


Appendix J

Soil Survey and Land Resource Assessment

FINAL REPORT

Drayton Mine Extension EA:

Soil Survey and Land Resource Assessment Report

Prepared for:
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GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Drayton Mine Extension EA

Soil Survey and Land Resource Assessment Report

Prepared for **Hansen Bailey Consulting**

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1.0 INTRODUCTION

1.1 Objectives

GSS Environmental (GSSE) was commissioned by Hansen Bailey to undertake a land resource assessment, with respect to soils, rural land capability and agricultural suitability classification, for a proposed open-cut extension at Anglo Coal Drayton Mine (Drayton). This land resource assessment is being undertaken as part of a larger Environmental Assessment (EA). The EA is being prepared by Hansen Bailey to accompany a Project Application to the NSW Department of Planning (DoP) for the proposed mine extension. As part of the proposed extension, the area will be subject to substantial ground disturbance resulting from extended operations, such as topsoil stripping, drilling and blasting, and high-wall advancement.

The proposed disturbance is located in three separate areas. These areas are North Pit, East Pit and South Pit. These areas will be referred to collectively as the 'study areas'. The study areas are described further in **Section 1.2** of this report. A location plan is presented as **Figure 1**. To assist with management of topsoil reserves and planning for post-mining rural land capability, a field survey of soil material in the study area and classification of pre-mining rural land capability was undertaken by GSSE. The major objectives of this assessment include:

1. To describe and classify soils within the study areas;

2. Analyse the identified soil units to assess their suitability for salvage and re-use as topsoil/growth media in future land rehabilitation projects;

3. Identify pre-mining rural land capability and agricultural suitability classes to assist with post-mining rehabilitation planning; and

4. Identify any potentially adverse soil materials requiring special management during rehabilitation of post-disturbance areas.

The following report presents the results of the field survey undertaken by GSSE and the assessment of soil resources within the survey areas. A glossary of commonly used soils terms is presented in **Appendix 1**.

1.2 Location

Drayton is located in the Upper Hunter Valley, 13 kilometres (km) South of Muswellbrook. The proposed area of disturbance comprises three separate study areas, namely; North Pit, East Pit and South Pit. All three study areas are located within the existing Drayton Mining Leases (ML).

North Pit study area is located at the Northern end of Drayton and is bounded to the East by the Drayton rail loop, to the South by Drayton open-cut operations and to the West by Mt Arthur Coal mine. Thomas Mitchell Drive traverses the Northern boundary of the North Pit study area.

The North Pit study area is approximately 1200 metres (m) East to West and 900 m North to South, and encompasses approximately 78 ha.

East Pit study area is located in the central Eastern section of Drayton. It is bounded to the North by rehabilitated land, to the West and South by Drayton mining operations, and to the East by Liddell Power Station land, including the Liddell Ash Dam and an overland conveyor. The East Pit study area is approximately 1100 m East to West and 1600 m North to South, and encompasses approximately 83 ha.

The South Pit study area is located in the South of Drayton. It is bounded to the North by Drayton mining operations, to the East by Liddell Power Station land and an overland conveyor, to the West by Mt Arthur Coal ML and to the South by grazing land. The Study area is approximately 2500 m East to West and 1100 m North to South, and encompasses approximately 228 ha.

The Hunter Valley region contains extensive coal resources at depth. Other coal operations in the district include Mt Arthur Coal (BHP Billiton) to the West, Bengalla Mine (Bengalla Mining Company) approximately 18 km North-west, and Hunter Valley Operations (Rio Tinto Coal Australia) approximately 18 km South-east. Liddell and Bayswater Power Stations (Macquarie Generation) are also located adjacent to the Eastern boundary. Other major surface land uses in the region include beef and dairy cattle grazing, vineyards, horse studs, as well as small areas of cropping along the Hunter River alluvial plains to the South.

1.3 Topography, Landuse and Vegetation

As the study areas are proposed extensions of an existing open-cut mining operation, the topography and drainage in all three areas have been substantially modified by mining activities. Over 50% of the natural landform within the Northern and Eastern study areas has been altered through mining. The Southern study area is less impacted by previous mining and a greater proportion of the natural landform remains relatively undisturbed. Most of the native vegetation within the study areas has been cleared and replaced with pasture species as a result of grazing, which was the dominant pre-mining land use within the area.

North Pit

The North Pit study area consists mainly of mining disturbed ground, including a haul road and embankment, process waste emplacement, open-cut pit and overburden dumps. As a result, little of the natural topography still remains. The land in the North-eastern quarter of the study area is however relatively undisturbed and is comprised of a small area of relatively flat ground that slopes gently to Ramrod Creek, which traverses the area from South-east to North-west. Surface run-off from this undisturbed landform drains to Ramrod Creek, which then flows into the Hunter River South-west of Muswellbrook.

Although most of the native vegetation has been cleared, scattered eucalypts, casuarinas and acacias cover the undisturbed sections of the study area. The South-western third of this undisturbed area has also been revegetated with eucalypt species which have grown to approximately 8-12 m in height and form an open canopy throughout this limited area.

Riparian grasses and sedges dominate the banks and limited alluvial plain associated with Ramrod Creek. A small area of remnant woodland covers the North-eastern corner of the study area, adjacent to the product stockpiles. This vegetation consists of tall open forest, dominated by Eucalypt and Casuarina species, with an open understorey dominated by native and introduced pasture species. For further detail on vegetation, refer to **Appendix F** ″Drayton Extension, Flora & Fauna Assessment″ by Hansen Bailey (2006).

East Pit

This study area is dominated by the advancing open-cut pit, and less than 25% of the natural landform remains undisturbed by mining. The undisturbed landform consists of a small area of moderately sloping land, up to 200 m wide, which drops towards a drainage line, formerly part of Bayswater Creek that would naturally drain the area to the South-east. This creek has been blocked in the South-east by the Liddell Ash Dam wall.

The majority of the native vegetation within the study area has been cleared for mining and grazing purposes. A narrow corridor of eucalypts and casuarinas follows the banks of the drainage line, otherwise the study area consists mainly of Rhodes grass-Couch-Kikuyu open grassland community with the occasional scattered eucalypt. For further detail on vegetation present, refer to **Appendix F** ″Drayton Extension, Flora & Fauna Assessment″ by Hansen Bailey (2006).

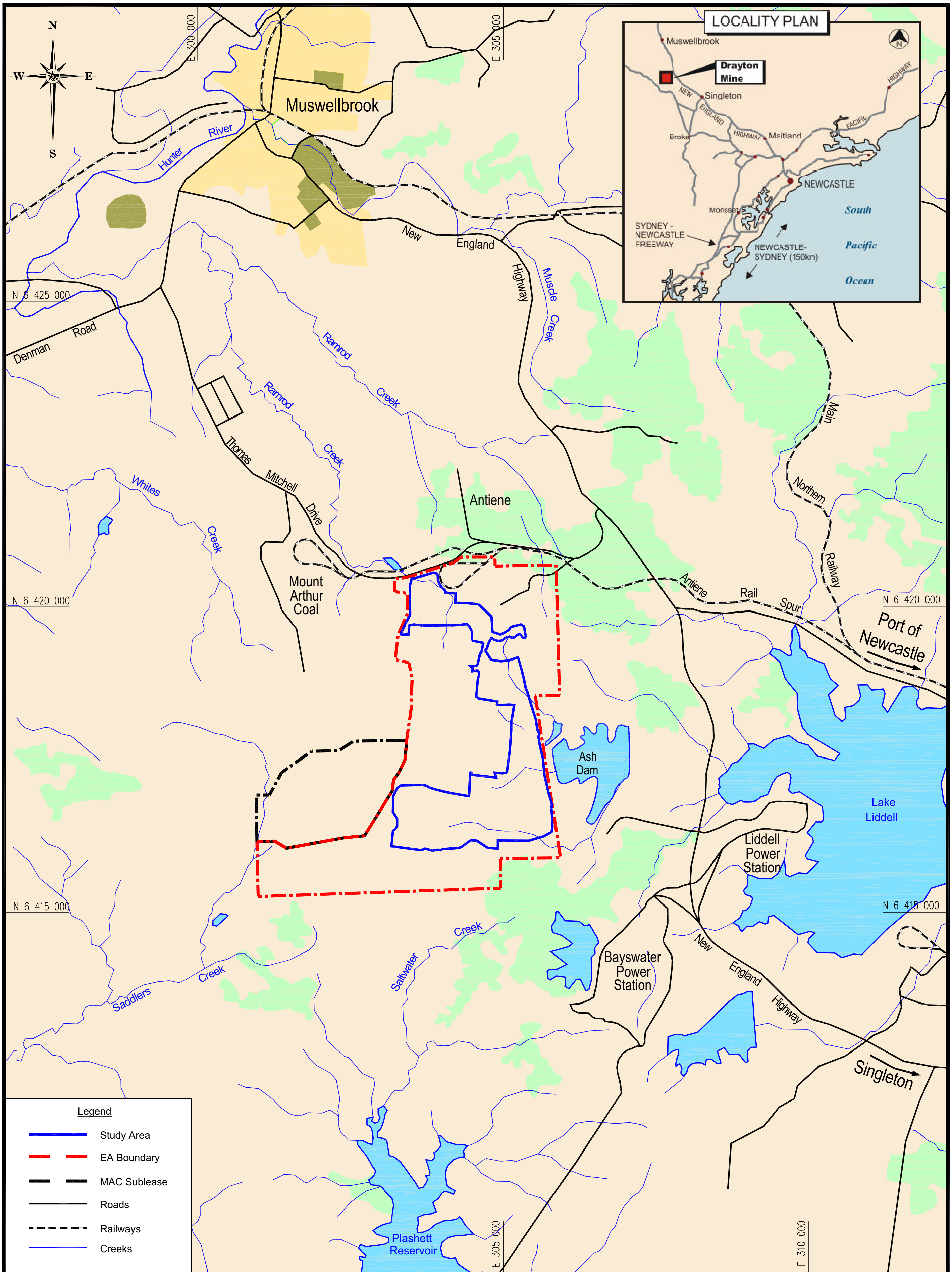
Two areas of reshaped and revegetated landform comprise the North-eastern corner of the study area. These reshaped landforms typically consist of relatively uniforms slopes of approximately 10^{o} with vegetation dominated by Rhodes grass-Couch-Kikuyu open grassland community.

South Pit

The South Pit study area is dominated by a low rounded hill (Rocky Knob) situated in the West of the area, and a spurline that descends gently to the East. The hill ranges in height from 310 m at the crest to 180 m at the East of the site, with relatively steep upper slopes that flatten into undulating footslopes in the East of the study area. The Northern slope of the spurline is steep and generally forms the Northern boundary of the study area. Mining related disturbance, consisting mainly of haul roads and advancing mining operations, is also generally confined to the area North of this steep slope. A deeply incised drainage line, flowing towards the East, parallels the South side of the spurline. Surface run-off from the majority of the study area flows into this drainage line, which discharges into the Liddell Ash Dam. An earthen wall has been constructed across this drainage line approximately halfway down the slope to form Delpah Dam. This dam wall has been battered and revegetated with grass species.

With the exception of the steep slope on the Northern boundary of the study area which still retains some scattered eucalypts, almost the entire study area has been cleared of native vegetation and is now dominated by pasture grass species. A narrow riparian corridor, dominated by sedgeland-grassland species such as Spiky Rush and Common Reed, is associated with the lower reaches of the dominant drainage line below Delpah Dam.

Scattered canopy trees such as Grey-box Eucalypts and Rough-barked Apple were also present along the riparian corridor. A small area of reshaped and revegetated landform is integrated into the Southern slopes of the hill in the West of the study area. The reshaped landform is generally moderately sloping, with vegetation dominated by pasture grass species. Two revegetated bands of trees have also been established on the hill, one near the hillcrest and another on the steep Northern midslopes.



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Drayton Mine
Site Location Plan

Figure 1

0 3km

2.0 LAND RESOURCE SURVEY METHODOLOGY

2.1 Introduction

A soil survey and land capability assessment was undertaken to identify and characterise land resources within the Drayton study areas. The field component of the survey was conducted during July 2006.

2.2 Mapping

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

1) Aerial photographs and topographic maps

Aerial photo and topographic map interpretation was used as a remote sensing technique, allowing detailed analysis of the landscape and mapping of features related to the distribution of soils within the survey areas.

2) Previous soil survey results

A survey of the region (including the areas surveyed in this assessment) was undertaken by Kovac and Lawrie (1991) at a scale of 1:250,000. The survey map and report present a broadscale guide to the soil and landscape unit distribution in the upper Hunter Valley Region, and provides a framework for more detailed surveys. The survey identified the Liddell (ld) soil landscape unit as the dominant landscape unit covering the Drayton study areas. However, observations recorded during the field survey indicated that the South Pit study area was more likely associated with the Brays Hill (br) soil landscape unit.

A soil survey conducted as part of a previous Drayton EIS (HLA Envirosciences, 2002) was also reviewed. This survey was based on field investigations conducted on an area that largely overlapped with the East Pit study area and the North-eastern part of the South Pit study area. The survey assessed soil unit distribution at a more detailed scale and identified dark clays and yellow duplex as being the dominant soil units. Subsequently, this 2002 EIS survey was referenced as a background source of information on the geology and soil units likely to be encountered within these two study areas.

3) Stratified observations

Upon drafting of mapping units, surface soil exposures throughout the study areas, were visually assessed to ascertain potential mapping units, delineate soil unit boundaries and determine preferred locations for targeted subsurface investigation.

2.3 Profiling

A total of seventeen (17) soil profile exposures were assessed at selected sites to enable soil profile descriptions to be made. The soil profile site locations are shown in **Figure 2**.

Subsurface exposure was generally undertaken by backhoe excavation of test pits to between 1 and 1.5 m deep. The test pit locations were chosen to provide representative profiles of the soil types encountered during the survey. The soil layers were generally distinguished on the basis of changes in texture, structure and colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994).

Numerous observations of existing exposed profiles were also conducted to confirm soil units and boundaries between different soils. Soils in the North Pit study area were generally identified and delineated through observations of surface exposure, due to concerns of potential interference with the sensitive Archaeological sites that occur within the study area. Soils associated with the steep slopes (Rocky Knob) in the South Pit study area were also generally assessed through surface observations (in conjunction with mapping and aerial photo surveys), due to difficulties with backhoe accessibility and the abundance of surface exposures due to track and drill pad cuttings.

2.4 Field Assessment

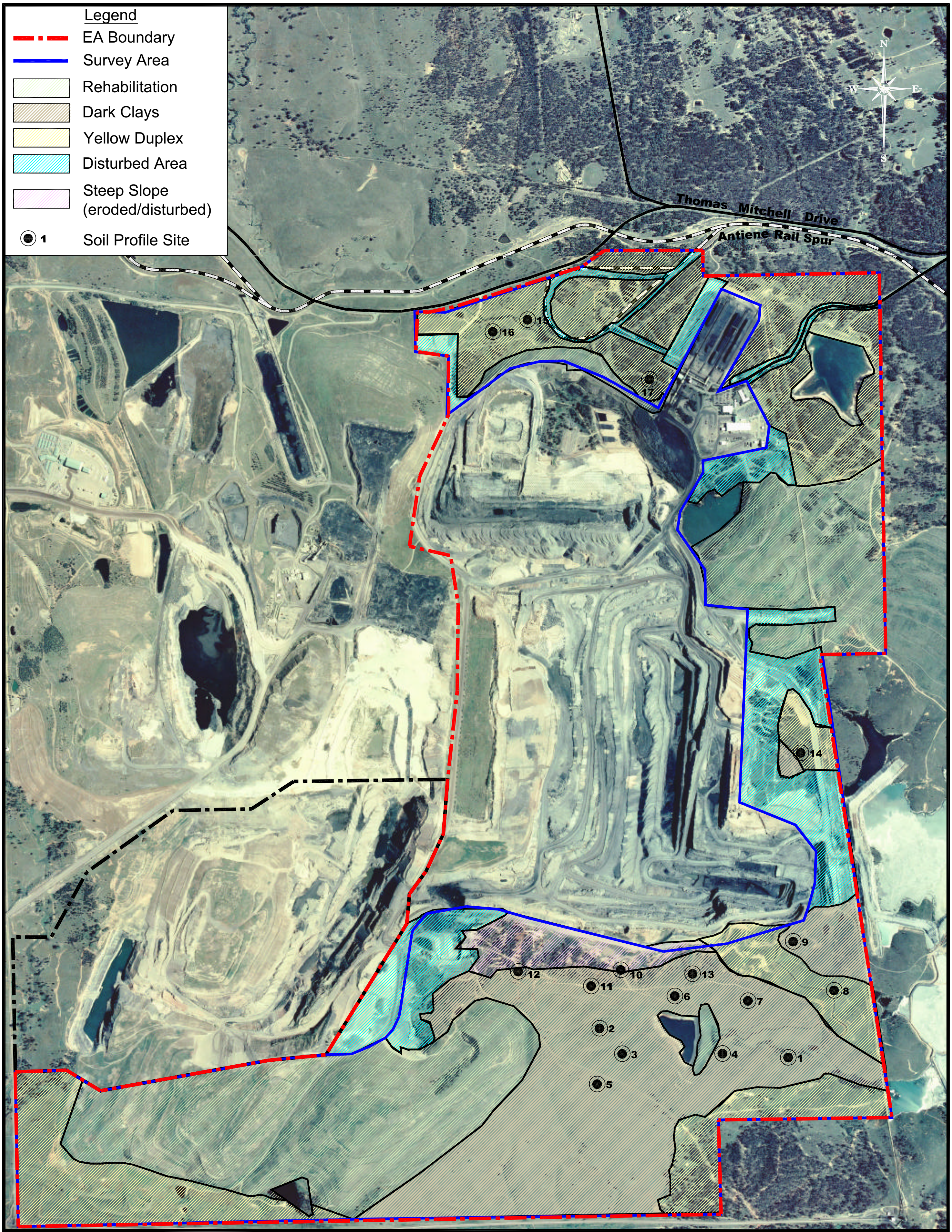
Soil layers at each profile site were assessed according to a procedure devised by Elliot & Veness (1981) for the recognition of suitable topdressing materials. This procedure assesses soils based on grading, texture, structure, consistence, mottling and root presence. A detailed explanation of the Elliot & Veness procedure is presented in **Appendix 2** to this report. The system remains the benchmark for land resource assessment in the Australian coal mining industry.

2.5 Laboratory Testing

Soil samples were collected from the exposed soil profiles of major soil units within the study areas. Of the samples collected, representative samples were selected for subsequent laboratory analysis at the Department of Lands' Soil Research Centre at Scone, NSW.

Selection of samples for analysis was based on establishing the geochemical suitability of surface and near-surface soil horizons for use as topdressing in rehabilitation works and to identify soils that may require particular management.

Soil layers are signified by /1, /2 and /3 in the sample ID with the surface horizon being /1 and subsoil horizons being /2, /3 & /4. Samples were not collected, or were not analysed, from sites 10-14 & 17 as these profiles displayed similar soil characteristics to other sites already selected for analysis.



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Source : Dames and Moore (1980) and Umwelt (2000)

Drayton Mine
Soil Types & Profile Sites

Figure 2

0 250 500 750 1000m

Table 1 shows samples analysed.

Table 1: Soil samples selected for Laboratory Analysis

Site	Samples	Site	Samples
1	1/1, 1/2 & 1/3	7	7/1, 7/2 & 7/3
2	2/1, 2/2 & 2/4	8	8/1, 8/2 & 8/3
3	3/1, 3/2 & 3/4	9	9/1, 9/2 & 9/3
4	4/1, 4/2 & 4/3	15	15/1, 15/2 & 15/3
5	5/1, 5/2 & 5/3	16	16/1
6	6/1, 6/2 & 6/3		

The samples were subsequently analysed for the following parameters:

- Particle Size Analysis;
- Emerson Aggregate Test (soil aggregate slaking and coherence);
- pH; and
- Electrical Conductivity.

A description of the significance of each test and typical values for each soil characteristic are included in **Appendix 3**.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for stripping and re-use for the rehabilitation of disturbed areas. The soil test results for the soil survey are provided in **Appendix 4**.

2.6 Land Capability Assessment

The land capability assessment of the study areas was conducted according to the Department of Natural Resources (DNR) (formerly the NSW Soil Conservation Service) rural land capability assessment system. The system consists of eight classes, which classify land on the basis of an increasing soil erosion hazard and decreasing versatility of use. It recognises the following three types of land uses:

- land suitable for cultivation;
- land suitable for grazing; and
- land not suitable for rural production.

These capability classifications identify limitations on the use of the land as a result of the interaction between the physical resources and a specific land use. The principal limitation recognised by these capability classifications is the stability of the soil mantle (Soil Conservation Service, 1986).

The method of land capability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses. The classification does not necessarily reflect the existing land use, rather it indicates the potential of the land for uses such as crop production, pasture improvement and grazing.

The system allows for land to be allocated into eight possible classes (with land capability decreasing progressively from Class I to Class VIII). The classes are described in **Table 2** below.

A description of land capability classification for all land within the study areas is discussed in **Section 3.2**.

Table 2: Land Capability Classes

Land Class	Land Suitability	Land Definition
Class I	Regular Cultivation	No erosion control requirements
Class II	Regular Cultivation	Simple requirements such as crop rotation and minor strategic works
Class III	Regular Cultivation	Intensive soil conservation measures required such contour banks and waterways
Class IV	Grazing, occasional cultivation	Simple practices such as stock control and fertiliser application
Class V	Grazing, occasional cultivation	Intensive soil conservation measures required such contour ripping and banks
Class VI	Grazing only	Managed to ensure ground cover is maintained
Class VII	Unsuitable for rural production	Green timber maintained to control erosion
Class VIII	Unsuitable for rural production	Should not be cleared, logged or grazed
U	Urban areas	Unsuitable for rural production
M	Mining & quarrying areas	Unsuitable for rural production
Source: Soil Conservation Service of NSW (1986).		

2.7 Agricultural Land Suitability Assessment

Agricultural land suitability is an alternative land classification system used to assess land suitability, relative to a specific type of agricultural production. The system consists of five classes, which assess land on the basis of increasing suitability and potential for agricultural production. As well as assessing land capability (soils, geology, soil erosion, topography and climate), agricultural suitability considers industry specific factors that may influence potential production. The same piece of land may be classed differently, depending on selected land-use.

The system allows for land to be allocated into five (5) possible classes (with suitability decreasing progressively from Class 1 to Class 5). The classes are described in **Table 3** below**.**

A description of agricultural suitability classification for all land within the study areas is discussed in **Section 3.3**.

Table 3: Agricultural Suitability Classes

Agricultural Land Suitability	
Class	**Description**
1	Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.
2	Arable land suitable for regular cultivation for crops but not suited to continuous cultivation. It has a moderate to high suitability for agriculture but edaphic (soil factors) or environmental constraints reduce the overall level of production and may reduce the cropping phase to a rotation with sown pastures.
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 or other factors including climate may limit the capacity for cultivation and soil conservation or drainage works may be required.
4	Land suitable for grazing but not cultivation. Agriculture is based on native pastures or improved pastures based on minimum tillage techniques. Production may be seasonally high but the overall production level is low as a result of major environmental constraints.
5	Land unsuitable for agriculture or at best only to light grazing. Agricultural production is low or zero as a result of severe constraints, including economic factors, which preclude land improvement.

3.0 RESULTS

3.1 Soils

Soil Unit Type

The two major soil units identified during the soil survey were dark clays and yellow duplex soils. The dark clays dominated the Southern parts of the study areas, with the yellow duplex soils dominating the Northern areas. A minor area of highly eroded and disturbed steeply sloping land in the South Pit (Rocky Knob) study area was identified as 'steep slopes'. A substantial proportion of the land, especially in the North and East Pit study areas was also classified as 'disturbed' and 'rehabilitated'. The characteristics and distribution of these soil types are discussed in detail below. The distribution of the soil units observed during the soil survey is illustrated in **Figure 2**.

Minor areas of shallow alluvial soils are located along Ramrod Creek in the North Pit study area. However, these alluvial soils are generally limited in distribution and depth and overly the same subsoil clays as the adjacent yellow duplex soils. With respect to topsoil stripping depth or management requirements, these soils present little difference from the surrounding yellow duplex soils. Therefore they have not been included as a separate soil unit in the soil unit descriptions, or **Figure 2**.

A description of each soil unit is presented in this section, along with representative profile descriptions for the two major soil units. **Appendix 2** provides a brief guideline to interpreting soil analytical results.

Dark Clays

Dark clays were dominant across the Southern study areas and were observed as consisting mainly of dark red brown uniform clay soils. The soil unit was recorded across the majority of the South Pit study area, generally south of the dominant steep spurline, and in a small area of the East Pit study area. These soils closely resemble the Red Clay soil unit commonly associated with the Brays Hill soil landscape unit (Kovac & Lawrie, 1991). Although generally a dark reddish brown, the soils were observed to vary in colour from a bright red to a deep chocolate brown (see **Plates 1 & 2**).

A weathered grey brown variant was observed in the South-eastern part of the East Pit study area. Some of the soils in this area were also observed to have been subject to previous inundation. The soil unit varied in depth, with shallow sites observed on the mid to upper slopes of the South Pit study area and deeper profiles observed on the lower slopes. Where shallow profiles were described, the profile was observed to overly a light yellow to yellowish red weathered volcanic bedrock. Weathered volcanic rocks, 6 cm to 20 cm in diameter, were commonly observed throughout the profile.

Topsoil

The topsoil is typically 15 cm to 20 cm deep and dark reddish brown in colour. On the upper slopes this was observed as a dark chocolate brown in some areas.

Texture is loam to clayey loam, which should allow for moderate infiltration and water holding capacity, both necessary for effective vegetative growth. Structure is weak to moderate and crumby to polyhedral. The topsoils are structurally stable (Emerson rating of 8/3(1) to 5 – slightly or non-dispersive), therefore, will not be prone to surface sealing, leading to effective infiltration and aeration for root development.

The soils are non-saline (EC range of 0.05 to 0.94 dS/m) and generally neutral to mildly alkaline (pH range of 5.4 to 6.6). The sites generally displayed a healthy surface pasture cover and root penetration in the topsoil was common, indicating potential suitability for post-mining vegetation establishment. This topsoil is suitable for stripping and use as topdressing material in post-mine vegetation establishment.

Subsoil

The subsoil ranges in depth, generally up to between 90 cm and 110 cm, with some shallower profiles on upper slopes. The subsoil is generally reddish brown to dark reddish brown, with a strong blocky structure. The textures are most commonly medium clays, grading to heavy to heavy clays with depth.

The subsoil is considered to be non-saline (typical EC range of 0.14 to 0.83 dS/m), with alkalinity increasing with depth (pH range of 6.3 to 9.3). Emerson ratings are between 2(1) (moderately dispersive) and 6 (non-dispersive). The constraining factors include fine texture (high clay content) and massive structure, therefore resulting in poor aeration and infiltration and inferior structural characteristics. The subsoil also displayed high alkalinity at depth and high rock content. This subsoil layer is not suitable for stripping and use as a topdressing material. A typical dark clay profile is presented in **Table 4**. Examples of dark clay profiles are presented in **Plates 1** and **2**.

Table 4: Typical Dark Clay Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.17	Dark reddish brown (5YR 3/2) clayey loam. Weak consistence and weak pedality with crumby peds 5-10 mm. Roots are common. 2-10% weathered igneous stones 60-200 mm in diameter. The lower boundary is clear and even to layer 2.
2	0.17 – 0.46	Dark reddish brown (5YR 3/4) medium clay. Moderate consistence and strong pedality with rough-faced angular blocky peds 20-50 mm. Few roots and <2% stones. The lower boundary is diffuse to layer 3.
3	0.46 – 0.76	Dark reddish brown (2.5Y 3/4) heavy clay. Very strong consistence and the layer is apedal massive. No roots or stones. The boundary is clear and irregular to layer 4.
4	0.76 - >1.23	Weathered yellow (10YR 8/6) igneous bedrock.

Plate 1: Dark Clay at Site 6, displaying typical red brown uniform clay profile.

Plate 2: Dark Clay at Site 6, displaying darker colour variability within the soil unit.

Yellow Duplex

The yellow duplex soils are generally located throughout the Northern parts of the study areas and consist mainly of yellow solodics. The yellow solodic soil unit is commonly associated with the Brays Hill and Liddell soil landscape units (Kovac & Lawrie, 1991). With the exception of minor areas of shallow alluvial soils associated with Ramrod Creek, yellow duplex soils were observed to cover almost all of the undisturbed North Pit study area. Minor areas of Yellow Duplex were also recorded in the East and South Pit study areas. Where they occurred in the North Pit study area, they were generally associated with the lower slopes and drainage lines in the North and East of the area. These soils have a clear to sharp boundary between the sandy to silty loam surface horizons and the underlying clay subsoils. These soils are associated with the gently falling drainage lines, flat areas and gently rising slopes throughout the study areas. Surface soils in the far East of the North Pit study area (adjacent to West of the product stockpile and rail load-out) were observed to be contaminated with coal fines. Some hardsetting and surface scarring was noted in surface soils observed amongst the revegetated trees in the North Pit study area. This may have been caused by exposure of subsoils during deep-ripping prior to tubestock planting, rather than topsoil characteristics.

Topsoil

The topsoil ranges in depth from 14 cm to 25 cm and is generally dark brown in colour, with most sites displaying a bleached light yellowish brown A2 horizon. The soils are weakly structured with textures ranging from silty loams to sandy loams, or apedal single grained. These textural groups will allow for moderate to high infiltration and water holding capacity, both necessary for effective vegetative growth. The topsoils are structurally stable (Emerson rating of 8/5 to 3(1) – slightly or non-dispersive), therefore, should not be prone to surface sealing, leading to effective infiltration and aeration for root development.

The soils are non-saline (EC range of 0.04 to 0.07 dS/m) and generally neutral to mildly alkaline (pH range of 5.5 to 6.2). The sites generally displayed a moderate to sporadic surface pasture cover and root penetration in the topsoil was common, indicating potential suitability for post-mining vegetation establishment. This topsoil is generally suitable for stripping and use as topdressing material in post-mine vegetation establishment.

Subsoil

The subsoil ranges in depth, up to 90 cm. It is generally yellowish brown, yellowish red or reddish brown, with weak to moderate blocky structure, grading to massive at depth. The textures are most commonly medium clays, becoming heavier with depth. The soil is generally non-saline to low salinity (EC of range of 0.51 to 1.19 dS/m) and of low to moderate alkalinity (pH range of 6.7 to 8.4). Emerson ratings of between 2(1) and 2(3) indicate moderately dispersive subsoil. The constraining factors include fine texture (high clay content) and massive structure, increasing the potential for poor aeration and infiltration, potential for dispersiveness and hardsetting, and inferior structural characteristics. This subsoil layer is not suitable for stripping and use as a topdressing material. A typical yellow duplex profile is presented in **Table 5**. An example of a yellow duplex profile is presented in **Plate 3**.

Table 5 : Typical Yellow Duplex Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.14	Dark brown (10YR 3/3) silty loam. Weak consistence with weak, angular to sub-angular peds 2-5 mm. Generally <10% stones and roots commonly occur in the layer. The lower boundary is clear and even to layer 2.
2	0.14 – 0.26	Bleached light yellowish brown (10YR 6/4) silty loam A2 horizon. Weak consistence with weak, angular to sub-angular peds 5-10 mm. Generally <10% stones and few roots. The lower boundary is clear and even to layer 3.
3	0.26 – >1.01	Dark yellowish brown (10YR 4/4) medium clay. Moderate consistence and generally apedal massive. No roots or stones.

Plate 3: Yellow Duplex at Site 10, displaying duplex soil profile.

Steep Slopes (eroded/disturbed)

Within the South Pit study area, the soils associated with the steep Northern slope of the dominant spurline were observed to be highly eroded and disturbed. This disturbance has most likely been caused through the establishment of drill pads and tracks on the steep slopes, as well as the accelerated gullying and surface scalding usually associated with the clearing of vegetation from steep slopes. As a result, the soils were observed to be highly weathered and a lot of topsoil had been lost to erosion. The soils on the upper slopes were observed as weathered reddish brown clays overlying volcanic bedrock. On the lower slopes the soils were observed to be weathered light yellowish brown sands overlying reddish brown clays. The soils of these steep slopes, whether topsoil or subsoil, are not considered suitable for stripping and use as a topdressing material.

Disturbed and Rehabilitated Land

Disturbed or reshaped ground associated with open-cut mining operations was observed throughout the study areas, as indicated in **Figure 2**. The North and East Pit study areas were especially impacted, with over 50% of these study areas identified as disturbed. Such disturbance includes:

- mining infrastructure, haul roads and other traffic areas;
- open-cut pits, highwalls and topsoil stripped areas;
- overburden dumps and process waste emplacements;
- dams and drains; and
- dam walls, embankments and batters.

Within these areas, the natural ground has generally been removed, or disturbed to a significant degree. As a result, the remaining or newly placed material is most likely to be considered overburden or mine waste, and is not suitable for recovery and use as a topdressing material.

Where this disturbed land has been reshaped, topdressed with a suitable growth medium (such as previously stripped topsoil) and revegetated, it has been identified as 'rehabilitated' for the purposes of this survey. Small areas of this rehabilitated land are located throughout all three study areas, as indicated on **Figure 2**. This rehabilitated landform is distinguished from disturbed land in that suitable topsoil resources have been re-spread over the landform. Although no depths were measured during the survey, common practice is to re-spread topsoil to a depth of 10-15 cm. This re-spread material is most likely considered suitable for recovery and further re-use in post-mining rehabilitation.

3.2 Land Capability

Land Capability is an assessment system that classifies land from a soil conservation perspective. Land is classed from Class I to Class VIII, based on the decreasing versatility of use, as limited by an increase in soil erosion hazard. A full explanation of the eight (8) classes is presented in **Table 2**.

The majority of the land within the North and East Pit study areas is considered to be Class M, unsuitable for agricultural production due to mining. The small area of undisturbed land in the North Pit study area is limited to Class V. The land is generally suitable for grazing with intensive management measures, but not suitable for cultivation owing to a combination of limitations resulting from the presence of yellow duplex soils, including subsoil alkalinity, structure, texture, and potential for instability and dispersion.

The small area of undisturbed land in the East Pit study area is also limited to Class V due to the presence of yellow duplex soils and moderate slope steepness.

Within the South Pit study area, those areas impacted by mining development are considered as Class M. The areas of undisturbed, moderately sloping dark clay soil, with good pasture cover, are limited to Class IV due to soil rockiness and slope prevent a lower classification.

Those areas of moderately sloping yellow duplex, with a good pasture cover, are limited to Class V due to soil characteristics and slope.

The steeper slopes of the hill and spurline on dark clays are limited to Class VI. Grazing is possible in these areas, but with careful management to ensure pasture cover is maintained.

Those steeper slopes demonstrating significant existing erosion or situated on yellow duplex soils are limited to Class VII and are considered unsuitable for agricultural production.

3.3 Agricultural Land Suitability

Agricultural land suitability classifies land relative to a specific type of agricultural production. The system classes land Class 1 to Class 5 based on increasing potential for agricultural production. A full explanation of the five (5) classes is presented in **Table 3**. The current, or most recent, agricultural land-use within the study areas is cattle grazing.

The undisturbed land within the North and East Pit study areas is Class 4; suitable for grazing with significant limitations. This is due to soil characteristics for the yellow duplex in the North Pit study area, and soil rockiness and slope in the East Pit study area.

Undisturbed land, situated on moderate slopes within the South Pit study area is Class 4; suitable for grazing but not cultivation. This is due to soil characteristics for the yellow duplex and soil rockiness and slope for the dark clay areas.

Mining disturbed land, steep eroded land and steep yellow duplex land within the study area is limited to Class 5; unsuitable for agriculture, or at best light grazing. This is either due to mining disturbance, slope steepness, soil structure and instability or existing erosion.

4.0 RECOMMENDATIONS

4.1 Topsoil Suitability

Details of the soil test results (refer **Appendix 4**) were used in conjunction with the field assessment (refer **Appendix 2**) to determine the depth or thickness of soil materials that are suitable for stripping and re-use as a surface cover in the rehabilitation of disturbed areas. Suitable stripping depths for each soil unit are provided in **Table 6**.

Dark clays are suitable to be stripped for re-use as topdressing material to 20 cm on upper slopes, and 25 cm on the less steep lower slopes. Although generally of weak structure, these topsoils have a loam to clayey loam texture. Below these respective depths, the subsoil displayed increased clay content, massive structure and increased alkalinity with depth. Some areas of this soil unit also displayed a high content of large rocks (6-20 cm) throughout the profile. If large rock (>6 cm) content exceeds 10% in the topsoil, it should not be used in post-mining pasture rehabilitation, as excessive surface stoniness may reduce the land capability (and agricultural suitability) of the final rehabilitated landform; however, this material would still be suitable for treed or habitat rehabilitation.

The suitable stripping depth for the yellow solodics is approximately 15 cm. Although generally weak in structure, the topsoil consists of sandy loams and silty loams, is relatively stable, and neutral to slightly alkaline in pH. Instability in the subsoil horizons, combined with elevated alkalinity and moderate Emerson's ratings indicate dispersion and erosion potential. The clayey structure and increasingly massive structure with depth are also major constraints in the material's value as a surface cover material. Therefore, the subsoil (>15 cm depth) has been deemed unsuitable for re-use in the rehabilitation of the post-mining landform.

If additional material is required for use as a surface cover in post-mining rehabilitation, marginal subsoil material may be ameliorated by mixing with sandy material or gypsum. If sufficient volumes of sandy material (>75% sand content) are available locally, then mixing with excessively clayey subsoil (as identified in yellow solodics and dark clays) should provide a more suitable surface material with improved structural and infiltration properties. Alternatively, the addition of gypsum (at a rate of 5 – 10 t/ha), should also assist in improving subsoil structure, if excessively clayey. The addition of gypsum may also assist in reducing the potential for dispersion (and erosion or surface hardsetting) in subsoils that were identified as unsuitable due to poor Emerson's ratings. The selected ameliorant should be mixed thoroughly with the subsoil material during stockpiling and/or placement.

Due to the existing disturbance and potential for erosion, as well as evidence of topsoil loss due to previous erosion, the soils of the steep slopes (South Pit study area) are not considered suitable for recovery and use as a topdressing material in rehabilitation works.

The surface material in areas of mining disturbance generally consists of overburden or waste materials and is not considered suitable for recovery and re-use for topdressing during rehabilitation.

The depth of topsoil resources already re-spread in areas of established rehabilitation is estimated at 10-15 cm.

Table 6: Suitable topsoil stripping depths for soil types

Soil Unit Type	Suitable Stripping Depth (cm)
Dark Clays (upper slopes)	20
Dark Clays (lower slopes)	25
Yellow Duplex	15
Rehabilitated	10-15
Steep Slopes	Not suitable for stripping
Disturbed Land	Not suitable for stripping

4.2 Topsoil Stripping and Handling

The following topsoil stripping and stockpiling techniques are appropriate to prevent excessive soil deterioration:

- Strip material to the depths stated in **Table 6**, subject to further investigation as required. Topsoil should be maintained in a slightly moist condition during stripping. Material should not be stripped in either an excessively dry or wet condition.
- Place stripped material directly onto reshaped overburden and spread immediately (if mining sequences, equipment scheduling and weather conditions permit) to avoid the requirement for stockpiling (when available).
- Grading or pushing soil into windrows with graders or dozers for later collection by elevating scrapers, or for loading into rear dump trucks by front-end loaders, are examples of less aggressive soil handling systems. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material.
- Soil transported by dump trucks may be placed directly into storage. Soil transported by bottom dumping scrapers is best pushed to form stockpiles by other equipment (eg: dozer) to avoid tracking over previously laid soil by the scraper.
- The surface of soil stockpiles should be left in as coarsely textured a condition as possible in order to promote infiltration and minimise erosion until vegetation is established to prevent anaerobic zones forming.

- As a general rule, maintain a maximum stockpile depth of 3 m. Clayey soils, such as the dark clay topsoil, should be stored in lower stockpiles for shorter periods of time compared to sandier soils, such as the topsoil sourced from the yellow duplex soils.

- If long-term stockpiling is planned (i.e.: greater than 12 months), seed and fertilise stockpiles as soon as possible.

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

4.3 Topsoil Respreading

Where possible, suitable topsoil should be re-spread directly onto reshaped areas. Where topsoil resources allow, topsoil should be spread to a minimum depth of 100 mm on all regraded spoil. Topsoil should be spread, treated and seeded in one consecutive operation. To prevent loss of topsoil to wind and water erosion, topsoil should not be left spread and untreated/unseeded.

4.4 Landform Design and Erosion Control

Rehabilitation strategies and concepts proposed for the Drayton Extension Project area have been formulated according to results of industry wide research and experience.

Post Disturbance Regrading

The main objective of regrading is to produce slope angles, lengths and shapes that are compatible with the proposed land use and not prone to an unacceptable rate of erosion. Integrated with this is a drainage pattern that is capable of conveying runoff from the newly created catchments whilst minimising risk of erosion and sedimentation. Final slope gradient should not exceed approximately 18^0.

Erosion & Sediment Control

The most significant means of controlling surface flow on disturbed areas is to construct contour furrows or contour banks at intervals down the slope. The effect of these is to divide a long slope into a series of short slopes with the catchment area commencing at each bank or furrow. This prevents runoff from reaching a depth of flow or velocity that would cause erosion. As the slope angle increases, the banks or furrows must be spaced closer together until a point is reached where they are no longer effective.

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

Graded banks are essentially a much larger version of contour furrows, with a proportionately greater capacity to store runoff and/or drain it to some chosen discharge point.

The banks are constructed away from the true contour, at a designed gradient (1% to 2%) so that they drain water from one part of a slope to another; for example, towards a watercourse or a sediment control dam.

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

The construction of sediment control dams is recommended for the purpose of capturing sediment laden runoff prior to off-site release. Sediment control dams are responsible for improving water quality throughout the mine site and enhance the ecological diversity of the area.

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

- Each dam should be located so that runoff may easily directed to it, without the need for extensive channel excavation or for excessive channel gradient. Channels must be able to discharge into the dam without risk of erosion. Similarly, spillways must be designed and located so as to safely convey the maximum anticipated discharge.
- The material from which the dam is constructed must be stable. Dispersible clays, such as the subsoils (> 15-20 cm depth) of the yellow duplex soils, will require treatment with lime, gypsum and/or bentonite to prevent failure of the wall by tunnel erosion. Failure by tunnelling is most likely in dams which store a considerable depth of water above ground level, or whose water level fluctuates widely. Dams should always be well sealed, as leakage may lead to instability, as well as allowing less control over the storage and release of water.
- The number and capacity of dams should be related to the total area of catchment and the anticipated volume of runoff. The most damaging rains, in terms of erosion and sediment problems are localised, high intensity storms.

Seedbed Preparation

Thorough site preparation should be undertaken to ensure optimum establishment and growth of vegetation. All topsoiled areas should be contour ripped (after topsoil spreading) to create a “key” between the soil and the spoil. Ripping should be undertaken on the contour and the tines lifted for approximately 2 m every 200 m to reduce the potential for channelised erosion. Best results will be obtained by ripping when soil is moist and when undertaken immediately prior to sowing. The respread topsoil surface should be scarified prior to, or during seeding, to reduce run-off and increase infiltration. This can be undertaken by contour tilling with a fine-tined plough or disc harrow.

5.0 REFERENCES

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Appendix 1 – Glossary

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

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

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

Consistence
The attribute of the soil material that is expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation or rupture.

Electrical Conductivity
The property of the conduction of electricity through water extract of soil. Used to determine the soluble salts in the extract, and hence soil stability.

Emerson Aggregate Test (EAT)
A classification of soil based on soil aggregate coherence when immersed water. Classifies soils into eight classes and assists in identifying whether soils will slake, swell or disperse.

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

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

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

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

Particle Size Analysis (PSA)
The determination of the of the amount of the different size fractions in a soil sample such as clay, silt, fine sand, coarse sand and gravel.

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

pH
A measure of the acidity or alkalinity of a soil.

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

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

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

Ped
An individual, natural soil aggregate.

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

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

Appendix 2 – Field Assessment Procedure

FIELD ASSESSMENT PROCEDURE

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

Structure Grade

Good permeability to water and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade (Charman, 1978) and depends on the proportion of coarse peds in the soil surface.

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

Consistence - Shearing Test

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

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

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

Consistence - Disruptive Test

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates.

Mottling

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeabilities; however, some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.

Macrostructure

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

Texture

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

Root Density and Root Pattern

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

Field Exposure Indicators

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

Appendix 3 – Soil Information

TEST SIGNIFICANCE AND TYPICAL VALUES

Particle Size Analysis

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

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

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

Emerson Aggregate Test

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

Class 1	-	very dispersible soils with a high tunnel erosion susceptibility.
Class 2	-	moderately dispersible soils with some degree of tunnel erosion susceptibility.
Class 3	-	slightly or non-dispersible soils which are generally stable and suitable for soil conservation earthworks.
Class 4-6	-	more highly aggregated materials which are less likely to hold water. Special compactive efforts are required in the construction of earthworks.
Class 7-8	-	highly aggregated materials exhibiting low dispersion characteristics.

The following subdivisions within Emerson classes may be applied:

(1) slight milkiness, immediately adjacent to the aggregate

(2) obvious milkiness, less than 50% of the aggregate affected

(3) obvious milkiness, more than 50% of the aggregate affected

(4) total dispersion, leaving only sand grains.

Salinity

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

0 to 1 very low salinity, effects on plants mostly negligible.

1 to 2 low salinity, only yields of very sensitive crops are restricted.

greater than 2 saline soils, yields of many crops restricted.

pH

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

LABORATORY TEST METHODS

Particle Size Analysis

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

Emerson Aggregate Test

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

EC

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

pH

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

Appendix 4 – Soil Test Results

Department of Lands

Land Administration & Management
Property & Spatial Information

Soil Conservation Service

SOIL TEST REPORT

Scone Research Service Centre

REPORT NO:	SCO06/199R1
REPORT TO:	Lachlan Crawford GSS Environmental 4/56 Industrial Drive Mayfield NSW 2304
REPORT ON:	Thirty one soil samples Drayton Soil Survey
PRELIMINARY RESULTS ISSUED:	Not issued
REPORT STATUS:	Final
DATE REPORTED:	14 August 2006
METHODS:	Information on test procedures can be obtained from Scone Research Service Centre

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

GHolman.

G Holman
(Technical Officer)

Scone Research Service Centre, PO Box 283 Scone 2337, Gundy Road Scone 2337
Ph: 02 6545 1666, Fax: 02 6545 2520

New South Wales Government

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO06/199R1
Client Reference: Lachlan Crawford
GSS Environmental
4/56 Industrial Drive
Mayfield NSW 2304

Lab No	Method	C1A/4	C2A/3	P7B/1 Particle Size Analysis (%)					P9B/2
	Sample Id	EC (dS/m)	pH	clay	silt	f sand	c sand	gravel	EAT
1	Drayton Site 1 / 1	0.05	6.4	36	20	35	8	1	3(1)
2	Drayton Site 1 / 2	0.14	7.5	59	13	23	5	0	3(2)
3	Drayton Site 1 / 3	0.83	9.0	50	13	27	9	1	4
4	Drayton Site 2 / 1	0.21	5.4	35	20	39	6	0	8/3(1)
5	Drayton Site 2 / 2	0.14	7.0	64	9	24	3	0	5
6	Drayton Site 2 / 4	0.25	7.9	33	10	36	21	0	6
7	Drayton Site 3 / 1	0.21	5.7	30	20	40	10	<1	8/3(1)
8	Drayton Site 3 / 2	0.10	6.3	69	12	16	3	0	5
9	Drayton Site 3 / 4	0.05	7.7	30	18	37	15	<1	5
10	Drayton Site 4 / 1	0.07	5.8	37	20	30	13	<1	8/3(1)
11	Drayton Site 4 / 2	0.05	7.0	65	17	14	4	0	8/3(1)
12	Drayton Site 4 / 3	0.41	9.1	48	36	7	7	2	4
13	Drayton Site 5 / 1	0.94	6.4	33	24	30	9	4	5
14	Drayton Site 5 / 2	0.64	8.7	56	16	19	7	2	4
15	Drayton Site 5 / 3	1.07	9.0	56	13	18	11	2	4
16	Drayton Site 6 / 1	0.27	6.6	25	22	43	10	<1	5

Gtto6mca.

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO06/199R1
Client Reference: Lachlan Crawford
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4/56 Industrial Drive
Mayfield NSW 2304

Lab No	Method	C1A/4	C2A/3	P7B/1 Particle Size Analysis (%)					P9B/2
	Sample Id	EC (dS/m)	pH	clay	silt	f sand	c sand	gravel	EAT
17	Drayton Site 6 / 2	0.12	7.6	58	15	21	6	<1	3(1)
18	Drayton Site 6 / 3	0.77	9.0	56	9	24	9	2	4
19	Drayton Site 7 / 1	0.12	5.9	23	26	35	14	2	8/5
20	Drayton Site 7 / 2	0.09	7.0	53	17	20	7	3	3(1)
21	Drayton Site 7 / 3	0.26	9.3	28	15	37	20	<1	3(1)
22	Drayton Site 8 / 1	0.04	6.1	15	7	33	31	14	3(1)
23	Drayton Site 8 / 2	0.11	7.3	41	8	19	31	1	2(1)
24	Drayton Site 8 / 3	0.51	8.4	33	11	17	39	<1	3(1)
25	Drayton Site 9 / 1	0.12	5.4	24	19	32	19	6	8/3(1)
26	Drayton Site 9 / 2	0.21	6.7	46	14	21	17	2	3(1)
27	Drayton Site 9 / 3	0.82	6.9	55	18	20	7	<1	2(1)
28	Drayton Site 15 / 1	0.06	5.5	12	34	47	7	<1	8/3(1)
29	Drayton Site 15 / 2	1.19	5.5	15	25	47	12	1	8/5
30	Drayton Site 15 / 3	0.51	6.7	42	23	31	4	<1	2(3)
31	Drayton Site 16 / 1	0.07	6.2	15	14	53	16	2	8/5

END OF TEST REPORT