation.

**Plate 3: Tenosol Soil Profile**

**Plate 4: Tenosol Landscape Setting**

### 3.2.4 Soil Type 3a – Red Kandosols

*Description:* The Red Kandosol includes ferruginous (lateritic) gravelly and non or sparse gravelly massive red earth soils. These are mostly deep (>1 metre) soils with a sandy loam to loamy surface grading to yellowish red or red clay loam, or medium to heavy clay subsoils, locally underlain by ferruginous gravelly clay-clayey gravel substrates. The topsoil is non-dispersive to moderately dispersive, mainly non-saline to slightly saline with a sample that was moderately saline. The topsoil varies from slightly acidic to mildly alkaline, although when tested it was consistently neutral. The subsoils are typically non-dispersive, although extremely sodic soils with elevated levels of dispersability are also present. The subsoil is generally non-saline to slightly saline, and from mildly alkaline to neutral. The analytical information of the representative site for this soil type is presented in **Table 4** below.

*Location:* This soil type occurs on gently to moderately inclined slopes and undulating low rises, as well as some higher alluvial terraces and outwash slopes, on undulating plains and dissection slope interfluves, on crestal plains, lower slopes and on mid to lower valley slopes. They encompass an area of 2052.2 hectares, or 16.6 per cent of the EIS study area, as shown in **Figure 3**. This soil type is represented by sites B37, C68 and C91.

*Landuse:* The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

*Management:* Generally the topsoil and immediate subsurface soil of this soil type do not display any specific management risk related to potential disturbance during stripping. Both layers exhibit structure and chemical characteristics that would be suitable as surface cover in rehabilitation. The increased presence of clay with depth throughout the profile restricts the use of the subsoil as a topdressing material. Therefore, topsoil can be salvaged for reuse in rehabilitation at a recommended depth of approximately 30 centimetres.

**Plate 5: Kandosols Soil Profile**

**Plate 6: Red Kandosols Landscape Setting**

**Table 4 – Red Kandosol Laboratory Results**

| Depth | Colour | pH | | ECe | | CEC | | ESP | | EAT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | Munsell | # | Rating | % | Rating | # | Rating | % | Rating | # | Rating |
| 0 - 20 | Dark reddish-brown | 6.26 | Slightly acid | 0.3 | Non saline | 4.51 | Very low | 4 | Non sodic | 3(2) | Slight |
| 20 - 60 | Yellowish-red | 7.38 | Neutral | 0.3 | Non saline | 5.78 | Very low | 21 | Strongly sodic | 3(4) | Moderate |
| 60 - 100 | Yellowish-red | 7.74 | Mildly alkaline | 0.4 | Non saline | 6.65 | Low | 102 | Extremely sodic | 3(4) | Moderate |

The Red Kandosol profile is represented by: **Figure 3aA**, which shows the ECe and pH trend with depth, **Figure 3aB**, which shows the soil texture throughout the profile, and **Figure 3aC**, which shows the trend of exchangeable cations with depth. The entire data collection for this soil type, which includes laboratory results from the 2007, 2009 and 2011 studies, can be found in **Appendix 3**.

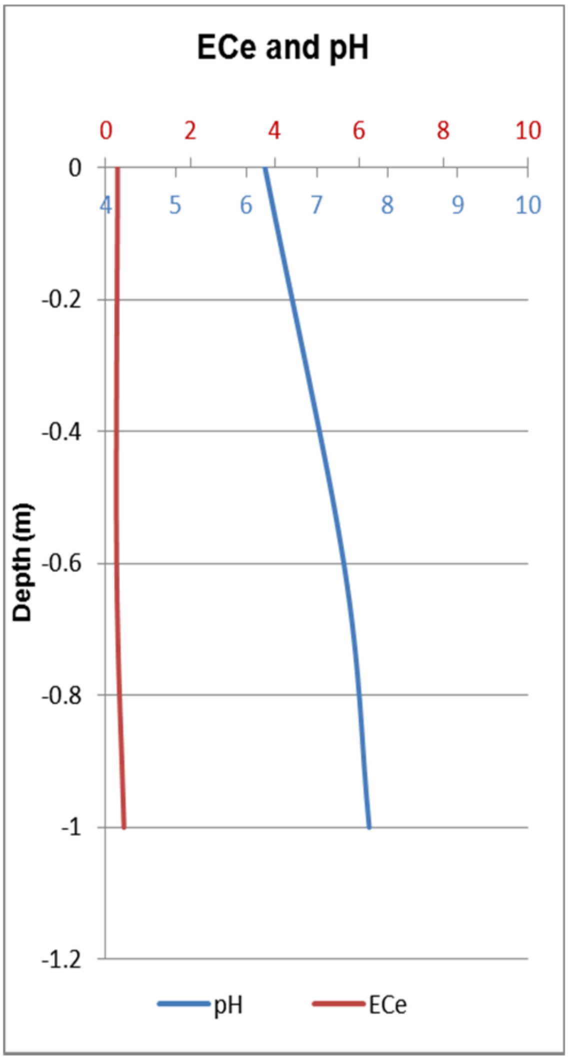



**Figure 3aA :ECe and pH profile trends**

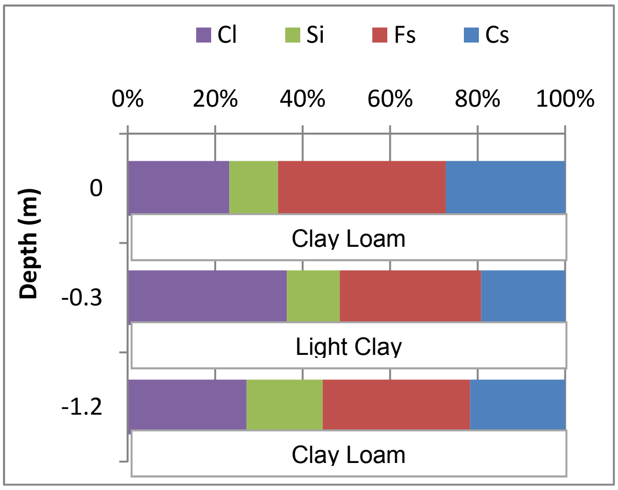



**Figure 3aB: Particle Size Analysis**

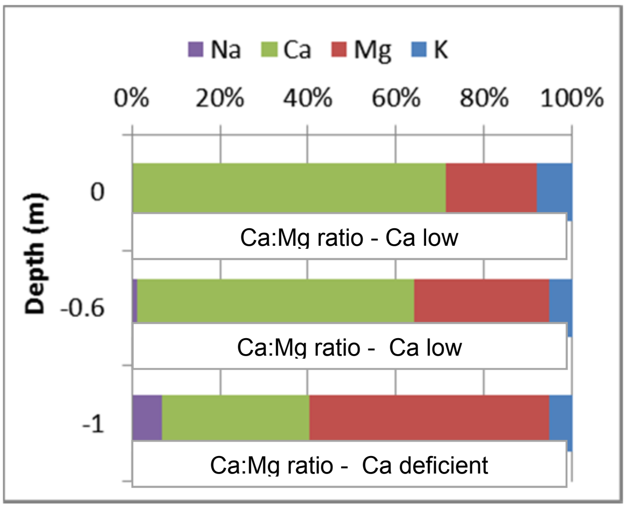



**Figure 3aC: Exchangeable Cations**

### 3.2.5 Soil Group 3b – Brown Kandosol

*Description:* The Brown Kandosol comprise deep (>1 metre) mainly massive yellow-brown earths with sandy loam to light clayey surface soils grading to light to medium or heavy clay subsoils, locally with ferruginous gravelly layers included. The topsoil is typically slightly to moderately dispersive, non-saline, though in some instances slightly saline, and mainly neutral to slightly acidic. The subsoils are moderately to strongly dispersive, generally non-saline, with some slightly to moderately saline soils present, and mildly to moderately alkaline. The analytical information of the representative site for this soil type is presented in **Table 5** below.

*Location:* This soil type occurs on gently inclined slopes to drainage lines, on flat to depressional plains, in depressional drainage ways and on gently inclined broadly rounded interfluves and low rises. They encompass an area of 402.7 hectares, or 3.3 per cent of the EIS study area as shown in **Figure 3**. This soil type is represented by site C104.

*Landuse:* The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

*Management:* Generally the topsoil does not display any specific management risk related to potential disturbance during stripping. The topsoil layer exhibits structure and chemical characteristics that would be suitable as surface cover in rehabilitation. The subsoil ranges from moderate to strongly dispersive and would require erosion control structures to be implemented if disturbed. An application of gypsum to reduce the management risks in the subsoil when stripped may be beneficial. The recommended stripping depth of this soil is 0.50 metres.

**Plate 7: Brown Kandosol Soil Profile**

**Plate 8: Brown Kandosol Landscape Setting**

**Table 5 – Brown Kandosol Laboratory Results**

| Depth | Colour | pH | | ECe | | CEC | | ESP | | EAT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | Munsell | # | Rating | % | Rating | # | Rating | % | Rating | # | Rating |
| 0 - 5 | Brown | 6.8 | Neutral | 0.38 | Non saline | 8.47 | Low | 0 | Non sodic | 5 | Slight |
| 5 - 15 | Brown | 6.8 | Neutral | 0.26 | Non saline | 5.62 | Very low | 0 | Non sodic | 3(1) | Slight |
| 15 - 50 | Brown | 6.9 | Neutral | 0.1 | Non saline | 3.8 | Very low | 0 | Non sodic | 2(1) | Moderate to high |
| 50 - 70 | Yellowish brown | 7.4 | Mildly alkaline | 0.17 | Non saline | 5.34 | Very low | 2 | Non sodic | 2(1) | Moderate to high |
| 130 - 140 | Yellowish brown | 7.9 | Moderately alkaline | 0.6 | Non saline | 7.56 | Low | 13 | Sodic | 2(1) | Moderate to high |

The Brown Kandosol profile is represented by: **Figure 3bA**, which shows the ECe and pH trend with depth, **Figure 3bB**, which shows the soil texture throughout the profile, and **Figure 3bC**, which shows the trend of exchangeable cations with depth. The entire data collection for this soil type, which includes laboratory results from the 2007, 2009 and 2011 studies, can be found in **Appendix 3**.

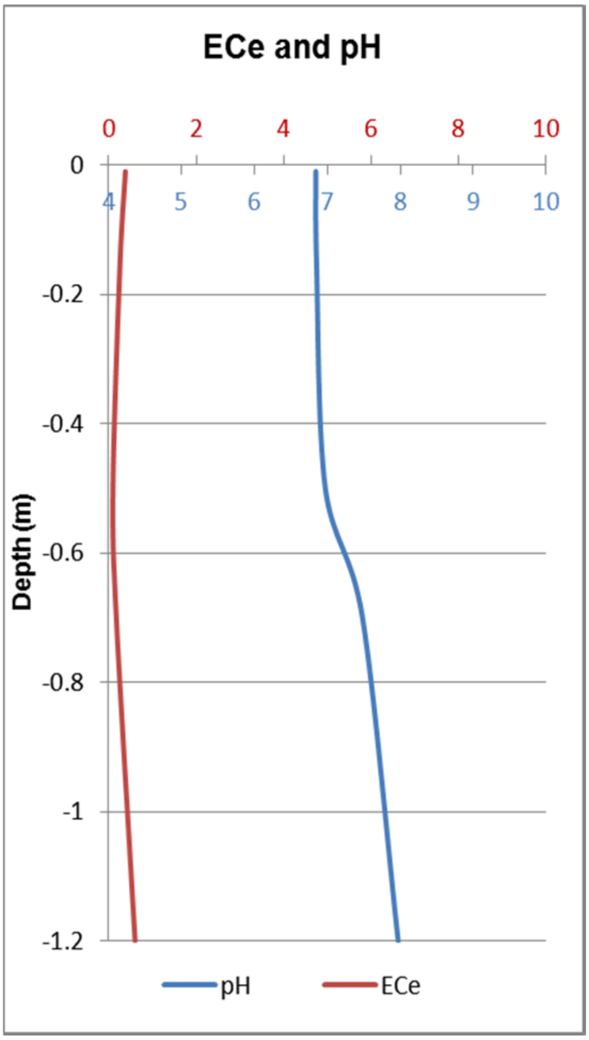



**Figure 3bA: ECe and pH profile trends**

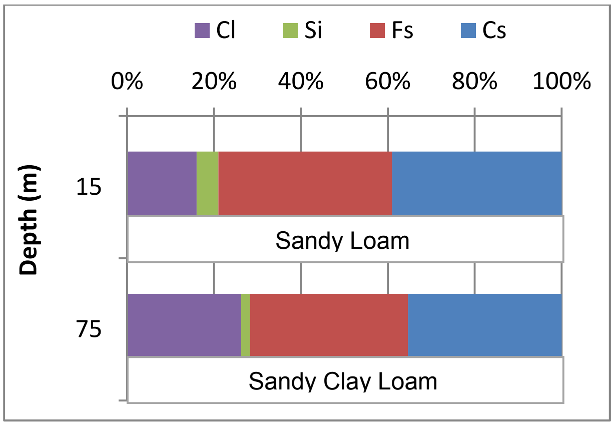



**Figure 3bB: Particle Size Analysis**

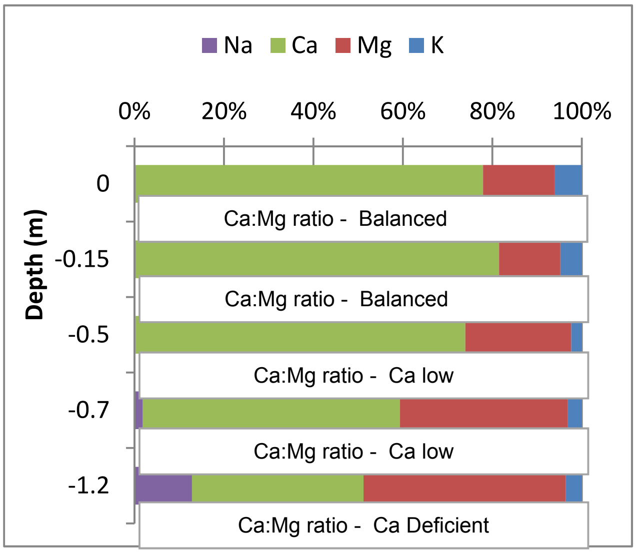



**Figure 3bC: Exchangeable Cations**

### 3.2.6 Soil Group 4 – Brown Kurosols

_Description:_ The Brown Kurosol is comprised of a deep loamy surface duplex soil with a pale gravelly clay sub-surface horizon, an acidic to strongly acidic dark brown heavy clay subsoil horizon, underlain by mottled reddish-brown and grey heavy clay lower subsoil where approaching the (very strongly acidic) weathered rock substrate. The topsoil is moderately dispersive and slightly to moderately saline with a neutral pH. The subsoil's were strongly dispersive, highly saline and highly acidic. The analytical information of the representative site for this soil type is presented in **Table 6** below.

_Location:_ This soil type occurs on gently to moderately inclined foot slopes in a small area to the north west of the EIS study area, encompassing an area of 186.7 hectares, or 1.5 per cent of the EIS study area as shown in **Figure 3**. This soil type is represented by site A77.

_Landuse:_ The land overlying these soils is currently used for extensive grazing, having been largely cleared of trees, cultivated and improved with native and exotic pasture species.

_Management:_ Generally the topsoil does not display any specific management risk related to potential disturbance during stripping. The topsoil layer exhibits structure and chemical characteristics that would be suitable as surface cover in rehabilitation. However, where stone content becomes prohibitive to re-use on rehabilitation, material should not be salvaged for that purpose. The subsoil is strongly dispersive, highly saline and highly acidic and are therefore not suitable for use as a topdressing in rehabilitation. Furthermore, erosion control measures should be implemented during the exposure of this soil. The recommended stripping depth of this soil is 0.30 metres.

**Plate 9: Kurosol Soil Profile**

**Plate 10: Kurosol Landscape setting**

**Table 6 – Brown Kurosol Laboratory Results**

| Depth | Colour | pH | | ECe | | CEC | | ESP | | EAT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | Munsell | # | Rating | % | Rating | # | Rating | % | Rating | # | Rating |
| 0 -15 | Dark brown | 7.2 | Neutral | 0.34 | Non saline | 14.8 | Moderate | 9 | Marginally sodic | 3(3) | Moderate |
| 15 - 30 | Dark brown | 7.5 | Mildly alkaline | 3.27 | Slightly saline | 22.5 | Moderate | 65 | Strongly sodic | 3(4) | Moderate |
| 60 - 80 | Dark brown | 8.4 | Moderately alkaline | 8.6 | Highly saline | 27.4 | High | 110 | Strongly sodic | 2(2) | High |
| 100 - 110 | Strong brown | 4.7 | Very strongly acid | 10.8 | Highly saline | 23.4 | Moderate | 165 | Strongly sodic | 2(2) | High |

The Brown Kandosol profile is represented by: **Figure 4A**, which shows the ECe and pH trend with depth, and **Figure 4B**, which shows the trend of exchangeable cations with depth. The entire data collection for this soil type, which includes laboratory results from the 2007 study, can be found in **Appendix 3**.

### 3.2.7 Soil Group 5 – Brown Chromosol

<u>Description:</u> The Brown Chromosol includes deep (>1 metre) mostly thick sandy and loamy surface duplex soils generally with a pale (A2) horizon over brown or yellow-brown, sometimes diffusely mottled non-sodic to marginally sodic, non-saline sandy clay or medium to heavy clay subsoils. The topsoil is structurally stable with a low potential for dispersion. The majority of topsoil is non-saline although can be slightly saline and is slightly acidic to moderately alkaline. The subsoil varies from slightly dispersive to strongly dispersive, is generally slightly to non-saline, although occasionally moderately saline, and is neutral to slightly alkaline pH value. The analytical information of the representative site for this soil type is presented in **Table 7** below.

<u>Location:</u> These soils occur on alluvial terraces and on broadly rounded rises and dissection slope interfluves, common throughout the eastern areas of the EIS study area, encompassing an area of 1861.2 hectares, or 15.1 per cent of the EIS study area as shown in **Figure 3**. This soil type is represented by C82 and C121.

<u>Landuse:</u> The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

<u>Management:</u> Generally the topsoil of this soil unit does not display any specific management risk related to potential disturbance during stripping. The clay subsoils should not be recovered or used as a surface cover in rehabilitation due to high clay content, massive structure and alkalinity. The sandy loam topsoil is considered generally suitable as a surface cover during rehabilitation. The topsoil is suitable for stripping to a depth of 0.4 metres.

**Plate 11: Chromosol Soil Profile**

**Plate 12: Chromosol Landscape Setting**

**Table 7 – Brown Chromosol Laboratory Results**

| Depth | Colour | pH | | ECe | | CEC | | ESP | | EAT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | Munsell | # | Rating | % | Rating | # | Rating | % | Rating | # | Rating |
| 0 - 15 | Dark brown | 6.4 | Slightly acid | 0.5 | Non saline | 1.79 | Very low | 0 | Non sodic | 5 | Slight |
| 15 - 40 | Dark brown | 6.5 | Slightly acid | 0.2 | Non saline | 1.13 | Very low | 0 | Non sodic | 5 | Slight |
| 40 - 100 | Dark yellowish brown | 7.1 | Neutral | 0.7 | Non saline | 11.7 | Low | 7 | Marginally sodic | 5 | Slight |

The Brown Kandosol profile is represented by: **Figure 5A**, which shows the ECe and pH trend with depth, **Figure 5B**, which shows the soil texture throughout the profile, and **Figure 5C**, which shows the trend of exchangeable cations with depth. The entire data collection for this soil type, which includes laboratory results from the 2007, 2009 and 2011 studies, can be found in **Appendix 3**.

### 3.2.8 Soil Group 6 – Brown Sodosols

Description: The Brown Sodosol comprise medium to deep hard-set thin loamy surface duplex soils usually with a pale or bleached sub-surface (A2) horizon with dark brown, yellowish-brown and in places reddish-brown, light medium to heavy clay deep subsoils. The topsoil is non-dispersive to moderately dispersive, is generally moderately saline, and the topsoil was generally neutral, or in some instances moderately acidic. The subsoils are generally highly sodic and dispersive, moderately to highly saline, and moderately acidic to moderately alkaline. The analytical information of the representative site for this soil type is presented in **Table 8** below.

Location: These soils occur on alluvial flats, back-plains and older alluvial plains, on gently inclined plains, gently undulating rises dissection and on slope interfluves and slopes to drainage, encompassing an area of 1933.7 hectares, or 15.7 per cent of the EIS study area as shown in **Figure 3**. This soil type is represented by site B40.

Landuse: The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

Management: Generally the sandy clay loam topsoil does not display any specific management risk related to potential disturbance during stripping. The clay subsoils are generally considered unsuitable for stripping, mainly due to the high sodicity and associated dispersion characteristics of Sodosols. The clay subsoils should not be recovered or used as surface cover for rehabilitation. Due to the variation in the topsoil depth, the sandy loam topsoil is considered suitable for stripping to a depth of 0.25 metres. The topsoil is believed to be suitable as a surface cover in the establishment of vegetation.

**Plate 13: Sodosol Soil Profile**

**Plate 14: Sodosol Landscape Setting**

**Table 8 – Brown Sodosol Laboratory Results**

| Depth | Colour | pH | | ECe | | CEC | | ESP | | EAT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | Munsell | # | Rating | % | Rating | # | Rating | % | Rating | # | Rating |
| 0 - 25 | Dark yellowish brown | 7 | Neutral | 0.92 | Non saline | 8.52 | Low | 0 | Non sodic | 5 | Slight |
| 25 - 50 | Dark yellowish brown | 7.4 | Mildly alkaline | 0.6 | Non saline | 12.8 | Moderate | 7 | Marginally sodic | 2 (3) | Very high |
| 50 - 90 | Yellowish brown | 8 | Moderately alkaline | 1.12 | Non saline | 15.6 | Moderate | 12 | Sodic | 2 (3) | Very high |

The Brown Kandosol profile is represented by: **Figure 6A**, which shows the ECe and pH trend with depth, **Figure 6B**, which shows the soil texture throughout the profile, and **Figure 6C**, which shows the trend of exchangeable cations with depth. The entire data collection for this soil type, which includes laboratory results from the 2007, 2009 and 2011 studies, can be found in **Appendix 3**.

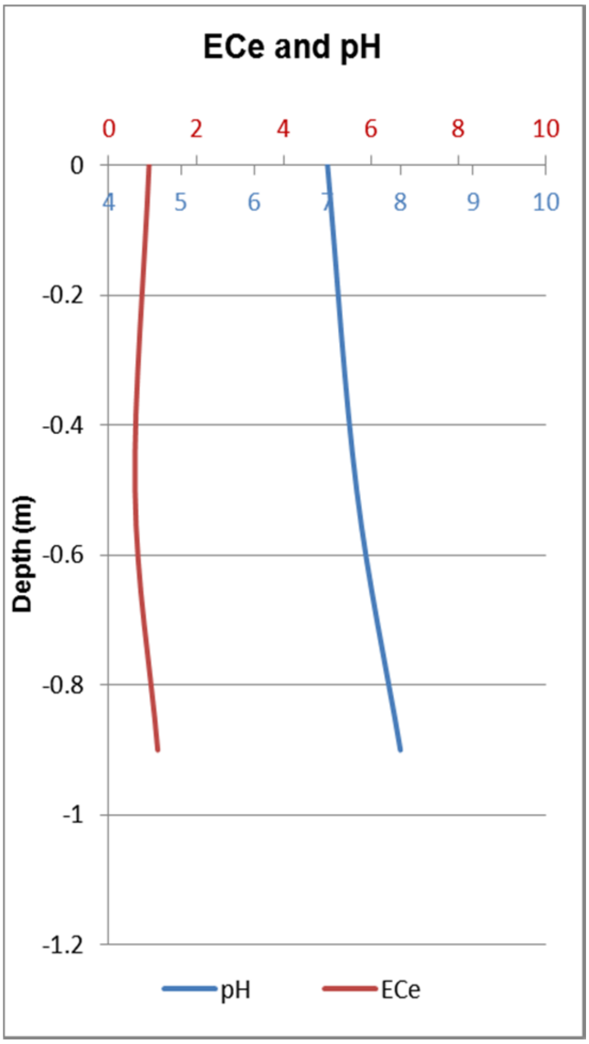



**Figure 6A: ECe and pH profile trends**

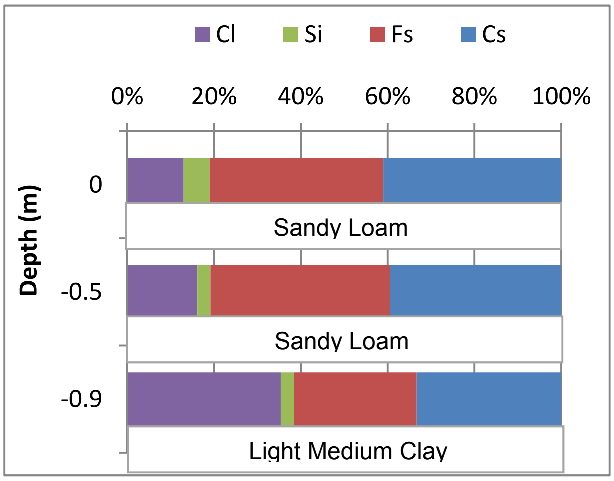



**Figure 6B: Particle Size Analysis**

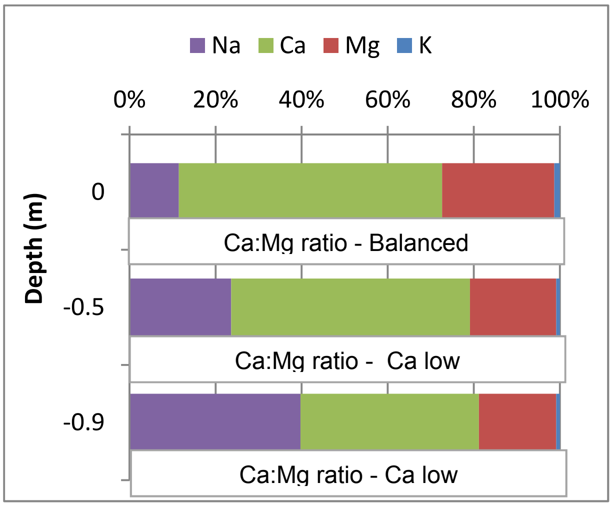



**Figure 6C: Exchangeable Cations**

### 3.2.9 Soil Group 7 – Brown Dermosols

*Description:* The Brown Dermosols generally include deep (>1 metre) mainly uniform clay soil profiles in places with a hard-set or thin weak self-mulching clay loam to medium clay surface horizon over dark brown structured clay soils (locally tending to incipient cracking clay soils); or, brown to yellow-brown weakly structured to massive, clay subsoils. The topsoil is non-dispersive to moderately dispersive, is non-saline and varied from slightly acidic to moderately alkaline, with occasionally high gravel content. The subsoils are generally moderately to highly dispersive, though are occasionally slightly to non-dispersive, are mainly saline and varied from acidic to highly alkaline. The analytical information of the representative site for this soil type is presented in **Table 9** below.

*Location:* These soils occur on alluvial plains, on depressional plains with prominent gilgai development and on older alluvial plains. The soils are common throughout the western areas of the EIS study area, encompassing an area of 984.6 hectares, or 8 per cent of the EIS study area as shown in **Figure 3**. This soil type is represented by sites B21 and C72.

*Landuse:* The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

*Management:* The topsoil is generally considered suitable for stripping for use as surface cover or intermediate layer below the surface layer in rehabilitation. The clay subsoils are considered to be unsuitable for stripping for use as surface cover due to high sodicity, moderate salinity and pH ranges generally limiting for the growth of vegetation. The recommended stripping depth for this soil is 0.2 metres.

**Plate 15: Dermosol Soil Profile**

**Plate 16: Dermosol Landscape Setting**

**Table 9 – Brown Dermosol Laboratory Results**

| Depth | Colour | pH | | ECe | | CEC | | ESP | | EAT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | Munsell | # | Rating | % | Rating | # | Rating | % | Rating | # | Rating |
| 0 - 10 | Brown | 8.3 | Moderately alkaline | 0.8 | Non saline | 20.6 | Moderate | 2 | Non sodic | 2(3) | Very high |
| 10 - 30 | Strong brown | 9.1 | Very strongly alkaline | 5.1 | Moderately saline | 27.2 | High | 19 | Strongly sodic | 2(3) | Very high |
| 30 - 120 | Strong brown | 8.5 | Strongly alkaline | 8.9 | Highly saline | 21.3 | Moderate | 44 | Strongly sodic | 2(3) | Very high |

The Brown Kandosol profile is represented by: **Figure 7A**, which shows the ECe and pH trend with depth, **Figure 7B**, which shows the soil texture throughout the profile, and **Figure 7C**, which shows the trend of exchangeable cations with depth. The entire data collection for this soil type, which includes laboratory results from the 2007, 2009 and 2011 studies, can be found in **Appendix 3**.

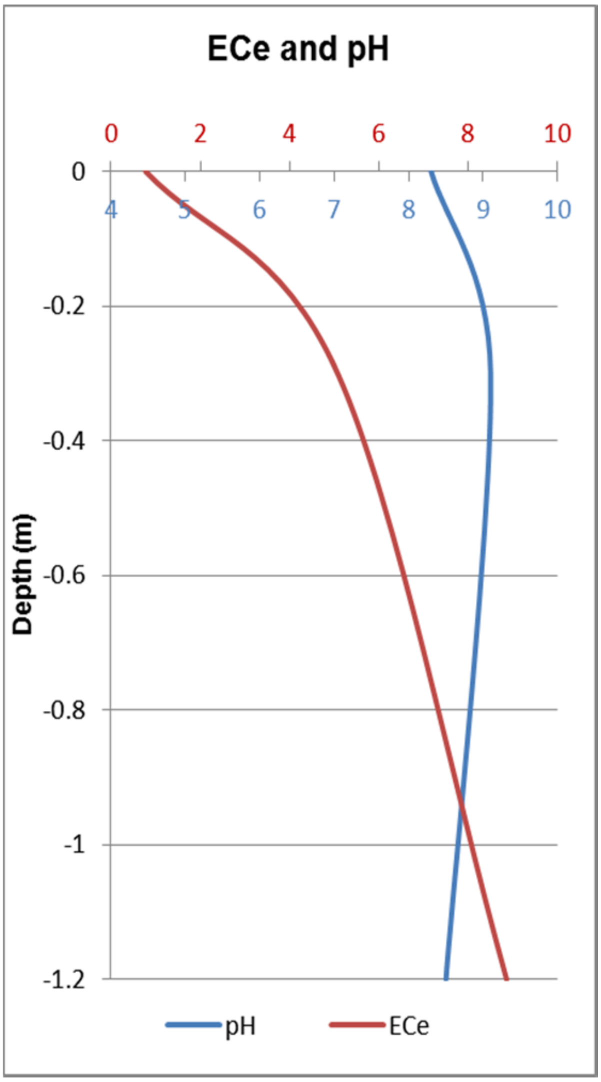



**Figure 7A: ECe and pH profile trends**

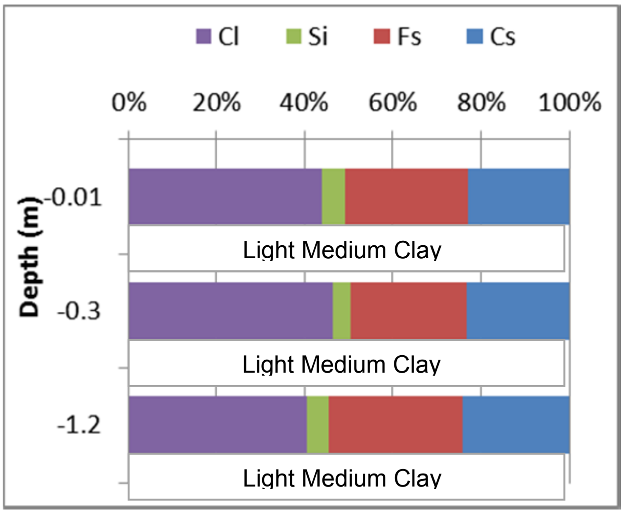



**Figure 7B: Particle Size Analysis**

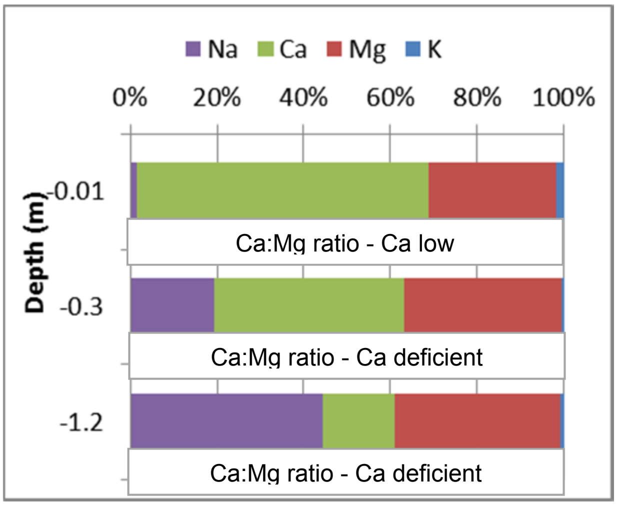



**Figure 7C: Exchangeable Cations**

### 3.2.10 Soil Group 8a – Shallow Vertosols

*Description:* The Vertosols comprises shallow to medium deep (<1 metre) cracking clay soils with a thin weak self-mulching surface soil over dark brown or brownish black sodic moderately saline heavy clay subsoils underlain by weathered rock. The topsoil is typically non-dispersive, although occasionally has moderate dispersion ratings, is non-saline to slightly saline, and neutral to slightly alkaline. The subsoils are sometimes non-dispersive, although are generally moderately to highly dispersive. They vary from non-saline to highly saline and are slightly acidic to moderately alkaline. The key characteristics of the Vertosols is their uniform medium to heavy clay texture throughout the profile, pronounced swelling and shrinkage properties on wetting and drying, and usually moderate to high levels of sodicity and/or salinity in the subsoil horizons. Unlike the Deep Vertosols, the Shallow Vertosols are not typically associated with gilgai presence. The analytical information of the representative site for this soil type is presented in **Table 10** below.

*Location:* These soils occur on undulating plains and gently to moderately inclined slopes, but mainly on crestal areas and lower slopes in strongly undulating lands and on low rocky rises associated with the Tertiary Basalt geological regime. They encompass an area of 846.7 hectares, or 6.9 per cent of the EIS study area as shown in **Figure 3**. This soil type is represented by site C54.

*Landuse:* The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

*Management:* These soils are texturally unsuitable for use as surface cover for rehabilitation.

**Plate 17: Shallow Vertosol Soil Profile**

**Plate 18: Shallow Vertosol Landscape Setting**

**Table 10 – Shallow Vertosol Laboratory Results**

| Depth | Colour | pH | | ECe | | CEC | | ESP | |
|---|---|---|---|---|---|---|---|---|---|
| cm | Munsell | # | Rate | % | Rate | # | Rate | % | Rate |
| 0 - 20 | Brownish Black | 8.2 | Moderately alkaline | 0.1 | Non saline | 38.5 | High | 0 | Non sodic |
| 20 - 40 | Brownish Black | 8.5 | Strongly alkaline | 0.2 | Non saline | 43.3 | Very high | 0 | Non sodic |

The Shallow Vertosol profile is represented by: **Figure 8aA**, which shows the ECe and pH trend with depth, **Figure 8aB**, which shows the soil texture throughout the profile, and **Figure 8aC**, which shows the trend of exchangeable cations with depth. The entire data collection for this soil type, which includes laboratory results from the 2007 and 2011 studies, can be found in **Appendix 3**.

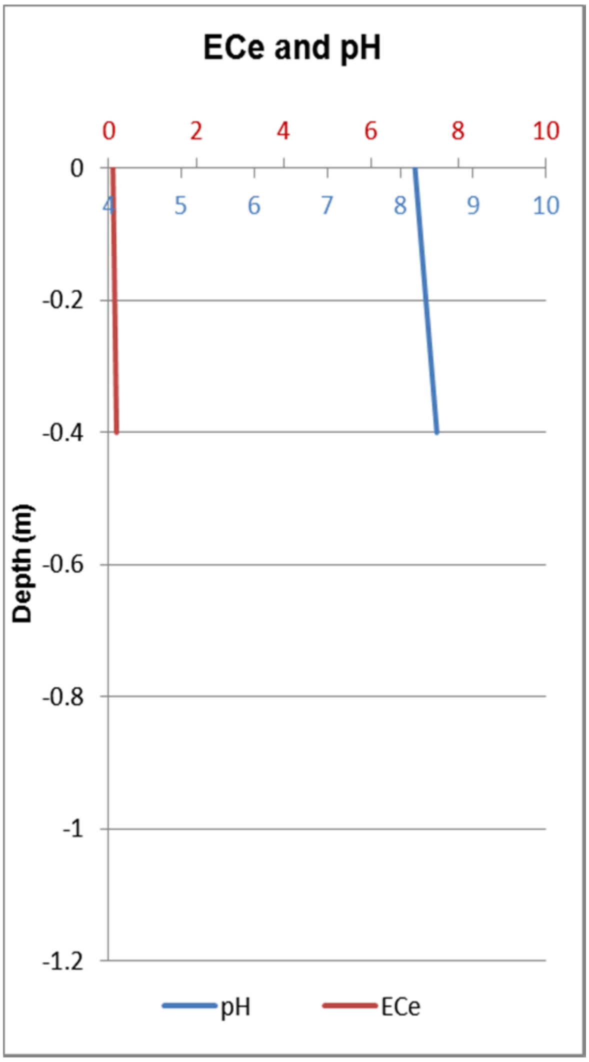



**Figure 8aA: ECe and pH profile trends**

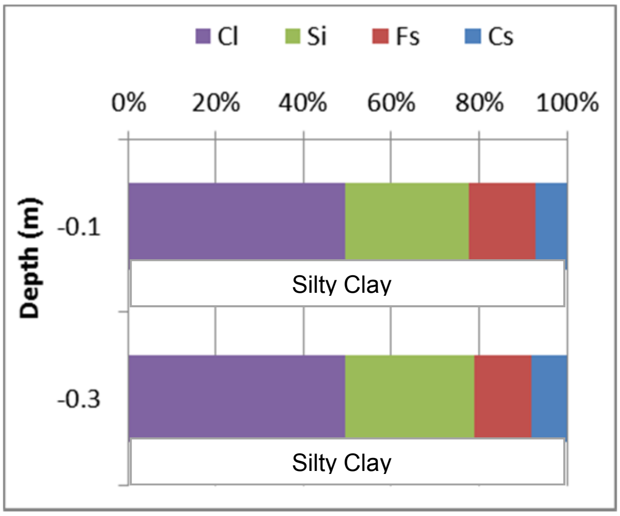



**Figure 8aB: Particle Size Analysis**

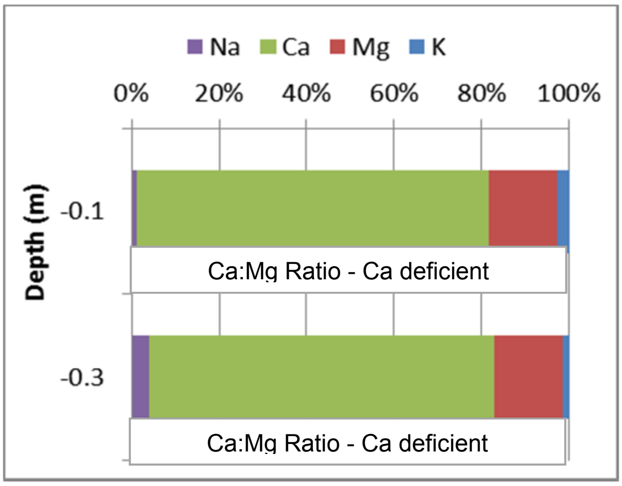



**Figure 8aC : Exchangeable Cations**

### 3.2.11 Soil Type 8b - Deep Vertosol

*Description:* Vertosols are characterised by deep (>1 metre) cracking clay soils with a thin weak self-mulching surface soil over dark brown or brown strongly structured mostly sodic heavy clay subsoils, tending to massive, strongly sodic, often calcareous heavy clay in the deeper subsoils. The topsoil is mainly non-dispersive, occasionally moderately dispersive. It varies from non-saline to moderately saline and is slightly acidic to slightly alkaline. The subsoils are generally non-dispersive to moderately dispersive, moderately saline to extremely saline, and neutral to moderately alkaline. The key characteristics of the Vertosols is their uniform medium to heavy clay texture throughout the profile, pronounced swelling and shrinkage properties on wetting and drying. The Deep Vertosols are widely associated with gilgai micro relief. The analytical information of the representative site for this soil type is presented in **Table 11** below.

*Location:* This soil type occurs extensively mainly in the northern sector of the EIS study area comprising drainage-ways, drainage flats and alluvial plain, on near level older alluvial plains and gently undulating plain, and on gently inclined slopes, foot-slopes and low rises. They encompass an area of 589.2 hectares, or 4.77 per cent of the EIS study area, as shown in **Figure 3**. This soil type is represented by observation point A10.

*Landuse:* The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

*Management:* These soils are texturally unsuitable for use as surface cover for rehabilitation.

**Plate 19: Deep Vertosol Soil Profile**

**Plate 20: Deep Vertosol Landscape Setting**

**Table 11 – Deep Vertosol Laboratory Results**

| Depth | Colour | pH | | ECe | | CEC | | ESP | | EAT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | Munsell | # | Rate | % | Rate | # | Rate | % | Rate | # | Rate |
| 0 - 20 | Very dark grey-brown | 7.06 | Neutral | 0.4 | Non saline | 62 | Very high | 1 | Non sodic | 5 | Slight |
| 20 - 60 | Very dark grey-brown | 7.45 | Mildly alkaline | 1.2 | Non saline | 65.5 | Very high | 2 | Non sodic | 5 | Slight |
| 60 - 100 | Very dark grey-brown | 8.1 | Moderately alkaline | 0.8 | Non saline | 66.9 | Very high | 3 | Non sodic | 5 | Slight |
| 110 - 170 | Very dark grey-brown | 8.12 | Moderately alkaline | 1.9 | Non saline | 69.3 | Very high | 4 | Non sodic | 5 | Slight |

The Deep Vertosol profile is represented by: **Figure 8bA**, which shows the ECe and pH trend with depth, and **Figure 8bB**, which shows the trend of exchangeable cations with depth. The entire data collection for this soil type, which includes laboratory results from the 2007and 2009 studies, can be found in **Appendix 3**.

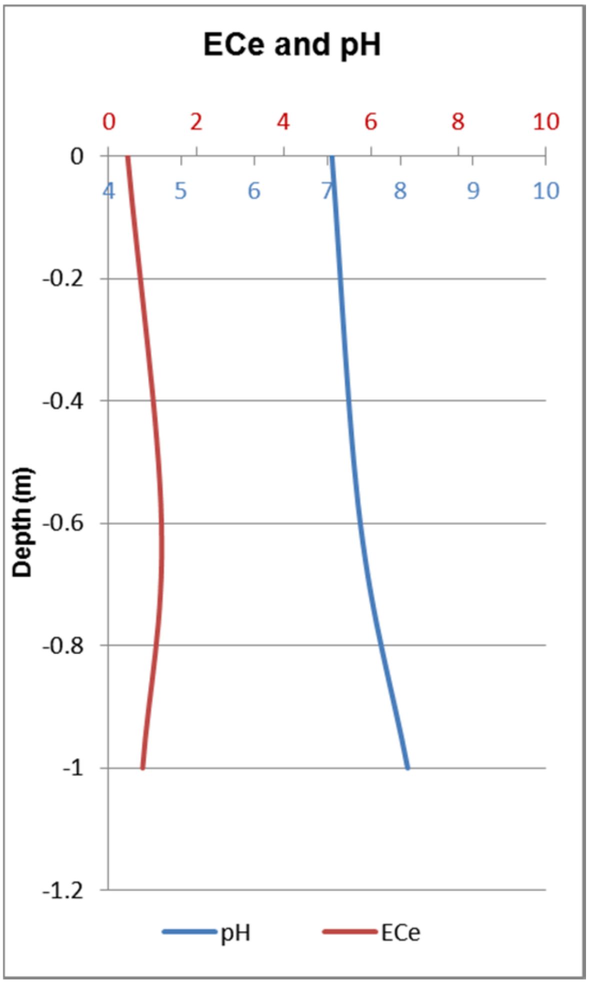



**Figure 8bA: ECe and pH profile trends**

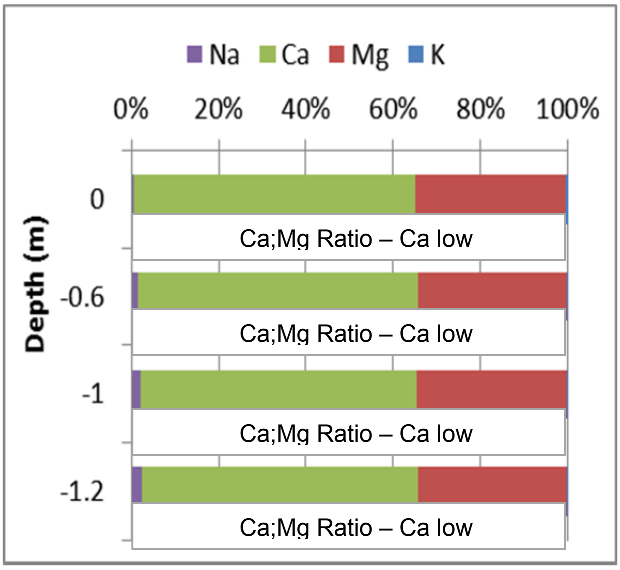



**Figure 8bB: Exchangeable**

### 3.2.12 Soil Group 8c – Deep Salic Vertosols

*Description:* Vertosols are characterised by deep (>1 metre) cracking clay soils mostly with self-mulching surface soils over dark grey-brown or brownish black strongly structured heavy clay subsoils with shiny slickensides surfaces tending to massive calcareous, marginally to highly saline heavy clay in the deeper subsoils. The topsoil is mainly non-dispersive, varies from non-saline to high saline and is moderately acidic to moderately alkaline. The subsoil is mainly non-dispersive, occasionally moderately dispersive, is moderately saline to extremely saline and neutral to moderately alkaline. The key characteristics of the Deep Vertosols are: their uniform medium to heavy clay texture throughout the profile, pronounced swelling and shrinkage properties on wetting and drying, and usually moderate to high levels of sodicity and/or salinity in the subsoil horizons. The Deep Salic Vertosols are widely associated with gilgai micro relief. The analytical information of the representative site for this soil type is presented in **Table 12** below.

*Location:* This soil type occurs extensively in the EIS study area and is particularly common in the north eastern areas, comprising drainage-ways, drainage flats and alluvial plain, on near level older alluvial plains and gently undulating plain, and on gently inclined slopes, foot-slopes and low rises. They encompass an area of 589.2 hectares, or 4.77 per cent of the EIS study area, as shown in **Figure 3**. This soil type is represented by pit B35.

*Landuse:* The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

*Management:* These soils are texturally unsuitable for use as surface cover for rehabilitation. Potential for these soils to impact on infrastructure such as the incidental mine gas management infrastructure should be assessed as part of detailed design, and management such as use of hydrated lime may be required.

**Plate 21: Deep Salic Vertosol Soil Profile**

**Plate 22: Deep Salic Vertosol Landscape Setting**

**Table 12 – Deep Salic Vertosol Laboratory Results**

| Depth | Colour | pH | | ECe | | CEC | | ESP | | EAT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | Munsell | # | Rate | % | Rate | # | Rate | % | Rate | # | Rate |
| 0 - 0.15 | Dark brown | 7.1 | Neutral | 0.86 | Non saline | 21.8 | Moderate | 1 | Non sodic | 5 | Slight |
| 0.15 - 0.4 | Dark brown | 8.4 | Moderately alkaline | 2.06 | Slightly saline | 38.6 | High | 2 | Non sodic | 5 | Slight |
| 0.4 - 0.9 | Dark brown | 8.4 | Moderately alkaline | 5.25 | Moderately saline | 37.8 | High | 7 | Marginally sodic | 5 | Slight |

The Deep Salic Vertosol profile is represented by: **Figure 8cA**, which shows the ECe and pH trend with depth, **8cB**, which shows the soil texture throughout the profile, and **Figure 8cC**, which shows the trend of exchangeable cations with depth. The entire data collection for this soil type, which includes laboratory results from the 2007, 2009 and 2011 studies, can be found in **Appendix 3**.

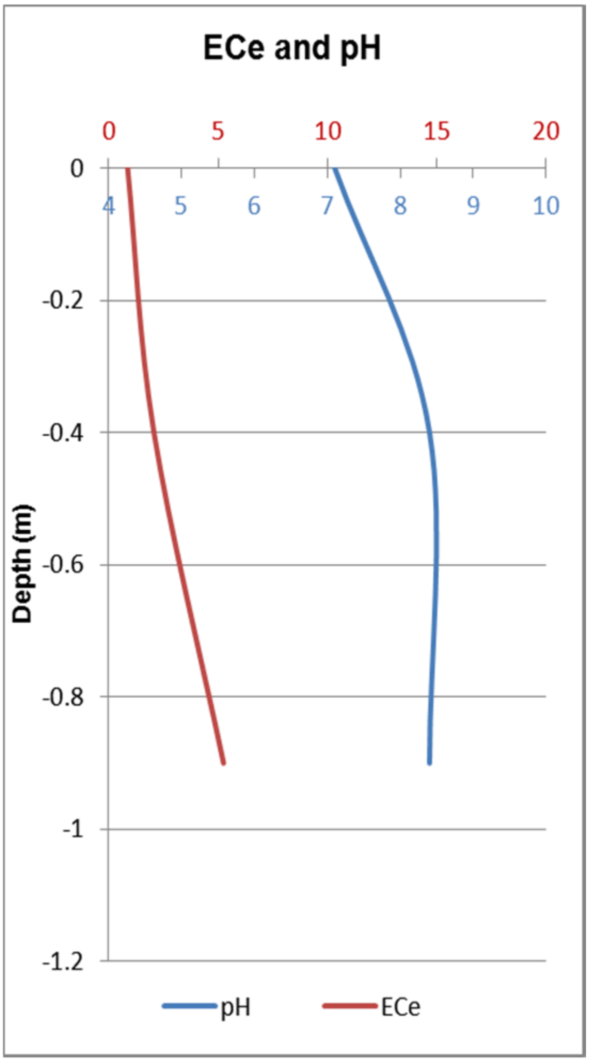



**Figure 8cA : ECe and pH profile trends**

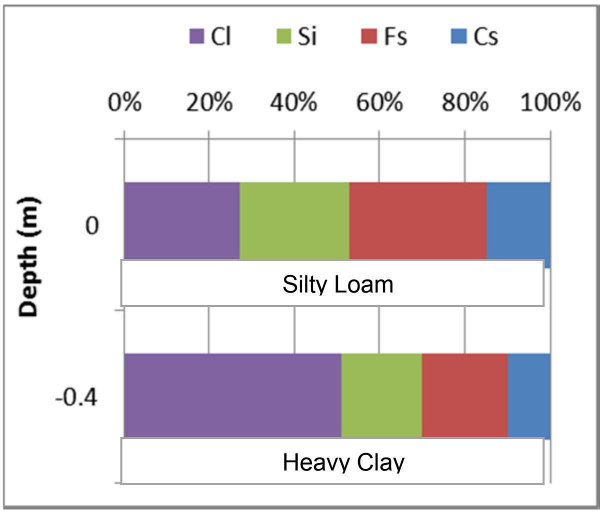



**Figure 8cB : Particle Size Analysis**

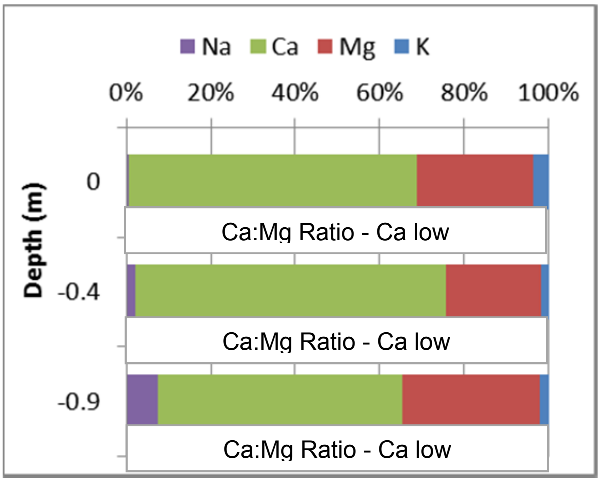



**Figure 8cC: Exchangeable Cations**

# 4.0 AGRICULTURAL LAND ASSESSMENT

Land is assessed for its suitability for agricultural activities and its relative agricultural importance for the region. This comprises a two part process. Firstly, the EIS study area's overall suitability ranking for each soil type is determined in accordance with the Department of Environment and Heritage Protection (formerly DERM) land suitability classification system (**Section 4.1**). Secondly, these suitability rankings are interpreted using the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI 1993) and translated into ALC (**Section 4.2**). These land classes are subsequently compared against the local shire planning document to determine which classes are considered to be Good Quality Agricultural Land (GQAL) for the specific region (**Section 4.3**). Land Assessment is carried out for both pre and post- mining circumstances.

## 4.1 Land Suitability Assessment

Agricultural land suitability of the EIS study area has been assessed largely using criteria provided in the *Guidelines for agricultural land evaluation in Queensland* (DPI 1990). The method of land suitability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses. The classification does not necessarily reflect the existing land use. Rather, it indicates the potential of the land for such uses as crop production, pasture improvement and grazing. The system allows for land to be allocated into five possible classes (with land suitability for productive agriculture decreasing progressively from Class 1 to Class 5) on the basis of a specified land use that allows optimum production with minimal degradation to the land resource in the long term. Land is considered less suitable as the severity of limitations for a land use increases. Increasing limitations may reflect any combination of:

- Reduced potential for production;
- Increased inputs to achieve an acceptable level of production; and/or
- Increased inputs required to prevent land degradation.

The agricultural land suitability classes are described in **Table 13**.

**Table 13 – Scheme for Classifying Land Suitability**

| LS Class | Orders | LS Class Descriptor | Description |
|---|---|---|---|
| 1 | S<br>Suitable | S1<br>None/Minor Limitations<br>(Highly Suitable) | Land with negligible limitations, which is highly productive requiring only simple management practices to maintain economic production. |
| 2 | | S2<br>Minor Limitations<br>(Moderately Suitable) | Land with minor limitations which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production. |
| 3 | | S3<br>Moderate Limitations<br>(Marginally suitable) | Land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production. |

| LS Class | Orders | LS Class Descriptor | Description |
|---|---|---|---|
| 4 | N<br>Not Suitable | N1 (or S4)<br>Marginal Land<br>(Presently Unsuitable) | Marginal lands with severe limitations which make it doubtful whether the inputs required achieving and maintaining production outweigh the benefits in the long term (presently considered unsuitable due to the uncertainty of the land to achieve sustained economic production) |
| 5 | | N2 (or S5)<br>Unsuitable | Unsuitable land with extreme limitations that preclude its use for the proposed purpose. |

Source: NCST 2008.

A land suitability assessment provides an analysis on how 'fit' a given area of land is for a specific type of land utilisation (e.g. rainfed cropping or grazing). The analysis considers the area's land use characteristics (e.g. soil pH), land quality attributes (e.g. moisture availability) and how these match conditions that are necessary for 'successful and sustained' implementation of a specific land utilisation type (NCST 2008; DME 1995; Shields and Williams 1991).

GSSE's land suitability analysis provides a proportional land suitability assessment whereby each soil type's characteristics and attributes are cross-referenced against the Queensland Department of Mines & Energy (DME) (1995) 'criteria checklist' for 'rainfed broadacre cropping' and 'beef cattle grazing'. The overall land suitability ranking for each specific soil type is determined by the most severe limitation, or a combination of the varying limitations. For this reason the major limiting factors determining land suitability will be presented.

### 4.1.1 Calculation of Plant Available Water Capacity and Effective Rooting Depth

The primary land suitability assessment attribute is 'moisture'. The indicator for moisture is plant available water capacity (PAWC). PAWC is an estimate of the amount of moisture stored in the soil profile that is available for plant extraction. It is generally defined as the difference between field capacity and permanent wilting point. PAWC is calculated for the soil profile by summing the available water capacity values at regular intervals for the distance of the soil's effective rooting depth (ERD).

ERD is defined as the soil depth to which 90 per cent of the plant roots will extract water (Burgess 2005). ERD can be estimated through observed rooting depth, soil chemical parameters or a standardised depth can be used (McKenzie *et al* 2008). For the purposes of this project, area assessment ERD has been determined from both observed rooting depth and the chemical parameters as defined in **Table 14**.

**Table 14 – Effective Rooting Depth Criteria**

| Limitation # | Descriptor | ERD occurs where: |
|---|---|---|
| 1 | $EC_{1:5}$ for sorghum and wheat[1] (90% yield reduction threshold) | >0.8 dS/m |
| 2 | Chlorine (Cl) 1:5 | >1000 ppm |
| 3 | ESP | >20% where clay content is >25% |
| 4 | pH | <5.5 |
| 5 | Depth to C horizons | -- |
| 6 | Unsuitable subsoil structure | moderate or strong columnar structure, sandy free draining horizons, significant rock content |

Source: Burgess 2003

PAWC can be directly measured in the field, estimated from textural classes or interpolated using a Queensland approved software program (PAWCER). GSSE calculated PAWC using the PAWCER software program for each soil unit. Each soil unit's PAWC is detailed in **Table 15**. These values are used in the Land Suitability Assessment.

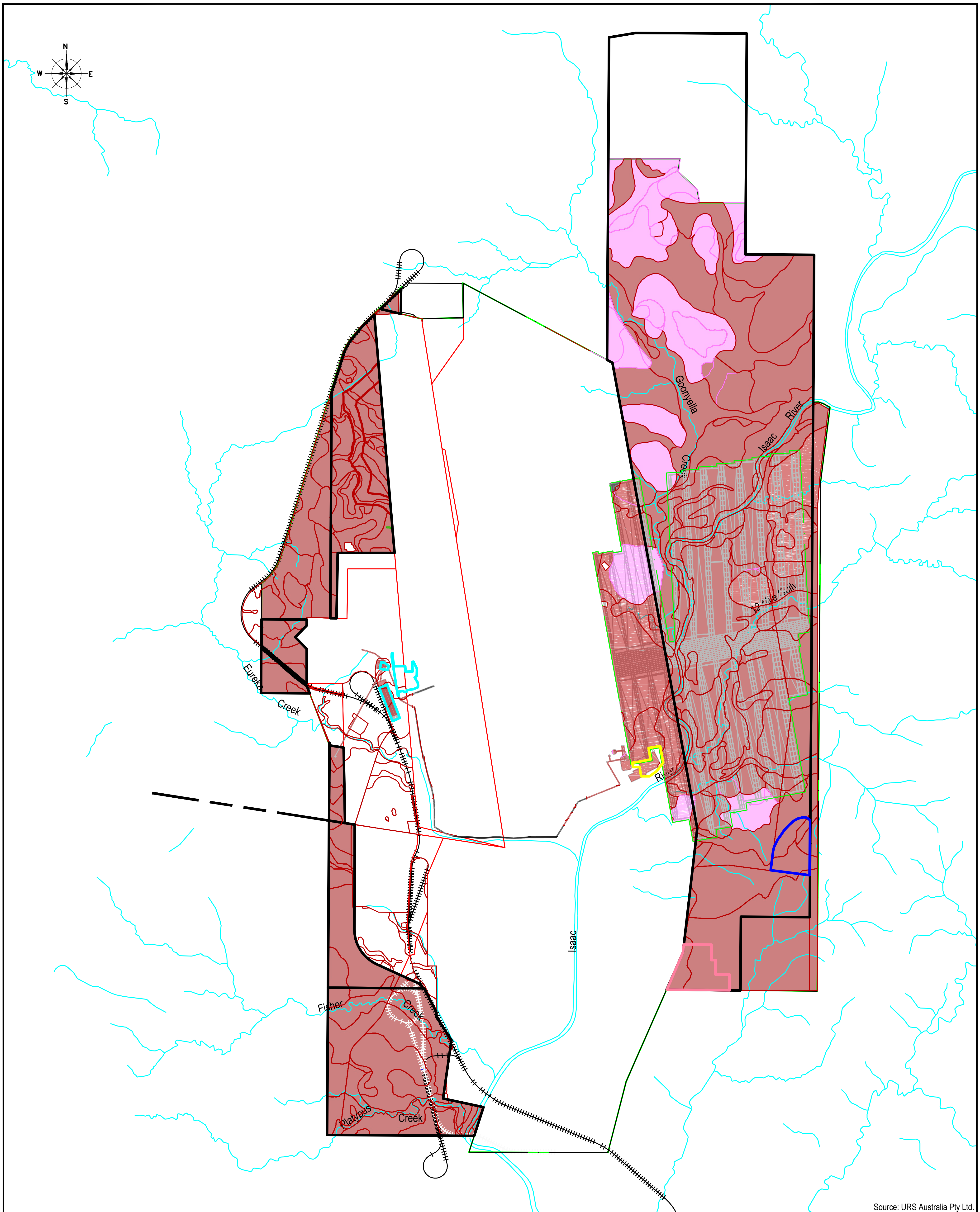
**Table 15 – Effective Rooting Depth (ERD), Available Water Capacity (AWC) and PAWC**

| Soil Unit | Horizon | Limitation/s | Average ERD Depth (cm) | Average AWC (mm) | Average PAWC (mm) |
|---|---|---|---|---|---|
| **1. Lithic Rudosol** | 1 | - | n/a | n/a | n/a |
| | | **Total** | **0** | **0** | **0** |
| **2. Tenosol** | 1 | none | 40 | 64 | 64 |
| | 2 | 6 | 40 | 64 | 0 |
| | | **Total** | **80** | **128** | **64** |
| **3a. Red Kandosol** | 1 | 2 | 20 | 48 | 48 |
| | 2 | 2 | 40 | 52 | 52 |
| | 3 | 1,2 | 40 | 96 | 96 |
| | | **Total** | **100** | **196** | **196** |
| **3b. Brown Kandosol** | 1 | none | 30 | 48 | 48 |
| | 2 | none | 50 | 80 | 80 |
| | | **Total** | **80** | **128** | **128** |
| **4. Brown Kurosol** | 1 | none | 15 | 19.5 | 19.5 |
| | 2 | none | 15 | 19.5 | 19.5 |
| | 3 | 1, 2, 3 | 30 | 36 | 0 |
| | 4 | 1, 3, 4 | 50 | 60 | 0 |
| | | **Total** | **110** | **39** | **39** |
| **5. Brown Chromosol** | 1 | none | 15 | 30 | 30 |
| | 2 | none | 25 | 50 | 50 |
| | 3 | none | 60 | 78 | 78 |
| | | **Total** | **100** | **158** | **158** |
| **6. Brown Sodosol** | 1 | none | 25 | 50 | 50 |
| | 2 | none | 25 | 50 | 50 |
| | 3 | none | 40 | 52 | 52 |
| | | **Total** | **90** | **152** | **152** |

| | | | | | |
|---|---|---|---|---|---|
| **7. Brown Dermosol** | 1 | none | 10 | 13 | 13 |
| | 2 | none | 20 | 26 | 26 |
| | 3 | 1, 2, 3 | 90 | 117 | 0 |
| **Total** | | | **120** | **156** | **39** |
| **8a. Shallow Vertosols** | 1 | none | 20 | 24 | 24 |
| | 2 | none | 20 | 24 | 24 |
| | 3 | none | 60 | 72 | 72 |
| **Total** | | | **100** | **120** | **120** |
| **8b. Deep Vertosols** | 1 | none | 20 | 26 | 26 |
| | 2 | none | 40 | 52 | 52 |
| | 3 | none | 50 | 65 | 65 |
| | 4 | none | 60 | 78 | 78 |
| **Total** | | | **170** | **221** | **221** |
| **8c. Deep Salic Vertosols** | 1 | 3 | 15 | 19.5 | 0 |
| | 2 | 3 | 30 | 39 | 0 |
| | 3 | 3 | 75 | 97.5 | 0 |
| **Total** | | | **120** | **156** | **0** |

### 4.1.2 Land Suitability Rankings

The EIS study area's soil units have been assessed against the criteria for 'rainfed cropping' and 'broadacre grazing' land utilisation types as per the guidelines. The first limitation for land utilisation is moisture and each soil unit's average PAWC is provided in **Table 16**. The adjusted water availability value considers soil characteristics as well as the requirement for adequate rainfall which is required for sustainable yields. Where soil units have been classified as unsuitable for cropping (**Table 16**), these soil units have been subsequently assessed for their suitability for pastoral activities (refer **Table 17**). **Figure 9** and **Figure 10** illustrate their spatial distribution.




Source: URS Australia Pty Ltd.

LEGEND

- Project Site
- BMA ML & MLA Boundaries - Dec 2008
- Rail Line
- Proposed Mining Lease
- MIA (30.2)
- Broadmeadow Extension (131.35 ha)
- CHPP (53.9 ha)
- Accommodation Village (108.7 ha)

Land Suitability - Cropping

- Class 4
- Class 5

0 2.0 4.0km

Base Plan Data Source: RWC & Geo-spectrum (Australia) Pty Ltd.

| Version | Date: | Author: | Checked: | Approved: |
|---|---|---|---|---|
| 2 | 23/11/11 | ZJ | MH | CR |
| 3 | 30/11/11 | ZJ/LF | MH | CR |
| 4 | 1/12/11 | LF | MH | CR |
| 5 | 6/12/11 | LF | AR | CR |
| 6 | 02/02/12 | RH | RH | CR |
| 7 | 12/06/13 | LF | AK | CR |

# FIGURE 9

## Land Suitability - Cropping

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project:
Red Hill Mining Lease EIS

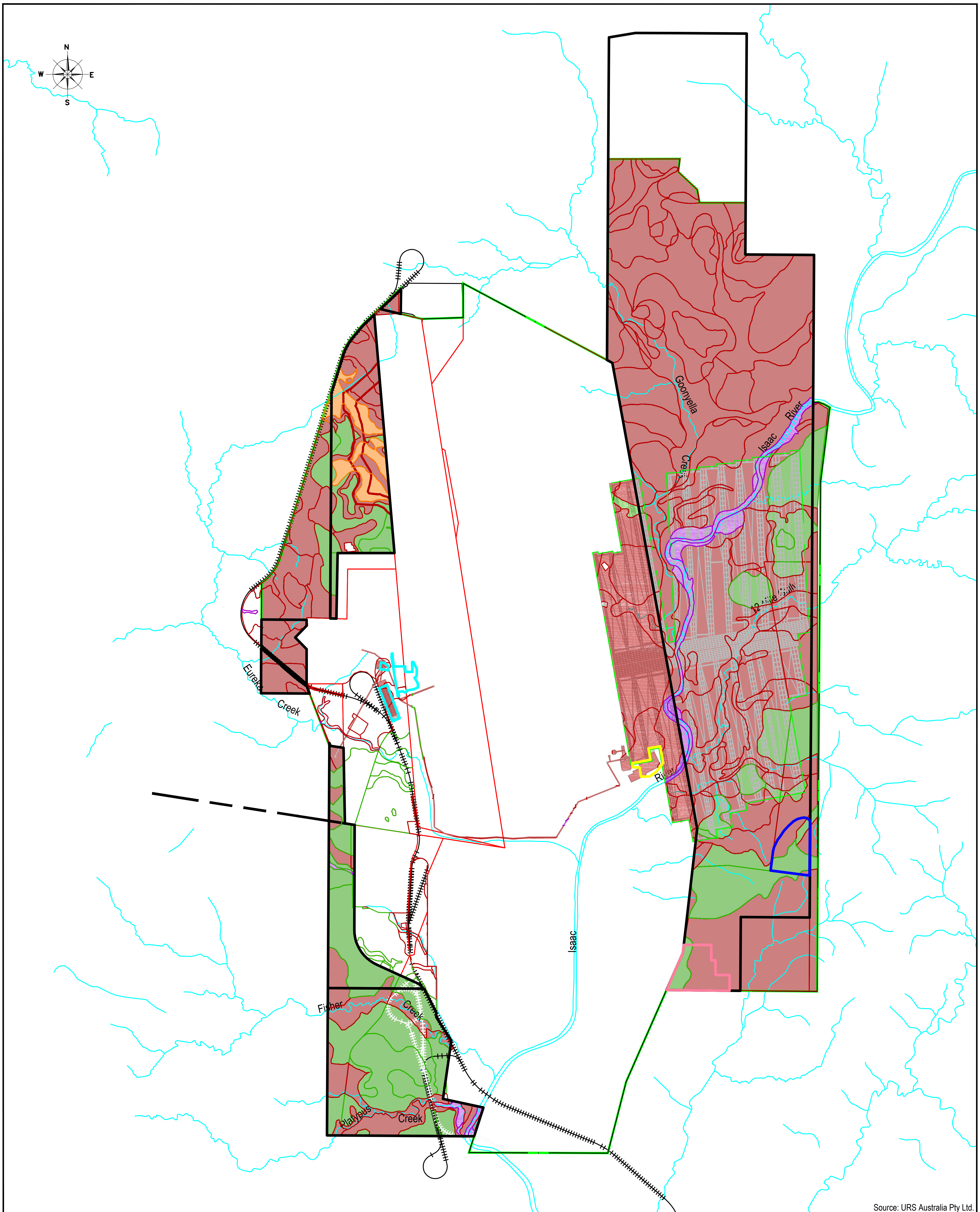
Client:
URS Australia Pty Ltd

File:
Fg9_URS03-029_LandSuitability-Cropping_130822

Projection:
MGA 94 Zone 55

V:\URS03-029\Figures\Final\CAD\August 2013 Update\Fg9_URS03-029_LandSuitability-Cropping_130822.dwg

*To be printed A3*




LEGEND

- Project Site
- BMA ML & MLA Boundaries - Dec 2008
- Rail Line
- Proposed Mining Lease
- MIA (30.2)
- Broadmeadow Extension (131.35 ha)
- CHPP (53.9 ha)
- Accommodation Village (108.7 ha)

Land Suitability - Grazing

- Class 2
- Class 3
- Class 4
- Class 5

0 2.0 4.0km

Base Plan Data Source: RWC & Geo-spectrum (Australia) Pty Ltd.

| Version | Date: | Author: | Checked: | Approved: |
|---|---|---|---|---|
| 2 | 23/11/11 | ZJ | MH | CR |
| 3 | 30/11/11 | ZJ/LF | MH | CR |
| 4 | 1/12/11 | LF | MH | CR |
| 5 | 6/12/11 | LF | AR | CR |
| 6 | 02/02/12 | RH | RH | CR |
| 7 | 12/06/13 | LF | AK | CR |

## FIGURE 10

Land Suitability - Grazing

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project: Red Hill Mining Lease EIS

Client: URS Australia Pty Ltd

File: Fg10_URS03-029_LandSuitability-Grazing_130822

Projection: MGA 94 Zone 55

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**Table 16 – Land Suitability Ranking for Rainfed Broadacre Cropping**

| Limitations | Soil Types | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3a | 3b | 4 | 5 | 6 | 7 | 8a | 8b | 8c |
| Tabled Water availability | n/a | **5** | 1 | 2 | **5** | 1 | 1 | **5** | 3 | 1 | **5** |
| Adjusted Water availability | 5 | 5 | 5 | 5 | 5 | 5 | 5 | **5** | 4 | 4 | 5 |
| Nutrient deficiency | n/a | n/a | 2 | 3 | 2 | 2 | 2 | **5** | 2 | 2 | 2 |
| Soil physical factors | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| Soil workability | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 |
| Salinity | n/a | n/a | 1 | 1 | **5** | 1 | 1 | **4** | 1 | 1 | 1 |
| Rockiness | **4** | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| Microrelief | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| Wetness | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 | 2 | 3 | 3 |
| Topography | 1 | 1 | 2 | 2 | 1 | 2 | 3 | 1 | 1 | 1 | 1 |
| Water erosion | **4** | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 |
| Flooding | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Overall Ranking:** | **5** | **5** | **5** | **5** | **5** | **5** | **5** | **5** | **4** | **4** | **5** |
| **Soil Type Suitable?** | **No** | **No** | **No** | **No** | **No** | **No** | **No** | **No** | **Marginal** | **Marginal** | **No** |

**Table 17 – Land Suitability Ranking for Beef Cattle Grazing**

| Limitations | Soil Types | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3a | 3b | 4 | 5 | 6 | 7 | 8a | 8b | 8c |
| Water availability | n/a | **4** | 1 | 1 | **5** | 1 | 1 | 5 | 2 | 1 | 5 |
| Nutrient deficiency | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| Soil physical factors | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| Salinity | n/a | n/a | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 |
| Rockiness | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| Microrelief | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| pH | n/a | n/a | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| ESP % | n/a | n/a | 1 | 1 | 2 | 1 | 1 | 4 | 1 | 2 | 3 |
| Wetness | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| Topography | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Water erosion | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 |
| Flooding | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Vegetation regrowth | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Overall Ranking:** | **3** | **4** | **2** | **2** | **5** | **2** | **3** | **3*** | **3** | **3** | **3*** |
| **Soil Type Suitability** | **Yes** | **No** | **Yes** | **Yes** | **No** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** |

** Modified due to field observations.*

### 4.1.3 Post-mining Land Suitability

The proposed post-mining land use for the EIS study area is expected to be a mosaic of grassland and bushland as it is now, however given the proposed post mining landform there will also be areas of ponding throughout the disturbance footprint. In terms of soil conservation and agricultural land suitability, there is minimal planned disturbance over the areas suitable for rainfed cropping. However, disturbance within the RHM, which is dominated by grazing land, is anticipated to include subsidence of longwall panels on average three to five metres and up to six metres, and surface disturbance for gas drainage infrastructure. The proposed disturbances are predicted to have an impact on the land suitability classes associated with beef cattle grazing, as outlined in **Table 18** below and shown in **Figure 11**.

**Table 18 – Land Suitability Pre and Post Mining**

| Land Suitability Class (Beef Cattle Grazing) | Existing Area External ML | Existing Area Internal ML | Post Mining Area External ML | Post Mining Area Internal ML |
|---|---|---|---|---|
| | ha | ha | ha | ha |
| 2 | 3886.8 | 17.1 | 3838.2 | 7.6 |
| 3 | 7002.7 | 955.3 | 6665.2 | 813.9 |
| 4 | 269.51 | 25.2 | 260.71 | 25.2 |
| 5 | 135.44 | nil | 530.34 | 150.9 |
| **Total Area** | **11,294.45** | **997.5** | **11,294.45** | **997.5** |

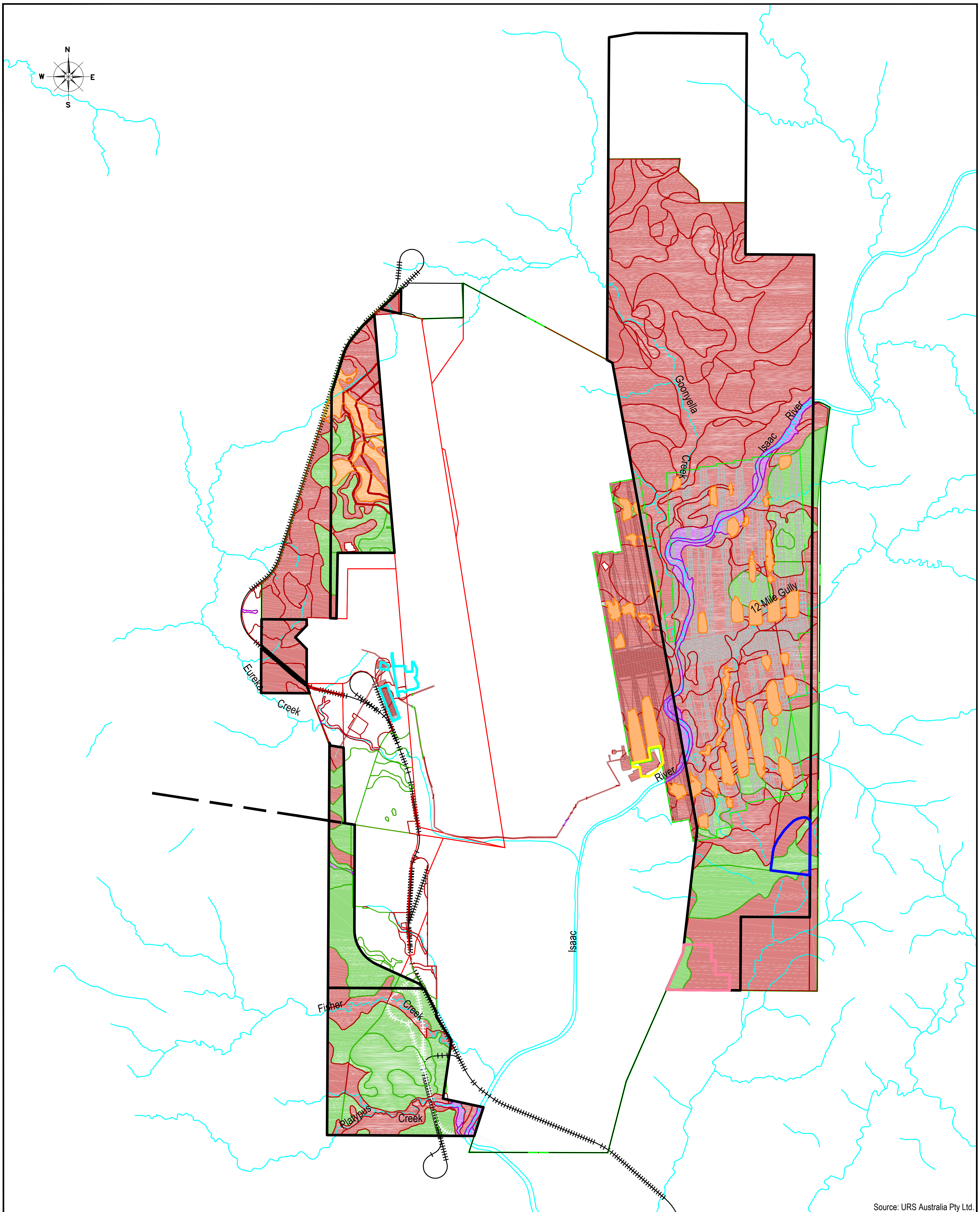
According to the Red Hill Mining lease EIS Section 7, the mapped potential ponding extent represents the worst case scenario. The ponding modelling assumes that no works are undertaken to drain or partially drain the voids, no erosion occurs along the overflow flowpaths, and no sedimentation occurs in the voids. It is expected that if no drainage works are undertaken, their storage capacities could gradually diminish overtime as erosion of the overflow flowpaths occurs, and sediment is deposited in the voids, similar to the processes described in the subsidence impacts on Isaac River geomorphology in **Section 7.2.6**, however there will be no change to the surface area of the ponds shown in **Figure 11** as Land Suitability Class 5 and **Figure 12** as ALC D.

Despite these relatively simple assumptions to define a worst case scenario for potential ponding in the subsidence voids, the mapped potential ponding extents were considered a reasonable basis to assess worst case potential impacts of ponding on Land Suitability and ALC.

The mapping of potential subsidence void ponding extents and volumes (outside the Isaac River channel) identified 44 significant ponding areas (larger than two hectares). The areas of potential ponding would be up to 40 hectares, and the average area would be approximately 12 hectares.

In order to sustain the desired land use without degradation, it is important that the post-mining land only be used in accordance with the limits of the land suitability class. Soil conservation practices such as erosion and sediment control, stocking rate control and establishment or re-establishment of permanent pasture are recommended for areas of mining impact. The overriding principle is to maintain the most beneficial future use of land that can be sustained in view of the range of limiting factors. The proposed post-mining land must provide and sustain a sufficient bulk of nutritious forage in addition to the following management considerations in the event of future low density grazing:

- The ability to access and manage livestock;
- Flood free and relatively dry ground conditions in non-ponded areas;
- Adequate stock drinking water and shelter; and
- Stock routes throughout the land.




LEGEND

- Project Site
- BMA ML & MLA Boundaries - Dec 2008
- Rail Line
- Proposed Mining Lease
- MIA (30.2)
- Broadmeadow Extension (131.35 ha)
- CHPP (53.9 ha)
- Accommodation Village (108.7 ha)

Land Suitability - Grazing

- Class 2
- Class 3
- Class 4
- Class 5

0 2.0 4.0km

Base Plan Data Source: RWC & Geo-spectrum (Australia) Pty Ltd.

| Version | Date: | Author: | Checked: | Approved: |
|---|---|---|---|---|
| 2 | 23/11/11 | ZJ | MH | CR |
| 3 | 30/11/11 | ZJ/LF | MH | CR |
| 4 | 1/12/11 | LF | MH | CR |
| 5 | 6/12/11 | LF | AR | CR |
| 6 | 02/02/12 | RH | RH | CR |
| 7 | 14/03/12 | LF | CR | CR |
| 8 | 13/06/12 | LF | AK | CR |

# FIGURE 11

## Post Mining Land Suitability - Grazing

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Environmental, Land and Project Management Consultants

Project: Red Hill Mining Lease EIS

Client: URS Australia Pty Ltd

File: Fg11_URS03-029_PostLS-Grazing_130822

Projection: MGA 94 Zone 55

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## 4.2 Agricultural Land Class Assessment & GQAL

The EIS study area was also assessed against the ALC system, which is used to identify potential GQAL in accordance with the *Guidelines for the identification Good Quality Agricultural Land* (DPI 1993) (referred to as the GQAL guidelines*)*. Agricultural land is defined as land used for crop or animal production, but excluding intensive animal uses (i.e. feedlots and piggeries). GQAL is land which is capable of sustainable use for agriculture, with a reasonable level of inputs, and without causing degradation of land or other natural resources.

The DPI guidelines have been introduced to provide local authorities and development proponents with a system to identify areas of GQAL for planning and project approval purposes. Descriptions of the ALCs are provided in **Table 19**.

The ALC classification system combines land suitability assessments for a number of specific land utilisation types into a single land classification. This ALC classification system has four categories: Arable (A), Limited arable (B), Pastoral (C) and Non-agricultural (D) (refer **Table 20**).

**Table 19 – Scheme for Classifying Agricultural Land**

| Class | Name | Description |
|---|---|---|
| **A** | Arable land<br>(Crop land) | Land that is suitable for current and potential crops with limitations to production which range from none to moderate levels. |
| **B** | Limited arable land<br>(Limited crop land) | Land that is marginal for current and potential crops due to severe limitations; and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping. |
| **C** | Pastoral land | Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment. |
| **D** | Non-agricultural land | Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage. |

Source: DPI 1993.

**Table 20 – Broadacre Cropping Land Suitability Ranking and Agricultural Land Class Correlation**

| LS Ranking | Description | ALC |
|---|---|---|
| 1 | High quality land with few or minor limitations | A |
| 2 | Land with minor limitations | A |
| 3 | Moderate limitations to sustaining its use. | A |
| 4 | Marginal land requiring major inputs to sustain the use. | B or C |
| 5 | Unsuitable due to extreme limitations. | C or D |

The overall land suitability rating of 1-5 is translated into an ALC rating of A-D. Additionally, for the Central West Queensland region, ALC C is further divided into three sub-classes of C1, C2 and C3, according to potential grazing quality, as outlined in **Table 21** below.

**Table 21 – Beef Cattle Grazing Land Suitability Ranking and ALC**

| LS Rating | Land Suitability Description (DME 1995) | ALC | ALC Description | B. Forster DERM (per comm., 2010)) |
|---|---|---|---|---|
| 1 | High quality land with few or minor limitations | C1 | Good quality grazing and/or highly suitable for pasture improvement | Brigalow vegetation; appropriate for fattening beef cattle; good grazing on sown pastures and can withstand ground disturbance. |
| 2 | Land with minor limitations | C1 | | Brigalow vegetation and/or transitional vegetation to poplar box vegetation communities. |
| 3 | Moderate limitations to sustaining its use | C2 | Moderate quality grazing and/or moderately suitable for pasture improvement. | Eucalypt woodland, poplar box, narrow-leaved eucalyptus, gum-top woodlands; low-moderate PAWC and low-moderate fertility; good grazing on native pastures without ground disturbance; appropriate for beef cattle breeders. |
| 4 | Marginal land requiring major inputs to sustain the use | C3 | Low quality grazing, grazing of native pastures with limited suitability for pasture improvement. | Tea-tree vegetation; usually characterised by steep country or mangrove flats. |
| 5 | Unsuitable due to extreme limitations. | D | Not suitable | Unsuitable due to extreme limitations. |

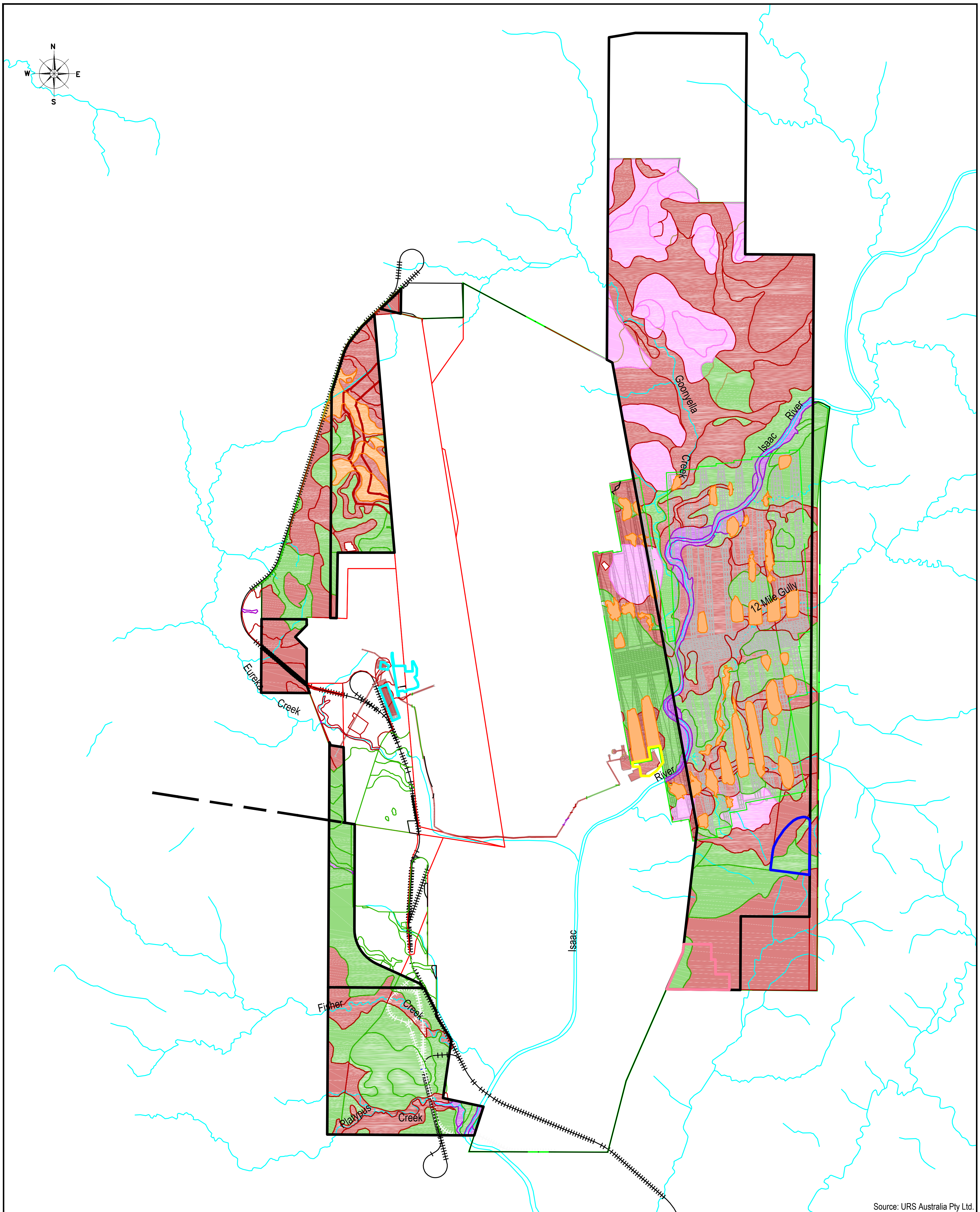
### 4.2.1 Good Quality Agricultural Results

The Isaac Regional Council classifies the ALC Classes A, B and C1 as GQAL. As such, **Table 22** shows the amount of GQAL in the EIS study area. According to the Isaac Regional Council Planning Scheme ALC A, B & C1 are considered GQAL. The EIS study area contains 6,161.06 hectares of GQAL under the above definition. The spatial distribution of this classification is shown in **Figure 12**.

**Table 22 – Agricultural Land Class (ALC) and GQAL**

| Soil Type | Cropping LS Rating | Grazing LS Rating | Equivalent ALC | GQAL | EIS study area (external mining lease) | EIS study area (internal mining lease) | Area (%) |
|---|---|---|---|---|---|---|---|
| | | | | | Area (ha) | Area (ha) | |
| 1. Lithic Rudosol | - | 3 | C2 | No | 426.0 | 2.8 | 3.5 |
| 2. Tenosol | - | 4 | C3 | No | 269.51 | 25.18 | 2.4 |
| 3a. Red Kandosol | - | 2 | C1 | Yes | 2051.8 | 0.35 | 16.6 |
| 3b. Brown Kandosol | - | 2 | C1 | Yes | 386.0 | 16.7 | 3.3 |
| 4. Brown Kurosol | - | 5 | D | No | 186.7 | x | 1.5 |
| 5. Brown Chromosol | - | 2 | C1 | Yes | 1,444.53 | 416.7 | 15.1 |
| 6. Brown Sodosol | - | 3 | C2 | No | 1,757.31 | 176.4 | 15.7 |
| 7. Brown Dermosol | - | 3 | C2 | No | 816.6 | 168 | 8.0 |
| 8a. Shallow Vertosol | 4 | 3 | B | Yes | 692.1 | 154.6 | 6.8 |
| 8b. Deep Vertosol | 4 | 3 | B | Yes | 589.2 | x | 4.8 |
| 8c. Deep Salic Vertosol | - | 3 | C2 | No | 2674.8 | 36.8 | 22 |
| | | | | **Total** | **11,294.55** | **1,032.83** | **100%** |

Based on the anticipated ponding in the proposed post mining landform, there is a reduction of 394.9 hectares external to the mining lease and 150.9 hectares inside the existing mining lease, of grazing land (ALC – C) to permanent or semi-permanent ponding unsuitable for grazing (ALC – D). The ponding may be considered a potential water storage source for cattle however for the purposes of this assessment it is considered ALC – D.




## LEGEND

- Project Site
- BMA ML & MLA Boundaries - Dec 2008
- Rail Line
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- Broadmeadow Extension (131.35 ha)
- CHPP (53.9 ha)
- Accommodation Village (108.7 ha)

**Agricultural Land Class**

- Class B (GQAL)
- Class C1 (GQAL)
- Class C2
- Class C3
- Class D

0 2.0 4.0km

Base Plan Data Source: RWC & Geo-spectrum (Australia) Pty Ltd.

| Version | Date: | Author: | Checked: | Approved: |
|---|---|---|---|---|
| 2 | 23/11/11 | ZJ | MH | CR |
| 3 | 30/11/11 | ZJ/LF | MH | CR |
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| 5 | 6/12/11 | LF | AR | CR |
| 6 | 02/02/12 | RH | RH | CR |
| 7 | 14/03/12 | LF | CR | CR |
| 7 | 13/06/13 | LF | AK | CR |

# FIGURE 12

## Agricultural Land Class - GQAL

**GSS ENVIRONMENTAL**
Environmental, Land and Project Management Consultants

Project: Red Hill Mining Lease EIS

Client: URS Australia Pty Ltd

File: Fg12_URS03-029_ALC-GQAL_130813

Projection: MGA 94 Zone 55

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## 4.4 Strategic Cropping Land Assessment

An assessment of the potential for the project to infringe on SCL has been undertaken using the *Protecting Queensland's Strategic Cropping Land: A Policy Framework* (DERM 2010; referred to as the Policy*)* as guidance.

In 2010 the Queensland Government released the Policy to protect Queensland's best cropping land from permanent alienation or diminished productivity due to the competing land-uses of agricultural, mining and urban development. This Policy provides a new framework and approach for the conservation and management of Queensland's best cropping land for long-term food production and regional growth. This land is called SCL and includes the best land that is currently being cropped as well as the best land resources that could be cropped in the future.

SCL is defined by soil, climatic and landscape characteristics which result in an area highly suitable for crop production. A staged assessment process has been used to identify whether SCL is present. As shown below in **Table 23**.

**Table 23 – Process of Assessing SCL**

| Step | Process | Action |
|---|---|---|
| 1 | Check if the land is in an SCL zone | **Yes**—Proceed to step 2<br>**No**—Land outside of the SCL zones is not subject to the SCL policy |
| 2 | Is the land shown as likely SCL on the trigger map? | **No**—Development proponent: No further assessment required under SCL policy<br>**No**—Landholder: May wish to conduct an assessment of the land to determine whether it is likely to be SCL and apply to 'opt in' to trigger map<br>**Yes**—Proceed to Step 3 |
| 3 | Identify which SCL zone the land is in—Western Cropping, Eastern Darling Downs, Coastal Queensland, Wet Tropics or Granite Belt zone. | Consult the appropriate SCL criteria |
| 4 | Conduct an on-ground assessment using the appropriate SCL criteria and guidelines. Proceed to Step 5. | |
| 5 | If the land is SCL and within a Strategic Cropping Protection Area, no further SCL validation assessment is required and development will be assessed under the SCL policy.<br>If the land is SCL and within the Strategic Cropping Management Area, the property will also need to be assessed for a history of cropping. If the land meets the SCL criteria and the history of cropping test, no further SCL validation assessment is required and development will be assessed under the SCL policy. Otherwise, the SCL policy will not apply. | |

Source: DERM 2011.

Initially, publicly available trigger maps were consulted to determine whether the EIS study area was likely to interact with an area of SCL. There is approximately 500 hectares of trigger mapped SCL that required field assessment and ground truthing. Preliminary field investigations were undertaken prior to the release of the SCL assessment guidelines in September 2011. This preliminary fieldwork found that there was potential SCL within the trigger mapped areas, however this would require further investigation and testing against the final SCL criteria to accurately determine if soil conditions meet the requirements. The soil criteria used to identify SCL is outlined below in **Table 24**.

**Table 24 – Summary of Criteria for Identifying SCL**

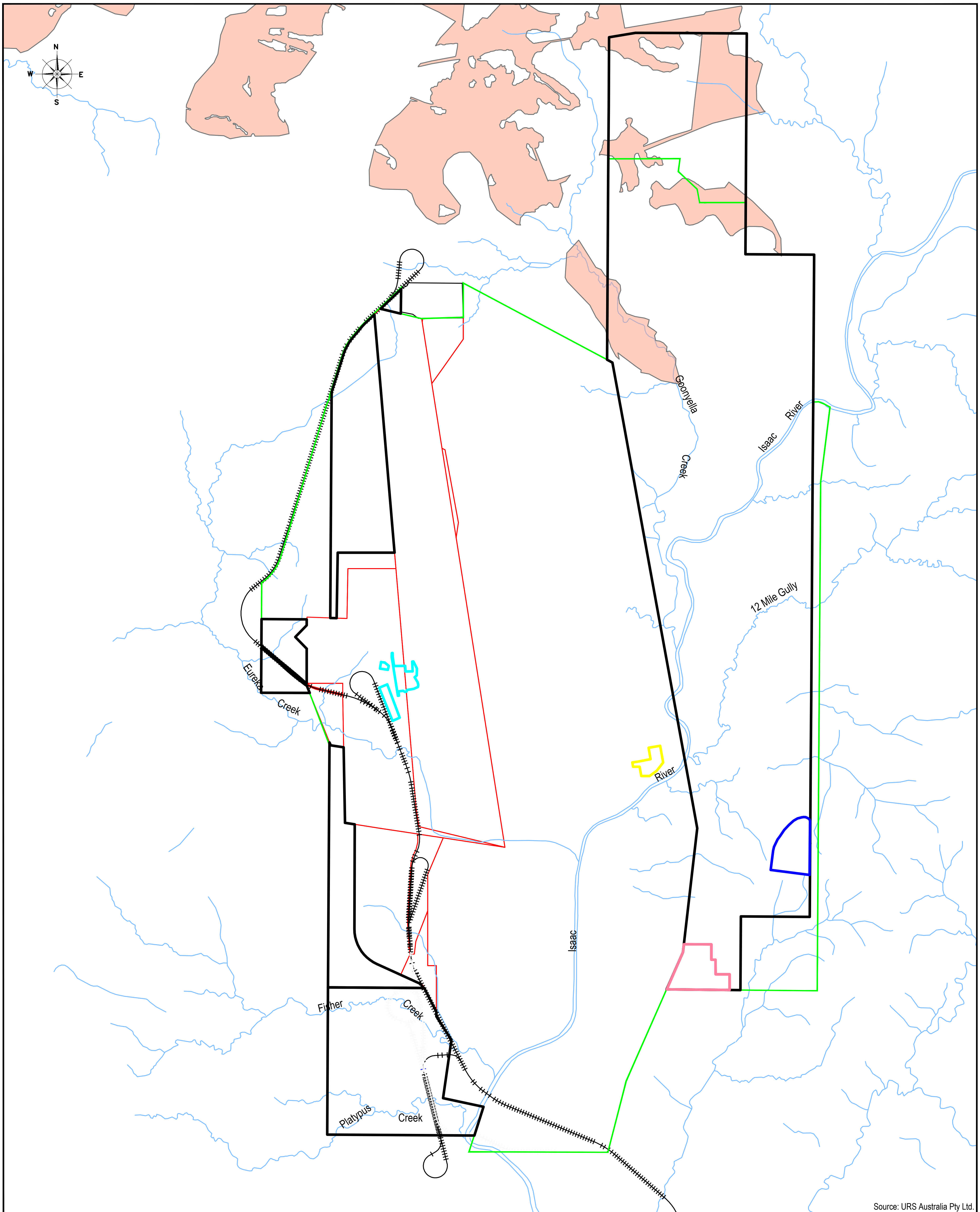
| Criteria | Criteria thresholds for each SCL zone | | | | |
|---|---|---|---|---|---|
| | Western Cropping | Eastern Darling Downs | Coastal Queensland | Wet Tropics | Granite Belt |
| 1. Slope | ≤ 3% | ≤ 5% | | | |
| 2. Rockiness | ≤ 20% for rocks > 60 mm diameter | | | | |
| 3. Gilgai microrelief | < 50% of land surface being gilgai microrelief of > 500 mm in depth | | | | |
| 4. Soil depth | ≥ 600 mm | | | | |
| 5. Soil wetness | Has favourable drainage | | | | Has satisfactory drainage |
| 6. Soil pH | For non-rigid soils, the soil at 300 mm and 600 mm soil depth must be greater than pH 5.0. For rigid soils, the soil at 300 mm and 600 mm soil depth must be within the range of pH 5.1 to pH 8.9 inclusive. | | | | |
| 7. Salinity | Chloride content < 800 mg/kg within 600 mm of the soil surface | | $EC_{1:5}$ < 0.56 dS/m within 600 mm of the soil surface | | |
| 8. Soil water storage | ≥ 100 mm to a soil depth or soil physico-chemical limitation of ≤1000 mm | | ≥ 75 mm to a soil depth or soil physico-chemical limitation of ≤1000 mm | ≥ 50 mm to a soil depth or soil physico-chemical limitation of ≤1000 mm | ≥ 25 mm to a soil depth or soil physico-chemical limitation of ≤1000 mm |

Section 4 of the *Protecting QLD's strategic cropping Land – Guidelines for applying the proposed strategic cropping land criteria* (DERM 2011) outlines the detail of each of the eight criteria and methodology for assessment.

Whist preliminary field investigations found some areas meeting most criteria shown above, there was no evidence of regular cropping and no evidence of cropping within the last 10 to 15 years. The history of cropping is a requirement for an area to be assessed under the SCL policy within the SCL Management Zone, which includes the EIS study area, as shown in Point 5 of **Table 23**.

**Figure 13** shows the presence of trigger mapped SCL in the north-eastern area of the site. This area of the EIS study area is not expected to be disturbed by mining operations, and it can be confirmed that there are no current or foreseeable impacts on the designated SCL. Should the scope of project activities change and potentially impact on a mapped area of SCL, BMA will undertake the following steps:

1. Undertake a 'History of Cropping' assessment for the project site to determine if a validation a decision could be applied for without further ground truthing.
2. In the event the EIS study area is considered not to fulfil all the required criteria for SCL, as preliminary investigations have indicated due to the lack of evidence of cropping in the area, a validation application will be prepared and submitted to the Department of Natural Resources and Mines for a validation decision, as described in Sections 42 and 44 - 50 of the *Strategic Cropping Land Act 2011*.
3. Alternatively, in the event the EIS study area is considered to fulfil all the required criteria for SCL, a protection application will be prepared and submitted to the Department of Natural Resources and Mines for a protection decision, as described in Sections 95 - 97 of the *Strategic Cropping Land Act 2011*.




LEGEND
- Project Site
- BMA ML & MLA Boundaries - Dec 2008
- Rail Line
- Trigger Mapped Potential SCL
- Proposed Mining Lease
- MIA (30.2)
- Broadmeadow Extension (131.35 ha)
- CHPP (53.9 ha)
- Accommodation Village (108.7 ha)

0 2.0 4.0km

Base Plan Data Source: RWC & Geo-spectrum (Australia) Pty Ltd.

| Version | Date: | Author: | Checked: | Approved: |
|---|---|---|---|---|
| 1 | 10/08/11 | LH | MH | CR |
| 2 | 23/11/11 | ZJ | MH | CR |
| 3 | 30/11/11 | ZJ/LF | MH | CR |
| 4 | 1/12/11 | ZJ/LF | MH | CR |
| 5 | 6/12/11 | LF | AR | CR |
| 6 | 13/6/13 | LF | AK | CR |

# FIGURE 13

## SCL Trigger Mapping

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project: Red Hill Mining Lease EIS

Client: URS Australia Pty Ltd

File: Fg13_URS03-029_SCL-TriggerMap_130613

Projection: MGA 94 Zone 55

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# 5.0 SOIL MANAGEMENT

## 5.1 Acid Sulfate Soil Potential

The potential for acid generation from regolith material (topsoil and subsoil) within the EIS study area is low. This does not include acid generation potential within the overburden material (consolidated bedrock below two to three metres depth). Acid Sulphate Soils (ASS), which are the main cause of acid generation within the soil mantle, are commonly found less than five metres above sea level, particularly in low-lying coastal areas such as mangroves, salt marshes, floodplains, swamps, wetlands, estuaries, and brackish or tidal lakes. The EIS study area is located within the Central Highlands region (which is approximately 150 kilometres from the coast at >260 metres AHD). There has been little history of acid generation from regolith material within this region.

## 5.2 Soil Stripping Assessment

All soils within the EIS study area have been assessed to determine suitability for stripping and re-use on rehabilitation sites. This assessment is an integral process for successful rehabilitation of the EIS study area. This report provides information on the following key areas related to the management of the soil resources associated with the project:

- Soil stripping assessment, which provides a soil stripping depth map indicating recommended stripping depths for soil salvage and re-use as topdressing in rehabilitation; and
- Soil management for soil that is stripped, stored and used as a topdressing material for rehabilitation.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for stripping and re-use for the rehabilitation of disturbed areas.

### 5.2.1 Soil Stripping Assessment Methodology

Determination of suitable soil to conserve for later use in mine rehabilitation has been conducted in accordance with Elliott and Veness (1981) and Elliot and Reynolds (2000). The approach remains the benchmark for land resource assessment in the Australian mining industry. This procedure involves assessing soils based on a range of physical and chemical parameters. **Figure 14** summarises the procedure for the selection of soil material for use as topdressing of areas disturbed by the project and **Table 25** lists the key parameters and corresponding desirable selection criteria.

**Table 25– Soil Stripping Suitability Criteria**

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

Gravel and sand content, pH and salinity were determined for all samples using the laboratory test results. Texture was determined in the field and cross referenced with laboratory results, specifically particle size analysis. All other physical parameters outlined in **Table 23** 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. Well-structured soils have higher infiltration rates and better aeration characteristics. Structureless soils, without pores, are considered unsuitable as topdressing materials.

The shearing test is used as a measure of the soil's ability to maintain structure grade. Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate. This is because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the excavation, transportation and spreading of topdressing material. Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both 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.

### 5.2.2 Potential Soil Stripping Depths

**Table 26** lists the recommended stripping depths for each soil type within the entire proposed EIS study area, however the soil types likely to undergo surface disturbance and be stripped of topsoil are those that lie on the areas which will be required for surface facilities. Therefore soils within the gas drainage infrastructure disturbance areas will be stripped and stockpiled adjacent the actual disturbance area and re-instated during rehabilitation. Whilst the subsoils in Table 26 are considered unsuitable for topdressing, they may be suitable for use as an intermediate or subsoil layer below the topsoil in the rehabilitated profile.

**Table 26 – Potential Stripping Depth for each Soil Type**

| Soil Type # | Soil Type | Area in EIS study area (ha) | Potential Topsoil Stripping Depth (m) | Potential Subsoil Stripping Depth* |
|---|---|---|---|---|
| 1 | Lithic Rudosol | 428.8 | Nil | Nil |
| 2 | Tenosol | 294.69 | 0.4 | 0.8 |
| 3a | Red Kandosol | 2052.15 | 0.3 | Nil |
| 3b | Brown Kandosol | 402.7 | 0.5 | Nil |
| 4 | Brown Kurosol | 186.7 | 0.3 | Nil |
| 5 | Brown Chromosol | 1861.23 | 0.4 | Nil |
| 6 | Brown Sodosol | 1933.71 | 0.25 | Nil |

| Soil Type | Soil Type | Area in EIS study area | Potential Topsoil | Potential Subsoil |
|---|---|---|---|---|
| 7 | Brown Dermosol | 984.6 | 0.2 | Nil |
| 8a | Shallow Vertosol | 846.7 | Nil | Nil |
| 8b | Deep Vertosol | 589.2 | Nil | Nil |
| 8c | Deep Salic Vertosol | 2711.6 | Nil | Nil |

### 5.2.3 Soil Management

The following management and mitigation strategies are recommended during mining, in order to reduce the potential for degradation within the EIS study area and adjoining lands. These strategies are based on the assessment of the existing site conditions and experience with the management of mining surface impacts at sites throughout New South Wales and Central Queensland, and apply to both topsoil and subsoil stripping, the following points should be read in conjunction with Section 5.5.7 of the Red Hill Mining Lease EIS and final management plans should be determined prior to the commencement of construction activities:

- Strip material to the depths stated in **Table 26**, subject to further field investigations during stripping activities.
- Soil should preferably be stripped in a slightly moist condition.
- Place stripped material directly onto the area to be rehabilitated and spread immediately (if mining sequences, equipment scheduling and weather conditions permit) to avoid the requirement for stockpiling.
- 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 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.
- The surface of soil stockpiles should be left in as coarsely structured a condition as possible in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming.
- As a general rule, maintain a maximum stockpile height of three metres. Clayey soils should be stored in lower stockpiles for shorter periods of time compared to coarser textured sandy soils.
- If long-term stockpiling is planned (i.e. greater than 12 months), seed and fertilise stockpiles as soon as possible. An annual cover crop species that produce sterile florets or seeds should be sown. A rapid growing and healthy annual pasture sward provides sufficient competition to minimise the emergence of undesirable weed species. The annual pasture species will not persist in the rehabilitation areas but will provide sufficient competition for emerging weed species and enhance the desirable micro-organism activity in the soil.

- Prior to re-spreading stockpiled topsoil onto disturbed areas (particularly onto designated tree seeding areas), an assessment of weed infestation on stockpiles should be undertaken to determine if individual stockpiles require herbicide application and / or 'scalping' of weed species prior to topsoil spreading.

- An inventory of available soil should be maintained to ensure adequate topsoil materials are available for planned rehabilitation activities.

- Topsoil will be spread to a minimum depth range of 0.1 metre. Soil respreading on steep slopes at depths exceeding 0.1 metre can be deleterious because of the 'sponge' effect which can cause slippage of the topsoil from the slope.

### 5.2.4 Topsoil Stripping Criteria

The potential for major land disturbance is likely to result from excavation of the infrastructure areas. It is recommended that topsoil be recovered in these areas of disturbance.

Soil analysis results were used in conjunction with the field assessment to determine the depth of soil materials suitable for recovery. Structural and textural properties of subsoils are the most significant limiting factors in determining depth of soil suitable for re-use. Salinity levels, pH and dispersion potential are also limiting factors in some soils in the EIS study area. Elliot and Reynolds (2000) described the basic procedure adopted in this survey for the recognition of suitable topdressing materials (refer **Table 27**). This procedure has been adapted to include sandy loams as suitable.

**Table 27 – Topsoil Stripping Criteria**

<table>
<tr><th>Descriptor</th><th>Reasoning</th><th>Desirable criteria</th></tr>
<tr><td>Structure Grade</td><td>Good permeability to water 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.<br>Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils without pores are considered unsuitable as topdressing materials.</td><td rowspan="4">- 30%peds present<br>- coherent when wet or dry<br>- EAT: < 2 (2)<br>- conductivity: < 1.5 dS/m<br>- exchangeable Na% < 12%<br>- pH: > 4.5 & < 8.4<br>- no mottle present<br>- finer than sandy loam<br>- sand & gravel content < 60%</td></tr>
<tr><td>Consistence – Shearing Test</td><td>The shearing test is used as a measure of the ability of soils to maintain structure grade.<br>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 extraction, transportation and spreading of topdressing material.<br>Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.</td></tr>
<tr><td>Consistence – Disruptive Test</td><td>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</td></tr>
<tr><td>Mottling</td><td>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.</td></tr>
</table>

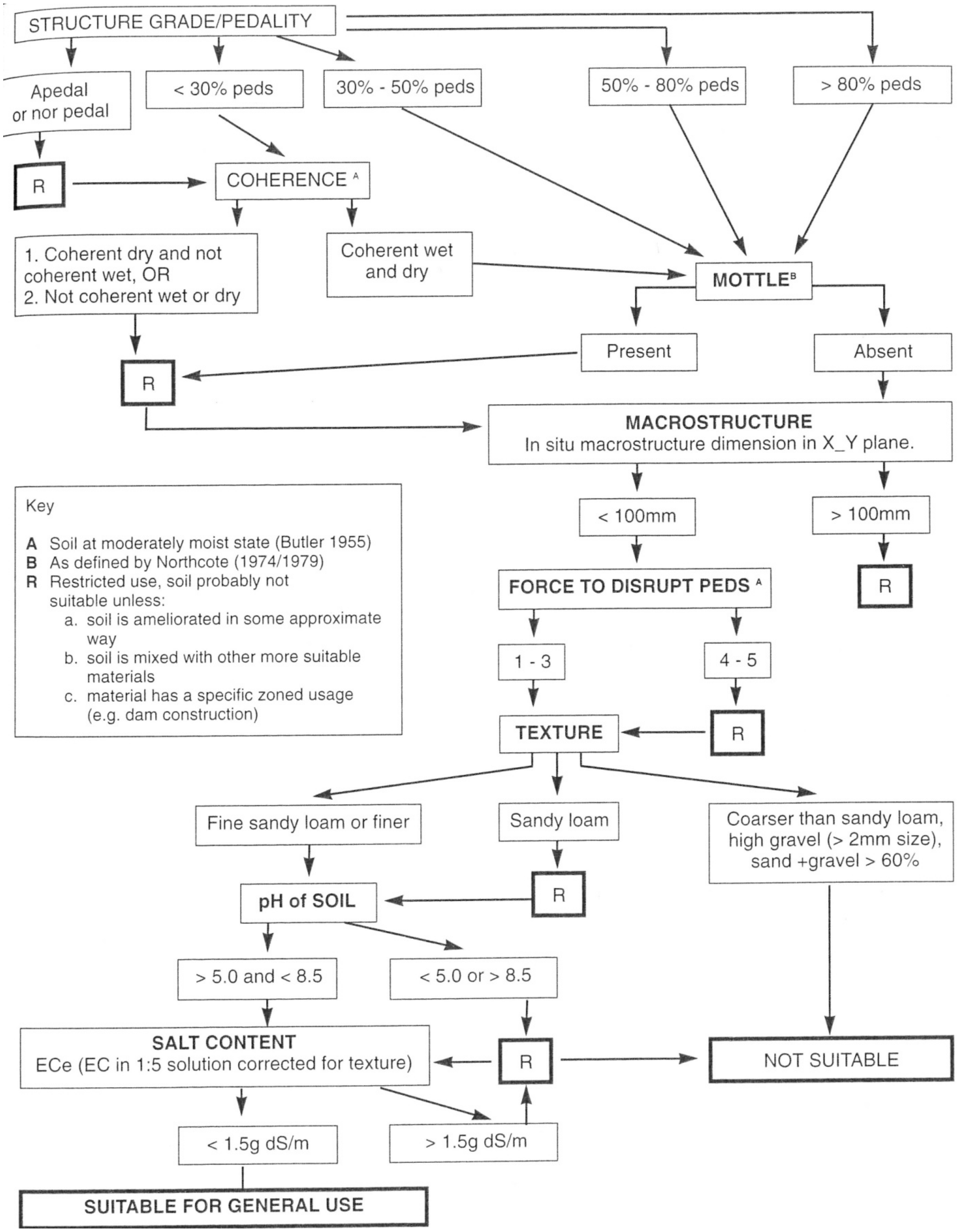


**Figure 14: Selection Process for Topdressing Material** (Source: Elliot and Reynolds 2000)

### 5.2.5 Erosion Potential of Soil Types

Soil samples were laboratory tested for dispersion using the Emerson Aggregate Test (EAT) and sodicity, using the Exchangeable Sodium Percentage (ESP). These tests indicate the susceptibility of a soil to losing its structure and binding capacity when wet, and therefore the erosion potential of the soil. Furthermore, a selection of soils were tested to determine the soil erodibility or k-factor by considering particle size analysis, mechanical dispersion and organic carbon.

In general all surface soils displayed low to moderate k-factors and therefore low to moderate erodibility. One sample of Brown Chromosol surface soil contained a high rating. If disturbance occurs within the vicinity of a drainage line, a moderately erodible soil could impact on the health of downstream watercourses, through an increase in the sediment load. These soils should, therefore, be managed to ensure that the soils are not disturbed without suitable erosion and sediment controls being implemented. These measures include the construction of structural soil conservation works such as contour, graded and diversion banks and drop structures, together with sediment control dams. The use of cover crops and/or organic ameliorants will reduce soil dispersion and surface crusting thereby reducing runoff and increasing infiltration, which will subsequently reduce erosion and sedimentation.

Appropriate erosion and sediment control measures should be in place prior to all surface disturbance of soils, as the risk of erosion is high once the ground cover is removed and subsoil is exposed. Appropriate measures are outlined in **Section 5.2.7** of this report, with further detailed measures to be developed in the erosion and sediment control plan which will be developed in conjunction with mine approvals.

#### 5.2.6 Potential Erosion Rates

There are three disturbance types to be assessed within the proposed project, consisting of underground mining footprint and infrastructure such as access tracks, gas drainage facilities, Red Hill accommodation village and the Red Hill CHPP. The Revised Universal Soil Loss Equation (RUSLE) has been used for the assessment of these areas to estimate the long term average soil loss rates that may result from sheet and rill flow during various levels of disturbance. It must be noted that wind and gully erosion is discussed separately in the section below.

The RUSLE calculates annual erosion rates based on the following equation:

$$\mathbf{A = R \cdot K \cdot LS \cdot C \cdot P}$$

Where: A = annual soil loss due to erosion [t/ha/yr]

R = rainfall erosivity factor

K = soil erodibility factor

LS = topographic factor derived from slope length and slope gradient

C = cover and management factor

P = erosion control practice factor

**Table 28** offers a comparison of disturbance levels which aims to highlight the higher risk activities in regard to erosion rates. It must be noted that assumptions have been made as to the specific values of soil and overburden characteristics, vegetation establishment success, climatic conditions, slope gradients and lengths and various management practices, and therefore the following values should only be used for comparison purposes. The calculations were made based on ‘worst case’ scenarios used consistently for all disturbance levels.

**Table 28 – Estimated Erosion Rates using the RUSLE**

| Disturbance Level | Rainfall Erosivity Factor (R) | Adjusted* Soil Erodibility Factor (K) | Topographic Factor (LS) | Cover and Management Factor (C) | Erosion Control Practice Factor (P) | Annual Soil Loss (A) (t/ha/yr) |
|---|---|---|---|---|---|---|
| Undisturbed Surface Pre Disturbance and Subsided Underground Areas | 1804 | 0.030 | 1.00 | 0.01 | 1.0 | 0.54 |
| Surface cleared of vegetation and topsoil | 1804 | 0.020 | 1.00 | 1.00 | 1.3 | 47.84 |

* Adjusted for dispersive materials by +20 per cent

**Table 28** above shows the disturbance level during mining and infrastructure activities. The key factor to observe in this result is the cover and management factor (C) which reflects the effect of cropping and management practices on erosion rates. However it is recommended that these areas and times of highest risk should have adequate sedimentation controls in place downstream to capture any material eroded from these slopes. Given the short duration of exposure and assuming typical sediment controls are established, this rate of soil loss would be adequately captured and within the site and therefore is considered an acceptable risk. The surface cleared of vegetation and topsoil category includes the infrastructure items such as gas drainage and Red Hill accommodation village, which will be located on relatively flat land, show a risk of moderate erosion due to the high cover and management factor. The underground mining footprint is considered with pre mining cover and management factors given the integrity of the surface protection will be maintained, albeit modified slope given the subsidence. Some surface cracking may be evident and may require repair on access tracks and other trafficable areas.

Gully erosion is not considered within the RUSLE equation above, however given the succession of erosion severity from rill to gully erosion, it is predicted that the same disturbance levels will contain the same risk rankings for gully erosion rates as the RUSLE equation has displayed. Gully erosion should be repaired and rehabilitated as soon as possible to reduce further erosion and sedimentation downstream.

Wind erosion has the potential to cause loss of material from exposed surfaces during the mining process. Management practices during mining may limit the extent of wind erosion. This can include reducing vehicle movements and earthworks on highly exposed areas during periods of extreme wind conditions. Furthermore, mine planning considerations for minimising exposed surfaces and timely rehabilitation activities may protect surface soil from wind erosion.

### 5.2.7 Landform Design and Erosion Control Measures

The main objective of regrading subsided slopes is to produce slope angles, lengths and shapes that are compatible with the proposed land use and not prone to an unacceptable rate of erosion. Integrated with this is a drainage pattern that is capable of conveying runoff from the newly created catchments whilst minimising the risk of erosion and sedimentation. The subsided landform will potentially create moderate to steep slopes above the edges of longwall panels which could increase the risk of erosion, especially with livestock movements to and from freshwater ponds. The status of erosion on these moderate to steep slopes will be monitored regularly and mitigation measures implemented if erosion becomes unacceptable. Refer to Section 5.5.7.2 of the Red Hill Mining Lease EIS.

Conservation earthworks have the effect of dividing a long slope into a series of short slopes with the catchment area commencing at each bank or furrow. This prevents runoff from reaching a depth of flow or velocity that would cause erosion. As the slope angle increases, the banks or furrows must be spaced closer together until a point is reached where they are no longer effective.

Contour ripping across the grade is by far the most common form of structural erosion control on mine sites, as it simultaneously provides some measure of erosion protection and cultivates the surface in readiness for sowing if required.

The construction of sediment control dams is recommended for the purpose of capturing sediment laden runoff from disturbed areas such as access tracks and gas drainage infrastructure, prior to off-site release. Sediment control dams are responsible for improving water quality throughout the mine site, and through the provision of semi-permanent water storages, enhance the ecological diversity of the area.

The following points should be considered when selecting sites for sediment control dams:

- Each dam should be located so that runoff may easily be directed to it, without the need for extensive channel excavation or for excessive channel gradient. Channels must be able to discharge into the dam without risk of erosion. Similarly, spillways must be designed and located so as to safely convey the maximum anticipated discharge;

- The material from which the dam is constructed must be stable. Dispersive clays will require treatment with gypsum to prevent failure of the wall by tunnel erosion. Failure by tunnelling is most common in dams which store a considerable depth of water above ground level, or whose water level fluctuates widely. Dams should always be well sealed, as leakage may lead to instability, as well as allowing less control over the storage and release of water; and

### 5.2.8 Topsoil Respreading & Seedbed Preparation

Sampling and analysis of topsoil resources, whether stockpiled or in-situ, is recommended prior to respreading. This will assist in identifying potential soil deficiencies and estimating required rates of fertiliser or ameliorant (i.e. gypsum or lime) application.

Where possible, suitable topsoil should be re-spread directly onto areas to be rehabilitated. Where topsoil resources allow, topsoil should be spread to a minimum depth of 10 centimetres on all regraded slopes. Topsoil should be spread, treated with fertilizer or ameliorants (if required) and seeded in one consecutive operation. This will reduce the potential for topsoil loss to wind and water erosion.

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

Thorough seedbed preparation should be undertaken to ensure optimum establishment and growth of vegetation. All topsoiled areas should be contour ripped (after topsoil spreading) to create a 'key' between the soil and the disturbed area subsoil. Ripping should be undertaken on the contour and the tynes lifted for approximately two metres every 200 metres to reduce the potential for channelised erosion. Best results will be obtained by ripping when soil is moist, and when undertaken immediately prior to sowing. The respread topsoil surface should be scarified prior to or during seeding in order to reduce run-off and increase infiltration. This can be undertaken by contour tilling with a fine-tyned plough or disc harrow.

### *5.2.9* Summary

The underground mining footprint and infrastructure such as access tracks, gas drainage infrastructure, accommodation village and the Red Hill CHPP has been calculated to cause an annual soil loss of 257.87 t/ha/yr. This can result in the sedimentation of nearby and catchment linked waterways, the degradation of soil surface resources and has the potential to compromise the post mining land-use.

Throughout the construction and operation phases of the project, soils should not be disturbed without suitable erosion and sediment controls being implemented, such as the following;

- Grading to produce appropriate slope angles, lengths and shapes;
- Contour ripping across the grade;
- Construction of sediment control dams; and
- Vegetation cultivation to establishment topsoil stability.
- Temporary erosion and sediment control structures

Additionally, general gully erosion is predicted that the same disturbance levels, and wind erosion is expected to cause loss of material from exposed surfaces during the mining process. Targeted mitigation measures should also be implemented to reduce the impact of these, including gully repair and exposed surface rehabilitation.

These measures are as per best practice and successful implementation will be effective in mitigating impacts to the immediate and surrounding landscape and the productivity of the land.

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