

East Boggabri Joint Venture

Proposed East Boggabri Coal Mine

Soils and Land Capability Study of Proposed Mine Site

Prepared by

Geoff Cunningham Natural Resource
Consultants Pty Ltd

May, 2005

Specialist Consultant Studies Compendium
Part 3a

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Soils and Land Capability Study

of the Project Site within the

Proposed East Boggabri Coal Mine

Prepared for: R.W. Corkery & Co. Pty. Limited
75 Kite Street
PO Box 80
ORANGE NSW 2800

On behalf of: East Boggabri Joint Venture
C/- Whitehaven Coal Mining Limited
PO Box 2440
FORTITUDE VALLEY QLD 4006

Prepared by: Geoff Cunningham Natural Resource Consultants Pty Ltd
9 The Crest
KILLARA NSW 2071 (ACN 058 178 493)

Telephone: (02) 9416 1995
Fax: (02) 9416 6626
Email: geoffcun@bigpond.net.au

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EXECUTIVE SUMMARY

Soils within the Project Site to be disturbed by the proposal ("the Study Area") have been described and two Soil Mapping Units 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 following.

- 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.
- The soils have a generally high structure grade and so can be stripped and respread using scrapers.
- For SMU 1 the topsoil material (to 15cm depth) and the subsoil (to about 65cm total depth below the original soil surface) is favourable for use in rehabilitating the disturbed landscape.
- For SMU 2 only 10cm of topsoil should be stripped.
- The remaining soil material from SMU 2 is sodic and because of the salinity and sodicity recorded should be mixed with overburden material and buried in the mine void as soon as this action is possible.
- The lower subsoil material in SMU 1 has some limitations imposed by dispersibility, and generally very high pH levels, however, some of this would have to be stripped to cover the shortfall in subsoil material resulting from the inability to use the subsoil from SMU 2.
- 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 III, VI and VII) and agricultural land suitability (Classes 3 and 5) of the Study Area has been determined.

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1 INTRODUCTION AND DESCRIPTION OF PROJECT

1.1 Introduction

The area studied comprised parts of the 'Thuin', 'Nagero' and 'Forest View' properties. The study was carried out for R. W. Corkery and Co. Pty. Limited on behalf of East Boggabri joint venture (the Proponent).

The Project Site Study Area (the "Study Area") for this soils and land capability study comprises a total area of approximately 395 hectares and is shown in **Figure 1**.

The soils study is limited to the area that would be disturbed by the proposed mining development but the land capability and agricultural land suitability assessments apply to the whole Project Site.

Field sampling of the area was carried out on 17th, 18th and 19th October, 2004 and 8th February, 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 East Boggabri Coal Mine, and
- (ii) the land capability and agricultural land suitability of the Project Site.

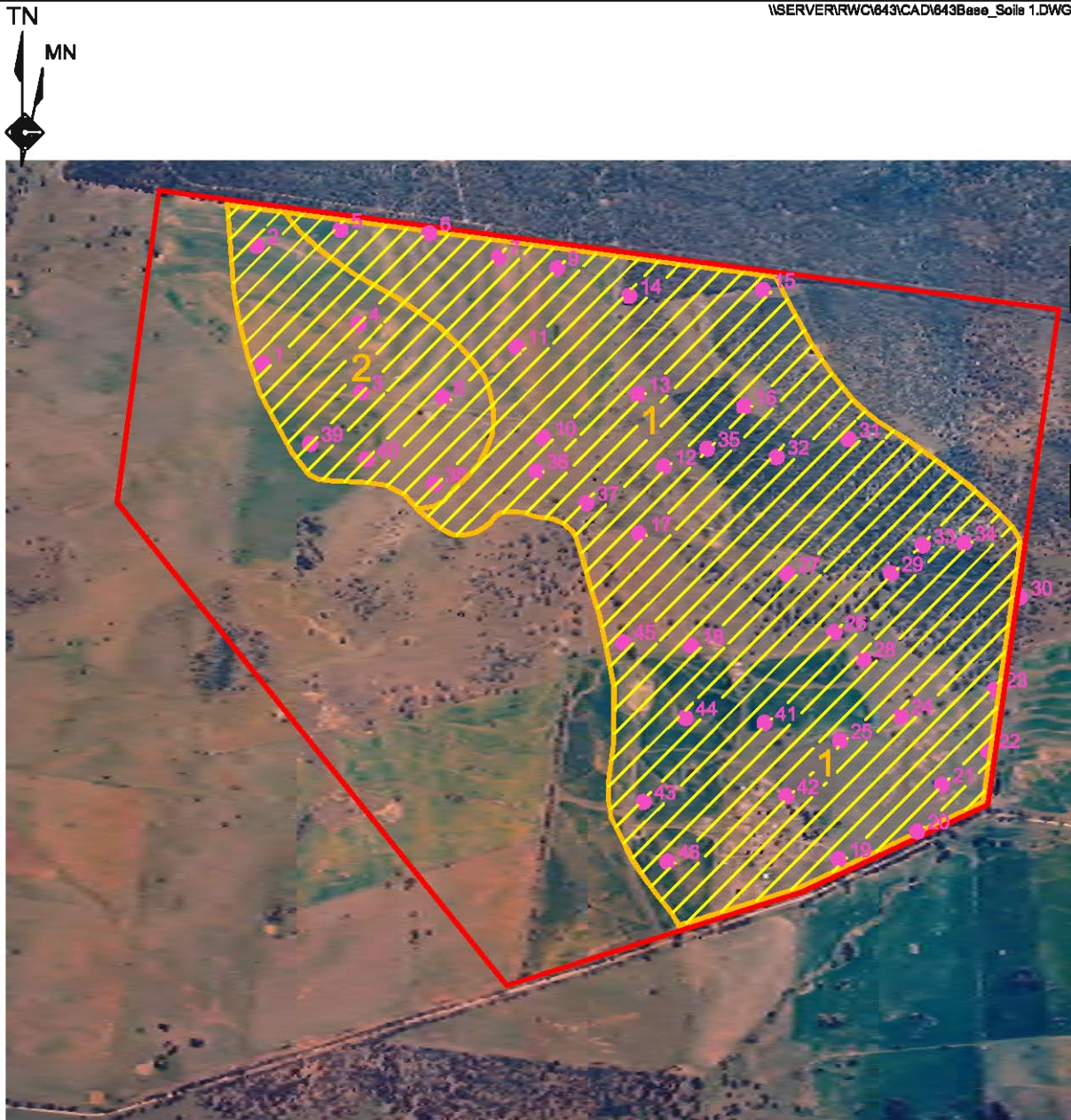
The report was required to include sufficient level of detail to satisfy the Department of Mineral Resources in relation to Mining Operations Plan guidelines and to satisfy the requirements of the Department of Infrastructure, Planning and Natural Resources' specifications for soil surveys associated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






This report describes the soils based upon forty six representative soil profiles as well as laboratory analyses of a selection of representative profiles and land capability of the Project Site.

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 identified on the Project Site;
- details of soil handling strategies and recommendations about soil stripping and stockpiling; and
- details of the land capability and agricultural suitability on the Project Site.

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- REFERENCE**
-  Project Site Boundary
 -  Study Area
 -  Soil Test Pit
 -  Soil Mapping Unit Boundary
 -  Soil Mapping Unit Reference

Note: Study area for the land capability and agricultural suitability assessment includes the Project Site in its entirety

SCALE 1:25 000

250 0 250 500 750 1000 1250 m

Base Map Source: Geo-Spectrum (Australia) Pty Ltd

Figure 1
PROJECT SITE STUDY AREA

1.2 Description of Proposal

The Proponent's objectives for the development and operation of the proposed East Boggabri Coal Mine are to:

- develop and operate a safe mine producing low ash, thermal coal;
- develop and operate the mine in a manner that complies with all statutory requirements;
- undertake all activities in an environmentally responsible manner, employing a level of control and integrating safeguards that would ensure compliance with appropriate criteria/goals or reasonable community expectations at all times;
- establish and/or maintain international and domestic markets for the coal produced;
- provide a boost to the local economies of Boggabri and Gunnedah and their surrounding districts through employment opportunities and the supply of services required for the operation of the coal mine;
- create a final landform amenable to a combination of agricultural and native vegetation conservation activities; and
- achieve the above objectives in a cost-effective manner and thereby ensure the ongoing viability of the proposed mine.

The proposal, if approved, would involve the following activities.

- Construction of a mine entrance on Goonbri Road and a mine access road from Goonbri Road to the coal processing area.
- Coal mining by open cut mining methods over an area of approximately 160ha referred to as the "open cut area". The open cut area has been defined by drilling and a review of economic, geological and environmental considerations.
- Programmed placement of overburden and interburden materials from the open cut area to a combination of out-of-pit and in-pit overburden emplacements.
- On-site crushing and temporary stockpiling of the mined coal within a defined coal processing area southwest of the open cut area.
- Establishment of a transport route between the Project Site and the Whitehaven CHPP and rail loading facility with the importation of road construction materials from the Whitehaven Coal Mine.
- Transportation of coal from the Project Site to the Whitehaven CHPP for washing and/or despatch to export markets via rail to the Port of Newcastle.
- Backloading of coarse reject material from the Whitehaven CHPP for placement in the mined out areas of the proposed East Boggabri Coal Mine.
- Installation of a range of services, structures and transportable buildings.
- Progressive shaping and rehabilitation of the mine area and other areas of disturbance.

In addition to these activities, the proposed mine would be operated with comprehensive systems to manage groundwater, surface water, noise, blasting, air quality, visibility, Aboriginal heritage, flora and fauna. The Project Site components are presented on **Figure 2**.

2 DESCRIPTION OF THE STUDY AREA

The Study Area covers an area of hills, low ridges and is located adjacent to the southern boundary of Leard State Forest. It comprises open, cleared gently sloping country some of which is presently farmed as well as more hilly areas that have been cleared to varying degrees in the past.

These latter areas are used for grazing with native and introduced species providing the pasture.

3 LITERATURE REVIEW

3.1 Current Information on the Soils of the Study Area

The area in which the proposed East Boggabri Coal Mine site is located lies within the boundaries of the Boggabri 1:100 000 scale topographic map sheet area. A soil survey by DIPNR is currently in progress for this area, although the report has yet to be finalised and published.

3.2 Soil Survey of the Boggabri Coal Project

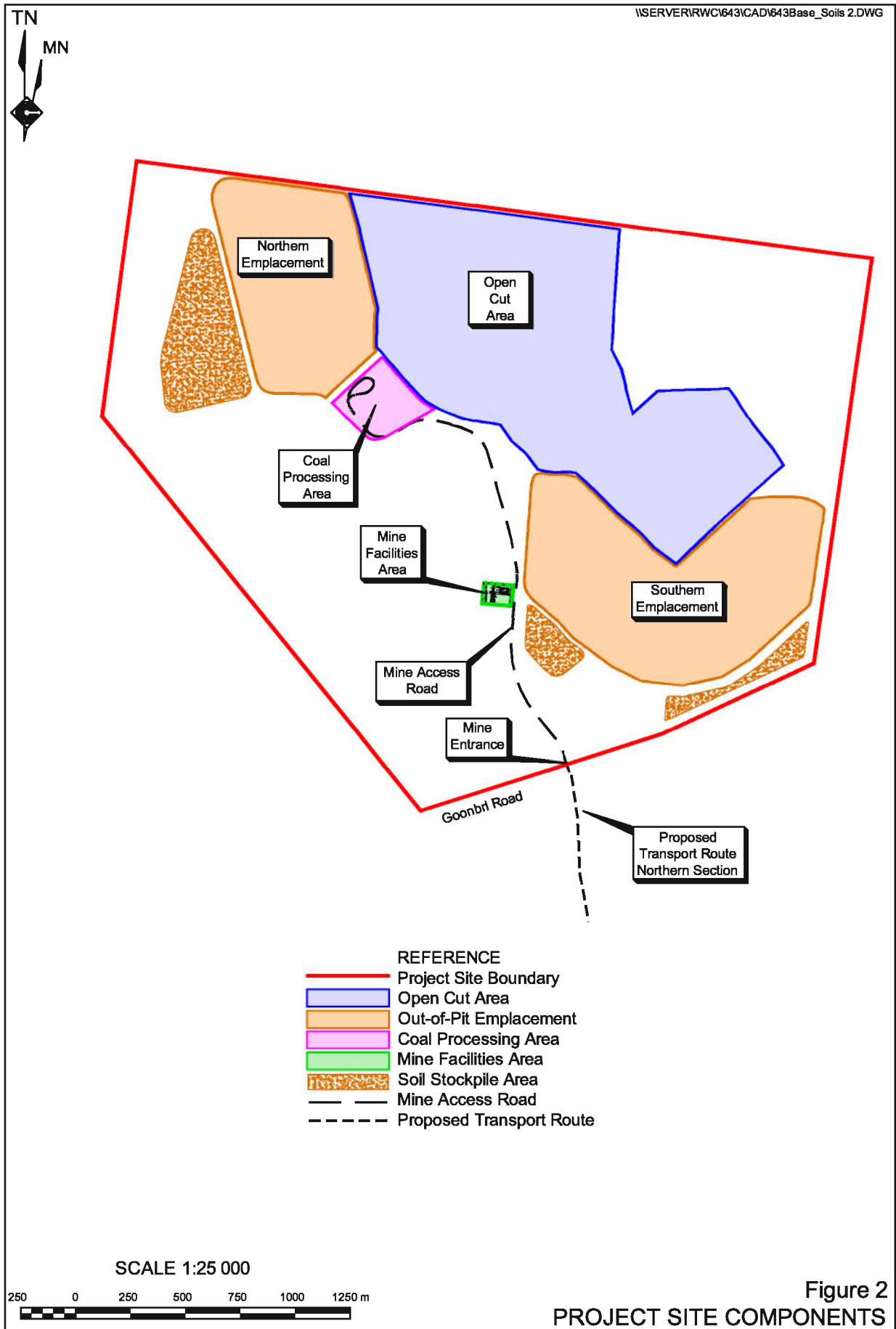
3.2.1 General

This soil survey, titled 'Soil – Overburden Characterisation of Boggabri Coal Prospect Area, Boggabri, NSW, Australia', was prepared in 1982 by Amax Coal Company (Wiram, 1982). It formed **Appendix 4** of the Environmental Impact Statement for the approved Boggabri Coal Project.

The study covered an area of some 1 200 hectares within Leard State Forest that lies immediately to the north of the current proposal Project Site Study Area.

The investigations initially used soil probes and hand-dug pits to characterize the soils but the hard setting subsoils prevented this approach from gaining worthwhile information and so backhoe pits were dug at 16 sites. These pits were a minimum of two metres deep.

The exposed soil profiles were fully described and samples from six of the pits were analysed to provide details of selected soil physical and chemical properties.



3.2.2 Details of Soils Described Within the Boggabri Coal Mine Area

3.2.2.1 General Description

Wiram (1982) noted that most of the soils within the Boggabri Coal Mine Study Area have developed from two main sources of parent material. The parent materials are:

- the residuum of weathered sandy conglomerates; and
- alluvium and / or colluvium derived from weathering of former soil profiles and bedrock of surrounding volcanic and sedimentary outcrops.

Wiram (1982) identified three major soil types.

1. Duplex soils (yellow and brown solodics).
2. Lithosols.
3. Structured loams.

The most common soils were the duplex soils with the lithosols and structured loams present in considerably less amounts.

A feature of all of these soil types was the presence, in all layers, of gravel and stone material.

3.2.2.2 Duplex Soils

These soils occupy more gently sloping terrain (3% to 8% slope) within Wiram's (1982) Study Area. The soils show a strong texture differentiation with an abrupt boundary (hardpan) between A and B horizons. The duplex soils normally have a conspicuously bleached A₂ horizon.

The A horizon ranges from a sandy loam to sandy clay loam in texture. The A₂ horizon has generally been leached of clay material and exhibits a coarser (more sandy) texture. There is a noticeable change in texture between the A₂ horizon and the B horizon with clay contents in the B horizon measured as high as 50%.

Throughout most profiles, traces of sand and pebbles are present in the B horizon.

Wiram (1982) indicates that the profiles of the duplex soils can be classed as being non-saline although he notes that the subsoils exhibit sodicity that would pose problems if the subsoil material was positioned near the surface of rehabilitated areas.

3.2.2.3 Lithosols

Lithosols are the second most abundant soils within Wiram's (1982) Study Area. They occur on the steeper sloping lands and ridge top areas. These soils lack horizon development apart from the occasional A₂ horizon.

For the most part the surface soil consists of gravelly material with the A horizon having a gravelly sandy loam texture.

3.2.2.4 Structured Loams

Wiram (1982) records his structured loam soils, or red and brown earths, in areas associated with the tributary drainage systems of the Study Area as well as in areas where severe geological faulting has occurred.

Wiram (1982) notes that these soils are relatively young and lack the complete soil development of the duplex soils. He further notes that the thickness of the A horizon appears to be a function of distance from the centre of the drainage line as well as frequency of flooding.

The structured loam soils lack A₂ horizons and the relatively thick topsoil commonly rests on the C horizon.

4 METHODOLOGY

4.1 Preparations

Prior to field investigations, the Study Area was subjected to stereoscopic airphoto interpretation 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 1:25 000 scale colour airphotos used were those produced by the Department of Land and Property Information.

The prints used in the stereoscopic interpretation were Boggabri Run 4, Print Nos. 91, 92, 93, flown on 6th September, 2001.

4.2 Field Procedures

For the soil study, sampling involved the complete description of 46 profiles to a depth of 2.5m or 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 sulfate). 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 DIPNR's SPADE Soil Database.

Samples from all layers in six of these profiles (No's 1, 9, 21, 23, 31 and 34) 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

5.1 Soil Mapping Units

From the information gained from both the detailed soil profile descriptions, and the additional check pits, two Soil Mapping Units (SMUs) were identified.

These SMUs are:

- **Soil Mapping Unit 1** – the majority of the Study Area including crests, upper, mid and lower slopes as well as depressions. The profile descriptions and analyses revealed that the soil types that are most prevalent within this SMU are the "sandy" and "duplex" soil types described below. A scattering of clayey soil types similar in profile description to the "sodic" soils described for SMU 2 also occurs through this SMU but should not cause any problems if they happen to have any saline/sodic tendencies.
- **Soil Mapping Unit 2** – the soils of the northwest section of the Study Area adjacent to Leard State Forest. These soils appear to be limited in their occurrence and resemble the sodic soils described by Wiram (1982) for a good proportion of the Forest.

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 twelve pits that were described in detail.

5.2 Soil Mapping Unit Descriptions

5.2.1 Introduction

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 2** or by consulting McDonald et al (1990) or Houghton and Charman (1986).

5.2.2 Soil Mapping Unit 1 – "Sandy" and "Duplex" Soils

Soil Mapping Unit 1 is a composite of two soil types that occur in a mosaic over the Study Area - the "sandy" soils and the "duplex" soils.

Both soil types have sandy surface layers but the "sandy" soils have a coarse textured profile either to below 100cm depth or to bedrock.

The "duplex" soils have a sandy surface layer that is generally much shallower than 100cm in thickness that overlies a much finer textured remainder of the profile.

Almost all of the "sandy" soils have bleached A₂ horizons – the exception being a soil from a depression.

5.2.2.1 "Sandy" Soils

“Plain English” Description:

Crest, upper slope, mid slope, lower slope and depression locations.

Soil 40 to 240cm deep; surface loose to firm or hard setting, surface gravel common rounded and angular 3cm to 4cm, sometimes surface stone to 8cm to 10cm present.

Topsoil - clayey sand, sandy clay loam, sandy loam or silty clay loam texture; roots common to many; pH 5.0 to 6.5; much rounded and angular gravel to 4cm present; massive or highly structured; bleached A₂ horizon present.

Subsoil - up to four subsoil horizons identified in sample pits; occasionally B horizon lacking in some soils on crests where the A2 horizon overlies rock; subsoil generally comprised of coarse textured material; occasionally profile resembles a "duplex" soil with an excessively deep (120cm) coarse layer overlying clay textured material; gravel common throughout the profile.

Technical Description (based on test pits):

(a) Australian Soil Classification Name: Grey Dermosol

(b) Field Description:

Layer 1 A1 horizon (always present); 9cm to 18cm thick; clayey sand, sandy clay loam, sandy loam or silty clay loam texture; roots common to many; no lime present; no manganese present; pH 5.0 to 6.5; much rounded and angular gravel to 4cm; not mottled; not bleached; brown (10YR5/3), brown (7.5YR4/2, 7.5YR5/3), grey brown (10R5/2), greyish brown (10YR5/2), pale brown (10YR6/3) dry; very dark greyish brown (10YR3/2), dark brown (7.5YR3/2), dark greyish brown (10 YR4/2) moist; massive and fabric rough or highly pedal, occasionally moderately pedal, peds rough-faced, polyhedral, <5mm to 10mm in size; very weak to firm consistency dry; hydrophobic or slightly so, sometimes not; *abrupt, clear or gradual to:-*

Layer 2 – A2 horizon (always present); 18cm to 47cm thick; sandy loam, sandy clay loam light sandy clay loam, clayey sand in texture; roots common to many; no lime present; no manganese present; pH 5.5 to 7.0; much rounded and angular gravel 1cm to 6cm; not mottled; bleached except for one depression profile; usually pink (7.5YR7/3), also brown (7.5YR5/2), light grey (10YR7/2), pinkish grey (7.5YR7/2) dry; brown (7.5YR4/2), dark brown (7.5YR3/2), dark greyish brown (10YR4/2), light brown (7.5YR6/4), strong brown (7.5YR5/6), very pale brown (10YR7/4), yellowish red (5YR5/6) moist; usually massive, fabric rough; sometimes moderately to highly pedal, peds rough-faced, polyhedral, <5mm to 10mm in size; weak to very firm consistency dry; not hydrophobic. *abrupt, clear or gradual to bedrock or lower horizon:*

Layer 3 – B1 horizon (usually present), 19cm to 85cm thick, clayey sand, loamy sand, sandy clay loam, sandy loam in texture; usually few roots, sometimes many; no lime present; usually no manganese stains present; pH 5.5 to 7.5, sometimes to pH 8.0; much rounded and angular gravel <1cm to 6cm, some stones to 8cm; not mottled; not bleached; light brownish grey (10YR6/2), light grey (10YR7/1), pink (5YR7/4, 5YR8/3, 7.5YR7/3, 7.5YR8/3), very pale brown (10YR8/2), white (2.5Y8/1) dry; brown (7.5YR4/3, 7.5YR5/2, 7.5YR5/3, brown (7.5YR5/4), greyish brown (10YR5/2), light brown (7.5YR6/4), pink (5YR7/3), reddish yellow (7.5YR6/6), white (2.5Y8/1), yellowish red (5YR5/6) moist; usually massive, fabric rough; sometimes moderately to highly pedal, polyhedral, 5mm to 10mm in size; very firm to very strong consistency dry; not hydrophobic; *abrupt, clear, gradual or diffuse to bedrock or lower horizon:-*

Layer 4 – **B2.1 horizon (sometimes present)** – 40cm to 141cm thick; sandy clay, sandy loam, clayey sand, sandy clay loam in texture; few roots; no lime present; manganese stains and concretions sometimes present; pH 6.0 to 7.5, sometimes 9.5 to 10; much angular and rounded gravel <1cm to 3cm, some cemented gravel to 6cm; not bleached; mainly whole coloured light grey (10YR7/2), pale brown (10YR6/3), pink (7.5YR7/3, 7.5YR7/4) dry; brown (7.5YR4/3), light olive brown (2.5Y5/3), reddish brown (5YR5/4) moist; sometimes mottled pale brown (10YR6/3), reddish brown (5YR4/4) dry; brown (7.5YR5/3), reddish brown 5YR4/4) moist; sometimes massive, fabric rough; more often highly pedal (100%), peds rough-faced, polyhedral or polyhedral / platy, <5mm to 15mm in size; strong consistency dry; not hydrophobic; *gradual to lower horizons:-*

Layer 5 - B2.2 horizon (sometimes present) – 25cm to 40cm thick; clay loam, clayey sand to sandy loam, medium clay, sandy clay in texture; usually no roots present; no lime present; manganese stains and concretions sometimes present; pH 7.5 to 9.5 to 10; much gravel, rounded 1cm to 5cm, grit sometimes common; not bleached; usually whole coloured; brown (7.5YR5/2), pink (7.5YR7/4), very pale brown (10YR7/3) dry; brown (7.5YR5/4), greyish brown (10YR5/2), pale brown (10YR6/3) moist; sometimes mottled, white (10YR8/1), brownish yellow (10YR6/6) dry; light brownish grey (10YR6/2), dark yellowish brown (10YR4/6) moist; massive, fabric rough or highly pedal (100%), peds polyhedral, 5mm to 15mm in size, strong to very strong consistency dry; *abrupt or gradual to lower horizon*:-

Layer 6 – B3 horizon (rarely present) – recorded 95cm thick; sandy clay loam; no lime present; much manganese staining; pH 8.0; some rounded gravel 1cm to 2cm; not mottled; not bleached; pale yellow (2.5Y8/2) dry; pale brown (10YR6/3) moist; peds rough-smooth faced, highly pedal (100%), polyhedral/platy, 5mm to 15mm in size; very firm to strong consistency dry; not hydrophobic.

5.2.2.2 "Duplex" Soils

Depression, lower slope, mid slope, upper slope or crest locations.

"Plain English" Description:

Soil to 250cm deep or more; surface condition soft, firm, hard setting or self-mulching; surface gravel round and angular 1cm to 8cm common, flattish stones to 40cm present at some sites; comprised of coarse textured surface horizons relatively abruptly overlying finer textured (more clayey) material.

Topsoil sandy loam or sandy clay loam, sometimes fine sandy clay loam to light clay; loam fine sandy, silty clay loam in texture; up to 26cm thick; roots common to many; pH 5.0 to 6.5; some to much angular and rounded gravel <1cm to 5cm; bleached A2 horizon sometimes present.

Subsoil recorded to 225cm thick; comprised of up to six horizons of generally clay textured material with some layers of sandier material; pH levels reach 9.5 to 10 in the subsoil material.

Technical Description (based on test pits):

(a) **Australian Soil Classification Name: Grey Chromosol**

(b) **Field Description:**

Layer 1 A1.1 horizon (always present) – 7cm to 26cm thick; sandy loam or sandy clay loam, sometimes fine sandy clay loam to light clay; loam fine sandy, silty clay loam; roots common to many; no lime present; no manganese present; pH 5.0 to 6.5; some to much angular and rounded gravel <1cm to 5cm; not mottled; not bleached; mainly brown (10YR5/2, 10YR5/3, 7.5YR4/2, 7.5YR4/3m, 7.5YR5/2, 7.5YR5/3), also greyish brown (10YR5/2), light brown (7.5YR6/3), pale brown (10YR6/3), pinkish grey (7.5YR6/2), reddish brown (5YR5/3), reddish grey (5YR5/2), very dark greyish brown (10YR3/2) dry; brown (7.5YR4/2), dark brown (7.5YR3/2), dark greyish brown (10YR4/2), dark reddish brown (5YR3/2), very dark grey (10YR3/1, 7.5YR3/1), very dark greyish brown (10YR3/2) moist; occasionally massive, fabric

rough; usually highly pedal (80% to 100%), sometimes moderately pedal (50% to 60%), peds rough-faced, occasionally rough / smooth-faced, polyhedral, <5mm to 10mm in size, firm to very firm consistency dry, sometimes weak or strong; sometimes hydrophobic or slightly so, mostly not hydrophobic; *abrupt, clear, gradual or sharp to:-*

Layer 2 – A1.2 horizon (occasionally present) – 9cm to 21cm; sandy loam; clay loam, silty clay loam, sandy clay in texture; roots few to many; no lime present; no manganese present; pH 6.0 to 7.0; rounded and angular gravel <1cm to 4cm common; not mottled, not bleached; brown (7.5YR5/2, 7.5YR5/3), pinkish grey (7.5YR6/2) dry; brown (7.5YR4/2), dark brown (7.5YR3/2) moist; sometimes massive, fabric rough; sometimes highly pedal (100%), polyhedral, 5mm to 15mm in size; very firm to strong consistency dry; not hydrophobic; *clear or gradual to:-*

Layer 3 – A2 horizon (sometimes present) – 10cm to 35cm thick; mainly sandy loam and sandy clay loam, also clayey sand, sand, sandy clay; roots common to many, occasionally few; no lime present; no manganese present; pH 5.0 to 7.0; much gravel rounded <1cm to 4cm, grit present; not mottled; bleached; light grey (7.5YR7/1), pink (7.5YR7/3), pinkish grey (7.5YR7/2), pinkish white (7.5YR8/2), very pale brown (10YR7/3), white (7.5YR8/1) dry; brown (10YR5/3, 7.5YR4/2, 7.5YR4/3, 7.5YR5/2, 7.5YR5/3, (7.5YR5/4), light brown (7.5YR6/4), light brownish grey (2.5Y6/2) moist; massive, fabric mainly rough, sometimes rough-smooth; usually not hydrophobic, sometimes slightly so; *abrupt, clear, diffuse or gradual to:-*

Layer 4 - B1 horizon (always present) - 8cm to 96cm thick; light to medium clay, often sandy or gritty, occasionally sandy clay loam or medium to heavy clay; usually few roots, sometimes common or many; usually no lime present, sometimes lime concretions and stains present; usually no manganese present, sometimes manganese stains and concretions recorded; pH 5.5 to 9.5 to 10; few flat mainly angular stones to 1cm or much rounded gravel 1cm to 5cm, grit present; not bleached; whole coloured; brown (10YR5/3, 7.5YR4/3, 7.5YR5/3, 7.5YR5/4), light brown (7.5YR6/2, 7.5YR6/4), pale brown (10YR6/2, 10YR6/3), pinkish grey (7.5YR6/2), yellowish red (5YR5/6) dry; brown (7.5YR4/2, 7.5YR4/3, 7.5YR4/4, 7.5YR5/3, (7.5YR5/4), dark brown (7.5YR3/2), dark greyish brown (10YR4/2), reddish brown (5YR4/4) moist; **sometimes mottled** in tones of brown (10YR5/2, 10YR5/3), dark brown (10YR5/4), dark greyish brown (10YR4/2), light grey (10YR7/1, 10YR7/2), pale brown (10YR6/3), pinkish white (7.5YR8/2), reddish brown (2.5YR4/4, 5YR5/3), reddish yellow (7.5YR6/6), very pale brown (10YR7/4), yellowish red (5YR4/6, 5YR5/6) dry; brown (10YR5/3, 7.5YR4/3), dark red (2.5YR3/6), grey (10YR5/1), greyish brown (10YR5/2), light brownish grey (10YR6/2), reddish brown (2.5YR4/4, 5YR4/3), reddish yellow (7.5YR6/8), very dark grey (10YR3/1), very dark greyish brown (10YR3/2), yellowish brown (10YR5/6), yellowish red (5YR5/6) moist; sometimes massive, fabric rough; usually highly pedal (100%), peds rough-faced or rough / smooth-faced, polyhedral, occasionally polyhedral / platy, <5mm to 20mm in size, strong to very strong consistency dry; not hydrophobic, rarely slightly so; *abrupt, clear, diffuse or gradual to:-*

Layer 5 – B 2.1 horizon (always present) – 3cm to 130cm thick; clayey sand; light, medium or medium to heavy clay (sometimes gritty or sandy), sandy loam, sandy clay loam or sandy clay in texture; roots absent or more usually few to common; usually no lime present, sometimes lime stains and concretions present; manganese absent or stains and concretions present; manganese stains and concretions present; pH 5.5 to 8.0 or 9.0 to 10, occasionally 4.5; some to much rounded, angular and flattened gravel <1cm to 4cm, sometimes stones to 10cm present; not bleached; usually whole coloured; brown (10YR5/3, 7.5YR5/2, 7.5YR5/3, 7.5YR5/4), greyish brown (10YR5/2), light brownish grey (10YR6/2, 2.5Y6/2), light grey (10YR7/2), pale brown (10YR6/3), very pale brown (10YR 7/3), white (7.5YR8/1), yellowish brown (10YR5/4) dry; brown (10YR4/3, 10YR5/3, 7.5YR4/2, 7.5YR4/3, 7.5YR5/2, 7.5YR5/3), greyish brown (10YR5/2), pale brown (10YR6/3), strong brown (7.5YR5/8), very pale brown

(10YR8/2), yellowish brown (10YR5/4) moist; sometimes mottled in tones of brown (10YR5/3, 7.5YR5/4), light brownish grey (10YR6/2, 2.5Y6/2), light grey (10YR7/2, 2.5Y7.2), pale brown (10YR6/3), pale yellow (2.5Y7/3), yellowish red (5YR5/6, 5YR4/6) dry; brown (7.5YR4/4, 7.5YR5/3), greyish brown (10YR5/2, 2.5Y5/2), light brownish grey (10YR6/2, 2.5Y6/2), light grey (2.5Y7.2), pale yellow (2.5Y7/3), yellowish brown (10YR5/4), yellowish red (5YR4/6, 5YR5/6) moist; occasionally massive, fabric rough; usually highly pedal (100%), peds rough/smooth-faced, occasionally smooth-faced or rough-faced, polyhedral, sometimes polyhedral / platy; <5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; not hydrophobic; *abrupt, diffuse or gradual to:-*

Layer 6 – B2.2 horizon (always present) – 24cm to 115cm thick; sandy / gritty light to medium clay, sandy clay sometimes clayey sand, sandy loam, silty clay loam; few roots present, sometimes absent; lime usually absent, occasionally lime stains and concretions present; many manganese stains and concretions present or manganese absent; pH 7.5 to 9.0, or 9.5 to 10, rarely 4.5; gravel absent or some gravel rounded and angular 1cm to 3cm present; not bleached; usually whole coloured; brown (7.5YR5/2, 7.5YR5/3, 7.5YR5/4), light brown (7.5YR6/3, 7.5YR6/4), light brownish grey (10YR6/2), pale brown (10YR6/3), pale yellow (2.5Y7/3), pinkish grey (7.5YR7.2), very pale brown (10YR7/3) dry; brown (10YR5/3, 7.5YR4/3, 7.5YR4/4, 7.5YR5/3, 7.5YR5/4), dark grey (7.5YR4/1), greyish brown (10YR5/2, 2.5Y5/2), light grey (2.5Y7/2), pale brown (10YR6/3) moist; occasionally mottled in tones of brown (7.5YR5/4), greyish brown (10YR5/2), light grey (10YR7/1), pale brown (10YR6/3) dry; brown (10YR5/3), grey (2.5Y6/1), greyish brown (10YR5/2), light brownish grey (10YR6/2) moist; peds rough / smooth-faced or rough-faced, highly pedal (100%), usually polyhedral, sometimes polyhedral / platy, <5mm to 15mm in size; very firm to very strong consistency dry; not hydrophobic; *abrupt, diffuse or gradual to bedrock or lower horizon:-*

Layer 7 – B2.3 horizon (sometimes present) – 37cm to 110cm thick; clayey sand, light to medium clay, medium clay, medium to heavy clay (clays sometimes sandy) in texture; few roots present, occasionally absent; lime absent or concretions present; manganese absent or many manganese stains and nodules present; pH usually 9.9 to 10, sometimes 8.0; some rounded and angular gravel to 4cm, some weathered rock, occasionally gravel absent; not bleached; usually whole coloured; brown (10YR5/3, 7.5YR5/3), greyish brown (10YR5/2), very pale brown (10YR7/3, 10YR8/2) dry; brown (10YR5/3, 7.5YR4/4), grey (10YR5/1), light brownish grey (2.5Y6/2), light grey (10YR7/2), light yellowish brown (10YR6/4) moist; sometimes mottled; brown (10YR5/3), light brown (7.5YR6/4), very pale brown (10YR7/3), yellowish brown (10YR5/4) dry; dark yellowish brown (10YR4/4), greyish brown (10YR5/2), light yellowish brown (2.5Y6/4), yellowish red (5YR5/6) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, occasionally polyhedral / platy, <5mm to 20mm in size, strong to very strong consistency dry; not hydrophobic; *diffuse or gradual to bedrock or lower horizon:-*

Layer 8 – B3 horizon (rarely present) – 37cm to 66cm thick; light to medium, medium, medium to heavy clay, sometimes sandy; few roots or roots absent; lime absent or some concretions present; manganese absent or manganese stains and nodules present; pH 8.0 to 10; some to much rounded and angular gravel <1cm to 3cm; not bleached; usually whole coloured; brown (10YR5/3), light brownish grey (10YR6/2), very pale brown (10YR7/3) dry; brown (10YR5/3), greyish brown (2.5Y5/2), light yellowish brown (10YR6/4) moist; sometimes mottled; brown (7.5YR5/3, 10YR5/3) dry; brown (7.5YR4/3, 10YR5/3) moist; peds rough / smooth-faced or smooth-faced, highly pedal (100%), polyhedral or polyhedral / platy, <5mm to 20mm in size, strong to very strong consistency dry; not hydrophobic.

5.2.3 Soil Mapping Unit 2 – "Clay" Soils

Lower slope, mid slope and upper slope locations.

"Plain English" Description:

Soil 92cm to 250cm deep; surface condition usually self-mulching and cracked, sometimes firm or hard setting, much surface gravel and stone rounded and angular 1cm to 20cm, occasionally gravel and stones absent; overlies bedrock or gritty material that is either weathered rock or deposited material.

Topsoils usually medium clay, sometimes sandy or gritty, also light clay, silty clay or medium to heavy clay; roots common to many; pH 5.5 to 8.0; some to much rounded and angular gravel <1cm to 5cm; highly pedal

Subsoils with up to six horizons identified; most horizons "clayey" in texture with distinct coarser textured layers occasionally present in some profiles; gravel common throughout the profile; pH varies but is generally in the 9.0 to 10 range lower in the subsoil; mottled or whole coloured ; usually highly structured, sometimes massive.

Technical Description (based on test pits):

(a) **Australian Soil Classification Name: Grey Vertisol**

(b) **Field Description:**

Layer 1 – A horizon (always present); 6cm to 33cm thick; usually medium clay, sometimes sandy or gritty, also light clay, silty clay or medium to heavy clay; roots common to many; no lime present; no manganese present; pH 5.5 to 8.0; some to much rounded and angular gravel <1cm to 5cm; not mottled; not bleached; brown (10YR5/2), brown (7.5YR4/2, 7.5YR5/2), dark brown (7.5YR3/2), light brownish grey (10YR6/2) dry; brown (7.5YR4/2), dark brown (7.5YR3/2), dark reddish brown (5YR2.5/2), greyish brown (10 YR5/2), very dark grey (7.5YR3/1) moist; peds rough-faced or rough/smooth-faced, highly pedal (100%), polyhedral, <5mm to 15mm in size; usually strong to very strong consistency, sometimes very firm, firm or weak, dry; not hydrophobic; *abrupt, clear, diffuse or gradual to:-*

Layer 2 – B1 horizon (always present) 14cm to 60cm thick; light, medium to heavy clay, sometimes sandy or gritty; few to many roots; usually no lime present, sometimes flecks and small lime concretions present; usually no manganese present, occasionally stains and nodules; pH 5.5 to 6.0 or 9.0 to 10; much gravel rounded and angular some flat 1cm to 4cm, some stones to 10cm; not bleached; usually whole coloured brown (7.5YR4/2, 7.5YR4/3, 7.5YR5/2, 7.5YR5/3), dark reddish grey (5YR4/2), light grey (10YR7/1, 10YR7/2); brown (7.5YR4/3, 7.5YR5/3), dark brown (7.5YR3/2); grey (10YR6/1), reddish brown (5YR4/3), reddish grey (5YR3/2) moist; occasionally mottled brown (7.5YR4/3), dark brown (7.5YR3/2) dry; brown (7.5YR4/3), very dark grey (7.5YR3/1) moist; occasionally massive, fabric rough; usually highly pedal; (100%), peds rough / smooth-faced, polyhedral, <5mm to 15mm in size; strong to very strong consistency, occasionally firm, dry; not hydrophobic; *abrupt, clear, diffuse or gradual to:-*

Layer 3 – B2.1 horizon (always present); 13cm to 90cm thick; light, medium or medium-heavy clay, sometimes gritty; usually few roots, at times absent or many; lime absent or present as stains and concretions; no manganese present, or sometimes stains evident; pH usually 9.0 to 10 sometimes 6.0 to 7.0; much rounded and angular gravel <1cm to 4cm, stones

(floaters) to 20cm; not bleached; usually whole coloured; brown (7.5YR4/3, 7.5YR5/4), dark reddish grey (5YR4/2), light brown (7.5YR6/3, 7.5YR6/4), light grey (10YR7/2), pink (7.5YR7/4) dry; reddish brown (5YR4/3), brown (7.5YR4/3, 7.5YR4/4), light brown (7.5YR6/3, light brown (7.5YR6/4) moist; sometimes mottled, light brownish grey (10YR6/2), very pale brown (10YR7/3), light grey (10YR7/2), yellowish brown (10YR5/8) dry; greyish brown (10YR5/2), yellowish brown (10YR5/4, 10YR5/8), brown (7.5YR5/4), grey (10YR5/1) moist; occasionally massive, fabric rough; usually highly pedal (100%), peds rough-faced or peds rough-smooth faced, highly pedal (100%), polyhedral occasionally polyhedral / platy, <5mm to 20mm in size; very firm to very strong consistency dry; not hydrophobic; *gradual or diffuse to:-*

Layer 4 – B2.2 horizon (rarely present) 7cm to 38cm thick; sandy loam, clayey sand; few roots; no lime present; no manganese present; pH 6.0 to 9.5 to 10; much gravel rounded <1cm to 6cm, sand and cemented grit present; not bleached; not mottled; very pale brown (10YR7/3), white (2.5Y8/1) dry; brown (7.5YR5/4), light grey (2.5Y7/2) moist; or mottled, dark grey (10YR4/1), brown (7.5YR4/4) dry and moist; massive – very hard when cemented grit; or highly pedal (100%), peds rough-faced, polyhedral, 5mm to 10mm in size, strong consistency dry; not hydrophobic; *abrupt, clear or gradual to:-*

Layer 5 – B2.3 horizon (sometimes present) 33cm to 103cm thick; light, medium to heavy clay, sometimes gritty, or sandy clay; few roots absent; no lime present or small lime concretions flecks and stains evident; occasionally manganese stains present; pH 8.0 to 9.5 to 10; some to much gravel rounded and angular 1cm to 6cm, some gravel lenses; not bleached; usually whole coloured; brown (7.5YR5/4), light brown (7.5YR6/3), light grey (10YR7//2), pale brown (10YR6/3), pink (7.5YR7/4) dry; brown (7.5YR5/3), light brown (7.5YR6/3), light brownish grey (10YR6/2), light olive brown (2.5y5/3), strong brown (7.5YR5/6), yellowish red (5YR5/6) moist; sometimes mottled; light grey (10YR7/2), grey brown (10YR5/2) dry; light brownish grey (2.5Y6/2), brown (10YR5/3) moist; peds rough-smooth faced, at times smooth faced, highly pedal (100%), polyhedral or polyhedral platy, <5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *gradual or diffuse to bedrock or lower horizon:-*

Layer 6 – B3 horizon (rarely present) 22cm to 115cm thick; gritty light clay, sandy clay in texture; no roots or few roots present; no lime present; manganese stains present or absent; pH usually 9.5 to 10, sometimes 4.5; rounded and angular gravel <1cm to 6cm as layers or lenses, gravel sometimes cemented, occasionally gravel absent; not bleached; sometimes whole coloured; brown (7.5YR5/2), very pale brown (10YR8/2) dry; dark greyish brown (10YR4/2), pale brown (10YR6/3) moist; sometimes mottled; white (10YR8/1), light grey (10YR7/2) dry; pale yellow (2.5Y8/2), light brownish grey (10YR6/2) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, < 5mm to 15mm in size, strong to very strong consistency dry; not hydrophobic; *clear to bedrock or lower horizon:-*

Layer 7 – B3 horizon (rarely present) 33cm to 40cm thick; sandy clay loam, gritty light clay in texture; no lime present; manganese stains present; pH 4.5 and 9.5 to 10; gravel absent or some rounded and angular gravel 2cm to 4cm present; not bleached; mottled; 90% white (2.5Y8/1, 10YR8/1), light brownish grey (2.5Y6/2), light grey (10YR7/2) dry; light brownish grey (10YR6/2, 2.5Y6/2), pale yellow (2.5Y8/2) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, 5mm to 10mm in size, strong to very strong consistency dry; not hydrophobic.

5.3 Soil Laboratory Analyses

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

The tests performed which were aimed at assessing the potential erodibility of the soils included:

- Particle Size Analysis (PSA);
- Dispersion % (D%);
- Emerson Aggregate Test (EAT); and
- Electrical Conductivity (EC).

Physical and Chemical Analyses

Tables 1 and **4** show the results obtained from laboratory analysis of the samples from the six pits.

Samples from five profiles from within SMU 1 (three "duplex" soils, two "sandy" soils) and one from SMU 2 were analysed in the laboratory.

Table 1a
Physical Laboratory Analysis Data for Selected Soil Profiles
(Whole Soil Particle Size Analysis)

Page 1 of 2

PIT	LAYER	TEXTURE (fine earth)#	DEPTH (cm)	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
PIT 1	1	Loam / clay loam	0-10	17	9	28	19	47	27
	2	Clay	10-40	45	11	19	13	32	12
	3	Clay	40-116	29	8	18	12	30	33
	4	Clay	116-219	47	11	18	14	32	10
PIT 9	1	Loamy sand	0-18	5	4	25	39	64	27
	2	Loamy sand	18-36	8	4	29	38	67	21
	3	Sandy clay loam	36-132	24	3	48	20	68	5
	4	Loam / clay loam	132-240	22	15	36	16	52	11
PIT 21	1	Loam	0-12	9	8	22	20	42	41
	2	Loamy sand	12-32	6	10	36	26	62	22
	3	Sand / loamy sand	32-75	1	5	18	32	50	44
	4	Clay loam	75-175	17	4	14	19	33	46
	5	Loamy sand	175-215	10	20	44	20	64	6
PIT 23	1	Loamy sand	0-8	4	8	22	20	42	46
	2	Loamy sand	8-30	6	9	22	23	45	40
	3	Loamy sand	30-43	4	7	20	17	37	52
	4	Clay loam	43-90	18	6	18	22	40	36
	5	Clay	90-136	38	7	20	18	38	17

Table 1a (cont'd)
Physical Laboratory Analysis Data for Selected Soil Profiles
(Whole Soil Particle Size Analysis)

Page 2 of 2

PIT	LAYER	TEXTURE (fine earth)#	DEPTH (cm)	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
PIT 31	1	Loamy sand	0-20	6	8	25	31	56	30
	2	Loam	20-48	11	11	18	24	42	36
	3	Clay	48-75	43	7	13	17	30	20
PIT 34	1	Loamy sand	0-11	4	8	14	28	42	46
	2	Loamy sand	11-56	5	6	19	26	45	44
	3	Loamy sand	56-75	7	9	9	42	51	33

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

Table 1b
Physical Laboratory Analysis Data for Selected Soil Profiles
(Whole Soil Particle Size Analysis)

PIT	LAYER	TEXTURE (fine earth)#	DEPTH (cm)	D %	D% level of dispersion	EAT	EAT level of dispersion
PIT 1	1	Loam / clay loam	0-10	320	Slight	3(2)	Slight
	2	Clay	10-40	42	Moderate	3(1)	Slight
	3	Clay	40-116	27	Slight	2(1)	Moderate / high
	4	Clay	116-219	98	Very High	1	Very high
PIT 9	1	Loamy sand	0-18	29	Slight	3(1)	Slight
	2	Loamy sand	18-36	44	Moderate	3(1)	Slight
	3	Sandy clay loam	36-132	32	Moderate	3(1)	Slight
	4	Loam / clay loam	132-240	30	Slight	2(1)	Moderate / high
PIT 21	1	Loam	0-12	46	Moderate	3(1)	Slight
	2	Loamy sand	12-32	89**	NA**	2(1)	Moderate / high
	3	Sand / loamy sand	32-75	100**	NA**	2(1)	Moderate / high
	4	Clay loam	75-175	42	Moderate	2(1)	Moderate / high
	5	Loamy sand	175-215	33	Moderate	3(2)	Slight
PIT 23	1	Loamy sand	0-8	20	Slight	8/3(1)	Negligible / slight
	2	Loamy sand	8-30	33	Moderate	3(1)	Slight
	3	Loamy sand	30-43	67	Very high	2(1)	Moderate / high
	4	Clay loam	43-90	60	High	2(1)	Moderate / high
	5	Clay	90-136	48	High	3(3)	High
PIT 31	1	Loamy sand	0-20	50	High	8/3(1)	Negligible / Slight
	2	Loam	20-48	50	High	3(1)	Slight
	3	Clay	48-75	36	Slight	3(1)	Slight
PIT 34	1	Loamy sand	0-11	20	Slight	8/3(1)	Negligible / slight
	2	Loamy sand	11-56	57	High	8/3(1)	Negligible / slight
	3	Loamy sand	56-75	33	Moderate	3(1)	Slight

Notes: D = Dispersion EAT = Emerson Aggregate Test # texture based on laboratory measurements
** - results not meaningful due to low clay %

6 DISCUSSION OF SOIL ANALYSES

6.1 Physical Attributes

6.1.1 Laboratory Analyses

The laboratory analysis results contained in **Table 1** are important in assessing the erodibility of the SMUs 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 seven selected soil profiles, when considered together, provide a good indication of the soil's likely behaviour in relation to the erosive forces encountered in the field.

6.1.2 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 all soils analysed 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 – ie. 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 forty six profiles that were examined indicated that the soils were generally more clayey than was shown in the laboratory analyses.

6.1.3 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 showed variable dispersibility as measured by this procedure, ranging from slight to medium and high.

The subsoil D% values usually ranged from moderate to very high (this last in the SMU 2 soil analysed which showed evidence of salinity and sodicity). 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 this is difficult since they already exhibit moderate to 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.

6.1.4 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 Land and Water Conservation 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**.

The EAT data in **Table 1** show that the surface layers of the soils analysed have a negligible to slight dispersibility rating.

The EAT levels in the subsoils varied and were generally moderate to high with the exceptions being the coarser textured soils of the hill country.

Based on this data it can be concluded that the EAT testing indicates that the topsoils in both SMUs show dispersibility values ranging from negligible and slight.

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)	

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

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

6.2 Soil Chemical Attributes

6.2.1 Laboratory Analysis

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**.

Table 4
Chemical Analyses Laboratory Analysis Data for Selected Soil Profiles

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PIT	LAYER	TEXTURE (fine earth)#	DEPTH (cm)	pH *	EC (dS/m)#
PIT 1 SMU 2	1	Loam / clay loam	0-10	5.5	0.07
	2	Clay	10-40	6.0	0.95
	3	Clay	40-116	9.5 – 10	1.55
	4	Clay	116-219	9.5 – 10	1.14
PIT 9 SMU 1	1	Loamy sand	0-18	6.0	0.04
	2	Loamy sand	18-36	6.0	0.01
	3	Sandy clay loam	36-132	9.5 – 10	0.10
	4	Loam / clay loam	132-240	9.5 – 10	0.12
PIT 21 SMU 1	1	Loam	0-12	6.5	0.02
	2	Loamy sand	12-32	6.5	0.02
	3	Sand / loamy sand	32-75	6.5	0.01

Table 4 (Cont'd)
Chemical Analyses Laboratory Analysis Data for Selected Soil Profiles

Page 2 of 2

PIT	LAYER	TEXTURE (fine earth)#	DEPTH (cm)	pH *	EC (dS/m)#
PIT 21 SMU 1 (cont.)	4	Clay loam	75-175	6.0	0.13
	5	Loamy sand	175-215	8.0	0.05
PIT 23 SMU 1	1	Loamy sand	0-8	5.5	0.04
	2	Loamy sand	8-30	5.5	0.03
	3	Loamy sand	30-43	5.5	0.01
	4	Clay loam	43-90	9.5 – 10	0.12
	5	Clay	90-136	8.0	0.12
PIT 31 SMU 1	1	Loamy sand	0-20	5.5	0.01
	2	Loam	20-48	6.0	0.01
	3	Clay	48-75	7.0	0.03
PIT 34 SMU 1	1	Loamy sand	0-11	5.5	0.01
	2	Loamy sand	11-56	7.0	0.01
	3	Loamy sand	56-75	7.5 – 8.0	0.04

6.2.2 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.

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 most of the twenty four 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 were very alkaline and outside the range acceptable for plant growth.

This indicates that the pH values of the topsoil layer that will 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.

6.2.3 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, sulfates 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 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 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.

Hazelton and Murphy (in press) note that EC_e values below 2.0 indicate non-saline horizons while values between 2 and 4 indicate slight salinity. Values between 4 and 8 indicate moderate salinity while those between 8 and 16 indicate high salinity.

The data in **Table 6** indicate that all topsoil materials within the four SMUs are non-saline.

A similar situation applies for the subsoils of five of the profiles subjected to laboratory analysis.

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

PIT	LAYER	TEXTURE (fine earth)#	DEPTH (cm)	EC (dS/m)#	MULTI-PLIER	CALCULATED EC _e	SOIL SALINITY STATUS
PIT 1	1	Loam / clay loam	0-10	0.07	9.5	0.67	Non-saline
	2	Clay	10-40	0.95	7.5	7.13	Moderately saline
	3	Clay	40-116	1.55	7.5	11.63	Highly saline
	4	Clay	116-219	1.14	7.5	8.55	Highly saline
PIT 9	1	Loamy sand	0-18	0.04	23	0.92	Non-saline
	2	Loamy sand	18-36	0.01	23	0.23	Non-saline
	3	Sandy clay loam	36-132	0.10	9.5	0.95	Non-saline
	4	Loam / clay loam	132-240	0.12	9.5	1.14	Non-saline
PIT 21	1	Loam	0-12	0.02	9.5	0.19	Non-saline
	2	Loamy sand	12-32	0.02	23	0.46	Non-saline
	3	Sand / loamy sand	32-75	0.01	23	0.23	Non-saline
	4	Clay loam	75-175	0.13	8.6	1.12	Non-saline
	5	Loamy sand	175-215	0.05	23	1.15	Non-saline
PIT 23	1	Loamy sand	0-8	0.04	23	0.92	Non-saline
	2	Loamy sand	8-30	0.03	23	0.69	Non-saline
	3	Loamy sand	30-43	0.01	23	0.23	Non-saline
	4	Clay loam	43-90	0.12	8.6	1.03	Non-saline
	5	Clay	90-136	0.12	7.5	0.90	Non-saline
PIT 31	1	Loamy sand	0-20	0.01	23	0.23	Non-saline
	2	Loam	20-48	0.01	9.5	0.10	Non-saline
	3	Clay	48-75	0.03	7.5	0.23	Non-saline
PIT 34	1	Loamy sand	0-11	0.01	23	0.23	Non-saline
	2	Loamy sand	11-56	0.01	23	0.23	Non-saline
	3	Loamy sand	56-75	0.04	23	0.92	Non-saline

The remaining profile, number 1 (from SMU 1), exhibits moderate salinity in the upper subsoil and high salinity for the lower subsoil.

This problem is further exacerbated by the sodicity of these subsoils and has been taken into account in preparing soil stripping recommendations for the Study Area. See Section 5.2.3 below for further discussion of this issue.

6.2.4 Soil Sodicity

As the work of Wiram (1982) indicated that many of the soils found within the Boggabri Coal Study Area in Leard State Forest were sodic at depth, the three horizons that showed moderate to high salinity levels with the first series of laboratory measurements were subjected to further analysis to determine the cation exchange capacity (CEC) and exchangeable Sodium content (both measured in milliequivalents per 100g).

Calculations of the exchangeable sodium percentage (ESP) were then carried out.

The data in **Table 7** show that these three saline layers are also highly sodic with obvious impacts for soil dispersibility and landscape stability if such material is used near the surface of rehabilitated lands.

It is of interest to note that the sodicity was noted in only one of the six profiles analysed and that this profile is typical of the area adjacent to Leard State Forest where Wiram (1982) recorded the existence of sodic soils.

Table 7
Sodicity of Selected Horizons

PIT	LAYER	TEXTURE (fine earth)#	DEPTH (cm)	EC (dS/m)#	EC me/100 g	Sodium me/100g	ESP	SODICITY LEVEL
PIT 1	1	Loam / clay loam	0-10	0.07	Not tested	x	x	x
	2	Clay	10-40	0.95	41.9	8.5	20.3	Strongly sodic
	3	Clay	40-116	1.55	43.4	12.6	29.0	Strongly sodic
	4	Clay	116-219	1.14	41.6	15.0	36.1	Strongly sodic

6.2.5 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 almost universally increase in alkalinity with depth (often to pH 9.5 to 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 to the north, west and south of the proposed area of disturbance.

The lands within the Study Area that have been cleared for cultivation have been subjected to soil erosion in the past and in order to minimize erosion a large number of diversion bank and waterway systems have been constructed on these lands. Much of the area protected by these bank and waterway systems is included within the area that would be disturbed by the proposed development.

Care should be taken to ensure that the rehabilitated post-mining landscape is protected by appropriate soil conservation measures and that these interface with any parts of existing systems that are not disturbed during development. To this end the assistance of the local staff of the Department of Lands (Soil Services) should be sought to design and construct alternative water disposal systems where they are required.

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.

Groundcover on some of the currently cultivated land may need to be managed carefully to ensure its maximisation during the initial years of the project if it is to be removed from cultivation. If these lands are to continue to be cultivated, then management should ensure that the degree of protection from soil erosion that is currently provided is maintained.

6.4 Soilloss Program

An appropriate method of assessing the erosion hazard associated with the soils of the Study Area is to use the Soilloss 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.

Soilloss 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

$$A = R * K * L * S * P * C \quad \text{where}$$

- 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 Soilloss, 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 8 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 8** for the three basic soil types 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 three typical soil profiles at the Study Area.

The only value for which estimates were used in the calculations were those for organic matter %. After a perusal of the data for this variable for duplex soils in the Leard State Forest (Wiram, 1982, values of 0.94% (topsoils) and 0.30% (subsoils) were chosen.

The Erodibility classes used were < 0.020 = LOW; 0.020 – 0.040 = MODERATE; > 0.040 = HIGH.

Table 8
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
"clay" SMU 2	1	0-10	0.034 moderate	10-40	0.016 low	0.025	moderate
"duplex" SMU 1	23	0-8	0.021 moderate	43-90	0.026 moderate	0.024	moderate
"sandy" SMU 1	34	0-11	0.039 moderate	11-56	0.025 moderate	0.032	moderate

The data in **Table 8** show that the SOILOSS program predicts that all of the soil types sampled at the Study Area 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 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 high pH and relatively high dispersibility in the subsoil materials, indicates that the subsoil materials will have to be very carefully managed during the life of the mine.

For the "clay" soil type that represents SMU 2, the SOILOSS model does not take into account the salinity and sodicity values that make the subsoil of this soil type more unstable.

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
- (e) the force necessary to disrupt peds

NOTE: The following descriptions of soil materials are based on the detail gained from all 46 profiles sampled in the field.

7.1 Stripping Recommendations for Soil Mapping Unit 1

7.1.1 Layer 1 (0cm to 15cm depth)

Mainly sandy loam and sandy clay loam, sometimes clay loam, silty clay loam clayey sand, fine sandy clay loam, light to medium clay; loam fine sandy, silty clay or silty clay loam; roots common to many; no lime present; no manganese present; pH 5.5 to 6.0, sometimes to pH 7.0; some to much rounded and / or angular gravel to 4cm to 5cm; not mottled ; not bleached; brown (10YR5/2), brown (10YR5/3, 7.5YR4/2, 7.5YR4/3, 7.5YR5/2, 7.5YR5/3), dark brown (7.5YR3/2), greyish brown (10YR5/2), light brown (7.5YR6/3), light brownish grey (10YR6/2), light grey (10YR7/2, 7.5YR7/1), pale brown (10YR6/3), pink (7.5YR7/3), pinkish grey (7.5YR6/2, 7.5YR7/2), reddish brown (5YR5/3), reddish grey (5YR5/2), very dark greyish brown (10YR3/2) or very pale brown (10YR7/3) dry; brown (7.5YR4/2, 7.5YR5/3, 7.5YR5/4), dark brown (7.5YR3/2), dark greyish brown (10YR4/2), dark reddish brown (5YR2.5/2, 5YR3/3), greyish brown (10 YR5/2), light brown (7.5YR6/4), reddish brown (5YR4/3), strong brown (7.5YR5/6), very dark grey (10YR3/1), very dark grey (7.5YR3/1), very dark greyish brown (10YR3/2) and yellowish red (5YR5/6) moist; massive or with rough-faced or (occasionally) rough / smooth-faced peds; highly pedal (100%, sometimes massive, occasionally moderately pedal, polyhedral, <5mm to 10mm in size; weak, firm or strong consistency dry; usually not hydrophobic, sometimes hydrophobic or slightly so.

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

This material is generally suitable for topsoiling on the basis of the Elliott and Veness key but some material is sandier than the ideal and 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 15cm. 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. 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 (15cm to 65cm)

Sandy loam, sandy clay loam or light to medium clay; some sands, clayey sands, silty clay loam, heavy clay; clays sometimes gritty or sandy; roots common or many, sometimes few; usually no lime present, occasionally stains, flecks or concretions present; usually no manganese present, occasionally stains or concretions; pH 5.5 to 7, occasionally to 4.5, some profiles with pH to 9.5 to 10; usually much rounded and angular gravel <1cm to 6cm, sometimes to 10cm, cemented sands sometimes present; usually not mottled, occasionally so; sometimes bleached, usually not; mainly whole coloured brown (10YR5/2, 10YR5/3, 7.5YR4/2, 7.5YR4/3, 7.5YR5/2, 7.5YR5/3, 7.5YR5/4), greyish brown (10YR5/2), light brown (7.5YR6/2, 7.5YR6/3, 7.5YR6/4), light brownish grey (10YR6/2, 2.5Y6/2), light grey (10YR7/1, 10YR7/2), 7.5YR7/1), pale brown (10YR6/2, 10YR6/3), pink (5YR7/4, 5YR8/3, 7.5YR7/3, 7.5YR7/4, 7.5YR8/3), pinkish grey (7.5YR6/2, 7.5YR7/2), pinkish white (7.5YR8/2), very pale brown (10YR 7/3, 10YR8/2), white (2.5Y8/1, 7.5YR8/1) and yellowish red (5YR5/6); sometimes mottled in tones of red, brown, yellow, pink and grey dry; brown (10YR4/3, 10YR5/3, 7.5YR4/2, 7.5YR4/3, 7.5YR4/4, 7.5YR5/2, 7.5YR5/3, 7.5YR5/4), dark brown (7.5YR3/2), dark grey (7.5YR4/1), dark greyish brown (10YR4/2), grey (10YR6/1), greyish brown (10 YR5/2, greyish brown (2.5Y5/2), light brown (7.5YR6/3, 7.5YR6/4), light brownish grey (2.5Y6/2), pink (5YR7/3), reddish brown (5YR4/3, 5YR4/4), reddish yellow (7.5YR6/6), strong brown (7.5YR5/6, 7.5YR5/8), very pale brown (10YR7/4), white (2.5Y8/1), yellowish brown (10YR5/4) and yellowish red (5YR5/6); sometimes mottled in tones of red, brown, yellow and grey dry moist; peds rough-smooth faced, sometimes massive, fabric rough; highly pedal (100%) or massive, peds usually polyhedral, sometimes polyhedral/ platy; <5 – 20mm, very strong to very strong consistency, sometimes very firm , rarely weak dry; usually not hydrophobic, very occasionally hydrophobic or slightly so.

Suitability Assessment: mainly structure grade 3; coherent dry, mottles usually absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer contains considerable though not excessive amounts of gravel; pH levels generally suitable although some areas have pH levels of up to 9.5 to 10. The extensive mixing of material during stripping and respreading should result in generally lower composite pH levels on the rehabilitated land; salt content 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 65cm. 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.

7.1.3 Layer 3 (Remainder of the Profile)

Although some sections of the area covered by SMU 1 have shallow profiles, many other sections have quite deep profiles consisting of material that is usually suitable for use as subsoil.

This material would not normally be retrieved but in view of the salinity and sodicity problems associated with the subsoils within SMU 2, it is important that sufficient subsoil material is recovered from the remainder of the Study Area to enable rehabilitation of the whole site.

As a consequence it is recommended that an additional 50cm of material be stripped from SMU 1 areas to compensate for the loss of subsoils material from SMU 1. The Layer 3 material from SMU 1 will have some limitations - particularly with regard to pH, the occasional presence of mottles, and the amount of gravel present.

Mixing during stripping will ameliorate these problems to some degree.

Recommendation – Strip a further 50cm layer from the remainder of the profile down to a depth of 115cm below the original surface where weathered rock is not present. Cease stripping on any area where as soon as rock is encountered

This material can be stockpiled for use in rehabilitating the SMU 2 area.

7.2 STRIPPING RECOMMENDATIONS FOR SOIL MAPPING UNIT 2

7.2.1 Layer 1 – 0cm to 10cm

Light to medium clay sometimes heavy clay, sometimes gritty; roots common to many; no lime present; no manganese present; pH 5.5 – 8.0; some to much rounded and angular gravel 1cm to 3cm; not mottled; not bleached; brown (7.5YR4/2, 7.5YR5/2), dark brown (7.5YR3/2) dry; brown (7.5YR4/2), dark brown (7.5YR3/2), dark reddish brown (5YR2.5/2), very dark grey (7.5YR3/1) moist; peds rough-smooth faced or rough-faced; highly pedal (100%); polyhedral, <5mm to 15mm, very firm to very strong consistency dry; not hydrophobic.

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

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

(NOTE: Topsoil stripping should be carried out on all areas that will be disturbed by mining and associated infrastructure development. Because of the limitations posed by salinity and sodicity of the remainder of the profile the material from below 10cm should be mixed with overburden material and buried in the mine void as soon as possible.

7.2.2 Remainder of the Profile

The material below 10cm depth should not be stripped and stockpiled because of its salinity and sodicity problems.

Recommendation – The most effective way of dealing with this problem is to strip the subsoil material from SMU 2 and blend it with the overburden material. The level of dilution of the saline and sodic material should pose few problems in such a situation.

The overburden that this saline and sodic material is mixed with should then be targeted for priority burial in the mine void once refilling of mined out areas commences.

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 area and construction of the mine access road, coal processing and mine facilities areas.

In addition, subsoil material will need to be stripped from the area to be disturbed by the proposed open cut area and overburden dumps 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 its effects 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 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 topsoils are not stripped when they are too moist as greater damage will occur at this time. Similar precautions should be taken with the subsoils.

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 dumps 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 will 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 the loss of soil material from the stockpiles, especially in the period before they are stabilised, eg. using geotextile "fences" or lines of hay 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 be sown with stabilising species as soon as possible after placement. Where stockpile construction is conducted in stages, the stockpiles should be progressively stabilised.

8.3 Special Considerations in Relation to SMU 2 Materials

The soils study of the Boggabri Coal area in Leard State Forest (Wiram, 1982) revealed that many of the soils within the area studied were sodic in the lower sections of the profile.

The present study has shown that soils in the northwestern section of the Study Area show similar characteristics and so will need to be managed in a different way to the soils of SMU 1 that occur over the main section of the area to be disturbed.

The data in **Table 7** show that the representative profile from this section of the Study Area was highly sodic below a depth of 10cm from the surface with sodicity increasing with depth. **Table 6** also indicates that these same layers are also saline with salinity also increasing with depth.

The soil stripping recommendations for SMU 2 indicate that only the top 10cm of the soil profile should be stripped as topsoil. Stockpiling of this material should not present problems. However, the subsoil materials, as a consequence of their saline and sodic properties, are likely to cause problems relating to the maintenance of stability as well as erosion prevention on any subsoil stockpiles that are created.

The most effective way of overcoming this problem is to strip the subsoil material from SMU 2 and blend it with the overburden material. The level of dilution of the saline and sodic material should pose few problems in such a situation.

The overburden that this saline and sodic material is mixed with should then be targeted for priority burial in the pit once refilling of mined out areas commences.

This course of action will obviously reduce the amount of subsoil material available for use in rehabilitation. As a consequence it has been recommended that a third layer of material is stripped from the SMU 1 area and used as subsoil for the SMU 2 area.

This material will have less than ideal pH levels and may have some dispersibility problems but it would be preferable to use it in rehabilitation instead of the natural material from the SMU 2 area.

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 DIPNR).

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 Project Site

9.2.1 Introduction

It should be noted that both the NSW Soil Conservation Service (DIPNR) 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 Project Site.

9.2.2 Land Capability Classification

9.2.2.1 Land Capability as Mapped by DIPNR

The 1:100 000 scale Land Capability map of the Boggabri map sheet area prepared by the former Soil Conservation Service of NSW (DIPNR, Parramatta - GIS) shows the Project Site to comprise Classes III, IV and VI land.

The lower slope areas are mapped as Class III lands (*land suited to regular cultivation provided it is suitably protected by soil conservation measures and practices*) by DIPNR.

The mid slopes and part of the upper slopes is mapped as Class IV land (*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*).

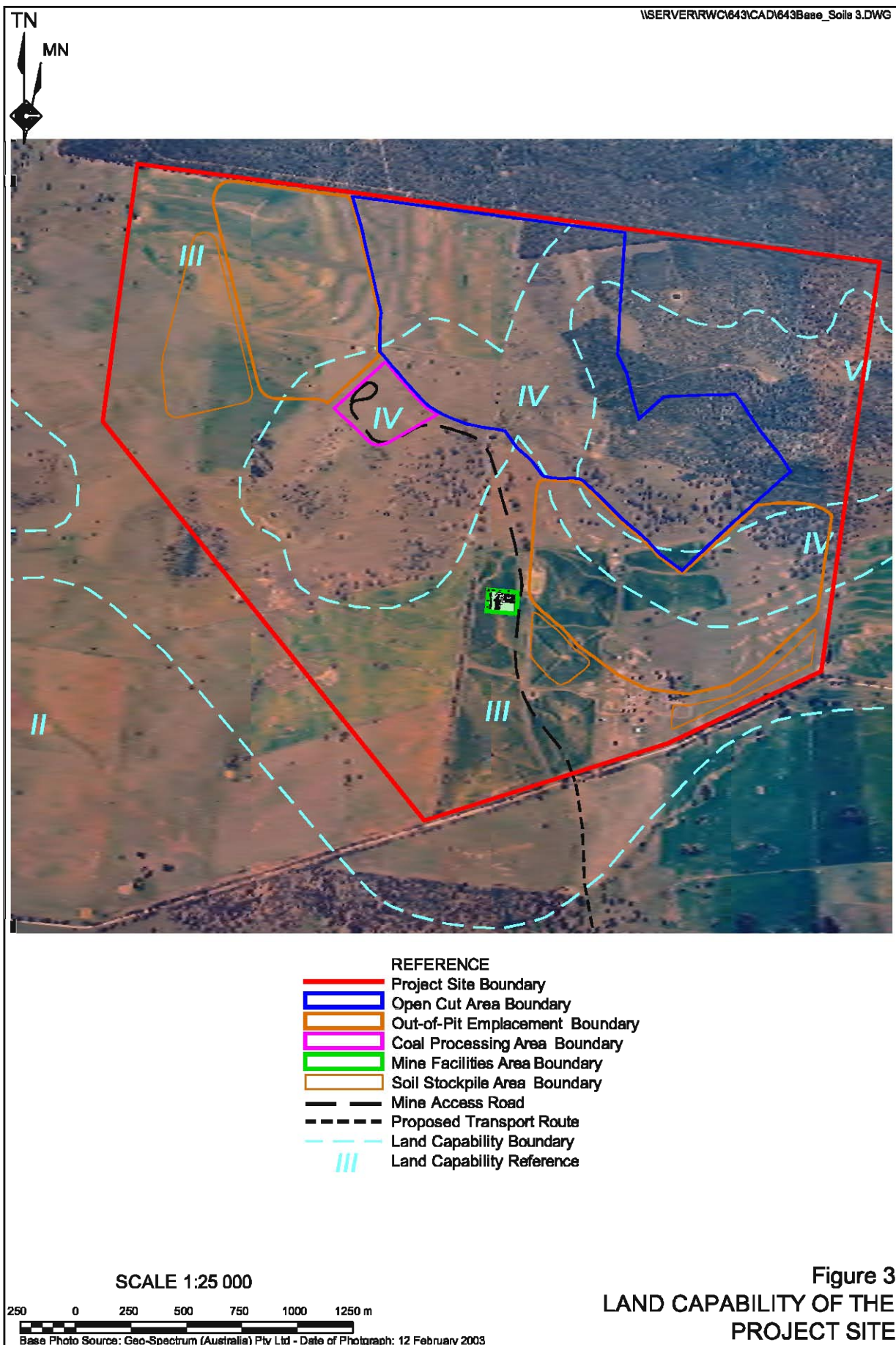
The remainder of the upper slopes and the ridge crests are mapped as Class VI lands (*land not capable of being cultivated but suitable for grazing; and application of soil conservation practices including limitation of stock, broadcasting of seed and fertilizer, prevention of fire and destruction of vermin*).

9.2.2.2 Current Assessment

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

- the DIPNR mapped Class III lands can be classed as Class III land;
- the DIPNR mapped Class IV lands are more realistically Class VI lands because of their potential to erode and the degree of slope. Parts of these lands have been cleared and cultivated in the past but most remain as purely pasture lands or have reverted to native timber regrowth; and
- the DIPNR mapped Class VI lands are more realistically mapped as Class VII land (*land best protected by green timber*).

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



9.2.3 Agricultural Land Suitability Classification

9.2.3.1 NSW Agriculture Assessment

Information supplied by NSW Department of Primary Industries (Agriculture) at Gunnedah (Kelly Hudson, pers. comm.) indicates that the Department has classified the lands of the Project Site using its agricultural land suitability system.

The maps showing the Project Site indicate that the lands are mainly Class 3 and Class 4 land.

The Class 4 land is located on the midslopes, upper slopes and crests while the Class 3 land forms a border around the base of the Class 4 land.

The NSW Department of Primary Industries (Agriculture) Land Suitability classification defines these land classes as follows:

- Class 3 lands are grazing lands or those well suited to pasture improvement. These lands have a moderate productivity and may be cultivated or cropped in rotation with pasture although soil and environmental constraints (eg. erosion hazard and soil structure breakdown) limit productivity.
- Class 4 lands are suited suitable for grazing (using native pastures or possibly for pasture improvement with minimum tillage) but not for cultivation.

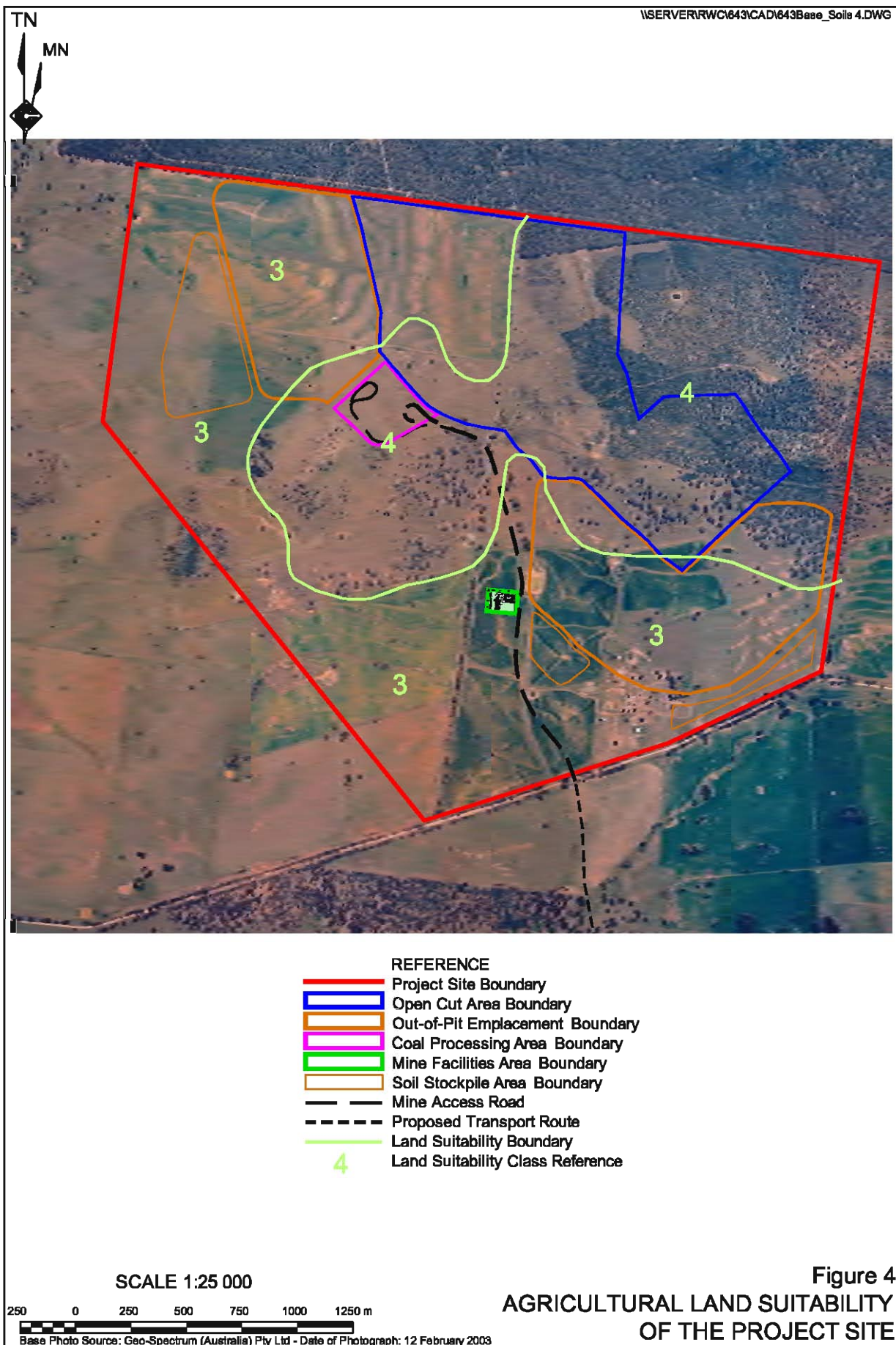
9.2.4 Current Assessment

A more detailed study of the Project Site indicates that the Class 3 lands shown in the NSW Department of Primary Industries (Agriculture) mapping is probably correct in a general sense although the actual boundary between the Class 3 and Class 4 lands is difficult to accurately pinpoint because of the map scale.

The Class 4 land is more appropriately mapped as Class 5 land because of its erosion potential, degree of slope, shallow soils and general infertility.

Class 5 agricultural land suitability lands are those unsuitable for agriculture or at best suited only to light grazing. Agricultural production is very low or zero as a result of severe constraints, including economic factors which preclude development.

The agricultural land suitability classes for the Project Site, as mapped in the present study, are shown in **Figure 4**.



10 OFF-SITE AND CUMULATIVE SOILS IMPACTS

In this Section the cumulative impacts of the proposed East Boggabri Coal Mine associated with both the Project Site activities and the transport route from the Project Site to Whitehaven Coal Mine are discussed. The soils of the proposed transport route are described in detail in Soils and Land Capability Study of the Proposed East Boggabri Coal Mine Site near Boggabri, NSW Part B: Soils and land Capability Study of the Proposed Transport Route (GCNRC, 2005b).

The impacts on soils would be limited to the immediate areas of disturbance at the proposed East Boggabri Coal Mine Project Site and the area that would be disturbed by construction of the proposed transport route.

The topsoil material to be stripped from the area of disturbance at the proposed East Boggabri Coal Mine Project Site would be progressively used in rehabilitation of the final landform.

The subsoil that is stripped from within Soil Mapping Unit 1 would also be used in the rehabilitation process. However the subsoil material from the Soil Mapping Unit 2 area would be buried in the overburden material to minimise any impact from its sodic and saline properties.

The topsoil material from the complete length of the transport route (Soil Mapping Units 3 and 4) would be used on-farm as agreed between the Proponent and individual landholders. The subsoil material from Soil Mapping Unit 1 (transport route) would be similarly used.

However because of the likely salinity of subsoil material from Soil Mapping Unit 4 this material would be transported either to the Project Site or Whitehaven Coal Mine, mixed with overburden and used as fill.

There would be no soil related off-site impacts as a consequence of the proposed development.

There would also be no significant cumulative impacts on the soils of the region since the stripping recommendations provide for the conservation of the topsoil and upper subsoil materials that would be disturbed and for their replacement on the final landform to provide a suitable base for re-establishment of native vegetation and / or pasture.

The roads constructed along the proposed transport route would remain in place as agreed between the Proponent and the individual landholders.

11 DIRECTOR-GENERAL'S REQUIREMENTS

The issues listed in **Table 9** are those related to soils that have been raised in the overall listing of the Director-General's Requirements. The organisation raising the issue has also been listed beside each issue.

Table 9
Director-General's Requirements

Environmental Aspect	Government Agency	Paraphrased Requirement	Relevant Soil Study Section(s)
Key Issues	DIPNR	The EIS must assess the following potential impacts of the proposal and describe what measures would be implemented to manage, mitigate or off-set these potential impacts: <ul style="list-style-type: none"> • Soil 	Part A – Section 8 Part B – Section 8
Location	DEC	Provide an overview of the local environment to enable the proposal to be assessed in terms of its local and regional environmental context including <ul style="list-style-type: none"> • Soil types and properties 	Part A – Section 3,9 Part B – Section 3,9
	DEC	Consider the significance of all potential impacts in the regional context.	Part A – Section 10 Part B - (covered in Part A, Section 10)
Cumulative Impacts	DIPNR	Consider cumulative impacts which may result from a number of activities with similar impacts interacting with the environment.	Part A – Section 10 Part B - (covered in Part A, Section 10)
Soil and Salinity Issues	DIPNR	Include a description of soil types in the area and any salinity or contamination issues that may arise as a result of the development.	Part A – Sections 4, 5, 6 Part B - Sections 4, 5, 6
	DPI	Apply “Best Practice” or soil handling and management. Complete extensive soil profiling prior to stripping of vegetation. Selectively strip topsoil and subsoil to secure and maintain the current available resources. Review utilisation of cleared vegetation in the rehabilitation program.	Part A – Sections 6, 7, 8 Part B - Sections 6, 7, 8

12 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 following.

- 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.
- The soils have a generally high structure grade and so can be stripped and respread using scrapers.
- For SMU 1 the topsoil material (to 15cm depth) and the subsoil (to about 65cm total depth below the original soil surface) is favourable for use in rehabilitating the disturbed landscape.
- For SMU 2 only 10cm of topsoil should be stripped.

- The remaining soil material from SMU 2 should be mixed with overburden material and buried in the pit as soon as this action is possible because of the salinity and sodicity recorded in the subsoil.
- The lower subsoil material in SMU 1 has some limitations imposed by dispersibility, and generally very high pH levels, however, some of this would have to be stripped to cover the shortfall in subsoil material resulting from the inability to use the subsoil from SMU 2.
- 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 and agricultural land suitability of the Study Area has been determined.

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Appendices

- Appendix 1 Soil Profile Descriptions From Required Backhoe Test Pits Field Descriptions**
- Appendix 2 Topsoil Stripping Suitability Key (After Elliott and Veness, 1981)**
- Appendix 3 Basis of Land Capability Classification (After Emery, Undated)**
- Appendix 4 Glossary of Terms**

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APPENDIX 1

Soil Profile Descriptions From Required Backhoe Test Pits Field Descriptions

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NOTE – in descriptions of peds the abbreviations ABL (angular blocky) and SABL (sub-angular blocky) are used frequently in the text.

Profile 1 - Mid slope location. Surface condition self-mulching, many surface stones rounded and angular to 10cm present.

0cm to 10cm; light to medium clay; many roots present; no lime present; no manganese present; pH 5.5; much rounded and angular gravel 1cm to 3cm; not mottled; not bleached; dark brown (7.5YR3/2) dry, dark reddish brown (5YR2.5/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *clear to:-*

10cm to 40cm; medium to heavy clay; roots common; some small lime flecks and concretions present; no manganese present; pH 6.0; much gravel to 2cm, occasional rounded stones 15cm to 20cm; not mottled; not bleached; dark reddish grey (5YR4/2) dry, reddish grey (5YR3/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

40cm to 116cm; medium clay; few roots; lime concretions present; no manganese present; pH 9.5 to 10; much gravel rounded and angular to 4cm; not mottled; not bleached; dark reddish grey (5YR4/2) dry, reddish brown (5YR4/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

116cm to 219cm; gritty medium to heavy clay; few roots; lime flecks present; no manganese present; pH 9.5 to 10; clay layer with pockets of rounded and angular gravel to 4cm; not mottled; not bleached; light brown (7.5YR6/3) dry, brown (7.5YR5/3) moist; peds smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong consistency dry; not hydrophobic; *diffuse to weathered rock.-*

Profile 2 - Depression location. Surface condition self mulching, cracked, surface gravel low to medium, 1cm to 2cm rounded and angular present.

16cm; loam fine sandy; roots common; no lime present; no manganese present; pH 5.5; some gravel present to 1cm; not mottled; not bleached; brown (10YR5/3) dry, dark greyish brown (10YR4/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5 mm in size; very weak consistency dry; not hydrophobic; *sharp to:-*

16cm to 51cm; sand; roots common; no lime present; no manganese present; pH 6.0; much angular gravel to 1cm; not mottled; bleached; very pale brown (10YR7/3) dry, brown (7.5YR5/2) moist; peds rough-faced, massive, massive loose, not hydrophobic; *abrupt to:-*

51cm to 90cm; sandy light clay; few roots; no lime present; no manganese present; pH 6.5; some angular gravel to 2cm; mottled; not bleached; 80% light grey (10YR7/2) 20% yellowish red (5YR4/6) dry, 80% greyish brown (10YR5/2) 20% dark red (2.5YR3/6) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

90cm to 120cm; medium clay; few roots; no lime present; manganese stains and concretions present; pH 7.5; some gravel to 1cm present; mottled; not bleached; 40% light brownish grey (10YR6/2) 60% brown (7.5YR5/4) dry, 40% greyish brown (10YR5/2) 60% brown (7.5YR4/4) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

120cm to 160cm; sandy loam; few roots; no lime present; manganese stains present; pH 7.5; no stones present; not mottled; not bleached; light brown (7.5YR6/4) dry, brown (7.5YR4/4) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

160cm to 200cm; sandy light medium clay; few roots; no lime present; manganese stains present; pH 9.0; no stones present; mottled; not bleached; 90% yellowish brown (10YR5/4) 10% brown (10YR5/3) dry, 90% dark yellowish brown (10YR4/4) 10% greyish brown (10YR5/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

200cm to 250cm; sandy light medium clay; few roots; no lime present; no manganese present; pH 8.5; weathering rock; mottled; not bleached; 90% brown (7.5YR5/3) 10% brown (10YR5/3) dry, 90% brown (7.5YR4/3) 10% brown (10YR5/3) moist; peds smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 3 - Upper slope location. *Surface self mulching/cracked, medium surface gravel and rounded and angular 1cm to 2cm up to 10cm present.*

0cm to 10cm; gritty medium clay; many roots; no lime present; no manganese present; pH 6.0; some gravel to 1cm present; not mottled; not bleached; brown (7.5YR4/2) dry, dark brown (7.5YR3/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

10cm to 50cm; medium clay; roots common; small lime concretions present; no manganese present; pH 9.0; some gravel to 1cm present; mottled; not bleached; 50% brown (7.5YR4/3) 50% dark brown (7.5YR3/2) dry, 50% brown (7.5YR4/3) 50% very dark grey (7.5YR3/1) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

50cm to 120cm; medium-heavy clay; few roots; small to large lime concretions present; manganese stains near base; pH 9.0; much angular and rounded gravel 5mm to 3cm; not mottled; not bleached; brown 7.5YR5/4, brown (7.5YR4/4) moist; mixed with white decomposing rock; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; very firm to strong consistency dry; not hydrophobic; *diffuse to:-*

120cm to 190cm; not sampled; weathering rock.

Profile 4 - Depression location. *Surface cracked, few surface stones to 15cm angular present.*

0cm to 14cm; sandy loam; many roots; no lime present; no manganese present; pH 6.5; some gravel to 1cm; not mottled; not bleached; brown (10YR5/3) dry, very dark greyish brown (10YR3/2) moist; peds rough-faced, highly pedal (80%), polyhedral, 5mm to 10mm in size; very weak consistency dry; not hydrophobic; *clear to:-*

14cm to 40cm; sandy clay; roots common; no lime present; manganese stains present; pH 6.5; many rounded and angular stones to 1cm; not mottled; not bleached; brown (7.5YR4/3) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

40cm to 43cm; sandy loam; roots common; no lime present; no manganese stains present; pH 7.0; some rounded and angular gravel to 4cm; not mottled; bleached; pale brown (10YR6/3) dry, brown (7.5YR4/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

43cm to 82cm; sandy light clay; few roots; no lime present; manganese stains present; pH 9.0; some angular gravel to <1cm; not mottled; not bleached; brown (7.5YR5/2) dry, dark grey (7.5YR4/1) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 10mm to 15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

82cm to 184cm; sandy medium clay; few roots; no lime present; much manganese staining and concretions present; pH 9.0; much rounded and angular gravel to 4cm; not mottled; not bleached; greyish brown (10YR5/2) dry, grey (10YR5/1) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

184cm to 245cm; sandy medium-heavy clay; few roots; no lime present, manganese concretions present, pH 9.0; much rounded and angular gravel <1cm to 3cm; not mottled; not bleached; light brownish grey (10YR6/2) dry, greyish brown (2.5Y5/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; very strong consistency dry; not hydrophobic.

Profile 5 - Lower slope location. *Surface self mulching/cracked, surface gravel medium to high rounded 2cm to 5cm present.*

0cm to 7cm; gritty silty clay; roots common; no lime present, no manganese present, pH 5.5; some gravel to 2cm flat and rounded; not mottled; not bleached; greyish brown (10YR5/2) dry, very dark grey (10YR3/1) moist; peds rough-faced, massive 60%, moderately pedal 40% , polyhedral, <5mm in size; weak consistency dry; not hydrophobic; *sharp to:-*

7cm to 28cm; clay loam to sandy clay; roots common; no lime present, no manganese present, pH 6.0; much gravel angular and rounded to 3cm; not mottled; not bleached; pinkish grey (7.5YR6/2) dry, brown (7.5YR4/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; very firm consistency dry; not hydrophobic; *clear to:-*

28cm to 38cm; sandy clay loam; roots common; no lime present, no manganese present, pH 6.5; much gravel angular and rounded to 5cm; not mottled; bleached; light grey (7.5YR7/1) dry, brown (7.5YR4/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

38cm to 70cm; gritty light clay; few roots; no lime present, no manganese present, pH 8.5; some gravel rounded to 2cm; mottled; not bleached; 90% light brownish grey (10YR6/2) 10% reddish yellow (5YR6/8) dry, 90% light yellowish brown (2.5Y6/4) 10% reddish yellow (5YR6/8) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong consistency dry; not hydrophobic; *gradual to:*

70cm to 96cm; clayey sand; no roots present; no lime present, no manganese present, pH 7.0; rounded and flattened gravel, much weathered rock; mottled; not bleached; 90% light grey (2.5Y7.2) 10% pale yellow (2.5Y7/3) dry, 90% light grey (2.5Y7.2) 10% pale yellow (2.5Y7/3) moist; peds rough / smooth faced, highly pedal (100%), polyhedral, 5mm to 20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

96cm to 120cm; clayey sand to sandy loam; no roots present; no lime present, no manganese present, pH 7.5; basically clayey, rounded gravel to 3cm; not mottled; not bleached; pale yellow (2.5Y7/3) dry, light grey(2.5Y7/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; very firm to strong consistency dry; not hydrophobic; *diffuse to:-*

120cm to 150cm; not sampled; no roots present; weathered rock/bedrock.

Profile 6 - Upper slope location. *Surface hardsetting, much surface stone present rounded to 10cm.*

0cm to 12cm; clayey sand; roots common; no lime present, no manganese present, pH 5.5; some gravel 1cm to 2cm rounded; not mottled; not bleached; greyish brown (10YR5/2) dry, very dark greyish brown (10YR3/2) moist, fabric rough, massive 50% moderately pedal 50%, polyhedral, 5mm to 10mm in size; weak consistency dry; not hydrophobic; *clear to:-*

12cm to 36cm; sandy loam; roots common; no lime present, no manganese present, pH 5.5; much gravel 2cm to 5cm rounded and angular; not mottled; bleached; pinkish grey (7.5YR7/2) dry, brown (7.5YR4/2) moist; fabric rough, massive 50% moderately pedal 50%, polyhedral, 5mm to 10mm in size; weak consistency dry; not hydrophobic; *clear to:-*

36cm to 91cm; clayey sand; few roots; no lime present, manganese stains present, pH 6.0; weathered conglomerate; not mottled; not bleached; white (2.5Y8/1) dry, white (2.5Y8/1) moist; fabric rough, massive, not hydrophobic.

Profile 7 - Upper slope location. *Surface hardsetting, much surface stone present.*

0cm to 9cm; sandy loam; many roots; no lime present, no manganese present, pH 6.0; angular rounded gravel 1cm to 2cm common; not mottled; not bleached; brown (7.5YR4/3) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm in size; very weak consistency dry; not hydrophobic; *clear to:-*

9cm to 18cm; sandy clay loam; many roots; no lime present, no manganese present, pH 6.0; much angular rounded gravel to 1cm to 3cm; not mottled; bleached; pink (7.5YR7/3) dry, light brown (7.5YR6/4) moist; peds rough-faced, massive 50% moderately pedal (50%), polyhedral, 5mm in size; very weak to weak consistency dry; not hydrophobic; *clear to:-*

18cm to 53cm; medium clay; many roots; no lime present, manganese stains present, pH 6.0; some rounded stones to 10cm; mottled; not bleached; 50% reddish brown (5YR5/3) 50% reddish brown (2.5YR4/4) dry, 50% reddish brown (5YR4/3) 50% reddish brown (2.5YR4/4) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

53cm to 100cm; light clay; few roots; no lime present, manganese stains present, pH 9.5 to 10; rounded angular gravel to 6cm common decreases towards base; mottled; not bleached; 90% brown (10YR5/3) 10% yellowish red (5YR4/6) dry, 90% greyish brown (2.5Y5/2) 10% yellowish red (5YR4/6) moist; peds rough-smooth faced, highly pedal (100%), polyhedral/platy, 5mm to 15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

100cm to 110cm; not sampled; weathered rock.

Profile 8 - Mid slope location. *Surface self mulching - cracked, rounded and angular surface gravel 2cm to 3cm common.*

0cm to 33cm; medium clay with some sand; roots common; no lime present, no manganese present, pH 8.0; much angular gravel to 1cm; not mottled; not bleached; brown (7.5YR4/2) dry, brown (7.5YR4/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

33cm to 83cm; gritty medium to heavy clay; few roots; many lime concretions present, manganese stains present, pH 9.5 to 10; much rounded gravel 1cm to 2cm, some to 5cm; not mottled; not bleached; brown (7.5YR5/3) dry, brown (7.5YR5/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *clear to:-*

83cm to 102cm; clayey sand; few roots; no lime present, no manganese present, pH 9.5 to 10; cemented grit and flat gravel; not mottled; not bleached; white (2.5Y8/1) dry, light grey (2.5Y7/2) moist; massive, rigid consistency dry; not hydrophobic; *gradual to:-*

102cm to 136cm; medium clay (sandy); few roots; no lime present, no manganese present, pH 9.5 to 10; some gravel to 1cm; not mottled; not bleached; pale brown (10YR6/3) dry, light olive brown (2.5Y5/3) moist; peds rough/smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic.

Profile 9 - Depression location. *Surface hardsetting, some rounded and angular surface gravel 1cm to 4cm present.*

0cm to 18cm; sandy loam; many roots; no lime present, no manganese present, pH 6.0; some rounded and angular gravel to 2cm; not mottled; not bleached, reddish grey (5YR5/2) dry, dark reddish brown (5YR3/2) moist; fabric rough, massive, not hydrophobic; *clear to:-*

18cm to 36cm; sandy loam; few roots; no lime present, no manganese present, pH 6.0; rounded and angular gravel 1cm to 2cm common; not mottled; not bleached, brown (7.5YR5/2) dry, dark brown (7.5YR3/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

36cm to 132cm; medium clay; few roots; lime concretions present, manganese stains present, pH 9.5 to 10; much rounded and angular gravel to 5cm; mottled; not bleached, 60% brown (10YR5/3) 40% dark brown (10YR5/4) dry, 60% grey (10YR5/1) 40% brown (7.5YR4/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

132cm to 240cm; sandy clay loam; few roots; lime stains present, manganese stains and concretions present, pH 9.5 to 10; pockets of gravel to 5cm present; not mottled; not bleached, light grey (10YR7/2) dry, pale brown (10YR6/3) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 10 - Upper slope location. *Surface hardsetting, surface gravel rounded and angular to 1cm to 3cm common.*

0cm to 11cm; sandy loam; roots common; no lime present, no manganese present, pH 5.0; much rounded and angular gravel to 1cm; not mottled; not bleached, brown (7.5YR5/3) dry, dark brown (7.5YR3/2) moist; fabric rough, massive, hydrophobic; *clear to:-*

11cm to 41cm; sandy loam; roots common; no lime present, no manganese present, pH 6.0; much rounded and angular gravel to 2cm; not mottled; bleached, pink (7.5YR7/3) dry, yellowish red (5YR5/6) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; very firm consistency dry; not hydrophobic; *gradual to:-*

41cm to 96cm; sandy clay loam; few roots; no lime present, no manganese present, pH 7.0; much flat rounded and angular gravel to 8cm; not mottled; not bleached, pink (5YR8/3) dry, pink (5YR7/3) moist; peds rough-faced, 50% massive to moderately pedal (50%), polyhedral, 5mm to 10mm in size; very firm consistency dry; not hydrophobic.

Profile 11 - Crest/low hill location. *Surface hardsetting, surface gravel rounded and angular 1cm to 5cm common.*

0cm to 16cm; sandy clay loam; many roots; no lime present, no manganese present, pH 5.5; gravel rounded and angular to 3cm common; not mottled; not bleached, brown (7.5YR5/3) dry, dark brown (7.5YR3/2) moist; peds rough-faced, 50% massive to moderately pedal (50%), polyhedral, <5mm to 10mm in size; weak consistency dry; not hydrophobic; *gradual to:-*

16cm to 48cm; sandy loam; many roots; no lime present, no manganese present, pH 6.0; much rounded gravel to 5cm; not mottled; bleached, pink (7.5YR8/3) dry, very pale brown (10YR7/4), fabric rough, massive, not hydrophobic; *gradual to:-*

48cm to 80cm; sandy loam; many roots; no lime present, no manganese present, pH 6.0; abundant angular and rounded gravel to 8cm; not mottled; not bleached, very pale brown (10YR8/2) dry, brown (7.5YR5/3) moist; fabric rough, massive, not hydrophobic.

Profile 12 - Mid slope location. *Surface hardsetting, few surface stones rounded to 10cm present.*

0cm to 17cm; clay loam to silty clay loam, many roots; no lime present, no manganese present, pH 5.0; much rounded and angular gravel 1cm to 4cm; not mottled; not bleached, reddish brown (5YR5/3) dry, dark reddish brown (5YR3/3) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; very firm to strong consistency dry; not hydrophobic; *clear to:-*

17cm to 49cm; light clay; many roots; small lime concretions present, no manganese present, pH 6.5 to 7.0; some flat and angular gravel to 4cm; not mottled; not bleached, brown (10YR5/3) dry, brown (7.5YR4/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

49cm to 102cm; sandy light clay; roots common; lime concretions present, no manganese present, pH 9.5 to 10; some gravel to 2cm; not mottled; not bleached, brown (7.5YR5/2) dry, brown (7.5YR5/2) moist; peds smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

102cm to 178cm; sandy medium clay; few roots; no lime present, manganese concretions and stains present, pH 9.5 to 10; some rounded gravel to 6cm with weathered rock; not mottled; not bleached, light brownish grey (10YR6/2) dry, greyish brown (10YR5/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral/platy, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 13 - Mid slope location. *Surface firm, surface stone absent.*

0cm to 13cm; silty clay loam; many roots; no lime present, no manganese present, pH 6.0; some gravel rounded and angular 1cm to 3cm; not mottled; not bleached, brown (7.5YR4/2) dry, very dark grey (7.5YR3/1) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm in size; firm consistency dry; not hydrophobic; *clear to:-*

13cm to 54cm; medium clay; roots common; no lime present, no manganese present, pH 7.0; rounded and angular gravel to 4cm common; not mottled; not bleached, light brown (7.5YR6/2) dry, brown (7.5YR4/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

54cm to 88cm; medium to heavy clay; few roots; lime stains present, no manganese present, pH 9.0; some gravel to <1cm present; not mottled; not bleached, brown (10YR5/3) dry, brown (10YR4/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

88cm to 155cm; medium to heavy clay; few roots; lime stains and concretions present, manganese stains common, pH 9.5 to 10; some weathered rock present; not mottled; not bleached, pale brown (10YR6/3) dry, brown (10YR5/3) moist; peds rough / smooth faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

155cm to 207cm; medium clay; no roots present; lime concretions present, manganese stains present, pH 9.5 to 10; weathered rock present; not mottled; not bleached, very pale brown (10YR8/2) dry, light brownish grey (2.5Y6/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 14 - Upper slope location. *Surface soft, surface stone absent.*

0cm to 9cm; fine sandy clay loam; many roots present; no lime present, no manganese present, pH 6.0; some rounded gravel 1cm to 3cm; not mottled; not bleached, very dark greyish brown (10YR3/2) dry, very dark grey (10YR3/1) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; very firm consistency dry; hydrophobic; *clear to:-*

9cm to 29cm; sandy medium clay; roots common; no lime present, no manganese present, pH 6.5; much rounded and angular gravel 1cm to 4cm; not mottled; not bleached, pale brown (10YR6/3) dry, brown (7.5YR4/3) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

29cm to 66cm; medium to heavy clay; few roots; no lime present, some manganese stains present, pH 9.0; some rounded and angular gravel 1cm to 2cm some to 5cm; mottled; not bleached, 50% brown (7.5YR5/4) 50% light brownish grey (2.5Y6/2) dry, 50% brown (7.5YR5/3) 50% light brownish grey (2.5Y6/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

66cm to 110cm; not sampled; few roots; weathered rock.

Profile 15 - Lower slope location. *Surface hardsetting, surface gravel rounded and angular 1cm to 8cm abundant.*

0cm to 12cm; sandy clay loam; many roots; no lime present, no manganese present, pH 6.0; some rounded and angular gravel to 3cm; not mottled; not bleached, brown (7.5YR5/3) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; firm consistency dry; not hydrophobic; *clear to:-*

12cm to 28cm; silty clay loam; many roots; no lime present, no manganese present, pH 7.0; much rounded gravel <1cm to 4cm; not mottled; not bleached, brown (7.5YR5/3) dry, dark brown (7.5YR3/2) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

28cm to 62cm; sandy clay; many roots; no lime present, no manganese present, pH 7.0; mainly rounded and angular gravel 1cm to 6cm; not mottled; not bleached, pale brown (10YR6/3) dry, brown (7.5YR5/4); fabric rough, massive, not hydrophobic; *diffuse to:-*

62cm to 95cm; medium to heavy clay; few roots; no lime present, no manganese present, pH 8.0; rounded and angular gravel and stones to 10cm common; not mottled; not bleached, light brownish grey (2.5Y6/2) dry, greyish brown (10YR5/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

95cm to 150cm; not sampled; occasional roots; basically weathering rock.

Profile 16 - Crest location. *Surface hardsetting, some rounded surface gravel to 4cm present.*

0cm to 17cm; sandy loam; many roots; no lime present, no manganese present, pH 5.5; many rounded and angular stones 1cm to 3cm; not mottled; not bleached, brown (7.5YR4/2) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm in size; weak consistency dry; hydrophobic; *gradual to:-*

17cm to 45cm; sandy loam; many roots; no lime present, no manganese present, pH 6.0; mainly gravel <1cm to 5cm; not mottled; bleached, pink (7.5YR7/4) dry, brown (7.5YR4/4) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

45cm to 90cm; sandy loam; few roots; no lime present, no manganese present, pH 7.0; mainly gravel angular and rounded <1cm to 4cm with some stones to 8cm; not mottled; not bleached, pink (7.5YR7/3) dry, light brown (7.5YR6/4) moist; fabric rough, massive, not hydrophobic.

Profile 17 - Lower slope location. *Surface self mulching/cracked, much rounded surface gravel 2cm to 5cm with occasional flattish stones to 40cm present.*

0cm to 19cm; sandy clay loam; many roots; no lime present, no manganese present, pH 6.0; much rounded some angular gravel 1cm to 4cm; not mottled; not bleached, brown (10YR5/2) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; firm consistency dry; not hydrophobic; *gradual to:-*

19cm to 42cm; medium clay; few roots; lime concretions and stains present, no manganese present, pH 6.5; few flat mainly angular stones to 1cm; mottled; not bleached, 50% brown (10YR5/2) 50% dark greyish brown (10YR4/2) dry, 50% very dark greyish brown (10YR3/2) 50% very dark grey (10YR3/1) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

42cm to 65cm; medium clay; few roots; many lime concretions present, no manganese present, pH 9.5 to 10; some angular gravel to <1cm; not mottled; not bleached, light brownish grey (10YR6/2) dry, greyish brown (10YR5/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral/platy, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

65cm to 180cm; medium clay; few roots; no lime present, no manganese present, pH 8.5; no stones present; mottled; not bleached, 50% light grey (10YR7/1) 50% greyish brown (10YR5/2) dry, 50% grey (2.5Y6/1) 50% greyish brown (10YR5/2) moist; peds smooth-faced, highly pedal (100%), polyhedral/platy, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 18 - Mid slope location. *Surface firm, much surface gravel rounded and angular 1cm to 3cm present.*

0cm to 14cm; sandy loam; many roots; no lime present, no manganese present, pH 6.0; much rounded gravel <1cm to 2cm; not mottled; not bleached, greyish brown (10YR5/2) dry, very dark greyish brown (10YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

14cm to 49cm; gritty medium to heavy clay; few roots; no lime present, manganese stains present, pH 7.0; much rounded and angular gravel 1cm to 3cm; mottled; not bleached, 95% strong brown (7.5YR5/6) 5% yellowish red (5YR4/6) dry, 95% yellowish red (5YR5/6) 5% yellowish red (5YR4/6) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

49cm to 112cm; gritty light clay; few roots; no lime present, manganese stains and concretions present, pH 9.5 to 10; much angular and flat gravel to 5cm; not mottled; not bleached, brown (7.5YR5/4) dry, yellowish brown (10YR5/4) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 19 - Lower slope location. *Surface hardsetting, much rounded surface gravel 1cm to 8cm present*

0cm to 30cm; sandy light medium clay; roots common; no lime present, no manganese present, pH 6.5; some rounded and angular gravel <1cm to 2cm; not mottled; not bleached, light brownish grey (10YR6/2) dry, greyish brown (10 YR5/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

30cm to 60cm; sandy light medium clay; few roots; no lime present, manganese stains and nodules present, pH 9.5 to 10; much rounded flat gravel to 3cm; not mottled; bleached, light grey (10YR7/1) dry, grey (10YR6/1), peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *clear to:-*

60cm to 105cm; gritty medium clay; no lime present, manganese stains present, pH 9.5 to 10; some rounded gravel to 4cm; mottled; not bleached, 90% light grey (10YR7/2) 10% yellowish brown (10YR5/8) dry, 90% grey (10YR5/1) 10% yellowish brown (10YR5/8) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

105cm to 123cm; clayey sand to sandy loam; no lime present, manganese stains and concretions present, pH 9.5 to 10; much flat and rounded gravel 3cm to 8cm; mottled; not bleached, 50% dark grey (10YR4/1) 50% brown (7.5YR4/4) dry, 50% dark grey (10YR4/1) 50% brown (7.5YR4/4) moist, peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *clear to:-*

123cm to 155cm; sandy clay; no lime present, no manganese present, pH 9.5 to 10; moderate amounts of rounded and angular gravel <1cm to 3cm; not mottled; not bleached, light grey (10YR7/2) dry, light brownish grey (10YR6/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

155cm to 177cm; sandy clay; no lime present, no manganese present, pH 9.5 to 10; cemented gravel layer with rounded gravel 1cm to 8cm; not mottled; not bleached, brown (7.5YR5/2) dry, dark greyish brown (10YR4/2) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong consistency dry; not hydrophobic; *clear to:-*

177cm to 210cm; sandy clay loam; no lime present, manganese stains present, pH 9.5 to 10; some rounded and angular gravel 2cm to 4cm; mottled; not bleached, 90% white (2.5Y8/1) 10% light brownish grey (2.5Y6/2) dry, 90% light brownish grey (10YR6/2) 10% light brownish grey (2.5Y6/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 20 - Lower slope location. *Surface loose, some surface gravel present.*

0cm to 9cm; sandy loam; many roots, no lime present, no manganese present, pH 6.0; much rounded gravel <1cm to 2cm; not mottled; not bleached, greyish brown (10YR5/2) dry, dark greyish brown (10 YR4/2) moist; fabric rough, massive, hydrophobic; *gradual to:-*

9cm to 50cm; clayey sand; roots common; no lime present, no manganese present, pH 6.0; much rounded gravel 1cm to 5cm; not mottled; bleached, light grey (10YR7/2) dry, brown (7.5YR5/3) moist; fabric rough, massive, not hydrophobic; *clear to:-*

50cm to 122cm; sandy loam; few roots; no lime present, no manganese present, pH 7.0; much rounded and angular gravel <1cm to 4cm; not mottled; not bleached, light brownish grey (10YR6/2) dry, brown (7.5YR5/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

122cm to 172cm; sandy clay; few roots; no lime present, no manganese present, pH 9.5 to 10, much angular and rounded gravel <1cm to 3cm; mottled; not bleached, 90% pale brown (10YR6/3) 10% reddish brown (5YR4/4) dry, 90% brown (7.5YR5/3) 10% reddish brown 5YR4/4) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

172cm to 204cm; medium clay; few roots; no lime present, no manganese present, pH 9.5 to 10, much angular and rounded gravel <1cm to 3cm; not mottled; not bleached, brown (7.5YR5/2) dry, greyish brown (10YR5/2) moist; peds rough-smooth faced, highly pedal (100%), polyhedral/platy, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 21 - Depression location. *Surface loose to firm, some rounded surface stone to 8cm to 10cm present.*

0cm to 12cm; silty clay loam; many roots; no lime present, no manganese present; pH 6.5; some rounded gravel mainly to 1cm some to 4cm; not mottled; not bleached, brown (7.5YR5/2) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; very weak consistency dry, not hydrophobic; *clear to:-*

12cm to 32cm; sandy clay loam; roots common; no lime present, no manganese present, pH 6.5; rounded gravel <1cm to 4cm common; not mottled; bleached, light grey (7.5YR7/1) dry, dark greyish brown (10YR4/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; very firm consistency dry; not hydrophobic; *gradual to:-*

32cm to 75cm; loamy sand; few roots; no lime present, no manganese present, pH 6.5; rounded gravel 1cm to 2cm common with some gravel pockets; not mottled; not bleached, light grey (10YR7/1) dry, greyish brown (10YR5/2) moist; fabric rough, massive, not hydrophobic; *clear to:-*

75cm to 175cm; sandy loam; few roots; no lime present, manganese stains and concretions present, pH 6.0; much rounded gravel to 8cm; not mottled; not bleached, pale brown (10YR6/3) dry, light olive brown (2.5Y5/3) moist; peds rough-faced, highly pedal (100%), polyhedral/platy, <5mm to 10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

175cm to 215cm; clay loam; no lime present, manganese stains present, pH 8.0; some rounded gravel to 3cm; mottled; not bleached, 60% white (10YR8/1) 40% brownish yellow (10YR6/6) dry, 60% light brownish grey (10YR6/2) 40% dark yellowish brown (10YR4/6) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

215cm to 240cm; not sampled; much rounded gravel to 8cm.

Profile 22 – Lower – mid slope location. *Surface loose, surface gravel and stone 1cm to 5cm and to 20cm present.*

0cm to 13cm; sandy clay loam; many roots; no lime present, no manganese present, pH 5.5; some rounded gravel 1cm to 5cm; not mottled; not bleached, pale brown (10YR6/3) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5-10mm in size; weak to firm consistency dry; not hydrophobic; *gradual to:-*

13cm to 45cm; sandy clay loam; many roots; no lime present, no manganese present, pH 6.0; gravel common rounded some angular <1cm to 6cm, not mottled; bleached, pinkish grey (7.5YR7/2) dry, brown (7.5YR4/3) moist; fabric-rough, massive, not hydrophobic; *gradual to:-*

45cm to 80cm; clayey sand; few roots; no lime present, manganese stains present, pH 6.5; gravel common rounded <1cm to 4cm, not mottled; not bleached, very pale brown (10YR8/2) dry, brown (7.5YR4/3) moist; fabric-rough, massive, not hydrophobic; *gradual to:-*

80cm to 120cm; clayey sand; few roots; no lime present, no manganese present, pH 6.5; main gravel zone mainly rounded <1cm to 3cm; not mottled; not bleached, light grey (10YR7/2) dry, brown (7.5YR4/3) moist; fabric-rough, massive, not hydrophobic; *gradual to:-*

120cm to 145cm; sandy clay; no roots observed, no lime present, manganese stains and concretions present, pH 7.5; gravel common rounded 1cm to 5cm; not mottled; not bleached, very pale brown (10YR7/3) dry, pale brown (10YR6/3) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

145cm to 240cm; sandy clay loam; no roots observed, no lime present, much manganese staining present, pH 8.0; some rounded gravel 1cm to 2cm; not mottled; not bleached, pale yellow (2.5Y8/2) dry, pale brown (10YR6/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral/platy, 5mm to 15mm in size; very firm to strong consistency dry; not hydrophobic.

Profile 23 - Mid slope location. *Surface firm, surface gravel and stone common rounded 3cm to 10cm.*

0cm to 8cm; sandy loam; many roots; no lime present, no manganese present, pH 5.5; much angular and rounded gravel <1cm to 5cm; not mottled; not bleached, brown (7.5YR5/2) dry, brown (7.5YR4/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm in size; very firm consistency dry; hydrophobic; *abrupt to:-*

8cm to 30cm; light clay; many roots; no lime present, no manganese present, pH 5.5; much rounded gravel 1cm to 3cm; not mottled; not bleached, pinkish grey (7.5YR6/2) dry, dark greyish brown (10YR4/2) moist; fabric rough, massive, slightly hydrophobic; *abrupt to:-*

30cm to 43cm; sandy clay loam; many roots; no lime present, no manganese present, pH 5.5; much rounded gravel 1cm to cm; not mottled; not bleached, light grey (10YR7/2) dry, brown (10YR5/3) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

43cm to 90cm; sandy clay loam to sandy light clay; few roots; no lime present, many manganese stains present, pH 9.5 to 10; some rounded gravel to 5cm; not mottled; not bleached, light brownish grey (10YR6/2) dry, greyish brown (2.5Y5/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

90cm to 136cm; medium to heavy clay; few roots; no lime present, no manganese present, pH 8.0; mainly clayey weathered rock some gravel to 3cm; not mottled; not bleached, very pale brown (10YR8/2) dry, light grey (10YR7/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 24 - Mid slope location. *Surface firm, surface stone common rounded 8cm to 10cm.*

0cm to 13cm; silty clay loam; many roots; no lime present, no manganese present, pH 5.5; rounded gravel <5mm to 3cm common; not mottled; not bleached, light brown (7.5YR6/3) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; weak consistency dry; slightly hydrophobic; *abrupt to:-*

13cm to 32cm; light clay; few roots; many lime flecks present, no manganese present, pH 9.0; much rounded gravel 1cm to 3cm; not mottled; not bleached, brown (7.5YR5/3) dry, brown (7.5YR4/3) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *abrupt to:-*

32cm to 42cm; medium to heavy clay; few roots; lime stains and concretions present, no manganese present, pH 8.5; rounded gravel 1cm to 4cm common; not mottled; not bleached, greyish brown (10YR5/2) dry, brown (10YR5/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

42cm to 69cm; silty clay loam; roots common; no lime present, no manganese present, pH 8.5; some rounded gravel <1cm; not mottled; not bleached, pale brown (10YR6/3) dry, brown (10YR5/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

69cm to 148cm; clayey sand; few roots; no lime present, no manganese present, pH 8.5; some rounded and angular gravel to 4cm; mottled; not bleached, 60% very pale brown (10YR7/3) 40% light brown (7.5YR6/4) dry, 60% light yellowish brown (2.5Y6/4) 40% yellowish red (5YR5/6) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 25 - Mid slope location. *Surface firm to hardsetting, surface gravel common rounded 1cm to 4cm.*

0cm to 23cm; light to medium clay; many roots; no lime present, no manganese present, pH 5.5; some gravel rounded to 1cm; not mottled; not bleached, brown (10YR5/2) dry, dark brown (7.5YR3/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; firm consistency dry; hydrophobic; *abrupt to:-*

23cm to 39cm; light clay; many roots; no lime present, no manganese present, pH 6.0; gravel common angular and rounded to 2cm; not mottled; bleached, light grey (10YR7/2) dry, brown (7.5YR5/3) moist; peds rough faced, highly pedal (100%), polyhedral, <5-10mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

39cm to 52cm; light clay; many roots; no lime present, no manganese present, pH 6.0; much gravel rounded to 6cm; not mottled; not bleached, light grey (10YR7/2) dry, brown (7.5YR4/3) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

52cm to 90cm; clayey sand; few roots; no lime present, no manganese present, pH 6.0; much gravel rounded <1 to 6cm, grit present; not mottled; not bleached, very pale brown (10YR7/3) dry, brown (7.5YR5/4) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

90cm to 97cm; clayey sand; few roots; no lime present, no manganese present, pH 6.0; sandy layer much grit and gravel rounded 1cm to 3cm; not mottled; not bleached, very pale brown (10YR7/3) dry, brown (7.5YR5/4) moist; fabric rough, massive, not hydrophobic; *clear to:-*

97cm to 140cm; medium to heavy clay; few roots; no lime present, no manganese present, pH 9.5 to 10; much gravel rounded 1- 6cm; not mottled; not bleached, pink (7.5YR7/4) dry, yellowish red (5YR5/6) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

140cm to 253cm; gritty light clay; few roots; no lime present, no manganese present, pH 9.5 to 10; gravel common rounded 1cm to 6cm with some gravel pockets; not mottled; not bleached, very pale brown (10YR8/2) dry, pale brown (10YR6/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 26 - Upper slope location. *Surface condition hardsetting, surface stone absent.*

0cm to 22cm; silty clay; many roots; no lime present, no manganese present, pH 6.0; some gravel rounded to 5cm; not mottled; not bleached, brown (7.5YR4/2) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; weak consistency dry; slightly hydrophobic; *abrupt to:-*

22cm to 49cm; medium clay; few roots; no lime present, no manganese present, pH 6.5; some gravel rounded <1cm; not mottled; not bleached, brown (7.5YR5/3) dry, brown (7.5YR4/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

49cm to 127cm; medium to heavy clay; few roots; many lime concretions present, no manganese present, pH 9.5 to 10; some gravel rounded <1cm; not mottled; not bleached, light brown (7.5YR6/3) dry, light brown (7.5YR6/3) dry, peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

127cm to 160cm; medium to heavy clay; few roots; small lime concretions and stains present, no manganese present, pH 9.5 to 10; gravel layer rounded to 8cm; not mottled; not bleached, light brown (7.5YR6/3) dry, light brown (7.5YR6/3) moist, peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

160cm to 250cm; not sampled; few roots; weathered rock.

Profile 27 - Crest location. *Surface loose, some surface gravel present rounded and angular to 5cm.*

0cm to 15cm; sandy loam; many roots; no lime present, no manganese present, pH 5.5; much gravel rounded <1cm to 3cm; not mottled; not bleached, brown (7.5YR5/3) dry, dark brown (7.5YR3/2) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

15cm to 40cm; sandy clay loam; many roots; no lime present, no manganese present, pH 6.0; much gravel rounded angular and flattish <1cm to 5cm with some stones to 10cm; not mottled; bleached, pink (7.5YR7/3) dry, brown (7.5YR4/3) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

40cm to 77cm; not sampled; few roots; weathered rock.

Profile 28 - Depression location. *Surface loose to firm, some surface gravel rounded to 3cm present.*

0cm to 18cm; sandy loam; many roots; no lime present, no manganese present, pH 6.5; much gravel rounded <1cm to 3cm; not mottled; not bleached, brown (10YR5/3) dry, very dark greyish brown (10YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm in size; weak consistency dry; not hydrophobic; *abrupt to:-*

18cm to 36cm; sandy clay loam; many roots; no lime present, no manganese present, pH 6.5; much gravel rounded to 1cm; not mottled; not bleached, brown (7.5YR5/2) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; weak to firm consistency dry; not hydrophobic; *gradual to:-*

36cm to 141cm; clayey sand; many roots to 100cm then few roots; no lime present, no manganese present, pH 7.5; much gravel rounded 1cm to 10cm; not mottled; not bleached, pink (7.5YR7/3) dry, brown (7.5YR5/4) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

141cm to 182cm; sandy clay loam; no roots observed, no lime present, no manganese present, pH 7.5; some gravel rounded 1cm to 3cm; not mottled; not bleached, pink (7.5YR7/4) dry, reddish brown (5YR5/4) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

182cm to 218cm; clayey sand to sandy loam; no roots observed, no lime present, no manganese present, pH 7.5; much gravel rounded 1cm to 4cm, grit common; not mottled; not bleached, pink (7.5YR7/4) dry, brown (7.5YR5/4) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

218cm to 225cm; not sampled; no roots observed, some gravel rounded 1cm to 3cm.

Profile 29 - Lower slope. *Surface hardsetting, surface gravel common rounded and angular 3cm to 4cm.*

0cm to 13cm; sandy loam; many roots; no lime present, no manganese present, pH 6.5; much gravel rounded <1cm to 4cm; not mottled; not bleached, brown (7.5YR5/3) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; weak consistency dry; hydrophobic; *abrupt to:-*

13cm to 60cm; clayey sand to sandy loam; many roots to 53cm then few; no lime present, no manganese present, pH 6.5; mainly gravel rounded 1cm to 6cm with some layering and pockets; not mottled; bleached, pink (7.5YR7/3) dry, light brown (7.5YR6/4) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

60cm to 145cm; sandy clay loam; few roots; no lime present, no manganese present, pH 6.5; much gravel rounded 1cm to 5cm; not mottled; not bleached, pink (5YR7/4) dry, yellowish red (5YR5/6) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

145cm to 235cm; sandy clay; few roots; no lime present, manganese stains present, pH 7.0; some gravel rounded 1cm to 6cm cemented; not mottled; not bleached, pink (7.5YR7/3) dry, reddish brown (5YR5/4) moist; fabric rough, massive, not hydrophobic.

Profile 30 - Mid slope location. *Surface loose, surface gravel common rounded to 8cm*

0cm to 13cm; sandy clay loam; many roots; no lime present, no manganese present, pH 5.5; much rounded gravel <1cm to 2cm; not mottled; not bleached, greyish brown (10YR5/2) dry, very dark greyish brown (10YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; firm to very firm consistency dry; not hydrophobic; *abrupt to:-*

13cm to 45cm; sandy clay loam; many roots; no lime present, no manganese present, pH 5.5; much rounded gravel <1cm to 3cm; not mottled; bleached, pinkish grey (7.5YR7/2) dry, brown (7.5YR5/3) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

45cm to 82cm; gritty medium to heavy clay; few roots; no lime present, no manganese present, pH 5.5 to 6.0; much rounded gravel 1cm to 5cm, grit present; mottled; not bleached, 90% pinkish white (7.5YR8/2) 10% reddish yellow (7.5YR6/6) dry, 100% reddish yellow (7.5YR6/8) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 31 - Crest location. *Surface hardsetting, much surface gravel rounded to 8cm.*

0cm to 20cm; sandy clay loam; many roots; no lime present, no manganese present, pH 5.5, much rounded gravel <1cm to 2cm; not mottled; not bleached, brown (7.5YR5/2) dry, dark brown (7.5YR3/2) moist; fabric rough, massive, slightly hydrophobic; *gradual to:-*

20cm to 48cm; light medium clay; few roots; no lime present, no manganese present, pH 6.0; much rounded gravel <1cm to 5cm, grit present; not mottled; not bleached, pale brown (10YR6/2) dry, brown (7.5YR4/2) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

48cm to 75cm; medium to heavy clay; few roots; no lime present, manganese stains present, pH 7.0; some gravel rounded to 2cm; not mottled; not bleached, pale brown (10YR6/3) dry, strong brown (7.5YR5/8) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; very strong consistency dry; not hydrophobic; *abrupt to:-*

75cm to 131cm; not sampled; few roots; decomposing conglomerate.

Profile 32 - Upper slope location. *Surface hardsetting, much surface gravel rounded to 8cm.*

0cm to 10cm; sandy loam; many roots; no lime present, no manganese present, pH 5.5; some gravel rounded 2cm to 5cm; not mottled; not bleached, grey brown (10R5/2) dry, very dark greyish brown (10YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; weak to firm consistency dry; slightly hydrophobic; *abrupt to:-*

10cm to 40cm; light sandy clay loam; many roots; no lime present, no manganese present, pH 5.5; much rounded and angular gravel 1cm to 6cm; not mottled; bleached, pink (7.5YR7/3) dry, brown (7.5YR4/3) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

40cm to 56cm; sandy clay loam; few roots; no lime present, manganese stains present, pH 5.5; rounded and flat gravel common to 8cm; not mottled; not bleached, pink (7.5YR7/3) dry, brown (7.5YR5/3) moist; fabric rough, massive, not hydrophobic.

Profile 33 - Upper slope location. *Surface firm, much surface gravel rounded 1cm to 5cm.*

0cm to 9cm; sandy clay loam; many roots; no lime present, no manganese present, pH 5.5; much rounded gravel <1cm to 3cm; not mottled; not bleached, brown (7.5YR5/2) dry, brown (7.5YR4/2) moist; fabric rough, massive, hydrophobic; *abrupt to:-*

9cm to 33cm; clayey sand; roots common; no lime present, no manganese present, pH 5.0; gravel common rounded 1cm to 4cm; not mottled; bleached, pinkish grey (7.5YR7/2) dry, brown (7.5YR5/3) moist; fabric rough, massive, slightly hydrophobic; *gradual to:-*

33cm to 69cm; clayey sand; few roots; no lime present, no manganese present, pH 4.5; cemented sand band, gravel absent, not mottled; not bleached, very pale brown (10YR8/2) dry, light brown (7.5YR6/4) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

69cm to 95cm; clayey sand; few roots; no lime present, no manganese present, pH 4.5; much rounded gravel 1cm to 4cm; not mottled; not bleached, white (7.5YR8/1) dry, very pale brown (10YR8/2) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

95cm to 165cm; gritty light clay; few roots; no lime present, no manganese present, pH 4.5; some gravel to 2cm; not mottled; not bleached, pinkish grey (7.5YR7.2) dry, pale brown (10YR6/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; very firm consistency dry; not hydrophobic.

Profile 34 - Upper slope/crest location. *Surface loose, some surface gravel present.*

0cm to 11cm; sandy clay loam; many roots; no lime present, no manganese present, pH 5.5; gravel common rounded <1cm to 3cm; not mottled; not bleached, brown (7.5YR4/2) dry, dark brown (7.5YR3/2) moist; fabric rough, massive, slightly hydrophobic; *gradual to:-*

11cm to 56cm; sandy loam; many roots; no lime present, no manganese present, pH 7.0; much gravel rounded <1cm to 4cm; not mottled; bleached, pink (7.5YR7/3) dry, strong brown (7.5YR5/6) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

56cm to 75cm; clayey sand; few roots; no lime present, no manganese present, pH 7.5 to 8.0; much gravel rounded <1cm to 3cm; not mottled; not bleached, pink (7.5YR8/3) dry, reddish yellow (7.5YR6/6) moist; fabric rough, massive, not hydrophobic.

Profile 35 - Mid slope location. *Surface firm, much surface gravel rounded 2cm to 5cm.*

0cm to 9cm; light clay; many roots; no lime present, no manganese present, pH 5.5; much rounded and angular gravel 1cm to 4cm; not mottled; not bleached, brown (7.5YR5/2) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; very firm to strong consistency dry; not hydrophobic; *gradual to:-*

9cm to 27cm; light clay; few roots; no lime present, no manganese present, pH 5.0; much gravel rounded and angular some flat 1cm to 4cm; not mottled; not bleached, light grey (10YR7/2) dry, reddish brown (5YR4/3) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

27cm to 117cm; light to medium clay; few roots; no lime present, no manganese present, pH 7.0; gravel common rounded and angular <1cm to 4cm; not mottled; not bleached, light brown (7.5YR6/4) dry, brown (7.5YR5/4) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; very firm to strong consistency dry; not hydrophobic; *diffuse to:-*

117cm to 166cm; light to medium clay; few roots; no lime present, manganese stains present, pH 8.0; gravel common rounded and angular 1-6cm; mottled; not bleached, 70% light grey (10YR7/2) 30% grey brown (10YR5/2) dry, 70%light brownish grey (2.5Y6/2) 30% brown (10YR5/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 36, -Crest location. *Surface firm, some surface stone angular and rounded to 10cm.*

0cm to 14cm; sandy loam; many roots; no lime present, no manganese present, pH 6.0; gravel common rounded 1cm to 3cm; not mottled; not bleached, brown (7.5YR5/2) dry, dark brown (7.5YR3/2) moist; fabric rough, massive, slightly hydrophobic; *abrupt to:-*

14cm to 38cm; sandy loam; many roots; no lime present, no manganese present, pH 6.5; much gravel and grit <1cm to 5cm; not mottled; bleached, light grey (10YR7/2) dry, brown (7.5YR4/3) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

38cm to 91cm; sandy loam; few roots; no lime present, no manganese present, pH 7.0; much rounded and angular gravel <1cm to 6cm; not mottled; not bleached, pink (7.5YR8/3) dry, brown (7.5YR5/4) moist; fabric rough, massive, not hydrophobic;

Profile 37 - Lower slope/depression location. *Surface loose, some surface gravel rounded 1-3cm some to 20cm.*

0cm to 14cm; sandy loam; many roots; no lime present, no manganese present, pH 6.0; some gravel rounded 1 to 2cm; not mottled; not bleached, brown (7.5YR5/2) dry, brown (7.5YR4/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5-10mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

14cm to 25cm; sandy loam; roots common; no lime present, no manganese present, pH 6.0; much gravel rounded <1cm to 3cm, grit present; not mottled; bleached, pinkish grey (7.5YR7/2) dry, brown (7.5YR4/2) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

25cm to 98cm; medium clay; few roots; lime concretions present, manganese stains present, pH 9.5-10; some gravel rounded 1cm to 2cm with grit pockets; mottled; not bleached, 95% pale brown (10YR6/3) 5% yellowish red (5YR5/6) dry, 95% brown (10YR5/3) 5% yellowish red (5YR5/6) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 38 - Mid slope location. *Surface self mulching/cracked, much surface stone rounded and angular to 15cm.*

0cm to 30cm; medium-heavy clay; many roots; no lime present, no manganese present, pH 8.0; some gravel rounded and angular to 3cm; not mottled; not bleached, dark brown (7.5YR3/2) dry, very dark grey (7.5YR3/1) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

30cm to 90cm; medium-heavy clay; many roots; no lime present, no manganese present, pH 9.0; some rounded and angular gravel to 1.5cm; not mottled; not bleached, brown (7.5YR4/2) dry, dark brown (7.5YR3/2) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, 5-15mm in size; strong to very strong consistency dry; not hydrophobic; *abrupt to:-*

90cm to 140cm; medium-heavy clay; no roots; some small lime concretions present, no manganese present, pH 9.5; much rounded and angular gravel and stones to 20cm; not mottled; not bleached, pink (7.5YR7/4) dry, light brown (7.5YR6/4) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

140cm to 190cm; light to medium clay; no roots; no lime present, manganese stains present, pH 9.0; partly weathering rock with pockets of angular gravel to 1.5cm; not mottled; not bleached, pink (7.5YR7/4) dry, light yellowish brown (10YR6/4) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

190cm to 280cm; not sampled; no roots; partly weathering rock with pockets of angular gravel to 1.5cm; not mottled; not bleached.

Profile 39 - Mid slope location. *Surface self mulching, some surface gravel rounded and angular 1cm to 8cm.*

0cm to 13cm; medium clay; many roots; no lime present, no manganese present, pH 6.0; some gravel <1cm to 2cm; not mottled; not bleached, brown (7.5YR4/2) dry, dark brown (7.5YR3/2) moist; peds rough- faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong consistency dry; hydrophobic; *clear to:-*

13cm to 37cm; medium to heavy clay; many roots; some small lime concretions present, no manganese present, pH 9.5 to 10; some angular and rounded gravel 1cm to 2cm; not mottled; not bleached, brown (7.5YR4/3) dry, brown (7.5YR4/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

37cm to 60cm; medium clay; few roots; much lime staining and some lime concretions present, no manganese present, pH 9.5 to 10; some angular gravel to 1cm with some rounded floaters 15cm to 20cm; not mottled; not bleached, brown (7.5YR4/3) dry, brown (7.5YR4/3) moist, peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

60cm to 95cm; gritty medium clay; few roots, small lime concretions present, no manganese present, pH 9.5 to 10; some angular gravel to 1cm; not mottled; not bleached, brown (7.5YR5/4) dry, strong brown (7.5YR5/6) moist; peds rough-smooth faced, highly pedal (100%), polyhedral/platy, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

95cm to 210cm; gritty medium clay; few roots; no lime present, manganese stains present, pH 5.5; some angular gravel <1cm to 2cm with scattered pockets of rounded stone to 5cm; not mottled; not bleached, very pale brown (10YR8/3) dry, very pale brown (10YR7/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

210cm to 250cm; gritty light clay; few roots; no lime present, manganese stains present, pH 4.5; no gravel observed; mottled; not bleached, 60% white (10YR8/1) 40% light grey (10YR7/2) dry, 60% pale yellow (2.5Y8/2) 40% light brownish grey (10YR6/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 40 - Mid slope location. *Surface self mulching, much surface gravel and stone rounded and angular 1cm to 20cm.*

0cm to 6cm; medium clay; many roots; no lime present, no manganese present, pH 6.0; some rounded gravel 1cm to 3cm; not mottled; not bleached, brown (7.5YR5/2) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 15mm in size; very firm to strong consistency dry; not hydrophobic; *abrupt to:-*

6cm to 20cm; medium clay; roots common; no lime present, no manganese present, pH 5.5; much rounded and angular gravel 1cm to 10cm; not mottled; not bleached, brown (7.5YR5/2) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

20cm to 74cm; medium clay; few roots; no lime present, no manganese present, pH 6.5; some grit present; mottled; not bleached, 90% light brownish grey (10YR6/2) 10% very pale brown (10YR7/3) dry, 90% greyish brown (10YR5/2) 10% yellowish brown (10YR5/4) moist; peds rough / smooth faced, highly pedal (100%), polyhedral/platy, 5mm to 20mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

74cm to 92cm; not sampled; weathered rock.

Profile 41 - Mid slope location. *Surface firm, much surface gravel rounded and angular 1cm to 8cm.*

0cm to 13cm; sandy clay loam; roots common; no lime present, no manganese present, pH 6.0; some angular gravel 1cm to 2cm; not mottled; not bleached, brown (7.5YR5/3) dry, dark brown (7.5YR3/2) moist; peds rough-faced, moderately pedal (50%), polyhedral, 5mm to 10mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

13cm to 33cm; sandy clay loam to sandy clay; roots common; no lime present, no manganese present, pH 6.5; much rounded gravel 1cm to 5cm; not mottled; bleached, pinkish grey (7.5YR7/2) dry, brown (7.5YR4/3) moist; fabric rough-smooth, massive; not hydrophobic; *gradual to:-*

33cm to 82cm; gritty medium clay; few roots; no lime present, manganese stains and concretions present, pH 9.5 to 10; much rounded gravel <1cm to 4cm; not mottled; not bleached, yellowish red (5YR5/6) dry, reddish brown (5YR4/4) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong to very strong consistency dry, not hydrophobic; *diffuse to:-*

82cm to 135cm; medium clay; few roots; no lime present, no manganese present, pH 9.5 to 10; some gravel to 1cm; not mottled; not bleached, pale brown (10YR6/3) dry, brown (10YR5/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

135cm to 166cm; sandy clay; few roots; no lime present, much manganese staining present, pH 9.5 to 10; much rounded gravel 1cm to 10cm; not mottled; not bleached, very pale brown (10YR7/3) dry, brown (7.5YR5/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

166cm to 250cm; sandy clay loam to sandy light clay; few roots; no lime present, much manganese staining present, pH 9.5 to 10; much rounded gravel <.5cm to 3cm; not mottled; not bleached, very pale brown (10YR7/3) dry, brown (7.5YR5/3) moist; peds smooth faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

250cm to 270cm; gritty light clay; few roots; no lime present, manganese stains and concretions present, pH 9.5 to 10; some rounded gravel to 2cm; not mottled; not bleached, light grey (2.5Y7/2) dry, light brownish grey (2.5Y6/2) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 42 - Lower slope location. *Surface firm, some surface gravel present.*

0cm to 10cm; clay loam to light clay; many roots; no lime present, no manganese present, pH 5.5; some gravel 1cm to 2cm; not mottled; not bleached, pinkish grey (7.5YR6/2) dry, brown (7.5YR4/2) moist; peds rough / smooth faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

10cm to 30cm; sandy loam; few roots; no lime present, no manganese present, pH 6.0; much gravel 1cm to 2cm gritty; not mottled; bleached, white (7.5YR8/1) dry, light brownish grey (2.5Y6/2) moist; fabric rough, massive, not hydrophobic; *gradual to:-*

30cm to 62cm; sandy clay loam; few roots; no lime present, no manganese present, pH 6.0; much gravel 1cm; mottled; not bleached, 95% light grey (10YR7/1) 5% very pale brown (10YR7/4) dry, 95% light brownish grey (10YR6/2) 5% yellowish brown (10YR5/6) moist; peds rough-faced, highly pedal (100%), polyhedral, 5-10mm in size; very firm consistency dry; not hydrophobic; *wavy and gradual to:*

-

62cm to 77cm; clayey sand; roots common; no lime present, manganese stains present, pH 6.0; much gravel <1cm to 2cm; mottled; not bleached, 60% light grey (10YR7/2) 35% pale brown (10YR6/3) 5% yellowish red (5YR5/6) dry, 60% light brownish grey (10YR6/2) 35% yellowish brown (10YR5/4) 5% yellowish red (5YR5/6) moist; fabric rough, massive, not hydrophobic; *abrupt to:-*

77cm to 185cm; sandy medium clay; few roots; no lime present, many manganese stains and nodules present, pH 7.5; some gravel rounded and angular 1cm to 3cm; mottled; not bleached, 50% pale brown (10YR6/3) 50% brown (7.5YR5/4) dry, 50% light brownish grey (10YR6/2) 50% brown (10YR5/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, <5mm to 15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

185cm to 250cm; light to medium clay; few roots; lime concretions present, many manganese stains and nodules present, pH 9.5 to 10; some gravel rounded to 2cm; not mottled; not bleached, very pale brown (10YR7/3) dry, light yellowish brown (10YR6/4) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong consistency dry; not hydrophobic.

Profile 43 - Mid slope location. *Surface condition firm, surface stone absent.*

0cm to 14cm; sandy clay loam; many roots present; no lime present, no manganese present, pH 5.5; some gravel rounded to 5cm; not mottled; not bleached, pale brown (10YR6/3) dry, very dark greyish brown (10YR3/2) moist; peds rough-faced, highly pedal (90%), polyhedral, <5mm to 10mm in size; firm consistency dry; not hydrophobic; *clear to:-*

14cm to 23cm; sandy clay; many roots present; no lime present, no manganese present, pH 7.0; gravelly layer-gravel to 2cm rounded and angular; not mottled; not bleached, pale brown (10YR6/3) dry, brown (7.5YR5/3) moist; peds rough-faced vesicular, highly pedal (100%), polyhedral, <5mm to 15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

23cm to 113cm; gritty light clay; few roots; no lime present, manganese stains present, pH 9.5 to 10; some rounded gravel to 1cm; not mottled; not bleached, greyish brown (10YR5/2) dry, yellowish brown (10YR5/4) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

113cm to 173cm; gritty light clay; few roots; no lime present, no manganese present, pH 9.5 to 10; some small gravel to 1cm; not mottled; not bleached, brown (7.5YR5/4) dry, brown (7.5YR4/3) moist; peds rough-faced, highly pedal (100%), polyhedral, <5mm to 15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

173cm to 213cm; light to medium clay; no roots present; lime nodules present, no manganese present, pH 9.5 to 10; layer of gravel rounded to 4cm; not mottled; not bleached, brown (7.5YR5/3) dry, brown (10YR4/3) moist; peds rough / smooth faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *clear to:-*

213cm to 250cm; medium clay; no roots present; no lime present, no manganese present, pH 9.5 to 10; some rounded gravel to 2cm, grit present; not mottled; not bleached, brown (10YR5/3) dry, brown (10YR5/3) moist; peds rough / smooth faced, highly pedal (100%), polyhedral/platy, <5mm to 20mm in size; strong consistency dry; not hydrophobic.

Profile 44 - Upper slope location. *Surface hardsetting, surface stone common.*

0cm to 16cm; sandy loam; many roots present; no lime present, no manganese present, pH 5.0; much rounded and angular gravel to 2cm present; not mottled; not bleached, brown (10YR5/3) dry, dark reddish brown (5YR3/2) moist; peds rough-faced, moderately pedal (60%), polyhedral, <5mm to 10mm in size; weak to firm consistency dry; not hydrophobic; *clear to:-*

16cm to 44cm; clayey sand; many roots present; no lime present, no manganese present, pH 7.0; much gravel rounded to 4cm; not mottled; bleached, pinkish white (7.5YR8/2) dry, brown (10YR5/3) moist; fabric rough, massive, not hydrophobic; *diffuse to:-*

44cm to 80cm; gritty medium clay; few roots; no lime present, no manganese present, pH 9.5 to 10; much rounded gravel to 5cm; not mottled; not bleached, brown (7.5YR5/4) dry, brown (7.5YR5/4) moist; peds rough / smooth faced, highly pedal (100%), polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *clear to:-*

80cm to 210cm; light to medium clay; no roots present; lime stains present, manganese stains and concretions present, pH 9.5 to 10; some rounded gravel 4cm; not mottled; not bleached, yellowish brown (10YR5/4) dry, brown (10YR5/3) moist; peds rough / smooth faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; very firm to strong consistency dry; not hydrophobic; *gradual to:-*

210cm to 250cm; gritty light to medium clay; no roots present; no lime present, many manganese stains and concretions present, pH 9.5-10; pockets of rounded gravel 2cm to 3cm; not mottled; not bleached, pale brown (10YR6/3) dry, brown (10YR5/3) moist; peds rough / smooth faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong consistency dry; not hydrophobic.

Profile 45 - Depression location. *Surface condition soft, some surface stone present.*

0cm to 10cm; loam fine sandy to sandy clay loam; many roots present; no lime present, no manganese present, pH 5.5; much gravel 1cm to 2cm rounded; not mottled; not bleached, brown (10YR5/3) dry, dark brown (7.5YR3/2) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; weak consistency dry; not hydrophobic; *sharp to:-*

10cm to 40cm; sandy loam; many roots present; no lime present, no manganese present, pH 6.0; much rounded gravel 1cm to 2cm; not mottled; bleached, very pale brown (10YR7/3) dry, brown (7.5YR5/4) moist; fabric rough, massive; not hydrophobic; *clear to:-*

40cm to 90cm; gritty light clay; few roots; no lime present, manganese stains present, pH 8.0; rounded and flattened gravel to 3cm - occasional pockets present; not mottled; not bleached, light brown (7.5YR6/4) dry, brown (7.5YR4/4) moist; peds rough-smooth faced, highly pedal (100%), polyhedral/platy, 5mm to 20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

90cm to 179cm; gritty light clay; few roots; no lime present, no manganese present, pH 9.0; gravel common rounded and flattened to 3cm; not mottled; not bleached, brown (7.5YR5/3) dry, brown (7.5YR4/3) moist; peds rough-smooth faced, highly pedal (100%), polyhedral/platy, 5mm to 20mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

179cm to 244cm; sandy clay; few roots; lime concretions present, no manganese present, pH 9.0; occasional gravel <1cm rounded; not mottled; not bleached, light brown (7.5YR6/3) dry, brown (7.5YR4/4) moist; peds rough-faced, highly pedal (100%), polyhedral, 5-15mm in size; strong to very strong consistency dry; not hydrophobic.

Profile 46 - Lower slope. *Surface condition soft, no surface stone present.*

0cm to 26cm; fine sandy clay loam to light clay; many roots present; no lime present, no manganese present, pH 6.5; gravel rounded angular and flat to 3cm common; not mottled; not bleached, greyish brown (10YR5/2) dry, very dark greyish brown (10YR3/2) moist; peds rough-faced, highly pedal (80%), polyhedral, 5mm to 10mm in size; strong consistency dry; not hydrophobic; *clear to:-*

26cm to 34cm; sandy clay; many roots present; lime stains present, no manganese present, pH 7.5; much gravel rounded <1cm to 2cm; not mottled; not bleached, pale brown (10YR6/3) dry, brown (7.5YR4/3) moist; peds rough-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; very firm consistency dry; not hydrophobic; *clear to:-*

34cm to 64cm; gritty light to medium clay; few roots present; lime concretions present, no manganese present, pH 8.0; some gravel generally rounded <1cm; not mottled; not bleached, very pale brown (10YR 7/3) dry, brown (7.5YR5/3) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

64cm to 142cm; light to medium clay; few roots present; lime stains and concretions present, no manganese present, pH 9.5 to 10; some gravel generally rounded <1cm; not mottled; not bleached, brown (7.5YR5/3) dry, brown (7.5YR5/4) moist; peds rough-smooth faced, highly pedal (100%), polyhedral, <5mm to 10mm in size; strong to very strong consistency dry; not hydrophobic; *diffuse to:-*

142cm to 252cm; medium to heavy clay; few roots present; no lime present, manganese stains and concretions present, pH 9.5 to 10; much grit and gravel 3cm to 4cm rounded, lenses of gravel; not mottled; not bleached, brown (7.5YR5/3) dry, brown (7.5YR4/4) moist; peds rough / smooth-faced, highly pedal (100%), polyhedral, 5mm to 15mm in size; strong to very strong consistency dry; not hydrophobic.

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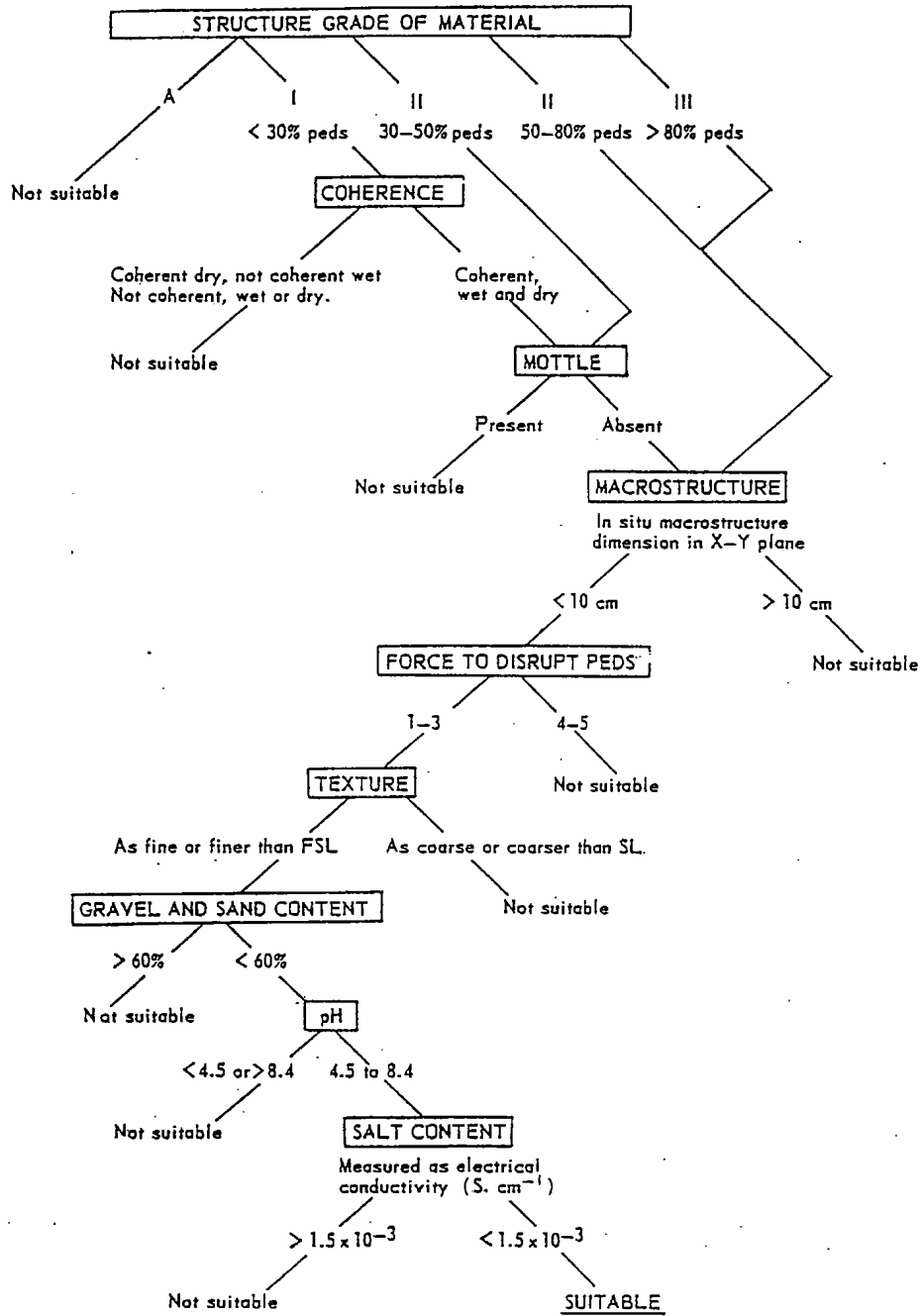
APPENDIX 2

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	CLASS SUBSCRIPTS	SPECIAL USES
	M Mining and quarrying areas.	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 of Terms

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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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