MOOLARBEN COAL PROJECT

Stage 2

APPENDIX II

Soil, Rural Land Capability and Agricultural Suitability Assessment

MOOLARBEN COAL PROJECT

SOIL, RURAL LAND CAPABILITY AND AGRICULTURAL SUITABILITY ASSESSMENT

Moolarben Coal Project

Stage 2

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1 INTRODUCTION

The Moolarben Coal Project (MCP) area is situated approximately 40 kilometres (km) north-east of Mudgee township and immediately east of the village of Ulan in central New South Wales (NSW).

Stage 1 of the MCP was approved by the NSW Minister for Planning in September 2007 and comprised three open cut coal mines, an underground coal mine with associated infrastructure. This report has been prepared to accompany an application for Stage 2 of the MCP that comprises an open cut coal mine, two underground coal mines and associated infrastructure that will be operated in conjunction with Stage 1 as an integrated mining complex.

This report is to determine the soil resource, rural land capability and agricultural suitability of the disturbance areas within the Stage 2 MCP area. Specifically, the objectives of this report are to:

- Detail the soil resources within the Stage 2 MCP area;
- Specify the rural land capability of the MCP area in accordance with the standard NSW eight class system (Cunningham *et al*., undated);
- Detail the agricultural suitability of the MCP area in accordance with the five class system (Riddler, 1996);
- Assess the potential impacts of the Project on soil and land resources and formulate soil resource management measures; and
- Provide land resource information useful for the development of the MCP rehabilitation strategy.

The soil resources, land capability and agricultural suitability of the MCP area have previously been classified by the following studies and publications at the specified broad scale:

- Landscapes of the Dubbo 1:250,000 Sheet (DLWC, 1998);
- 1:100,000 Land Capability Series Sheet 8833 - Gulgong (Conservation Service of NSW, 1982); and
- Agricultural Land Classification of Mudgee Shire (unpublished) (NSW Agriculture, undated).

A field survey of the lands within the MCP area was conducted by JAMMEL Environmental & Planning Services Pty Ltd (JAMMEL) in the period between August and November 2005 in accordance with the Department of Land and Water Conservation (DLWC) *Soil and Landscape Issues in Environmental Impact Assessment* guidelines (2000) in order to confirm and supplement the previous mapping and assessments detailed in this report.

2 GENERAL DESCRIPTION OF THE MOOLARBEN COAL PROJECT

The Moolarben Coal Project is located in the western coal fields of New South Wales, east of the village of Ulan and approximately 40 km north-east of Mudgee and 25 kilometres east of Gulgong townships.

The Moolarben EL6288 covers an area of approximately 110 square kilometres and in part borders Ulan Coal Mine, Goulburn River National Park, Munghorn Nature Reserve and the recently approved Wilpinjong Coal Project. The location of the MCP site and the disturbance areas are shown on **Figure 1**.

A summary of the major project components of Stage 2 of the Moolarben Coal Project are:

- One open cut mine, Open Cut 4;
- Two underground coal mines to produce coal predominantly for the export market;
- Coal handling facilities incorporating crushing plants, conveyors, raw coal, coal stackers/reclaimers that will integrate with the Stage 1 infrastructure;
- Mine access roads, internal access roads and haul roads;
- Water management infrastructure including the relocation of Murragamba and “Eastern” Creeks;
- Surface water storages and associated pump and pipeline system;
- Placement of overburden and coarse reject within mined-out voids;
- In-pit tailings storages;
- Rehabilitation of final mine landforms and embellishment of nearby landscapes;
- Relocation, closure and temporary closure of public roads within the area to be mined; and
- Relocation of utility infrastructure such as electrical and communication facilities impacted by mining or the relocation of mine related infrastructure.

3 METHODOLOGY

3.1 FIELD SURVEY

JAMMEL conducted field surveys between the 29th August 2005 and 20th September 2005. Open Pit examination of the dominant soil groups was undertaken on the 16th and 17th November 2005 to determine the soil profile physical properties. These surveys provide information which supplements existing soil landscape mapping of the MCP area (DLWC, 1998). The field survey only focused on the disturbance area identified as Open Cut 4.

The soil survey was undertaken based on a relaxed grid method survey to identify boundaries between the various soil types and soil landscapes within the MCP area. A total of 34 sites were sampled to a depth of 1 m, or to depth of refusal. The locations of the soil sampling sites are shown on **Figure 2.** Representative samples from each soil type and horizon were collected and analysed for physical and chemical properties. The details of which are contained in **Appendix 1.** Profile descriptions of the sampled sites are contained in **Appendix 2.**

Soil structure was accurately determined by conducting open pit soil assessments on each of the major soil types identified in the soil survey. These pits were excavated to a depth of 1.5 metres or to depth of refusal.

The survey also includes observations and reporting of MCP area to confirm and augment existing rural land capability and agricultural suitability mapping.

3.2 LABORATORY TESTING

Soil samples where taken from each soil layer throughout the profile and from every soil survey site (Figure 2). These soil samples where then bulked together with other samples from the same soil type and sent away for chemical and physical analyses.

Chemical and physical soil analyses were undertaken by a National Association of Testing Authorities, Australia (NATA) accredited soil laboratory. These results have been used for preliminary assessment of soil suitability for rehabilitation purposes.

The laboratory chemical analyses comprised of the following tests:

- pH_{CaCl}, pH_{H2O}, C, N, S, P(Colwell) PBI, K, Ca, Mg, Al, Na, Cl, Cu, Zn, Mn, Fe, B, EC.

The soil physical analysis tested for the following properties:

- Particle Size Analysis; and
- Emerson Aggregate Test.

Analytical (physical and chemical) results are presented in Appendices 1 and 2.

4 SOILS OF THE MOOLARBEN COAL PROJECT AREA

4.1 SOIL LANDSCAPES

The soil landscapes of the MCP area are based on those delineated by the Soil Landscapes of the Dubbo 1:250,000 Sheet (DLWC, 1998) and the soil types encountered during the field survey.

The Soil Landscapes of the Dubbo 1:250,000 Sheet (DLWC, 1998) identifies four main soil landscapes within the within the MCP area – Ulan, Lees Pinch, Bald Hill and Munghorn Plateau Soil Landscapes. The Ulan Soil Landscape covers the majority of the Open Cut disturbance areas with the MCP area whilst the Infrastructure Area is located on the boundary of the Ulan and Munghorn Plateau Soil Landscapes. The Bald Hill Soil Landscape is an isolated occurrence adjacent to Western extent of Open Cut 4. The landform characteristics, lithology, typical soils and limitations of these landscapes are summarised in **Table 1** and the mapped distribution is shown in **Figure 3.** The characteristics of the predominant soils for the Ulan, Lees Pinch, Bald Hill and Munghorn Plateau landscapes are also provided in **Tables 2, 3, 4 and 5**.

Table 1. Soil Landscapes of the MCP AREA

Landscape	Landform	Lithology	Typical soils	Limitations
Ulan	Low undulating rises and creek flats. Elevations between 360-570 m. Slopes between 2-10%. Local relief varies between 10-40 m.	*Undifferentiated and Illawarra Coal Measures* Shale, sandstone, conglomerate, chert, coal and torbanite.	Yellow podzolic, Yellow Solodic /solonetz, yellow and brown earths, and earthy sands.	Mod to high erosion hazard and susceptible to soil structure degradation. Imperfectly drained on the lower slopes and depressions. High soil salinity levels and low soil fertility.
Lees Pinch	Sandstone plateau and hill slopes with boulder debris. Elevations between 400-680 m. Slopes between 15-40%. Local relief from 60-240m.	*Narrabeen Group and Illawarra Coal Measures* Sandstone, Wollar sandstone, conglomeratic sandstone, chert, shale coal, torbanite.	Shallow siliceous sands, shallow acid soils, yellow earths, yellow podzolic soils.	Steep slopes are high erosion hazard when cover is low. Very low fertility, acidic surface soils. Low to very low water holding capacity and high permeability.
Munghorn Plateau	Low Undulating hills form plateaux from 600 – 700 m. Slopes from 3 – 10% and local relief varies from 20 – 60 m.	*Narrabeen Group and Illawarra Coal Measures* Sandstone, Wollar sandstone, conglomeratic sandstone, chert, shale coal, torbanite	Shallow siliceous sands, shallow acid soils, yellow earths, yellow podzolic soils.	High to very high erosion hazard when ground cover is low. Low soil fertility and low water holding capacity.
Bald Hill	Low Hillocks with elevations from 460 – 600 m. Slopes 10-35%. Local Relief from 60 – 120 m. Drainage lines are 300 – 500 m apart	*Tertiary Basalt*, Olivine basalt, dolerite, teschenite.	Euchrozems – chocolate soils Intergrades, Chocolate soils.	Steep Slopes with rock outcrops; stoniness; mod to high fertility and water holding capacity.

Source: Adopted from DLWC (1998)

Table 2. Characteristics of the predominant soils of the Ulan Soil Landscape

Characteristics	Yellow Podzolic Soil	Yellow Solodic Soil
Dominance	Common	Common
Landform element	Mid to lower slopes, flats	Drainage lines and depressions
Surface condition	Gravely or hard setting	Hard setting
Drainage	Imperfectly drained	Imperfectly to poorly drained
Permeability	Slow	Low to very low
Watertable Depth	Occasionally seasonal waterlogging	Perched and seasonal
Available water holding capacity	Mod	Mod
Depth to bedrock	60 to >100cm	>100cm
Flood hazard	Nil	Slight
pH (top)	Slightly acidic	Slightly acidic
Fertility (chemical)	Low	Low
Expected nutrient deficiencies	Nitrogen, Phosphorus, Sulphur	Nitrogen, Phosphorus, Sulphur
salinity	Low	Some salting evident as salt scalds
Erodibility (top)	Mod	Mod
Erodibility (sub)	High	High to very high
Erosion hazard	Mod	High
Structural degradation hazard	High	High
Land capability classification	3,4	4
Shrink-swell potential	Low	Low
Mass movement hazard	Not evident	Not evident

Source: Adopted from DLWC (1998)

Table 3. Characteristics of the predominant soils of the Lees Pinch Soil Landscape

Characteristics	Shallow Siliceous Sands	Yellow Earths	Yellow Podzolic Soil
Dominance	Dominant	Minor	Minor
Landform element	Crests to Mid slope	Lower Slopes	Upper Slopes
Surface condition	Loose	Hard setting	Loose
Drainage	Rapidly Drained	Moderately Well Drained	Well Drained
Permeability	Highly permeable	Mod to slow	Highly permeable
Watertable Depth	> 50 cm	180 cm	> 100 cm
Available water holding capacity	Very Low	Mod to Low	Low
Depth to bedrock	15 – 50 cm	180 cm	> 100 cm
Flood hazard	Nil	Nil	Low
pH (top)	Slightly acidic	Slightly acidic	Slightly acidic
Fertility (chemical)	Low	Low	Low
Expected nutrient deficiencies	Nitrogen , Phosphorus	Nitrogen, Phosphorus	Nitrogen, Phosphorus
salinity	Low	Low	Low
Erodibility (top)	High	Mod	Mod
Erodibility (sub)	Low	Mod	Mod
Erosion hazard	High	Mod	High
Structural degradation hazard	High	High	Mod
Land capability classification	VI, VII	V, VI	VI
Shrink-swell potential	Low	Low	Low to Mod
Mass movement hazard	Mod	Low	Mod to High

Source: Adopted from DLWC (1998)

Table 4. Characteristics of the predominant soils of the Bald Hill Soil Landscape

Characteristics	Euchrozems – Chocolate Soil Intergrades	Chocolate Soils
Dominance	Dominant	Minor
Landform element	Crests, upper slopes and Mid slopes	Lower Slopes
Surface condition	Friable	Friable
Drainage	Well Drained	Well Drained
Permeability	Moderately permeable	Moderately permeable
Watertable Depth	>200 cm	>100 cm
Available water holding capacity	High	Moderate
Depth to bedrock	>60 cm	>60 cm
Flood hazard	Nil	Low
pH (top)	Slightly acidic to neutral	Neutral to alkaline
Fertility (chemical)	Moderate to High	Moderate
Expected nutrient deficiencies	Nitrogen , Phosphorus, Sulfur	Nitrogen, Phosphorus, Sulfur
salinity	Low	Low
Erodibility (top)	Mod	Low
Erodibility (sub)	Low	Low
Erosion hazard	Low but high if low cover (steep slopes)	Low but high if low cover (steep slopes)
Structural degradation hazard	Mod	Mod
Land capability classification	VI, V, VII	V
Shrink-swell potential	Moderate to high	Moderate to high
Mass movement hazard	Slight	Low

Source: Adopted from DLWC (1998)

Table 5. Characteristics of the predominant soils of the Munghorn Plateau Landscape

Characteristics	Siliceous Sands	Yellow Earths	Yellow Podzolic Soil
Dominance	Dominant	Minor	Minor
Landform element	Crests to Mid slope	Lower Slopes	Drainage Lines
Surface condition	Loose	Loose	Hard setting
Drainage	Rapidly Drained	Well Drained	Moderately drained
Permeability	Highly permeable	Highly Permeable	Moderately Permeable
Watertable Depth	> 100 cm	> 100 cm	> 100 cm
Available water holding capacity	Low	Low	Low to Mod
Depth to bedrock	60 to > 100cm	80 to > 100cm	> 60cm
Flood hazard	Nil	Nil	Low
pH (top)	Moderately acid	Moderately acid	Slightly acid to neutral
Fertility (chemical)	Low	Low	Low
Expected nutrient deficiencies	Nitrogen , Phosphorus	Nitrogen, Phosphorus	Nitrogen, Phosphorus
salinity	Not Evident	Not Evident	Not Evident
Erodibility (top)	Mod	Mod	High
Erodibility (sub)	Mod	Mod	Mod
Erosion hazard	Mod to High	Mod	High
Structural degradation hazard	High	High	High
Land capability classification	IV, V, VI	IV, V, VI	IV
Shrink-swell potential	Low	Low	Low
Mass movement hazard	Nil	Nil	Nil

Source: Adopted from DLWC (1998)

4.2 GREAT SOIL GROUPS

The soils within the disturbance areas of the MCP described in this section are based on the Great Soil Group System (Stace *et al*., 1968). The Great Soil Group system is a wide classification of soils based on the soil morphological and chemical properties. Each Great Soil Group represents a range of soils in the field.

The major soil types encountered in the MCP area are described in the following subsections of this report and include red podzolic, yellow podzolic, earthy sands, red earths, alluvial, lithosols and Yellow Solodic soils. . The minor soil types of colluvial and Euchrozem soils have been identified but not described due to their low occurrence throughout the disturbance areas. **Figure 4** identifies the boundaries between these different soil types.

4.2.1 Yellow Podzolic (Yellow Chromosol)

Drainage: Imperfectly drained.
Measured Depth: 1.5 metres.
Surface Condition: Firm – Hard setting.
Landuse: Ranges from volunteer / native grasses, occasional cropping and improved pastures.
Location: This soil type occurs in Open Cut 4 disturbance areas. It occurs on lower slopes and minor drainage lines and shows a high occurrence of water logging and can be prone to soil salinity issues.
Fertility: These soils exhibit an acidic pH trend with low fertility characteristics The A horizon provides moderate accumulation of organic matter. The chemical limitations of this soil type are inherent and / or induced by agriculture activities and can be remedied through appropriate agronomic, soil amelioration and fertiliser recommendations.
Minor outbreaks of dryland salinity can occur within this soil type. These outbreaks are usually associated with a break of slope in surface topography.

Soil Profile Description

These soils are texture contrast soils with a light textured A horizon overlying a heavier textured, structured B horizon. A distinct pale A_2 is usually, but not always present and the profile is acidic. The B horizons are characterised by moderate polyhedral or angular blocky structure and tend to be friable when moist. A profile description consistent with the open pit investigations is listed below:-

Layer 1	A_1	0 .00 – 0.20	Hard setting, dark brown massive fine sandy loam texture; pH 4.5 – 5.5 Clear Boundary to:-
Layer 2	A_2	0.20 – 0.45	Dull yellowish – orange, (usually noticeably bleached) light Silty loam - light sandy clay loam texture; massive to platy structure; pH 4.5 – 5.5 Abrupt boundary to:-
Layer 3	B	0.45 – 1.50 +	Dull yellowish – brown, light – medium sandy clay; sub angular blocky structure; orange to red mottle present; pH 5.5 – 7.0

4.2.2 Red Podzolic (Red Chromosol)

Drainage: Moderately drained.
Measured Depth: 1.5 metres.
Surface Condition: Firm.
Landuse: Ranges from volunteer / native grasses, occasional cropping and improved pastures.
Location: These soils occur in isolated areas Open Cut 4. They generally occur on the upper mid slopes of the landscape and exhibit moderately well drained characteristics
Fertility: These soils exhibit an acidic pH trend with low fertility characteristics. The chemical limitations of this soil type are inherent and / or induced by agriculture activities and can be remedied through appropriate agronomic, soil amelioration and fertiliser recommendations. Small pockets of Red Podzolic soil are located within Open Cut 4 and exhibits high gravel content, generally in conjunction with poor chemical attributes.

Soil Profile Description

These soils are texture contrast soils with a light textured A horizon overlying a heavier textured, structured B horizon. A distinct pale A_2 is usually, but not always present and the profile is acidic. The B horizons are characterised by moderate polyhedral or angular blocky structure and tend to be friable when moist. A profile description consistent with the open pit investigations is listed below:-

Layer 1	A_1	0 .00 – 0.30	Hard setting, dark brown fine sandy loam texture; Weakly polyhedral structure pH 5.0– 6.0 Clear Boundary to:-
Layer 2	A_2	0.30 – 0.55	Dull yellowish – brown, (usually noticeably bleached) light Silty loam - light sandy clay loam texture; massive structure; pH 5.5 – 6.0 Abrupt boundary to:-
Layer 3	B	0.55 – 1.50 +	Brown to reddish brown, light – medium sandy clay; moderate sub angular blocky structure; orange to red mottle present; pH 5.5 – 7.0

4.2.3 Earthy Sands & Sands (Orthic Tenosols)

Drainage: Rapidly drained.
Measured Depth: 1.5 metres.
Surface Condition: Loose.
Landuse: Volunteer / native grasses.
Location: Earthy Sands occur extensively throughout the disturbance area These sands are extremely fragile and free draining.
Fertility: Fertility is low with low cation exchange capacity reducing the soils ability to retain nutrients and to sustain any ameliorated change.

Soil Profile Description

Earthy Sands are characterised by uniform profiles of coherent, clayey sands which are dominantly red in colour but in some cases yellow. These soils are usually deep and are characterised by uniform sand texture and a massive, single-grained structure. Its earthy appearance occurs from coating and bridging of sand grains by clayey materials. A profile description consistent with the open pit investigations is listed below:-

Layer 1	A_1	0 .00 – 0.30	Bright yellowish brown to very dark brown, sandy loam to fine sandy loam; single grained structure; pH 6.5 – 8.0 gradual change to:-
Layer 2	A_2	0.30 – 0.6	Dull yellowish brown, fine sandy loam texture; massive structure; pH of 6.5; clear to gradual change to:-
Layer 3	A_3	0.6 – 1.50 +	Bright brown or reddish brown sand, clayey sand, sandy loam or light sandy clay loam; single grained pH 6.0 – 7.5.

4.2.4 Yellow Solodic (Yellow Sodosol)

Drainage: Poorly drained.
Measured Depth: 1.5 metres.
Surface Condition: Hard set – surface crust.
Landuse: Volunteer / native grasses.
Location: Yellow Solodic soils occur predominantly in the low lying areas of Open Cut 4 associated with drainage from Cars Gap and the unnamed creek east of Murrgamba Creek and the Infrastructure Area.
Fertility: These soils have an acidic pH trend with poor fertility characteristics. Due to the dispersible nature of the soil it has poor trafficability qualities when wet. These soils are very erodible causing gully erosion to be a feature of these soils.
The chemical limitations of this soil type are inherent but can be remedied through appropriate agronomic, soil amelioration and fertiliser recommendations.

Soil Profile Description

Solodic soils are characterised strong texture contrast profiles with light texture surface soils overlying tough, hard and dense B horizons, which are usually unstable to wetting. The boundary between A and B horizon is abrupt to clear. There is also a characteristic bleached A_2 horizon. A profile description consistent with the open pit investigations is listed below:-

Layer 1	A_1	0 .00 – 0.30	Hard setting, brown sandy loam, loamy sand texture; Polyhedral to lenticular structure pH 5.0– 6.0 Clear Boundary to:-
Layer 2	A_2	0.30 – 0.55	Dull yellowish – brown, (usually noticeably bleached) light Silty loam - light sandy clay loam texture; massive structure; pH 5.5 – 6.0 clear boundary to:-
Layer 3	B	0.55 – 1.50 +	Dull orange, grey or yellowish brown, sandy clay loam ; moderate sub angular blocky structure; orange to red mottle present; pH 5.5 – 7.0

4.2.5 Lithosols (Inceptic Tenosol)

Lithosols are shallow skeletal stony or gravely soils with a thin A_1 horizon of organic matter generally occurring on upper slope and hill-top areas. Pedological development is low, consisting of weathering of underlying rocks and the gradual addition of organic matter in the A_1 horizon. Soil cover is discontinuous and rock outcrops are common.

Lithosols occur on the higher plateaus and sandstone escarpments associated with the Munghorn Gap Nature Reserve and lands within the Goulburn River National Park and lands owned by Ulan Coal Mines Limited to the north of the Infrastructure Area. All the land over the Underground mining area is dominated by the Lithosol soil type.

4.2.6 Alluvial (Tenosol)

Drainage: Rapidly drained.
Measured Depth: 1.5 metres.
Surface Condition: Loose.
Landuse: Ranges from improved pasture to occasional cropping
Location: Alluvial soils occur along the lower reaches Murragamba Creek, upstream of the Murragamba Creek road crossing.
Fertility: Nutrient supply is good as there is usually a reasonable supply of primary rock minerals.

Soil Profile Description

Alluvial soils generally occur on flats or valley bottoms where bed load sedimentation has occurred. Alluvial soils have no true pedological horizons other than an A horizon and are often weakly developed. The sedimentary layers of these soils can vary greatly in a number of characteristics including texture, stoniness, depth, colour and carbonate content. A profile description consistent with the open pit investigations is listed below:-

Layer 1	A_1	0 .00 – 0.25	Brownish Loam, fine sandy with 2 – 10% stones; weakly structured; Ph 7.5. Gradual change to;-
Layer 2	A_2	0.25 – 0.75	Loam, fine sandy; weakly structured; Gradual change to;-
Layer 3	A_3	0.75 – 1.50 +	Brown fine sandy loam; pH 7.5

The alluvial soils identified by this survey are all recent alluviums associated with Moolarben, Murragamba and Lagoon Creeks. The alluvium deposits are also in association with the Earthy Sands that were identified along the creeks. This mapping augments the mapping of the alluvial soil material as shown on the Gulgong 1:100 000 Geological Map (AGSO 2000), however the mapping identifies the soils are in a more confined distribution in relation to the creek system in compared to the AGSO mapping.

4.2.7 Red Earth (Red Kandosol)

Drainage: Rapidly Drained
Measured Depth: 1.00 + metres
Surface Condition: Loose
Landuse: Volunteer/Native Pasture and woodlands
Location: Isolated elevated hills adjacent to outcropping parent material within Open Cut 4 West.

Fertility: Nutrient levels are moderate to poor with high levels of soil acidity. Soils are prone to rill and gully erosion.

Soil Profile Description

Layer 1	A_1	0 .00 – 0.25	Brown to dull reddish sandy loam to loam; weak structure; pH 5.0 – 6.0; depth to 0.25 m. Clear Boundary to:-
Layer 2	A_2	0.25 – 0.55	Dull brown fine sand loam; weak structure; pH 5.5 clear to gradual boundary to:-
Layer 3	B	0.55 – 1.00 +	Dark red to reddish brown loam or fine sandy clay loam; weak structure pH 5.0 – 7.0. At depth light medium clay, moderately structured.

Red Earths occur in isolated areas though out the disturbance areas usually on elevated gravely rises. There is potential that these formations represent a prior stream formation.

5 RURAL LAND CAPABILITY ASSESSMENT

5.1 LAND CAPABILITY CLASS SYSTEM

The rural land capability assessment has been conducted in accordance with the standard NSW eight class system (Cunningham *et al*, undated). The system is based on the assessment of biophysical soil properties, with categories of land based on limitations such as erosion hazard, climate and slope. It recognises three types of land use, these being:-

- Land suitable for cultivation (Classes I to III);
- Land suitable for grazing (Classes IV to VI); and
- Land not suitable for rural production (Classes VII and VIII).

Rural land capability assessment based on the 1:100,000 Land Capability Series Sheet 8833 – Gulgong (Soil Conservation Service of NSW, 1982) identified six classes for the MCP area (Classes III to VIII). Field survey undertaken by JAMMEL in August to October 2005 delineated areas mapped as Class VI capability with isolated occurrences of surface salinity in the eastern area of Open Cut 4 with impeded drainage.

5.2 LAND CAPABILITY CLASSES OF THE MCP AREA

The land capability classes specific to the MCP area are described below and are shown on **Figure 5.**

5.2.1 Class IV

"Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation with soil conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or re-establishment of permanent pasture". (Cunningham et al., undated)

Small areas Open Cut 4 area are considered to have a Class IV capability. Slopes within the mapped area generally range between 1% and 6% with the soil types being generally yellow podzolic or red podzolic. These soils are of low fertility, with moderate to high erodibility. Other limitations include shallow soil depth and impeded drainage resulting in salinity.

These lands are considered incapable for regular cultivation of annual crops because of these limitations, however it would be capable of occasional cultivation for the establishment of permanent pasture, providing soil conservation practices were employed.

5.2.2 Class V

"Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation and structural conservation works such as absorption banks, diversion banks and contour ripping, together with the practices as in Class IV". (ibid.)

Class V capability land is predominant throughout Open Cut 4 area due to the fragile and water logging characteristics of the soils.

These lands are not considered capable of regular cultivation of annual crops because of the limitations described above; however capability would extend to the occasional cultivation with the use of structural soil conservation works for the purposes of establishment or regeneration of permanent pasture.

5.2.3 Class VI

"Land not capable of being regularly cultivated but suitable for grazing with conservation practices including limitation of stock, broadcasting of seed and fertiliser, prevention of fire and destruction of vermin. This class may require some structural works". (ibid.)

Class VI land is characterised by slopes within the mapped area generally range between 8% and 15% and occur on elevated and mid slope areas that are prone to gully and sheet erosion within the MCP area. The predominant soil types within Class VI capability are Lithosol, Yellow Podzolic, and Yellow Solodic Soil. Fertility of these soil types is generally low and with moderate to high erodibility.

Class VI land also identifies saline discharge areas which are characterised by prolonged water logging and saline scalding. The main limitation of these areas is intermittent water logging and soil salinity. These areas are located usually at a break of slope or a change in soil type. These areas are delineated by the VIs.

The land is not considered capable of regular cultivation of annual crops because of these limitations, but is suitable for grazing through conservation grazing practices.

5.2.4 Class VII

"Land best protected by green timber". (ibid.)

Class VII capability land is restricted to the elevated vegetated slopes and plateaus of the Munghorn Plateau Soil Landscape. These areas are predominantly located in the Munghorn Gap Nature Reserve. These lands have a moderate to high erosion hazard.

Class VII land is predominantly associated with Lithosols soils occurring on the steeper slopes and plateaus.

5.2.5 Class VIII

"Cliffs, lakes or swamps and other lands incapable of sustaining agricultural or pastoral production". (ibid.)

Class VIII capability land is restricted to the elevated plateaus and escarpments associated with the Munghorn Gap Nature Reserve surrounding the MCP area. The land is characterised by steep lands and cliffs. The soil cover comprises of discontinuous Lithosol soils with large areas of exposed rock.

6 AGRICULTURAL SUITABILITY ASSESSMENT

This agricultural suitability assessment draws on information available from the studies and publications sourced in this report, the MCP area field survey and aerial photograph interpretation. It complements the soil resource information along with rural land capability assessment to provide an overall appraisal of the land resource.

6.1 AGRICULTURAL LAND CLASSIFICATION SYSTEM

The agricultural suitability assessment was conducted in accordance with the five class system (Riddler, 1996), which classifies land according to its productivity for a wide range of agricultural activities.

Based on the Agricultural Land Classification of Mudgee Shire (unpublished) (NSW Agriculture, undated), the MCP area comprises Class 3, 4 and 5 agricultural land (**Figure 6**).

6.2 AGRICULTURAL LAND SUITABILITY OF THE MCP AREA

The agricultural suitability classes specific to the MCP area are detailed below and shown on Figure 6.

6.2.1 Class 3

"Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture. The overall production level is moderate because of edaphic or environmental constraints. Erosion hazard, soil structural breakdown and other factors including climate may limit the capacity for cultivation, and soil conservation or drainage works may be required". (ibid)

Class 3 agricultural suitability land is predominant on the valley floor and lower slopes of the MCP area. Small areas of farming for cereal crop production occur, however the dominant land use is primarily cattle and sheep grazing on pastures (improved and native). Erosion hazard, soil structural breakdown and climatic factors limit the capacity for cultivation.

Class 3 areas also include isolated occurrences of surface soil salinity within Open Cut 4 where poor soil drainage is experienced.

6.2.2 Class 4

"Land suitable for grazing but not for cultivation. Agriculture is based on native pastures or improved pastures established using minimum tillage techniques. Production may be seasonally high, but the overall production level is low as a result of major environmental constraints". (ibid)

Class 4 agricultural suitability land occurs in small locations throughout the valley floors and the lower slopes of the MCP area. These areas are represented by either shallow / sandy or dispersible (sodic) soils or land with steep slopes. In conjunction with there edaphic limitation also have moderate to high erosion hazard restricting the agricultural productivity.

6.2.3 Class 5

"Land unsuitable for agriculture or at best suited to only light grazing. Agricultural production is very low to zero as a result of severe constraints, including economic factors, which preclude land improvement". (ibid.)

Class 5 agricultural suitability land is associated with the escarpments and lower hills within and adjacent to the MCP areas. Class 5 areas are generally characterised by steeper slopes shallow soils and lower fertility land.

Negligible agricultural production is derived from these lands due to the significant constraints of slope, soil and location.

7 RESOURCE MANAGEMENT

Preservation and appropriate management of all topsoil material within the surface development areas of the MCP should be a priority to assist in future land rehabilitation activities post mining. The activities of stripping and stockpiling of soil resources prior to any mine-related disturbance other than clearing vegetation should comprise of the general resource management activities. All disturbance areas should be rehabilitated either progressively or immediately after the completion of mining activities.

The objectives of the soil resource management strategies are to:

- Optimise the recovery of topsoil and subsoil available for rehabilitation;
- Identify and quantify the potential soil resource;
- Manage topsoil and subsoil reserves so as not to degrade the resource;
- Assist in development of stripping and stockpiling procedures; and
- Establish effective methods for utilising available soil reserves in future rehabilitation work.

7.1 CONCEPTUAL SOIL RESOURCE MANAGEMENT STRATEGIES

Conceptual soil resource management strategies proposed for the MCP disturbance area are detailed in **Table 6**.

Table 6. Conceptual Soil Resource Management Strategies

Prior to Commencement of Stripping Activities	During Stripping and Stockpiling Activities	Prior to and During Rehabilitation Activities
• Quantification of soil resources (see below). • Characterisation of the suitability of material for rehabilitation purposes **(Sections 7.2 – 7.3).** • Formulation of stripping and stockpiling guidelines including the nomination of appropriate depths, scheduling, and location of areas to be stripped and stockpile locations (detailed in the Mining Operations Plan).	• Minimise over-clearing. • Selective stockpiling of soil according to type (i.e. Great soil Group, topsoil, subsoil) and salinity. • Storage of soil in a manner that does not compromise the long term viability of the resource **(Section 7.5).**	• Implementation of amelioration measures to ensure the long term viability of the soil resources and manage salinity (Section 7.2 – 7.3). • Management of soil suitability for rehabilitation (Section 7.5). • Progressive rehabilitation of final landforms as soon as practicable after completion or when areas are no longer required.

Topsoil recovery and management activities will occur in accordance with the progressive development program of MECP on all disturbance areas. The management activities of these soils will be determined by their individual characteristics and limitations. Sections 7.2 – 7.3 identify the individual disturbance areas and the soils identified within these areas, the soil resource availability and the specific management considerations that need to be addressed for the appropriate management of these soils. The suitability of these soils for rehabilitation of disturbed areas has been done using the methodology developed by Elliot & Veness (1981) based on the soil survey investigation findings.

Quantification of soil resources available for rehabilitation works, stripping and reapplication schedules and stockpiling inventories should be included as part of the Mining Operations Plan (MOP) in accordance with the requirements of the Department of Primary Industries (Department of Mineral Resources) during mining operations

7.2 OPEN CUT 4

Topsoil stripping and stockpiling activities will occur prior to surface disturbance in Open Cut 4. The disturbance area for this site is approximately 1270ha.

The soils occurring in this site have a moderate to high erodibility hazard and require special management to prevent severe land degradation. **Table 7** quantifies the suitability of the soil for rehabilitation based on the criteria established by Elliot & Veness (1981).

Table 7.
Top soil suitability classification based on Elliot & Veness (1981)

SoilType	Soil Horizon	Rehabilitation Suitability Classification	Comment
Yellow Solodic	A1	Suitable if ameliorated	Acid soil with Severe dispersive qualities, Excessive Mg levels (Low Ca:Mg ratio), poor fertility. Low Ca
	A2	Suitable if ameliorated	Acid soil with Severe dispersive qualities, Excessive Mg levels (Low Ca:Mg ratio), poor fertility, Low Ca
	B	Not Suitable	Dispersive Clay, Excessive Mg and NA levels
Yellow Podzolic	A1	Suitable if ameliorated	Acid soil with Severe dispersive qualities, Excessive Mg levels (Low Ca:Mg ratio), poor fertility.
	A2	Suitable if ameliorated	Acid soil with Severe dispersive qualities, Excessive Mg levels (Low Ca:Mg ratio), poor fertility
	B	Not Suitable	Dispersive Clay
Earthy Sands	A1	Suitable for Blending Only	Acid pH, Elevated Al levels, High Sand content
	A2	Suitable for Blending Only	Acid pH, Elevated Al levels , High Sand Content with moderate dispersive qualities
	A3	Suitable for Blending Only	Acid pH, Elevated mg levels, High Sand Content with severe dispersive qualities
Alluvial	A1	Suitable if Blended & Ameliorated	Acid soil with moderate dispersive qualities, Elevated mg levels, poor fertility.
	A2	Suitable if Blended & Ameliorated	Acid soil with moderate dispersive qualities, Excessive Mg levels (Low Ca:Mg ratio), poor fertility. Sand Gravel Content levels are high
	A3	Not Suitable	Dispersive Clay High NA & Mg Levels.
Red Podzolic	A1	Suitable if ameliorated	Acid soil with Severe dispersive qualities, Elevated Al levels, poor fertility.
	A2	Suitable if ameliorated blended	Acid soil with Severe dispersive qualities, Excessive Mg levels (Low Ca:Mg ratio), poor fertility. Sand Gravel Content exceeds 60%.
	B	Not Suitable	Dispersive Clay High NA & Mg Levels.
Red Earth	A1	Suitable for Blending Only	Acid pH, Elevated Al levels, High sand gravel content
	A2	Suitable for Blending Only	Acid pH, Elevated Al levels , High sand gravel content
	B	Suitable for Blending Only	Acid pH, Elevated mg levels, High sand gravel content
Euchrozem	A1-B	Highly Suitable	Neutral to alkaline pH, low erosion hazard, Moderate to high fertility, potentially elevated manganese at depth.
Lithosol		Not Suitable	No soil resource available

Table 8 indicates the approximate area each soil type occupies within the Open Cut 4 and infrastructure areas, the recommended stripping depth and approximate volume of material that would be available for rehabilitation purposes.

Table 8
Resource Availability

Type	Recommended Stripping Depth (m)	Open Cut and Infrastructure Stripping area (ha)	Volume (m^3)
Yellow Solodic	0.3*	543.8	1,631,400
Yellow Podzolic	0.3*	187.6	562,800
Earthy Sand	1	526.1	5,261,000
Red Podzolic	0.25*	43.7	109,250
Red Earth	1	35.5	355,000
Alluvial	0.45	9.3	41,850
Euchrozems	1#	8.1	81,000
Lithosol	0	265	-
Total	**N/A**	**1619.1^**	**8,042,300^**

* Stripping Depth has incorporated the blending of the top 0.1 - 0.2 m of the A2 horizon to increase topsoil volume.
# Subject to investigation prior to disturbance.
^ These calculations are inclusive of open cut, out of pit emplacements and infrastructure disturbance, approximately 240ha will be made up of infrastructure areas, where topsoil stripping may not occur across the full area.

Preliminary material balance calculations based on the recommended stripping depths outlined in Table 8 indicate an approximate topsoil volume of 8,000,000 m^3.

7.2.1 Topsoil suitability for rehabilitation purposes and management practices

Chemical and physical assessment of the soil properties within the Open Cut 4 West disturbance area (Appendix 1 and 2) indicate that the proposed soils for stripping would be suitable for rehabilitation purposes provided appropriate management practices are implemented and the relevant amelioration measures applied where necessary.

There are three (3) dominant soil types within the Open Cut 4 West disturbance area that have been assessed as having significant quantities of topsoil for reuse purposes for rehabilitation. These soils are, Yellow Solodic, Yellow Podzolic and Earthy Sands. Small quantities of Alluvial, Red Earths and Red Podzolics have been identified, however due to the small areas of these soils they have not been considered a significant resource for purposes of rehabilitation. However they can be blended with the major soil resources to increase resource volume.

The Yellow Solodic exhibits soil acidity (soil pH_{cacl} <5.0) and poor fertility characteristics. The chemical analysis and Emerson Aggregate testing identified soil dispersive qualities when soil particles are exposed to water. Very High Mg levels have been measured with low Ca levels resulting in a very low Ca:Mg levels and high soil dispersion qualities. Excessive levels of Mg have increased the CEC to very high levels. The dispersive nature of this soil makes it highly erodible and subject to severe structure decline. Handling of soil should only occur during optimum soil moisture conditions.

This issue can be overcome by a blended application of superfine lime (NV >95%) to increase the pH and Gypsum to displace the Mg quickly to return soil structure. However due to the excessive levels of Mg, trials will have to be conducted to determine appropriate amounts of ameliorants.

- A1 horizon: it is recommended that a blend of superfine lime (NV >95%) and gypsum (3 tonne of Lime and 3 tonne Gypsum per hectare) be considered to increase pH and improve the soil structure.
- A2 horizon: it is recommended that a blend of superfine lime (NV >95%) and gypsum (3 tonne of Lime and 3 tonne Gypsum per hectare) be considered to increase pH and improve the soil structure.

Any addition of organic inputs ie Biosolids, would be a highly recommended strategy to assist in improving soil structural issues.

The soil is deficient in major nutrients such as Phosphorus, Sulphur and nitrogen. However these nutritional issues can be addressed through the application of an appropriate fertiliser prior to reapplication on completed landforms during rehabilitation activities.

Blending of the A1 & A2 is considered acceptable with the appropriate soil amelioration to increase the soil resource volume. Blending of this soil with other soil resource material ie Earthy Sand could be undertaken to increase the topsoil volume. However, care must be taken not to exceed the sand and gravel content of 60%.

Soil salinity (E.C.se) has not been identified as an issue in the Yellow Solodic Soil.

The Yellow Podzolic also exhibited the same attributes as the Yellow Solodic, therefore the Management and treatment recommendations will be consistent. The High CEC combined with low pH and high Mg level makes the need for soil amelioration a priority before any other soil nutrient imbalance can be corrected. Trailing high rates of Blended Lime and Gypsum is recommended.

Blending of the A1 and A2 Horizons is essential to increase the soil resource volume due to the high sand and grave content of the A2.

Soil salinity (E.C.se) in both Yellow Podzolic soils has not been identified as an issue.

Small quantities The Red earth, Red Podzolic Alluvial soils area available for Blending, however careful consideration should be given to their chemical constraints. All these soil have an Acid pH and Low to Moderate CEC levels. The Earthy Sands in particular exhibit these characteristics and have toxic Al levels. Blending these soils with the main resource material in combination with their recommended soil ameliorant strategy is proposed.

After blending has been completed, additional soil testing should be undertaken to determine the real chemical attributes of the soil.

Soil salinity (E.C.se) in these soils were not been identified as an issue.

Euchrozems occupy only a small portion of the disturbance area, associated with the basalt caps below the out of pit emplacements. Given the significance of these soils in respect of their moderate to high fertility, good soil structure and association with endangered ecological communities their use in the post mining landscape where available will be an important component.

All the soils in the disturbance area are deficient in all major nutrients such as Phosphorus, Sulphur Nitrogen. However these nutritional issues can be addressed through the application of an appropriate fertiliser prior to reapplication on completed landforms during rehabilitation activities. Fertiliser recommendations should be based on agronomic species selection for the final rehabilitated landuse.

7.3 GUIDING PRINCIPLES FOR THE PREVENTION OF LAND DEGRADATION

The prevention of land degradation through the adoption of appropriate soil conservation practices should be an integral component of site management over the entire mining operation area (open cut areas).

The identification of land degradation issues in combination with immediate and correct remedial solutions provides good environmental management. The adoption of these principals along with broader land management activities to maintain the land within the MCP will be incorporated into a Land Management Plan.

The following guiding principals should be adhered too, to prevent or arrest any land degradation:-

- Continual monitoring and reporting on all mining areas for occurrences of soil erosion and landform irregularities;
- Minimise disturbance areas to all essential mining activities and infrastructure developments only;
- An Erosion and Sediment Control Plan to be prepared in accordance with the requirements of Managing Urban Stormwater: Soils and Construction (NSW Department of Housing, 1998) for all open cut mining and infrastructure disturbance area's;
- All erosion control and drainage works to be appropriately designed in accordance with Urban and Sediment Control Guidelines (NSW Department of Land and Water Conservation, 1992);
- Where surface irregularities are identified caused by underground mining activities and appropriate soil conservation measures are to be immediately implemented to prevent soil erosion;

- Prevent the diversion of overland flow to areas without adequate stable disposal areas;
- Revegetate all disturbed areas with appropriate revegetation species and techniques i.e. hydro mulching and seeding immediately after the mining activity has ceased or erosion has been controlled;
- All access roads and haul roads to be constructed with appropriate pavement surfaces and storm water drainage systems; and
- All temporary trails to be constructed in accordance with the "Guidelines for the planning, construction and maintenance of tracks" (DLWC 1994);

7.4 SOIL SUITABILITY FOR REHABILITATION PURPOSES AND MANAGEMENT PRACTICES

Rehabilitation of disturbed lands is an integral component of mining and post mining activities. The success of rehabilitation is determined by the level of planning, site preparation and site management that occurs. This document has outlined key constraints and provided specific guidelines to aid the rehabilitation process. The details of the identified management strategies and practices including timing of implementation and relevant methodology will be included in the MOP for the MCP.

The soil survey of the disturbance areas identified the dominant soils throughout the project area. From the physical assessment and the chemical analysis of the soils it was determined that the soils are suitable for rehabilitation with the appropriate soil ameliorant and nutrient inputs applied. These issues were discussed in **Sections 8.1 – 8.5** of this report. A small percentage of soils where deemed unsuitable due to having a very high in sand and gravel content or having extremely poor chemical features.

The key management practices for ensuring long term viability of the stockpiled soils is outlined in **Section 8.8,** however section 8.7.1 – 8.7.2 provides some key considerations that should also be addressed during the rehabilitation phase of all disturbed lands and the prevention of land degradation during underground and Open Cut mining activities.

7.4.1 The Management of Soil Salinity

Salinity levels across the majority of the project area have been classified as non – saline (EC_{se} < 2 dS/m) however there are some soils within the Open Cut 4 area which have been identified as saline discharge sites testing low to moderate salinity levels. These sites are relatively localised and easily identified. Use of these soils for rehabilitation purposes is possible by addressing the salinity issue during stockpiling and careful vegetative species selection during rehabilitation.

The key management practices are:

- Where practicable, saline soil types should be stripped and stockpiled separately over an aggregated substrate to allow leaching of salt concentrations (ECse) over time;
- Ensure species selection for rehabilitation purposes are tolerant of saline environments, additionally salinity occurrence is usually associated with water logging so species should also be able to withstand water logged environments; and
- Minimise the application of saline water through irrigation (water use). **Table 9** provides guidelines for irrigation water quality.

Table 9. Guidelines for irrigation of water based on salinity

Salinity	Comment	EC (ds/m)
Low	Water can be used with most crops on most soils and with all methods of water application with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices except in soil of extremely low permeability.	0.00 – 0.28
Medium	Water can be used if moderate leaching occurs. Plants with medium salt tolerance can be grown, usually without special measures for salinity control. Sprinkler irrigation with the more saline waters in this class may cause leaf scorch on salt-sensitive crops, especially at high temperatures in the daytime and with low application rates.	0.28 – 0.80
High	Water cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required, and the salt tolerance of the plants must be considered.	0.80 – 2.30
Very High	Water is not suitable for irrigation under ordinary conditions. Soils must be permeable, drainage adequate, water must be applied in excess to provide considerable leaching and salt tolerant crops should be selected.	2.30 – 5.50
Extremely High	Water may be used only on permeable, well-drained soils under good management, especially in relation to leaching and for salt tolerant crops, or for occasional emergency use.	> 5.50

(modified after Hart, 1974 in Taylor 1996)

The final land form and land use, post mining will dictate the composition and structure of species proposed to be established for the rehabilitation phase. Species selection should not only take into consideration climatic and soil nutritional issues but the occurrence of water logging and and salinity levels within the soils. Plant tolerance of soil salinity is measured in terms of root zone soil salinity conditions (where $E.C._{se}$). **Table 10** identifies these salinity classes.

Table 10. Salinity Soil Classes (ECse)

Salinity	EC_{se} (ds/m)
Non Saline	< 2
Slight	2 – 4
Moderate	4 – 8
High	8 – 16
Extreme	> 16

Marcar & Crawford (2004)

To achieve environmental outcomes in the post mining phase the re-establishment of native vegetation in certain areas will be desirable. There is ongoing research by bodies such as the Rural Industries Research and Development Corporation to assist in the establishment native vegetation in saline landscapes. As limited research exists within this topic area, it is envisaged that trials would be undertaken in partnership with these organisations to develop successful revegetation techniques.

The success of revegetating disturbed areas using native vegetation is improved through the use of irrigation. Findings on native vegetation species regeneration at NSW coal mines by the University of Queensland identified that seedling emergence (of native vegetation) and species richness is improved with irrigation. The quality of the water to be used for irrigation and soil constraints would be subject to further investigation as identified in Table 9.

A review of salt tolerance in Native Grasses of Temperate Australia undertaken by Brown (2003) has identified that certain native grasses can germinate and persist in moderate levels of salinity; however most research has been undertaken on extreme conditions and therefore not providing a clear picture of native grass tolerances.

However with the levels identified in the chemical analysis of the soils throughout the MCP, extreme saline soil conditions do not appear to occur.

7.4.2 Strategies for Improving Soil Health as a Plant Growth Medium

All the soils throughout the project area were of an acid pH trend and low in organic matter (%). These factors reduce the availability of nutrients and create and unfavourable microclimate for germination of plant seeds.

The key management practices to rectify these issues are:

- Application of the appropriate amount of soil ameliorant and fertiliser;
- The establishment of a cover crop for soil protection purposes and improvement in organic matter levels; and
- Use of imported organic materials such as bio-solids.

An option that is readily becoming accepted as a rehabilitation practice is the application of Biosolids. Biosolids products have been used successfully on mine sites and degraded agricultural lands providing organic matter inputs, soil amelioration effect and soil nutrients.

Disturbed and degraded land responds exceptionally well to high levels of organic matter and plant nutrients in dewatered biosolids. Lime amended biosolids products can improve degraded soils by rectifying the soil pH.

With sewerage treatment plants (STP) located throughout the Mid Western Regional Council area there is the potential to access a quantity of bio-solid material.

Mine site rehabilitation should be an adaptive process due to the unique situation each mining area faces ie climate, soil types, topography. It is recommended that ongoing trial work of revegetation techniques be undertaken to determine the most efficient and effective revegetation process for the mine site. Incorporation of new products and new ideas to improve rehabilitation success should be encouraged.

7.5 MEASURES TO ENSURE THE LONG TERM VIABILITY OF SOIL RESOURCES

The following soil stockpile management practices will improve the long term viability of the soil resource:

- Soil stockpiles to be located outside of proposed mining areas;
- Keep vehicular traffic to a minimum on the soils to be stripped. Exclude all traffic from soils that are sensitive to structural degradation;
- Use of loaders and trucks rather than scrapers to minimise structural degradation;
- Construction of stockpiles with a “rough” surface condition to reduce erosion hazard, improve drainage and promote revegetation;
- Soil Stockpiles will be no more then 60 cm high to maintain the soil microflora and macroflora biology. Where site constraints do not allow this, stockpiles will be no deeper then 3 meters in order to minimise problems with anaerobic conditions;
- Fertilise and seed stockpiles which are to be inactive for extended periods to maintain soil structure, organic matter and microbial activity;
- Installation of silt fences around stockpiles to control potential loss of stockpiled soil through erosion prior to vegetative stabilisation;
- Stockpiles to be deep-ripped to establish aerobic conditions, prior to reapplication of stockpiled soil for rehabilitation;
- The appropriate soil ameliorant be applied at an appropriate rate to dispersive soil stockpiles where necessary; and
- Implement appropriate weed control strategies particularly for any noxious weeds. Immediate revegetation will provide vegetative competition to assist with control of undesirable plant species.

8 GLOSSARY

The following terms are taken from *A Glossary of Terms Used in Soil Conservation* by Houghten and Charman (1986)

Acid Soil	A soil giving an acid reaction throughout most or all of the soil profile (precisely, below a pH of 7.0; practically, below a pH of 6.5). Generally speaking, acid soils become a problem when the pH drops below 5.5. At this level, and particularly below 5.0, certain nutrient toxicities and deficiencies may occur, adversely affecting plant growth and root nodulation. This may result in a decline in plant cover and increase in erosion hazard.
Alluvium	An extensive stream laid deposit of unconsolidated material, including gravel, sand, silt and clay. Typically it forms floodplains that develop deep alluvial soils.
Cation Exchange Capacity (CEC)	The total amount of exchangeable cations that a soil can absorb, expressed in centimoles of positive charge per kilogram of soil. Cations are positive ions such as calcium, magnesium, potassium, sodium, hydrogen, aluminium and manganese. These are the most important ones found in soils. Cation exchange is the process whereby these ions interchange between the soil solution and the clay or organic matter complexes in the soil. The process is very important as it has a major controlling effect on soil properties and behaviour, stability of soil structure, the nutrients available for plant growth, soil pH and the soils reaction to fertilisers and other added ameliorants.
Clay	Soil material consisting of mineral particles less then 0.002 mm in equivalent diameter. This generally includes the chemically active mineral part of the soil. Many of the important physical and chemical properties of the soil depend on the type and quantity of clay it contains.
Colluvium	Unconsolidated soil and rock material, moved largely by gravity, deposited on lower slopes and/or at the base of a slope.
Dispersive Soil	A structurally unstable soil which readily disperses into its constituent particles (Clay, Silt, Sand) in water. Highly dispersive soils are normally highly erodible and are likely to give problems related to field and earthwork tunnelling (**Sodic Soil**)
Duplex Soil	A soil which there is a sharp change in soil texture between the A and B horizons (such as Loam overlying clay). The soil profile is dominated by the mineral faction with a texture contrast of 1.5 soil texture groups or greater between the A & B horizons. Horizon boundaries are Clear to Sharp.
Drainage	The amount and rate of downward and lateral movement of water through the soil governed by both soil and site characteristics. It is assessed in terms of soil water status and the length of time horizons remain wet (soil bolus exudes water when squeezed). It can be difficult to assess in the field and cannot be based solely on soil profile morphology. Vegetation and topography may be useful guides. Soil permeability, groundwater level and seepage are also important. The presence of mottling often, but not always, reflects poor drainage.
Electrical Conductivity	A measure of the conduction of electricity through water or a water extract of soil. It can be used to determine the soluble salts in the extract and hence soil salinity. The unit of electrical conductivity is the siemens and soil salinity is normally expressed as deci-siemens per metre at 25°C. (Symbol: EC Units: dS/m.) Conductivity values of 1.5 (for a 1:5 soil:water suspension) or 4.0 (for a saturation extract) indicate the likely occurrence of plant growth restrictions.
Emerson Aggregate Test	A classification of soil aggregates based on their coherence in water. Small dry aggregates are placed in dishes of distilled water and their behaviour observed. The conditions under which they slake, swell and disperse allow the different aggregates to be separated into eight classes. The test is particularly valuable in a soil conservation context as it grades soil aggregates according to their stability in water. The test uses natural peds, with the first separation being based on slaking. Those aggregates which do not slake are placed in Class 7 if they swell and in Class 8 if they do not. Of those which do slake, which form the majority of soils, those which show complete soil dispersion are placed in Class 1 and those showing only partial dispersion are placed in Class 2. Those showing no dispersion are remoulded at field capacity and re-immerse in water. Aggregates which disperse after remoulding are placed in Class 3 and those which do not are further separated by the presence or absence of carbonate or gypsum. Those with carbonate or gypsum fall into Class 4, while those without are made up into a 1:5 suspension aggregates:water. Those soils which then show dispersion are placed in Class 5 and those which show flocculation fall into Class 6.

	(Reference: Emerson, w.w. (1967), 'A classification of soil aggregates based on their coherence in water', Aust. 1 Soil Res. 5, 47-57.)
Exchangeable Sodium Percentage (ESP)	The proportion of the cation exchange capacity occupied by sodium ions, expressed as a percentage. Sodic soil are categorised as those with ESP from 6 to 14 percent, strongly soils are those with a ESP of 15 percent or more. Soils with high ESP are typically unstable and as a consequence, have high erodibility and often present problems in soil conservation earthworks.
Gypsum	A naturally occurring soft crystalline mineral which is the hydrated for of calcium sulphate. Gypsum is normally used as a soil ameliorant to improve soil structure and reduce crusting in hard setting clayey soils. The applied calcium increases soil aggregation, which results in improved water infiltration, seed germination and root growth. Typical rates used are up to 5 t/ha, with heavier rates being required on highly sodic soils. Gypsum is also a useful source of nutrient calcium and sulfur, and can also be used for clearing muddy water in dams.
Hard setting	The condition of a dry surface soil when a compact, hard and apparently apedal condition prevails. Because of this characteristic, such soils tend to give rise to high rates of runoff compared with better structured soils. Clods formed by the tillage of hard setting soils usually retain the condition until completely broken down by further tillage operations. Soil on which surface sealing develops mayor may not be hard setting-a surface seal is criterion for the hard setting condition. The majority of soils throughout the wet-dry climatic zones of Australia set hard in the dry season.
Leaching	The removal in solution of the more soluble minerals and salts by water seeping through a soil, rock, ore body or waste material.
Lime	A naturally occurring calcareous material used to raise the pH of acid soils and/or supply nutrient calcium for plant growth. The term refers to the ground limestone ($CaCo_3$).
Lithosol (Skeletol soil)	A shallow soil showing minimal profile development and dominated by the presence of weathering rock and fragment there from. Such soils are typically found on steep slopes, exposed hill crest<; and rocky ranges where natural erosion exceeds the formation of new soil material.
Loam	A medium-textured soil of approximate composition 10 to 25 per cent clay, 25 to 50 per cent silt, and less than 50 per cent sand. Such a soil is typically well graded.
Mottling	The presence of more then one soil colour in the same soil horizon, not including different nodule colours. The subdominant colours normally occur as scattered blobs or blotches, which have definable differences in hue, value or chroma from the dominant colour. Mottling is often indicative of slow internal drainage, but may also be a result of parent material weathering.
Mining Operation Plan (MOP)	This is a document which each mine operator in NSW is required to prepare that demonstrates that the mining activity is applying current best mining practice to achieve agreed environmental outcomes. Site activities must not be undertaken other than in accordance with a MOP that has been accepted by the Department.
Particle Size Analyses (PSA)	The laboratory determination of the amounts of the different separates in a soil sample such as clay, silt, fine sand, coarse sand and gravel. The amounts are normally expressed as percentages by weight of dry soil and are determined by dispersion, sedimentation, sieving, micrometry or combinations of these techniques.
Ped	An individual natural soil aggregate.
pH	A measure of the acidity or alkalinity of a soil. A pH of 7.0 denotes neutrality; higher values indicate alkalinity, and lower values indicate acidity. Soil pH levels generally fall between 5.5 and 8.0 with most plants growing best in this range. See also acid soil. Soil pH is commonly measured in the field by a colorimetric method using Raupach's indicator.
Soil Aggregate	A unit of soil structure consisting of primary soil particles held together by cohesive forces or by secondary soil materials such as iron oxides, silica or organic matter. Aggregates may be natural, such as peds, or formed by tillage, such as crumbs and clods.
Soil Ameliorant	A substance used to improve the chemical or physical qualities of the soil. For example, the addition of lime to the soil to increase pH to the desired level for optimum plant growth, or the addition of gypsum to improves soil structure.

Soil Consistence	The resistance of soil material to deformation or rupture.
Soil Erodibility	The susceptibility of a soil to the detachment and transportation of soil particles by erosive agents. It is a composite expression of those soil properties that affect the behaviour of a soil and is a function of the mechanical, chemical and physical characteristics of the soil. It is independent of the other factors influencing soil erosion such as topography, land use, rainfall intensity and plant cover, but may be changed by management. The qualitative categories of soil erodibility used are low, moderate, high, very high and extreme. The most highly erodible soils are those that are most easily detached and transported by erosive forces. High soil dispersibility is a good indicator of high soil erodibility.
Soil Landscape	An area of land that has recognisable and specifiable topography and soils, that is capable of being presented on maps and of being described by concise statements. Thus, a soil landscape has a characteristic landform with one or more soil taxonomic units occurring in a defined way. It is often associated with the physiographic features of the landscape and is similar to a soil association but, in a soil landscape, the landform pattern is specifically described. The soil landscape may be named according to the soil taxonomic units present, the dominant unit or be given a geographic name based on a locality where it is well developed.
Soil Salinity	The characteristic of soils relating to their content of water-soluble salts. Such salts predominantly involve sodium chloride, but sulphates, carbonates and magnesium salts occur in some soils. High salinity adversely affects the growth of plants, and therefore increases erosion hazard. Soil salinity is normally characterised by measuring the electrical conductivity of a soil/water saturation extract and is expressed in deci-siemens per metre at 25°C (dS/m).
Soil Structure	The combination or spatial arrangement of primary soil particles (clay, silt, sand, gravel) into aggregates such as peds or clods and their stability to deformation. Structure may be described in terms of the grade, class and form of the soil aggregates. Soil structure is an important property with respect to the stability, porosity and infiltration characteristics of the soil. Well-structured soils tend to be more resistant to erosion due to their ability to absorb rainfall more freely and over longer periods, and because of the resistance of their aggregates to detachment and transport by raindrop splash and/or overland flow. They also have good soil/water/air relationships for the growth of plants. Poorly structured soils have, unstable aggregates and low infiltration rates. They tend to break down quickly under heavy rainfall which leads to soil detachment and erosion. Under certain conditions, surface sealing occurs and this gives rise to rapid and excessive runoff.
Soil Survey	The systematic examination, description, classification and mapping of soils, with the aim of categorising soil distribution within a defined area. In practice, most soil surveys also include statements on the geology, topography, climate and vegetation of the area concerned. They may be carried out for general use, in which case a wide range of soil properties is examined, or for a particular purpose such as crop irrigation or urban planning, in which case only a limited number of soil properties may be relevant.
Soil Texture	The coarseness or fineness of soil material as it effects the behaviour of a moist ball of soil when pressed between the thumb and forefinger. It is generally related to the proportion of soil particles of differing sizes (sand, silt, clay and gravel) in a soil, but it is also influenced by organic matter content, clay type and degree of structural development of the soil.
Soil Type	A general term used to describe a group of soils that can be managed similarly and which exhibit similar morphological features. It is largely a layman's term and now has no formal taxonomic meaning.
Surface Sealing	The orientation and packing of dispersed soil particles in the immediate surface layer of the soil, rendering it relatively impermeable to water. Typically occurs due to the effect of raindrop impact on bare soil and results in a reduction in infiltration. Runoff and the potential for soil erosion are thus increased, and a crust may form on drying out.

9 REFERENCES

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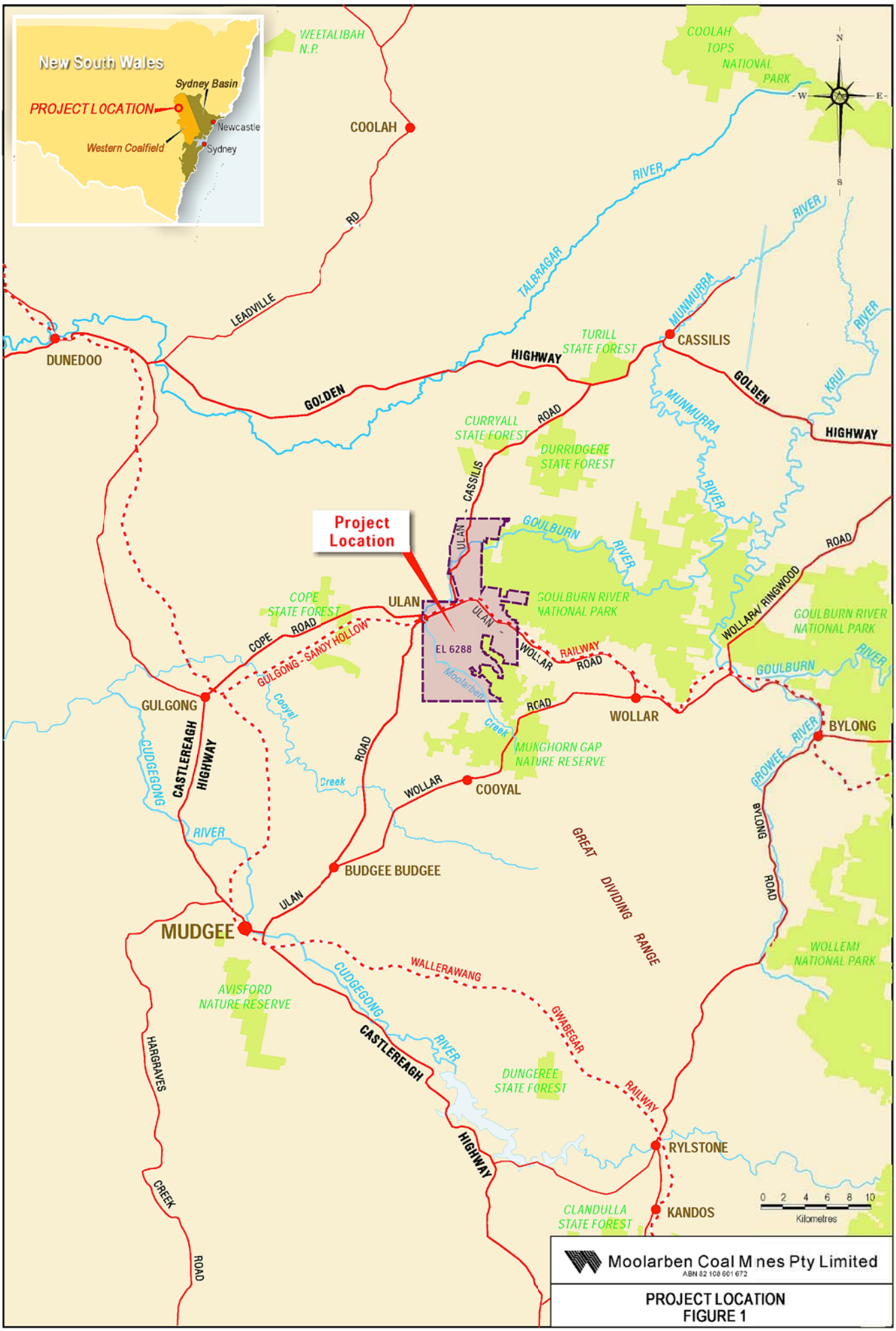
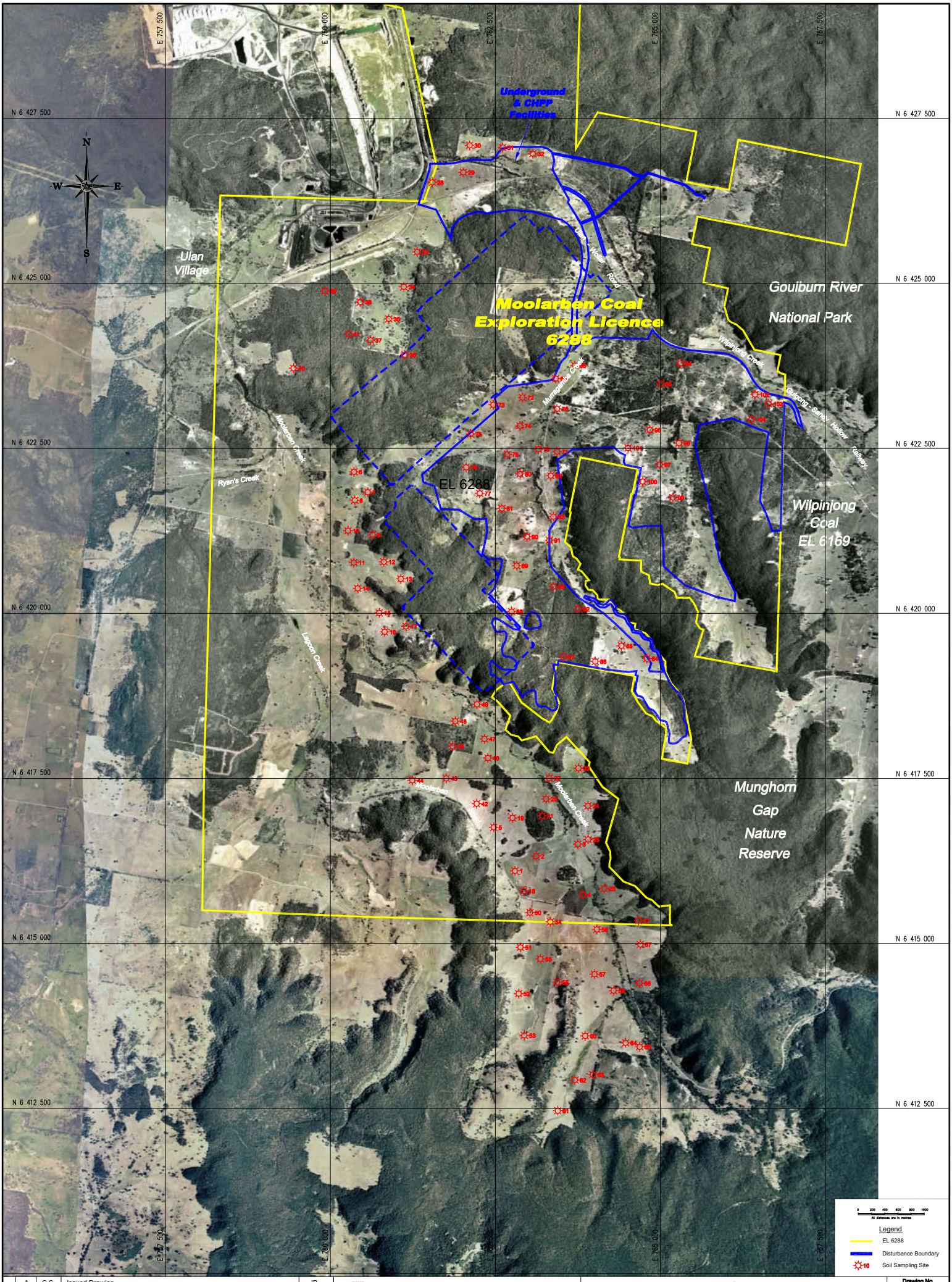
10 FIGURES


New South Wales
Sydney Basin
PROJECT LOCATION
Newcastle
Western Coalfield
Sydney
WEETALIBAH N.P.
COOLAH
COOLAH TOPS NATIONAL PARK
N
W
E
S
RIVER
RD
LEADVILLE
TALBRAGAR
MUNMURRA
RIVER
DUNEDOO
GOLDEN
HIGHWAY
TURILL STATE FOREST
CASSILIS
KRUI
CURRYALL STATE FOREST
ROAD
DURRIDGERE STATE FOREST
CASSILIS
Project Location
ULAN
GOULBURN
RIVER
COPE STATE FOREST
ULAN
GOULBURN RIVER NATIONAL PARK
WOLLAR/ RINGWOOD
ROAD
COPE
ROAD
GULGONG - SANDY HOLLOW
EL 6288
WOLLAR
RAILWAY
ROAD
Moolarben
Creek
GULGONG
Cooyal
Creek
ROAD
WOLLAR
MUNGHORN GAP NATURE RESERVE
BYLONG
GROWEE
RIVER
CUDGEGONG
CASTLEREAGH
HIGHWAY
RIVER
COOYAL
WOLLAR
ROAD
BUDGEE BUDGEE
GREAT
DIVIDING
RANGE
BYLONG
ROAD
ULAN
MUDGEE
WOLLEMI NATIONAL PARK
WALLERAWANG
GWABEGAR
RAILWAY
AVISFORD NATURE RESERVE
CUDGEGONG
RIVER
CASTLEREAGH
HIGHWAY
DUNGEREE STATE FOREST
HARGRAVES
CREEK
ROAD
RYLSTONE
CLANDULLA STATE FOREST
KANDOS
0 2 4 6 8 10
Kilometres
Moolarben Coal Mines Pty Limited
ABN 82 108 601 672
PROJECT LOCATION
FIGURE 1



Revision	Rev.	Drawn	Description	Approved
	A	C.S	Issued Drawing	JB

Moolarben Coal Mines Pty Limited
ABN 82 108 001 672
Level 14 213 Miller Street North Sydney NSW 2060
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Prepared by Co-Resources Pty Ltd Ph: 02 65 718888

Moolarben Coal Project
Soil Sampling Locations & Disturbance Areas
Figure 2

Drawing No.	Revision No.	Sheet Size
03164	A	A1

Date	Scale:	Drawn	Checked	Approved
23.06.08	1: 25,000	CS	JF	JB

Soil Landscapes		
Bald Hill	BH	Low Hillocks with elevations from 460-600m. Slopes 10-35%. Local relief from 60-120m. Drainage lines are 300-500m apart Tertiary Basalt, Olivine Basalt, Teschenite, Euchrozems - chocolates intergrades, Chocolate soils. Steep Slopes with rock outcrops; stoniness; mod to high fertility and water holding capacity.
Lees Pinch	LP	Sandstone Plateau and hill slopes with boulder debris. Elevations between 400-680m. Slopes between 15-40%. Local relief from 60-240m. Narrabeen Group and Illawarra Coal Measures Sandstone, Wollar Sandstone, Conglomerate Sandstone, Chert, Shale Coal & Torbanite. Shallow siliceous sands, shallow acid soils, yellow earths, yellow podzolic soils. Steep slopes are high erosion hazard when cover is low. Very low fertility, acidic surface soils. Low to very low water holding capacity and high permeability
Munghorn Plateau	MP	Low undulating hills form plateau from 600-700m. Slopes from 3-10% and local relief varies from 20-60m. Narrabeen Group and Illwarra Coal Measures Sandstove, Wollar sandstone, conglomerate sandstone, chert, shale coal, torbanite, shallow siliceous sands, shallow acid soils, yellow earths, yellow podzolic soils. High to very high erosion hazard when ground cover is low. Low soil fertility and low water holding capacity.
Turill	TI	Undulating low hills with some sandstone outcrops. Elevations vary from 440-560m above sea level, local relief to 30-90m. Slopes range between 5-20%. Narrabeen, Mudstone and Jurassic Shale and Sandstone. Yellow and brown earth sands, red, yellow and grey podzolics. Low fertility and water holding capacity. High to very high erosion hazard under cultivation. Salinity common.
Ulan	UL	Low undulating rises and creek flats. Elevations between 360-570m. Slopes between 2-10%. Local relief varies between 10-40m. Undifferentiated and Illwarra Coal Measures Shale, sandstone, conglomerate, chert, coal and torbanite. Yellow Podzolic, yellow solodic / solonetz, yellow and brown earths and earthy sands. Mod to high erosion hazard and susceptible to soil degradation. Imperfectly drained on the lower slopes and depressions. High soil salinity levels and low soil fertility.

0 200 400 600 800 1000
All distances are in metres

Legend
- EL 6288
- Disturbance Boundary
- Soil Landscapes

N

E 762 000 E 764 000 E 766 000 E 768 000
N 6 434 000 N 6 432 000 N 6 430 000 N 6 428 000 N 6 426 000 N 6 424 000 N 6 422 000
E 758 000 E 760 000

Ulan Coal Mines
Goulburn River National Park
Underground & CHPP Facilities
Ulan Village
Moolarben Coal Exploration Licence 6288
Goulburn River National Park
Wilpinjong Coal EL 6169
Ulan - Caerwills Road
Goulburn River
Ulan - Wollar Road
Murragamba Creek
Wilpinjong Creek
Gulgong - Sandy Hollow Railway
Moolarben Creek
Ryan's Creek

TI MP LP UL BH CS

Revision				
	A	C.S.	Issued Drawing	JB
	B	J.D.	Amendments to Land Use Tables	JB
	Rev.	Drawn	Description	Approved

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North Sydney NSW 2060 Fax: 02 9923 2427
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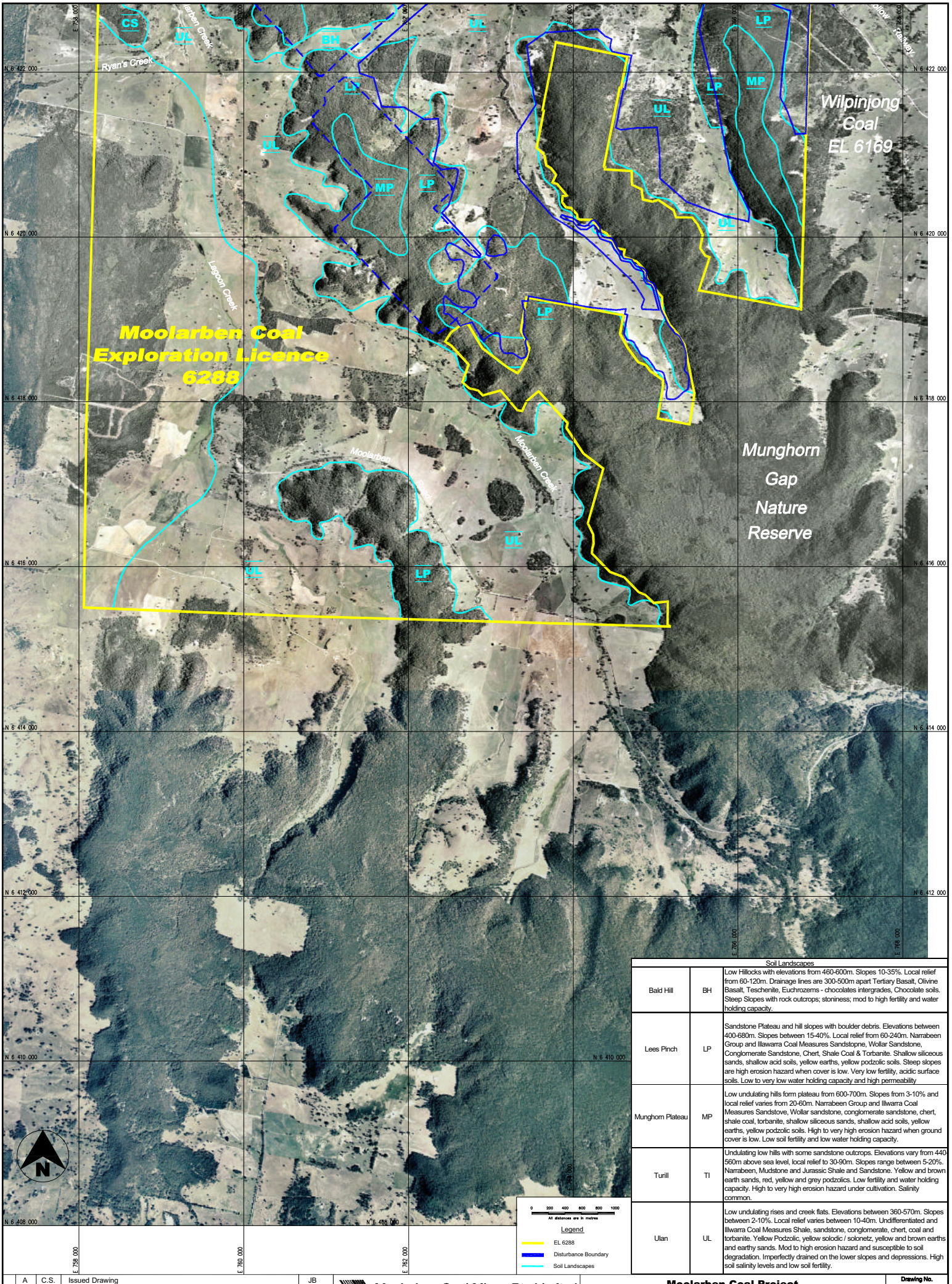
Moolarben Coal Project
Soil Landscapes - Figure 3
Sheet 1 of 2

Date	Scale:	Drawn	Checked	Approved	Sheet Size
09.10.08	1: 20000	JD	JB	JB	A1

Drawing No. 03165
Revision No. B



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	B	J.D.	Amendments to Land Use Tables	JB

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Moolarben Coal Project
Soil Landscapes - Figure 3
Sheet 2 of 2

Drawing No.	Revision No.	Date	Scale:	Drawn	Checked	Approved	Sheet Size
03165	B	09.10.08	1: 20000	JD	JB	JB	A1

Soil Type Classification

Item	Soil Type	Description
Al	Alluvial	Alluvial soils have no true pedological horizons other than an A horizon and are often weakly developed. They generally occur on flats or valley bottoms where bed load sedimentation has occurred. The sedimentary layers of these soils can vary greatly in a number of characteristics including texture, stoniness, depth, colour and carbonate content. Nutrient supply is good as there is usually a reasonable supply of primary rock minerals.
Yp	Yellow Podzolic	Yellow podzolic soils are identified by their strongly differentiated profiles with light, medium textured A horizons overlaying a yellow-brown clayey B horizon. The A_2 Horizon is usually noticeably bleached. Reddish or greyish mottling is common in the B horizon. pH is mildly to strongly acidic, becoming more acidic with depth. These soils are of limited fertility, with the A horizon providing moderate accumulation of organic matter.
Rp	Red Podzolic	Red podzolic soils feature a brownish-greyish A horizon overlaying a red B horizon of much higher clay content. The A horizon is usually weakly structured, whilst the B horizon consists of polyhedral or blocky pedology. A distinct pale A2 horizon is usually present and the profile is acidic. Fertility is generally low (with the A horizon retaining some organic matter) and decreases further with depth.
Ys	Yellow Solodic	Solodic soils are characterised by strong texture contrast profiles with light textured surface soils overlying tough, hard and dense B horizon, which are usually very unstable to wetting processes. The boundary between the A and B horizons is very abrup
Es	Earthy Sand & Sand	Earthy sands are characterised by uniform profiles of coherent, clayey sands which are dominantly red in colour but in some cases yellow. These soils are usually deep and are characterised by uniform sand texture and a massive, single-grained structure.
Eu	Euchrazem	Strongly structured red soils, often with fine shiny polyhedral peds. Soil texture eventually becomes more clay with depth.
Li	Lithosol	Lithosols are shallow skeletal stony or gravely s with a thin A_1 horizon of organic matter generally occurring on upper slope and hill-top areas. Pedological development is low, consisting of weathering of underlying rocks and the gradual addition of organic matter in the A1 horizon. Cover is discontinuous and rock outcrops are common.
Co	Colluvial	Soils derived from colluvial processes exhibiting no real horizon development with a high percentage of coarse gravels and cobles inter-dispersed throughout the profile. These materials are located high within the landscape usually at the footslopes of steep hills in a flow line experiencing high erosional activity in the upper slopes.
S	Saline	These soils are generally Yellow podzolic tha exhibit saline characteristics such as surface scalding. These soils need to be managed separately in view of their salinity levels.
Re	Red Earth	These soil areas are massive and porous, earthy soil material, reddish brown to red colour and a gradual increase to clay content with depth. Textures are sandy loams with high sand and quartzite gravel content. These soils are located around isolated elevated hills.

0 200 400 600 800 1000
All distances are in metres

Legend
- EL 6288
- Disturbance Boundary
- Ys — Soil Type Boundaries
- S23 — Soil Profile Site

Ulan Coal Mines

Goulburn River National Park

Underground & CHPP Facilities

Ulan Village

Moolarben Coal Exploration Licence 6288

Goulburn River National Park

Wilpinjong Coal EL 6169

Ulan - Cassilis Road

Goulburn River

Ulan - Wollar Road

Murragamba Creek

Wilpinjong Creek

Gulgong - Sandy Hollow Railway

Moolarben Creek

Ryan's Creek

N 6 434 000
N 6 432 000
N 6 430 000
N 6 428 000
N 6 426 000
N 6 424 000
N 6 422 000
E 758 000
E 760 000
E 762 000
E 764 000
E 766 000
E 768 000

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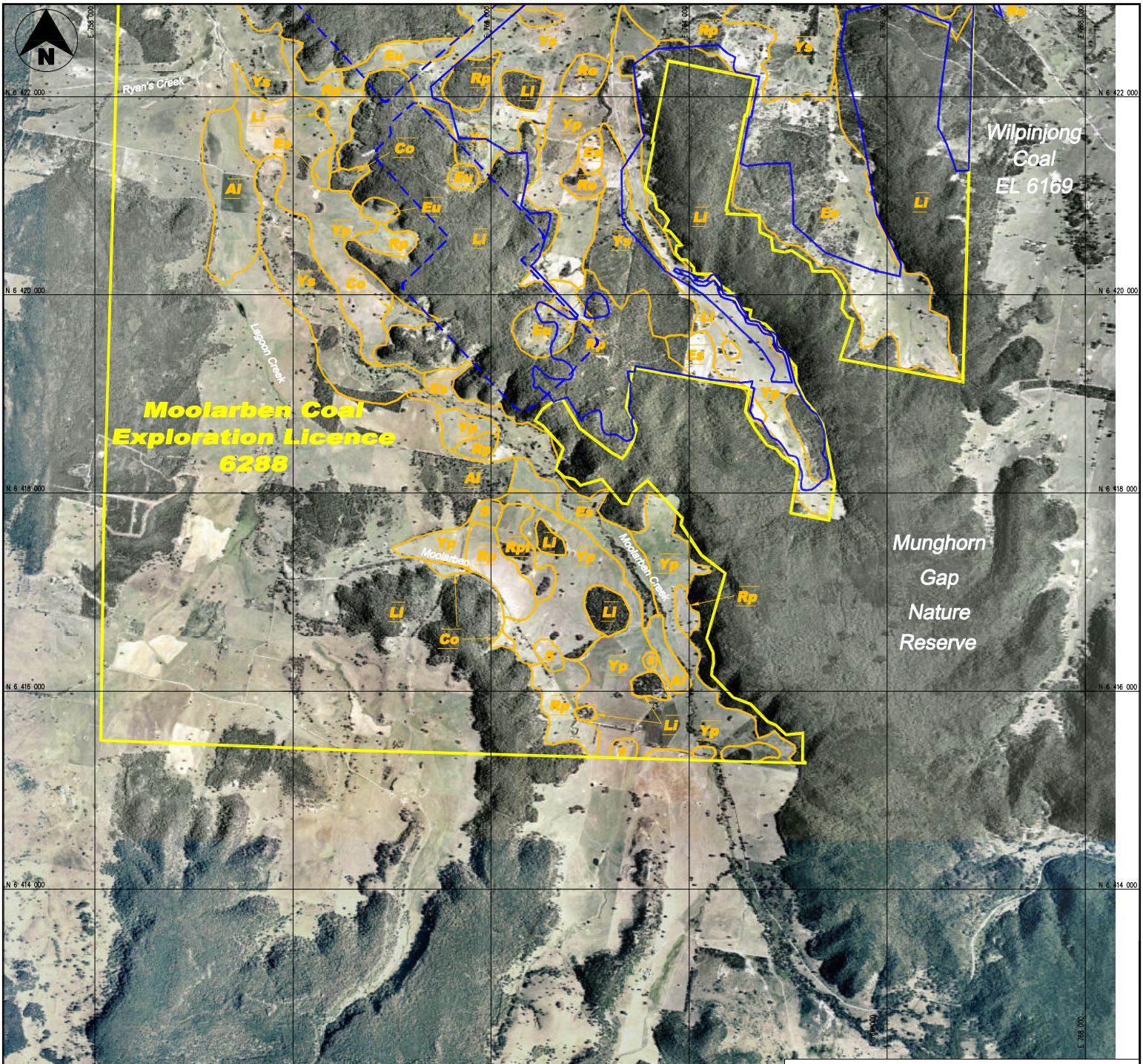
Moolarben Coal Project
Soil Type Boundaries - Figure 4
Sheet 1 of 2

Date	Scale:	Drawn	Checked	Approved
09.10.08	1: 20000	JD	JB	JB

Drawing No. 03166
Revision No. B
Sheet Size A1



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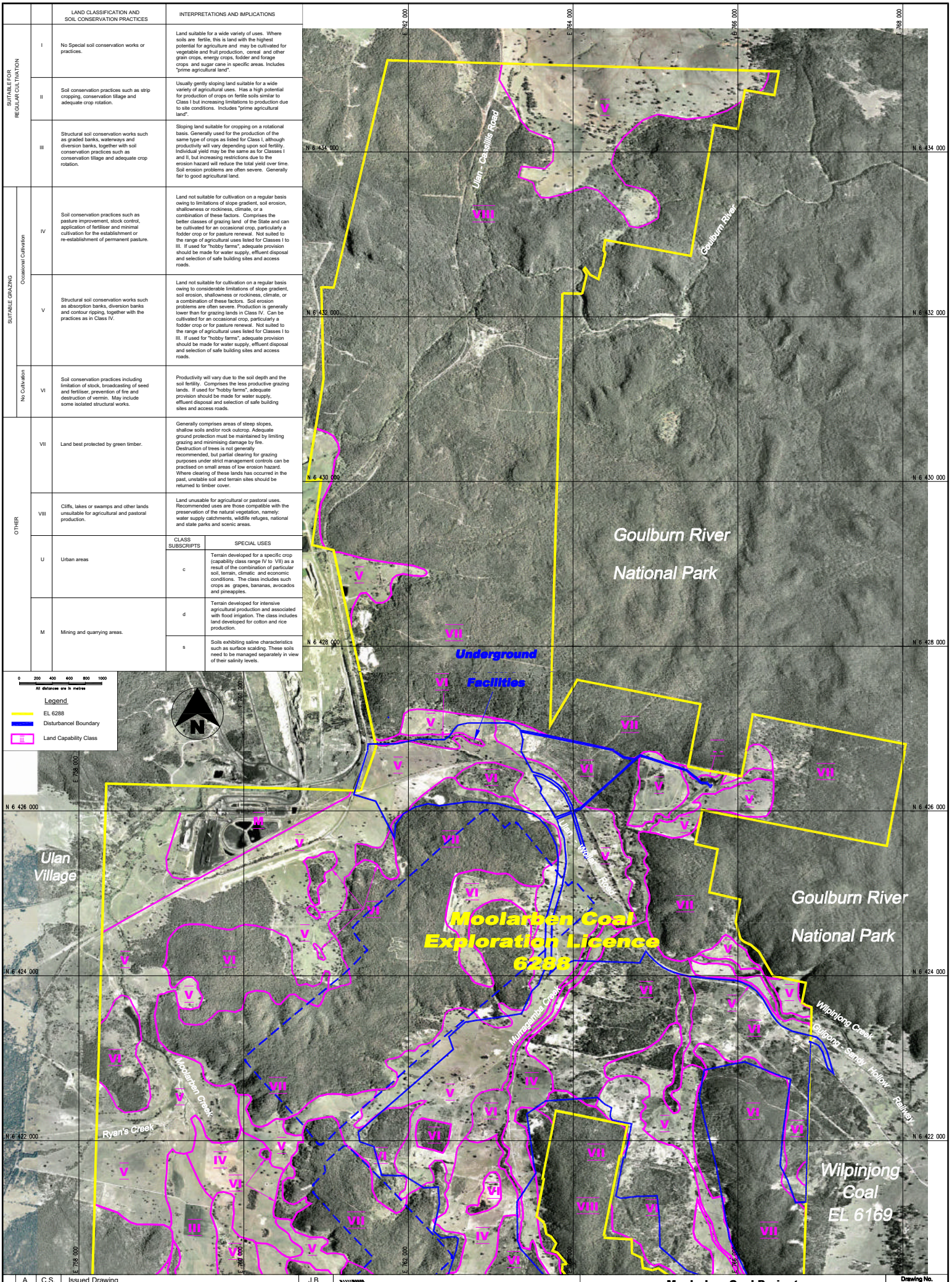
Moolarben Coal Project
Soil Type Boundaries - Figure 4
Sheet 2 of 2

Drawing No.	Revision No.	Date	Scale:	Drawn	Checked	Approved	Sheet Size
03166	B	09.10.08	1: 20000	JD	JB	JB	A1

		LAND CLASSIFICATION AND SOIL CONSERVATION PRACTICES	INTERPRETATIONS AND IMPLICATIONS
SUITABLE FOR REGULAR CULTIVATION	I	No Special soil conservation works or practices.	Land suitable for a wide variety of uses. Where soils are fertile, this is land with the highest potential for agriculture and may be cultivated for vegetable and fruit production, cereal and other grain crops, energy crops, fodder and forage crops and sugar cane in specific areas. Includes "prime agricultural land".
	II	Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotation.	Usually gently sloping land suitable for a wide variety of agricultural uses. Has a high potential for production of crops on fertile soils similar to Class I but increasing limitations to production due to site conditions. Includes "prime agricultural land".
	III	Structural soil conservation works such as graded banks, waterways and diversion banks, together with soil conservation practices such as conservation tillage and adequate crop rotation.	Sloping land suitable for cropping on a rotational basis. Generally used for the production of the same type of crops as listed for Class I, although productivity will vary depending upon soil fertility. Individual yield may be the same as for Classes I and II, but increasing restrictions due to the erosion hazard will reduce the total yield over time. Soil erosion problems are often severe. Generally fair to good agricultural land.
SUITABLE GRAZING — Occasional Cultivation	IV	Soil conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or re-establishment of permanent pasture.	Land not suitable for cultivation on a regular basis owing to limitations of slope gradient, soil erosion, shallowness or rockiness, climate, or a combination of these factors. Comprises the better classes of grazing land of the State and can be cultivated for an occasional crop, particularly a fodder crop or for pasture renewal. Not suited to the range of agricultural uses listed for Classes I to III. If used for "hobby farms", adequate provision should be made for water supply, effluent disposal and selection of safe building sites and access roads.
	V	Structural soil conservation works such as absorption banks, diversion banks and contour ripping, together with the practices as in Class IV.	Land not suitable for cultivation on a regular basis owing to considerable limitations of slope gradient, soil erosion, shallowness or rockiness, climate, or a combination of these factors. Soil erosion problems are often severe. Production is generally lower than for grazing lands in Class IV. Can be cultivated for an occasional crop, particularly a fodder crop or for pasture renewal. Not suited to the range of agricultural uses listed for Classes I to III. If used for "hobby farms", adequate provision should be made for water supply, effluent disposal and selection of safe building sites and access roads.
SUITABLE GRAZING — No Cultivation	VI	Soil conservation practices including limitation of stock, broadcasting of seed and fertiliser, prevention of fire and destruction of vermin. May include some isolated structural works.	Productivity will vary due to the soil depth and the soil fertility. Comprises the less productive grazing lands. If used for "hobby farms", adequate provision should be made for water supply, effluent disposal and selection of safe building sites and access roads.
OTHER	VII	Land best protected by green timber.	Generally comprises areas of steep slopes, shallow soils and/or rock outcrop. Adequate ground protection must be maintained by limiting grazing and minimising damage by fire. Destruction of trees is not generally recommended, but partial clearing for grazing purposes under strict management controls can be practised on small areas of low erosion hazard. Where clearing of these lands has occurred in the past, unstable soil and terrain sites should be returned to timber cover.
	VIII	Cliffs, lakes or swamps and other lands unsuitable for agricultural and pastoral production.	Land unusable for agricultural or pastoral uses. Recommended uses are those compatible with the preservation of the natural vegetation, namely: water supply catchments, wildlife refuges, national and state parks and scenic areas.
	U	Urban areas	
	M	Mining and quarrying areas.	

CLASS SUBSCRIPTS	SPECIAL USES
c	Terrain developed for a specific crop (capability class range IV to VII) as a result of the combination of particular soil, terrain, climatic and economic conditions. The class includes such crops as grapes, bananas, avocados and pineapples.
d	Terrain developed for intensive agricultural production and associated with flood irrigation. The class includes land developed for cotton and rice production.
s	Soils exhibiting saline characteristics such as surface scalding. These soils need to be managed separately in view of their salinity levels.



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	B	J.D.	Amendments to Land Use Tables	J.B

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Moolarben Coal Project
Land Capability Mapping - Figure 5
Sheet 1 of 2

Drawing No.	Revision No.	Date	Scale:	Drawn	Checked	Approved	Sheet Size
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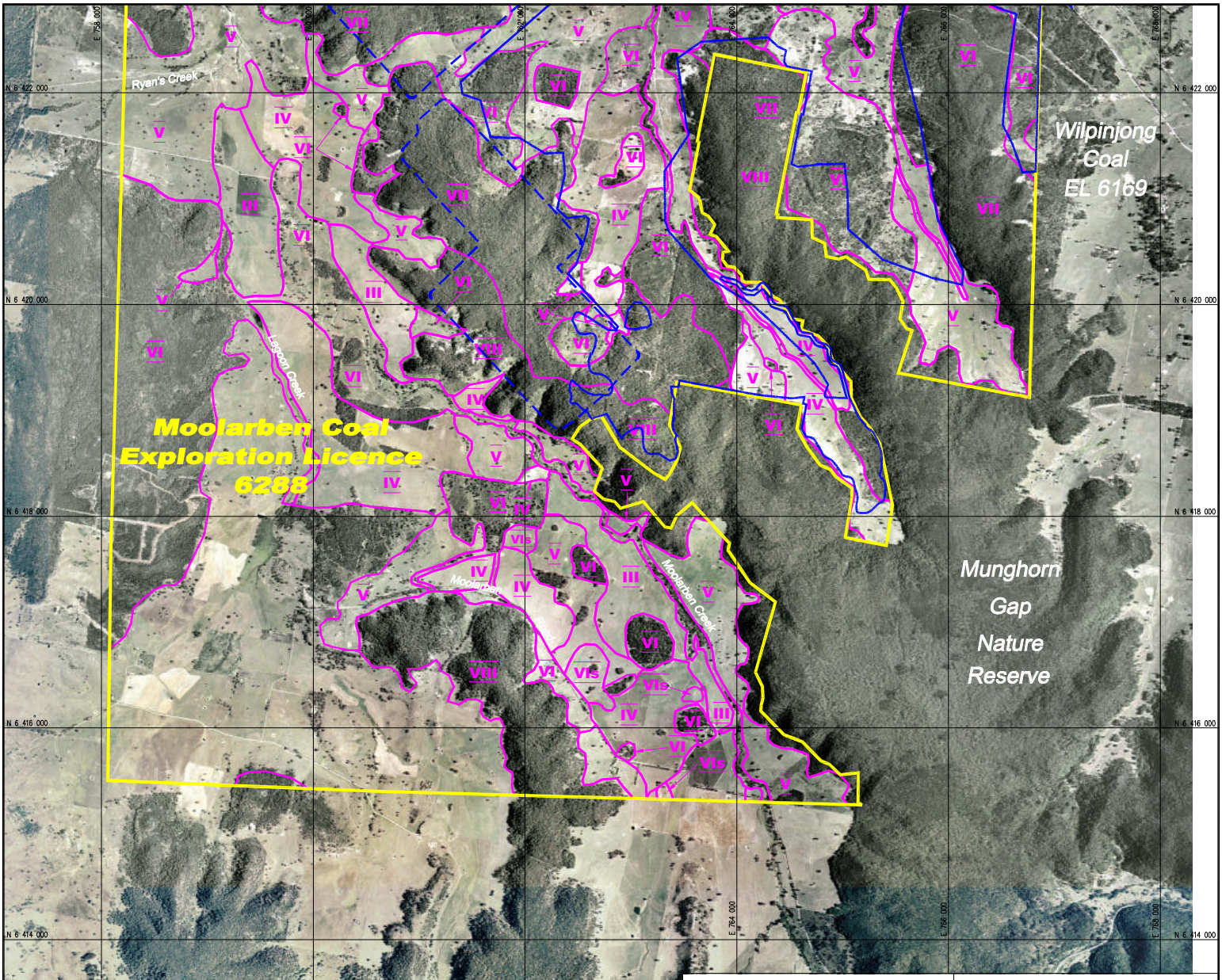

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	II	Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotation.	Usually gently sloping land suitable for a wide variety of agricultural uses. Has a high potential for production of crops on fertile soils similar to Class I but increasing limitations to production due to site conditions. Includes "prime agricultural land".
	III	Structural soil conservation works such as graded banks, waterways and diversion banks, together with soil conservation practices such as conservation tillage and adequate crop rotation.	Sloping land suitable for cropping on a rotational basis. Generally used for the production of the same type of crops as listed for Class I, although productivity will vary depending upon soil fertility. Individual yield may be the same as for Classes I and II, but increasing restrictions due to the erosion hazard will reduce the total yield over time. Soil erosion problems are often severe. Generally fair to good agricultural land.
SUITABLE GRAZING — Occasional Cultivation	IV	Soil conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or re-establishment of permanent pasture.	Land not suitable for cultivation on a regular basis owing to limitations of slope gradient, soil erosion, shallowness or rockiness, climate, or a combination of these factors. Comprises the better classes of grazing land of the State and can be cultivated for an occasional crop, particularly a fodder crop or for pasture renewal. Not suited to the range of agricultural uses listed for Classes I to III. If used for "hobby farms", adequate provision should be made for water supply, effluent disposal and selection of safe building sites and access roads.
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SUITABLE GRAZING — No Cultivation	VI	Soil conservation practices including limitation of stock, broadcasting of seed and fertiliser, prevention of fire and destruction of vermin. May include some isolated structural works.	Productivity will vary due to the soil depth and the soil fertility. Comprises the less productive grazing lands. If used for "hobby farms", adequate provision should be made for water supply, effluent disposal and selection of safe building sites and access roads.
OTHER	VII	Land best protected by green timber.	Generally comprises areas of steep slopes, shallow soils and/or rock outcrop. Adequate ground protection must be maintained by limiting grazing and minimising damage by fire. Destruction of trees is not generally recommended, but partial clearing for grazing purposes under strict management controls can be practised on small areas of low erosion hazard. Where clearing of these lands has occurred in the past, unstable soil and terrain sites should be returned to timber cover.
	VIII	Cliffs, lakes or swamps and other lands unsuitable for agricultural and pastoral production.	Land unusable for agricultural or pastoral uses. Recommended uses are those compatible with the preservation of the natural vegetation, namely: water supply catchments, wildlife refuges, national and state parks and scenic areas.
	U	Urban areas	
	M	Mining and quarrying areas.	

CLASS SUBSCRIPTS	SPECIAL USES
c	Terrain developed for a specific crop (capability class range IV to VII) as a result of the combination of particular soil, terrain, climatic and economic conditions. The class includes such crops as grapes, bananas, avocados and pineapples.
d	Terrain developed for intensive agricultural production and associated with flood irrigation. The class includes land developed for cotton and rice production.
s	Soils exhibiting saline characteristics such as surface scalding. These soils need to be managed separately in view of their salinity levels.

Revision				
A	C.S.	Issued Drawing		JB
B	J.D.	Amendments to Land Use Tables		JB
Rev.	Drawn	Description		Approved

Moolarben Coal Mines Pty Limited
ABN 82 108 601 672
Level 14 213 Miller Street North Sydney NSW 2060
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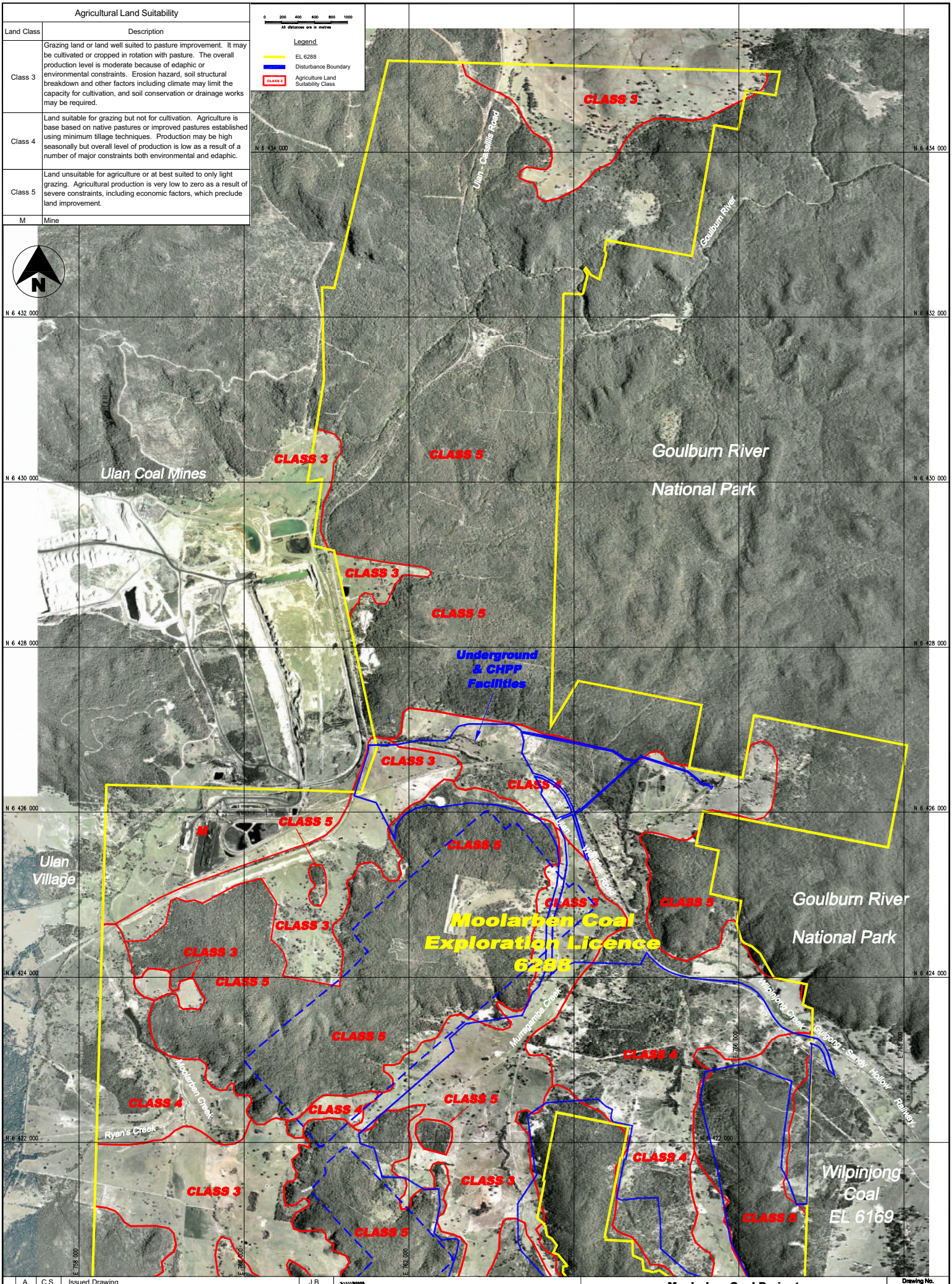
Prepared by Co-Resources Pty Ltd Ph: 02 65 718888

Moolarben Coal Project
Land Capability Mapping - Figure 5
Sheet 2 of 2

Drawing No.	Revision No.	Sheet Size
03167	B	A1

Date	Scale:	Drawn	Checked	Approved
09.10.08	1: 20000	JD	JB	JB



Revision				
	A	C.S.	Issued Drawing	J.B
	B	J.D.	Amendments to Land Use Tables	J.B
	Rev.	Drawn	Description	Approved

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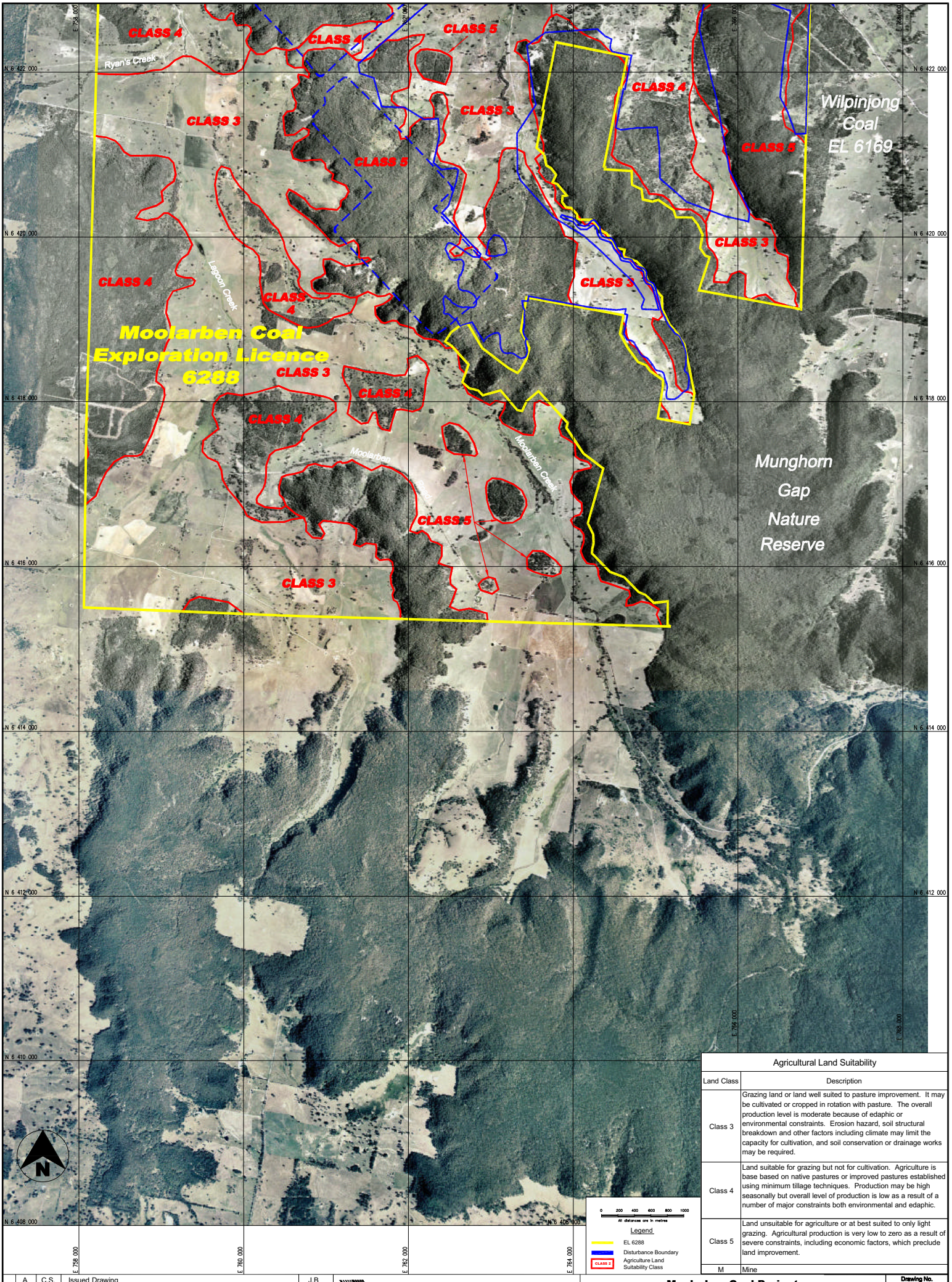
Moolarben Coal Project
Agricultural Suitability Mapping - Figure 6
Sheet 1 of 2

Date	Scale:	Drawn	Checked	Approved
09.10.08	1: 20000	JD	JB	JB

Drawing No.	Revision No.	Sheet Size
03168	B	A1



Agricultural Land Suitability	
Land Class	Description
Class 3	Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture. The overall production level is moderate because of edaphic or environmental constraints. Erosion hazard, soil structural breakdown and other factors including climate may limit the capacity for cultivation, and soil conservation or drainage works may be required.
Class 4	Land suitable for grazing but not for cultivation. Agriculture is base based on native pastures or improved pastures established using minimum tillage techniques. Production may be high seasonally but overall level of production is low as a result of a number of major constraints both environmental and edaphic.
Class 5	Land unsuitable for agriculture or at best suited to only light grazing. Agricultural production is very low to zero as a result of severe constraints, including economic factors, which preclude land improvement.
M	Mine

Revision				
A	C.S.	Issued Drawing		J.B
B	J.D.	Amendments to Land Use Tables		J.B
Rev.	Drawn	Description		Approved

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Moolarben Coal Project
Agricultural Suitability Mapping - Figure 6
Sheet 2 of 2

Drawing No.	Revision No.	Date	Scale:	Drawn	Checked	Approved	Sheet Size
03168	B	09.10.08	1: 20000	JD	JB	JB	A1

APPENDIX 1
PROFILE DESCRIPTIONS

OPEN CUT 4 WEST

Site No:			68	69	70	71
Coordinates (AGD 66)		E N	763591 6423568	763303 6423371	763323 6422914	763325 6422267
Landform Element:			drainage depression	Hill slope	Hill slope	Hill slope
Aspect:			Flat	East	West	West
Run on:			High	High	Moderate	Moderate
Run off:			High	High	Moderate	Moderate
Profile Drainage:			poorly drained	imperfectly drained	well drained	imperfectly drained
Site Disturbance:			extensive clearing	extensive clearing	occasional cultivation	occasional cultivation
Landuse:			volun./native pasture	volun./native pasture	cropping	cropping
Slope:			1%	6%	6%	4%
Surface Condition:			Soft	Firm	Loose	Loose
Erosion Hazard:	Type:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
	Degree:		High	High	Extreme	Very High
Surface Coarse Fragments:			Nil	Yes	Nil	Nil
Rock Outcrop:			Nil	< 2%	Nil	Nil
Groundwater Depth:			0.5 m	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Alluvial Soil (Um 5.22)	Yellow Podzolic (Dy 3.31)	Earthy Sand (Uc 5.31)	Yellow Podzolic (Dy 3.31)
Horizon:	Depth:		A1 0.0 - 0.25 A2 0.25 - 0.45 B 0.45 - 1.00	A1 0.0 - 0.15 A2 0.15 - 0.30 Auger Refusal	A1 0.0 - 0.25 A2 0.25 - 0.45 A3 0.45 - 0.7 B 0.7 - 1.00	A1 0.0 - 0.2 A2 0.2 - 0.4 B 0.4 - 1.00
	Boundary:		Gradual Gradual	Abrupt	Gradual Gradual Clear Clear	Abrupt Clear
	Colour:		10YR 4/2 10YR 5/2 10YR 6/1	10YR 3//3 10YR 5/5	10YR 5/3 10YR 6/3 10YR 7/3 5YR 5/8	10YR 3/3 10YR 5/2 10YR 7/6
	Mottles:		Grey (20% - 50%)	Nil	Orange (20% - 50%)	Orange (20% - 50%)
	Texture:		loam sandy loam loamy clay	loam loam	sand sand sand silty clay	loam silty loam sandy clay
	Coarse Fragments:		Nil Nil Nil	Nil Few (2 -10%)	Nil Nil Nil Few (2 -10%)	Very Few (< 2%) Nil Nil
	Structure:		Massive Massive Weak Pedality	Massive Massive Massive	Single Grained Single Grained Single Grained	Massive Massive Weak Pedality
	Dominant Ped Shape:		Granular Polyhedral Sub angular Blocky	Crumb Crumb Crumb	Granular Granular Granular	Granular Polyhedral Sub angular Blocky
	Consistency:		Very weak Very weak Moderate Firm	Very weak Very weak Very weak	Very weak Very Weak Very Weak	Very weak Very weak Moderate Firm
	Field pH:		5.5 5.5 6.0	4.5 5.0	5.5 4.5 6.0 4.5	5.0 5.5 6.0
	Segregations:		Nil	Nil	Nil	Nil

Site No:			72	73	74	75
Coordinates (AGD 66)		E N	762802 6423086	762359 6422975	762759 6422657	762014 6422532
Landform Element:			Hillslope	Hillcrest	Valley Flat	Hillcrest
Aspect:			East	West	Flat	East
Run on:			Moderate	Low	Moderate	Moderate
Run off:			Moderate	Moderate	Low	High
Profile Drainage:			imperfectly drained	imperfectly drained	imperfectly drained	poorly drained
Site Disturbance:			extensive clearing	cleared	extensive clearing	extensive clearing
Landuse:			volun./native pasture	volun./native pasture	improved pasture	volun./native pasture
Slope:			2	4	1	5
Surface Condition:			Hard set	Firm	Hard set	Hard set
Erosion Hazard:	Type:		Very High	Very High	High	High
	Degree:		Rill / Gully	Rill / Gully	Tunnel / Gully	Rill Gully
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			Nil	Nil	Nil	< 2%
Groundwater Depth:			Nil	Nil	1.5 m	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Yellow Solodic (Dy 3.31)	Red Podzolic Soil (Dr 2.81)	Yellow Solodic (Dy 3.31)	Red Podzolic (Dr 3.21)
Horizon:	Depth:		A1 0.00 - 0.15 A2 0.15 - 0.4 A3 0.40 - 1. 0	A1 0.00 - 0.2 A2 0.20 - 0.3 B 0.30 - 1.00	A1 0.00 - 0.20 A2 0.20 - 0.40 B 0.40 - 1.00	A1 0.00 - 0.20 A2 0.20 - 0.33 Auger refusal
	Boundary:		abrupt gradual	abrupt sharp	sharp sharp	Sharp
	Colour:		10YR 3/3 10YR 6/4 2.5YR 7/3	10YR 3/2 10YR 6/3 10YR 7/6	10YR 3/3 10YR 5/4 10YR 6/4	7.5YR 4/4 7.5YR 6/8
	Mottles:		Pale <2%	Red 20 – 50%	Grey 20 – 50%	
	Texture:		sandy loam sand clay loam clay	sandy loam sandy loam clay	loam clay loam clay	sandy loam loamy sand
	Coarse Fragments:		Nil Very Few (< 2%) Nil	Nil Very Few (< 2%) Very Few (< 2%)	Nil Nil Nil	Many (20% - 50%)
	Structure:		Massive Massive Weak Pedality	Massive Weak Pedality Moderate Pedality	Weak Pedality Weak Pedality Moderate Pedality	Massive Weak Pedality Moderate Pedality
	Dominant Ped Shape:		Granular Polyhedral Sub angular Blocky	Polyhedral Lenticular Sub angular blocky	Granular Lenticular Sub angular blocky	Polyhedral Lenticular Sub angular blocky
	Consistency:		Very weak Very weak Moderate Firm	Loose Moderate firm Moderate firm	Very Weak Very Weak Moderate Firm	Loose Moderate firm Moderate firm
	Field pH:		4.5 5.0 5.5	4.5 5.0 5.5	5.5 6.0 5.0	4.5 5.5
	Segregations:		Nil	Nil	Nil	Nil

Site No:			76	77	78	79
Coordinates (AGD 66)		E N	761947 6422030	762153 6421634	762569 6422225	763043 6422302
Landform Element:			valley flat	hillslope	valley flat	footslope
Aspect:			East	West	North	West
Run on:			Moderate	High	Moderate	High
Run off:			Moderate	Moderate	Low	Low
Profile Drainage:			poorly drained	imperfectly drained	poorly drained	poorly drained
Site Disturbance:			extensive clearing	extensive clearing	extensive clearing	extensive clearing
Landuse:			volun./native pasture	cropping	cropping	cropping
Slope:			2	3	2	1
Surface Condition:			Hard set	Hard set	Hard set	Hard set
Erosion Hazard:	Type:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
	Degree:		Very high	Very high	Very high	Very high
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			Nil	Nil	Nil	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Yellow Solodic (Dy 3.32)	Yellow Solodic (Dy 3.32)	Yellow Solodic (Dy 3.41)	Yellow Solodic (Dy 3.41)
Horizon:	Depth:		A1 0.0 - 0.1 A2 0.1 - 0.2 B 0.2 - 1.00	A1 0.0 - 0.2 A2 0.2 - 0.4 B 0.4 - 1.00	A1 0.0 - 0.1 A2 0.1 - 0.45 B 0.45 - 1.	A1 0.0 - 0.3 A2 0.3 - 0.5 B 0.5 - 1.0
	Boundary:		sharp sharp	abrupt clear	sharp clear	sharp sharp
	Colour:		10YR 4/4 10YR 5/3 2.5YR 6/1	10YR 3/3 10YR 6/4 10YR 5/6	10YR 3/3 10YR 6/4 10YR 7/3	10YR 3/4. 10YR 5/2. 10YR 7/2
	Mottles:		Grey 20 – 50%	Orange 20 – 50%	Pale 20 – 50%	Yellow 20 – 50%
	Texture:		loam silty loam sandy clay	sandy loam sandy loam sandy clay	loam silty loam clayey sand	loam loam clay
	Coarse Fragments:		Very Few (< 2%) Very Few (< 2%) Very Few (< 2%)	Nil Nil Nil	Nil Nil Nil	Nil Nil Nil
	Structure:		Weak Pedality Weak Pedality Moderate Pedality	Weak Pedality Weak Pedality Moderate Pedality	Weak Pedality Weak Pedality Moderate Pedality	Weak Pedality Weak Pedality Moderate Pedality
	Dominant Ped Shape:		Granular Lenticular Sub angular blocky	Granular Lenticular Sub angular blocky	Granular Lenticular Sub angular blocky	Granular Lenticular Sub angular blocky
	Consistency:		Very Weak Very Weak Moderate Firm	Very Weak Very Weak Moderate Firm	Very Weak Very Weak Moderate Firm	Very Weak Very Weak Moderate Firm
	Field pH:		6.0 5.5 6.0	5.0 5.5 7.0	4.5 5.0 5.5	5.0 5.0 5.0
	Segregations:		Nil	Nil	Nil	Nil

Site No:			80	81	82	83
Coordinates (AGD 66)		E	762763	762485	763226	763268
		N	6421929	6421409	6421900	6421282
Landform Element:			Hill crest	Hill slope	Hill slope	Hill slope
Aspect:			Flat	East	West	West
Run on:			Low	Moderate	High	High
Run off:			High	Moderate	High	Moderate
Profile Drainage:			mod. well drained	imperfectly drained	imperfectly drained	imperfectly drained
Site Disturbance:			timber/scrub /unused	improved pasture	volun./native pasture	volun./native pasture
Landuse:			extensive clearing	extensive clearing	extensive clearing	extensive clearing
Slope:			13	3	5	7
Surface Condition:			Firm	Loose	Firm	Firm
Erosion Hazard:	Type:		High	Very High	Very High	Very high
	Degree:		Sheet / Gully	Rill / Gully	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Many (20% - 50%)	Nil	Few (<2%)	Few (<2%)
Rock Outcrop:			< 2%	Nil	Nil	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Red Earth (Gn 2.25)	Earthy Sand (Uc 5.31)	Yellow Podzolic (Dy 5.31)	Yellow Podzolic (Dy 3.21)
Horizon:	Depth:		A1 0. - .25 A2 0.25 - 0.55 A3 0.55 - 1.00	A1 0.00 - 0.20 A2 0.20 - 0.35 B 0.35 - 1.00	A1 0.00 - 0.20 A2 0.20 - 0.35 Auger refusal.	A1 0.00 - 0.10 A2 0.1 - 0.50 B 0.50 - 0.65
	Boundary:		Clear Gradual	abrupt abrupt	abrupt	clear abrupt
	Colour:		10YR 4/6 7.5YR 7/6 7.5YR 6/8.	10YR 3/3 10YR 6/3 10YR 6/6	10YR 4/4 10YR 6/3	10YR 3/4 10YR 4/4 10YR 4/6
	Mottles:		Yellow (20% - 50%)	Yellow (20% - 50%)		
	Texture:		sandy loam loamy sand loamy sand	silty loam silty loam clay	silty loam sandy loam	sandy loam sandy clay loam sandy clay
	Coarse Fragments:		many (20-50%) many (20-50%) common (10-20%)	Nil Nil Nil	Nil few (2-10%)	Nil Nil Nil
	Structure:		Massive Massive Weak Pedality	Massive Massive Weak Pedality	Weak Pedality Weak Pedality Moderate Pedality	Weak Pedality Weak Pedality Moderate Pedality
	Dominant Ped Shape:		Crumb Polyhedral Sub angular Blocky	Granular Polyhedral Sub angular Blocky	Granular Lenticular Sub angular blocky	Granular Lenticular Sub angular blocky
	Consistency:		Loose Loose Weak	Very weak Very weak Moderate Firm	Very Weak Very Weak Moderate Firm	Very Weak Very Weak Moderate Firm
	Field pH:		5.5 5.0 5.0	5.0 6.0 7.5	5.0 5.5	5.5 5.5
	Segregations:		Nil	Nil	Nil	Nil

Site No:			84	85	86	87
Coordinates (AGD 66)		E N	764687 6419132	764298 6419324	763903 6419088	763420 6419157
Landform Element:			Hill slope	Hill slope	Hill slope	Hill crest
Aspect:			West	East	East	North
Run on:			Moderate	Very High	Low	Moderate
Run off:			Moderate	Moderate	Moderate	Moderate
Profile Drainage:			imperfectly drained	imperfectly drained	imperfectly drained	imperfectly drained
Site Disturbance:			occasional cultivation	occasional cultivation	occasional cultivation	no effective disturbance
Landuse:			volun./native pasture	timber/scrub/unused	volun./native pasture	timber/scrub/ unused
Slope:			4	2	3	6
Surface Condition:			Firm	Firm	Loose	Hard set
Erosion Hazard:	Type:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
	Degree:		very high	very high	very high	very high
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			Nil	< 2%	Nil	< 2%
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Yellow Podzolic (Dy5.31)	Yellow Podzolic (Dy 3.21)	Earthy Sand (Uc 5.31)	Shallow Soils (lithosol)
Horizon:	Depth:		A1 0.00 - 0.15 A2 0.15 - 0.45 B 0.45 - 1.00	A1 0.00 - 0.30 A2 0.30 - 0.45 B 0.45 - 1.00	A1 0.00 - 0.10 A2 0.10 - 0.45 A3 0.45 - 0.85 Auger refusal	A1 0.00 - 0.20 A2 0.20 - 0.50 B 0.50 - 0.70 Auger refusal.
	Boundary:		sharp abrupt	clear abrupt	clear gradual	clear abrupt
	Colour:		10YR 3/3 10YR 7/3 10YR 7//8	10YR 4/6 10YR 5/3 7.5YR 3/3	10YR 4/3 10YR 7/3 10YR 7/4 .	10YR 3/3. 10YR 6/2. 10YR 5/3
	Mottles:		Yellow (20% - 50%)	Orange (20% - 50%)	Orange (2% - 10%)	
	Texture:		sandy loam loamy sand sandy clay	loam sandy loam sandy clay	sandy loam sand sand	sandy loam sandy loam sandy clay
	Coarse Fragments:		Nil Nil Nil	Nil Nil Nil	Nil Nil Nil	Few (2 – 10%) Few (2 – 10%) common (10-20
	Structure:		Massive Massive Weak Pedality	Massive Massive Weak Pedality	Single Grained Single Grained Single Grained	Massive Massive Weak Pedality
	Dominant Ped Shape:		Granular Polyhedral Sub angular Blocky	Granular Polyhedral Sub angular Blocky	Granular Granular Granular	Crumb Crumb Sub angular blocky
	Consistency:		Very weak Very weak Moderate Firm	Very weak Very weak Moderate Firm	Very weak Very Weak Very Weak	Loose Moderately Weak Moderately Firm
	Field pH:		4.5 5.5 4.5	5.0 5.5 6.0	4.5 5.0 6.0	4.5 5.5 5.5
	Segregations:		Nil	Nil	Nil	Nil

Site No:			88	89	90	91
Coordinates (AGD 66)		E N	762634 6419843	762712 6420538	762868 6420980	763206 6420925
Landform Element:			Foot slope	Hill slope	Hill slope	Valley Flat
Aspect:			North	North	East	North
Run on:			Moderate	Moderate	High	Moderate
Run off:			Moderate	Moderate	Moderate	Low
Profile Drainage:			imperfectly drained	imperfectly drained	well drained	Poorly Drained
Site Disturbance:			occasional cultivation	occasional cultivation	extensive clearing	extensive clearing
Landuse:			timber/scrub/unused	volun./native pasture	volun./native pasture	volun./native pasture
Slope:			5	4	3	2
Surface Condition:			Firm	Firm	soft	Hard set
Erosion Hazard:	Type:		Very High	Very High	Very High	Very High
	Degree:		Rill / Gully	Rill / Gully	Rill / Gully	Gully
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			Nil	< 2%	2% - 10%	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Red Podzolic Soil (Dr 3.22)	Yellow Podzolic (Dy 3.21)	Red Earth (Gn 2.25)	Yellow Solodic (Dy 3.33)
Horizon:	Depth:		A1 0.00 - 0.2 A2 0.20 - 0.40 B 0.40 - 1.00	A1 0.00 - 0.20 A2 0.20 - 0.40 B 0.40 - 1.00	A1 0.00 - 0.25 A2 0.25 - 0.55 B 0.55 - 1.00	A2 0.00 - 0.05 B 0.05 - 1.00
	Boundary:		abrupt abrupt	clear abrupt	clear gradual	sharp
	Colour:		10YR 4/4. 7.5YR 4/6 5YR 4/8	10YR 2/3 10YR 3/3. 10YR 4/4	7.5YR 4/4. 7.5YR 5/4. 7.5YR 5/8 Quartzite gravel.	A1 horizon has been eroded. 10YR 3/4. 2.5Y 6/4
	Mottles:					
	Texture:		silty loam sandy loam sandy clay	loam loam sandy clay	sandy loam sandy loam sandy clay	silty loam clay
	Coarse Fragments:		Very Few (<2 %) Very Few (< 2 %) Very Few (< 2 %)	Nil Nil Nil	Nil Very Few (< 2 %) Many (20 – 50%)	Nil Nil
	Structure:		Massive Weak Pedality Moderate Pedality	Massive Massive Weak Pedality	Massive Massive Weak Pedality	Weak Pedality Weak Pedality Moderate Pedality
	Dominant Ped Shape:		Polyhedral Lenticular Sub angular blocky	Granular Polyhedral Sub angular Blocky	Crumb Polyhedral Sub angular Blocky	Granular Lenticular Sub angular blocky
	Consistency:		Loose Moderate firm Moderate firm	Very weak Very weak Moderate Firm	Loose Loose Weak	Very Weak Very Weak Moderate Firm
	Field pH:		5.0 6.0 6.5	5.0 5.5 6.0	5.0 5.0 5.0	5.5 7.5
	Segregations:		Nil	Nil	Nil	Nil

Site No:			92	93
Coordinates (AGD 66)		E N	763646 6419884	763267 6420220
Landform Element:			Hill slope	valley flat
Aspect:			East	North
Run on:			High	Moderate
Run off:			Moderate	Low
Profile Drainage:			imperfectly drained	Poorly drained
Site Disturbance:			no effective disturbance	extensive clearing
Landuse:			volun./native pasture	volun./native pasture
Slope:			3	1
Surface Condition:			Firm	Hard set
Erosion Hazard:	Type:		Rill / Gully	Rill / Gully
	Degree:		High	extreme
Surface Coarse Fragments:			Nil	Nil
Rock Outcrop:			Nil	Nil
Groundwater Depth:			Nil	Nil
Salinity Evidence:			Nil	Nil
Soil Classification:			Yellow Podzolic (Dy 3.31)	Yellow Solodic (Dy2.31)
Horizon:	Depth:		A1 0.00 - 0.10 A2 0.10 - 0.35 Auger refusal.	A1 0.00 - 0.10 A2 0.10 - 0.50 B 0.50 - 1.00
	Boundary:		sharp	abrupt abrupt
	Colour:		10YR 3/3 10YR 5/3	10YR 3/3. 10YR 6/2 10YR 6/3
	Mottles:			Gley (20% - 50%)
	Texture:		silty loam silty loam	loam sandy clay loam sandy clay
	Coarse Fragments:		Nil Nil Nil	Nil Nil Nil
	Structure:		Weak Pedality Weak Pedality Moderate Pedality	Weak Pedality Weak Pedality Moderate Pedality
	Dominant Ped Shape:		Granular Lenticular Sub angular blocky	Granular Lenticular Sub angular blocky
	Consistency:		Very Weak Very Weak Moderate Firm	Very Weak Very Weak Moderate Firm
	Field pH:		4.5 5.5	5.0 5.5 6.0
	Segregations:		Nil	Nil

OPEN CUT 4 EAST

Site No:			94	95	96	97
Coordinates (AGD 66)		E N	765190 6423600	764889 6423290	764727 6422593	764876 6422070
Landform Element:			valley flat	Hill crest	valley flat	valley flat
Aspect:			Flat	Flat	Flat	North
Run on:			High	Moderate	Moderate	Moderate
Run off:			Moderate	Moderate	Moderate	Low
Profile Drainage:			Poorly Drained	Well Drained	imperfectly drained	Poorly Drained
Site Disturbance:			no effective disturbance	no effective disturbance	extensive clearing	extensive clearing
Landuse:			volun./native pasture	volun./native pasture	volun./native pasture	volun./native pasture
Slope:			1	1	1	1
Surface Condition:			Hard set	Loose	Hard set	Hard Set
Erosion Hazard:	Type:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
	Degree:		extreme	Very High	Very High	Very High
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			Nil	Nil	Nil	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Yellow Solodic (Dy 3.33)	Earthy Sand (Uv 5.31)	Yellow Solodic (Dy 3.31)	Yellow Solodic (Dy 3.41)
Horizon:	Depth:		A1 0.00 - 0.05 A2 0.05 - 0.10 B 0.10 - 1.00	A1 0.00 - 0.10 A2 0.10 - 0.50 B 0.50 - 1.00	A1 0.00 - 0.2 A2 0.20 - 0.40 Auger refusal.	A1 0.00 - 0.2 A2 0.20 -0.50 B 0.50 - 1.00
	Boundary:		sharp sharp	clear abrupt	sharp	abrupt abrupt
	Colour:		10YR 5/3 10YR 6/3 10YR 6/8	10YR 5/3 10YR 7/3 7.5YR 7/8	10YR 3/2. 10YR 6/2.	10YR 3/3 10YR 7/3 10YR 7/2
	Mottles:		Yellow (20% - 50%)	Orange (10% - 20%)		Yellow (20% - 50%)
	Texture:		silty loam silty loam clay	loamy sand sand sandy clay	loam loam	loam silty loam sandy clay
	Coarse Fragments:		Nil Nil Nil	Nil Nil Nil	Nil Common (10% - 20%) Nil	Nil Nil Nil
	Structure:		Weak Pedality Weak Pedality Moderate Pedality	Single Grained Single Grained Single Grained	Weak Pedality Weak Pedality Moderate Pedality	Weak Pedality Weak Pedality Moderate Pedality
	Dominant Ped Shape:		Granular Lenticular Sub angular blocky	Granular Granular Granular	Granular Lenticular Sub angular blocky	Granular Lenticular Sub angular blocky
	Consistency:		Very Weak Very Weak Moderate Firm	Very weak Very Weak Very Weak	Very Weak Very Weak Moderate Firm	Very Weak Very Weak Moderate Firm
	Field pH:		4.5 6.0 8.0	4.5 5.0 6.5	5.0 5.5	5.0 5.5 6.0
	Segregations:		Nil	Nil	Nil	Nil

Site No:			98	99	100	101
Coordinates (AGD 66)		E N	765171 6422397	765079 6421573	764620 6421813	764399 6422322
Landform Element:			Gully	Hill slope	Hill slope	Hill crest
Aspect:			Flat	West	North	West
Run on:			Moderate	High	Moderate	Low
Run off:			Fast	Moderate	Low	Moderate
Profile Drainage:			Poorly Drained	Well Drained	Imperfectly drained	Mod. well drained
Site Disturbance:			extensive clearing	limited clearing	extensive clearing	extensive clearing
Landuse:			volun./native pasture	volun./native pasture	volun./native pasture	volun./native pasture
Slope:			< 1%	5	4	3
Surface Condition:			Hard set	Loose	Hard set	Loose
Erosion Hazard:	Type:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
	Degree:		Extreme	High	Very high	High
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			Nil	Nil	Nil	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Yellow Solodic (Dy3.31)	Earthy Sand (Uc 5.31)	Yellow Solodic (Dy 3.42)	Earthy Sand (Uc 5.31)
Horizon:	Depth:		A1 0.00 - 0.10 A2 0.10 - 0.20 B 0.20 - 1.00	A1 0.00 - 0.15 A2 0.15 - 0.90 B 0.90 - 1.00	A1 0.0 - 0.15 A2 0.15 - 0.40 B 0.40 - 1.00	A1 0.00 - 0.20 A2 0.20 - 0.65 B 0.65 - 1.00
	Boundary:		abrupt sharp	abrupt clear	abrupt abrupt	abrupt clear
	Colour:		10YR 4/3 10YR 6/4 10YR 7/2	10YR 3/3. 10YR 6/6. 10YR 7/8.	10YR 3/3 10YR 7/3 10YR 7/2	10YR 3/3. 10YR 6/6. 10YR 7/8.
	Mottles:		Pale (10% - 20%)	Orange (10% - 20%)	Grey (20% - 50%)	Orange (2% - 10%)
	Texture:		loam clay loam clay	sandy loam sand sandy clay	loam sandy clay loam sandy clay	sandy loam sand clay loam
	Coarse Fragments:		Nil Few (<2%) Nil	Nil Nil Nil	Nil Nil Few (<2%)	Nil Nil Nil
	Structure:		Weak Pedality Weak Pedality Moderate Pedality	Single Grained Single Grained Single Grained	Weak Pedality Weak Pedality Moderate Pedality	Single Grained Single Grained Single Grained
	Dominant Ped Shape:		Granular Lenticular Sub angular blocky	Granular Granular Granular	Granular Lenticular Sub angular blocky	Granular Granular Granular
	Consistency:		Very Weak Very Weak Moderate Firm	Very weak Very Weak Very Weak	Very Weak Very Weak Moderate Firm	Very weak Very Weak Very Weak
	Field pH:		4.5 5.5 5.5	4.5 5.0 6.0	5.5 6.0 7.0	4.5 5.0 6.0
	Segregations:		Nil	Nil	Nil	Nil

APPENDIX 2

CHEMICAL ANALYSES Laboratory Test Abbreviations

Test	Symbol	Units
Cation exchange capacity	CEC	meq/100g
Exchangeable sodium percentage	ESP	%
Electrical Conductivity (1:5 :water)	EC	dS/m
Electrical Conductivity (saturation extract)	EC_{se}	dS/m
pH (1:5 :water)	pH_w	pH Units
Emerson Aggregate Test	EAT	

Parameter	Units	80, 90 Red Earth		
Depth	cm	0 - 25	25 - 55	55 - 100
Soil Texture		Sandy Loam	Sandy Loam	Sandy Clay
pH_{CaCl}		4.5	4.5	4.5
pH_{H2O}		5.5	5.4	5.5
C	%	0.68	0.29	0.18
N	mg/kg	5	1	1
S	mg/kg	3.2	4	2.5
P (Colwell)	mg/kg	7	2	2
K	meq/100g	0.27	0.14	0.05
Ca	meq/100g	0.67	0.45	0.47
Mg	meq/100g	0.27	0.16	0.44
Al	meq/100g	0.12	0.19	0.18
Na	meq/100g	0.02	0.03	0.04
Cl	mg/kg	2	2	3
Cu	mg/kg	0.15	0.16	0.9
Zn	mg/kg	0.14	0.13	0.08
Mn	mg/kg	8.03	6.66	1.22
Fe	mg/kg	28.24	12.01	6.91
B	mg/kg	0.1	0.1	0.1
EC	dS/m	0.01	0.01	0.01

Calculations				
CEC	meq/100g	1.35	0.97	1.18
Ca/Mg Ratio		2.48	2.81	1.07
EC_{se}	dS/m	0.14	0.14	0.08
Al Saturation	%	8.89%	19.59%	15.25%
ESP	%	1.48%	3.09%	3.39%
Exch K	%	20.00%	14.43%	4.24%
Exch Ca	%	49.63%	46.39%	39.83%
Exch Mg	%	20.00%	16.49%	37.29%

Particle Size Analysis				
Clay	%	8%	8%	10%
Silt	%	4%	3%	3%
Fine Sand	%	32%	29%	27%
Coarse Sand	%	38%	37%	34%
Gravel	%	18%	23%	26%

Emerson Aggregate Test (EAT)		3(1)	3(1)	5

Parameter	Units	88 Red Podzolic		
Depth	cm	0 - 20	20 - 30	30 - 100
Soil Texture		Silty Loam	Sandy Loam	Sandy Clay
pH_{CaCl}		4.5	4.5	4.9
pH_{H2O}		5.4	6	5.9
C	%	1.06	0.39	0.32
N	mg/kg	6	1	1
S	mg/kg	2.1	2.6	31.3
P (Colwell)	mg/kg	4	2	2
K	meq/100g	0.26	0.13	0.18
Ca	meq/100g	1.71	1.58	1.26
Mg	meq/100g	0.47	0.81	4.58
Al	meq/100g	0.24	0.12	0.18
Na	meq/100g	0.02	0.06	1.22
Cl	mg/kg	3	5	99
Cu	mg/kg	0.29	0.29	0.23
Zn	mg/kg	0.66	0.36	0.11
Mn	mg/kg	15.87	8.76	3.12
Fe	mg/kg	49.23	31.22	34.96
B	mg/kg	0.2	0.1	0.5
EC	dS/m	0.01	0.01	0.14

Calculations				
CEC	meq/100g	2.7	2.7	7.42
Ca/Mg Ratio		3.64	1.95	0.28
EC_{se}	dS/m	0.10	0.14	1.05
Al Saturation	%	8.89%	4.44%	2.43%
ESP	%	0.74%	2.22%	16.44%
Exch K	%	9.63%	4.81%	2.43%
Exch Ca	%	63.33%	58.52%	16.98%
Exch Mg	%	17.41%	30.00%	61.73%

Particle Size Analysis				
Clay	%	8%	13%	48%
Silt	%	11%	8%	10%
Fine Sand	%	20%	16%	7%
Coarse Sand	%	28%	51%	23%
Gravel	%	3%	12%	12%

Emerson Aggregate Test (EAT)		8/3(1)	3(1)	2(3)

Parameter	Units	74, 75, 76, 77, 78, 79, 82, 83, 91, 92, 93, 94, 96, 97, 98, 100 Yellow Solodic		
Depth	cm	0 - 10	10 - 40	40 - 100
Soil Texture		Loam	Silty Loam	Sandy Clay
pH_{CaCl}		4.8	4.6	6.6
pH_{H2O}		5.7	6.1	7.6
C	%	1.7	0.91	0.23
N	mg/kg	1	1	2
S	mg/kg	3.2	3.8	13
P (Colwell)	mg/kg	3	2	2
K	meq/100g	0.33	0.27	0.23
Ca	meq/100g	2.29	1.59	1.52
Mg	meq/100g	23.96	17.51	1.41
Al	meq/100g	0.27	0.12	0.08
Na	meq/100g	0.21	0.22	2.16
Cl	mg/kg	13	13	125
Cu	mg/kg	0.51	0.39	0.73
Zn	mg/kg	1.33	0.93	0.042
Mn	mg/kg	23.96	17.51	1.41
Fe	mg/kg	76.48	32.5	21.62
B	mg/kg	0.3	0.2	0.6
EC	dS/m	0.02	0.02	0.16

Calculations				
CEC	meq/100g	27.06	19.71	5.4
Ca/Mg Ratio		0.10	0.09	1.08
EC_{se}	dS/m	0.19	0.19	1.20
Al Saturation	%	1.00%	0.61%	1.48%
ESP	%	0.78%	1.12%	40.00%
Exch K	%	1.22%	1.37%	4.26%
Exch Ca	%	8.46%	8.07%	28.15%
Exch Mg	%	88.54%	88.84%	26.11%

Particle Size Analysis				
Clay	%	14%	16%	34%
Silt	%	15%	23%	11%
Fine Sand	%	30%	26%	20%
Coarse Sand	%	39%	32%	29%
Gravel	%	2%	3%	6%

Emerson Aggregate Test (EAT)		3(1)	2(1)	2(3)

Parameter	Units	68, 71, 72, 73, 81, 84, 85, 89 Yellow Podzolic		
Depth	cm	0 - 20	20 - 40	40 - 100
Soil Texture		Loam	Silty Loam	Sandy Clay
pH_{CaCl}		4.7	4.9	5.6
pH_{H2O}		5.7	6.2	7.1
C	%	1.48	0.78	0.21
N	mg/kg	2	1	1
S	mg/kg	4.3	4.4	6
P (Colwell)	mg/kg	7	3	4
K	meq/100g	0.48	0.26	0.18
Ca	meq/100g	3.6	3.17	1.36
Mg	meq/100g	35.28	18.26	3.44
Al	meq/100g	0.19	0.12	0.09
Na	meq/100g	0.08	0.16	1.1
Cl	mg/kg	9	9	9
Cu	mg/kg	0.48	0.42	0.34
Zn	mg/kg	1041	0.029	0.15
Mn	mg/kg	32.58	18.26	3.44
Fe	mg/kg	66.74	26.83	16.78
B	mg/kg	0.2	0.3	0.4
EC	dS/m	0.01	0.01	0.06

Calculations				
CEC	meq/100g	39.63	21.97	6.17
Ca/Mg Ratio		0.10	0.17	0.40
EC_{se}	dS/m	0.10	0.10	0.45
Al Saturation	%	0.48%	0.55%	1.46%
ESP	%	0.20%	0.73%	17.83%
Exch K	%	1.21%	1.18%	2.92%
Exch Ca	%	9.08%	14.43%	22.04%
Exch Mg	%	89.02%	83.11%	55.75%

Particle Size Analysis				
Clay	%	18%	16%	23%
Silt	%	19%	20%	8%
Fine Sand	%	22%	23%	17%
Coarse Sand	%	39%	34%	40%
Gravel	%	2%	7%	12%

Emerson Aggregate Test (EAT)		3(1)	3(1)	2(3)

Parameter	Units	69 Alluvial		
Depth	cm	0 -25	25 - 45	45 - 100
Soil Texture		loam	sandy loam	Clay Loam
pH_{CaCl}		5	4.7	5.4
pH_{H2O}		5.9	5.7	6.8
C	%	1.52	0.5	0.27
N	mg/kg	3	1	1
S	mg/kg	6.6	4.5	6.8
P (Colwell)	mg/kg	6	3	2
K	meq/100g	0.38	0.14	0.13
Ca	meq/100g	2.84	1.67	2.05
Mg	meq/100g	2.29	1.75	2.14
Al	meq/100g	0.07	0.09	0.1
Na	meq/100g	0.18	0.24	0.56
Cl	mg/kg	22	32	52
Cu	mg/kg	1.41	0.8	0.6
Zn	mg/kg	2.88	0.55	0.37
Mn	mg/kg	53.87	16.84	19.61
Fe	mg/kg	114.04	56.04	25.74
B	mg/kg	0.4	0.2	0.3
EC	dS/m	0.05	0.04	0.06

Calculations				
CEC	meq/100g	5.76	3.89	4.98
Ca/Mg Ratio		1.24	0.95	0.96
EC_{se}	dS/m	0.48	0.56	0.52
Al Saturation	%	1.22%	2.31%	2.01%
ESP	%	3.13%	6.17%	11.24%
Exch K	%	6.60%	3.60%	2.61%
Exch Ca	%	49.31%	42.93%	41.16%
Exch Mg	%	39.76%	44.99%	42.97%

Particle Size Analysis				
Clay	%	27%	18%	21%
Silt	%	29%	13%	18%
Fine Sand	%	15%	9%	26%
Coarse Sand	%	25%	55%	31%
Gravel	%	4%	5%	4%

Emerson Aggregate Test (EAT)		3(1)	3(1)	2(1)

Parameter	Units	70, 86, 95, 99, 101 Earthy Sands		
Depth	cm	0 - 10	10 - 60	60 - 100
Soil Texture		sandy loam	sand	sand
pH_{CaCl}		4.3	4.4	4.8
pH_{H2O}		5.3	5.3	6
C	%	0.55	0.25	0.15
N	mg/kg	1	1	1
S	mg/kg	1.6	1.2	3.3
P (Colwell)	mg/kg	3	2	2
K	meq/100g	0.07	0.04	0.05
Ca	meq/100g	0.45	0.44	1.1
Mg	meq/100g	0.14	0.19	0.98
Al	meq/100g	0.15	0.1	0.07
Na	meq/100g	0.01	0.03	0.08
Cl	mg/kg	2	2	4
Cu	mg/kg	0.06	0.02	0.1
Zn	mg/kg	0.17	0.07	0.07
Mn	mg/kg	3.9	1.09	0.4
Fe	mg/kg	34.11	14.67	9.37
B	mg/kg	0.1	0.1	0.2
EC	dS/m	0.01	0.01	0.01

Calculations				
CEC	meq/100g	0.82	0.8	2.28
Ca/Mg Ratio		3.21	2.32	1.12
EC_{se}	dS/m	0.14	0.23	0.23
Al Saturation	%	18.29%	12.50%	3.07%
ESP	%	1.22%	3.75%	3.51%
Exch K	%	8.54%	5.00%	2.19%
Exch Ca	%	54.88%	55.00%	48.25%
Exch Mg	%	17.07%	23.75%	42.98%

Particle Size Analysis				
Clay	%	5%	7%	20%
Silt	%	8%	6%	6%
Fine Sand	%	24%	31%	23%
Coarse Sand	%	60%	50%	42%
Gravel	%	3%	6%	9%

Emerson Aggregate Test (EAT)		3(1)	3(1)	5