Appendix F

Soil Survey and Land Resource Assessment Report

F

URS Australia Ltd

FINAL

Caval Ridge Project

Soil Survey and Land Resource Assessment Report

March 2009

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

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1.0 INTRODUCTION

GSS Environmental (GSSE) was commissioned by URS on behalf of the BHP Billiton Mitsubishi Alliance (BMA) to undertake a soil survey and land resource assessment for the Caval Ridge Project, located in Central Queensland. The Caval Ridge Project is a proposed open cut operation located about 5-10 kms south of Moranbah. For the remainder of this report, the area of the Caval Ridge Project studied during this survey will be referred to as the "project site". The project site covers an area of approximately 6,508 ha.

As the Caval Ridge Mine will be developed within the project site, soil resources will be impacted by mining operations. Excavation of the open cut pit and construction of out-of-pit overburden stockpiles, haul roads, other service roads, dams, drains and administration area will result in ground disturbance. 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. If not adequately managed, impacts within the project sites may also cause impacts further downstream through the sedimentation of watercourses, especially if hostile soils (i.e. saline or sodic) are encountered. Disturbance to the ground surface and landscape character may also reduce the agricultural suitability of land within the project site or downstream.

1.1 Objectives

To assist BMA with operational topsoil and land management, a survey of soil resources and pre-mining assessment of agricultural land capability and suitability was undertaken by GSSE in November 2007. The major objectives of this assessment were to:

- describe and classify soils and land suitability within the potential areas of mining impact;
- assess the suitability of soil units for recovery and use as topsoil/growth media in the rehabilitation of areas impacted during mining operations; and
- identify any potentially hostile soil, such as highly sodic, acidic or saline material, that may require special management if disturbed during mining operations.

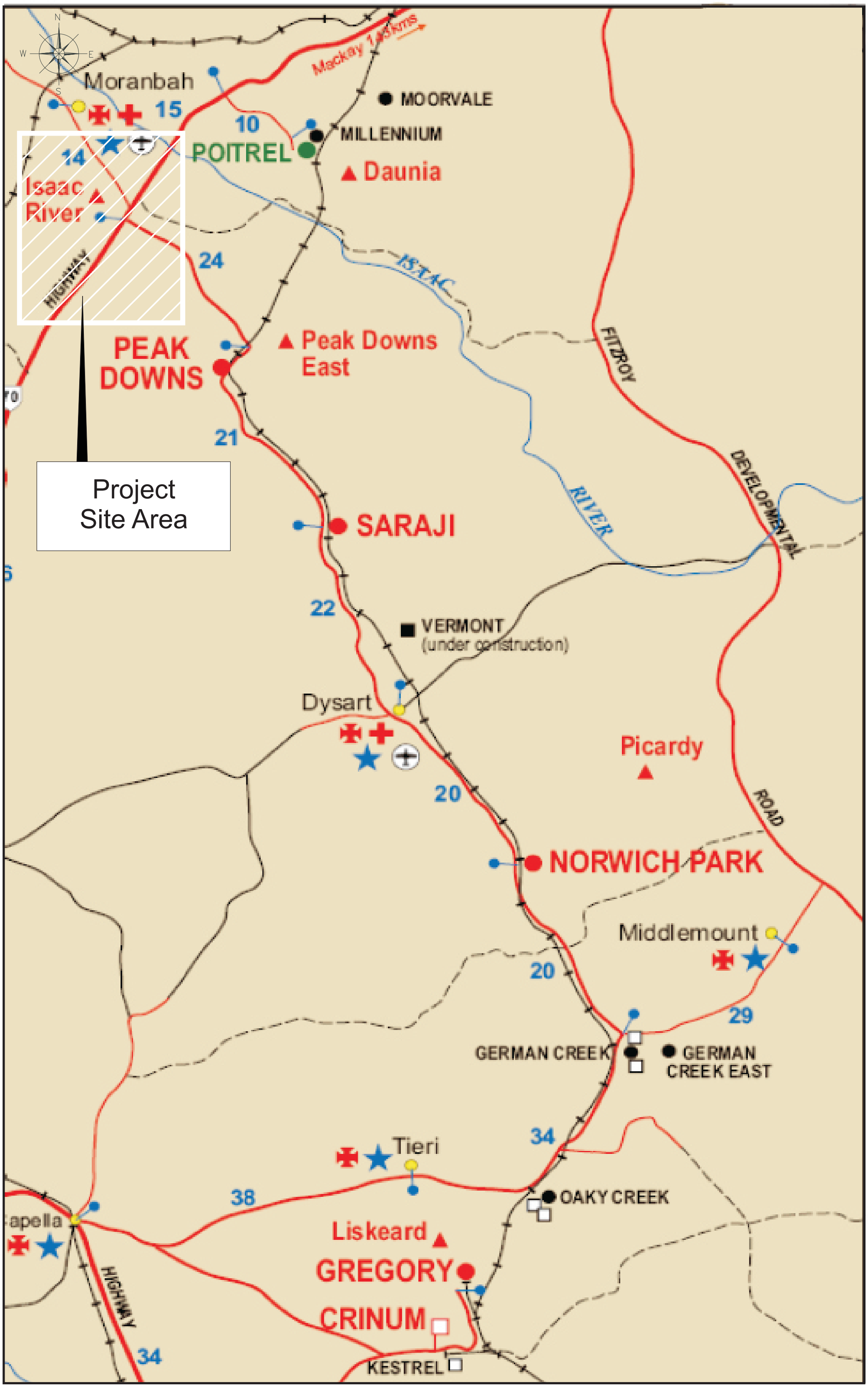
The following report presents the results of the survey undertaken by GSSE and the assessment of soil resources and agricultural capability and suitability within the project site.

1.2 Location

The project site is located in the Central Queensland Bowen Basin, within the Belyando Shire. The project site lies some 150 km south-west of Mackay and 6.2 km south of Moranbah. The project site traverses the Peak Downs Highway immediately to the west of the Peak Downs Highway / Dysart – Moranbah Road intersection.

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, Peak Downs (immediately to the south) and Goonyella Riverside (some 30 km to the north), have been operating since 1968. Other regional industries include beef cattle grazing and limited cropping.

A locality map, showing the project site in a regional context, is provided in **Figure 1**. The specific study is shown in all subsequent Figures in this report.



0 10 20
Kilometres

FIGURE 1

Location Plan

Project: Caval Ridge Land Resource Assessment

Client: URS

Version:	Date:	Author:	Checked:	Approved:
1	17-1-08	LF	RM	RM
2	9-10-08	LF	CR	RM
3	7-11-08	LF	CR	RM

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File: URS03-003

Projection:

1.3 Geology

The Moranbah area is located within the Bowen Basin of Central Queensland, a coal resource area of international significance. The Bowen Basin is about 600 km long and up to 250 km wide, and contains vast resources of Permian black coals. Of these black coals, the later Permian coals of the Moranbah Coal Measures are favoured, as they provide uniformly high grade coking coals. The project site is situated over a section of the Moranbah Coal Measures, which range in thickness from 250 m to 300 m, and variably consist of sandstone, shale, mudstone and coal. The aggregate thickness of coal in the Moranbah Coal Measures ranges from 12 m to 24 m, and may consist of up to eight seams.

Geological regions in the vicinity of the project site are shown in **Figure 2**.

1.4 Landform, Topography & Geomorphology

The topography of the project site is generally flat to undulating. Elevation across the project site range from 220 mAHD to 274 mAHD, and surface slopes are typically <1% grading to east-north east towards the Isaac River which is the most prominent regional drainage feature.

The project site consists of the following geomorphological land zones of Cainozoic age:

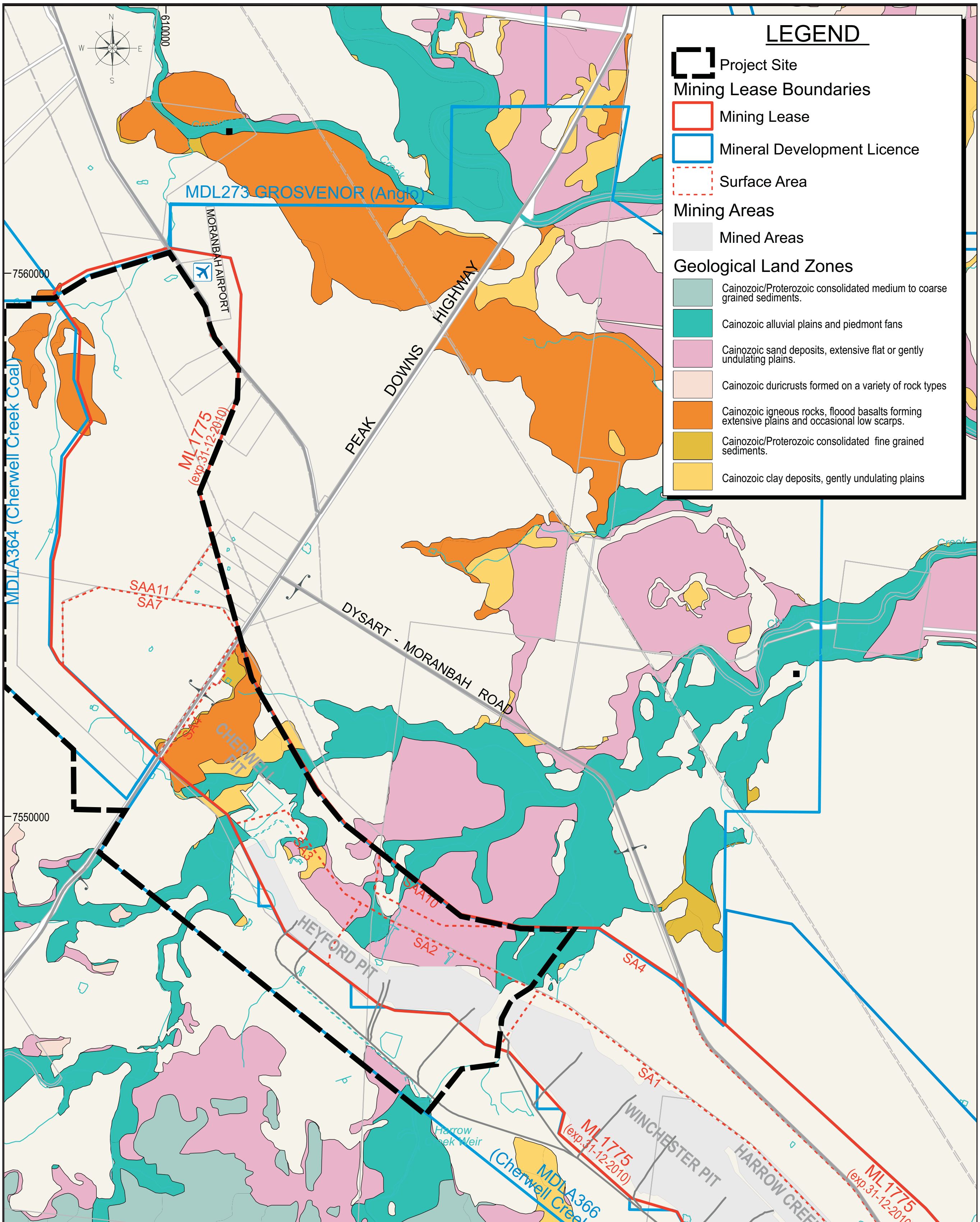
- Alluvial plains and piedmont fans adjoining the Cherwell & Heyford Pits;
- Clay deposits under gently undulating plains within the Cherwell Pit area;
- Sand deposits on extensive flat or gently undulating plains adjoining the Heyford Pit;
- Igneous rocks, flood basalts forming extensive plains and occasional low scarps to the north of the Cherwell Pit; and
- Duricrusts formed on a variety of rock types.

Figure 3 shows the location of these land zones.

1.5 Vegetation

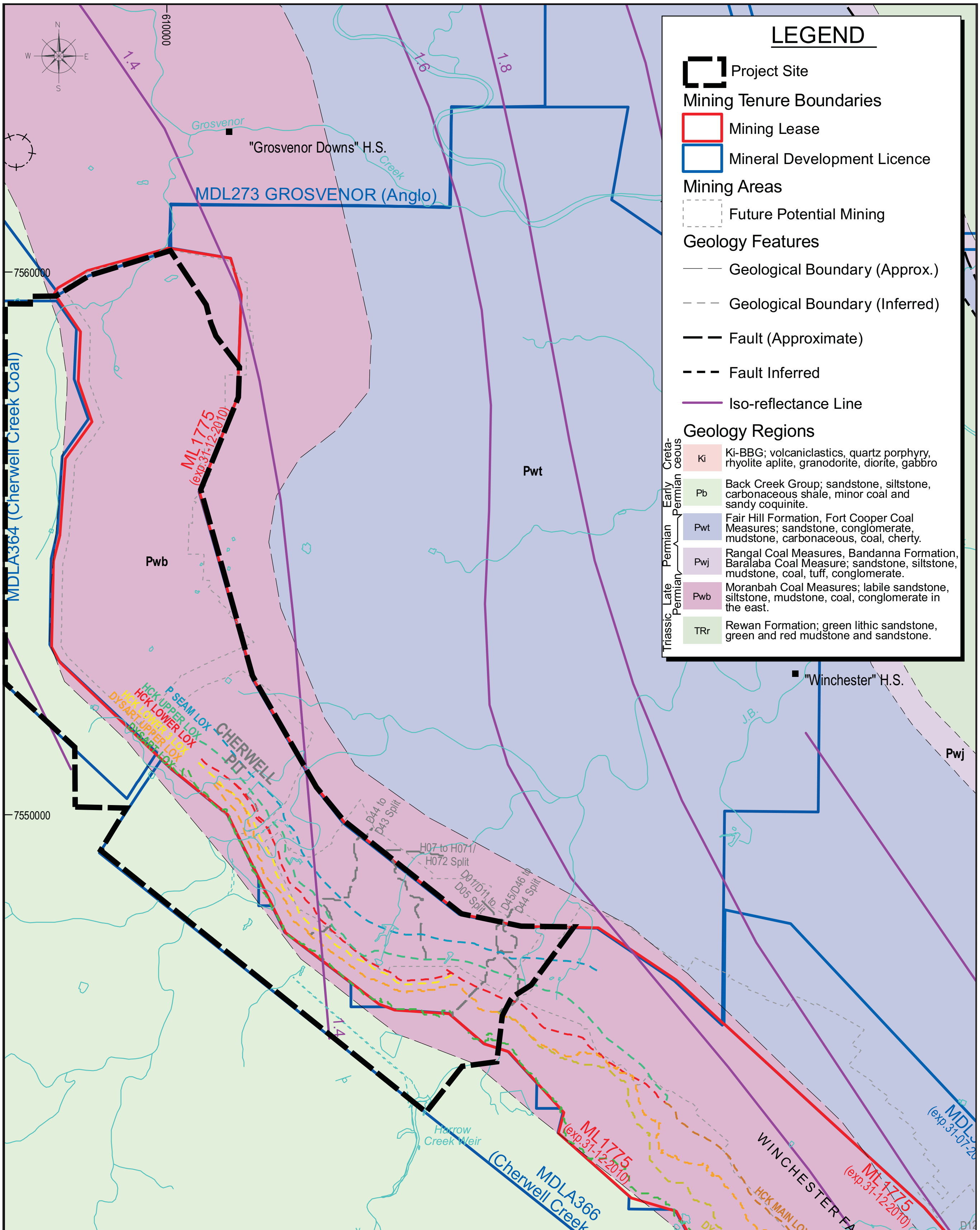
The vast majority of the project site has been cleared of the original vegetation cover. Where they have not been cleared, tablelands and dissected remnants of the upper Tertiary surfaces carry Narrow-leaved Ironbark (*Eucalyptus crebra*) woodland on the earths of undulating plateaus and Bendee Wattle (*Acacia catenulata*) or Lancewood (*Acacia shirleyi*) on the rocky hills. The lower parts of the Tertiary surface are dominated by Brigalow (*Acacia harpophyla*) and Dawson Gum (*Eucalyptus cambageana*) communities on undulating duplex soils, although these lower areas have been subject to broad scale clearing and less than 10% of the original vegetation cover remains.

Several infestations of Parthenium Weed (*Parthenium hysterophorus*) were observed in the project site, especially in association with the darker heavy clay soils.



Scale 1:100,000 (A4)	**FIGURE 3**	Project: Caval Ridge Land Resource Assessment
0 1 2 3 4 Kilometres	Geomorphological Land Zones	Client: URS
	GSS ENVIRONMENTAL Environmental, Land and Project Management Consultants	File: URS03-003
		Projection:

Version:	Date:	Author:	Checked:	Approved:
1	17-1-08	LF	RM	RM
2	9-10-08	LF	CR	RM
3	7-11-08	LF	CR	RM



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0 1 2 3 4 Kilometres

FIGURE 2

Geology

Project: Caval Ridge Land Resource Assessment

Client: URS

File: URS03-003

Projection:

Version:	Date:	Author:	Checked:	Approved:
1	17-1-08	LF	RM	RM
2	9-10-08	LF	CR	RM
3	7-11-08	LF	CR	RM

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2.0 SOIL SURVEY METHODOLOGY

2.1 Introduction

A soil survey and land resource assessment was undertaken in November 2007 to classify soil profile types, assess suitable topsoil material and identify the potentially hostile soil material within the Caval Ridge project site. The survey was conducted in accordance with the survey methodology described in this section. The survey results are presented in **Section 3** of this report.

2.2 Mapping

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

1) Aerial photographs and topographic maps - Aerial photo and topographic map interpretation was used as a remote sensing technique, allowing detailed analysis of the landscape and mapping of features related to the distribution of soils within the project site.

2) Previous soil survey results - A number of previous studies have been undertaken in the area. Information sourced for this report was compiled from the following studies:

- GTES (2000) Peak Downs Mine Land Suitability and Capability Assessment of Mine Lease Areas;
- GTES (2000) Wattle / Ripstone 1: 25,000 soils map;
- NRA (1993) 1: 50,000 capability map;
- Raine (1990) 1: 25,000 soils map; and
- Galloway *et al* (1967) 1: 500,000 Land Systems.

GTES (2000) Peak Downs Mine Land Suitability and Capability Assessment of Mine Lease Area

GTES described 44 sites in 2000 to assist in the definition of land suitability for all mine lease areas. This work focused on areas south of the Peak Downs highway and represents a mapping scale of 1: 50,000. The area north of the Peak Downs highway was initially mapped from air photographs into similar patterns with limited field checking by GTES in May 2000. Basically, soil units described in the area follow those of Galloway et al (1967) with mapping reconnaissance scale intensity at about 1: 250,000.

GTES (2000) – Wattle / Ripstone Soils

Approximately 1000 hectares of soils of the Wattle and Ripstone Pits in advance of mining were mapped at a scale of 1: 25,000 by Graham Tuck of GTES (2000) which followed methods described by Gunn et al (1988) and the DME (1995). A total of 37 sites were described with representative soils sampled for detailed laboratory analysis. Five soil types were described:

A1 – non-cracking clays of brigalow and associated species,

A2 – cracking melanhole clays of brigalow and associated species,

B1 – texture contrast soils of brigalow, eucalypt woodlands,

B2 – sandy, texture contrast soils of eucalypt woodlands; and

C1 – deep loamy sand recent alluvia.

Natural Resource Assessments (1993)

Areas in advance of PDM mining were assessed for land capability at 1: 50,000 scale using the work of Raine (1990) and CSIRO (Galloway et al, 1967) in addition to a further 13 field descriptions. NRA delineated a total of 14 soil units.

Raine (1990)

Steve Raine mapped areas in advance of PDM mining in 1990 at a sampling scale of 1: 25,000. He described 60 sites from which the following soils were isolated:

- two black and brown self mulching clays on basis of soil depth,
- five duplex soils on the basis of depth of A horizon and reaction trend,
- earthy sands and loams.

Isaac-Comet Land Systems (Galloway et al 1967)

CSIRO (Galloway et al, 1967) mapped land systems at a scale of 1:500,000 for the Isaac-Comet area which included all Mine Lease areas currently designated for the Peak Downs Mine. Land systems mapped in the survey area and soil units identified are summarized in **Table 1**. Electronic soils data for the Project site was also referenced from the Interactive Resource and Tenure Map (IRTM) webGIS, available through the Queensland Department of Natural Resources and Water (DNRW) website. These surveys were referenced to gain an indication of likely soil units situated within the Project site.

3) Stratified observations

Following production of an approximate soil map, surface soil exposures throughout the potential disturbance areas were visually assessed to verify potential soil units, delineate soil unit boundaries and determine preferred locations for targeted subsurface investigations.

Table 1 - CSIRO Land Systems and units on Caval Ridge Mine

Land Systems	Land Unit	Description
Connors	2 3	Deep sandy loam recent alluvia Texture contrast levees and floodplains – older alluvia
Daunia	5 1	Brigalow with associated species with cracking and non-cracking clays Sandy rises of Ironbark and polar box
Durrandella	1 3 4	Flat and undulating mesa tops up to 3% slope with uniform sandy and shallow soils Jump-ups, breakaways and low stony hills. Undulating, foot-slopes below mesas
Humboldt	3 4 5	Undulating plains of texture contrast soils with thin sandy surface over alkaline clays of brigalow, blackbutt and polar box Cracking and non-cracking soils with brigalow blackbutt Melanhole cracking clays of brigalow
Monteagle	3	Undulating plains and lowlands with texture contrast soils poplar box and ironbark
Oxford	1	Shallow cracking clays on basalt
Source: Galloway et al, 1967		

2.3 Profiling

A total of seventeen (17) soil profile exposures were assessed at selected sites to enable soil profile descriptions to be made. These soil profile exposures were excavated with a backhoe. Soil profile site locations are shown in **Figure 4**. Sub-surface exposure locations were selected to provide representative profiles of the soil types encountered over the project sites. The soil layers were generally distinguished on the basis of changes in texture and/or colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994). Photographs of soil profile exposures were also taken.

Numerous surface exposures were also assessed to confirm soil units and boundaries between different soils.

2.4 Field Assessment

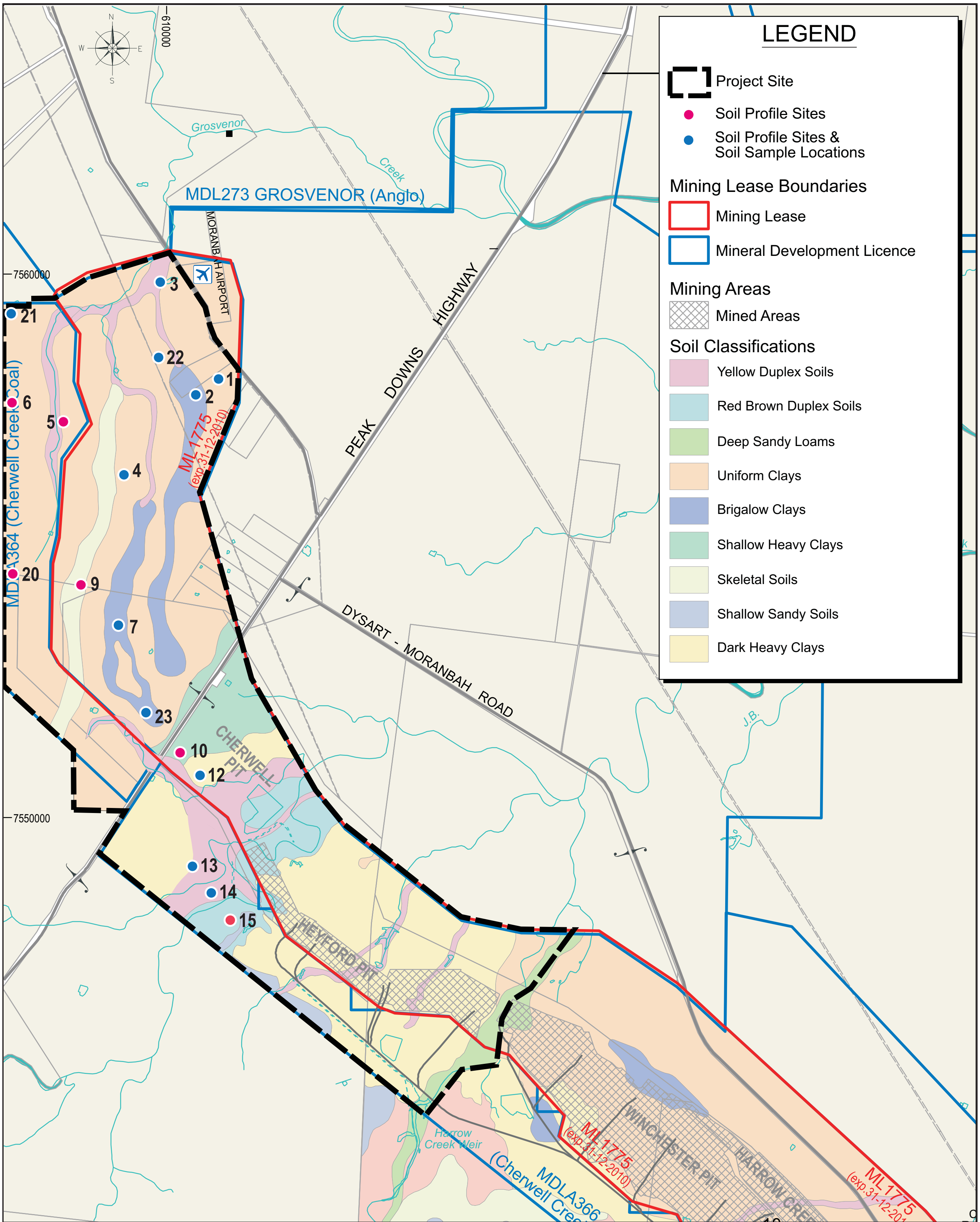
Soil profiles within the project sites were assessed generally in accordance with the soil classification procedures in the Australian Soil and Land Survey Field Handbook (McDonald et al, 1990). Soil layers at each profile site were also assessed according to a procedure devised by Elliot and Veness (1981) for the recognition of suitable topsoil material. This procedure assesses soils based on grading, texture, structure, consistence, mottling and root presence. A more detailed explanation of the Elliot and Veness procedure is presented in **Appendix 1** to this report. The system remains the benchmark for land resource assessment in the Australian coal mining industry.

2.5 Laboratory Testing

Soil samples were collected from the exposed soil profiles to a depth of less than 2 m below ground surface and subsequently despatched to the Department of Lands Soil & Water Testing Laboratory at Scone, NSW for analysis.

Samples were analysed to establish the geochemical suitability of surface and near-surface soil horizons as a potential growth medium, and identify high value or high risk soils. Soil layers are signified by /1, /2 and /3 in the sample ID with the surface horizon being /1 and subsoil horizons being /2 & /3. Samples were analysed from the following sites (as shown on **Figure 4**):

- Site 1 – 1/1, 1/2 & 1/3
- Site 2 – 2/1, 2/2 & 2/3
- Site 3 – 3/1, 3/2 & 3/3
- Site 4 – 4/1, 4/2 & 4/3
- Site 7 – 7/1, 7/2 & 7/3
- Site 12 – 12/1, 12/2 & 12/3
- Site 13 – 13/1, 13/2 & 13/3
- Site 14 – 14/1, 14/2 & 14/3
- Site 21 – 21/1, 21/2 & 21/3
- Site 22 – 22/1, 22/2 & 22/3
- Site 23 – 23/1, 23/2 & 23/3



Scale 1:100,000 (A4)

0 1 2 3 4
Kilometres

FIGURE 4

Soil Classifications
& Sample Locations

Project: Caval Ridge Land Resource Assessment

Client: URS

File: URS03-003

Projection:

Version:	Date:	Author:	Checked:	Approved:
1	21-1-08	LF	RM	RM
2	19-5-08	LF	RM	RM
3	9-10-08	LF	CR	RM
4	7-11-08	LF	CR	RM

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The samples were subsequently analysed for the following parameters:

- Particle size analysis.
- Emerson Aggregate Test (soil aggregate slaking and coherence).
- pH.
- Electrical conductivity.
- Total nitrogen.
- Available phosphorus.
- Cation exchange capacity (CEC) & exchangeable cations.

Profiles 5, 6, 8, 9, 10 and 15 were not analysed as they displayed similar soil characteristics to previously sampled profiles.

A description of the significance of each test and typical values for each soil characteristic is included in **Appendix 2**.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for recovery and use as a growth medium in rehabilitation and to identify potentially hostile material. The soil test results for the soil survey are provided in **Appendix 3**.

2.6 Land Capability Assessment

The project site was assessed in accordance with Rosser *et al* (1974) for pre-mining land capability. The system includes eight (8) possible classifications and refers to the overall agricultural potential of the land. The various classes are provided in **Table 2**.

Table 2 - Land Capability Classes

Category	Class	Description
Suitable for Cultivation	**Class I**	No special practices required.
	Class II	Simple management practices required.
	Class III	Complex or intensive practices required to sustain cropping.
	Class IV	Occasional or limited cultivation but with severe management inputs required to prevent degradation.
Not Suitable for Cultivation	**Class V**	Suitable soil and topography for crops but economically not viable. High quality grazing land.
	Class VI	Moderately susceptible to degradation requiring proper management to sustain use.
	Class VII	Highly susceptible to degradation requiring severe restrictions on use; grazing may be conducted with rigorous management inputs required to prevent degradation.
Not Suitable for Grazing	**Class VIII**	Wildlife reserves, bushland, recreation or water supply catchments.

2.7 Land Suitability Assessment

Agricultural land suitability of the project site has been assessed largely using criteria provided in the *Guidelines for agricultural land evaluation in Queensland* (Queensland Department of Primary Industries, Land Resources Branch, 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 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 increase. 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 3**.

Table 3 - Agricultural Land Suitability Classes

Class	Description
Class 1	Land with negligible limitations, which is highly productive requiring only simple management practices to maintain economic production.
Class 2	Land with minor limitations which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production.
Class 3	Land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production.
Class 4	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).
Class 5	Unsuitable land with extreme limitations that preclude its use for the proposed purpose.

2.7.1 Good Quality Agricultural Land

The project site, and immediately surrounding land, were also assessed to identify potential Good Quality Agricultural Land (GQAL) in accordance with the *Guidelines for the identification Good Quality Agricultural Land* (Qld DPI & DHLG&P, 1993) (referred to as the Good Quality Agricultural Land guidelines).

Agricultural land is defined as land used for crop or animal production, but excluding intensive animal uses (i.e. feedlots and piggeries). Good quality agricultural land 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 good quality agricultural land for planning and project approval purposes. Descriptions of the agricultural land classes are provided in **Table 4**.

Table 4 - Agricultural Land Classes

Class	Description
Class A	**Crop land** - Land that is suitable for current and potential crops with limitations to production which range from none to moderate levels.
Class B	**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.
Class C	**Pasture 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.
Class 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.

3.0 RESULTS

3.1 Soils

The following soil units were identified within the project site:

- Uniform Clays
- Yellow Duplex Soils
- Brigalow Clays
- Skeletal Soils
- Shallow Heavy Clays
- Dark Heavy Clays

The distribution of these soils is illustrated in **Figure 4**. Exposed profiles of major soil units are shown in **Plates 1** to **7**. A glossary of commonly used soils terms is presented in **Appendix 4**.

Uniform Clay

The soil unit occurs on the undulating plains which include minor areas of linear gilgai. This soil unit generally consist of yellowish and reddish brown to light brownish and reddish yellow uniform clays. Uniform soils display little textural change down the profile. This soil unit is associated in the north western areas of the project site. This soil unit encompasses approximately 41% of the project site.

A representative profile of this soil unit is presented in **Table 5.** A typical Uniform Clay profile is shown in **Plate 1.**

Topsoil

The topsoil is approximately 15 cm in depth and light yellowish brown in colour. Textures include clay loam to light clay, with a weak to moderate platy to sub-angluar blocky structure. Clay content varies between 17% and 39%.

Emerson ratings of between 2(1) and (3)1 indicate that this soil is moderately dispersive to slightly dispersive and generally stable. Some sites (e.g. 4 & 22) display high levels of stability with Emerson ratings of 6 and 8. The topsoil is non-saline (EC 0.04 to 0.32 dS/m) and generally slightly acid (pH 6.4-7.0).

Total nitrogen levels range from low (0.13%) to moderate (0.18%). Available phosphorus levels vary widely from very low (site 22 – 3 mg/kg) to low (site 4 – 9 mg/kg) to moderate (site 1 – 21 mg/kg). Total CEC is high. Exchangeable Na% is low. Ca and Mg are high whilst K levels are low (site 4 - 0.2 me/100g) to high (site 22 - 1.7 me/100g).

A sparse to consistent pasture grass cover (generally Buffel Grass dominated) was noted and root penetration was observed as many to common.

Subsoil

The lower boundary of the soil varied between 45 cm and 69 cm in depth. Subsoil colour is yellowish brown to brown and reddish yellow to yellowish red. Texture includes clay loams clays to clays. Structure is generally moderate and angular blocky or massive.

The subsoils are moderately dispersible to generally stable (Emerson ratings of 4 to 2(1) and alkaline (pH 7.1 to 9). Clay content in the subsoils was between 29% and 44% and is non-saline to saline at depth (e.g. Site 1 has an EC of 1.71 ds/m in layer 3).

Root penetration was noted as common to none and stone content is generally low.

Limiting Factors

Generally the Uniform Clay topsoil does not display any specific management risk related to potential disturbance during stripping. The clay subsoil is texturally and structurally unsuitable for stripping. Salinity levels and alkalinity increases with depth and are prohibitive with respect to supporting vegetation. The clay subsoils should not be recovered or used as a surface cover in rehabilitation, due to high clay content, massive structure, high salinity and alkalinity.

The Uniform Clay topsoil is suitable for stripping to a depth of 15 cm. The topsoil is generally considered suitable as a surface cover in the establishment of vegetation.

Table 5 - Uniform Clay profile

SOIL UNIT: UNIFORM CLAY		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.15	Yellowish brown (10YR5/4) clay loam. Weak consistence, angular-blocky peds, 5-10 mm diameter. Many roots and nil stone content. The lower boundary is sharp and even to layer 2.
2	0.15 – 0.69	Yellowish brown (10YR5/4) clay loam. Moderate consistence, sub-angular blocky peds, 20-50 mm diameter. Roots noted as common and stone content minor. The boundary is clear to layer 3.
3	0.69 – 1.05+	Light yellowish brown (10YR6/4) clay loam. Strong consistence and massive. Stone and root content noted as nil.

Plate 1 - Uniform Clay profile

Table 6 and **Plate 2** provide the red variant to the soil profile described above.

Table 6 - Uniform Clay (red variant)

SOIL UNIT: UNIFORM CLAY		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.20	Reddish brown (7.5YR4/6). Moderate consistency and pedality. Angular blocky, 10-20 mm peds. Roots noted as many and 10-20% sub-rounded weathered stones 2-6 mm in diameter. Boundary is clear to layer 2.
2	0.20 – 1.05	Yellowish Red (5YR5/6) clay loam. Moderate consistence. Angluar blocky, 10-20 mm peds. Roots noted as many. Stone content 10-20%. Weathered stones 6-20 mm diameter. Boundary is clear to layer 3.
3	1.05 – 1.25+	Reddish yellow (7.5YR6/6) clay loam. Strong consistence and Apedal massive. No roots stone content 2-10%, 2-6 mm in diameter.

Plate 2 - Uniform Clay (red variant) profile

Yellow Duplex Soil

This soil unit is associated with the floodplain areas, and encompasses some 10% of the project site. The soil is characterised by dark yellow sandy and clay loam of varying depths.

A representative profile of this soil unit is presented in **Table 7**. A typical Yellow Duplex Soil profile is presented in **Plate 3**.

Topsoil

The topsoil generally consists of a coarser textured surface layer, overlying a structured clay horizon up to 15 cm in depth. It is generally dark yellow to brown in colour. The structure of the fine layer is typically single grained, with the underlying horizon formed by moderate angular-blocky peds. Texture generally consists of loam to clay loam, with clay content of approximately 22% and sand content of 60%.

The topsoil is structurally stable, with an Emerson rating of 8/3(1), indicating a low potential for dispersion. The topsoil is generally of low salinity (EC of 0.09 dS/M) and slightly alkaline (pH of 7.1).

Total nitrogen and available phosphorus levels are moderate (0.15% & 15 mg/kg, respectively). Total CEC is high. Exchangeable Na% is low. Ca, K and Mg levels are high.

Stones were observed throughout some profile of this soil unit. The stones were generally rounded to sub-rounded and sedimentary in origin. Surface stone cover observed to vary between 2% and 20%. Surface vegetation generally consisted of Buffel Grass pasture. Root penetration in the topsoil was noted as common.

Subsoil

Yellowish brown subsoils show strong consistence and are massive in structure. Textures consist mainly of light clays, with clay content between 26% and 43%.

The subsoils are non-saline (EC range of 0.04 to 0.15 dS/m) and alkaline (pH range of 8.5 to 9.1). Stabile subsoils indicate a low potential for dispersion, with Emerson ratings of 4 to 5. Root penetration in the soil was moderate in the initial subsoil to none low down and stone content was typically between 5-10%.

Limiting Factors

Generally the Yellow Duplex topsoil does not display any specific management risk related to potential disturbance during stripping. The lower level clay subsoil is texturally and structurally unsuitable for stripping. Alkalinity increases with depth and is prohibitive with respect to supporting vegetation. The lower clay subsoils should not be recovered or used as a surface cover in rehabilitation, due to high clay content, massive structure and alkalinity.

The Yellow Duplex topsoil is suitable for stripping to a depth of 40 cm. The topsoil is generally considered suitable as a surface cover in the establishment of vegetation.

Table 7 - Yellow Duplex Soils profile

SOIL UNIT: YELLOW DUPLEX SOILS		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.15	Dark yellow (10YR5/4) clay loam. Moderate consistence with angular-blocky peds, 5-10mm in diameter. Roots many and 2-10% weathered sedimentary stones 2-6mm diameter. Lower boundary is sharp to layer 2.
2	0.15- 0.45	Yellowish brown (10YR5/3) light clay. Strong consistence and massive. Roots few to common and 20%--50% weathered sedimentary stones, 2-6mm diameter. Boundary is clear to layer 3.
3	0.45 – 1.45+	Yellowish brown (10YR7/4) light clay. Strong consistence and massive. Roots and stone content not noted.

Plate 3 - Yellow Duplex Soil profile

Brigalow Clays

The soil unit occurs on the lowlands and plains (up to 1% slope). These areas contain melanhole and normal gilgai. The soil is characterised by brown light to medium clays throughout the profile. The unit encompasses some 6% of the project site.

A representative profile of this soil unit is presented in **Table 8.** A typical Brigalow Clay profile is shown in **Plate 4.**

Topsoil

The topsoil consists of a fine surface layer, 10-15 cm in depth. It is generally light brown in colour with a weak platy structure. Clay content is approximately 25%.

The soil is non-saline (EC of 0.17 dS/m) and moderately alkaline (pH of 8.0). Structurally the topsoil is generally stable with an Emerson rating of 3(1). Stones are minimal in the profile. Root penetration in the topsoil is common.

Subsoil

The boundary of the sub-soil varies in depth to approximately 40 cm. It is generally brown with moderate sub-angular blocky pedality and light clay texture. Clay content within the subsoil is approximately 37%. Below 100 cm the sub-soil becomes apedal massive.

The subsoil is non-saline (EC of 0.11 dS/m) and moderately alkaline (pH of 8.9). With an Emerson Rating of 4 the subsoil does not exhibit dispersion potential.

Few roots penetrate the subsoil and no stones were observed. Stone content increased below 100 cm depth, as weathered bedrock fragments were encountered.

Limiting Factors

Generally the Brigalow Clay topsoil does not display any specific management risk related to potential disturbance during stripping. The lower level clay subsoil is texturally and structurally unsuitable for stripping. Alkalinity increases with depth and is prohibitive with respect to supporting vegetation.

The Brigalow Clay topsoil is suitable for stripping to a depth of 15 cm. The topsoil is generally considered suitable as a surface cover in the establishment of vegetation.

Table 8 - Brigalow Clay profile

SOIL UNIT: BRIGALOW CLAY		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.15	Brown (10YR5/3) light clay. Weak consistency and pedality. Platy <2mm primary peds. Roots are common. Stone content <2%, weakly weathered sub-rounded stones, 2-6 mm diameter. Boundary is clear & wavy to layer 2.
2	0.15- 0.40	Brown (10YR4/3) light clay. Moderate consistency and pedality. Sub-angular blocky, 2-5 mm peds. Roots noted as few. Stone content 2-10%, weakly weathered sub-rounded stones, 2-6 mm diameter. Boundary is clear but uneven to layer 3.
3	0.40 – 1.10+	Brownish yellow (10YR6/6) light clay. Strong consistency and apedal massive. No roots. Nil stone content.

Plate 4 - Brigalow Clay profile

Skeletal Soils

This soil unit is characterised by shallow reddish brown stony clay soils associated with the steeper eroded side slopes and ridgelines throughout the project site. The soil unit encompasses some 3% of the project site. Description of the soil unit was based on surface observations and no samples were collected.

A representative profile of this soil unit is presented in **Table 9**. A typical Skeletal Soil profile is presented in **Plate 5**.

Topsoil

The topsoil consists of a surface layer approximately 5-10 cm in depth. It is generally light reddish/brown with a weak angular-blocky pedal structure.

Surface stones were generally observed over the surface of the soil unit. The stones were generally between 2-50 mm in diameter, rounded to sub-rounded and sedimentary in origin. Surface stone density was observed to vary between 10% and 90%.

Root penetration in the topsoil was noted as common.

Subsoil

During excavation, refusal occurred at approximately 80 cm in depth. It is generally light reddish brown with a moderate angular blocky structure, going to massive below 45 cm.

Limiting Factors

Iron stone and other rock matter is well within the soil profile. Stripping is not recommended due to significant rock content.

Table 9 - Skeletal Soils profile

SOIL UNIT: SKELETAL SOILS		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.10	Light reddish brown light clay. Weak consistency and pedality. Angular blocky, 5-10 mm peds. Roots noted as common. Stone content 10-20% sub-rounded weathered stones. Boundary is sharp to layer 2.
2	0.10- 0.45	Light reddish brown medium clay. Weak consistency and pedality. Angular blocky, 5-10 mm peds. Roots noted as common. Stone content 50-90% sub-rounded weathered stones. Boundary is clear to layer 3.
3	0.45 – 0.80+	Red/yellow medium clay. Strong consistency and apedal massive. No roots. High stone content matter, 50-90%, 20-60 mm diameter.

Plate 5 - Skeletal Soil profile

Shallow Heavy Clays

Shallow dark cracking clays occur on undulating plains and low hills within the project site. Description of the soil unit was based on surface observations and no samples were collected. The soil unit encompasses some 9% of the project site.

A representative profile of this soil unit is presented in **Table 10**. A typical Shallow Heavy Clay profile is presented in **Plate 6**.

Topsoil

The topsoil consisted of a fine surface layer, 5-10 cm in depth. It is generally a very dark grey/black colour, with a crumby structure and heavy clay texture.

Stones were noticeably minimal in the soil profile. Root penetration in the topsoil was noted as common.

Subsoil

The lower boundary of the subsoil varies in depth to approximately 70 cm. It is generally black with a moderate sub-angular blocky pedality and heavy clay texture. Below 100 cm, the structure becomes apedal massive.

Few roots penetrate the subsoil and no stones were observed. Stone content increased below 100 cm depth, as weathered bedrock fragments were encountered.

Limiting Factors

Generally the Shallow Heavy Clay topsoil is marginally suitable for stripping due to high clay content, massive structure, high salinity and alkalinity.

The Shallow Heavy Clay topsoil can be stripped to a depth of 10 cm. The topsoil is generally considered marginally suitable as a surface cover in the establishment of vegetation.

Table 10 - Shallow Heavy Clay profile

SOIL UNIT: SHALLOW HEAVY CLAY		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.10	Dark greyish heavy clay. Weak consistence and weak pedality, with 2-5 mm crumby peds. Roots are common and 2-10% sub-rounded stones, 2-6 mm in diameter are present. The lower boundary is sharp and even to layer 2.
2	0.10- 0.70	Black and heavy clay. Moderate consistence and moderate pedaility. Sub-angular blocky, rough faced, 50-100 mm, peds. Roots are common and 2-10% stones, 2-6 mm diameter are present. The boundary is clear and wavy to layer 3.
3	0.70 – 1.20+	Grey white weathered sedimentary material.

Plate 6 - Shallow Heavy Clay profile

Dark Heavy Clay

The Dark Heavy Clay consists of heavy dark uniform clays, with a fine mulched surface layer, Given that the unit is a uniform soil, very little textural change down the profile occurs. *Parthenium* infestation was heavy in areas where this unit occurs. The soil unit represents 26% of the project site.

A representative of this profile is presented in **Table 11.** A typical Dark Heavy Clay profile is presented in **Plate 7**.

Topsoil

The topsoil consists of a very fine textured surface layer, 5-10 cm in depth. It is generally a very dark grey/black colour, with a crumby structure and heavy clay texture. Clay content is approximately 58%.

The soil is non-saline (EC of 0.14) and moderately alkaline (pH of 8.2). Structurally, the topsoil was stable with an Emerson Rating of 4. This indicates little potential for dispersion or surface hardsetting.

Total nitrogen and available phosphorus levels are low (0.09% & 11 mg/kg, respectively). Total CEC is very high. Exchangeable Na% is low. Ca and Mg are very high whilst K levels are moderate.

Stones were noticeably minimal in the soil profile. Root penetration in the topsoil was noted as common.

Subsoil

The initial boundary of the subsoil varies in depth to approximately 45 cm. It is generally black with a moderate sub-angular blocky pedality and heavy clay texture. Clay content within the subsoil is approximately 61%. Below 100 cm, the structure becomes apedal massive. Clay content increases to 67%.

The subsoil is non-saline (EC of 0.12 dS/m) and moderately alkaline (pH of 8.7). With an Emerson Rating of 4 the subsoil does not exhibit any dispersion potential.

Few roots penetrate the subsoil and no stones were observed. Stone content increased below 100 cm depth, as weathered bedrock fragments were encountered.

Limiting Factors

Generally the Dark Heavy Clay topsoil is marginally suitable for stripping due to high clay content, massive structure, high salinity and alkalinity.

The Dark Heavy Clay topsoil can be stripped to a depth of 10cm. The topsoil is generally considered marginally suitable as a surface cover in the establishment of vegetation particularly given that the surface horizon will contain a substantial seed bank of *Parthenium* which potentially could re-spread throughout the rehabilitated post mining landform if specific weed control practices are not implemented.

Table 11 - Dark Heavy Clay profile

SOIL UNIT: DARK HEAVY CLAY		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.10	Dark greyish heavy (10YR3/1) clay. Weak consistence and weak pedality, with 2-5 mm crumby peds. Roots are common and 2-10% sub-rounded stones, 2-6 mm in diameter are present. The lower boundary is sharp and even to layer 2.
2	0.10 – 0.45	Black and heavy clay (10YR3/1). Moderate consistence and moderate pedaility. Sub-angular blocky, rough faced, 50-100 mm, peds. Roots are common and 2-10% stones, 2-6 mm diameter are present. The boundary is clear and wavy to layer 3.
3	0.45 – 1.25+	Black and heavy clay (10YR3/1). Strong consistence and apedal massive. No roots and stone content 2-10%, 2-6 mm diameter.

Plate 7 - Dark Heavy Clay profile

3.2 Topsoil Suitability

The major land disturbance is likely to result from excavation of the open cut pit, placement of out-of-pit overburden dumps and haul road construction. It is recommended that topsoil be recovered in these areas of disturbance. Soil analysis results (refer **Appendix 3**) were used in conjunction with the field assessment (refer **Appendix 1**) to determine the depth or thickness of soil materials suitable for recovery. Structural and textural properties of subsoils are the most significant limiting factors in determining depth of soil suitability for re-use. However, salinity levels, pH and dispersion potential are also limiting factors in some soils in the project sites. Indicative soil analyte levels with respect to soil suitability follow.

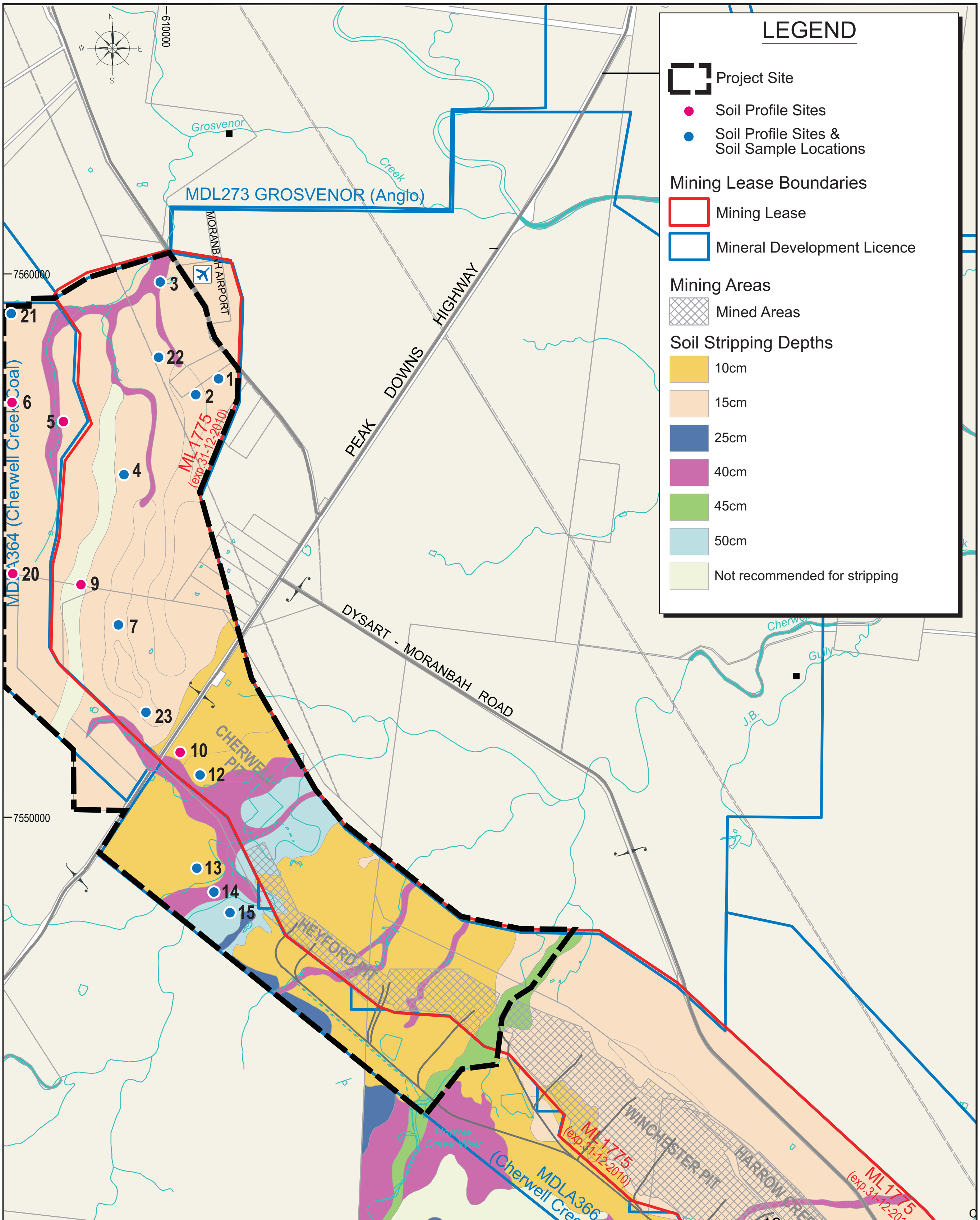
Structure	-	> 30% peds present
	-	coherent when wet or dry
	-	no mottle present
Texture	-	finer than sandy loam
	-	sand & gravel content < 60%
Dispersion	-	EAT > 2 (2)
	-	exchangeable Na% < 12%
pH	-	> 4.5 & < 8.4
Conductivity	-	< 1.5 dS/m

Recommended topsoil depths for each soil unit are provided in **Table 12** and are presented in **Figure 5**.

Table 12 - Recommended soil stripping depths for soil types

Soil Unit	Recommended Stripping Depth (cm)
Uniform Clays	15
Yellow Duplex Soils	40
Brigalow Clays	15
Skeletal Soils	Not recommended for stripping
Shallow Heavy Clays ^	10
Dark Heavy Clays ^	10
Shallow Sandy Soils	25
Red Brown Duplex Soils	50
Deep Sandy Loams	45

^ High clay content material may benefit from mixing with a sandy textured material for use in rehabilitation.



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0 1 2 3 4

Kilometres

FIGURE 5

Soil Stripping Depths

Project: Caval Ridge Land Resource Assessment

Client: URS

Version:	Date:	Author:	Checked:	Approved:
1	9-10-08	LF	CR	RM
2	7-11-08	LF	CR	RM

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Projection:

3.3 Erosion Potential

Some of the Uniform Clay sites have indicated a moderate erosion potential with Emerson Aggregate Test ratings of 2 to 3, which indicates a moderate potential for dispersion and surface hardsettingness. Once this material is disturbed, the potential for erosion may be increased. If this disturbance occurs within the vicinity of a drainage line, this 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.

3.4 Potential Acid Generating Material

The potential for acid generation from regolith material (topsoil and subsoil) within the project site is low. This does not include acid generation potential within the overburden material (consolidated bedrock below 2-3 m depth), which was not assessed during this survey.

Acid Sulphate Soils (ASS), which are the main cause of acid generation within the soil mantle, are commonly found less than 5 m above sea level, particularly in low-lying coastal areas such as mangroves, salt marshes, floodplains, swamps, wetlands, estuaries, and brackish or tidal lakes. The project site is located within the Central Highlands region (which is located approximately 150 km from the coast at > 260 m AHD). There has been little history of acid generation from regolith material with this region.

3.5 Land Capability

The majority of the project site is considered Class VI – not suitable cultivation and is moderately susceptible to degradation requiring proper management to sustain the land use. Some Class V land occurs in the vicinity of the north end of the existing Heyford Pit. It is high quality grazing land.

The rocky hills and ridgelines, along with the highly eroded and Skeletal Soils, are considered to be Class VII - land that is highly susceptible to degradation requiring severe restrictions for use. Grazing may be conducted with rigorous management inputs required to prevent degradation.

Class V, VI and VII lands are all grazing land classes and are not suitable for cultivation. The distribution of these land capability classes within the project site can be found in **Figure 6**, for the project site.

3.6 Land Suitability

3.6.1 Pre-Mining

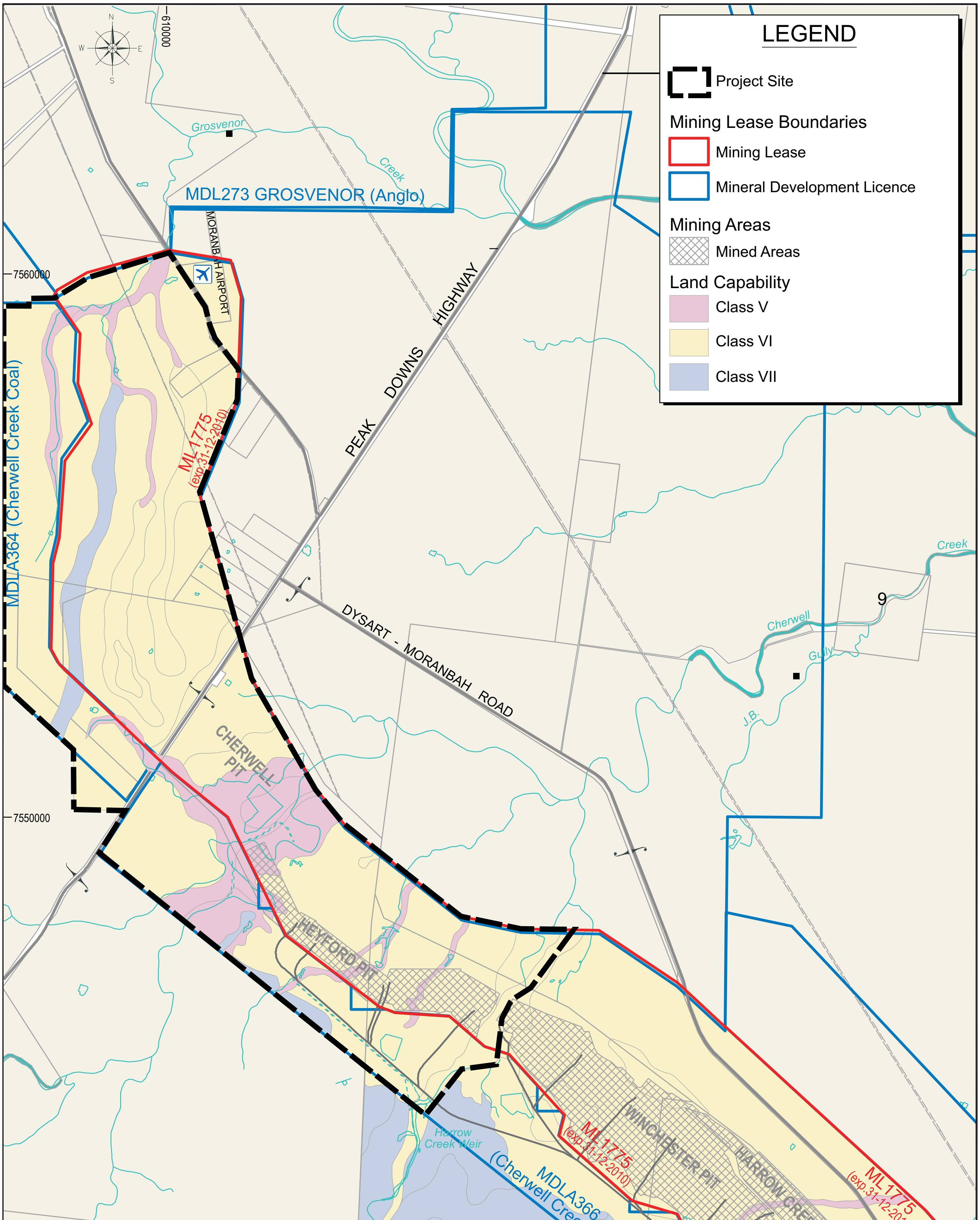
The project site is currently used for low intensity cattle grazing. As a result of this historical and current land use, there has been extensive tree clearing throughout the area. The land use is consistent with that of the adjoining land, which is also predominantly used for low intensity cattle grazing. Land suitability classes, with respect to both cropping & grazing are provided in **Table 13** for each soil unit.

The majority of land within the project sites is Class 5 with respect to cropping. The land is unsuitable for cropping. Some Duplex Soils in the vicinity of the north end of the existing Heyford Pit are Class 4 lands that are extremely marginal for cropping. This includes the well drained areas of flat to gently sloping Duplex Soils. The lands are Class 2 land with respect to grazing which is suitable for low intensity grazing, with minor limitations that lower production or require management practices. The remainder of the project site is Class 2 & 4 land with respect to grazing potential i.e. land that has either moderate limitations or is marginal grazing land.

Table 13 - Land Suitability Classes

Soil Unit	Cropping	Grazing
Yellow Duplex Soils	5	3
Red Brown Duplex Soils	4	2
Deep Sandy Loams	5	4
Uniform Clays	5	2
Brigalow Clays	5	3
Shallow Heavy Clays	5	2
Skeletal Soils	5	4
Shallow Sandy Soils	5	4
Dark Heavy Clays	5	3

The vast majority of land within the project site is unsuitable for cropping. The Red Brown Duplex Soils are marginally suitable for cropping, however the inputs required to achieve and maintain production will generally outweigh the benefits of cropping this soil unit in the long term. Grazing suitability varies throughout the project site. Land with minor limitations includes areas containing Red Brown Duplex Soils, Uniform Clays and Shallow Heavy Clays. Land with Moderate limitations includes areas containing Yellow Duplex Soils, Brigalow Clays and Dark Heavy Clays and marginal grazing lands encompass the Deep Sandy Loams, Skeletal Soils and the Shallow Sandy Soils.



Scale 1:100,000 (A4)
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Kilometres

FIGURE 6

Land Capability

Project: Caval Ridge Land Resource Assessment

Client: URS

File: URS03-003

Projection:

Version:	Date:	Author:	Checked:	Approved:
1	21-1-08	LF	RM	RM
2	9-10-08	LF	CR	RM
3	7-11-08	LF	CR	RM

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3.6.2 Good Quality Agricultural Land

NRW (1995) have mapped the majority of the project site as Class C – suitable for improved or native pastures due to limitations that preclude cultivation for crop production. Some Class A land occurs within the project site but does not occur within the pit footprint area and, therefore, will not be disturbed. Approximately 4% of the project site is Class A land. The remainder is Class C land. Figure 4.13 shows Good Quality Agricultural Land within the project site.

3.6.3 Post Mining

Although detailed closure options were not available during the production of this report, the proposed post-mining land use for the project sites is expected to be a mosaic of grassland and bushland. In terms of soil conservation and agricultural land suitability, the proposed impacts are considered manageable and the proposed post-mining land use of grassland and bushland combination is considered achievable for those areas not subject to significant landscape modification (open cut pit and out-of-pit overburden dumps). In the areas impacted by significant landscape modification, agricultural suitability class may be altered. Where significant impacts interact with drainage lines within the Class 2 or Class 3 lands, a greater level of management input may be required to prevent land degradation and change in suitability class.

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 agricultural suitability class. Soil conservation practices such as 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.

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

Provided that environmental controls such as structural soil conservation works (refer **Section 3.3**) and effective revegetation are in place and operating properly during mine construction and operation, there should be no adverse effects to the project site or the surrounding grazing land.

4.0 DISTURBANCE MANAGEMENT

The following management and mitigation strategies are recommended for implementation during mining, in order to reduce the potential for degradation within the project sites and adjoining lands. These recommendations 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.

4.1 Topsoil Stripping and Handling

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

- Strip material to the depths stated in **Table 10**, subject to further investigation as required.
- Topsoil should be maintained in a slightly moist condition during stripping. Material should not be stripped in either an excessively dry or wet condition.
- Marker pegs should be used to indicate required stripping depth in the uniform clays (brown clays and dark clays). Especially where over-stripping may expose potentially dispersive subsoils.
- Place stripped material directly onto reshaped overburden and spread immediately (if mining sequences, equipment scheduling and weather conditions permit) to avoid the requirement for stockpiling.
- Grading or pushing soil into windrows with graders or dozers for later collection by elevating scrapers, or for loading into rear dump trucks by front-end loaders, are examples of 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 bottom dumping 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 textured a condition as possible in order to promote infiltration and minimise erosion until vegetation is established and to prevent anaerobic zones forming.
- As a general rule, maintain a maximum stockpile height of 3 m. Clayey soils, such as the brown clay topsoil, should be stored in lower stockpiles for shorter periods of time (i.e. less than 12 months) compared to sandier soils, selected from the alluvial 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.
- An inventory of available suitable surface cover material should be maintained to ensure adequate topsoil materials are available for planned rehabilitation activities.

4.2 Topsoil Respreading

Not all reshaped overburden areas will require topdressing using conserved topsoil reserves. Topsoil can often be more of a hindrance when direct tree seeding techniques are implemented in the revegetation program, as it allows weed and grass species to compete with trees. Therefore, some zones throughout the progressive rehabilitation areas will be devoid of replaced topsoil to enhance tree and shrub germination and establishment.

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 reshaped areas. Where topsoil resources allow, topsoil should be spread to a minimum depth of 10 cm on all regraded spoil.

Topsoil should be spread, treated with fertilizer or ameliorants (if required) and seeded in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion.

Prior to re-spreading stockpiled topsoil onto reshaped overburden (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.

4.3 Landform Design and Erosion Control

Rehabilitation strategies and concepts proposed below have been formulated according to results of industry-wide research and experience.

Post Disturbance Regrading

The main objective of regrading 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. Final slope gradient should not exceed 17%, or approximately 10^0.

Erosion & Sediment Control

The most significant means of controlling surface flow on disturbed areas is to construct contour furrows or contour banks at intervals down the slope. The effect of these is to divide 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.

Graded banks are essentially a much larger version of contour furrows, with a proportionately greater capacity to store runoff and/or drain it to some chosen discharge point. The banks are constructed away from the true contour, at a designed gradient (0.5% to 1%) so that they drain water from one part of a slope to another; for example, towards a watercourse or a sediment control dam.

Eventually, runoff that has been intercepted and diverted must be disposed of down slope. The use of engineered waterways using erosion blankets, ground-cover vegetation and/or rip rap is recommended to safely dispose of runoff downslope.

The construction of sediment control dams is recommended for the purpose of capturing sediment laden runoff 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, such as the subsoils of the dark clays, will require treatment with lime, gypsum and/or bentonite to prevent failure of the wall by tunnel erosion. Failure by tunnelling is most likely 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.
- The number and capacity of dams should be related to the total area of catchment and the anticipated volume of runoff. The most damaging rains, in terms of erosion and sediment problems are localised, high intensity storms.

Seedbed Preparation

Thorough seedbed preparation should be undertaken to ensure optimum establishment and growth of vegetation. All topsoiled areas should be contour ripped using a small dozer with a 3 tyned ripper attachment (after topsoil spreading) to create a “key” between the soil and the spoil. Ripping should be undertaken on the contour and the tynes lifted for approximately 2 m every 200 m 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, to reduce run-off and increase infiltration. This can be undertaken by contour tilling with a fine-tyned plough or disc harrow.

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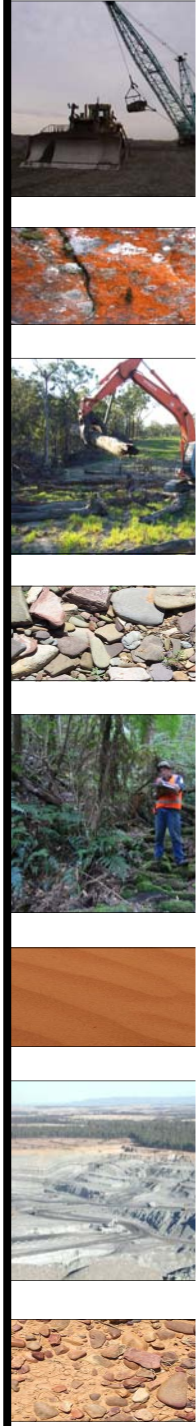
Field Assessment Procedure



APPENDIX 1

FIELD ASSESSMENT PROCEDURE

Elliott and Veness (1981) have described the basic procedure, adopted in this survey, for the recognition of suitable topdressing materials. In this procedure, the following soils factors are analysed. They are listed in decreasing order of importance.

Structure Grade

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 (Charman, 1978) and depends on the proportion of coarse peds in the soil surface.

Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils without pores are considered unsuitable as topdressing materials.

Consistence - Shearing Test

The shearing test is used as a measure of the ability of soils to maintain structure grade.

Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the extraction, transportation and spreading of topdressing material.

Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

Consistence - Disruptive Test

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.

Mottling

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeabilities; 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.

Macrostructure

Refers to the combination or arrangement of the larger aggregates or peds in the soil. Where these peds are larger than 10 cm (smaller dimension) in the subsoil, soils are likely to either slake or be hardsetting and prone to surface sealing. Such soils are undesirable as topdressing materials.

Texture

Sandy soils are poorly suited to plant growth because they are extremely erodible and have low water holding capacities. For these reasons soils with textures equal to or coarser than sandy loams are considered unsuitable as topdressing materials for climates of relatively unreliable rainfall, such as Central Queensland.

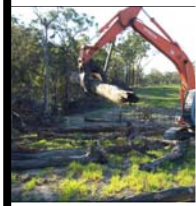
Root Density and Root Pattern

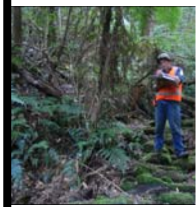
Root abundance and root branching is a reliable indicator of the capability for propagation and stockpiling.

Field Exposure Indicators

The extent of colonisation of vegetation on exposed materials as well as the surface behavior and condition after exposure is a reliable field indicator for suitability for topdressing purposes. These layers may alternate with other layers which are unsuitable. Unsuitable materials may be included in the topdressing mixture if they are less than 15cm thick and comprise less than 30 per cent of the total volume of soil material to be used for topdressing. Where unsuitable soil materials are more than 15 cm thick they should be selectively discarded.








APPENDIX 2

Soil Information

TEST SIGNIFICANCE AND TYPICAL VALUES

Particle Size Analysis

Particle size analysis measures the size of the soil particles in terms of grainsize fractions, and expresses the proportions of these fractions as a percentage of the sample. The grainsize fractions are:

clay	(<0.002 mm)
silt	(0.002 to 0.02 mm)
fine sand	(0.02 to 0.2 mm)
medium and coarse sand	(0.2 to 2 mm)

Particles greater than 2 mm, that is gravel and coarser material, are not included in the analysis.

Dispersion Percentage

Dispersion percentage is a measure of soil dispersibility representing the proportion of clay plus fine silt (<0.005 mm approximately) in a soil which is dispersible and is expressed as a percentage. The following rankings of dispersion percentage are applicable:

0 – 30%	low
30 – 50%	moderate
50 – 65%	high
65 – 100%	very high

Emerson Aggregate Test

Emerson aggregate test measures the susceptibility to dispersion of the soil in water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in water. The test indicates the credibility and structural stability of the soil and its susceptibility to surface sealing under irrigation and rainfall. Soils are divided into eight classes on the basis of the coherence of soil aggregates in water. The eight classes and their properties are:

Class 1 - very dispersible soils with a high tunnel erosion susceptibility.

Class 2 - moderately dispersible soils with some degree of tunnel erosion susceptibility.

Class 3	-	slightly or non-dispersible soils which are generally stable and suitable for soil conservation earthworks.
Class 4-6	-	more highly aggregated materials which are less likely to hold water. Special compactive efforts are required in the construction of earthworks.
Class 7-8	-	highly aggregated materials exhibiting low dispersion characteristics.

The following subdivisions within Emerson classes may be applied:

(1) slight milkiness, immediately adjacent to the aggregate
(2) obvious milkiness, less than 50% of the aggregate affected
(3) obvious milkiness, more than 50% of the aggregate affected
(4) total dispersion, leaving only sand grains.

Salinity

Salinity is measured as electrical conductivity on a 1:5 soil:water suspension to give EC (1:5). The effects of salinity levels expressed as EC at 25^{o} (*d*S/cm), on plants are:

0 to 1	very low salinity, effects on plants mostly negligible.
1 to 2	low salinity, only yields of very sensitive crops are restricted.
greater than 2	saline soils, yields of many crops restricted.

pH

The pH is a measure of acidity and alkalinity. For 1:5 soil:water suspensions, soils having pH values less than 4.5 are regarded as strongly acid, 4.5 to 5.0 moderately acidic, and values greater than 7.0 are regarded as alkaline. Most plants grow best in slightly acidic soils.

Phosphorus

Phosphorus is an important soil component indicating a main limiting growth factor. The phosphorus that is available to the plant is only a small fraction of the total amount of phosphorus in the soil. Extractable phosphorus was determined by the Bray No. 2 test.

Available phosphorus at 5 ppm is considered the deficiency limit whereas levels greater than 25 ppm are very high.

Phosphorus Sorption

Phosphorus sorption relates to the ability of a soil to remove phosphorus from solution and assimilate it within the soil matrix. Sorption index ratings are:

0 – 3	low
3 – 4.5	moderate
4.5 – 6	high
>6	very high

Nitrogen

Nitrogen is another important component of soil indicating a main limiting growth factor. The total amount of nitrogen in the soil was determined by the Kjeldahl method, which is essentially a wet-oxidation procedure. The total nitrogen of soils ranges from less than 0.2 per cent in subsoils to greater than 2.5 per cent in peats.

The surface layer of most cultivated soils contains between 0.06 to 0.5% N. As a guide, the following figures for total nitrogen may be used:

less than 0.1% N	low
0.1 to 0.2% N	medium
more than 0.2% N	high

Cation Exchange Capacity and Exchangeable Cations

The concentration of cations is expressed as milli-equivalents (me)/100 g or mmol/kg. This takes account of their different valencies and atomic weights. The total quantities of cations that a soil can hold is called the cation exchange capacity (CEC), also expressed as me/100 g.

The five most abundant cations in soils are calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}) and in strongly acid soils, aluminum (Al^{3+}). The cations manganese (Mn^{2+}), iron (Fe^{2+}), copper (Cu^{2+}) and zinc (Zn^{2+}) are usually in amounts that do not contribute significantly to the cation complement. The following rankings are applicable:

Cation (me/100g)	Ranking				
	Very low	**Low**	**Moderate**	**High**	**Very High**
CEC	<5	5-10	0.-15	15-35	>35
Na	<0.1	0.1-0.3	0.3-0.7	0.7-2.0	>2.0
K	<0.2	0.2-0.4	0.4-0.7	0.7-2.0	>2.0
Ca	<2	2-5	5-10	10-20	>20
Mg	<0.3	0.3-1.0	1.0-3.0	3.0-8.0	>8.0

Soils or substrates having values of exchangeable sodium percentage (ESP) exceeding 5 me% are described as sodic, and greater than 15 me% as strongly sodic. The clay particles in such soils are liable to disperse on wetting, causing structure to deteriorate and surface sealing to occur.

Organic Carbon

Organic Carbon content can be directly related to the levels of soil organic matter and is based on the (Walkley – Black) chromic acid method. Percentage organic matter can be obtained by multiplying percentage organic carbon by 1.72. This factor is based on the assumption that organic matter in the soil has a constant carbon composition of 58 per cent.

The following rankings of organic carbon are applicable:

0 – 0.5%	very low
0.5 – 1.5%	low
1.5 – 2.5%	moderate
2.5 – 5.0%	high
>5%	very high

LABORATORY TEST METHODS

Particle Size Analysis

Determination by sieving and hydrometer of percentage, by weight, of particle size classes: Gravel >2mm, Coarse Sand 0.2-2 mm, Fine Sand 0.02-0.2 mm, Silt 0.002-0.2 mm and Clay <0.002 mm SCS Standard method. Reference - Bond, R, Craze B, Rayment G, and Higginson (in press 1990) **Australia Soil and Land Survey Laboratory Handbook**, Inkata Press, Melbourne.

Dispersion Percentage

Ratio of particles less than 0.005mm that remain in suspension in distilled water after two hours settling time compared to the total amount of materials less than 0.005mm. Expressed as a percentage. Determination by hydrometer. SCS Standard Method. Reference: Ritchie, J.A. (1963) Earthwork Tunnelling and the Application of Soil Testing Procedures. **Journal of Soil Conservation Service of NSW** 19, 111-129.

Emerson Aggregate Test

An eight class classification of soil aggregate coherence (slaking and dispersion) in water. SCS Standard Method closely related to Australian Standard AS1289. The degree of dispersion is included in brackets for class 2 and 3 aggregates. Reference - Bond R., Craze, B., Rayment, G., Higginson, F.R., (in press 1990). **Australian Soil and Land survey Laboratory Handbook**, Inkata Press, Melbourne.

EC

Electrical Conductivity determined on a 1:5 soil:water suspension. Prepared from the fine earth fraction of the sample. Reference - Bond R, Craze B, Rayment G, Higginson FR (in press 1990) **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

pH

Determined on a 1:5 soil:water suspension. Soil refers to the fine earth fraction of the sample. Reference - Bond, R., Craze, B., Rayment, G., Higginson, F.R. (in press 1990). **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

Nitrogen

Measurement of soil total N is based on wet oxidation known as the Kjeldahl method. Reference - Bond, R., Craze, B., Rayment, G., Higginson, F.R. (in press 1990). **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

Phosphorus

The Bray phosphorus method extracts plant available phosphorus from the soil matrix using fluoride after centrifugation. Reference - Bond, R., Craze, B., Rayment, G., Higginson, F.R. (in press 1990). **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

Phosphorus Sorption

A standard phosphorus solution is added to a soil. After equilibrium the phosphorus remaining in solution is measured colorimetrically and the phosphorus "fixed" by the soil determined by difference. Reference – Abott TS (1987) BCRI Soil Testing Methods.

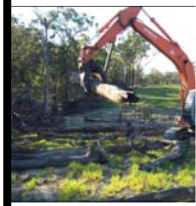
Cation Exchange Capacity

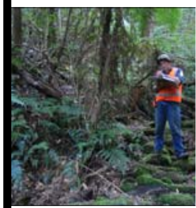
CEC and exchangeable cations are determined by a single extraction using unbuffered (AgTU)+. Reference - Bond, R., Craze, B., Rayment, G., Higginson, F.R. (in press 1990). **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

Organic Carbon

Walkley-Black method. Organic matter is oxidized by dichromate. The amount of dichromate reduced is determined by titration with ferrous sulphate using Ferroin Indicator. Reference – Allison LE in Black CA et al (1965). Methods of Soil Analysis 1372-1378.








APPENDIX 3

Soil Test Results

Department of Lands

Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO07/378R1
REPORT TO:	R Masters GSS Environmental PO Box 3214 Wamberal NSW 2260
REPORT ON:	Twenty seven soil samples ON: URS3-07-03 Peak Downs Nth
PRELIMINARY RESULTS ISSUED:	Not issued
REPORT STATUS:	Final
DATE REPORTED:	21 December 2007
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

SR Young

G Holman
(Technical Officer)

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO07/378R1
Client Reference: R Masters
GSS Environmental
PO Box 3214
Wamberal NSW 2260

Lab No	Method	C1A/4	C2A/3	P7B/1 Particle Size Analysis (%)					P9B/2	Colour	
	Sample Id	EC (dS/m)	pH	clay	silt	f sand	c sand	gravel	EAT	Dry	Moist
1	1/1	0.12	6.9	26	14	24	32	4	3(2)	10YR4/4	10YR3/4
2	1/2	0.24	8.1	51	4	17	22	6	2(2)	10YR5/6	10YR4/6
3	1/3	1.71	9.0	49	9	18	24	0	2(1)	10YR5/6	10YR4/6
4	2/1	0.13	8.3	57	14	16	12	1	7/4	10YR5/3	10YR4/3
5	2/2	0.24	8.7	59	12	16	11	2	4	10YR4/3	10YR3/3
6	2/3	1.87	5.4	55	31	11	3	0	2(1)	10YR6/4	10YR5/6
7	3/1	0.09	7.1	22	17	39	22	0	8/3(1)	10YR5/4	10YR3/4
8	3/2	0.04	8.5	43	19	28	9	1	5	10YR5/3	10YR3/3
9	3/3	0.15	9.1	26	20	29	18	7	4	10YR7/4	10YR5/6
10	4/1	0.32	6.4	39	10	20	20	11	6	5YR4/4	5YR3/4
11	4/2	0.64	6.9	48	4	14	22	12	6	5YR4/6	5YR3/4
12	4/3	1.38	6.8	60	8	18	13	1	2(1)	5YR5/6	5YR4/6
13	7/1	0.08	7.4	37	15	31	14	3	3(1)	10YR4/4	10YR3/3
14	7/2	0.22	9.0	44	18	24	12	2	4	10YR4/4	10YR3/4
15	7/3	1.34	8.9	46	17	23	10	4	4	10YR5/6	10YR4/6

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO07/378R1
Client Reference: R Masters
GSS Environmental
PO Box 3214
Wamberal NSW 2260

Lab No	Method	C1A/4	C2A/3	P7B/1 Particle Size Analysis (%)					P9B/2	Colour	
	Sample Id	EC (dS/m)	pH	clay	silt	f sand	c sand	gravel	EAT	Dry	Moist
16	12/1	0.14	8.2	58	14	15	12	1	4	10YR3/1	10YR2/1
17	12/2	0.12	8.7	61	9	17	12	1	4	10YR3/1	10YR2/1
18	12/3	0.59	8.7	67	4	17	11	1	4	10YR3/1	10YR2/1
19	21/1	0.08	7.0	32	13	28	21	6	2(1)	10YR5/4	10YR4/4
20	21/2	0.06	7.1	29	13	25	24	9	2(1)	10YR5/4	10YR4/4
21	21/3	1.34	8.8	33	13	28	25	1	2(2)	10YR6/4	10YR5/6
22	22/1	0.04	6.9	17	15	43	25	<1	8/3(1)	7.5YR4/6	7.5YR3/4
23	22/2	0.24	9.2	36	15	25	18	6	4	5YR5/6	5YR4/6
24	22/3	0.29	9.3	29	19	27	22	3	3(1)	7.5YR6/6	7.5YR5/6
25	23/1	0.17	8.0	25	14	34	26	1	3(1)	10YR5/3	10YR3/3
26	23/2	0.11	8.9	37	11	28	23	1	4	10YR4/3	10YR3/3
27	23/3	0.96	9.5	36	15	28	21	1	2(1)	10YR6/6	10YR5/8

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO07/378R1

Client Reference: R Masters
GSS Environmental
PO Box 3214
Wamberal NSW 2260

Lab No	Method	C5A/3 CEC & exchangeable cations (me/100g)					C8A/2
	Sample Id	CEC	Na	K	Ca	Mg	P (mg/kg)
1	1/1	16.7	0.7	0.8	7.6	3.9	21
4	2/1	40.6	1.1	0.3	15.8	14.1	15
7	3/1	21.3	0.4	1.4	12.0	3.7	15
10	4/1	16.8	0.5	0.2	9.2	3.1	9
13	7/1	27.9	0.8	0.8	14.8	7.0	14
16	12/1	54.4	1.0	0.4	27.5	19.6	11
19	21/1	23.0	1.0	0.8	7.2	10.6	4
22	22/1	17.2	0.1	1.7	9.0	2.8	3
25	23/1	27.7	0.3	2.2	16.4	6.1	62

END OF TEST REPORT

SGS

CTW.2707043

Certificate of Analysis

This is to certify that the undermentioned sample(s) were analysed and this certificate was issued at SGS Agritech, 214 McDougall St., Toowoomba QLD 4350. Phone: 0011+61+7+46330599. NATA accredited laboratory 2120.

APPLICANT: DEPARTMENT OF LANDS
PO BOX 283
SCONE NSW 2337

ORDER NO.: Job # SCO07/378

SAMPLE(S) RECEIVED: 20 December 2007 **CERTIFICATE ISSUED:** 02 January 2008

SAMPLE NO.:	COMMODITY	MARKINGS	TEST	RESULT	UNITS
2007028683	Soil	SCO07/378/~~4~~ 1	Nitrogen	1329.0	mg/kg
2007028684	Soil	SCO07/378/4	Nitrogen	1646.0	mg/kg
2007028685	Soil	SCO07/378/7	Nitrogen	1498.0	mg/kg
2007028686	Soil	SCO07/378/10	Nitrogen	1495.0	mg/kg
2007028687	Soil	SCO07/378/13	Nitrogen	1683.0	mg/kg
2007028688	Soil	SCO07/378/16	Nitrogen	887.0	mg/kg
2007028689	Soil	SCO07/378/19	Nitrogen	1631.0	mg/kg
2007028690	Soil	SCO07/378/22	Nitrogen	1836.0	mg/kg
2007028691	Soil	SCO07/378/25	Nitrogen	2391.0	mg/kg

METHOD PRN002

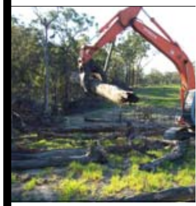
Results are on a 'as received' basis

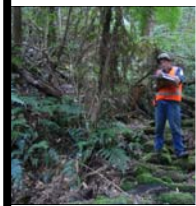
Robert Lascelles
Chief Chemist
For and on behalf c
SGS Australia Pty Ltd

The results apply only to the sample analysed. The sample on which the test was performed was not collected by or on behalf of SGS Agritech. This certificate is discrete and can only be reproduced in full. The analysis was performed between 20/12/2007 and 31/12/2007

SGS Australia Pty Ltd ABN 44 000 964 278 | SGS Agritech Toowoomba 214 McDougall St Toowoomba QLD 4350 PO Box 549 Toowoomba QLD 4350 t +61 (0)7 4633 0599 f +61 (0)7 4633 0711 www.au.sgs.com








Glossary

APPENDIX 4

A Horizon

The original top layer of mineral soil divided into A_1 (typically from 5 to 30 cm thick; generally referred to as topsoil

Alluvial Soils

Soils developed from recently deposited alluvium, normally characterise little or no modification of the deposited material by soil forming processes, particularly with respect to soil horizon development.

Brown Clays

Soil determined by high clay contents. Typically, moderately deep to very deep soils with uniform colour and texture profiles, weak horizonation mostly related to structure differentiation.

Consistence

Comprises the attributes of the soil material that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation or rupture.

Electrical Conductivity

The property of the conduction of electricity through water extract of soil. Used to determine the soluble salts in the extract, and hence soil stability. (Soil Landscapes of Singleton 1991)

Emmerson's Aggregate Test (EAT)

A classification of soil based on soil aggregate coherence when immersed water. Classifies soils into eight classes and assists in identifying whether soils will slake, swell or disperse (Soil Landscapes of Singleton, 1991)

Gravel

The >2 mm materials that occur on the surface and in the A_1 horizon and include hard, coarse fragments.

Lithosols

Stony or gravelly soils lacking horizon and structure development. They are usually shallow and contain a large proportion of fragmented rock. Textures usually range from sands to clay loams.

Loam

A medium, textured soil of approximate composition 10 - 25% clay, 25 - 50% silt and <50% sand.

Mottling

The presence of more than one soil colour in the same soil horizon, not including different nodule or cutan colours.

Particle Size Analysis (PSA)

The determination of the of the amount of the different size fractions in a soil sample such as clay, silt, fine sand, coarse sand and gravel. (Soil Landscapes of Singleton 1991)

Pedality

Refers to the relative proportion of peds in the soil (as strongly pedal, weakly pedal or non-pedal).

pH

A measure of the acidity or alkalinity of a soil.

Solodic Soils

Strong texture differentiation with a very abrupt wavy boundary between A and B horizons, a well-developed bleached A2 horizon and a medium to coarse blocky clay B horizon.

Soloths

Similar to a solodic soil but acidic throughout the profile. Tends to be a more typical soil of the humid regions where the exchangeable cations in the B Horizon of the solodised soils have been leached out.

Podzolics

Podzolic soils are acidic throughout and have a clear boundary between the topsoil and subsoil. The topsoils are loams with a brownish grey colour. The lower part of the topsoil has a pale light colour and may be bleached with a nearly white, light grey colour.

Ped

An individual, natural soil aggregate. (Soil Landscapes of Singleton 1991)

Sodicity

A measure of exchangeable sodium in the soil. High levels adversely affect soil stability, plant growth and/or land use.

Soil mantle

The upper layer of the Earth's mantle, between consolidated bedrock and the surface, that contains the soil. Also known as the regolith.