MOOLARBEN COAL PROJECT

APPENDIX 9

Soil, Rural Land Capability and Agricultural Suitability Assessment

MOOLARBEN COAL PROJECT

SOIL, RURAL LAND CAPABILITY AND AGRICULTURAL SUITABILITY ASSESSMENT

Underground
Infrastructure Area
Open Cuts 1, 2, 3

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1 INTRODUCTION

The proposed 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).

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

- Detail the soil resources within the 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- Agricultural Land Classification of Mudgee Shire (unpublished) (NSW Agriculture, undated).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 the Moolarben Coal Project are:-

- Three open cut mines to produce coals for the export and domestic markets;
- An underground coal mine to produce coal predominantly for the export market;
- Coal handling facilities incorporating crushing plants, conveyors, raw coal and project coal stockpiles, coal preparation plant, coal stackers/reclaimers;
- Rail spur, rail loop, train loading infrastructure and transportation of product coals to market by train;
- Mine access roads, internal access roads and haul roads;
- Water management infrastructure including dams in Bora Creek and the relocation of Spring Creeks;
- Water supply bores, surface water storages and associated pump and pipeline system;
- Placement of overburden and coarse reject within mined-out voids;
- Out-of-pit and 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 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 focuses on the disturbance areas identified as the Infrastructure Area, Open Cut 1, Open Cut 2, and Open Cut 3.

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 51 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 found in isolated areas within the Underground operations and adjacent to Open Cut 2. 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 Australian Soil Classification (Isbell 1996) is identified in brackets next to the Great Soil Group name. 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 Yellow Podzolic, Red Podzolic, Earthy Sands, Yellow Solodic, Lithosols and Alluvial soils. The minor soil types of colluvial and Euchrazem 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 is the dominant soil type throughout the Open Cut 2 and Open Cut 3 disturbance areas. They occur on lower slopes and minor drainage lines and show 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 predominantly in the disturbance areas of Open Cut 2 and Open Cut 3. 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. A small area of Red Podzolic soil is associated with the Palaeo Channel (Wash Out) within Open Cut 3 and exhibits high gravel content 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 predominantly on the northern side of the Infrastructure Area associated with the Munghorn Plateau Soil Landscape. These sands are extremely fragile and free draining. There are deposits of sand found along Moolarben Creek in the Open Cut 3 disturbance areas.
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 1 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 identified within the MCP area associated with Moolarben Creek flowing through Open Cut 3.
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 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.

No alluvial soils were identified west of the Palaeo Channel in Open Cut 3, therefore making the distance between the eastern extent to Open Cut 3 and the alluvial soils approximately 200 meters.

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 disturbance areas of Open Cut 3 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 III

"Land can be regularly cultivated with structural soil conservation works such as diversion banks, graded banks and waterways, together with soil conservation practices such as strip cropping, conservation tillage and adequate crop rotations". (Cunningham et al., undated)

This land occurs in a small on the valley floor within the Open Cut 2 disturbance area within minor area on the Eastern fringe of Open Cut 3. These areas have deeper soils with a slope range of less then 3%. There are instances where saline discharge sites have been identified (occurring at a break of slope). These areas have been mapped as Class VI_s.

5.2.2 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)

Class IV land has been identified in both Open Cut 2 and Open Cut 3 disturbance areas. These areas have slopes ranging 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.

5.2.3 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 occurs in both Open Cut 2 and 3 disturbance areas and is generally associated with mid slopes ranging from 6 to 12%. The main limitations of these areas include shallow soil depth, high rock content, erosion hazard and evidence of soil salinity.

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.

5.2.4 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. Land around the Moolarben Creek has also been classified VI due to its erodible banks and the fragile nature of the soils.

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.

5.2.5 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 and Ulan Coal Mines Limited Land surrounding the MCP area. 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.

5.2.6 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 and Goulburn River National Park 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 3 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 MID WESTERN REGIONAL COUNCIL LAND ZONING

The current Mid Western Regional Council Local Environmental Plan (LEP) has zoned certain parts of the local government area *7(b) Environment Protection – Nature Conservation*. This zone is for the protection and conservation of important environmental features within the Shire. The land that has been zoned 7(b) is predominantly the elevated hill slopes and sandstone escarpments within the landscape. These areas provide environmental and aesthetic enjoyment to the residents of the shire.

Small areas along the valley floor of this zone will be affected by the mining activities in Open Cuts 1, 2 and 3 as shown in **Figure 7**.

The mapping of land zone 7(b) has been done based on Cadastral Lot boundaries or parts thereof encompassing the forested hill slopes. The mapping was not done to specific terrain or landscape features and therefore has created anomalies by causing small sections of escarpment footslopes and valley floor areas to be mapped as zone 7(b) land.

The disturbance areas associated with Open Cut mining will occur along the valley floor and will not impact on the elevated hilly slopes that are offered protection under the 7 (b) zoning. Therefore the landscape and environmental setting of the hill slope area will be retained.

Zone 7 (b) does not preclude the activity of mining from this land subject to the advertisement of the development and the compliance of the activity with other council and regulatory bodies.

The soils within the area are a combination of colluvial and yellow podzolic, both with moderate to high erodibility and low fertility characteristics. These soils are representative of other soils identified within the MCP area and will be treated in accordance with the soil management strategies identified in Section 8 of this report.

8 RESOURCE MANAGEMENT

8.1 SOIL RESOURCE MANAGEMENT STRATEGIES

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. The activities of stripping and stockpiling of soil resources prior to any mine-related disturbance will be undertaken in accordance with the general soil resource management activities. All disturbance areas will be rehabilitated either progressively or immediately after the completion of mining activities.

The MCP soil resource management strategies are:-

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

Soil resource management strategies proposed for the MCP disturbance areas are detailed in **Table 6**.

Table 6. 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 8.2 – 8.5).** • 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 8.6).**	• Implementation of amelioration measures to ensure the long term viability of the soil resources and manage salinity (Section 8.2 – 8.5). • Management of soil suitability for rehabilitation (Section 8.7). • 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 MCP on all disturbance areas. The management activities of these soils will be determined by their individual characteristics and limitations. Sections 8.2 – 8.5 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 undertaken 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 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.

Reapplication of topsoil will occur in accordance with the rehabilitation schedule and will occur concurrently with topsoil stripping activities to minimise topsoil handling.

8.2 INFRASTRUCTURE AREA

Topsoil stripping and stockpiling activities will occur prior to any surface disturbance activities to allow for the establishment of the permanent infrastructure facilities including administration, workshops, bathhouse structures, roads, coal handling and loading facilities. The disturbance area for this site is 120.67 ha.

The soils occurring in this area are predominantly Yellow Solodics and Earthy Sands. These soils have a very 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. Infrastructure Area Topsoil Suitability Classifications

SoilType	Soil Horizon	Rehabilitation Suitability Classification	Comment
Yellow Solodic	A_1	Suitable if ameliorated	Mildly acid soil with minor dispersive qualities
	A_2	Suitable if ameliorated	Dispersive soil with high sodium & magnesium levels
	B	Not Suitable	Dispersive Clay
Earthy Sand	A_1	Suitable for Blending	Sand + Gravel greater then 60%. Blending with a high clay content soil would be acceptable.
	A_2	Suitable for Blending	Sand + Gravel greater then 60%. Blending with a high clay content soil would be acceptable.
Lithosol		Not Suitable	No soil resource available

Classification based on Elliot & Veness (1981)

Table 8 indicates the approximate area each soil type occupies within the Infrastructure Area, the recommended stripping depths and the approximate volume of material that would be available for rehabilitation purposes.

Table 8. Infrastructure Area Resource Availability

Type	Recommended Stripping Depth (m)	Stripping area (ha)	Volume (m^3)
Yellow Solodic	0.10	82.81	82 810
Earthy Sand	0.30	37.58	112 740
Lithosol	0.00	0.28	0
Total	**N/A**	120.67	195 550

* Stripping Depth has incorporated the blending of the top 0.1 – 0.2 m of the A2 horizon to increase topsoil volume.

Preliminary material balance calculations based on the recommended stripping depths outlined in Table 8 indicate an approximate topsoil volume of 195 550m^3.

8.2.1 Topsoil Suitability for Rehabilitation Purposes and Management Practices

Chemical and physical assessment of the soil properties within the Infrastructure Area (**Appendix 1 and 2**) indicates that only the Yellow Solodic soil proposed for stripping would be suitable for rehabilitation purposes provided that appropriate management practices are implemented and the relevant amelioration measures applied where necessary. Both the A_1 and where necessary the A_2 horizon are potentially suitable for reuse in post disturbance rehabilitation activities.

The Yellow Solodic exhibits an acid soil pH trend (pH_{cacl} <5.0) and poor fertility characteristics. The chemical analysis and Emerson Aggregate Test (EAT) identified soil dispersive qualities when soil particles are exposed to water. (This is more prevalent in the A_2 Horizon). Elevated Sodium (Na) and Magnesium (Mg) levels would be affecting these soil structural issues.

To overcome the soil acidity issue in the A_1 horizon it is recommended that superfine lime (NV >95%) be applied at a rate of approximately 3 tonne per hectare to raise the pH to 5.5. The A_2 horizon however has both elevated

levels of Na and Mg so it is recommended that a blend of lime and gypsum (2 tonne of Lime and 2 tonne Gypsum) be considered to increase pH and improve the soil structure.

The soil is deficient in major nutrients such as Phosphorus and Sulphur. 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 A_1 & A_2 of the Yellow Solodic soil is considered acceptable when the appropriate soil amelioration measures are undertaken to increase the soil resource volume. However due to the high sand content of the Yellow Solodic soils, blending with the Earthy Sand to increase the topsoil volume is not recommended.

The most significant disturbance will be in the product stockpiling, employee and workshop facilities. This infrastructure occurs predominantly on the Yellow Sodic Soils. Rehabilitation of this area will not be required until the end of the mining life however stockpiling and protecting a future reserve of topsoil is essential. These strategies are outlined in section 8.8. All traffic areas should be constructed with appropriate pavement surfaces with storm water drainage systems adequately armoured to prevent scouring and erosion.

The Earthy Sand has been determined not suitable for top dressing as the primary soil resource due to its high sand and gravel content (> 60%). Additionally the sand is extremely acidic with low fertility. Its low Cation Exchange Capacity (CEC) indicates its poor ability to sustain any amelioration effect to improve its pH and fertility levels. The sand is also extremely fragile and prone to soil erosion.

Blending the Earthy Sand with higher clay content soils within the MCP would be acceptable providing the sand and gravel content is not increased over 60%.

Soil salinity (measured by Electrical Conductivity saturated extract -E.C.se) has not been identified as an issue in both these soil types.

It is recommended that the Earthy Sand soil be protected from any major disturbance including limiting and controlling the impact from trafficking. Management strategies applied to this soil type should aim to limit disturbance and improve the organic carbon levels. However, where permanent infrastructure is proposed, the disturbance areas should be kept to a minimum with soil stabilisation activities occurring as soon as practical. All traffic areas should be constructed with appropriate pavement surfaces with storm water drainage systems adequately armoured to prevent scouring and erosion.

Site disturbance within the Earthy Sands is generally restricted to the development of the rail infrastructure and associated culvert drainage of Bora Creek under the rail line, water storages and emergency tailings storage. This disturbance will only be within the rail corridor and not across the whole soil resource area. After the initial impact of construction the area will not be subject to ongoing disturbance, allowing all undisturbed lands to revegetate. Immediately after construction of the rail loop, all disturbed areas will be hydro mulched and seeded with native grasses endemic to the area.

The construction of any water holding structure will require engineering design and the importation of suitable dam construction material to improve the dam wall engineering properties and provide for an impervious lining.

8.3 OPEN CUT 1

Topsoil stripping and stockpiling activities will occur prior to any surface disturbance to allow for mining activities to occur in Open Cut 1. The disturbance area for this site is 316.57 ha.

The soils occurring in this area are predominantly Yellow Solodic soils, Yellow Podzolic soils with shallow Lithosol soils around the perimeter of the open cut. The soils in this area have a very high erodibility hazard and require special management to prevent severe land degradation. **Table 9** quantifies the suitability of the soil for rehabilitation based on the criteria established by Elliot & Veness (1981).

Table 9. Open Cut 1 Topsoil Suitability Classifications

Soil Type	Soil Horizon	Rehabilitation Suitability Classification	Comment
Yellow Solodic	A_1	Suitable if ameliorated	Acid soil with minor dispersive qualities
	A_2	Suitable if ameliorated	Dispersive soil high sodium & magnesium levels
	B	Not Suitable	Dispersive Clay
Yellow Podzolic	A_1	Suitable if ameliorated	Acid soil with moderate dispersive qualities (high Mg levels), Elevated Al levels and poor fertility
	A_2	Suitable if ameliorated	Moderate dispersive qualities (high magnesium levels), poor fertility
	B	Not Suitable	Dispersive Clay
Lithosol		Not Suitable	No soil resource available

Classification based on Elliot & Veness (1981)

Table 10 indicates the approximate area each soil type occupies within the Open Cut 1 disturbance area, the recommended stripping depth and approximate volume of material that would be available for rehabilitation purposes.

Table 10. Open Cut 1 Resource Availability

Type	Recommended Stripping Depth (m)	Stripping area (ha)	Volume (m^3)
Yellow Solodic	0.2*	86.92	173 840
Yellow Podzolic	0.3*	98.78	296 340
Lithosol	0.0	130.87	0
Total	**N/A**	**316.57**	**470 180**

* Stripping Depth has incorporated the blending of the top 0.1- 0.2 m of the A2 horizon to increase topsoil volume.

Preliminary material balance calculations based on the recommended stripping depths outlined in Table 9 indicate an approximate topsoil volume of 470 180 m^3.

8.3.1 Topsoil suitability for rehabilitation purposes and management practices

Chemical and physical assessment of the soil properties within the Open Cut 1 area (Appendix 1 and 2) indicate that both the Yellow solodic and the Yellow podzolic soils would be suitable for rehabilitation purposes provided that appropriate management practices are implemented and the relevant amelioration measures applied where necessary. Due to the skeletal nature of Lithosol soils, there is limited to no soil resource available for stripping.

The Yellow Solodic exhibits an acid soil pH trend (soil pH_{cacl} <5.0) and poor fertility characteristics. The chemical analysis and EAT identified soil dispersive qualities when soil particles are exposed to water. (This is more prevalent in the A_2 Horizon). Elevated Sodium (Na) and Magnesium (Mg) levels would be affecting these soil structural issues.

To overcome the soil acidity issue in the A_1 horizon it is recommended that superfine lime (NV >95%) be applied at a rate of approximately 3 tonne per hectare to raise the pH to 5.5. The A_2 horizon however has both elevated levels of Na and Mg so it is recommended that a blend of lime and gypsum (2 tonne of Lime and 2 tonne Gypsum) be considered to increase pH and improve the soil structure.

The soil is deficient in major nutrients such as Phosphorus and Sulphur. 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 A_1 & A_2 is considered acceptable with the appropriate soil amelioration to increase the soil resource volume. Blending of this soil with other soil resource material i.e. Earthy Sand could be undertaken to increase the topsoil volume. However care must be taken not the 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 (Unbleached A_2 Horizon) and Yellow Podzolic (Bleached A_2 Horizon) have different chemical characteristics such as soil acidity levels and exchangeable cation concentrations within the A_1 horizon requiring different amelioration products and therefore should be treated separately. However the A_2 horizons have similar chemical and physical characteristics despite soil colour differences caused be leaching processes.

The Yellow Podzolic (Unbleached A_2) A_1 horizon, has an acidic pH level and the EAT identified slight dispersion qualities. The Ca:Mg ratio is extremely high indicating a Mg deficiency. To increase the soil pH_{cacl} to a level of 5.5 it is recommended that the soil be ameliorated with Lime at a rate of 1.8 t/ha. Blending the A_1 and A_2 horizon together will assist in increasing the Mg level as the A_2 horizon has an elevated Mg level. The Cation Exchange Capacity (CEC) is within a moderate level indicating that the soil has the ability to sustain any amelioration effect.

The Yellow Podzolic (Bleached A_2) exhibits neutral pH trend in the A1horizon but has elevated Aluminium and manganese levels, It is assumed that a surface application of lime may have been applied to these soils prior to soil testing to create this anomaly. There are also elevated Mg levels indicating potential dispersion concerns, however the EAT only identified slight dispersive qualities. Further testing of this soil should be undertaken during the Mining Operations Planning (MOP) process. The CEC of this soil is low therefore the soil amelioration effect may be short lived.

The A2 horizons of both these soils have similar attributes and are suitable to be blended with their respective A1 horizons to assist in increasing top soil volumes. The soil has slight dispersive qualities so an application of gypsum at a rate of 2.5 t/ha would assist in improving soil structure. Blending of the A_1 and A_2 horizons would be acceptable to increase the soil resource volume.

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

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

8.4 OPEN CUT 2

Topsoil stripping and stockpiling activities will occur prior to any surface disturbance to allow for mining activities to occur in Open Cut 2. The disturbance area for this site is 144.57 ha.

The soils occurring in this area have a moderate to high erodibility hazard and require special management to prevent severe land degradation. **Table 11** quantifies the suitability of the soil for rehabilitation based on the criteria established by Elliot & Veness (1981).

Table 11. Open Cut 2 Topsoil Suitability Classifications

SoilType	Soil Horizon	Rehabilitation Suitability Classification	Comment
Yellow Podzolic-unbleached A2 horizon	A_1	Suitable if ameliorated	Acid soil with minor dispersive qualities, Mg deficiency, poor fertility
	A_2	Suitable if ameliorated	Acid soil displaying moderate dispersive qualities (high sodium & magnesium levels), poor fertility
	B	Not Suitable	Dispersive Clay
Yellow Podzolic _ Bleached A2	A_1	Suitable if ameliorated	Acid soil with moderate dispersive qualities (high Mg levels), Elevated Al levels and poor fertility
	A_2	Suitable if ameliorated	Moderate dispersive qualities (high magnesium levels), poor fertility
	B	Not Suitable	Dispersive Clay
Red Podzolic	A_1	Suitable if ameliorated	Minor dispersive qualities after remoulding, poor fertility
	A_2	Suitable if ameliorated	Dispersive soil high sodium & magnesium levels
	B	Not Suitable	Dispersive Clay
Earthy Sand	A_1	Suitable for Blending	Sand + Gravel greater then 60%. Blending with a high clay content soil would be acceptable.
	A_2	Suitable for Blending	Sand + Gravel greater then 60%. Blending with a high clay content soil would be acceptable.
Colluvial	A	Suitable for blending	Small area of soil resource only – Should be blended with soil material to increase soil volume
Euchrazem	A	Suitable for blending	Small area of soil resource only – Should be blended with soil material to increase soil volume
Lithosol		Not Suitable	No soil resource available

Classification based on Elliot & Veness (1981)

Table 12 indicates the approximate area each soil type occupies within the Open Cut 2 area, the recommended stripping depth and approximate volume of material that would be available for rehabilitation purposes.

Table 12. Open Cut 2 Resource Availability

Type	Recommended Stripping Depth (m)	Stripping area (ha)	Volume (m^3)
Yellow Podzolic	0.3*	41.71	125 130
Red Podzolic	0.3*	39.43	118 290
Lithosol	0.0	36.35	0
Euchrazem	0.3	7.04	21 120
Earthy Sands	0.3	4.25	12 750
Colluvial	0.2	15.79	31 580
Total	**N/A**	**144.57**	**308 870**

* Stripping Depth has incorporated the blending of the top 0.1 - 0.2 m of the A2 horizon to increase topsoil volume.

Preliminary material balance calculations based on the recommended stripping depths outlined in Table 12 indicate an approximate topsoil volume of 308 870 m^3.

8.4.1 Topsoil suitability for rehabilitation purposes and management practices

Chemical and physical assessment of the soil properties within the Open Cut 2 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 four (2) dominant soil types within Open Cut 2 that have been assessed as having significant quantities of topsoil for reuse purposes for rehabilitation. These are Yellow Podzolic (Bleached A_2 horizon and Bleached A_2 horizon) and the Red Podzolics. Small quantities of colluvial soils were identified within small flow lines located at foot slopes of the surrounding hills and escarpments, as well as a small deposit of earthy sands (< 5 ha). These soils 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 Podzolic (Unbleached A_2 Horizon) and Yellow Podzolic (Bleached A_2 Horizon) have different chemical characteristics such as soil acidity levels and exchangeable cation concentrations within the A_1 horizon requiring different amelioration products and therefore should be treated separately. However the A_2 horizons have similar chemical and physical characteristics despite soil colour differences caused be leaching processes.

The Yellow Podzolic (Unbleached A2) A1 horizon, has an acidic pH level and the EAT identified slight dispersion qualities. The Ca:Mg ratio is extremely high indicating a Mg deficiency. To increase the soil pH_{cacl} to a level of 5.5 it is recommended that the soil be ameliorated with Lime at a rate of 1.8 t/ha. Blending the A_1 and A_2 horizon together will assist in increasing the Mg level as the A_2 horizon has an elevated Mg level. The Cation Exchange Capacity (CEC) is within a moderate level indicating that the soil has the ability to sustain any amelioration effect.

The Yellow Podzolic (Bleached A_2) exhibits neutral pH trend in the A_1 horizon but has elevated Aluminium and Manganese levels. It is assumed that a surface application of lime may have been applied to these soils (in past agricultural practices) prior to soil testing to create this anomaly. There are also elevated Mg levels indicating potential dispersion concerns, however the EAT only identified slight dispersive qualities. Further testing of this soil should be undertaken prior to the Mining Operations Planning process. The CEC of this soil is low therefore the soil amelioration effect may only be short lived.

The A_2 horizons of both these soils have similar attributes and are suitable to be blended with their respective A1 horizons to assist in increasing top soil volumes. The soil has slight dispersive qualities so an application of gypsum at a rate of 2.5 t/ha would assist in improving soil structure. Blending of the A_1 and A_2 horizons would be acceptable to increase the soil resource volume.

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

The Red Podzolic A_1 & A_2 horizon both exhibit good characteristics for topsoil re use outside an acidic pH and low nutritional levels. Therefore both horizons are suitable for blending to increase the soil resource volume. To improve the soil pH an application of superfine lime (NV >95%) should be applied at a rate of 1.6 tonne/ha.

Soil salinity (E.C.se) in the Red Podzolic soils was not been identified as an issue.

All the soils in Open Cut 2 are deficient in all major nutrients such as Phosphorus and Sulphur. 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 appropriate to assist the establishment of native endemic vegetation as part of the final rehabilitation plan.

8.5 OPEN CUT 3

Topsoil stripping and stockpiling activities will occur prior to any surface disturbance to allow for mining activities to occur in Open Cut 3. The disturbance area for this site is 253.48 ha.

The soils occurring in this area are predominantly Yellow Podzolic (including saline soils) Red Podzolic, have moderate to high erodibility hazard and require special management to prevent severe land degradation. **Table 13** quantifies the suitability of the soil for rehabilitation based on the criteria established by Elliot & Veness (1981).

Table 13. Open Cut 3 Topsoil Suitability Classifications

SoilType	Soil Horizon	Rehabilitation Suitability Classification	Comment
Yellow Podzolic	A_1	Suitable if ameliorated	Acid soil with minor dispersive qualities, Mg deficiency, poor fertility
	A_2	Suitable if ameliorated	Acid soil displaying moderate dispersive qualities (high sodium & magnesium levels), poor fertility
	B	Not Suitable	Dispersive Clay
Yellow Podzolic (Saline)	A_1	Suitable if ameliorated & Treated	Dispersive Clay
	A_2	Suitable if ameliorated & Treated	Dispersive Clay
	B	Not Suitable	Dispersive Clay
Red Podzolic	A_1	Suitable if ameliorated	Minor dispersive qualities after remoulding, poor fertility
	A_2	Suitable if ameliorated	High dispersive qualities identified in EAT.
	B	Not Suitable	Dispersive Clay
Red Podzolic (Palaeo Channel)	A_1	Not suitable	Highly Acid and toxic Aluminium levels. Low CEC
	A_2	Not suitable	Elevated Na & Mg levels and sand and gravel content greater then 60%
	B	Not Suitable	Dispersive Clay
Colluvial	A	Suitable for blending	Small area of soil resource only – Should be blended with soil material to increase soil volume
Lithosol		Not Suitable	No soil resource available

Classification based on Elliot & Veness (1981)

Table 14 indicates the approximate area each soil type occupies within the Infrastructure disturbance area, the recommended stripping depth and approximate volume of material that would be available for rehabilitation purposes.

Table 14. Open Cut 3 Resource Availability

Type	Recommended Stripping Depth (m)	Stripping area (ha)	Volume (m^3)
Yellow Podzolic	0.3*	78.71	236 130
Yellow Podzolic (Saline)	0.2	11.37	22 740
Red Podzolic	0.3*	70.83	212 490
Red Podzolic (Palaeo) Channel)	0	14.94	0
Colluvial	0.2	6.36	12 720
Lithosol	0	71.27	0
Total	**N/A**	**253.48**	**484 080**

* Stripping Depth has incorporated the blending of the top 0.1 - 0.2 m (or deeper) of the A2 horizon to increase topsoil volume.

Preliminary material balance calculations based on the recommended stripping depths outlined in Table 14 indicate an approximate top volume of 484 080 m^3.

8.5.1 Topsoil suitability for rehabilitation purposes and management practices

Chemical and physical assessment of the soil properties within the Open Cut 3 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) types of soils within the Open Cut 3 area however only five soil types have been assessed as having significant quantities of topsoil or desirable attributes for reuse purposes and these are Yellow Podzolic (Bleached and Unbleached A_2 Horizon) , Yellow Podzolic (Saline), Red Podzolic (Excluding the Red Podzolic occurring on the Palaeo Channel formation). Small quantities of colluvial soils were identified within small flow lines located at foot slopes of the surrounding hills and escarpments (< 5 ha). This soil has not been considered a significant resource for purposes of rehabilitation; however they can be blended with the major soil resources to increase resource volume.

A wash out or Palaeo Channel has been identified adjacent to the eastern extent of Open Cut 3. There were no alluvial soils identified within this area, however the Red Podzolic soil that was identified has been deemed not suitable for rehabilitation purposes due to the soils poor chemical and physical properties of high acidity and aluminium levels. These soils should be buried so as not to have adverse effects on rehabilitation success and that the use of this soil type for topdressing purposes should be avoided.

Adjacent to this Palaeo channel is evidence of soil salinity. Soils exhibiting salinity symptoms should be managed separately. These soils are associated with the Yellow Podzolic soil group. These soils exhibited low salinity levels in the A_1 and A_2 horizons with the levels increasing at depth. The soils had very high levels of Na and Mg indicating major structural issues. The A_1 and A_2 horizons could be used for rehabilitation purposes if gypsum was applied at a rate of 2.5 t/ha to improve soil structure. These soils should be managed separately and only used if required. They should not be blended with any other soil

The Yellow Podzolic (Unbleached A_2 Horizon) and Yellow Podzolic (Bleached A_2 Horizon) have different chemical characteristics such as soil acidity levels and exchangeable cation concentrations within the A_1 horizon requiring different amelioration products and therefore should be treated separately. However the A_2 horizons have similar chemical and physical characteristics despite soil colour differences caused be leaching processes.

The Yellow Podzolic (Unbleached A2) A1 horizon, has an acidic pH level and the EAT identified slight dispersion qualities. The Ca:Mg ratio is extremely high indicating a Mg deficiency. To increase the soil pH_{cacl} to a level of 5.5 it is recommended that the soil be ameliorated with Lime at a rate of 1.8 t/ha. Blending the A_1 and A_2 horizon together will assist in increasing the Mg level as the A_2 horizon has an elevated Mg level. . The Cation Exchange Capacity (CEC) is within a moderate level indicating that the soil has the ability to sustain any amelioration effect.

The Yellow Podzolic (Bleached A_2) exhibits neutral pH trend in the A1 horizon but has elevated Aluminium and manganese levels, It is assumed that a surface application of lime may have been applied to these soils prior to soil testing to create this anomaly. There are also elevated Mg levels indicating potential dispersion concerns, however the EAT only identified slight dispersive qualities. Further testing of this soil should be undertaken prior to the MOP process. The CEC of this soil is low therefore the soil amelioration effect may be short lived.

The A_2 horizons of both these soils have similar attributes and are suitable to be blended with their respective A1 horizons to assist in increasing top soil volumes. The soil has slight dispersive qualities so an application of gypsum at a rate of 2.5 to/ha would assist in improving soil structure. Blending of the A_1 and A_2 horizons would be acceptable to increase the soil resource volume.

The Red Podzolic A_1 horizon exhibit good characteristics for topsoil re use outside an acidic pH and low nutritional levels. To improve the soil pH of the A_1 horizon an application of superfine lime (NV >95%) should be applied at a rate of 1.6 tonne/ha. The A_2 horizon however demonstrates high dispersive qualities. With no apparent chemical reason why, care should be taken to reduce mechanical handling of this resource to preserve its structure. Blending of this horizon with the A_1 horizon should only be considered if additional topsoil material is required to increase the soil resource volume.

Soil salinity (E.C.se) in the Red Podzolic soils was not been identified as an issue.

All the soils in the disturbance area are deficient in all major nutrients such as Phosphorus and Sulphur. 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.

8.6 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);

8.7 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.

8.7.1 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 soils throughout the Open Cut 3 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 15 provides guidelines for irrigation water quality.

Table 15. 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 can not 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 16** identifies these salinity classes.

Table 16. 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 on going 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 15.

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.

8.7.2 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.

8.8 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.

9 GLOSSARY

The following terms are taken from A glossary or 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.

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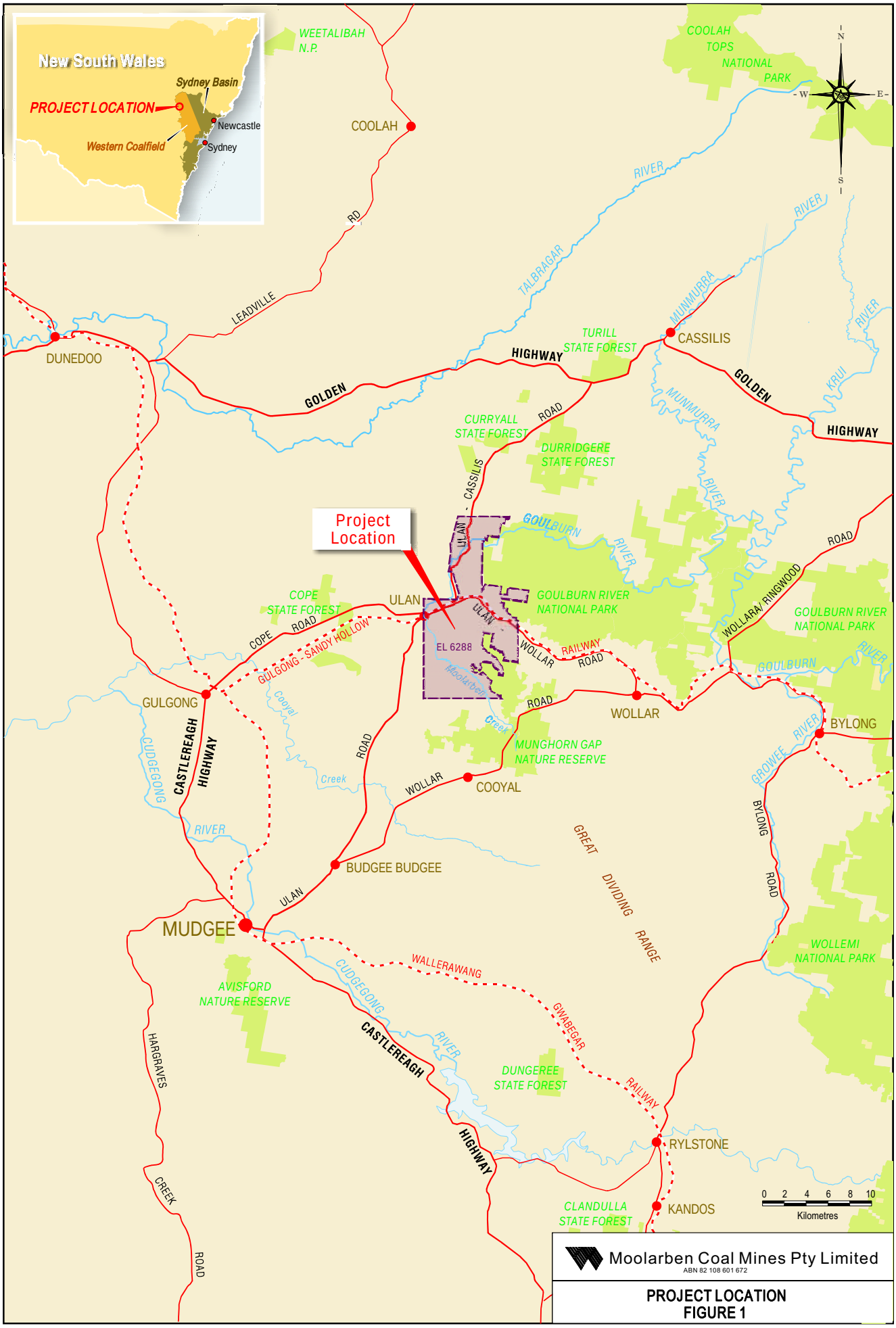
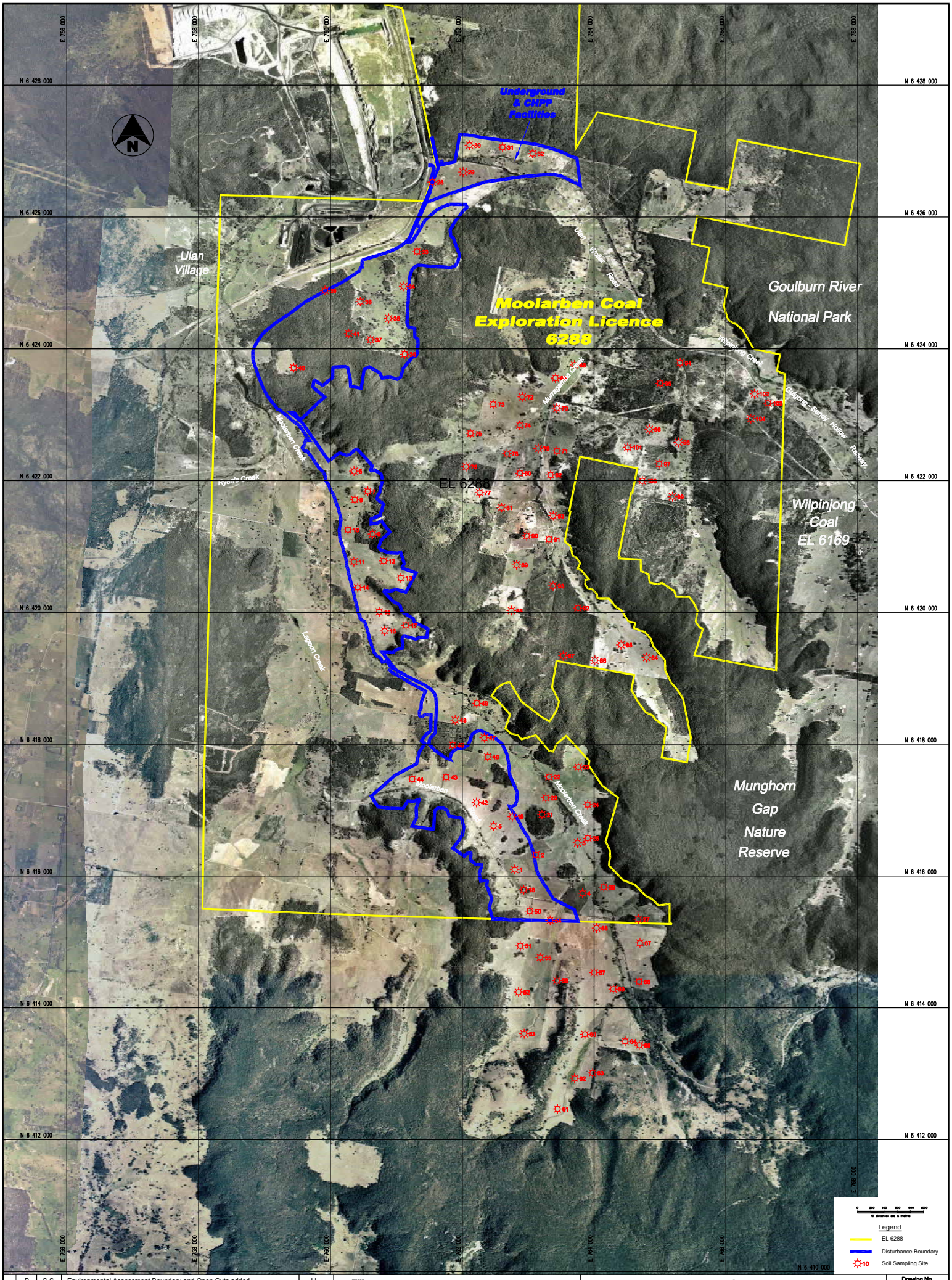
11 FIGURES



Moolarben Coal Mines Pty Limited
ABN 82 108 601 672

PROJECT LOCATION
FIGURE 1



Revision				
B	C.S.	Environmental Assessment Boundary and Open Cuts added		J.L.
C	N.M.	Disturbance Boundary Added.		J.L.
Rev.	Drawn	Description		Approved

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Moolarben Coal Project
Soil Sampling Locations & Disturbance Areas
Figure 2

Drawing No.	Revision No.	Sheet Size
01169	C	A1

Date	Scale:	Drawn	Checked	Approved
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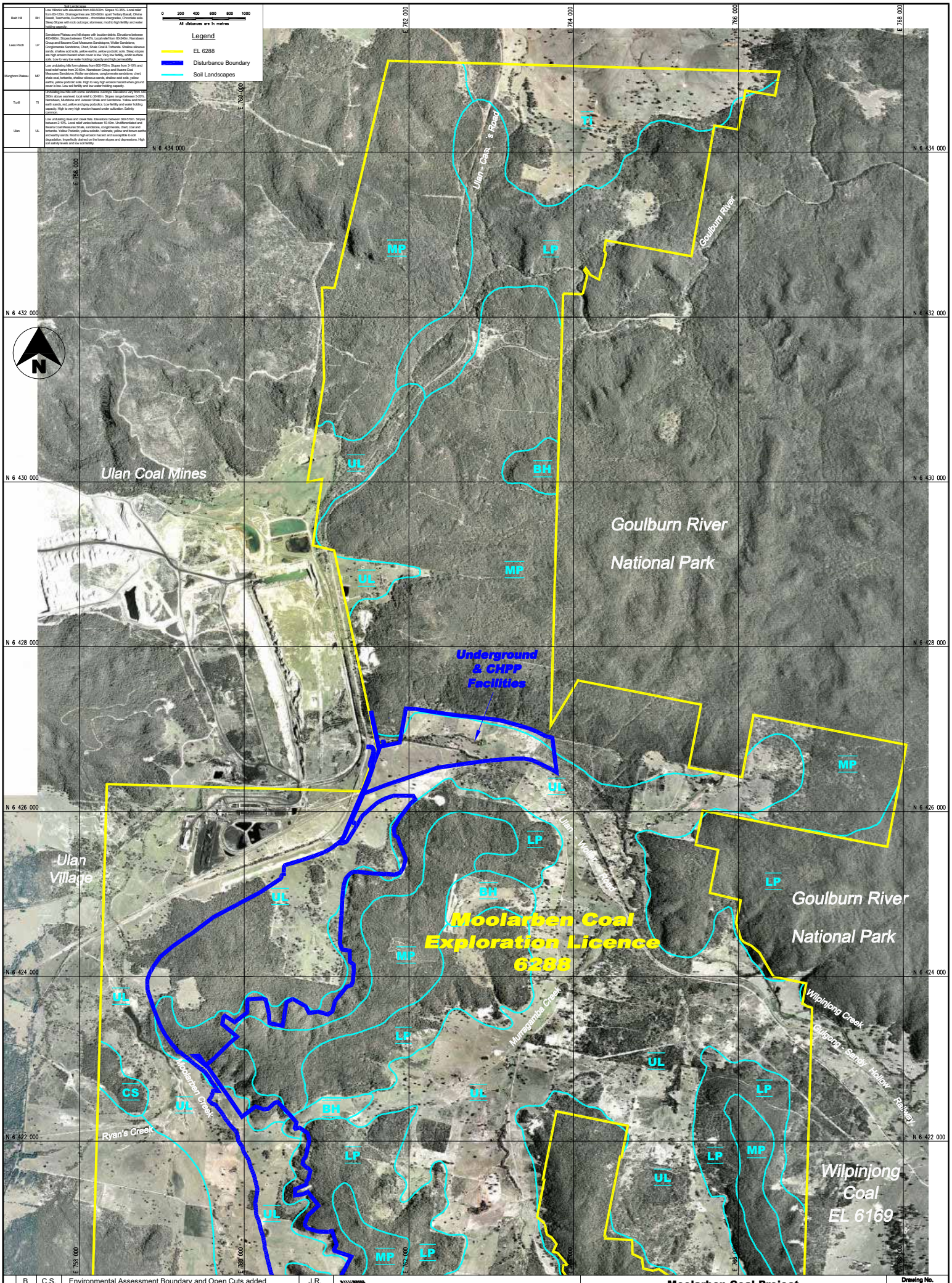

Revision	Rev.	Drawn	Description	Approved
	B	C.S.	Environmental Assessment Boundary and Open Cuts added	J.R.
	C	C.S.	All data clipped to EL Boundary and New Soil Landscape class	J.R.
	D	C.S.	Open Cut Areas Updated	JF
	E	N.M.	Disturbance Boundary Added.	JF

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Moolarben Coal Project
Soil Landscapes - Figure 3
Sheet 1 of 2

Date	Scale:	Drawn	Checked	Approved	Sheet Size
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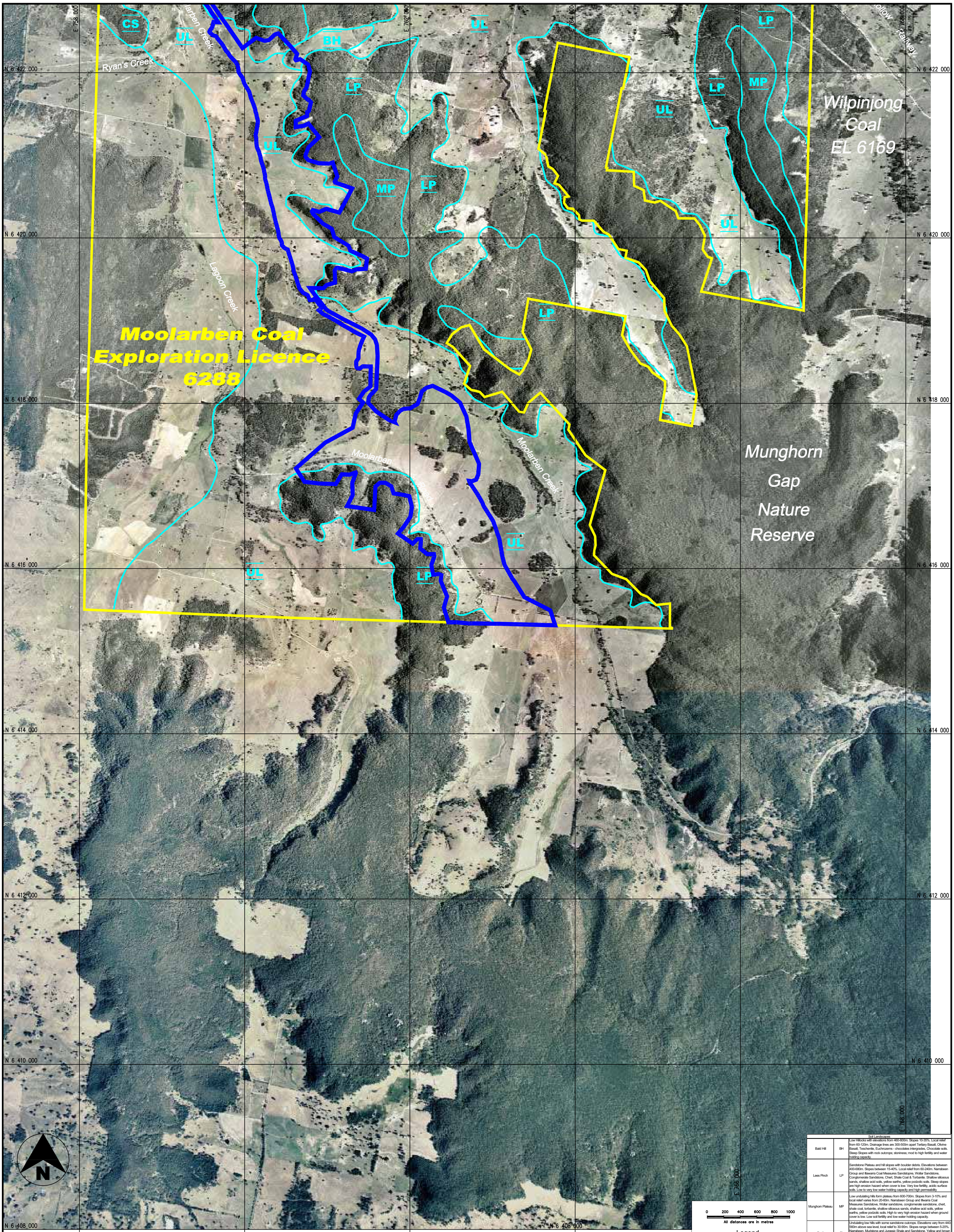
Drawing No. 01166
Revision No. E



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 Sandstopne, 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.

Rev.	Drawn	Description	Approved
B	C.S.	Environmental Assessment Boundary and Open Cuts added	J.R.
C	C.S.	All data clipped to EL Boundary and New Soil Landscape class	J.R.
D	C.S.	Open Cut Areas Updated	JF
E	N.M.	Disturbance Boundary Added.	JF

Revision

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

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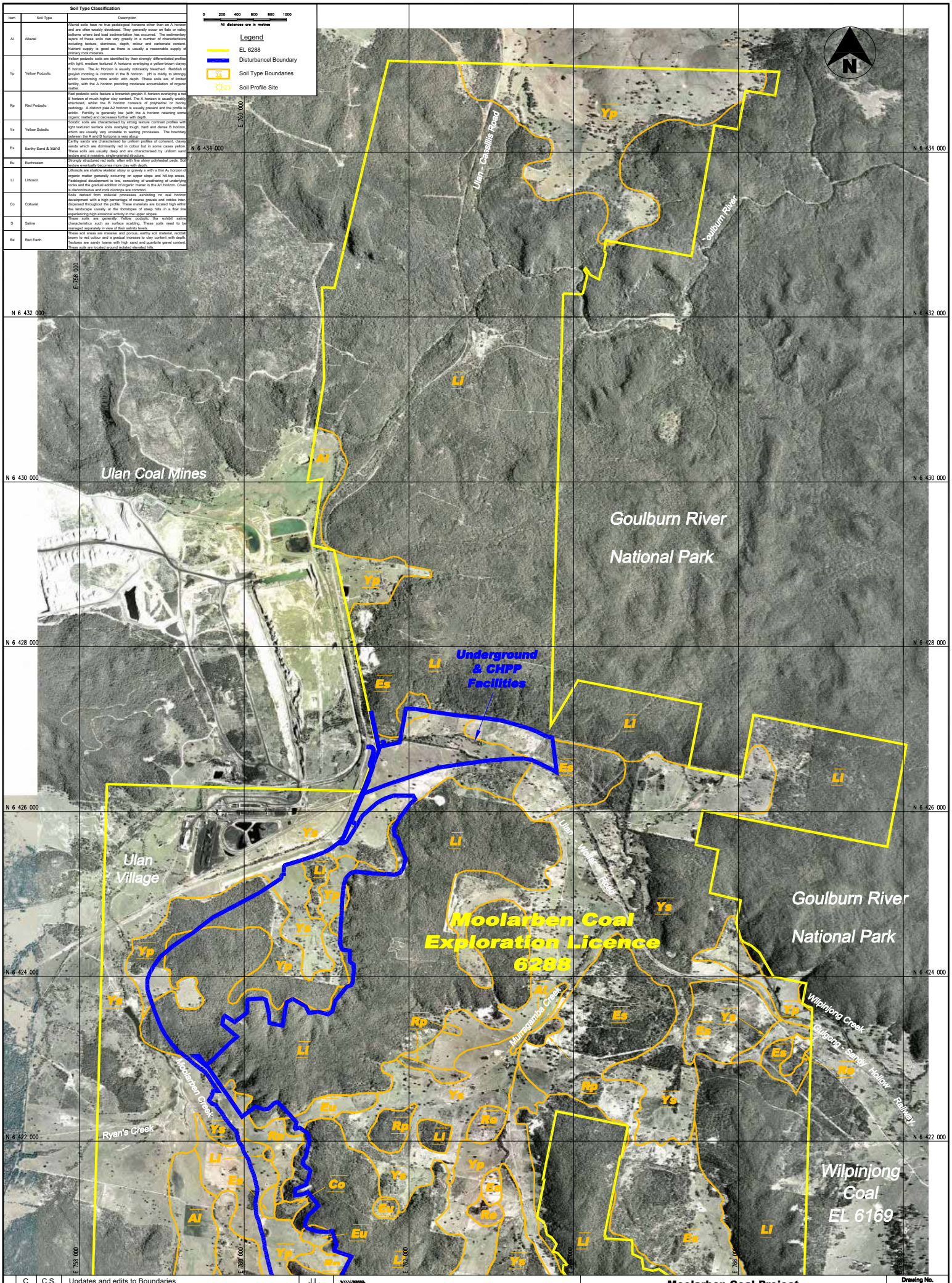
Drawing No. 01166

Revision No. E



Revision				
C	C.S.	Updates and edits to Boundaries	J.L.
D	C.S.	Environmental Assessment Boundary and Open Cuts added	J.R.
E	C.S.	All data clipped to EL Boundary	J.R.
F	C.S.	Open Cut Areas Updated	J.F.
G	N.M.	Disturbance Boundary Added.	J.L.
Rev.	Drawn	Description	Approved

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

Drawing No.	Revision No.
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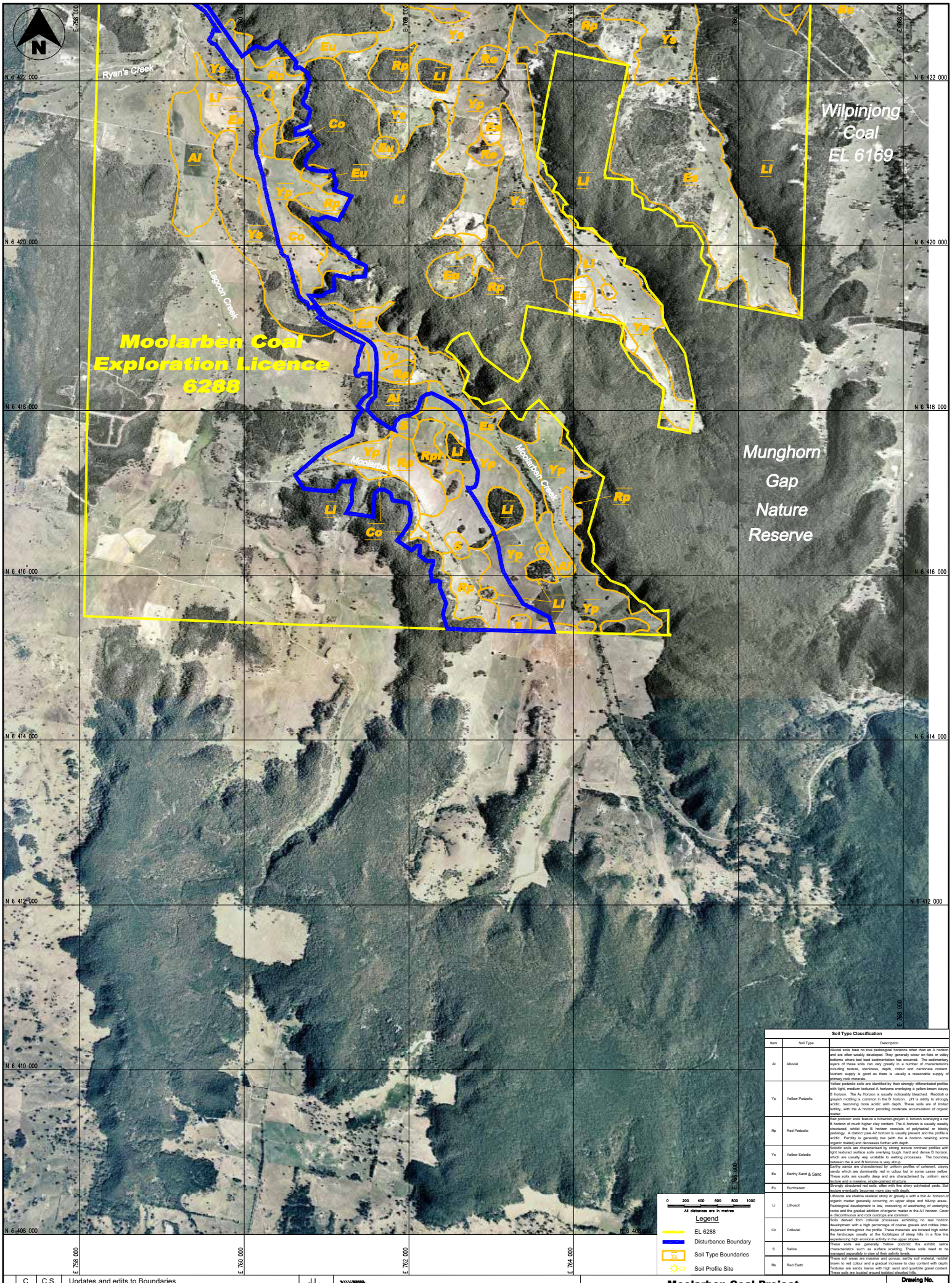

Soil Type Classification		
Item	Soil Type	Description
Al	Alluvial	Alluvial soils have no true pedological horizons other than an A horizon and are often weakly developed. They generally occur on flats or valley bottoms where fast load sedimentation has occurred. The sedimentary layers of these soils 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	Euchrozem	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 A1 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 the 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
- Soil Type Boundaries
- Soil Profile Site

Revision				
	Rev.	Drawn	Description	Approved
	C	C.S.	Updates and edits to Boundaries	J.L.
	D	C.S.	Environmental Assessment Boundary and Open Cuts added	J.R.
	E	C.S.	All data clipped to EL Boundary	J.R.
	F	C.S.	Open Cut Areas Updated	J.F.
	G	N.M.	Disturbance Boundary Added.	J.L.

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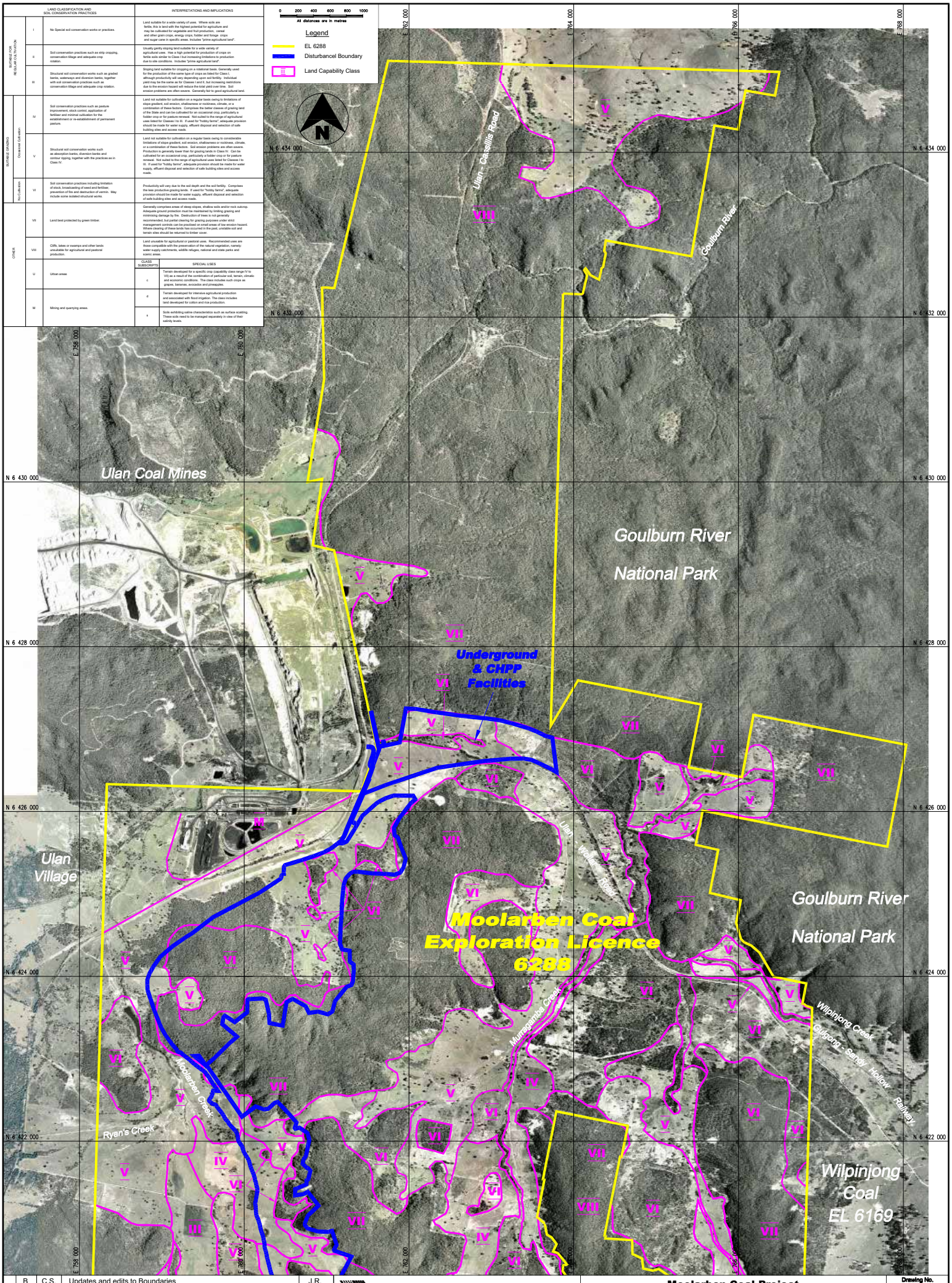
Moolarben Coal Project
Soil Type Boundaries - Figure 4
Sheet 2 of 2

Date	Scale:	Drawn	Checked	Approved	Sheet Size
02.05.06	1: 20000 @ A1	NM	JF	JL	A1

Drawing No. 01023
Revision No. G



Revision				
B	C.S.	Updates and edits to Boundaries	J.R.
C	C.S.	Environmental Assessment Boundary and Open Cuts added	J.R.
D	C.S.	All data clipped to EL Boundary	J.R.
E	C.S.	Open Cut Areas Updated	J.F.
F	N.M.	Disturbance Boundary Added.	J.L.
Rev.	Drawn	Description	Approved

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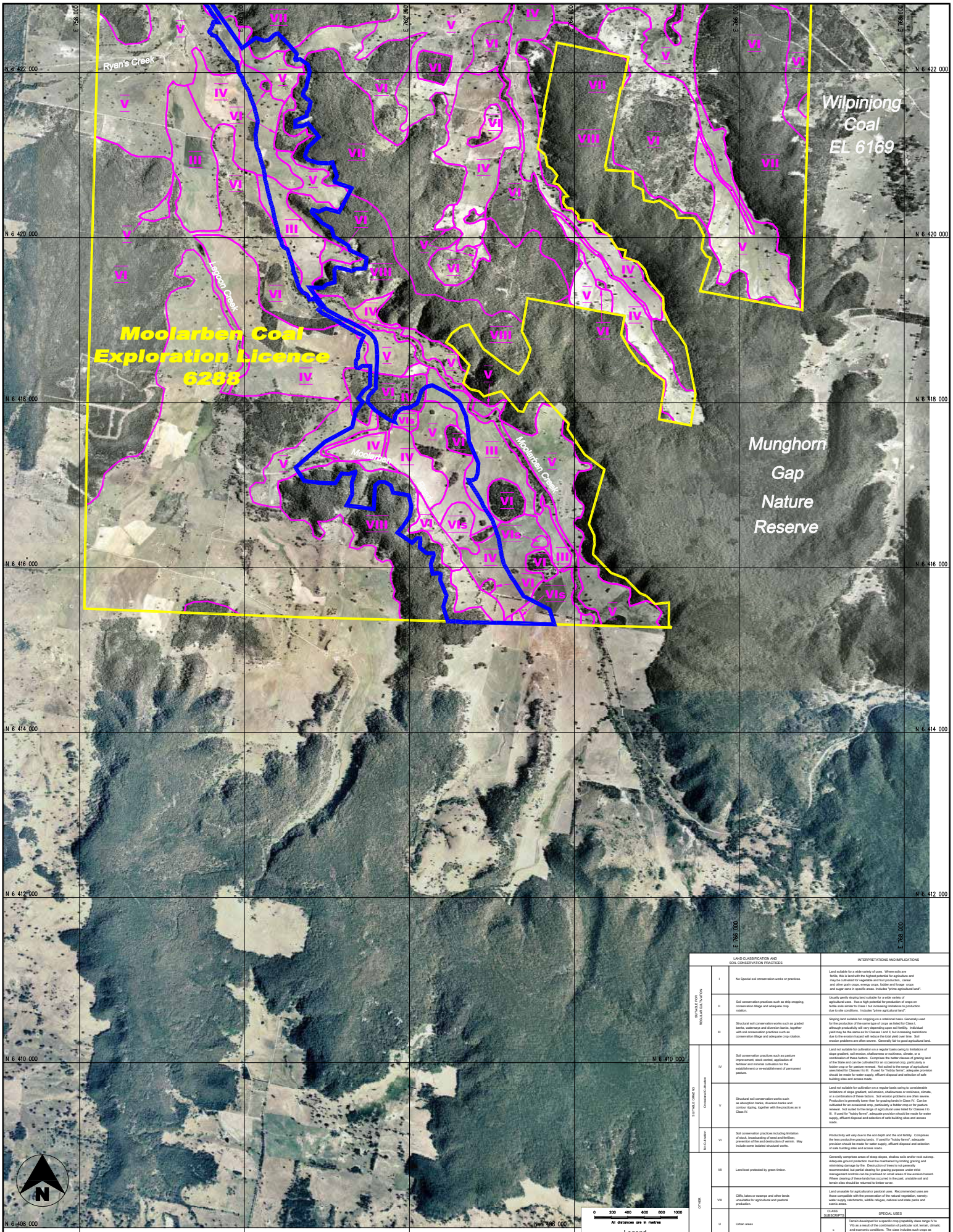
Moolarben Coal Project
Land Capability Mapping - Figure 5
Sheet 1 of 2

Drawing No.	Revision No.	Date	Scale:	Drawn	Checked	Approved	Sheet Size
01022	F	02.05.06	1: 20000 @ A1	NM	JF	JL	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, sweep 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 FOR GRAZING	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.
	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 unsuitable 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.

0 200 400 600 800 1000
All distances are in metres

Legend
- EL 6288
- Disturbance Boundary
- Land Capability Class

Revision	Rev.	Drawn	Description	Approved
	B	C.S.	Updates and edits to Boundaries	J.R.
	C	C.S.	Environmental Assessment Boundary and Open Cuts added	J.R.
	D	C.S.	All data clipped to EL Boundary	J.R.
	E	C.S.	Open Cut Areas Updated	J.F.
	F	N.M.	Disturbance Boundary Added.	J.L.

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

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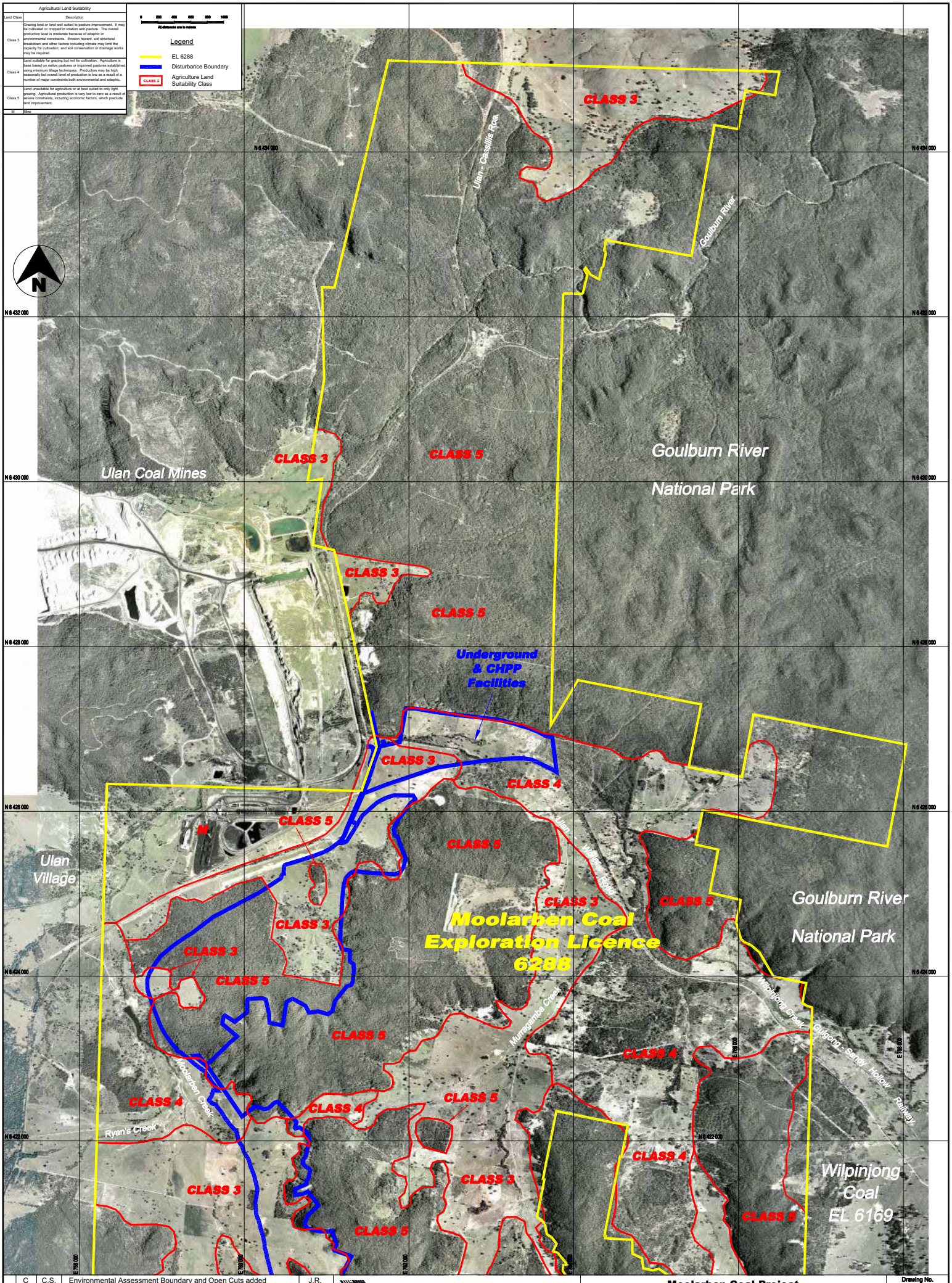

Revision				
	C	C.S.	Environmental Assessment Boundary and Open Cuts added	J.R.
	D	C.S.	All data clipped to EL Boundary	J.R.
	E	C.S.	Open Cut Areas Updated	J.F.
	F	N.M.	Disturbance Boundary Added.	J.L.
	G	C.S.	Agriculture Boundaries Updated	J.L.
	Rev	Drawn	Description	Approved

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

Drawing No.	Revision No.
01024	G

Date	Scale:	Drawn	Checked	Approved	Sheet Size
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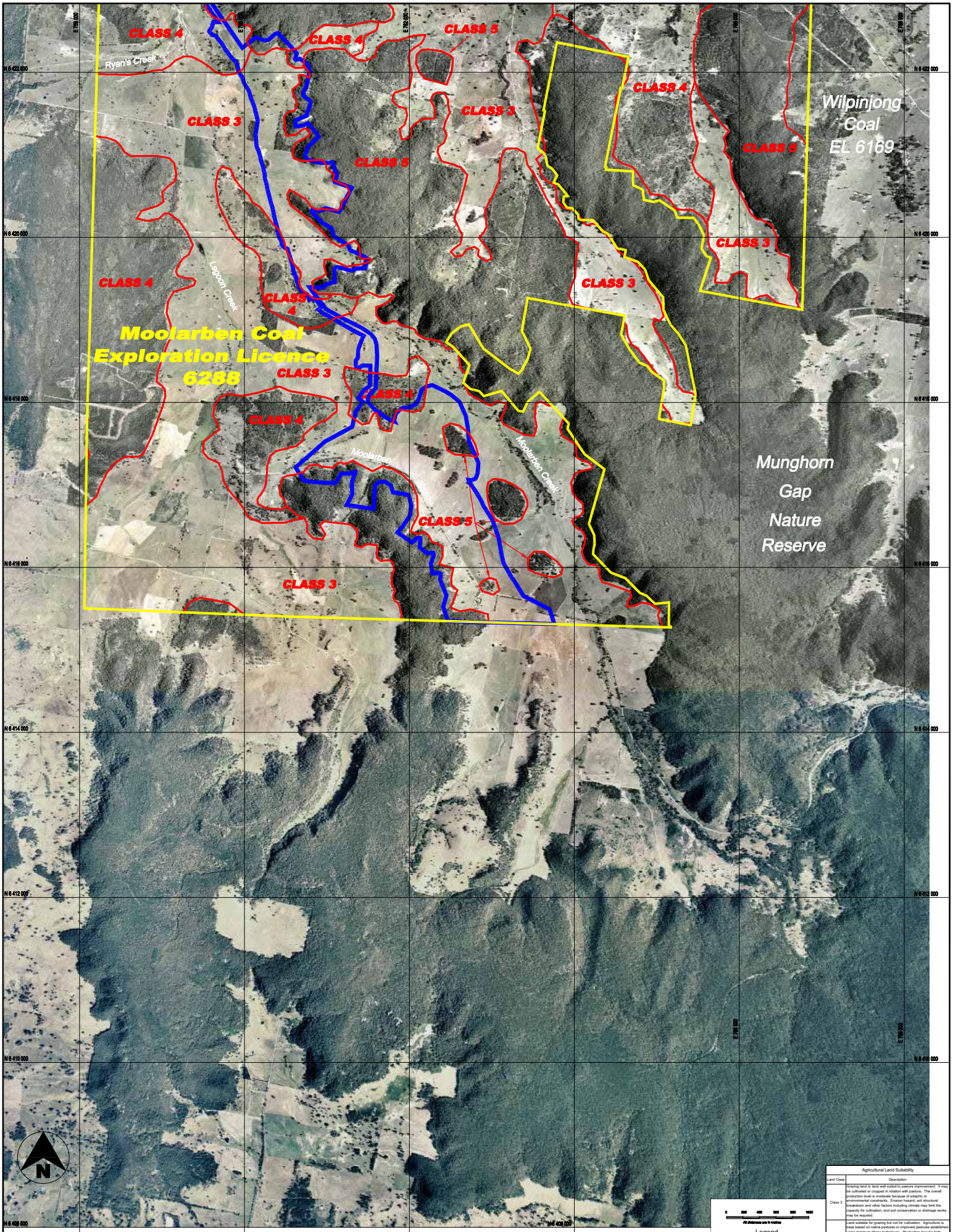

Agricultural Land Suitability	
Land Class	Description
Class 3	Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture. The overall production level is moderate because of edaphic or environmental constraints. Erosion hazard, soil structural breakdown 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				
	C	C.S.	Environmental Assessment Boundary and Open Cuts added	J.R.
	D	C.S.	All data clipped to EL Boundary	J.R.
	E	C.S.	Open Cut Areas Updated	J.F.
	F	N.M.	Disturbance Boundary Added.	J.L.
	G	C.S.	Agriculture Boundaries Updated	J.L.
	Rev	Drawn	Description	Approved

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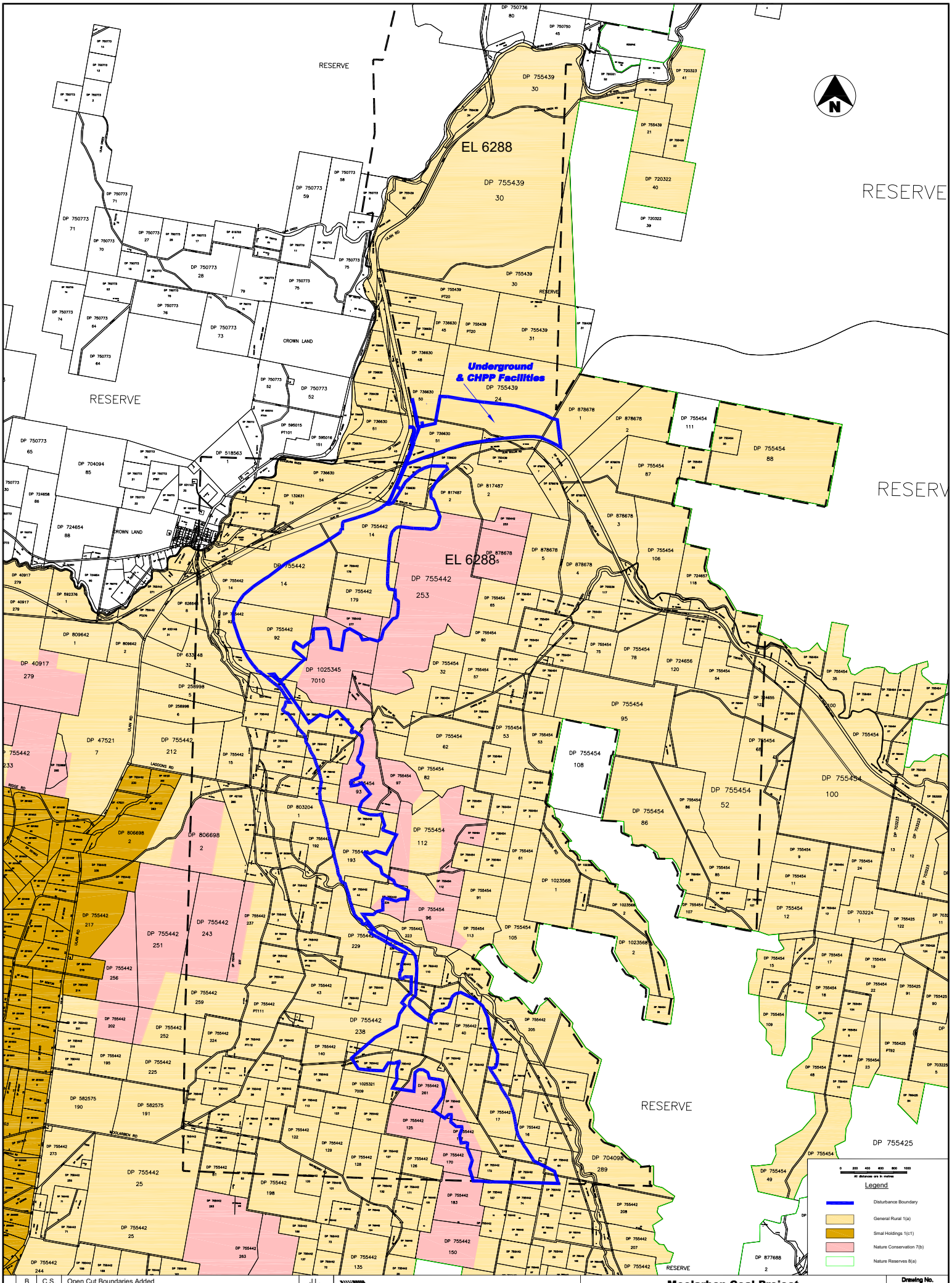
Moolarben Coal Project
Agricultural Suitability Mapping - Figure 6
Sheet 2 of 2

Drawing No.	Revision No.	Date	Scale:	Drawn	Checked	Approved	Sheet Size
01024	G	23.05.06	1:20000 @ A1	CS	JF	JL	A1



Revision	Rev.	Drawn	Description	Approved
	B	C.S.	Open Cut Boundaries Added	J.L.
	C	C.S.	Environmental Assessment Boundary and Open Cuts added	J.L.
	D	N.M.	Disturbance Boundary Added.	J.L.

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Moolarben Coal Project
Mid Western Regional Council LEP Land Zoning
Figure 7

Drawing No.	Revision No.	Date	Scale:	Drawn	Checked	Approved	Sheet Size
01165	D	02.05.06	1: 25,000	NM	JR	JL	A1

APPENDIX 1
PROFILE DESCRIPTIONS

INFRASTRUCTURE AREA

Site No:			28	29	30	31
Coordinates (AGD 66)		E N	761434 6426347	761902 6426498	761998 6426907	762498 6426875
Landform Element:			Hill slope	Hill slope	Hill slope	Hill slope
Aspect:			North	North	South	South
Run on:			Moderate	Moderate	Moderate	Moderate
Run off:			Low	Low	Low	Moderate
Profile Drainage:			imperfectly drained	imperfectly drained	imperfectly drained	imperfectly drained
Landuse:			volun./native pasture	volun./native pasture	volun./native pasture	volun./native pasture
Slope:			1%	1%	2%	2%
Site Disturbance:			Extensive Clearing	Extensive Clearing	Extensive Clearing	Extensive Clearing
Surface Condition:			Firm	Firm	Soft	Soft
Erosion Hazard:	Type:		Very High	Very High	Very High	Very High
	Degree:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
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	Yellow Solodic Dy 3.33	Yellow Solodic Dy3.32	Yellow Solodic Dy 3.31
Horizon:	Depth:		A1 0 - 0.2 A2 0.2 - 0.6 B 0.6 - 1 +	A1 0 - 0.2 A2 0.2 - 0.75 B 0.75 - 1 +	A1 0 - 0.2 A2 0.2 - 0.45 A3 0.45 - 0.75 B 0.75 - 1 +	A1 0 - 0.1 A2 0.1 - 0.4 B 0.4 - 1 +
	Boundary:		Sharp Abrupt	Clear Clear	Abrupt Abrupt	Abrupt Abrupt
	Colour:		7.5YR 5/6 wet 10YR 6/8 wet 10YR 7/6 wet	7.5YR 5/3 wet 10YR 5/6 wet 10YR 7/6 wet	10YR 4/3 wet 10YR 6/3 wet 10YR 6/5 wet	7.5YR 3/3 wet 10YR 6/3 wet 10YR 6/5 wet
	Mottles:		yellow (10% - 20%)	Orange (20% - 50%)		yellow (20% - 50%)
	Texture:		sandy loam sandy clay loam sandy clay	sandy loam loamy sand sandy clay	sandy loam loamy sand sandy clay	silty loam sandy clay loam sandy clay
	Coarse Fragments:		Yes (5% - 10%) Yes (10% - 20%) Nil	Yes (5% - 10%) Yes (10% - 20%) Nil	Yes (5% - 10%) Yes (10% - 20%) Nil	Yes (5% - 10%) Yes (10% - 20%) Nil
	Structure:		Weak Pedality Massive Moderate Pedality	Weak Pedality Massive Moderate Pedality	Weak Pedality Massive Moderate Pedality	Weak Pedality Massive Moderate Pedality
	Dominant Ped Shape:		Lenticular Platy Sub angular Blocky	Lenticular Platy Sub angular Blocky	Lenticular Platy Sub angular Blocky	Lenticular Platy Sub angular Blocky
	Consistency:		Very Weak Very Weak Moderately Firm	Very Weak Very Weak Moderately Firm	Very Weak Very Weak Moderately Firm	Very Weak Very Weak Moderately Firm
	Field pH:		5.0 5.5 7.5	4.5 5.0 6.0	4.5 5.0 5.0	5.5 5.0 4.5
	Segregations:		Nil	Nil	Nil	Nil

INFRASTRUCTURE AREA continued

Site No:		32
Coordinates (AGD 66)	E N	762956 6426780
Landform Element:		Hill slope
Aspect:		South
Run on:		Low
Run off:		Low
Profile Drainage:		Rapidly drained
Site Disturbance:		extensive clearing
Landuse:		volun./native pasture
Slope:		4%
Surface Condition:		Soft
Erosion Hazard:	Type:	Very High
	Degree:	Rill / Gully
Surface Coarse Fragments:		Nil
Rock Outcrop:		Nil
Groundwater Depth:		Nil
Salinity Evidence:		Nil
Soil Classification:		Earthy Sand Uc1.22
Horizon:	Depth:	A1 0 - 0.25 A2 0.25 – 0.45 A3 0.45 - 1 +
	Boundary:	gradual gradual
	Colour:	10YR 5/4 wet 10YR 4/6 wet 10YR 5/8 wet
	Mottles:	Nil
	Texture:	sand loamy sand loamy sand
	Coarse Fragments:	Nil Nil Yes (10%-20%)
	Structure:	Single Grained Single Grained Single Grained
	Dominant Ped Shape:	Granular Granular Granular
	Consistency:	Very weak Very Weak Very Weak
	Field pH:	5.5 5.0 5.0
	Segregations:	Nil

OPEN CUT 1

Site No:			33	34	35	36
Coordinates (AGD 66)		E N	761202 6425292	761001 6424764	760773 6424278	761017 6423734
Landform Element:			Hill slope	Hill slope	ValleyFlat	Hill slope
Aspect:			West	West	North	North West
Run on:			Moderate	Moderate	Low	Moderate
Run off:			Low	Moderate	Low	Low
Profile Drainage:			poorly drained	Very poorly drained	poorly drained	imperfectly drained
Site Disturbance:			extensive clearing	extensive clearing	extensive clearing	extensive clearing
Landuse:			volun./native pasture	volun./native pasture	volun./native pasture	volun./native pasture
Slope:			2%	5%	1%	5%
Surface Condition:			Firm	Firm	Firm	Firm
Erosion Hazard:	Type:		High	Very High	Very High	High
	Degree:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			Nil	2 – 10%	Nil	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Yellow Solodic Dy 3.42	Yellow Podzolic Dy 3.22.	Yellow Solodic Dy 3.42	Yellow Podzolic Dy 3.43
Horizon:	Depth:		A1 0 - 0.15 A2 0.15 - 0.35 B 0.35 - 1 +	A1 0 - 0.15 A2 0.15 - 0.2 B 0.2 - 1 +	A1 0 - 0.1 A2 0.1 - 0.2 B 0.2 - 1 +	A1 0 - 0.3 A2 0.3 - 0.4 B 0.4 - 0.7 refusal
	Boundary:		abrupt abrupt	sharp abrupt	sharp abrupt	abrupt abrupt
	Colour:		7.5YR 5/3 wet 10YR 6/4 wet 10YR 5/3 wet	10YR 3/2 wet 10YR 6/4 wet	10YR 3/3 wet 10YR 5/3 wet 10YR 7/6 wet	10YR 3/3 wet 10YR 7/6 wet 10YR 6/6 wet
	Mottles:		Yellow (20% - 50%)	orange (10% - 20%)	yellow (20% - 50%)	yellow (20% - 50%)
	Texture:		loam silty loam clay	loam silty loam clay	silty loam silty loam clay	silty loam silty loam sandy clay
	Coarse Fragments:		Yes (5% - 10%) Yes (10% - 20%) Nil	Nil Yes (10%- 20%) Yes (5% - 10%)	Yes (5% - 10%) Yes (10% - 20%) Nil	Nil Yes (5%-10%) Nil
	Structure:		Weak Pedality Massive Moderate Pedality	Massive Massive Moderate Pedality	Weak Pedality Massive Moderate Pedality	Massive Weak Pedality Strong Pedality
	Dominant Ped Shape:		Lenticular Platy Sub angular Blocky	Polyhedral Crumb Sub angular blocky	Lenticular Platy Sub angular Blocky	Crumb Polyhedral Sub angular blocky
	Consistency:		Very Weak Very Weak Moderately Firm	Very Weak Weak Moderate	Very Weak Very Weak Moderately Firm	Very weak Very weak Moderately firm
	Field pH:		5.5 6.0 6.5	6.0 6.5 7.0	5.0 5.0 5.0	5.5 6.0 7.5
	Segregations:		Nil	Nil	Nil	Nil

OPEN CUT 1 continued

Site No:			37	38	39	40
Coordinates (AGD 66)		E N	760497 6423955	760342 6424533	759805 6424700	759330 6423531
Landform Element:			Hill slope	Hill slope	Hill slope	Hill slope
Aspect:			East	East	North	West
Run on:			Moderate	Moderate	Moderate	Moderate
Run off:			Low	Low	Low	Low
Profile Drainage:			well drained	poorly drained	imperfectly drained	imperfectly drained
Site Disturbance:			extensive clearing	cleared	No effective disturbance	extensive clearing
Landuse:			volun./native pasture	volun./native pasture	Timber/scrub/unused	volun./native pasture
Slope:			4%	1%	1%	2%
Surface Condition:			Firm	Hardset	soft	Firm
Erosion Hazard:	Type:		High	Very High	Very High	High
	Degree:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			2 – 10%	Nil	Nil	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Yellow Podzolic Dy 3.31	Yellow Solodic Dy 2.32	Earthy Sand Uc1.23	Yellow Podzolic Dy 3.31
Horizon:	Depth:		A1 0 - 0.2 A2 0.2 - 0.5 refusal	A1 0 - 0.15 A2 0.15 - 0.35 B 0.35 - 1 +	A1 0 - 0.15 A2 0.15 - 0.35 refusal	A1 0 - 0.15 A2 0.15 - 0.45 B 0.45 - 1 +
	Boundary:		abrupt	Abrupt abrupt	abrupt	abrupt abrupt
	Colour:		10YR 4/4 wet 7.5YR 6/4 wet	7.5YR 4/4 wet 10YR 5/4 wet 10YR 7/3 wet	10YR 4/3 wet 10YR 5/3 wet	10YR 2/2 wet 10YR 4/2 wet 10YR 5/4 wet
	Mottles:			Yellow (10% - 20%)		orange (20% - 50%)
	Texture:		loam sandy loam	silty loam sandy loam sandy clay	sandy loam silty loam	loam silty loam sandy clay
	Coarse Fragments:		Nil Yes (5%-10%) Nil	Yes (5% - 10%) Yes (10% - 20%) Nil	Nil Nil	Nil Yes (5%-10%) Nil
	Structure:		Massive Weak Pedality Strong Pedality	Weak Pedality Massive Moderate Pedality	Single Grained Single Grained	Massive Weak Pedality Strong Pedality
	Dominant Ped Shape:		Crumb Polyhedral Sub angular blocky	Lenticular Platy Sub angular Blocky	Granular Granular	Crumb Polyhedral Sub angular blocky
	Consistency:		Very weak Very weak Moderately firm	Very Weak Very Weak Moderately Firm	Very weak Very Weak	Very weak Very weak Moderately firm
	Field pH:		5.5 6.0	5.5 6.0 7.5	4.5 5.5	6.5 6.0 5.5
	Segregations:		Nil	Nil	Nil	Nil

OPEN CUT 1 continued

Site No:			41
Coordinates (AGD 66)		E N	760166 6424047
Landform Element:			Hill slope
Aspect:			North
Run on:			Low
Run off:			Low
Profile Drainage:			Imperfectly drained
Site Disturbance:			extensive clearing
Landuse:			Timber/scrub/unused
Slope:			4%
Surface Condition:			Firm
Erosion Hazard:	Type:		Very High
	Degree:		Rill / Gully
Surface Coarse Fragments:			Nil
Rock Outcrop:			10 – 20%
Groundwater Depth:			Nil
Salinity Evidence:			Nil
Soil Classification:			Earthy Sand Uc 1.23
Horizon:	Depth:		A1 0 - 0.15 A2 0.15 - 0.5 refusal
	Boundary:		gradual
	Colour:		10YR 3/3 wet 10YR 6/4 wet
	Mottles:		
	Texture:		sandy loam clay loam sandy
	Coarse Fragments:		Nil Nil
	Structure:		Single Grained Single Grained
	Dominant Ped Shape:		Granular Granular
	Consistency:		Very weak Very Weak
	Field pH:		5.5 5.0
	Segregations:		Nil

OPEN CUT 2

Site No:			6	7	8	9
Coordinates (AGD 66)		E N	760247 6421961	760454 6421653	760257 6421528	760527 6421006
Landform Element:			Hill slope	Hill Crest	Hill slope	Gully
Aspect:			West	West	West	West
Run on:			High	High	High	High
Run off:			Moderate	Moderate	High	High
Profile Drainage:			imperfectly drained	imperfectly drained	imperfectly drained	Moderately well drained
Site Disturbance:			cleared	extensive clearing	extensive clearing	Limited clearing
Landuse:			Improved pasture	volun./native pasture	volun./native pasture	Timber/scrub/unused
Slope:			5%	7%	5%	4%
Surface Condition:			Firm	Firm	Firm	Firm
Erosion Hazard:	Type:		High	High	High	High
	Degree:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Yes	Yes	Yes	Nil
Rock Outcrop:			Nil	< 2%	< 2%	2 – 10%
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Red Podzolic DR 3.11	Red Podzolic DR 3.21	Yellow Podzolic Dy3.21	Colluvial
Horizon:	Depth:		A 0 - 0.25 B 0.25 - 1 +	A1 0 - 0.1 A2 0.1 - 0.3 B 0.3 - 1 +	A1 0 - 0.1 A2 0.1 - 0.25 B 0.25 - 1 +	A1 0 - 0.1 A2 0.1 - 0.3 B 0.3 - 0.55
	Boundary:		abrupt	abrupt sharp	abrupt abrupt	abrupt abrupt
	Colour:		7.5YR 4/4 wet 2.5YR 4/8 wet	10YR 4/4 wet 10YR 4/4 wet 2.5YR 4/8 wet	10YR 5/4 wet 10YR 6/4 wet 10YR 6/5 wet	7.5YR 3/3 wet 10YR 4/2 wet 10YR 4/2 wet
	Mottles:			red (20% - 50%)	Yellow (20% - 50%)	Orange (10% - 20%)
	Texture:		silty loam clay	silty loam loam clay	loam silty loam clay	loam sandy clay sandy clay
	Coarse Fragments:		Yes (10% - 20%) Yes (20%-50%)	Yes (10% - 20%) Yes (20%-50%) Nil	Nil Yes (5%-10%) Nil	Yes Yes Yes
	Structure:		Weakly Pedality Weakly Pedality	Weakly Pedality Weakly Pedality Strongly Pedality	Massive Weak Pedality Strong Pedality	Not consolidated
	Dominant Ped Shape:		Granular Lenticular	Granular Lenticular Sub angular blocky	Crumb Polyhedral Sub angular blocky	Polyhedral Polyhedral Angular blocky
	Consistency:		Loose Moderately weak	Loose Moderately weak Moderately firm	Very weak Very weak Moderately firm	Loose Moderately weak Moderately firm
	Field pH:		5.0 5.5	5.5 5.0 5.5	5.0 5.5 6.0	5.0 5.5 5.5
	Segregations:		Nil	Nil	Nil	Nil

OPEN CUT 2 continued

Site No:			10	11	12	13
Coordinates (AGD 66)		E N	760154 6421070	760244 6420586	760697 6420598	760955 6420339
Landform Element:			Hill slope	Hill slope	Hill Crest	Foot slope
Aspect:			West	West	West	West
Run on:			Moderate	Moderate	High	High
Run off:			Moderate	Moderate	Moderate	High
Profile Drainage:			imperfectly drained	imperfectly drained	Moderately well drained	Moderately well drained
Site Disturbance:			occasional cultivation	cleared	extensive clearing	extensive clearing
Landuse:			Improved pasture	volun./native pasture	volun./native pasture	volun./native pasture
Slope:			4%	4%	7%	6%
Surface Condition:			Firm	Firm	Soft	Firm
Erosion Hazard:	Type:		Moderate	High	Moderate	Moderate
	Degree:		Sheet / Rill	Rill / Gully	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			Nil	Nil	Nil	2 – 10%
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Nil	Nil
Soil Classification:			Earthy Sand Uc 4.13	Yellow Podzolic Dy 3.22	Euchrozem Gn3.13	Red Podzolic Dr 3.21
Horizon:	Depth:		A1 0 - 0.15 A2 0.15 - 0.8 B 0.8 - 1 +	A1 0 - 0.2 A2 0.2 - 0.5 B 0.5 - 1 +	A1 0 - 0.2 A2 0.2 - 0.4 refusal	A1 0 - 0.2 A2 0.2 - 0.35 refusal
	Boundary:		clear clear	abrupt sharp	clear	sharp
	Colour:		10YR 3/3 wet 10YR 6/3 wet 10YR 3/3 wet	10YR 4/3 wet 10YR 6/4 wet 10YR 5/6 wet	10YR 4/4 wet 10YR 4/4 wet	7.5YR 3/3 wet 10YR 4/2 wet
	Mottles:			Orange (20% - 50%)		
	Texture:		silty loam sandy loam loamy sand	sandy loam loamy sand sandy clay	sandy loam sandy loam	silty loam sandy loam
	Coarse Fragments:		Nil Yes (5%-10%) Nil	Nil Yes (10%- 20%) Yes (5% - 10%)	Nil Yes (10% - 20%)	Yes (10% - 20%) Yes (20%-50%)
	Structure:		Single Grained Single Grained Single Grained	Massive Massive Moderate Pedality	Weakly Pedality Weakly Pedality	Weakly Pedality Weakly Pedality
	Dominant Ped Shape:		Granular Granular Granular	Polyhedral Crumb Sub angular blocky	Polyhedral Polyhedral	Granular Lenticular
	Consistency:		Very weak Very Weak Very Weak	Very Weak Weak Moderate	Moderately weak Moderately Polyhedral	Loose Moderately weak
	Field pH:		5.0 4.5 4.5	4.5 5.0 6.0	4.5 5.0	5.5 6.5
	Segregations:		Nil	Nil	Nil	Nil

OPEN CUT 2 continued

Site No:			14	15	16	17
Coordinates (AGD 66)		E N	760302 6420196	760628 6419824	760710 6419536	761035 6419619
Landform Element:			Valley Flat	Foot slope	Foot Slope	Gully
Aspect:			West	West	West	West
Run on:			Moderate	High	High	High
Run off:			Low	Moderate	Low	Moderate
Profile Drainage:			imperfectly drained	Moderately well drained	imperfectly drained	Moderately well drained
Site Disturbance:			extensive clearing	extensive clearing	extensive clearing	extensive clearing
Landuse:			Improved pasture	volun./native pasture	volun./native pasture	volun./native pasture
Slope:			1%	5%	3%	5%
Surface Condition:			Firm	Firm	Firm	Firm
Erosion Hazard:	Type:		High	High	Moderate	High
	Degree:		Sheet / Rill	Sheet / Rill	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Nil	Yes	Nil	Nil
Rock Outcrop:			Nil	Nil	Nil	2 – 10%
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Salinity Evident	Salinity Evident	Nil
Soil Classification:			Yellow Podzolic Dy 3.32	Yellow Podzolic Dy 3.32	Red Podzolic Dr 3.31	Colluvial
Horizon:	Depth:		A1 0 - 0.2 A2 0.2 – 0.45 B 0.45 - 1 +	A1 0 - 0.15 refusal	A1 0 - 0.25 A2 0.25 - 0.45 refusal	A1 0 - 0.5 A2 0.5 - 1 +
	Boundary:		abrupt abrupt		abrupt	clear
	Colour:		7.5YR 4/6 wet 5YR 5/8 wet 5YR 5/8 wet	10YR 3/3 wet		10YR 4/4 wet 10YR 4/4
	Mottles:		orange (20% - 50%)			
	Texture:		loam clay loam clay	silty loam	silty loam silty loam	silty loam sandy loam
	Coarse Fragments:		Nil Yes (5%-10%) Nil	Nil Yes (5%-10%) Nil	Yes (10% - 20%) Yes (20%-50%)	Yes Yes
	Structure:		Massive Weak Pedality Strong Pedality	Massive Weak Pedality Strong Pedality	Weakly Pedality Weakly Pedality	Not consolidated
	Dominant Ped Shape:		Crumb Polyhedral Sub angular blocky	Crumb Polyhedral Sub angular blocky	Granular Lenticular	Polyhedral Polyhedral
	Consistency:		Very weak Very weak Moderately firm	Very weak Very weak Moderately firm	Loose Moderately weak	Loose Moderately weak
	Field pH:		5.0 5.5 6.0	5.5	5.5 6.0	6.0 7.0
	Segregations:		Nil	Nil	Nil	Nil

OPEN CUT 3

Site No:		1	2	3	4
Coordinates (AGD 66)	E N	762684 6415915	763007 6416037	763636 6416319	763613 6415554
Landform Element:		Hill slope	Hill slope	Valley Flat	Valley Flat
Aspect:		East	East	Flat	Flat
Run on:		Moderate	Moderate	Moderate	Moderate
Run off:		Moderate	Moderate	Low	Moderate
Profile Drainage:		imperfectly drained	imperfectly drained	Moderately well drained	imperfectly drained
Site Disturbance:		Occasional Cultivation	Occasional Cultivation	Occasional Cultivation	Occasional Cultivation
Landuse:		volun./native pasture	improved pasture	improved pasture	cropping
Slope:		3%	5%	1%	1%
Surface Condition:		Firm	Firm	Firm	Soft
Erosion Hazard:	Type:	Moderate	High	High	Moderate
	Degree:	Rill / Gully	Rill / Gully	Rill / Gully	Sheet / Rill
Surface Coarse Fragments:		Nil	Nil	Nil	Nil
Rock Outcrop:		Nil	Nil	Nil	Nil
Groundwater Depth:		Nil	Nil	Nil	Nil
Salinity Evidence:		Nil	Nil	Salinity Evident	Nil
Soil Classification:		Red Podzolic Dr 3.33	Yellow Podzolic Dy 3.41	Alluvial Um 1.22	Yellow Podzolic Dy 3.42
Horizon:	Depth:	A1 0 - 0.3 A2 0.3 - 0.55 B 0.55 - 1 +	A1 0 - 0.15 A2 0.15 - 0.44 B 0.44 - 1 +	A1 0 - 0.25 A2 0.25 - 0.45 B 0.45 - 1 +	A1 0 - 0.15 A2 0.15 - 0.35 B 0.35 - 1 +
	Boundary:	clear clear	abrupt abrupt	clear clear	abrupt abrupt
	Colour:	7.5YR 4/3 wet 7.5YR 4/4 wet 5YR 4/6 wet	10YR 3/4 wet 10YR 6/4 wet 7.5YR 7/6 wet	7.5YR 3/3 wet 10YR 3/3 wet 10YR 7/8 wet	10YR 3/4 wet 10YR6/4 wet 10YR 6/8 wet
	Mottles:	red (10% - 20%)	Orange (20% - 50%)	Orange (20% - 50%)	orange (10% - 20%)
	Texture:	silty loam sandy loam sandy clay loam	silty loam sandy loam sandy clay	sandy loam silty loam sandy clay	silty loam silty loam sandy clay
	Coarse Fragments:	Nil Yes (5% - 10%) Nil	Nil Yes (10%- 20%) Yes (5% - 10%)	Nil Yes (5% - 10%) Yes (10%- 20%)	Nil Yes (10%- 20%) Yes (5% - 10%)
	Structure:	Weak Pedality Weak Pedality Strong Pedality	Massive Massive Moderate Pedality	Massive Massive Massive	Massive Massive Moderate Pedality
	Dominant Ped Shape:	Granular Platy Sub angular blocky	Polyhedral Crumb Sub angular blocky	Crumb Crumb Crumb	Polyhedral Crumb Sub angular blocky
	Consistency:	Loose Moderately Weak Moderately Firm	Very Weak Weak Moderate	Very weak Very weak Very weak	Very Weak Weak Moderate
	Field pH:	5.5 5.5 7.0	5.0 5.5 5.5	5.0 6.5 7.5	5.0 6.0 6.5
	Segregations:	Nil	Nil	Nil	Nil

OPEN CUT 3 continued

Site No:			5	18	19	20
Coordinates (AGD 66)		E N	762364 6416575	762821 6415609	762648 6416716	763157 6417004
Landform Element:			Hill Slope	Hill Crest	Hill Slope	Valley Flat
Aspect:			East	North	East	Flat
Run on:			Moderate	Moderate	Moderate	Moderate
Run off:			Moderate	Moderate	Moderate	Low
Profile Drainage:			imperfectly drained	Moderately well drained	imperfectly drained	imperfectly drained
Site Disturbance:			extensive clearing	limited clearing	extensive clearing	extensive clearing
Landuse:			Improved pasture	timber/scrub/unused	Improved pasture	Improved pasture
Slope:			4%	6%	3%	1%
Surface Condition:			Firm	Firm	Firm	Firm
Erosion Hazard:	Type:		High	High	High	Moderate
	Degree:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Yes	Nil	Nil	Nil
Rock Outcrop:			Nil	2 – 10%	Nil	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Salinity Evident	Nil	Salinity Evident	Nil
Soil Classification:			Yellow Podzolic Dy 3.33	Shallow Soils (Lihosol)	Yellow Podzolic Dy 3.42	Yellow Podzolic Dy 3.42
Horizon:	Depth:		A1 0 - 0.1 A2 0.1 - 0.25 B 0.25 - 0.55 refusal	A1 0 - 0.15 A2 0.15 - 0.3 B 0.3 - 0.9 refusal	A1 0 - 0.2 A2 0.2 - 0.4 B 0.4 - 1 +	A1 0 - 0.2 A2 0.2 - 0.4 B 0.4 - 1 +
	Boundary:		abrupt abrupt	abrupt sharp	abrupt abrupt	abrupt abrupt
	Colour:		7.5 YR 3/3 wet 10YR 6/8 wet 10 YR 6/8 wet	10YR 6/4 wet 10YR 6/3 wet 5YR 5/6 wet	7.5YR 4/4 wet 10YR 4/6 wet 10YR 5/8 wet	7.5YR 3/4 wet 10YR 5/2 wet 5YR 5/8 wet
	Mottles:		orange (10% - 20%)	red (10% - 20%)		Orange (2% - 10
	Texture:		sandy loam sandy loam sandy clay	sandy loam sandy loam sandy clay	sandy loam sandy loam sandy clay	loam sandy loam clay
	Coarse Fragments:		Nil Yes (5%-10%) Nil	Yes (20% - 50%) Yes (10% - 20%) Nil	Nil Yes (10%- 20%) Yes (5% - 10%)	Nil Yes (10%- 20%) Yes (5% - 10%)
	Structure:		Massive Weak Pedality Strong Pedality	Massive Massive Weak Pedality	Massive Massive Moderate Pedality	Massive Massive Moderate Pedality
	Dominant Ped Shape:		Crumb Polyhedral Sub angular blocky	Crumb Crumb Sub angular blocky	Polyhedral Crumb Sub angular blocky	Polyhedral Crumb Sub angular blocky
	Consistency:		Very weak Very weak Moderately firm	Loose Moderately Weak Moderately Firm	Very Weak Weak Moderate	Very Weak Weak Moderate
	Field pH:		4.5 5.5 6.5	5.5 6.0 6.0	4.5 5.5 6.0	4.5 5.5 5.5
	Segregations:		Nil	Nil	Nil	Nil

OPEN CUT 3 continued

Site No:			21	22	23	24
Coordinates (AGD 66)		E N	763097 6416749	763204 6417321	763648 6417470	763791 6416899
Landform Element:			Hill Slope	Valley Flat	Hill Slope	Hill Slope
Aspect:			North	West	West	West
Run on:			Moderate	Moderate	High	High
Run off:			Moderate	Low	Moderate	Moderate
Profile Drainage:			Moderately well drained	Moderately well drained	imperfectly drained	imperfectly drained
Site Disturbance:			limited clearing	extensive clearing	extensive clearing	extensive clearing
Landuse:			timber/scrub/unused	volun./native pasture	volun./native pasture	volun./native pasture
Slope:			7%	<1%	5%	5%
Surface Condition:			Firm	Firm	Firm	Firm
Erosion Hazard:	Type:		High	Moderate	Moderate	High
	Degree:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			Nil	Nil	Nil	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Salinity Evident	Nil	Salinity Evident	Nil
Soil Classification:			Shallow soils (Lithosol)	Earthy Sand Uc 4.13	Yellow Podzolic Dy 3.22	Yellow Podzolic Dy 3.41
Horizon:	Depth:		A1 0 - 0.07 A2 0.07 - 0.35 refusal	A1 0 - 0.2 A2 0.2 - 0.6 A3 0.6 - 1 +	A1 0 - 0.2 A2 0.2 - 0.5 B 0.5 - 1 +	A1 0 - 0.2 A2 0.2 - 0.5 B 0.5 - 1 +
	Boundary:		Abrupt	clear gradual	abrupt abrupt abrupt	sharp sharp
	Colour:		10YR 4/3 wet 10YR 7/2 wet	2.5YR 5/3 dry 2.5YR 7/3 dry 2.5YR 6/4 wet	7.5YR 5/3 wet 10YR 5/6 wet 10YR 7/6 wet 10YR 7/3 wet	10YR 3/3 wet 10YR 6/4 wet 10YR 6/8 wet
	Mottles:				orange (20% - 50%)	Orange (20% - 50%)
	Texture:		sandy loam sandy loam	silty loam sand sand	sandy loam sand sand sandy clay	loam sandy clay loam clay
	Coarse Fragments:		Yes (20% - 50%) Yes (10% - 20%) Nil	Nil Yes (5%-10%) Nil	Nil Yes (10%- 20%) Yes (5% - 10%)	Nil Yes (10%- 20%) Yes (5% - 10%)
	Structure:		Massive Massive Weak Pedality	Single Grained Single Grained Single Grained	Massive Massive Moderate Pedality	Massive Massive Moderate Pedality
	Dominant Ped Shape:		Crumb Crumb Sub angular blocky	Granular Granular Granular	Polyhedral Crumb Sub angular blocky	Polyhedral Crumb Sub angular blocky
	Consistency:		Loose Moderately Weak Moderately Firm	Very weak Very Weak Very Weak	Very Weak Weak Moderate	Very Weak Weak Moderate
	Field pH:		4.5 5.5	4.5 5.0 5.5	4.5 5.0 5.0 4.5	4.5 5.0 5.5
	Segregations:		Nil	Nil	Nil	Nil

OPEN CUT 3 continued

Site No:			25	26	27	42
Coordinates (AGD 66)		E N	763794 6416390	764037 6415646	764559 6415161	762103 6416931
Landform Element:			Hill Slope	Hill Slope	Hill Slope	Hill Slope
Aspect:			West	West	West	East
Run on:			High	High	Moderate	Moderate
Run off:			Moderate	Moderate	Low	Moderate
Profile Drainage:			well drained	poorly drained	imperfectly drained	Moderately well drained
Site Disturbance:			extensive clearing	occasional cultivation	extensive clearing	extensive clearing
Landuse:			Improved pasture	volun./native pasture	Improved pasture	Improved pasture
Slope:			6%	4%	5%	4%
Surface Condition:			Firm	Firm	Firm	Firm
Erosion Hazard:	Type:		Moderate	High	Moderate	Moderate
	Degree:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Nil	Nil	Nil	Nil
Rock Outcrop:			<2%	<2%	Nil	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Salinity Evident	Nil	Nil
Soil Classification:			Red Podzolic Dr 3.31	Yellow Podzolic Dy 3.22	Earthy Sand Uc 1.23	Red Podzolic Dr 3.33
Horizon:	Depth:		A1 0 - 0.2 A2 0.2 - 0.55 B 0.55 - 1 +	A1 0 - 0.2 A2 0.2 - 0.4 B 0.4 - 1 +	A1 0 - 0.2 A2 0.2 - 0.9 B 0.9 - 1 +	A1 0 - 0.2 A2 0.2 - 0.4 B 0.4 - 1 +
	Boundary:		abrupt abrupt	sharp sharp	gradual Gradual	abrupt abrupt
	Colour:		10YR 3/3 wet 10YR 6/3 wet 7.5YR 6/8 wet	10YR 3/3 wet 10YR 5/3 wet 7.5YR 5/8 wet	10YR 4/3 wet 10YR 7/2 wet	10YR 3/3 wet 10YR 6/3 wet 7.5YR 5/8 wet
	Mottles:		orange (20% - 50%)	orange (10% - 20%)		Orange (2% - 10%)
	Texture:		sandy loam loamy sand sandy clay	silty loam sandy loam sandy clay	loam sandy loam sandy clay	loam clay loam clay
	Coarse Fragments:		Nil Yes (5% - 10%) Nil	Nil Yes (5%-10%) Nil	Nil Yes (5%-10%) Nil	Nil Yes (5% - 10%) Nil
	Structure:		Weak Pedality Weak Pedality Strong Pedality	Massive Weak Pedality Strong Pedality	Single Grained Single Grained Single Grained	Weak Pedality Weak Pedality Strong Pedality
	Dominant Ped Shape:		Granular Platy Sub angular blocky	Crumb Polyhedral Sub angular blocky	Granular Granular Granular	Granular Platy Sub angular blocky
	Consistency:		Loose Moderately Weak Moderately Firm	Very weak Very weak Moderately firm	Very weak Very Weak Very Weak	Loose Moderately Weak Moderately Firm
	Field pH:		4.5 6.0 4.5	5.5 6.0 4.5	5.5 5.0 4.5	5.0 6.0 7.0
	Segregations:		Nil	Nil	Nil	Nil

OPEN CUT 3 continued

Site No:			43	44	46	47
Coordinates (AGD 66)		E N	761644 6417315	761129 6417288	762276 6417629	762224 6417915
Landform Element:			Hill Slope	Hill Slope	Hill Crest	Valley Flat
Aspect:			East	West	East	East
Run on:			Moderate	High	Low	Moderate
Run off:			Low	High	Moderate	Low
Profile Drainage:			imperfectly drained	Moderately well drained	Moderately well drained	Moderately well drained
Site Disturbance:			extensive clearing	occasional cropping	extensive clearing	extensive clearing
Landuse:			Improved pasture	cropping	Improved pasture	Improved pasture
Slope:			4%	3%	4%	1%
Surface Condition:			Firm	Firm	Firm	Firm
Erosion Hazard:	Type:		moderate	Very High	High	High
	Degree:		Rill / Gully	Rill / Gully	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Yes	Nil	Nil	Nil
Rock Outcrop:			Nil	Nil	Nil	Nil
Groundwater Depth:			Nil	Nil	Nil	Nil
Salinity Evidence:			Nil	Nil	Salinity Evident	Nil
Soil Classification:			Yellow Podzolic Dy 3.33	Yellow Podzolic Dy 3.36	Red Podzolic Dr 3.41 (ancient Stream)	Alluvial Um 5.22
Horizon:	Depth:		A1 0 - 0.15 A2 0.15 - 0.4 B 0.4 - 8.05 refusal	A1 0 - 0.2 A2 0.2 - 0.55 B 0.55 - 1 +	A1 0 - 0.1 A2 0.1 - 0.45 B 0.45 - 1 +	A1 0 - 0.25 A2 0.25 - 0.75 A3 0.75 - 1 +
	Boundary:		abrupt abrupt	abrupt abrupt	abrupt abrupt	clear gradual
	Colour:		10YR 5/8 wet 10YR 7/6 wet 10YR 6/8 wet	10YR 3/4 wet 10YR 6/6 wet 10YR 5/8 wet	10YR 5/3 wet 10YR 7/4 wet 5YR 5/8 wet	7.5YR 3/4 wet 7.5YR 4/6 wet 7.5YR 5/6 wet
	Mottles:		yellow (10% - 20%)	red (10% - 20%)	Orange (10% - 20%)	
	Texture:		silty loam sandy loam silty clay	silty loam sandy loam clay	sandy loam loamy sand clay	loam sandy loam sandy loam
	Coarse Fragments:		Nil Yes (5%-10%) Nil	Nil Yes (5%-10%) Nil	Yes (10% - 20%) Yes (20%-50%) Nil	Nil Yes (5% - 10%) Yes (10%- 20%)
	Structure:		Massive Weak Pedality Strong Pedality	Massive Weak Pedality Strong Pedality	Massive Massive Moderate Pedality	Massive Massive Massive
	Dominant Ped Shape:		Crumb Polyhedral Sub angular blocky	Crumb Polyhedral Sub angular blocky	Crumb Granular Sub angular blocky	Crumb Crumb Crumb
	Consistency:		Very weak Very weak Moderately firm	Very weak Very weak Moderately firm	Loose Loose Moderately firm	Very weak Very weak Very weak
	Field pH:		4.5 5.0 7.5	5.5 6.0 6.0	5.5 4.5 4.5	6.0 6.5 5.5
	Segregations:		Nil	Nil	Nil	Nil

OPEN CUT 3 continued

Site No:			48	49	45
Coordinates (AGD 66)		E N	761783 6418186	761744 6417805	762111 6418439
Landform Element:			Hill Slope	Valley flat	Hill slope
Aspect:			East	West	east
Run on:			Moderate	Moderate	Low
Run off:			Low	Low	Moderate
Profile Drainage:			poorly drained	Moderately well drained	imperfectly drained
Site Disturbance:			extensive clearing	occasional cultivation	Limited clearing
Landuse:			Improved pasture	cropping	Improved pasture
Slope:			4%	1%	4%
Surface Condition:			Firm	soft	Hardset
Erosion Hazard:	Type:		High	High	High
	Degree:		Rill / Gully	Rill / Gully	Rill / Gully
Surface Coarse Fragments:			Nil	Nil	Nil
Rock Outcrop:			Nil	2 – 10%	Nil
Groundwater Depth:			Nil	Nil	Nil
Salinity Evidence:			Salinity Evident	Nil	Nil
Soil Classification:			Red Podzolic Dr 2.31	Earthy Sand Uc 5.22	Shallow Soils (Lithosol)
Horizon:	Depth:		A1 0 -0.15 A2 0.15 - 0.30 refusal	A1 0 - 0.15 A2 0.15 - 0.45 B 0.45 - 0.7 refusal	A1 0 – 0.2 A2 0.2 – 0.8 A3 0.8 – 1 +
	Boundary:		abrupt	abrupt abrupt	clear gradual
	Colour:		10YR 3/3 wet 10YR 3/4 wet	10YR 5/4 wet 10YR 7/3 wet 2.5Y 7/2 wet	7.5YR 4/4 wet 7.5YR 5/8 wet 10YR 5/8 wet
	Mottles:		Red		Red
	Texture:		loam loam	loam sandy loam sandy clay	silty loam sandy clay loam clay loam sandy
	Coarse Fragments:		Nil Yes (5% - 10%) Nil	Nil Yes (5%-10%) Nil	Yes (20% - 50%) Yes (10% - 20%) Nil
	Structure:		Weak Pedality Weak Pedality Strong Pedality	Single Grained Single Grained Single Grained	Massive Massive Weak Pedality
	Dominant Ped Shape:		Granular Platy Sub angular blocky	Granular Granular Granular	Crumb Crumb Sub angular blocky
	Consistency:		Loose Moderately Weak Moderately Firm	Very weak Very Weak Very Weak	Loose Moderately Weak Moderately Firm
	Field pH:		5.0 5.5	5.0 5.5 5.5	5.5 6.0 6.5
	Segregations:		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	2, 4, 11, 19, 20 23, 24,34 Yellow Podzolic Bleached A2		
Depth	cm	0 - 10	10 - 35	35 - 100
Soil Texture		Silty Loam	Silty Loam	Sandy Clay
pH_{CaCl}		5.7	5.6	5.7
pH_{H2O}		6.2	6.3	6.7
C	%	1.08	0.38	0.17
N	mg/kg	7	4	6
S	mg/kg	4.9	2.9	5.9
P (Colwell)	mg/kg	14	3	2
PBI		37.2	19.8	38.9
K	meq/100g	0.47	0.18	0.25
Ca	meq/100g	0.25	1.25	1.37
Mg	meq/100g	0.55	0.44	0.49
Al	meq/100g	0.1	0.04	0.04
Na	meq/100g	0.04	0.05	0.06
Cl	mg/kg	7	7	21
Cu	mg/kg	0.95	0.69	0.81
Zn	mg/kg	1.18	0.27	0.39
Mn	mg/kg	31.92	7.66	2.57
Fe	mg/kg	905	352	535
B	mg/kg	0.3	0.2	0.2
EC	dS/m	0.05	0.01	0.04

Calculations				
CEC	meq/100g	1.41	1.96	2.21
Ca/Mg Ratio		0.45	2.84	2.80
EC_{se}	dS/m	0.48	0.10	0.30
Al Saturation	%	7.09%	2.04%	1.81%
ESP	%	2.84%	2.55%	2.71%
Exch K	%	33.33%	9.18%	11.31%
Exch Ca	%	17.73%	63.78%	61.99%
Exch Mg	%	39.01%	22.45%	22.17%

Particle Size Analysis				
Clay	%	10%	8%	30%
Silt	%	13%	15%	9%
Fine Sand	%	29%	30%	21%
Coarse Sand	%	44%	36%	32%
Gravel	%	4%	11%	8%

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

Parameter	Units	8, 5, 14, 15, 26, 36, 37, 40, 43, 44 Yellow Podzolic Unbleached A2		
Depth	cm	0 - 10	10 - 35	35 - 100
Soil Texture		Loam	Silty Loam	Clay
pH_{CaCl}		4.8	5.1	5.7
pH_{H2O}		5.8	6.2	6.7
C	%	1.75	0.64	0.32
N	mg/kg	9	5	3
S	mg/kg	5.8	5.7	12.1
P (Colwell)	mg/kg	18	5	3
PBI		69.9	34.3	66.1
K	meq/100g	0.51	0.26	0.45
Ca	meq/100g	4.12	2.21	2.7
Mg	meq/100g	0.12	0.89	4.16
Al	meq/100g	0.03	0.01	0
Na	meq/100g	0.11	0.13	0.39
Cl	mg/kg	11	9	29
Cu	mg/kg	0.98	0.8	1.07
Zn	mg/kg	2.2	0.59	0.47
Mn	mg/kg	23.87	7.45	4.16
Fe	mg/kg	1624	787	753
B	mg/kg	0.5	0.3	0.4
EC	dS/m	0.03	0.02	0.06

Calculations				
CEC	meq/100g	4.89	3.5	7.7
Ca/Mg Ratio		34.33	2.48	0.65
EC_{se}	dS/m	0.29	0.19	0.35
Al Saturation	%	0.61%	0.29%	0.00%
ESP	%	2.25%	3.71%	5.06%
Exch K	%	10.43%	7.43%	5.84%
Exch Ca	%	84.25%	63.14%	35.06%
Exch Mg	%	2.45%	25.43%	54.03%

Particle Size Analysis				
Clay	%	16%	15%	29%
Silt	%	16%	12%	10%
Fine Sand	%	31%	31%	20%
Coarse Sand	%	33%	31%	35%
Gravel	%	4%	11%	6%

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

Parameter	Units	6, 7, 13, 16 Red Podzolic		
Depth	cm	0 - 10	10 - 35	35 - 100
Soil Texture		Loam	Loam	Clay
pH_{CaCl}		5.2	4.7	4.5
pH_{H2O}		6.1	5.7	5.9
C	%	1.16	1.06	0.48
N	mg/kg	6	3	1
S	mg/kg	2.9	2.7	3
P (Colwell)	mg/kg	5	9	2
PBI		34.2	58.3	107.4
K	meq/100g	0.52	0.46	0.56
Ca	meq/100g	5.2	3.83	1.57
Mg	meq/100g	0.91	1.32	10.38
Al	meq/100g	0.02	0.06	0.25
Na	meq/100g	0.03	0.07	0.64
Cl	mg/kg	4	8	24
Cu	mg/kg	0.53	0.68	1.65
Zn	mg/kg	1.03	0.25	0.88
Mn	mg/kg	14.99	7.9	1.45
Fe	mg/kg	587	571	986
B	mg/kg	0.3	0.3	0.4
EC	dS/m	0.01	0.01	0.03

Calculations				
CEC	meq/100g	6.68	5.74	13.4
Ca/Mg Ratio		5.71	2.90	0.15
EC_{se}	dS/m	0.10	0.10	0.17
Al Saturation	%	0.30%	1.05%	1.87%
ESP	%	0.45%	1.22%	4.78%
Exch K	%	7.78%	8.01%	4.18%
Exch Ca	%	77.84%	66.72%	11.72%
Exch Mg	%	13.62%	23.00%	77.46%

Particle Size Analysis				
Clay	%	8%	12%	60%
Silt	%	14%	11%	17%
Fine Sand	%	25%	18%	16%
Coarse Sand	%	38%	23%	7%
Gravel	%	15%	36%	0%

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

Parameter	Units	1, 25, 42, 48, 50 Red Podzolic		
Depth	cm	0 - 10	10 - 35	35 - 100
Soil Texture		Loam	Silty Loam	Clay
pH_{CaCl}		4.9	7.4	6
pH_{H2O}		5.8	7.9	6.5
C	%	2.01	0.43	0.37
N	mg/kg	11	4	4
S	mg/kg	4.9	4	9.3
P (Colwell)	mg/kg	17	2	2
PBI		46.2	49.1	96.3
K	meq/100g	0.64	0.28	0.49
Ca	meq/100g	5.02	5.4	6.08
Mg	meq/100g	1.05	1.16	3.75
Al	meq/100g	0.09	0	0
Na	meq/100g	0.06	0.05	0.3
Cl	mg/kg	15	7	20
Cu	mg/kg	0.86	0.46	0.98
Zn	mg/kg	1.92	0.24	0.36
Mn	mg/kg	39.37	3.33	4.94
Fe	mg/kg	777	470	683
B	mg/kg	0.4	0.2	0.4
EC	dS/m	0.03	0.13	0.1

Calculations				
CEC	meq/100g	6.86	6.89	10.62
Ca/Mg Ratio		4.78	4.66	1.62
EC_{se}	dS/m	0.29	1.24	0.75
Al Saturation	%	1.31%	0.00%	0.00%
ESP	%	0.87%	0.73%	2.82%
Exch K	%	9.33%	4.06%	4.61%
Exch Ca	%	73.18%	78.37%	57.25%
Exch Mg	%	15.31%	16.84%	35.31%

Particle Size Analysis				
Clay	%	16%	26%	47%
Silt	%	17%	16%	15%
Fine Sand	%	33%	24%	19%
Coarse Sand	%	29%	24%	17%
Gravel	%	5%	10%	2%

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

Parameter	Units	32 Earthy Sand	
Depth	cm	0 – 25*	25 – 100*
Soil Texture		Sand	Loam Sand
pH_{CaCl}		4.5	4.7
pH_{H2O}		5.4	5.6
C	%	0.2	0.08
N	mg/kg	1	1
S	mg/kg	1.4	1.9
P (Colwell)	mg/kg	4	2
PBI		16.1	25.4
K	meq/100g	0.04	0.03
Ca	meq/100g	0.28	0.15
Mg	meq/100g	0.12	0.12
Al	meq/100g	0.02	0.07
Na	meq/100g	0.01	0.02
Cl	mg/kg	2	2
Cu	mg/kg	0.39	0.38
Zn	mg/kg	0.21	0.11
Mn	mg/kg	3.69	1.94
Fe	mg/kg	18.13	10.15
B	mg/kg	0.2	0.2
EC	dS/m	0.01	0.01
Calculations			
CEC	meq/100g	0.47	0.39
Ca/Mg Ratio		2.33	1.25
ESP	%	2.13%	5.13%
EC_{se}	dS/m	0.23	0.14
Al Saturation	%	4.26%	17.95%
Exch K	%	8.51%	7.69%
Exch Ca	%	59.57%	38.46%
Exch Mg	%	25.53%	30.77%
Exch Na	%	2.13%	5.13%
Particle Size Analysis			
Clay	%	4%	5%
Silt	%	3%	5%
Fine Sand	%	12%	24%
Coarse Sand	%	75%	50%
Gravel	%	6%	16%
Emerson Aggregate Test (EAT)		8/3(1)	3(1)

* 3 Horizons were identified in the sand soil profile however due to the poor characteristics of these soils for rehabilitation the A2 horizon was bulked into the A3 horizon for chemical testing.

Parameter	Units	46 Red Podzolic (Palaeo Channel)		
Depth	cm	0 - 10	10 - 35	35 - 100
Soil Texture		Sandy Loam	Loamy Sand	Clay
pH_{CaCl}		4.5	5.1	4.2
pH_{H2O}		5.3	5.9	5.4
C	%	1.13	0.22	0.38
N	mg/kg	5	2	1
S	mg/kg	2.4	3	7.5
P (Colwell)	mg/kg	10	4	2
PBI		35.2	28.1	119.2
K	meq/100g	0.15	0.06	0.16
Ca	meq/100g	0.8	0.53	0.57
Mg	meq/100g	0.23	0.37	5.17
Al	meq/100g	0.3	0.07	0.73
Na	meq/100g	0.02	0.07	0.4
Cl	mg/kg	3	8	18
Cu	mg/kg	0.5	0.4	0.57
Zn	mg/kg	0.31	0.14	0.2
Mn	mg/kg	7.14	4.1	4.44
Fe	mg/kg	486	752	1212
B	mg/kg	0.2	0.2	0.4
EC	dS/m	0.01	0.01	0.02

Calculations				
CEC	meq/100g	1.5	1.1	7.03
Ca/Mg Ratio		3.48	1.43	0.11
EC_{se}	dS/m	0.14	0.10	0.12
Al Saturation	%	20.00%	6.36%	10.38%
ESP	%	1.33%	6.36%	5.69%
Exch K	%	10.00%	5.45%	2.28%
Exch Ca	%	53.33%	48.18%	8.11%
Exch Mg	%	15.33%	33.64%	73.54%

Particle Size Analysis				
Clay	%	7%	4%	50%
Silt	%	3%	5%	2%
Fine Sand	%	35%	19%	16%
Coarse Sand	%	36%	29%	28%
Gravel	%	19%	43%	4%

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

Parameter	Units	54, 64 Yellow Podzolic (Saline)		
Depth	cm	0 - 10	10 - 30	30 - 100
Soil Texture		Loam	Clay loam	Sandy Clay
pH_{CaCl}		5.9	6.6	6.6
pH_{H2O}		7	8.1	7.4
C	%	1.48	0.21	0.16
N	mg/kg	3	1	1
S	mg/kg	11.8	11.2	108
P (Colwell)	mg/kg	6	3	4
PBI		55.1	24.7	71.3
K	meq/100g	0.39	0.14	0.32
Ca	meq/100g	2.48	0.65	1.12
Mg	meq/100g	6.44	2.1	7.6
Al	meq/100g	0	0	0
Na	meq/100g	1.01	0.68	4.36
Cl	mg/kg	59	39	487
Cu	mg/kg	0.83	0.52	0.79
Zn	mg/kg	0.86	0.16	0.46
Mn	mg/kg	41.92	19.2	7.36
Fe	mg/kg	2508	688	906
B	mg/kg	0.3	0.2	0.2
EC	dS/m	0.09	0.05	0.59

Calculations				
CEC	meq/100g	10.32	3.57	13.4
Ca/Mg Ratio		0.39	0.31	0.15
EC_{se}	dS/m	0.86	0.43	4.43
Al Saturation	%	0.00%	0.00%	0.00%
ESP	%	9.79%	19.05%	32.54%
Exch K	%	3.78%	3.92%	2.39%
Exch Ca	%	24.03%	18.21%	8.36%
Exch Mg	%	62.40%	58.82%	56.72%

Particle Size Analysis				
Clay	%	18%	11%	33%
Silt	%	28%	18%	14%
Fine Sand	%	26%	21%	24%
Coarse Sand	%	26%	45%	22%
Gravel	%	2%	5%	7%

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

Parameter	Units	18, 21, 45 Palaeo Channel Shallow Soils		
Depth	cm	0 - 10	10 - 35	35 - 100
Soil Texture		Sandy loam	Sandy loam	Sandy Clay
pH_{CaCl}		4.5	4.7	4.8
pH_{H2O}		5.3	5.6	5.8
C	%	1.82	0.31	0.33
N	mg/kg	3	1	3
S	mg/kg	8.9	4.4	20.4
P (Colwell)	mg/kg	5	2	3
PBI		46.6	25.6	67.9
K	meq/100g	0.2	0.13	0.32
Ca	meq/100g	1.46	0.44	0.74
Mg	meq/100g	0.8	0.65	7.25
Al	meq/100g	0.12	0.09	0.09
Na	meq/100g	0.13	0.06	0.83
Cl	mg/kg	43	11	72
Cu	mg/kg	0.42	0.42	0.78
Zn	mg/kg	0.53	0.24	0.56
Mn	mg/kg	15.25	3.27	4.46
Fe	mg/kg	1506	742	691
B	mg/kg	0.3	0.2	0.3
EC	dS/m	0.03	0.01	0.09

Calculations				
CEC	meq/100g	2.71	1.37	9.23
Ca/Mg Ratio		1.83	0.68	0.10
EC_{se}	dS/m	0.42	0.14	0.68
Al Saturation	%	4.43%	6.57%	0.98%
ESP	%	4.80%	4.38%	8.99%
Exch K	%	7.38%	9.49%	3.47%
Exch Ca	%	53.87%	32.12%	8.02%
Exch Mg	%	29.52%	47.45%	78.55%

Particle Size Analysis				
Clay	%	6%	12%	59%
Silt	%	4%	8%	2%
Fine Sand	%	25%	27%	9%
Coarse Sand	%	39%	42%	29%
Gravel	%	26%	11%	1%

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

Parameter	Units	3 , 47 Alluvial		
Depth	cm	0 - 30	30 - 60	60 - 100
Soil Texture		Sandy loam	Silty Loam	Sandy Clay
pH_{CaCl}		4.8	5.8	6.4
pH_{H2O}		5.5	6.8	7.2
C	%	2.13	0.38	0.13
N	mg/kg	11	3	2
S	mg/kg	5.4	3.9	19
P (Colwell)	mg/kg	21	5	4
PBI		52.1	39.9	33.4
K	meq/100g	0.81	0.38	0.28
Ca	meq/100g	4.22	3.94	2.68
Mg	meq/100g	1.21	1.34	1.53
Al	meq/100g	0.06	0	0
Na	meq/100g	0.14	0.19	0.65
Cl	mg/kg	111	20	148
Cu	mg/kg	0.97	0.84	0.65
Zn	mg/kg	2.43	0.41	0.28
Mn	mg/kg	44.18	23.49	8.35
Fe	mg/kg	1150	854	494
B	mg/kg	0.4	0.3	0.2
EC	dS/m	0.14	0.01	0.16

Calculations				
CEC	meq/100g	6.44	5.85	5.14
Ca/Mg Ratio		3.49	2.94	1.75
EC_{se}	dS/m	1.96	0.10	1.20
Al Saturation	%	0.93%	0.00%	0.00%
ESP	%	2.17%	3.25%	12.65%
Exch K	%	12.58%	6.50%	5.45%
Exch Ca	%	65.53%	67.35%	52.14%
Exch Mg	%	18.79%	22.91%	29.77%

Particle Size Analysis				
Clay	%	15%	15%	17%
Silt	%	14%	15%	12%
Fine Sand	%	27%	36%	26%
Coarse Sand	%	38%	27%	34%
Gravel	%	6%	7%	11%

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

Parameter	Units	10, 22, 27,39, 41, 49 Earthy Sands		
Depth	cm	0 - 25	25 - 75	75 - 100
Soil Texture		Silty Loam	Sandy Loam	Loamy Sand
pH_{CaCl}		4.6	4.8	4.6
pH_{H2O}		5.5	6	5.9
C	%	1.28	0.29	0.23
N	mg/kg	5	3	3
S	mg/kg	3.9	2.5	3.9
P (Colwell)	mg/kg	7	2	2
PBI		44.7	21	30.2
K	meq/100g	0.32	0.15	0.16
Ca	meq/100g	2.42	1.02	1.2
Mg	meq/100g	0.89	0.66	1.18
Al	meq/100g	0.1	0.08	0.08
Na	meq/100g	0.1	0.14	0.17
Cl	mg/kg	15	11	12
Cu	mg/kg	0.7	0.53	0.55
Zn	mg/kg	1.44	0.34	0.22
Mn	mg/kg	14.02	5.54	5.19
Fe	mg/kg	1450	698	834
B	mg/kg	0.2	0.2	0.3
EC	dS/m	0.02	0.01	0.01

Calculations				
CEC	meq/100g	3.83	2.05	2.79
Ca/Mg Ratio		2.72	1.55	1.02
EC_{se}	dS/m	0.19	0.14	0.23
Al Saturation	%	2.61%	3.90%	2.87%
ESP	%	2.61%	6.83%	6.09%
Exch K	%	8.36%	7.32%	5.73%
Exch Ca	%	63.19%	49.76%	43.01%
Exch Mg	%	23.24%	32.20%	42.29%

Particle Size Analysis				
Clay	%	9%	9%	10%
Silt	%	7%	8%	11%
Fine Sand	%	30%	29%	29%
Coarse Sand	%	51%	46%	43%
Gravel	%	3%	8%	7%

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

Parameter	Units	28, 29, 30, 31, 33, 35, 38 Yellow Solodic Soils		
Depth	cm	0 - 10	10 - 35	35 - 100
Soil Texture		Loam	Silty Loam	Clay
pH_{CaCl}		4.7	5.1	4.8
pH_{H2O}		5.7	6.4	6.2
C	%	2.11	0.43	0.49
N	mg/kg	9	2	2
S	mg/kg	5.7	4.4	9.1
P (Colwell)	mg/kg	3	2	23
PBI		57.9	29	55.8
K	meq/100g	0.71	0.28	0.62
Ca	meq/100g	6.55	2.304	3.3
Mg	meq/100g	2.17	1.37	6.55
Al	meq/100g	0.06	0.04	0
Na	meq/100g	0.14	0.3	0.7
Cl	mg/kg	18	22	52
Cu	mg/kg	0.7	0.68	0.98
Zn	mg/kg	1.07	0.26	0.51
Mn	mg/kg	13.68	5.55	11.82
Fe	mg/kg	1271	729	574
B	mg/kg	0.4	0.2	0.6
EC	dS/m	0.02	0.02	0.06

Calculations				
CEC	meq/100g	9.63	4.294	11.17
Ca/Mg Ratio		3.02	1.68	0.50
EC_{se}	dS/m	0.19	0.19	0.35
Al Saturation	%	0.62%	0.93%	0.00%
ESP	%	1.45%	6.99%	6.27%
Exch K	%	7.37%	6.52%	5.55%
Exch Ca	%	68.02%	53.66%	29.54%
Exch Mg	%	22.53%	31.90%	58.64%

Particle Size Analysis				
Clay	%	11%	13%	39%
Silt	%	10%	12%	9%
Fine Sand	%	23%	26%	21%
Coarse Sand	%	48%	38%	27%
Gravel	%	8%	11%	4%

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