INTEGRA COAL

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ABN: 96 118 030 998

Glennies Creek Open Cut Coal Mine

Soils Survey and Land Capability Assessment

Prepared by

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Specialist Consultant Studies Compendium: Part 6

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Soils Survey and Land Capability Assessment

of the

Glennies Creek Open Cut Coal Mine

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EXECUTIVE SUMMARY

Soils in the Study Area have been described and two Soil Mapping Units [SMUs] have been identified. No soil assessments were made of the rehabilitated lands because of their previous disturbance and generally shallow soil covering.

The physical and chemical attributes of the soils of the undisturbed lands within the Study Area have been quantified through a combination of field assessment and laboratory testing and may be described as follows.

- The soils of the Study Area are currently relatively stable but have a generally moderate erodibility rating as determined from laboratory data and the SOILOSS computer model.
- Topsoils in both SMUs generally have a low dispersibility but the subsoils have generally moderate to very high dispersibility indicating a need for rapid protection of stockpiled material and newly-rehabilitated areas by mulches and vegetation cover.
- The soils generally have a high structure grade and so can be stripped and respread using scrapers.
- For SMU 1, the topsoil material [to 20cm depth] and the subsoil [to about 70cm total depth below the original soil surface] is suitable for use in rehabilitating the disturbed landscape.
- For SMU 2 the topsoil material [to 10cm depth] and the subsoil [to about 70cm total depth below the original soil surface] is suitable for use in rehabilitating the disturbed landscape.
- The lower subsoils of both SMUs are generally moderately saline and so should not be used as subsoil material during the rehabilitation process.
- All soils will be subject to structural degradation if worked when too moist.
- The soils on rehabilitated lands are not suitable for stripping and replacement.

Depth of stripping recommendations have been provided along with advice on stabilising the soil stockpiles in the period between stripping and respreading.

The pre-mining Land Capability [**Classes V and M**] and Agricultural Land Suitability [**Classes 3, 4** and **5**] of the Study Area have been determined.

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1 INTRODUCTION AND DESCRIPTION OF THE PROJECT

1.1 Introduction

The study was carried out for R.W. Corkery and Co Pty Limited on behalf of Integra Coal Operations Pty Ltd [the Proponent].

The soils study is limited to the surface area that would be disturbed by the proposed open cut mining development [ie. the Study Area], including the area to be mined or otherwise disturbed for construction of associated facilities as well as the area to be covered by waste rock emplacements [see **Figure 1]**. The land capability and agricultural land suitability assessments apply to the whole Project Site. The Project Site incorporates all disturbance associated with proposed mining-related activities, ie. open cut mining, out-of-pit waste rock emplacement, contractor facilities, internal haul routes A to E, the site access road off Middle Falbrook Road and the Camberwell Coal Handling and Preparation Plant [CHPP].

1.2 Sampling Limitations

1.2.1 Soils

Soils on the areas associated with the rehabilitated Camberwell waste rock emplacement were not sampled because of the general shallowness of the replaced topsoil and the occurrence of rock and large stones on, or close to, the surface.

It would be difficult to strip such material and the final stripped product would be of a very mixed composition. It was considered that the rehabilitated areas on the Camberwell Lease are best left in place as they would maintain the stability of the post-mining landform until it is covered by material extracted from the proposed Glennies Creek Open Cut Coal Mine. The absence of soil recovered from these areas would require soil to be replaced thinner than it is stripped to provide for coverage of the entire disturbed area [refer to Section 8.2.3].

In addition, Haul Route Corridors D and E and the Camberwell CHPP were not sampled because these areas have been subject to extensive mining-related disturbance.

1.2.2 Land Capability and Agricultural Land Suitability

The Land Capability and Agricultural Land Suitability studies were confined to the undisturbed lands within the Project Site.

1.3 Details of Study Brief and Sampling

Field sampling of the area was carried out on 2nd and 3rd May, 2005.

The brief for the study required the preparation of a report on:

(i) the soils on that part of the Project Site likely to be disturbed as a result of the proposed development of the Glennies Creek Coal Mine; and

(ii) the land capability and agricultural land suitability of the Project Site.

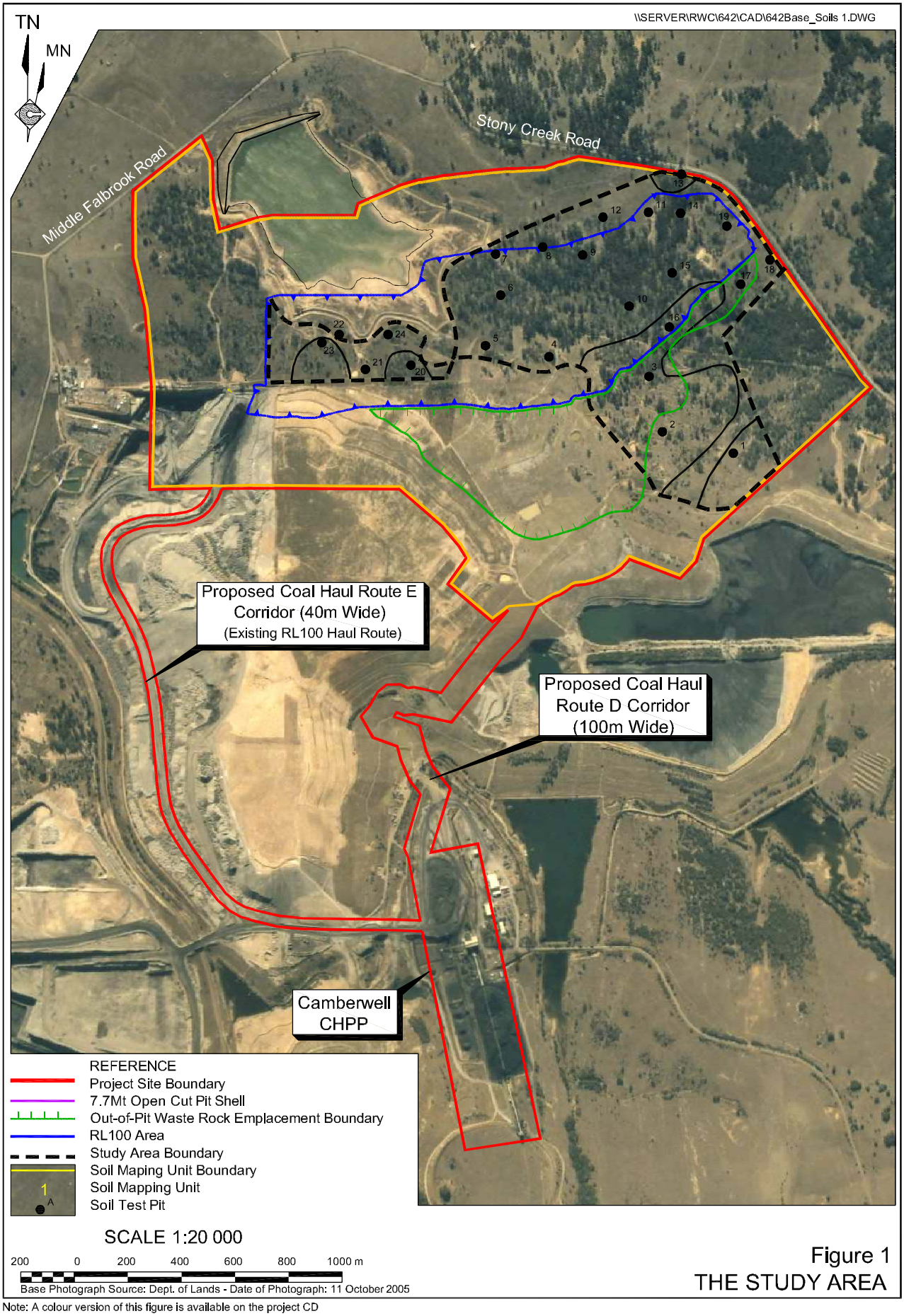

Figure 1
THE STUDY AREA

Note: A colour version of this figure is available on the project CD

The report was required to include sufficient level of detail to satisfy the Department of Primary Industries [Mineral Resources] in relation to Mining Operations Plan guidelines and to satisfy the requirements of the Department Natural Resources' specifications for soil surveys associated with proposed mining operations.

This report describes the soils of the Study Area based upon twenty four representative soil profiles as well as laboratory analyses of a selection of samples from representative profiles.

In particular, this report provides:

- the results of the field survey and laboratory testing of samples;
- a discussion of the results of field survey and laboratory physical and chemical analysis in technical as well as “Plain English” terms;
- a discussion of the stripping suitability of the soil materials found at the Study Area;
- details of soil handling strategies and recommendations about soil stripping and stockpiling; and
- details of the Land Capability and Agricultural Land Suitability at the Project Site.

1.4 Description of Proposal

The proposed open cut coal mine development involves the following activities [**Figure 1**].

- Construction of a site access road off Middle Falbrook Road.
- Construction of the open cut facilities area [including transportable offices, a bathhouse, a crib room, a report room, first aid facilities and stores; as well as a workshop, lay-down areas, parking facilities and associated infrastructure].
- Coal mining by open cut methods within a pit shell covering approximately 90ha [7.7Mt reserve]. Within this area, drilling has identified three principal coal seams amenable to mining by open cut methods, namely the:
    - Middle / Lower Liddell;
    - Barrett; and
    - Hebden seams.
- Transportation of run-of-mine [ROM] coal to the Camberwell Coal Handling and Preparation Plant [CHPP] via a combination of internal haul routes A to E [see **Figure 1**].
- When required, stockpiling of ROM coal at a temporary ROM coal stockpile area located at the top of the active open cut ramp or at the existing RL100 Stockpile Area, with subsequent transportation to the Camberwell CHPP [see **Figure 1**].

- Highwall / auger mining. During the course of the open cut mining, there may be opportunities to undertake mining from the northern highwall using either highwall or auger mining methods to extract additional coal. These methods of mining would result in underground extraction for a maximum length of approximately 300m from the base of the highwall. The final distance would depend on the type of mining undertaken. Highwall or auger mining would not occur outside the Project Site boundaries, nor would not result in subsidence of the ground surface. The coal that would be extracted by this method would be in addition to the 7.7Mt to be extracted by open cut mining methods.
- Programmed placement of waste rock materials from the open cut. Initially this would be to an out-of-pit emplacement, with subsequent placement out-of-pit as well as to in-pit in areas where mining has been completed. The proposed out-of-pit emplacement would have a disturbance footprint of approximately 43ha [see **Figure 1**].
- Storage and washing of ROM coal and dispatch of product coal from the Camberwell CHPP.
- Progressive reshaping and rehabilitation of all areas of mining-related disturbance. Overall, the total disturbed area to be rehabilitated would be approximately 139ha.
- Implementing and maintaining comprehensive systems to manage noise, vibration, air quality, visibility, surface water, groundwater, flora, fauna and Aboriginal heritage issues.

2 DESCRIPTION OF THE STUDY AREA

The Study Area is located adjacent to the Middle Falbrook Road at Glennies Creek and is 12km north of Singleton. The Study Area covers some 138ha [Project Site totals approximately 376ha] and is shown in **Figure 1**.

The Study Area comprises low rises and shallow valleys to the north of the present Camberwell Open Cut Coal Mine. It is bordered on the north by the Middle Falbrook and Stony Creek Roads.

The Study Area comprises gently sloping country supporting a mixture of native vegetation remnants and more open cleared land some of which is a rehabilitated waste rock emplacement. A further section has been used by the management of Camberwell Coal Mine to store low mounds of topsoil and supports cover of native and introduced groundcover species and regenerating native shrubs and trees.
The Study Area is grazed, in part, but not cultivated.

A search of the Register of Contaminated Sites revealed that the Study Area was not listed as such and there are no known contaminated sites located within the Study Area.

3 LITERATURE REVIEW

3.1 Soil Landscapes of the Singleton 1: 250 000 Sheet [Kovac and Lawrie, 1991; Kovac, 1991]

3.1.1 General

The area in which the proposed Glennies Creek Open Cut Coal Mine Project Site is located lies within the boundaries of the Singleton 1: 250 000 scale topographic map sheet area.

A soil survey report for this area was prepared by Kovac and Lawrie [1991] with the accompanying map being prepared by Kovac [1991].

Kovac [1991] shows the Study Area to lie within the Sedgefield Soil Landscape delineated by Kovac and Lawrie [1991].

Sedgefield Soil Landscape is described as occurring north of Singleton on ' *Permian mudstone, sandstone, conglomerate, siltstone, shale and coal seams.*' The landform is describe as comprising ' *Undulating low hills, relief 40-60m, slopes to 6%*'.

The soils are *'Yellow Soloths [Dy3.41] on upper to midslopes with Yellow Solodic Soils [Dy3.42] on lower slopes and in drainage lines. Black Soloths [Dd3.31] in areas of seepage. Some salting in drainage lines'*.

3.1.2 Details of the Soils of Sedgefield Soil Landscape

Of the three soil types described by Kovac and Lawrie [1991] for the Sedgefield Soil Landscape only two occur within the Study Area. These are the Yellow Soloths and the Yellow Solodic Soils. Generic details of these soil types are set out below.

3.1.2.1 Yellow Soloths

Topsoil - Surface hardsetting.
'Brown fine sandy loam with weak structure; pH 6.0.
Clear change to bleached dull yellowish brown fine sandy loam; apedal; pH 6.5; depth to 15cm'.

Subsoil – *'Clear change to bright brown medium clay with strong structure; prominent orange mottling; pH 7.0.*
Gradual change with depth into yellowish brown medium clay with brown mottling and decreasing pH'.

'On Muree sandstone'.

3.1.2.2 Yellow Solodic Soils

Topsoil - Surface hardsetting and gravelly.
'Yellowish brown sandy loam colluvium; single grained, pH 6.5; depth to 7cm.
Overlies brown sandy loam; massive; pH 5.5; depth to 10cm. Sharp change to bleached brown sandy loam; massive; pH 7.0; depth to 20cm'.

Subsoil - *'Clear change to dull yellowish brown medium clay with strong structure; orange and grey mottling [to 30%]; pH 6.5.'*

Gradual change with depth into a yellowish brown medium clay with orange mottling; strongly structured; pH 7.0.'

4 METHODOLOGY

4.1 Preparations

The Study Area was subjected to stereoscopic interpretation of 1: 10,000 scale colour airphotos prior to, and during, the field survey to ascertain the nature of the landforms present at the site and to develop a broad appreciation of the landform units that would require sampling.

The photographs used were those produced by Geo-Spectrum [Australia] Pty Limited. The prints used in the stereoscopic interpretation were Glennies Creek Colliery Run 4, prints 6761, 6762, 6763.

4.2 Field Procedures

For the soil study, sampling involved the complete description of twenty four profiles to a depth of 2.5m or to the depth of backhoe refusal. The locations of the soil sampling sites within the Study Area are shown in **Figure 1**.

The soil profiles at each pit location were fully described in the field after a detailed examination of the different layers.

For each test profile [site] described, details of the following soil properties were noted.

- Texture
- Fabric
- Structure
- Consistence
- Boundary sharpness
- Colour [moist and dry]
- Gravel/stone occurrence
- Presence of roots
- Presence of lime
- Presence of manganese
- pH

Soil pH was measured using the Raupach method [Raupach indicator and barium sulphate]. Soil colour [moist and dry] was determined using Munsell soil colour charts [Macbeth, 1992]. The classification of the soils that were described was based on Isbell [1996].

In determining the soil classifications the CD-ROM titled "The Australian Soil Classification - An Interactive Key" [Jacquier *et al*, 2001] was used.

The information obtained was recorded in a form that is compatible with that required for entry on soil data cards used in the DNR's SPADE Soil Database.

Samples from all layers in five profiles [Nos 2, 6, 9, 15 and 22] were forwarded to the Department of Lands' NATA - registered soil testing laboratory at Scone for more detailed analysis to determine the following properties.

- Range of particle size [particle size analysis].
- Dispersion percentage.
- Coherence [Emerson aggregate test].
- Electrical conductivity.

4.3 Soil Stripping Suitability

The stripping suitability of the soils at the sites sampled using the backhoe pits was determined on the basis of the procedure outlined by Elliott and Veness [1981].

From the data gained in this process, recommendations on the depths of topsoil and subsoil stripping were developed.

5 RESULTS

From the information gained from the detailed soil profile descriptions, two Soil Mapping Units [SMUs] were identified.

- **Soil Mapping Unit 1** – occurs on the more elevated ridgetops within the Study Area with some minor occurrences scattered through the remainder of the Study Area. The profile descriptions and analyses revealed that the soil types that are most prevalent within this SMU are deeper topsoiled duplex soils usually with A_1 and A_2 horizons overlying generally clayey material.
- **Soil Mapping Unit 2** – the soils of the remainder of the Study Area generally occupy the mid to lower slopes and drainage depressions. The profile descriptions and analyses revealed that the soil types that are most prevalent within this SMU usually have a single, shallow A horizon overlying clay material.

The soil mapping unit boundaries are shown in **Figure 1**.

It is important to note that not all soil layers described for each of the Soil Mapping Units are present in every profile. Soils are inherently variable in nature and while they may have similar overall characteristics they may vary in layer detail and properties.

Appendix 1 contains detailed information on the layers present in the twenty four profiles.

5.1 Soil Mapping Unit Descriptions

Descriptions of the layers found in the profiles of the two SMUs identified within the Study Area are set out below.

In each case, the soil within each unit is described in two ways – a “Plain English” version followed by a technical description.

Definitions of the technical terms used in the descriptions can be found in **Appendix 4** or by consulting McDonald *et al* [1990] or Houghton and Charman [1986].

5.2 Soil Mapping Unit 1 – Soils of the Higher Crests

5.2.1 "Plain English" Description

Soil - 53 to 210cm deep; crest / upper slope location, surface condition hard setting, firm or firm and cracked; surface gravel and stone usually absent, occasionally moderate levels of surface gravel present, 1-3cm in size, rounded and angular.

Topsoil - 10-35cm thick; sandy clay loam, silty clay loam, sometimes loam or silty clay; usually many roots, sometimes roots common; no lime present; no manganese present; pH 5.0 to 6.0; gravel and stones absent, or some rounded or angular gravel present, 1-3cm in size; not mottled; sometimes bleached A_2 horizon present; massive or highly structured.

Subsoil - up to four subsoil horizons identified in sample pits; subsoil generally comprised of clay textured material that is sometimes gritty; occasionally more sandy horizons present at the base of the profile; pH usually within the 4.0 to 7.0 range; usually highly structured.

5.2.2 Technical Description [based on test pits]

[a] Australian Soil Classification Names – Brown and Grey Chromosols or Kurosols

[b] Field Description:

Layer 1 - A1.1 Horizon - Layer always present [9-27cm thick]

Sandy clay loam, silty clay loam, sometimes loam or silty clay; usually many roots, sometimes roots common; no lime present; no manganese present; pH 5.0 to 6.0; gravel and stones absent, or some rounded or angular gravel present, 1-3cm in size; not mottled; sometimes bleached; brown [10YR5/2, 10YR5/3, 2.5YR5/3], greyish brown [10YR5/2], light brownish grey [10YR6/2] dry; dark brown [10YR3/3], dark greyish brown [10YR4/2], dark reddish brown [5YR3/3], very dark grey [10YR3/1], very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [80 - 100% [usually], polyhedral, <5-15mm in size; sometimes massive, fabric rough; firm, very firm or strong consistency dry; usually hydrophobic; *usually abrupt [sometimes clear or gradual] to:-*

Layer 2 - A1.2 Horizon - Layer sometimes present [19-47cm thick]

Sandy clay loam, silty clay; roots common to many; no lime present; no manganese present; pH 5.5 to 6.0; much rounded gravel 1- 4cm in size; not mottled; not bleached; light brownish grey [10YR6/2], pale brown [10YR6/2]dry; brown [7.5YR4/3], dark brown [10YR3/3] moist; massive, fabric rough; sometimes hydrophobic *sharp or abrupt to:-*

Layer 3 - A2 Horizon - Layer sometimes present [8-24cm thick]

Sandy clay loam or sandy clay; roots common; no lime present; no manganese present; pH 5.0 to 6.0; much gravel, rounded or angular to 2-10cm in size; not mottled; bleached; light grey [10YR7/2], very pale brown [10YR8/2], white [10YR8/1] dry; brown [10YR5/3]; dark greyish brown [10YR4/2], yellowish brown [10YR5/4] moist; peds rough-faced, highly pedal [100%], polyhedral, <5mm in size; weak to firm consistency dry; sometimes massive, fabric rough; not hydrophobic; *sharp, clear or gradual to:-*

Layer 4 – B1 Horizon - Layer always present [16-64cm thick]

Sandy clay, sandy light clay, medium clay, medium to heavy clay; roots few to many; no lime present; no manganese present; pH 5.0 - 6.0; gravel and stones often absent, sometimes much rounded gravel present, to 4cm in size; not bleached; usually whole coloured, brown [7.5YR4/2, 7.5YR5/3], grey brown [10YR5/2], light brown [10YR6/4], light brownish grey [2.5Y6/2], reddish brown [2.5YR4/3 dry, brown [7.5YR4/3], dark brown [7.5YR3/2, 7.5YR3/3], light brownish grey [2.5Y6/4], reddish brown [5YR4/3], strong brown [7.5YR4/6] moist; sometimes mottled, dark greyish brown[10YR4/6], reddish yellow [7.5YR6/8],light brownish grey [10YR6/2], reddish yellow [5YR6/8] dry; dark greyish brown[10YR4/6], strong brown [7.5YR5/8], brown 10YR5/3], yellowish red [5YR5/6] moist; usually highly pedal [100%], peds rough - / smooth-faced, polyhedral, <5-15mm in size; sometimes subangular blocky; 10-25mm in size; occasionally massive, fabric rough; very firm to very strong consistency dry; not hydrophobic; *abrupt, clear, gradual or diffuse to:-*

Layer 5 – B2 Horizon - Layer usually present [40-101cm thick]

Clayey sand; sandy medium clay; gritty light clay, medium clay, medium -heavy clay, heavy clay; usually few roots, sometimes absent or common; no lime present; usually no manganese present, sometimes stains present; pH 5.0 - 7.0, occasionally 8.5; gravel and stone usually absent, sometimes rounded gravel to 3cm or angular stones to 10cm present; not mottled; not bleached; brown [7.5YR5/4], light brown [7.5YR6/3], pale brown [10YR6/3] [sometimes with flecks of white [10YR8/1], reddish brown [5YR4/3], very pale brown [10YR7/4] dry, brown [2.5YR5/3] to reddish brown [2.5YR5/4], brown [7.5YR4/3], brown 10YR5/3] with flecks of brownish yellow [10YR6/6], reddish brown [5YR4/3], strong brown [10YR5/8, 7.5YR4/6] moist; usually highly pedal [100%], peds rough- faced, peds smooth - faced or rough- / smooth-faced, polyhedral, <5-20mm in size; strong to very strong consistency dry; occasionally massive fabric earthy / rough fabric; not hydrophobic; over bedrock or *clear or diffuse to:-*

Layer 6 – B3 Horizon – Layer sometimes present [73-100cm thick]

Heavy clay; few roots; no lime present; manganese absent or many manganese stains present; pH 4.5 -5.0; some weathering rock or flat sandstone floaters to 50cm in size present; not bleached; mottled; red [5YR4/3], light brownish grey [10YR6/2], dark brown [7.5YR3/2], grey [7.5YR8/1], red [10YR4/6] dry, red [5YR4/3, 10YR4/6], greyish brown [10YR5/2], dark brown [7.5YR3/2], light brownish grey [10YR6/2], moist; peds smooth- faced or rough- / smooth- faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic.

5.3 Soil Mapping Unit 2 - Soils of the Mid and Lower Slopes and Drainage Depressions

5.3.1 "Plain English" Description

Soil recorded to 247cm deep; midslope, lower slope and drainage depression, occasional lower crest location; surface firm to hardsetting, sometimes cracked; surface gravel absent or rounded or angular gravel 3-10cm in size present, sometimes stones to 25cm recorded.

Topsoil - 5-30cm thick, sometimes with a narrow A_2 horizon present; usually silty clay or silty clay loam, sometimes loam, clay loam or light to medium clay textured; many roots, occasionally few; no lime present; no manganese present; pH 5.0 - 6.0; angular and rounded gravel to 3cm present, sometimes stones to 20cm present, or gravel and stone absent**,** gravel layers sometimes discontinuous and sometimes in lenses; not mottled; usually not bleached; highly pedal.

Subsoil - recorded to 225cm thick; comprised of up to four horizons of generally medium to heavy clay textured material; pH levels reach 9.0 deep in the subsoil material.

5.3.2 Technical Description [based on test pits]

[a] Australian Soil Classification Names – Brown [occasionally Red or Grey] Chromosols or Kurosols

[b] Field Description:

Layer 1 - A1 Horizon - Layer always present [5-30cm thick]

Usually silty clay or silty clay loam, sometimes loam, clay loam or light to medium clay; many roots, occasionally few; no lime present; no manganese present; pH 5.0 - 6.0; angular and rounded gravel to 3cm in size present, sometimes stones to 20cm in size present, or gravel and stone absent**,** gravel layers sometimes discontinuous and sometimes in lenses; not mottled; usually not bleached; brown [10YR5/3, 10YR5/3, 7.5YR5/2, 7.5YR5/3], dark greyish brown 10YR4/2], greyish brown [10YR5/2], light brown [7.5YR6/3], light brownish grey [10YR6/2], pale brown [10YR6/3] dry, brown [10 YR4/3, 7.5YR4/3], dark brown [7.5YR3/2, 10YR3/2], dark greyish brown [10YR4/2], dark yellowish brown [10YR3/4], very dark greyish brown [10YR3/2] moist; peds rough- faced, highly pedal [usually 100%], polyhedral, <5-20mm in size; firm to very strong consistency [occasionally weak] dry; sometimes massive, fabric rough; hydrophobic or not hydrophobic; *usually sharp or abrupt sometimes gradual to:-*

Layer 2 - A2 Horizon - Layer sometimes present [6-13cm thick]

Usually silty clay sometimes sandy light to medium clay; roots few to many; no lime present; no manganese present; pH 5.5 - 6.0; some or much rounded or angular gravel to 1cm in size, occasional stones to 20cm in size, sometimes gravel and stones absent; some angular gravel to 1cm; not mottled; often bleached or apparently so; greyish brown [10YR5/2], light brownish grey [10YR6/2], light grey [10YR7/2] dry, brown [10YR5/3, 7.5YR4/3], dark brown [7.5YR3/2], dark greyish brown [10YR4/2] moist; often massive, fabric rough; sometimes peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; sometimes hydrophobic; *sharp, abrupt or clear to:-*

Layer 3 – B1 Horizon - Layer always present [11-66cm thick]

Light to medium clay, medium to heavy clay; medium clay, heavy clay; roots few to many; no lime present; usually no manganese present, occasionally stains recorded; pH 5.0 – 7.0, occasionally 8.0; gravel and stones usually absent, sometimes lenses of gravel present or rounded or angular gravel common, occasional stones to 25cm in size present in some profiles; not bleached; **usually not mottled**; brown [10YR5/3, 7.5YR5/2, 7.5YR5/3], light brownish grey [10YR6/2], light olive brown [2.5Y5/3], light yellowish brown [10YR6/4], pale brown [10YR6/3],reddish yellow [5YR6/6], yellowish brown [10YR5/4] dry, brown [10YR4/3, 10YR5/3, 7.5YR4/3, 7.5YR4/4], dark brown [7.5YR3/3], dark greyish brown [10YR4/2], olive brown [2.5Y4/3], red [5YR5/6], reddish brown [2.5YR4/4], yellowish brown [10YR5/4] moist; **sometimes mottled in colours of;** brown [19YR5/3], 7.5YR5/3], light red [2.5YR6/6], red [2.5YR5/6], reddish brown [2.5YR4/4], very pale brown [10YR8/4] dry, brown [7.5YR5/3], dark brown [7.5YR3/2], dark greyish brown [10YR4/2], light yellowish brown [10YR6/4], red [10R4/6], reddish brown [2.5YR4/3, 2.5YR4/4], reddish yellow [5YR6/8] moist; peds usually rough- / smooth- faced, sometimes rough-faced or smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; very firm to very strong consistency dry; not hydrophobic; *sharp, abrupt, clear, gradual or diffuse to:-*

Layer 4 – B2.1 Horizon - Layer usually present [24-175cm thick]

Clayey sand, sandy light clay, light to medium clay, medium clay, medium to heavy clay, heavy clay; few roots, occasionally many; no lime present; usually no manganese present , occasionally stains present; pH 4.0 to 9.0, usually 5.0 to 7.5; gravel and stones absent or rounded or angular gravel to 4cm in size present in whole horizon or lenses; not bleached ; **usually whole coloured**; brown [10YR5/3, 7.5YR4/2], brownish yellow [10YR6/6], light grey [2.5Y7/2], light yellowish brown [10YR6/4, 2.5Y6/4], pale brown [10YR6/3], reddish yellow [5YR6/6], very pale brown [10YR7/4], very pale brown [10YR7/3] with flecks of red [2.5YR5/6], yellow [10YR7/6] dry; brown [10YR4/3, 10YR5/3, 7.5YR4/2], brownish yellow [10YR6/6], light olive brown [2.5Y5/4], pale brown [10YR6/3], yellowish brown [10YR5/4], yellowish brown [10YR5/4] with flecks of red [2.5YR5/6], yellowish red 5YR5/6] moist; **sometimes mottled in colours of**; red [2.5YR5/6], light red [2.5YR5/6], pale red [2.5YR6/2], pale brown [10YR6/3], brownish yellow [10YR6/6], light grey [10YR7/2], very pale brown [10YR7/3, 10YR7/4]dry, brown [10YR5/3], 5YR4/6, 7.5YR5/3], brownish yellow [10YR6/6], light yellowish brown [10YR6/4], pale brown [10YR6/3], reddish yellow [5YR6/8], yellowish red [5YR5/6, 5YR4/6] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-20mm in size; very firm to very strong consistency dry; not hydrophobic; *clear, -gradual or diffuse to:-*

Layer 5 – B2.2 Horizon - Layer usually present [30-90cm thick]

Light to medium [sometimes gritty], medium clay, medium to heavy clay, heavy clay; usually few roots, occasionally roots absent; no lime present; manganese absent or many stains and concretions present in some profiles; pH 4.0 – 8.0, usually between 5.5 and 7.0; gravel and stones absent or pockets of rounded gravel to 2cm in size present; not bleached; **sometimes whole coloured**; light yellowish brown [10YR6/4], pale brown [10YR6/3], very pale brown [10YR7/4] dry, brown [10YR4/3], light yellowish brown [2.5Y6/3], yellowish brown [10YR5/4] moist; **more usually mottled in colours of**: brownish yellow [10YR6/6], light grey [10YR7/1], light red [2.5YR6/8], pale brown [10YR6/3], pale yellow [2.5Y8/2], pink [7.5YR7/4], red [2.5YR5/6], reddish yellow [7.5YR6/6], very pale brown [10YR7/3, 10YR7/4, 10YR8/3],white [7.5YR8/1], yellowish red [5YR5/6] dry, brown [10YR5/3], brownish yellow [10YR6/6], light brownish grey [5YR5/6], light grey [2.5Y7/2, 7.5YR7/1], red [2.5YR5/6, 2.5YR5/8], reddish yellow [5YR6/6], strong brown [7.5YR5/8, 7.5YR5/6], very pale brown [10YR7/4],

yellowish brown [10YR5/4], yellowish red [5Yr4/6] moist; peds usually rough- / smooth-faced [sometimes smooth-faced], highly pedal [100%], polyhedral, <5-15mm in size; strong to very strong consistency dry; rarely massive, fabric rough / smooth; not hydrophobic; *bedrock or diffuse to:-*

Layer 6 – B3 Horizon - Layer rarely present [44-100cm thick?]

Light to medium clay, medium clay, heavy clay; few roots or roots absent; no lime present; manganese nodules present or absent; pH 4.0 - 8.5; gravel and stones absent; bleached; **mottled in colours of**; light yellowish brown 10YR6/4], pale brown [10YR6/3], red [2.5YR5/6], reddish yellow [5YR6/6], very pale brown [10YR8/2], yellowish brown 10YR5/6] dry, dark yellowish brown[10YR4/4], light yellowish brown 10YR6/4], pale yellow [2.5Y7/3], red [2.5YR4.8], strong brown [7.5YR5/6], yellowish red [5YR5/6] moist; peds rough- / smooth-faced or smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong to very strong consistency dry; not hydrophobic.

5.4 Soil Laboratory Analyses

Twenty one samples from five soil profiles were selected for laboratory analysis at the Department of Lands Soil and Water testing Laboratory at Scone.

The tests performed aimed at assessing the potential erodibility of the soils [Particle Size Analysis [PSA], Dispersion % [D%] and Emerson Aggregate Test [EAT]] and Electrical Conductivity [EC].

5.4.1 Physical and Chemical Analyses

Tables 1 and **4** show the results obtained from laboratory analysis of the samples from the five soil profiles.

Samples from three profiles from within SMU 1 and two from SMU 2 were analysed in the laboratory.

6 DISCUSSION OF SOIL ANALYSES

6.1 Physical Attributes

The laboratory analysis results contained in **Table 1** are important in assessing the erodibility of the soil units found within the Study Area.

The three tests [Particle Size Analysis, Dispersion %, Emerson Aggregate Test] carried out on samples from each of the horizons within the five selected soil profiles, when considered together, provide a good indication of a soil's likely behaviour in relation to the erosive forces encountered in the field.

Table 1
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
SMU 1 PIT 2	1	Loamy sand	0-14	12.4	17.5	39.2	30.9	70.4	3
	2	Sandy loam	14-36	16.4	9.8	32.8	41.0	73.8	39
	3	Sandy clay loam	36-69	27.8	5.6	22.2	44.4	66.7	46
	4	Sandy clay loam	69-120	23.2	8.5	28.0	40.2	68.3	18
SMU 1 PIT 6	1	Loam	0-14	19.6	22.7	41.2	16.5	57.7	3
	2	Silt loam	14-25	22.0	26.0	34.0	18.0	52.0	50
	3	Clay	25-61	57.0	14.0	24.0	5.0	29.0	<1
	4	Silty clay	61-102	43.0	28.0	27.0	2.0	29.0	<1
SMU 1 PIT 22	1	Loam	0-10	14.8	17.3	34.6	33.3	67.9	19
	2	Loam	10-29	15.0	15.0	32.5	37.5	70.0	60
	3	Clay	29-132	35.0	11.3	20.0	33.8	53.8	20
	4	Sandy clay loam	132-144	26.3	3.9	19.7	50.8	69.7	24
SMU 2 PIT 9	1	Loam	0-10	17.1	20.0	41.4	21.4	62.9	30
	2	Clay	10-49	59.8	13.4	17.5	9.3	26.8	3
	3	Silty clay	49-97	48.5	32.3	15.2	4.1	19.2	1
	4	Silty clay	97-147	51.0	42.0	6.0	1.0	7.0	<1
	5	Silty clay loam	147-247	35.0	48.0	16.0	1.0	17.0	<1
SMU 2 PIT 15	1	Loam	0-10	23.2	17.2	36.4	23.2	59.6	1
	2	Loam	10-23	19.8	20.9	38.5	20.9	59.3	9
	3	Clay	23-43	45.9	12.2	29.6	12.2	41.8	2
	4	Clay	43-116	43.0	20.0	32.0	5.0	37.0	<1
SMU 1 PIT 2	1	Loamy sand	0-14	28	Slight	8/3[1]	Negligible / slight	1	Loamy sand
	2	Sandy loam	14-36	50	Moderate	2[1]	High – moderate	2	Sandy loam
	3	Sandy clay loam	36-69	63	High	2[3]	Very high	3	Sandy clay loam
	4	Sandy clay loam	69-120	46	Moderate	3[2]	Slight	4	Sandy clay loam

Notes: PSA = Particle Size Analysis # texture based on laboratory measurements

Table 1 [Cont'd]
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	D %	D% level of dispersion	EAT	EAT level of dispersion
SMU 1 PIT 6	1	Loam	0-14	39	Moderate	8/3[2]	Negligible / slight
	2	Silt loam	14-25	56	High	2[1]	High – moderate
	3	Clay	25-61	74	Very high	2[3]	Very high
	4	Silty clay	61-102	78	Very high	2[1]	High - moderate
SMU 1 PIT 22	1	Loam	0-10	25	Slight	8/3[2]	Negligible / slight
	2	Loam	10-29	25	Slight	2[1]	High – moderate
	3	Clay	29-132	61	High	2[2]	High
	4	Sandy clay loam	132-144	54	High	2[3]	Very high
SMU 2 PIT 9	1	Loam	0-10	27	Slight	2[2]	High
	2	Clay	10-49	76	Very high	2[3]	Very high
	3	Silty clay	49-97	69	Very high	2[1]	High – moderate
	4	Silty clay	97-147	58	High	2[1]	High – moderate
	5	Silty clay loam	147-247	52	High	2[1]	High - moderate
SMU 2 PIT 15	1	Loam	0-10	25	Slight	8/3[2]	Negligible / slight
	2	Loam	10-23	54	High	2[1]	High – moderate
	3	Clay	23-43	73	Very high	2[1]	High – moderate
	4	Clay	43-116	85	Very high	1	Very high

Notes: D = Dispersion EAT = Emerson Aggregate Test # texture based on laboratory measurements

6.1.1 Particle Size Analysis

The Particle Size Analysis [PSA] test shows the amounts of gravel, clay, silt, fine sand and coarse sand contained within each sample.

The results shown in **Table 1** are those contained in the laboratory test report.

From this data it is evident that some soils that were analysed [particularly those from SMU 1] contain relatively high levels of gravel however these are not sufficient to cause the material to be unsuitable for use in rehabilitation works.

The texture class of each soil layer is determined by analysis of the material [fine earth fraction] that is less than 2mm in size – i.e. the sample from each tested horizon with the gravel removed. The calculated texture of the fine earth fraction of each of the layers tested in the laboratory is shown in **Table 1**.

It should be noted that the field textures of almost all layers of the twenty four profiles that were examined indicated that the soils were generally more clayey than was shown in the laboratory analyses.

6.1.2 Dispersion Percentage

The Dispersion Percentage [D%] test indicates the proportion of the soil material less than 0.005 mm in size that will disperse on wetting [i.e. the clay and some of the silt fractions].

Hazelton and Murphy [in press] provide the following guides to the interpretation of D% values [**Table 2**].

Table 2
Interpretation of Dispersion Percentage Values
[after Hazelton and Murphy, in press]

D% Value	Dispersion Rating
< 6	Negligible
6 – 30	Slight
30 – 50	Moderate
50 – 65	High
> 65	very high

In interpreting the results of the values of dispersion percentage obtained in laboratory testing it is important to consider other related soil attributes such as the Particle Size Analysis [PSA] and Emerson Aggregate Test [EAT] data.

Soil horizons with high clay contents and high Dispersion % values will be more dispersive in practice than those with a high Dispersion % value and a low clay content in the soil.

The D% values shown in **Table 1** indicate that the topsoils of both SMUs showed slight dispersibility as measured by this procedure.

The subsoil D% values usually ranged from high to moderate to very high in both SMUs. Many of the subsoils contain moderate to high levels of clay and this fact undoubtedly makes them more dispersive than the analyses indicate - although for many samples this is difficult since they already exhibit moderate to very high values.

Given these indications of dispersibility, the erosion potential is undoubtedly high for any areas of exposed subsoil.

Consequently, appropriate measures need to be taken to protect the stockpiles of stripped subsoil. The same material, when respread, should be afforded rapid protection from soil erosion in the form of vegetative cover.

6.1.3 Emerson Aggregate Test

This test provides a measure of the coherence of soil aggregates when they are immersed in water. Natural peds are used [Houghton and Charman, 1986] and the method used by the Department of Lands to determine the Emerson Class Number is fully described in Craze *et al* [1993].

Basically, the degree of soil aggregate stability increases from Class 1 through to Class 8. Classes 2 and 3 have a number of subclasses based on the degree of dispersion.

Aggregates in Emerson Classes 1 and 2 are generally regarded as being unstable while those in Classes 4 to 8 are considered to be stable.

Hazelton and Murphy [in press] present a summary of the Emerson Aggregate Classes. This is contained in **Table 3**.

Table 3
Comparison of Aggregate Dispersibility and Emerson Aggregate Classes [after Hazelton and Murphy, in press]

Aggregate Dispersibility	Emerson Aggregate Classes*
Very High	1 and 2[3]
High	2[2]
High to Moderate	2[1]
Moderate	3[4] and 3[3]
Slight	3[2], 3[1] and 5
Negligible / Aggregated	6,7,and 8

*** NOTE** – the subclasses of the Emerson Aggregate Test [EAT] Classes are as follows:
[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 [NB – Class 2[4] is equivalent to Class 1]

The EAT data in **Table 1** show that the surface layers of the soils from SMU 1 analysed have a negligible to slight dispersibility rating. However, for SMU 2 the topsoil dispersibility as measured by the EAT was more variable – negligible to slight to high.

The EAT levels in the subsoils from both SMU 1 and SMU 2 were mostly high to moderate, high or very high.

Based on the EAT testing, the topsoils in both SMUs exhibit a low degree of dispersibility.

However, the subsoil material in both SMUs is generally moderately to very highly dispersible, making it essential that any exposed subsoil is adequately protected from soil erosion.

As a consequence, this subsoil material would require adequate protection by vegetative cover in the stockpile and rehabilitation stages.

6.2 Soil Chemical Attributes

Laboratory testing of the samples extended only to an examination of the electrical conductivity. Soil pH was measured in the field using the Raupach method. The results of the laboratory analyses and the field pH measurements are contained in **Table 4**.

6.2.1 Soil pH

In general, the pH [water] range in most soils is between 4.0 and 8.5 although pH values above and below this range are measured at times [Glendinning, 1990].

This range of soil pH levels is generally accepted as being one that is suitable for plant growth.

The pH 6.0 to 6.5 range is usually regarded as the optimum for growth of most plants and there are some more serious impacts on the growth of many species at the lower, or acid, end of the range.

Table 4
Chemical Analyses Laboratory Analysis Data for Selected Belmont Soil Profiles

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	pH *	EC [dS/m]#
SMU 1 PIT 2	1	Loamy sand	0-14	5.0	0.02
	2	Sandy loam	14-36	5.0	0.04
	3	Sandy clay loam	36-69	5.0	0.17
	4	Sandy clay loam	69-120	8.5	0.40
SMU 1 PIT 6	1	Loam	0-14	6.0	0.05
	2	Silt loam	14-25	5.5	0.08
	3	Clay	25-61	5.5	0.62
	4	Silty clay	61-102	5.5	0.70
SMU 1 PIT 22	1	Loam	0-10	5.5	0.08
	2	Loam	10-29	5.5	0.06
	3	Clay	29-132	5.5	0.48
	4	Sandy clay loam	132-144	5.0	0.48
SMU 2 PIT 9	1	Loam	0-10	6.0	0.21
	2	Clay	10-49	4.5	0.71
	3	Silty clay	49-97	4.0	0.58
	4	Silty clay	97-147	4.0	0.83
	5	Silty clay loam	147-247	4.0	0.70
SMU 2 PIT 15	1	Loam	0-10	6.0	0.03
	2	Loam	10-23	5.5	0.01
	3	Clay	23-43	5.5	0.08
	4	Clay	43-116	5.5	0.20

Notes: # texture based on laboratory measurements * field measurement

As the pH scale [between 0 and 14] is a logarithmic one, a soil with a pH of 5.0 is ten times as acid as a soil of pH 6.0 and 100 times as acid as one with a pH of 7.0.

Perusal of the data in the pH column in **Table 4** indicates that all of the twenty one topsoil and subsoil samples tested showed pH levels within the 4.0 to 8.5 range.

In general, the uppermost soil layer had a pH within the acceptable range but some of the lower layers in soils that were not subjected to laboratory analysis [see **Appendix 1**] were very alkaline and outside the range acceptable for plant growth.

This indicates that the pH values of the topsoil layer that would be stripped from both SMUs for use in rehabilitation are within acceptable limits.

However, the upper subsoil material to be stripped and stockpiled will, in some sites at least, have higher than ideal pH values. This should not present a problem as the process of stripping and respreading will mix the soil materials from higher and lower pH areas and result in material with an acceptable pH level.

6.2.2 Electrical Conductivity

Soil salinity is a measure of the presence of water-soluble salts, mainly of sodium, calcium and magnesium in the soil solution. These salts may be chlorides, sulphates or carbonates and can have a major impact on plant growth if they occur in sufficiently large quantities.

The level of salinity in a soil sample is determined by measuring the electrical conductivity [EC] of a 1:5 soil / water suspension.

As the published salinity tolerance data for crops and pastures is based on the electrical conductivity of a saturated extract of the soil solution, a series of conversion factors, based on the estimated water holding capacity of soil sample, are used to convert the measured EC value to one for the conductivity of the saturated extract [EC_e].

The electrical conductivity of the 1:5 soil / water suspension and that of the saturated extract are measured in units called deciSiemens / metre [dS/m].

The measured level of electrical conductivity of the 1:5 soil / water suspension is multiplied by the appropriate factor in **Table 5** [extracted from Hazelton and Murphy, in press] based on the measured soil texture.

Table 6 shows the calculated EC_e values for the samples analysed in the laboratory and shows the salinity status of the various horizons based on these EC_e values.

Table 5
Texture Class Multipliers for Calculating EC_e Values

Soil Texture Class	Multiplier Factor
loamy sand, clayey sand, sand	23
sandy loam, fine sandy loam, light sandy clay loam	14
loam, loam fine sandy, silt loam, sandy clay loam	9.5
clay loam, silty clay loam, fine sandy clay loam, sandy clay, silty clay, light clay	8.6
light medium clay	7.5
medium clay	5.8
heavy clay	5.8

Table 6
Calculated EC_e Values and Salinity Status for Selected Soil Profiles

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	EC [dS/m]#	MULTI-PLIER	CALCULATED EC_e	SOIL SALINITY STATUS
SMU 1 PIT 2	1	Loamy sand	0-14	0.02	23	0.46	Non-saline
	2	Sandy loam	14-36	0.04	14	0.56	Non-saline
	3	Sandy clay loam	36-69	0.17	9.5	1.62	Non-saline
	4	Sandy clay loam	69-120	0.40	9.5	3.80	Slightly saline
SMU 1 PIT 6	1	Loam	0-14	0.05	9.5	0.48	Non-saline
	2	Silt loam	14-25	0.08	9.5	0.76	Non-saline
	3	Clay	25-61	0.62	5.8	3.60	Slightly saline
	4	Silty clay	61-102	0.70	8.6	6.02	Moderately saline
SMU 1 PIT 22	1	Loam	0-10	0.08	9.5	0.76	Non-saline
	2	Loam	10-29	0.06	9.5	0.57	Non-saline
	3	Clay	29-132	0.48	5.8	2.78	Slightly saline
	4	Sandy clay loam	132-144	0.48	9.5	4.56	Moderately saline
SMU 2 PIT 9	1	Loam	0-10	0.21	9.5	2.0	Non- / slightly saline
	2	Clay	10-49	0.71	5.8	4.12	Moderately saline
	3	Silty clay	49-97	0.58	8.6	5.00	Moderately saline
	4	Silty clay	97-147	0.83	8.6	7.14	Moderately saline
	5	Silty clay loam	147-247	0.70	8.6	6.02	Moderately saline
SMU 2 PIT 15	1	Loam	0-10	0.03	9.5	0.29	Non-saline
	2	Loam	10-23	.0.01	9.5	0.10	Non-saline
	3	Clay	23-43	0.08	5.8	0.46	Non-saline
	4	Clay	43-116	0.20	5.8	1.16	Non-saline
Note: # texture based on laboratory measurements							

Hazelton and Murphy [in press] note that EC_e values below 2.0 indicate non-saline horizons while values between 2.0 and 4.0 indicate slight salinity. Values between 4.0 and 8.0 indicate moderate salinity while those between 8.0 and 16.0 indicate high salinity.

The data in **Table 6** indicate that all topsoil materials within the two SMUs are non-saline or [rarely] slightly saline.

The situation with the subsoils tested is less clear-cut, with some being non-saline or slightly saline while others were **moderately saline**.

This variability signals a need for caution in dealing with these subsoils since it is difficult to assign absolute salinity values to the two SMUs. As a consequence the subsoils of both SMUs will have to be treated cautiously when being stockpiled.

One positive aspect of the variability is that the mixing process during stripping is likely to cause dilution of any saline material to levels where its impact in the stripped subsoils would be likely to be minimal.

6.2.3 Likelihood of Encountering Acid Sulfate Soils

Acid sulfate soils are basically confined to coastal estuarine floodplain areas in New South Wales.

These soils are extremely acidic soil layers that develop as a consequence of the aeration of soil materials that are rich in iron sulfides, primarily pyrite [FeS].

When drainage or excavation brings these previously waterlogged soil layers into contact with oxygen, the pyrite is oxidised to form sulfuric acid.

If the production of acid exceeds the neutralising capacity of the particular soil such that the pH falls below 4.0, these soils are known as acid sulfate soils.

The soils at the Study Area usually increase in alkalinity with depth [often to pH 9.5 - 10] and are not waterlogged. There is a considerable quantity of neutralising capacity in all soils at the site.

As a consequence of these features and the fact that the site is not located on a coastal estuarine floodplain it is extremely unlikely that any acid sulfate soils will impact in any way on the mine during its working life or on the success of subsequent rehabilitation.

6.3 Erosion Potential

The soils within the Study Area are currently generally stable except for some minor areas of sheet erosion on the slopes and some gully erosion in the main drainage lines.

Because the Study Area is centred on an elevated landscape, water drains generally to the north of the proposed area of disturbance.

Groundcover varies over the site, however the cleared and remnant vegetation areas generally support a good cover of native and naturalised species.

It will be essential, if erosion is to be prevented, to maintain an adequate groundcover on the existing landscape, on any stockpiles during the mine's operation and on the reformed landscapes after rehabilitation work is carried out.

6.4 SOILOSS Program

An appropriate method of assessing the erosion hazard associated with the soils of the Study Area is to use the SOILOSS computer program devised by Rosewell and Edwards [1988] and updated by Rosewell [1993].

This program computes soil loss values for a given site under various land uses and climatic [rainfall] conditions and so provides an indication of erosion hazard.

SOILOSS is based on the Universal Soil Loss Equation or USLE described by Wischmeier and Smith [1978] and subsequently updated as the Revised Universal Soil Loss Equation or RSLE [Renard *et al*, 1993].

The USLE is

A = R * K * L * S * P * C where

A is the average annual soil loss [tonnes / hectare]
R is the rainfall erosivity factor, a measure of the erosive power of the rain
K is the soil erodibility factor, a measure of the resistance of the soil to erosion
L is the slope length factor
S is the slope steepness factor
P is the support practice factor, a measure of the effect on erosion of soil conservation measures such as contour cultivation and bank systems
C is the crop and cover management factor

In using SOILOSS, the rainfall erosivity factor is obtained from maps provided with the program manual [Rosewell, 1993].

Soil erodibility is either estimated from details of the soil type and soil surface texture by comparison with a table of soils presented by the program or is derived from a knowledge of soil particle size analysis, organic matter content, surface soil structure and profile permeability.

Slope length and steepness factors are derived from field measurements and / or examination of topographic maps or airphotos.

The support practice factor is estimated by the program from a description of the land management practices in use, details of cultivation direction and information on bank systems if these are present.

To determine the value of the 'K' factor for use in the program, a generic or standard method can be utilised from within the program to indicate the likely soil losses from a range of crop rotations and management practices.

In addition, a more detailed approach can be used to determine likely soil loss given the availability of precise detail relating to sowing dates, cultivation practices etc.

Provision is made within the program for estimating soil loss from areas with a range of non-arable uses.

Table 7 provides details of the calculated erodibility values [K] and erodibility ratings for topsoils and subsoils from a selection of soil profiles in the Study Area.

The erodibility estimates contained in **Table 7** for the two soil types [SMUs] recorded from the Study Area have been calculated using part of the overall SOILOSS program capability and the Particle Size Analysis and other data for five typical soil profiles at the Study Area.

Table 7
Soil Erodibility Values and Ratings for a Selection of Soils

SOIL and SMU	PIT NUMBER	TOPSOIL LAYER [cm]	TOPSOIL 'K' RATING	SUBSOIL LAYER [cm]	SUBSOIL 'K' RATING	AVERAGE 'K' RATING [WHOLE SOIL]	SOIL MAPPING UNIT ERODIBILITY
SMU 1	PIT 2	0-14	0.040 [moderate / high]	36-69	0.023 [moderate]	0.032	Moderate
SMU 1	PIT 6	0-14	0.042 [high]	25-61	0.014 [low]	0.028	Moderate
SMU 1	PIT 22	0-10	0.035 [moderate]	29-132	0.021 [moderate]	0.028	Moderate
SMU 2	PIT 9	0-10	0.044 [high]	49-97	0.023 [moderate]	0.034	Moderate
SMU 2	PIT 15	0-10	0.032 [moderate]	43-116	0.025 [moderate]	0.029	Moderate

The only value for which estimates were used in the calculations were those for organic matter. After discussions with Department of Natural Resources staff [Greg Chapman pers. comm. 22nd June, 2005] values for this variable for the two SMUs in the Study Area of 1.5% [topsoils] and 1.0% [subsoils] were chosen.

The Erodibility classes used were:

- < 0.020 = LOW;
- 0.020 – 0.040 = MODERATE; and
- > 0.040 = HIGH.

The data in **Table 7** shows that the SOILOSS program predicts that all of the soil types from the Study Area, that were laboratory tested, have MODERATE erodibility.

Because of the MODERATE erodibility of the soils as assessed by the SOILOSS analysis, they should be managed carefully during the stripping, stockpiling and rehabilitation stages to ensure that soil structure damage is minimal and that they are suitably protected by vegetation or some other medium at all times.

This erodibility constraint, when considered with the measured relatively high dispersibility and salinity in the subsoil materials, indicates that the subsoil materials will have to be very carefully managed during the life of the mine.

7 STRIPPING SUITABILITY OF SOIL MATERIALS

An approach has been developed by Elliott and Veness [1981] to determine the stripping suitability of soil materials found at a site where stripping of upper soil layers is required. The key used in this method of stripping suitability assessment is contained in **Appendix 2**.

This method has been used in the present study.

The basis for the Elliott and Veness approach is that not all soil material that might be available for topdressing of disturbed sites is suitable for agricultural or pastoral use: some may be poorly structured, too sandy or gravelly or too poorly drained to allow a stabilising vegetative cover to develop.

In their work, Elliott and Veness established that there are a number of critical soil physical attributes that can be used to distinguish between suitable and unsuitable topdressing materials. These are:

[a] soil structure;
[b] soil macrostructure;
[c] soil coherence;
[d] soil texture; and
[e] the force necessary to disrupt peds.

NOTE: The following descriptions of soil materials are based on the detail gained from all 24 profiles sampled in the field.

7.1 Stripping Recommendations for Soil Mapping Unit 1

7.1.1 Layer 1 - 0-20cm depth -Topsoil

Usually loam, sandy clay loam, silty clay loam, deeper layers may be sandy clay; silty clay, medium clay, medium - heavy clay; roots usually common to many; no lime present; no manganese present; pH 5.0 – 6.0; gravel and stones absent or some to much rounded or angular gravel present, 1-10cm in size, sometimes present in lenses; not mottled; sometimes bleached or apparently so; brown [10YR5/3, 2.5YR5/3, 7.5YR5/3], dark greyish brown [10YR4/2], greyish brown [10YR5/2], light brownish grey [10YR6/2], light grey [10YR7/2], pale brown [10YR6/2], reddish brown [2.5YR4/3, very pale brown [10YR8/2], white [10YR8/1] dry, brown [10YR5/3], brown [7.5YR4/3], dark brown [10YR3/3], dark greyish brown [10YR4/2], dark reddish brown [5YR3/3], reddish brown [5YR4/3], very dark grey [10YR3/1], very dark greyish brown [10YR3/2], yellowish brown [10YR5/4] moist; **usually highly pedal** [100%], peds rough- faced or rough- / smooth-faced, polyhedral, <5-15mm in size; firm to very strong consistency dry, sometime weak; **sometimes massive**, fabric rough; surface layers often hydrophobic, lower material not so.

Suitability Assessment: mainly structure grade 3, sometimes structureless; coherent dry, mottles absent; macrostructure suitable; force to disrupt peds generally suitable; texture; layer contains much gravel in some profiles; pH levels suitable; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key. It contains considerable though not excessive amounts of gravel. The material also contains valuable seed, organic matter, nutrient reserves and has other favourable attributes.

This allows it to be stripped and stockpiled as **topsoil** provided suitable stripping and storage methods are used [discussed later in this report].

> **Recommendation** – Strip all of the Layer 1 topsoil to a depth of 20cm below the present ground surface. Although there is some variation in soil texture within this SMU, the soil material from all parts of the SMU 1 area can be mixed and stored in the same topsoil stockpiles.

[NOTE: Topsoil stripping should be carried out on all areas that will be disturbed by mining and associated infrastructure development within the boundaries of SMU 1. It should not be necessary to remove any subsoil from those areas to be used for roads, buildings, hardstand areas etc. However, on areas where the disturbance is deeper - ie. areas to be mined, waste rock emplacements etc - the subsoil should be stripped as indicated for layers 2 and 3 below].

7.1.2 Layer 2 – 20-70cm depth - Subsoil

Clayey sand; sandy clay loam, sandy light clay; sandy clay, silty clay, medium clay, medium - heavy clay; few to many roots, occasionally roots absent; no lime present; no manganese present; pH 5.0-6.5; gravel and stones absent or some to much usually rounded gravel present, 2-5cm in size, occasionally stone to 15cm present; mostly not bleached, occasionally bleached or apparently so; **usually whole coloured**; brown [2.5YR5/3, 7.5YR4/2, 7.5YR5/3], grey brown [10YR5/2], light brown [10YR6/4], light brownish grey [10YR6/2, 2.5Y6/2], light grey [10YR7/2], pale brown [10YR6/2, 10YR6/3], reddish brown [2.5YR4/3, 5YR4/3], very pale brown [10YR7/4, 10YR8/2], white [10YR8/1] dry, dark brown [7.5YR3/2, 10YR3/3], dark reddish brown [5YR3/3], dark brown [7.5YR3/3], dark greyish brown [10YR4/2], reddish brown [5YR4/3], brown [7.5YR4/3, 10YR5/3], strong brown [7.5YR4/6], yellowish brown [10YR5/4], strong brown [10YR5/8], light brownish grey [2.5Y6/4] moist; **occasionally mottled in colours of** dark greyish brown[10YR4/6], light brownish grey [10YR6/2], reddish yellow [5YR6/8, 7.5YR6/8] dry, brown 10YR5/3], dark greyish brown[10YR4/6], strong brown [7.5YR5/8], yellowish red [5YR5/6] moist; **usually highly pedal** [100%], peds rough- / smooth-faced, occasionally smooth-faced or rough-faced, usually polyhedral, sometimes subangular blocky, <5-25mm in size; very firm to very strong consistency dry, rarely weak ; **occasionally massive**, fabric rough; usually not hydrophobic.

Suitability Assessment: mainly structure grade 3; coherent dry, mottles usually absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer contains some gravel in some profiles; pH levels suitable; salt content generally suitable.

This material is suitable for use as subsoil on the basis of the Elliott and Veness key. This allows it to be stripped and stockpiled as **subsoil** provided suitable stripping and storage methods are used [discussed later in this report].

> **Recommendation** – Strip all of the Layer 2 subsoil to a depth of 50cm below the base of Layer 1 - ie. a total depth from the surface of 70cm. Although there is some variation in soil texture within this SMU, the subsoil material from all parts of the SMU 1 area can be mixed and stored in the same subsoil stockpiles.
>
> Stripping should cease if bedrock is encountered.

7.1.3 Layer 3 [Remainder of the Profile]

Although some sections of the Study Area covered by SMU 1 have shallow profiles, some other sections have deeper profiles consisting of material that may be suitable for use as subsoil. However, because of the likelihood of this material being saline, it is recommended that it not be stripped and stockpiled for use in rehabilitation unless absolutely necessary.

7.2 Stripping Recommendations for Soil Mapping Unit 2

7.2.1 Layer 1 - 0-10cm depth -Topsoil

Usually silty clay or silty clay loam, sometimes loam, clay loam or light to medium clay; usually many roots, occasionally few; no lime present; no manganese present; pH 5.0 - 6.0; angular and rounded gravel to 3cm in size present, sometimes stones to 20cm in size present, or gravel and stone absent**,** gravel layers sometimes discontinuous and sometimes in lenses; usually not bleached; **usually whole coloured;** brown [10YR5/3, 10YR5/3, 7.5YR5/2, 7.5YR5/3], dark greyish brown 10YR4/2], greyish brown [10YR5/2], light brown [7.5YR6/3], light brownish grey [10YR6/2], pale brown [10YR6/3] dry, brown [10 YR4/3, 7.5YR4/3], dark brown [7.5YR3/2, 10YR3/2], dark greyish brown [10YR4/2], dark yellowish brown [10YR3/4], very dark greyish brown [10YR3/2] moist; **rarely mottled in colours of** ; brown [7.5YR5/3], red [2.5YR5/6] dry; dark brown [7.5YR3/2], reddish brown [2.5YR4/4] moist; peds rough- faced, occasionally rough- / smooth- faced, highly pedal [usually 100%], polyhedral, <5-20mm in size; firm to very strong consistency [occasionally weak] dry; sometimes massive, fabric rough; hydrophobic or not hydrophobic; *usually sharp or abrupt sometimes gradual to:*

Suitability Assessment: mainly structure grade 3, sometimes structureless; coherent dry, mottles generally absent and when present only minor; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer contains some gravel in some profiles; pH levels suitable; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key. It contains some gravel. The material also contains valuable seed, organic matter, nutrient reserves and has other favourable attributes.

This allows it to be stripped and stockpiled as **topsoil** provided suitable stripping and storage methods are used [discussed later in this report].

> **Recommendation** – Strip all of the Layer 1 topsoil to a depth of 10cm below the present ground surface. Although there is some variation in soil texture within this SMU, the soil material from all parts of the SMU 1 area can be mixed and stored in the same topsoil stockpiles. A shallower stripping depth than that recommended for SMU 1 has been recommended for the SMU 2 topsoil because of the occurrence of clayey material at a generally shallower depth in this SMU.

[NOTE: Topsoil stripping should be carried out on all areas that will be disturbed by mining and associated infrastructure development within the boundaries of SMU 2. It should not be necessary to remove any subsoil from those areas to be used for roads, buildings, hardstand areas etc. However, on areas where the disturbance is deeper - ie. areas to be mined, waste rock emplacements etc - the subsoil should be stripped as indicated for layers 2 and 3 below].

7.2.2 Layer 2 – 10-70cm depth – Subsoil

Loam, silty clay loam, light to medium clay [occasionally sandy]; medium clay, medium to heavy clay, heavy clay; roots few to many; no lime present; occasional manganese stains present; pH usually 5.0 to 7.5, occasionally 4.0, 4.5, 8.0,8.5 or 9.0; gravel and stones mostly absent, sometimes some to much rounded or angular gravel to 3cm in size and / or stones to 25cm in size present; usually not bleached, occasionally bleached or apparently so; **usually whole coloured**; brown [10YR5/3, 5YR5/3, 7.5YR5/2, 7.5YR5/3], greyish brown [10YR5/2], light brown [7.5YR6/3, 2.5Y6/4], light brownish grey [10YR6/2], light grey [10YR7/2], light olive brown [2.5Y5/3], light yellowish brown [10YR6/4], pale brown [10YR6/3], reddish yellow [5YR6/6], very pale brown [10YR7/3] with flecks of red [2.5YR5/6], very pale brown [10YR7/4], yellow [10YR7/6], yellowish brown [10YR5/4] dry, brown [10YR4/3, 10YR5/3, 7.5YR4/3,7.5YR4/4, 7.5YR5/3], brownish yellow [10YR6/6, dark brown [7.5YR3/2], dark greyish brown [10YR4/2], light olive brown [2.5Y5/4], olive brown [2.5Y4/3], red [5YR5/6], reddish brown [2.5YR4/4], very dark greyish brown [10YR3/2], yellowish brown [10YR5/4] sometimes with flecks of red [2.5YR5/6], yellowish red 5YR5/6] moist; **sometimes mottled in colours of** brown [10YR5/3, 7.5YR5/3, brownish yellow [10YR6/6], light grey [10YR7/1, 10YR7/2], light red [2.5YR5/6, 2.5YR6/6], pale brown [10YR6/3], pale red [2.5YR6/2], pink [7.5YR7/4], red [2.5YR5/6], reddish brown [2.5YR4/4], very pale brown [10YR7/3, 10YR7/4, 10YR8/4] dry, brown [10YR5/3, 5YR4/6, 7.5YR5/3, brownish yellow [10YR6/6], dark brown [7.5YR3/2], dark greyish brown [10YR4/2], light brownish grey [5YR5/6], light yellowish brown [10YR6/4], pale brown [10YR6/3], red [10R4/6, reddish brown [2.5YR4/3, 2.5YR4/4], reddish yellow [5YR6/8], strong brown 7.50YR5/6], yellowish red [5YR5/6, 5YR4/6] moist; usually highly pedal [100%], rarely moderately pedal [50%]; peds rough- / smooth-faced, sometimes rough-faced or smooth-faced, polyhedral, <5-20mm in size; very firm to very strong consistency dry, rarely weak; occasionally massive, fabric rough; usually not hydrophobic.

Suitability Assessment: mainly structure grade 3; coherent dry, mottles usually absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer occasionally contains some gravel in some profiles; pH levels suitable; salt content variable but mixing during stripping should ameliorate this aspect making the material generally suitable.

This material is suitable for use as subsoil on the basis of the Elliott and Veness key. This allows it to be stripped and stockpiled as **subsoil** provided suitable stripping and storage methods are used [discussed later in this report].

> **Recommendation** – Strip all of the Layer 2 subsoil to a depth of 60cm below the base of Layer 1 - ie. a total depth from the surface of 70cm. Although there is some variation in soil texture within this SMU, the subsoil material from all parts of the SMU 2 area can be mixed and stored in the same subsoil stockpiles.
>
> Stripping should cease if bedrock is encountered.

7.2.3 Layer 3 [Remainder of the Profile]

Although some sections of the Study Area covered by SMU 2 may have shallow profiles, other sections have deeper profiles consisting of material that may be suitable for use as subsoil. However, because of the likelihood of this material being saline, it is recommended that it not be stripped and stockpiled for use in rehabilitation unless absolutely necessary.

8 HANDLING STRIPPED SOILS

8.1 General Issues

Stripping of topsoil materials is proposed for those sections of the Study Area to be used for the development of the proposed open cut mine, out-of-pit waste rock emplacement and construction of the surface facilities, site access road and Haul Roads A and B [where it is not on rehabilitated land].

In addition, subsoil material would need to be stripped from the area to be disturbed by the proposed open cut mine and out-of-pit waste rock emplacement for later use in rehabilitation.

It is appropriate to consider, in this report, the techniques for handling the soil materials that are to be stripped, stockpiled and then respread during the rehabilitation phase.

The recommendations made are based on an interpretation of the results of soil survey at the site and the associated laboratory analysis data.

As a general rule in soil stripping, stockpiling etc, the weaker [more sandy] the *in situ* structure of the soil being removed, the more care that is required in all phases of handling. The soil needs to be handled [disturbed] as little as possible to minimise mechanical damage to soil structure that will be detrimental to rapid establishment of ground cover once rehabilitation works commence.

There have been a number of studies in the past relating to the impact of the stripping and stockpiling of soils associated with mining and similar activities.

Working of soils in situations where the soil moisture content is unfavourable can have detrimental impacts on soil structure [Elliott and Veness, 1985; Hunter and Currie, 1956]. There are also unfavourable effects related to mixing of soil materials with different fertility levels, textures and other critical soil properties.

Stockpiling also has an effect on soil structure, although there is evidence that the impacts are, at least to some degree, reversible. Jenkin *et al* [1987] have noted that these effects seem similar to those of normal agricultural uses on soils.

Dougall [1950] has noted that stockpiling of soil results in some structure breakdown and changes associated with some other physical and chemical properties.

However, despite these negative impacts, Elliott and Veness [1985] conclude that the quality of stockpiled soil can, in fact, improve with time – especially in the outer layers of material.

8.2 Stripping and Stockpiling Recommendations

8.2.1 Earthmoving Procedures

As mentioned previously, the topsoils and subsoils to be moved within the Study Area generally have good structure. However, the topsoil structure is generally somewhat weaker than that of the subsoils - particularly in the moist state.

As a consequence, improper or excessive handling of the material during the stripping and stockpiling operation has the potential to destroy the soil structure by mechanically breaking down the soil aggregates that are present.

Notwithstanding the comments above, the generally good structure grades of both topsoils and subsoils will allow the stripping operation to be carried out using machines such as bulldozers or open-bowl scrapers. However, the scrapers should dump their loads neatly to form a uniform dump that requires little further forming prior to establishment of a vegetation cover.

Even so, care should be taken also to ensure that both topsoils and subsoils are not stripped when they are too moist as greater damage will occur at this time.

Driving of machinery on the topsoil and subsoil stockpiles, other than the scrapers during unloading, should be kept to an absolute minimum to maximise soil aggregation and prevent compaction.

Ideally the topsoil stockpiles should be 60cm to 1 metre high but, if necessary, higher stockpiles can be used. These should not exceed about 2 metres in height.

The subsoil stockpiles should not exceed 3 metres in height.

8.2.2 Soil Conservation Measures

Stockpiles should preferably be positioned where runoff water from upslope does not pose a problem, with the best stockpile sites being on a level ridgetop.

However, if a suitably-sized ridgetop site is not available, an upper slope position or some other relatively level area would be an acceptable alternative, provided an appropriate soil conservation bank design is used immediately above the site to prevent erosion of the stockpile by run-on water.

In addition, measures should be taken to minimise loss of soil material from the stockpiles, especially in the period before they are stabilised, eg using geotextile “fences” or lines of hay / straw bales etc.

The stockpile surfaces should be left with a 'rough’ but even surface to assist in runoff control and seed retention and germination and should be sown with stabilising species as soon as possible after placement. Where stockpile construction is conducted in stages, the stockpiles should be progressively stabilised.

8.2.3 Rehabilitation Measures

As the soil from the Camberwell waste rock emplacement is not to be recovered, the soil that is stripped would need to be replaced in slightly thinner layers than was originally stripped to provide for sufficient soil coverage over the entire disturbance area.

This is often the case with waste rock emplacements given that the soil is stripped from a flat footprint area and replaced over a “hill” with larger surface area. Calculation of the depth of soil to be applied to this area would be part of the detailed mine design. The species that would be replanted on the rehabilitated area and those that may naturally establish from seed contained in the topsoil should be able to cope with the shallower soil depth as most, if not all, are adapted to growth on relatively shallow sites.

9 LAND CAPABILITY

9.1 Methodology

Houghton and Charman [1986] in their "Glossary of Terms Used in Soil Conservation" define land capability as follows.

> "The ability of land to accept a type and intensity of use permanently, or for specified periods under specific management, without permanent damage".

They further note that land capability is "…an expression of the effect of biophysical land resources, including climate, on the ability of land to sustain use without damage under various uses such as crop production requiring regular tillage, grazing, woodland or wildlife. Land capability involves consideration of:

- the various land resources;
- the production to be obtained from the land;
- the activities or inputs required to achieve that production;
- the risks of damage to the land, on-site or off-site, resulting from those activities; and
- the inter-relations of the above".

Houghton and Charman note that land capability is taken into account in determining land suitability – another form of land classification relating to use for various purposes.

Land that is used beyond its capability ultimately loses its productive capacity as a consequence of exhaustion of soil nutrient supplies or the development of various forms of land degradation.

The land capability classification system used in New South Wales has been described by Emery [undated] and is a modification of the system devised and used by the former USDA Soil Conservation Service in the United States of America.

Emery's paper [in its Table 1] contains details of the Land Capability legend used on land capability maps prepared by the former Soil Conservation Service of New South Wales [now part of Department of Natural Resources [DNR]].

This shows the hierarchical classification used in the eight class system based on the management and protection needs of different types of land ranging from land needing no special soil conservation works or practices [Class 1] through to land that is unsuitable for agricultural or pastoral production [Class 8].

Emery's table also shows two other land capability classes – Mining and Urban land use – and also deals with class subscripts used to further subdivide some capability classes. The information presented by Emery is contained in **Appendix 3**.

9.2 Land Capability and Agricultural Land Suitability Classification of the Study Area

It should be noted that both the NSW Soil Conservation Service [DNR] Land Capability mapping and the Agricultural Land Suitability mapping of NSW Department of Primary Industries [Agriculture] were carried out at a very different scale to that of the present study and in most cases the assessments were subjected to only limited field checking.

As a consequence, there are often differing assessments that result from more detailed examination of relatively small study areas.

9.2.1 Land Capability as Mapped by DNR

The 1: 100 000 scale Land Capability map of the Camberwell map sheet area prepared by the former Soil Conservation Service of NSW [DNR, Parramatta - GIS] shows the Project Site to comprise mainly **Class V** land with the possibility that it borders on **Class IV** land to the southwest. This latter land has been mined and / or used a waste rock emplacement and much of it has been rehabilitated.

As a consequence, it is doubtful if any **Class IV** land remains within the Project Site.

Class IV land is *land not capable of being regularly cultivated but suitable for grazing with occasional cultivation; and requiring soil conservation practices such as pasture improvement, application of fertilizer and minimal cultivation for the establishment or re-establishment of permanent pasture*.

Class V land is *land not capable of being regularly cultivated but suitable for grazing with occasional cultivation; and requiring structural soil conservation works such as absorption banks, diversion banks and contour ripping, together with such practices such as pasture improvement, application of fertilizer and minimal cultivation for the establishment or re-establishment of permanent pasture*.

The areas that have been disturbed by activities related to mining have been designated Class M.

9.2.2 Current Assessment

After a stereoscopic interpretation of airphotos of the site and field assessments during the vegetation and soil surveys, it is evident that:

- the most of the Project Site can be classed as **Class V** land; and
- the land that has been disturbed by activities associated with mining can be designated **Class M** land.

The land capability classes for the Project Site as mapped in the present study are shown in **Figure 2**.

The post-mining landform would be classified as predominantly **Class VII** land (land best protected by green timber) with areas of **Class V** land.

9.3 Agricultural Land Suitability Classification

9.3.1 NSW Department of Primary Industries [Agriculture] Assessment

Information supplied by NSW Department of Primary Industries [Agriculture] at Tocal [Glenda Briggs, pers.comm.] indicates that the Department has classified the lands of the Study Area using its agricultural land suitability system [Cunningham *et al*, undated; Hulme *et al*, 2002].

The Study Area is mapped as mainly **Class 3** land with smaller areas of **Class 4** land on ridges. The agricultural land suitability class definitions for this particular mapping differ slightly from that presented by Cunningham *et al* [undated] and Hulme *et al* [2002]. The definitions supplied with the map section by the Department [Glenda Briggs pers. comm.] are used in this report.

Class 3 agricultural suitability land is described as '*Lands not suitable for regular cultivation. Includes some arable and some pasture lands with moderate levels of pasture production. Well suited to pasture improvement and can be cultivated for an occasional crop*'.

Class 4 agricultural suitability land is described as *'Land not suited to cultivation. Poor grazing or lands with seasonal grazing capabilities. Overall level of production is low*'.

9.3.2 Current Assessment

After a stereoscopic interpretation of airphotos of the site and field assessments during the vegetation and soil surveys, it is evident that the undisturbed lands within the Project Site comprise **Class 3** and **Class 4** lands however, the exact boundaries determined after the closer assessments associated with the soil and flora surveys of the area may not exactly coincide with those supplied by NSW Department of Primary Industries [Agriculture].

The disturbed lands within the Project Site can be classed as **Class 5** land - *'Land not suited for agriculture*'.

The agricultural land suitability classes for the Project Site as mapped in the present study are shown in **Figure 3**.

Once mechanical rehabilitation work is complete on the reshaped landscape, the land would need to be kept free of domestic livestock so that a suitable cover of native ground cover, tree and shrub species develops. The land would be classed as predominantly **Class 5** (not suitable for agriculture) with areas of **Class 3** or **4** land as the long-term reaction to grazing is unknown.

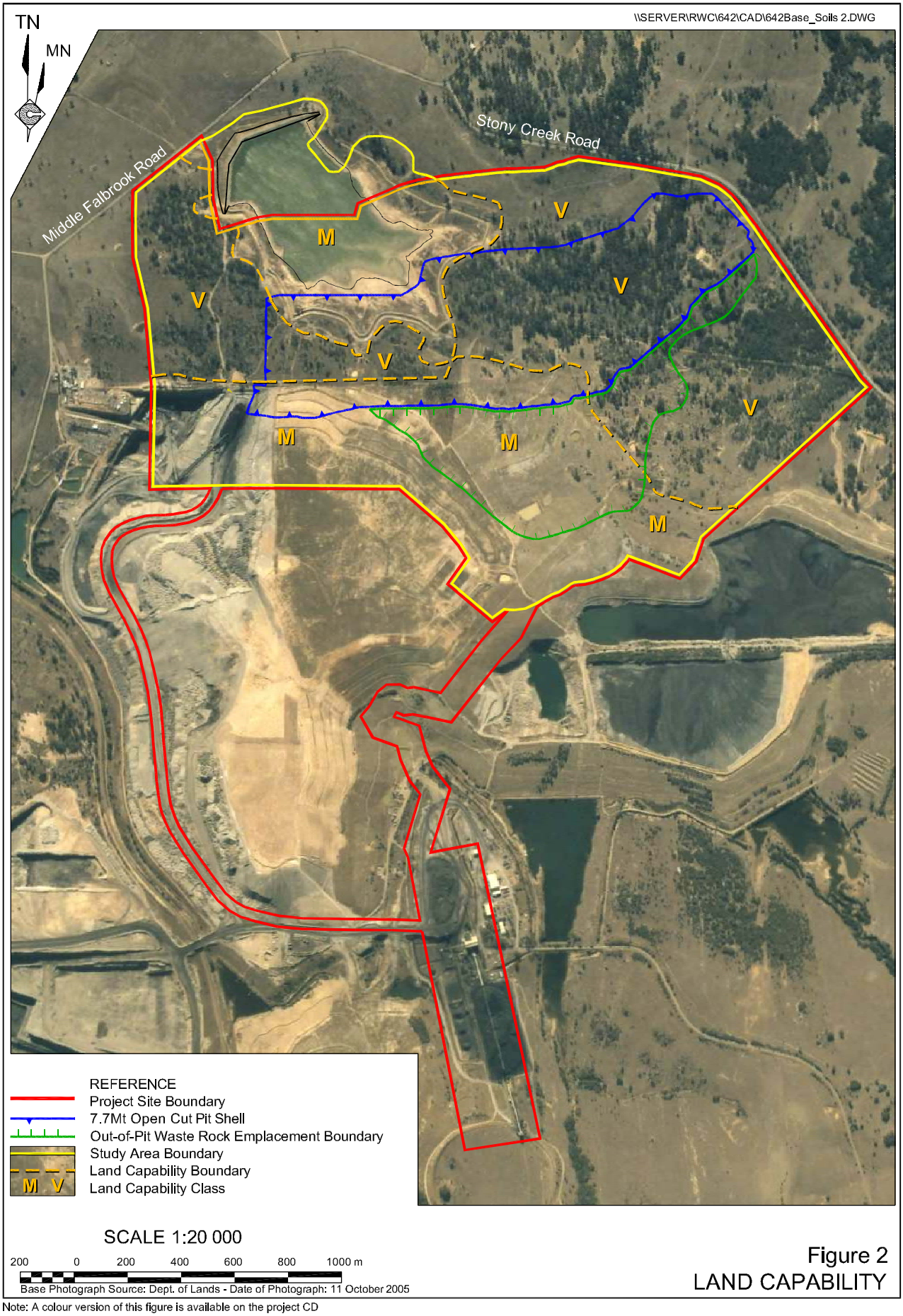

Figure 2
LAND CAPABILITY

Note: A colour version of this figure is available on the project CD

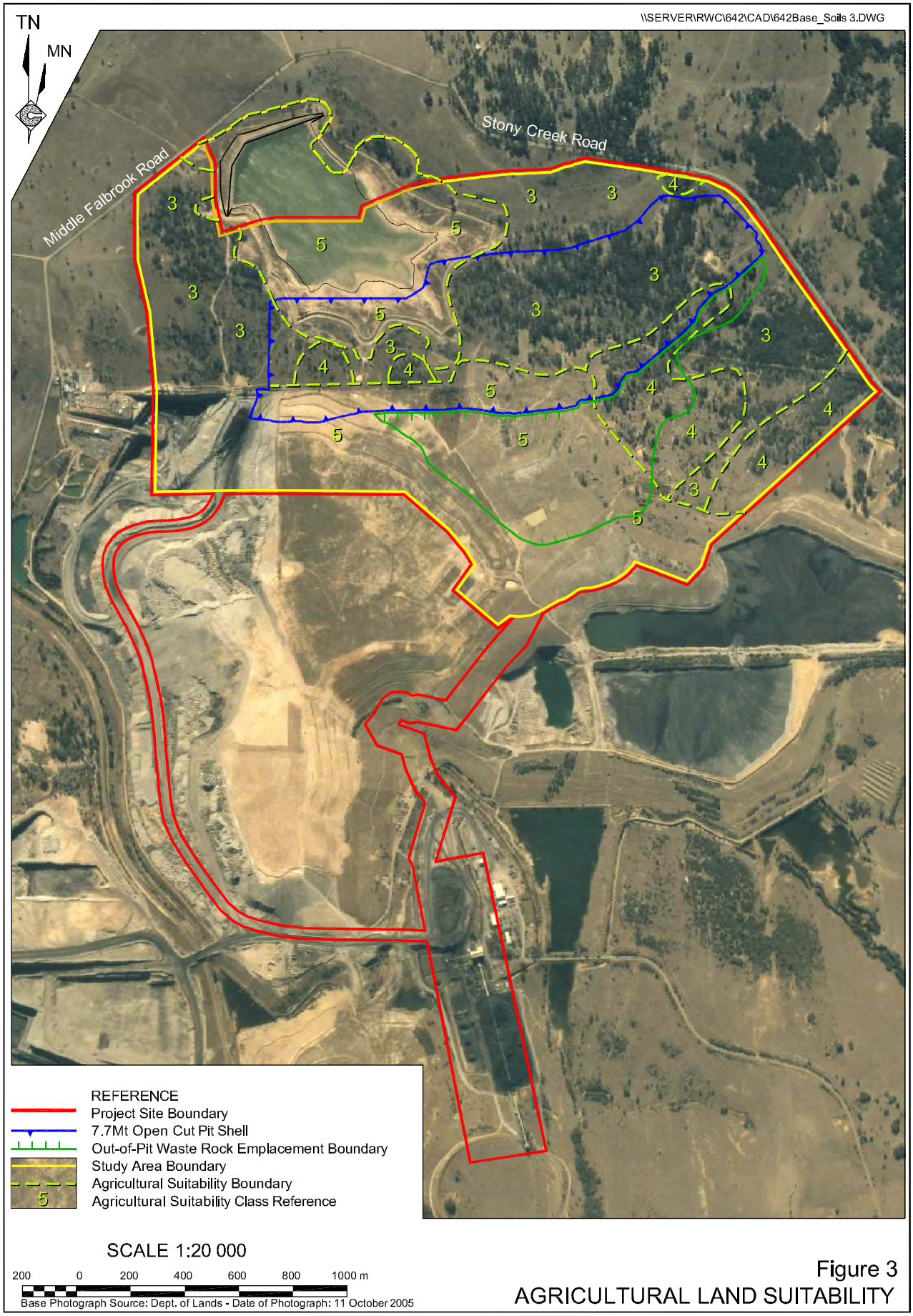

Figure 3
AGRICULTURAL LAND SUITABILITY

Note: A colour version of this figure is available on the project CD

10 SUMMARY OF DIRECTOR-GENERAL'S REQUIREMENTS

The issues required to be addressed in this study as outlined in the Director-General's Requirements are noted in **Table 8** along with details of the section[s] of this study where they are addressed.

Table 8
Coverage of Environmental Assessment Requirements and Environmental Issues in the Soils Survey and Land Capability Report

ENVIRONMENTAL REQUIREMENTS RAISED BY THE DIRECTOR-GENERAL RELATING TO SOILS [25.01.07]		
		Relevant Section[s]
Key Assessment Requirements, namely: *Soils -* **References** • *Managing Urban Stormwater: Soils and Construction Volume 14th Edition* [Landcom]. • *Acid Sulfate Soil Manual* [NSW Acid Sulfate Soil Advisory Committee 1998].		Section 6.2.3; Section 8
ENVIRONMENTAL REQUIREMENTS RAISED BY GOVERNMENT AGENCIES RELATING SOILS		
Government Agency	**Paraphrased Requirement**	**Relevant Section[s]**
Department of Primary Industries [Undated]	The Proponent should apply 'Best Practice' for soil handling and management. The Proponent needs to complete extensive soil profiling prior to stripping of vegetation. Selective stripping of the topsoil and subsoil should be utilised to efficiently secure and maintain the current available resources. The utilisation of the cleared vegetation in the rehabilitation program should also be reviewed in the EA.	Section 8

11 CONCLUSION

Soils in the Study Area have been described and two Soil Mapping Units have been identified.

The physical and chemical attributes of the soils of the Study Area have been quantified through a combination of field assessment and laboratory testing and indicate:

- the soils are currently relatively stable but have a generally moderate erodibility rating as determined using the laboratory data obtained from samples from the Study Area in the SOILOSS computer model;
- topsoils in both SMUs generally have a low dispersibility but the subsoils have generally moderate to very high dispersibility indicating a need for rapid protection of stockpiled material and newly-rehabilitated areas by mulches and vegetation cover;

- the soils have a generally high structure grade and so can be stripped and respread using scrapers;
- for SMU 1 the topsoil material [to 20cm depth] and the subsoil [to about 70cm total depth below the original soil surface] is favourable for use in rehabilitating the disturbed landscape;
- for SMU 2 the topsoil material [to 10cm depth] and the subsoil [to about 70cm total depth below the original soil surface] is favourable for use in rehabilitating the disturbed landscape;
- the lower subsoils of both SMUs are generally moderately saline and so should not be used as subsoil material during the rehabilitation process; and
- all soils will be subject to structural degradation if worked when too moist.

Depth of stripping recommendations have been provided along with advice on stabilising the soil stockpiles in the period between stripping and respreading.

The pre-mining Land Capability [**Classes V and M**] and Agricultural Land Suitability [**Classes 3, 4** and **5**] of the Study Area have been determined.

The volume of topsoil and subsoil that becomes available following the recommended stripping procedures is likely to result in the rehabilitated landscape having a shallower depth of soil than the pre-mining landscape because of the configuration of the final landscape. However, the species that would be replanted on the rehabilitated area, and those that may naturally establish from seed contained in the topsoil, should be able to cope with the shallower soil depth as most, if not all, are adapted to growth on relatively shallow sites.

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APPENDICES

Appendix 1: Soil Profile Descriptions from Required Backhoe Test Pits

Appendix 2: Topsoil Suitability Stripping Key [after Elliott and Veness, 1981]

Appendix 3: Basis of Land Capability Classification [after Emery, undated]

Appendix 4: Glossary

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Appendix 1

Soil Profile Descriptions from Required Backhoe Test Pits - Field Descriptions

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Appendix 1
Soil Profile Descriptions from Required Backhoe Test Pits - Field Descriptions

Profile 1 [SMU 1]- *Crest / upper slope location*; s*urface condition hard setting; surface stones absent; rock outcrop nearby*

0-15cm - loam; many roots present; no lime present; no manganese present; pH 5.0; gravel and stones absent; not mottled; not bleached; light brownish grey [10YR6/2] dry; dark greyish brown [10YR4/2] moist; peds rough-faced, highly pedal [80%], polyhedral, <5-10mm in size; firm consistency dry; hydrophobic; *clear to:-*

15-23cm - sandy clay loam; roots common; no lime present; no manganese present; pH 5.5; much gravel, angular to 10cm in size; not mottled; bleached; white [10YR8/1] dry; yellowish brown [10YR5/4] moist; peds rough- faced, highly pedal [100%], polyhedral, <5mm in size; firm consistency dry; not hydrophobic; *gradual to:-*

23-53cm - medium clay; few roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; mottled; not bleached; 95% dark greyish brown[10YR4/6], 5% reddish yellow [7.5YR6/8] dry, 95% dark greyish brown[10YR4/6], 5% strong brown [7.5YR5/8] moist; peds rough- / smooth-faced, highly pedal [100%], subangular blocky, 10-25mm in size; very strong consistency dry; not hydrophobic;
gradual to:-

Profile 2 [SMU 2] - *Crest location*; s*urface condition hard setting; moderate levels of surface gravel present, 1-3m rounded and angular*

0-14cm - sandy clay loam; roots common; no lime present; no manganese present; pH 5.0; some rounded gravel present to 1cm in size; not mottled; not bleached; light brownish grey [10YR6/2] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5 mm in size; firm consistency dry;
hydrophobic; *abrupt to:-*

14-36cm - sandy clay; roots common; no lime present; no manganese present; pH 5.0; much rounded gravel to 2cm in size; not mottled; bleached; very pale brown10YR8/2] dry, brown [10YR5/3] moist; peds rough faced, highly pedal [100%], polyhedral, <5mm in size; weak consistency dry; not hydrophobic; *clear to:-*

36-69cm - sandy light clay; few roots; no lime present; no manganese present; pH 5.0; much rounded gravel to 3cm in size; not mottled; not bleached; light brownish grey [2.5Y6/2] dry, light brownish grey [2.5Y6/4] moist; peds rough - / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm to strong consistency dry; not hydrophobic; *clear to:-*

69-120cm - sandy medium clay; few roots; no lime present; some manganese present; pH 8.5; gravel and stone absent; not mottled; not bleached; pale brown [10YR6/3] with flecks of white [10YR8/1] dry; brown 10YR5/3] with flecks of brownish yellow [10YR6/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 3 [SMU 1] - *Crest location*; s*urface condition firm; surface gravel and stone absent*

0-12cm - silty clay loam; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry, dark brown [10YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; hydrophobic; a*brupt to:-*

12-59cm - medium - heavy clay; few roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; reddish brown [2.5YR4/3] dry, reddish brown [5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; hydrophobic;
clear to:-

59-99cm - medium -heavy clay; few roots; no lime present; no manganese present; pH 5.0; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/3] dry, reddish brown [5YR4/3] moist; peds smooth – faced, highly pedal [100%], polyhedral, <5-15mm in size; strong to very strong consistency dry; not hydrophobic; *clear to:-*

99-172cm - heavy clay; few roots; no lime present; many manganese stains; pH 5.0; some weathering rock; mottled; not bleached; 25% red [5YR4/3], 25% light brownish grey [10YR6/2], 50% dark brown [7.5YR3/2] dry, 25% red [5YR4/3], 25% greyish brown [10YR5/2], 50% dark brown [7.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic

Profile 4 [SMU 2] - *Midslope location*; s*urface condition hard setting few surface stones present; to 15cm, angular*

0-20cm - silty clay loam; many roots; no lime present; no manganese present; pH 5.5; some gravel from <1cm to 15cm in size; not mottled; not bleached; light brown [7.5YR6/3] dry; brown [7.5YR4/3] moist; peds rough –faced, moderately pedal [50%], polyhedral, <5-10mm in size; very firm consistency dry; not hydrophobic;
abrupt to:-

20-40 - light to medium clay ; roots common; no lime present; manganese stains present; pH 5.0; gravel and stones absent; mottled; not bleached; 98% brown [7.5YR5/3], 2% reddish brown [2.5YR4/4] dry; 98% brown [7.5YR5/3], 2% red [10R4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral <5-15mm in size; very strong consistency dry; not hydrophobic; *abrupt to:-*

40-70cm - medium clay; few roots; no lime present; no manganese stains present; pH 5.0; gravel and stones absent; mottled; not bleached; 70% pale brown [10YR6/3], 30% red [2.5YR5/6] dry, 70% brown [7.5YR5/3], 30% yellowish red [5YR5/6] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 10-20mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

70-160cm - light to medium clay; few roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; light yellowish brown [10YR6/4] dry, light yellowish brown [2.5Y6/3] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic.

Profile 5 [SMU 2] - *Depression location; surface hard setting; surface gravel and stone absent*

0-25cm - silty clay loam; many roots; no lime present; no manganese present; pH 5.0; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, brown [7.5YR5/3] moist; fabric rough; massive; not hydrophobic; *abrupt to:-*

25-41cm - light to medium clay; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, brown [10YR4/3] moist; peds rough- faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

43-75cm -light to medium clay; many roots; no lime present; some manganese stains present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry; brown [10YR4/3] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

75-122cm - light to medium clay; few roots; no lime present; many manganese stains present; pH 6.0; lenses of angular gravel; not mottled; not bleached; pale brown [10YR6/3] dry; brown [10YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

122-212cm - light to medium clay; no roots present; no lime present; manganese nodules present; pH 8.5; gravel and stones absent; mottled; not bleached; 98% pale brown [10YR6/3], 2% yellowish brown 10YR5/6] dry, 98% dark yellowish brown [10YR4/4], 2% strong brown [7.5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic.

Profile 6 [SMU 2] - *Crest location; surface hard setting; medium amounts of surface gravel present; rounded to 1-3cm*

0-14cm - silty clay loam; many roots; no lime present; no manganese present; pH 6.0; some flat angular gravel <1-2cm in size; not mottled; not bleached; greyish brown [10YR5/2] dry, very dark greyish brown [10YR3/2] moist; peds rough- faced, highly pedal [100%], polyhedral, <5-10mm in size; weak consistency dry; hydrophobic;
abrupt to:-

14-25cm - medium clay; many roots; no lime present; no manganese present; pH 5.5; much gravel to 3cm in size, rounded; not mottled; not bleached; light brownish grey [10YR6/2] dry, dark greyish brown [10YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

25-61cm - medium clay; few roots; no lime present; no manganese stains present; pH 5.5; gravel and stones absent; mottled; not bleached; 90% light grey [10YR7/2], 10% pale red [2.5YR6/2] dry, 90% brown [5YR4/6], 10% yellowish red 5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

61-102cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; mottled; not bleached; 95% reddish yellow [7.5YR6/6], 5% white [7.5YR8/1] dry; 95% strong brown [7.5YR5/8], 5% light grey [7.5YR7/1] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral ,5-10mm in size; very strong consistency dry; not hydrophobic

Profile 7 [SMU 2] - *Lower slope location; surface condition firm; medium amounts of surface gravel present; 1-3cm, rounded*

0-9cm - silty clay; many roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry, very dark greyish brown [10YR3/2] moist; peds rough- faced, highly pedal [100%], polyhedral, 5-10mm in size; weak to firm consistency dry; not hydrophobic; *abrupt to:-*

9-36cm - medium to heavy clay; many roots; no lime present; no manganese present; pH 6.0; top of this horizon has lenses of bleached rounded gravel to 1cm in size; not mottled; not bleached; yellowish brown [10YR5/4] dry, reddish brown [2.5YR4/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *clear to:-*

36-87cm - heavy clay; few roots; no lime present; manganese stains present; pH 6.0; gravel and stones absent; not mottled; not bleached; yellow [10YR7/6] dry; yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic

Profile 8 [SMU 2] - *Midslope location; surface hard setting; surface gravel absent*

0-20cm – loam; few roots; no lime present; no manganese present; pH 6.0; some angular gravel to 3cm in size; not mottled; not bleached; brown [5YR5/3] dry, brown [7.5YR4/3] moist; massive, fabric rough, not hydrophobic; *gradual to:-*

20-60cm - medium clay; few roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/4] moist; peds rough- / smooth-faced; highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

60-94cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; not bleached; brownish yellow [10YR6/6], brownish yellow [10YR6/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

94-131cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 7.0; some weathering rock; not mottled; not bleached; very pale brown [10YR7/4] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

131-175cm - medium clay; few roots; no lime present; no manganese present; pH 7.0; weathering rock; mottled; not bleached; 70% reddish yellow [5YR6/6], 30% light yellowish brown 10YR6/4] dry, 70% yellowish red [5YR5/6], 30% light yellowish brown [10YR6/4] moist; peds smooth- faced; highly pedal [100%], polyhedral, <5-10mm in size; very strong consistency dry; not hydrophobic

Profile 9 [SMU 2]- Depression location; s*urface condition firm; some rounded surface gravel to 3-4cm present*

0-10cm - clay loam; many roots; no lime present; no manganese present; pH 6.0; discontinuous layers of rounded and angular gravel to 3cm in size; not mottled; not bleached; brown [7.5YR5/2] dry, dark brown [7.5YR3/2] moist; peds rough- / smooth-faced; highly pedal [100%], polyhedral, 5-15mm in size; very firm consistency dry; hydrophobic; *gradual to:-*

10-49cm - light to medium clay; roots common; no lime present; no manganese present; pH 4.5; some rounded and angular gravel to 2cm in size common; not mottled; not bleached; brown [7.5YR5/3] dry, dark brown [7.5YR3/3] moist; peds rough- / smooth-faced; highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; hydrophobic; *gradual to:-*

49-97cm - light to medium clay; few roots; no lime present; no manganese present; pH 4.0; gravel and stones absent; not mottled; not bleached; very pale brown [10YR7/3] with flecks of red [2.5YR5/6] dry, yellowish brown [10YR5/4] with flecks of red [2.5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

97-147cm - medium to heavy clay; few roots; no lime present; manganese concretions present; pH 4.0; gravel and stones absent; mottled; not bleached; 10% light red [2.5YR6/8], 90% very pale brown [10YR8/3] dry, 10% red [2.5YR5/8], 90% yellowish brown [10YR5/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

147-247cm - heavy clay; few roots; no lime present; no manganese present; pH 4.0; gravel and stones absent; mottled; not bleached; 80% very pale brown [10YR8/2], 20% red [2.5YR5/6] dry, 80% pale yellow [2.5Y7/3], 20% red [2.5YR4.8] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic

Profile 10 [SMU 2] - *Midslope location;* s*urface condition loose; surface gravel absent*

0-12cm; silty clay; many roots; no lime present; no manganese present; pH 5.5; much angular gravel to 1-3cm in size in discontinuous layers; not mottled; generally not bleached but patches at base of horizon; light brownish grey [10YR6/2] dry, very dark greyish brown [10YR3/2] moist; fabric rough; massive; not hydrophobic; *abrupt to:-*

12-30cm - medium to heavy clay; roots common; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; apparently bleached; reddish yellow [5YR6/6] dry, red [5YR5/6] moist; peds rough-faced, highly pedal [100%], polyhedral, 10-20mm in size; very strong consistency dry; not hydrophobic; *clear to:-*

30-71cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 5.5; some gravel to 1cm in size; mottled; not bleached; 80% very pale brown 10YR7/4], 20% very pale brown [10YR7/3] dry, 80% brownish yellow [10YR6/6], 20% pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

71-116cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; mottled; not bleached; 50% pale yellow [2.5Y8/2], 50% reddish yellow [7.5YR6/6] dry, 50% light grey [2.5Y7/2], 50% reddish yellow [5YR6/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; very strong consistency dry; not hydrophobic

Profile 11 [SMU 2] - *Midslope location;* s*urface condition hardsetting / cracked; low to medium amounts of surface gravel present, angular to 1-4cm*

0-13cm - silty clay; many roots; no lime present; no manganese present; pH 5.5; much angular gravel to 1cm in size; not mottled; not bleached; greyish brown [10YR5/2] dry, very dark greyish brown [10YR3/2] moist; fabric rough, massive; not hydrophobic; *abrupt to:-*

13-19cm - silty clay; many roots; no lime present; no manganese present; pH 6.0; mainly rounded gravel to 1cm in size; not mottled; apparently bleached; light brownish grey [10YR6/2] dry, dark brown [7.5YR3/2] moist; fabric rough; massive; not hydrophobic; *sharp to:-*

19-46cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; mottled; not bleached; 80% very pale brown [10YR8/4], 20%light red [2.5YR6/6] dry, 80% light yellowish brown [10YR6/4], 10% reddish yellow [5YR6/8] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

46-70cm - heavy clay; few roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; mottled; not bleached; 90% very pale brown [10YR7/4], 10% light red [2.5YR5/6] dry, 90% light yellowish brown [10YR6/4], 10% reddish yellow [5YR6/8] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic

Profile 12 [SMU 1] - *Crest location;* s*urface firm; surface gravel absent*

0-9cm - sandy clay loam; many roots; no lime present; no manganese present; pH 5.5; some angular gravel to 1cm in size; not mottled; not bleached; brown [10YR5/3] dry, very dark greyish brown [10YR3/2] moist; fabric rough; massive; not hydrophobic; *abrupt to:-*

9-29cm - sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; much rounded gravel to 1- 4cm in size; not mottled; not bleached; pale brown [10YR6/2] dry, brown [7.5YR4/3] moist; fabric rough; massive; not hydrophobic; *abrupt to:-*

29-45cm - sandy clay; few roots; no lime present; no manganese present; pH 6.5; some rounded gravel to 3cm in size; not mottled; not bleached; light brown [10YR6/4] dry, strong brown [7.5YR4/6] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

45-113cm - clayey sand; roots absent; no lime present; no manganese present; pH 6.0; cemented grit with rounded gravel inclusions to 3cm in size; not mottled; not bleached; very pale brown [10YR7/4] dry, strong brown [10YR5/8] moist; fabric earthy / rough; massive; not hydrophobic

Profile 13 [SMU 1] - *Crest location; surface firm; some surface gravel present; rounded 1-3cm*

0-11cm - loam; many roots; no lime present; no manganese present; pH 5.0; some gravel, rounded and angular, 1-2cm in size; not mottled; not bleached; dark greyish brown [10YR4/2] dry, very dark grey [10YR3/1] moist; fabric rough; massive; hydrophobic; *abrupt to:-*

11-35cm - sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; rounded gravel to 4cm in size common; not mottled; bleached; light grey 10YR7/2] dry, dark greyish brown [10YR4/2] moist; fabric rough; massive; not hydrophobic; *sharp to:-*

35-99cm - sandy clay; few roots; no lime present; no manganese present; pH 5.5; rounded gravel to 4cm in size common; mottled; not bleached; 90% light brownish grey [10YR6/2], 10% reddish yellow [5YR6/8] dry, 90% brown 10YR5/3], 10% yellowish red [5YR5/6] moist; fabric rough; massive; not hydrophobic

Profile 14 [SMU 2] - *Drainage depression location; surface firm and cracking; surface stone present, rounded to 8cm*

0-30cm - silty clay; many roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, dark greyish brown [10YR4/2] moist; peds rough- faced, highly pedal [100%], polyhedral, <5-10mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

30-43cm - silty clay; roots common; no lime present; no manganese present; pH 6.0; some angular gravel to 1cm in size; not mottled; apparently bleached; light brownish grey [10YR6/2] dry, dark greyish brown [10YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

43-109cm - medium clay; few roots; no lime present; no manganese present; pH 8.0; gravel and stones absent; not mottled; not bleached; light yellowish brown [10YR6/4] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistency dry; not hydrophobic; *clear to:-*

109-170cm - sandy light clay; few roots; no lime present; no manganese present; pH 8.0; mainly rounded gravel to 4cm in size; not mottled; not bleached; brown [7.5YR4/2] dry, brown [7.5YR4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very firm consistency dry; not hydrophobic; *clear to:-*

170-200cm - gritty light to medium clay; few roots; no lime present; many manganese nodules present; pH 8.0; cemented grit with angular gravel inclusions to 2cm in size; mottled; not bleached; 50% very pale brown [10YR7/3], 50% yellowish red [5YR5/6] dry, 50% brown [10YR5/3] , 50% yellowish red [5Yr4/6] moist; fabric rough / smooth; massive; not hydrophobic

Profile 15 [SMU 2]- *Mid slope location; surface hardsetting; crusted surface gravel and stone absent*

0-10cm - silty clay loam; many roots; no lime present; no manganese present; pH 6.0; occasional gravel to 2cm in size; not mottled; not bleached; light brownish grey 105YR6/2] dry, dark greyish brown [10YR4/2] moist; peds rough- faced, highly pedal [100%], polyhedral, 5-15mm in size; firm consistency dry; hydrophobic; *sharp to:-*

10-23cm - sandy light to medium clay; few roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; bleached; light grey [10YR7/2] dry, brown [10YR5/3] moist; fabric rough, massive; hydrophobic; *clear to:-*

23-43cm - medium clay; few roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; apparently bleached; pale brown [10YR6/3] dry, brown [10YR5/3] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; not hydrophobic; *sharp to:-*

43-116cm - medium clay; few roots; no lime present; no manganese present; pH 5.5; pockets of rounded gravel to 2cm in size; mottled; not bleached; 50% pale brown [10YR6/3], 50% brownish yellow [10YR6/6] dry, 50% brown [10YR5/3], 50% brownish yellow [10YR6/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic

Profile 16 [SMU 1] - *Crest location; surface firm and cracked; surface gavel and stone absent*

0-10cm - silty clay; many roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; greyish brown [10YR5/2] dry, very dark grey [10YR3/1] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; hydrophobic; *abrupt to:-*

10-70cm - medium clay; many roots; no lime present; no manganese present; pH 5.0; gravel and stones absent; not mottled; apparently bleached; brown [7.5YR5/3] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

70-110cm - heavy clay; few roots; no lime present; no manganese present; pH 5.0; gravel and stones absent; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [2.5YR5/3] to reddish brown [2.5YR5/4] moist; peds smooth- faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

110-210cm - heavy clay; few roots; no lime present; no manganese present; pH 4.5; some flat sandstone floaters to 50cm in size; mottled; not bleached; 80% grey [7.5YR8/1], 20% red [10YR4/6] dry, 80% light brownish grey [10YR6/2], 20% red [10YR4/6] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic

Profile 17 [SMU 2] - *Mid slope location; surface hardsetting; surface gravel and stone absent*

0-5cm - light to medium clay; many roots; no lime present; no manganese present; pH 6.0; some rounded gravel, to 2cm in size, present; not mottled; not bleached; pale brown [10YR6/3] dry, dark yellowish brown [10YR3/4] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *abrupt to:-*

5-25cm - light to medium clay; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; mottled; not bleached; 60% brown [7.5YR5/3], 40% red [2.5YR5/6] dry; 60% dark brown [7.5YR3/2], 40% reddish brown [2.5YR4/4] moist; peds rough- / smooth- faced; highly pedal [100%], polyhedral, <5-20 mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

25-60cm - heavy clay; few roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; reddish yellow [5YR6/6] dry, yellowish red 5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

60-145cm - heavy clay; few roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; mottled; not bleached; 70% light grey [10YR7/1], 30% pink [7.5YR7/4] dry, 70% light brownish grey [5YR5/6], 30% strong brown 7.50YR5/6] moist; peds smooth-faced highly pedal [100%], polyhedral, <5-10mm in size; very strong consistency dry; not hydrophobic

Profile 18 [SMU 2] - *Drainage depression location; surface firm; surface gravel and stone absent*

0-10cm - silty clay; many roots; no lime present; no manganese present; pH 6.0; some angular gravel to 1.5cm in size; not mottled; not bleached; light brownish grey [10YR6/2] dry, dark greyish brown [10YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic;
sharp to:-

10-72cm - heavy clay; many roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry, brown [!10YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

72-140cm - heavy clay; few roots; no lime present; no manganese present; pH 7.0;
some rounded gravel to 1-2cm in size; not mottled; not bleached; pale brown [10YR6/3] dry, brown [10YR5/3] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-20mm in size; very strong consistency dry; not hydrophobic

Profile 19 [SMU 2] - *Lower slope location;* s*urface firm, cracked; surface gravel and stone absent*

0-10cm - silty clay; many roots; no lime present; no manganese present; pH 6.0; gravel and stones generally absent but sporadic pockets of bleached gravel present at base of layer in parts; not mottled; not bleached; light brownish grey [10YR6/2] dry, brown [10 YR4/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; slightly hydrophobic; *sharp to:-*

10-53cm - medium to heavy clay; many roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; light olive brown [2.5Y5/3] dry, olive brown [2.5Y4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

53-106cm - medium to heavy clay; few roots; no lime present; manganese stains present; pH 9.0; some angular and rounded gravel to 1cm in size; not mottled; not bleached; light yellowish brown [2.5Y6/4] dry, light olive brown [2.5Y5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic

Profile 20 [SMU 1] - *Crest location;* s*urface firm, cracked; surface gravel and stone absent*

0-27cm - sandy clay loam; many roots; no lime present; no manganese present; pH 5.5; scattered pockets of angular gravel to 2cm in size; not mottled; not bleached; brown [2.5YR5/3] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; hydrophobic;
gradual to:-

27-71cm - medium to heavy clay; many roots; no lime present; no manganese present, pH 6.0; gravel and stones absent; not mottled; apparently bleached; brown [7.5YR4/2] dry, dark brown [7.5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

71-172cm - medium clay; roots common; no lime present; no manganese present; pH 7.0; some angular stones to 10cm in size; not mottled; not bleached; brown [7.5YR5/4] dry, strong brown [7.5YR4/6] moist; peds rough-faced, highly pedal [100%], polyhedral, 10-20mm in size; strong consistency dry; not hydrophobic

Profile 21 [SMU 2] - *Midslope location;* s*urface firm; surface gravel and stone absent*

0-10cm - silty clay; many roots; no lime present; no manganese present; pH 6.5; some lenses of angular gravel, to 3cm in size; not mottled; not bleached, brown [10YR5/3] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic; *gradual to:-*

10-45cm - medium to heavy clay; many roots; no lime present; no manganese present; pH 7.0; gravel and stones absent; mottled; not bleached; 60% reddish brown [2.5YR4/4], 40% brown [10YR5/3] dry, 60% reddish brown [2.5YR4/3], 40% dark greyish brown [10YR4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

45-142cm - medium clay; few roots; no lime present; no manganese present; pH 8.5; gravel and stones absent; not mottled; not bleached; light yellowish brown [10YR6/4] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

142-174cm - heavy clay; roots absent; no lime present; no manganese present; pH 7.0; gravel and stones absent; mottled; not bleached; 50% very pale brown, [10YR7/4], 30% red [2.5YR5/6], 20% pale yellow [2.5Y8/2] dry, 50% very pale brown [10YR7/4], 30% red [2.5YR5/6], 20% light grey [2.5Y7/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; very strong consistency dry; not hydrophobic

Profile 22 [SMU 1] - *Crest location;* s*urface hardsetting, cracked; surface gravel and stone absent*

0-10cm - silty clay loam; many roots; no lime present; no manganese present; pH 5.5; some rounded gravel to 3cm in size; not mottled; not bleached; brown [10YR5/2] dry, very dark greyish brown [10YR3/2] moist; fabric rough; massive; hydrophobic; *sharp to:-*

10-29cm - silty clay; many roots; no lime present; no manganese present; pH 5.5; gravel common, rounded, to 4cm in size; not mottled; not bleached, light brownish grey [10YR6/2] dry, dark brown [10YR3/3] moist; fabric rough; massive; not hydrophobic; *sharp to:-*

29-54cm - medium clay; roots common; no lime present; manganese stains present; pH 5.5; gravel and stone common, to 15cm in size, rounded, some lenses of larger stones; not mottled; not bleached; grey brown [10YR5/2] dry, dark brown [7.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

54-132cm - gritty light clay; few roots; no lime present; no manganese present; pH 5.0; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; very strong consistency dry; not hydrophobic

Profile 23 [SMU 2] - *Mid to upper slope location;* s*urface loose to firm; moderate amounts of surface gravel and stone, rounded and angular to 25cm*

0-10cm - silty clay; many roots; no lime present; no manganese present; pH 5.5; much angular and rounded gravel and stone to 20cm in size; not mottled; not bleached; dark greyish brown 10YR4/2] dry, dark brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; hydrophobic; *sharp to:-*

10-20cm - silty clay; many roots; no lime present; no manganese present; pH 6.0; much rounded gravel and stone, 1-20cm in size; not mottled; not bleached; greyish brown [10YR5/2] dry, brown [7.5YR4/3] moist; fabric rough; massive; not hydrophobic; *sharp to:-*

20-70cm - gritty medium clay; many roots; no lime present; no manganese present; pH 7.0; much rounded gravel and stone, 1-25cm in size; not mottled; apparently bleached; brown [7.5YR5/2] dry, brown [10YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

70-215cm - clayey sand; few roots; no lime present; no manganese present; pH 7.5; much rounded stone to 45cm; not mottled; not bleached; light grey [2.5Y7/2] dry, pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic

Profile 24 [SMU 2] - *Lower slope location;* s*urface firm; some surface gravel, rounded, to 5cm*

0-13cm - silty clay; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; very strong consistency dry; hydrophobic; *sharp to:-*

13-38cm - light to medium clay; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; yellowish brown [10YR5/4] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

38-85cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 7.5; gravel and stones absent; not mottled; not bleached; very pale brown [10YR7/4] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic

Appendix 2

Topsoil Stripping Suitability Key [after Elliott and Veness, 1981]

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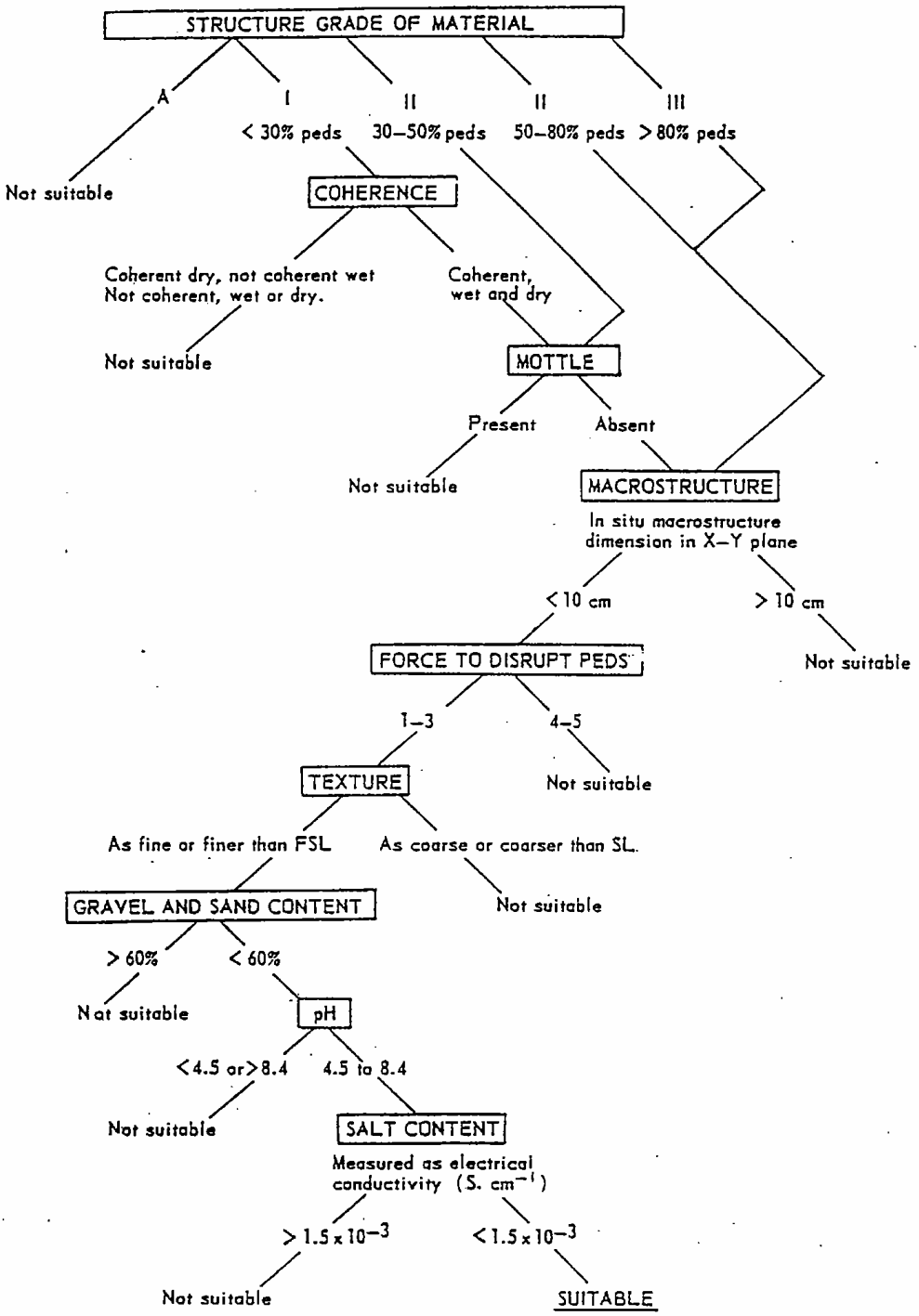
Procedure for the selection of material for use in topdressing of disturbed areas.



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Appendix 3

Basis of Land Capability Classification [after Emery, undated]

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Table 1 *Land Capability Map Legend*

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

CLASS SUBSCRIPTS	SPECIAL USES
c	Terrain developed for a specific crop (capability class range IV to VII) as a result of the combination of particular soil, terrain, climatic and economic conditions. The class includes such crops as grapes, bananas, avocados and pineapples.
d	Terrain developed for intensive agricultural production and associated with flood irrigation. The class includes land developed for cotton and rice production.

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Appendix 4

Glossary

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apedal - describes a soil in which none of the soil material occurs in the form of peds in the moist state. Such a soil is without apparent structure and is typically massive or single-grained.

consistence - the degree of resistance to deformation or rupture exhibited by a soil.

fabric - the appearance of a soil when examined with a 10x hand lens with the similarities and differences between samples being based on presence or absence of ped, lustre or its absence of the ped surfaces and the presence, size and arrangement of voids within the soil sample.

horizon - a layer of soil material within a soil profile with distinct characteristics and properties that are produced by soil forming processes, and that are different from those of the layers above and below.

hydrophobic - describes soils that are water repellent and that resist wetting when dry. Drops of water do not spread spontaneously over their surface and into the pores.

lateritic - describes soil layers comprised of iron-rich material, often concentrated in separate nodules [gravel] or as masses of individual nodules cemented together.

massive - the condition of a soil layer in which the layer appears as a coherent or solid mass that is largely devoid of peds.

ped - an individual natural soil aggregate or unit of structure.

structure - describes 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.

texture - the coarseness or fineness of soil material as it affects 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 is influenced by the organic matter content as well.

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