Extension of Warkworth Coal Mine

technical reports

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Technical Reports

for

Coal & Allied on behalf of Warkworth Mining Limited

August 2002

Warkworth Mining Limited

COAL & ALLIED
A Rio Tinto Group Company

Extension of Warkworth Coal Mine

environmental impact statement

PART A

Soils and Land Capability Study

by Global Soil Systems

WARKWORTH COAL MINE EXTENSION

SOIL AND LAND CAPABILITY SURVEY REPORT

Prepared for

Coal and Allied Operations Pty Ltd

Prepared by

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Principal
Global Soil Systems

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Soil and Land Capability Survey Report

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1.0 INTRODUCTION

1.1 Objectives

Global Soil Systems (GSS) was commissioned by Coal and Allied Operations Pty Ltd (CNA) to undertake soil and land capability surveys of the proposed Warkworth Mine extension area. The surveys were completed during May 2002.

The major objectives of this survey were to:

(1) describe, classify and map soils / land capability within the study area; and

(2) analyse the various soil units to identify their suitability for topdressing of disturbed areas within the study area.

The following report describes the results of the soil and land capability surveys undertaken by GSS.

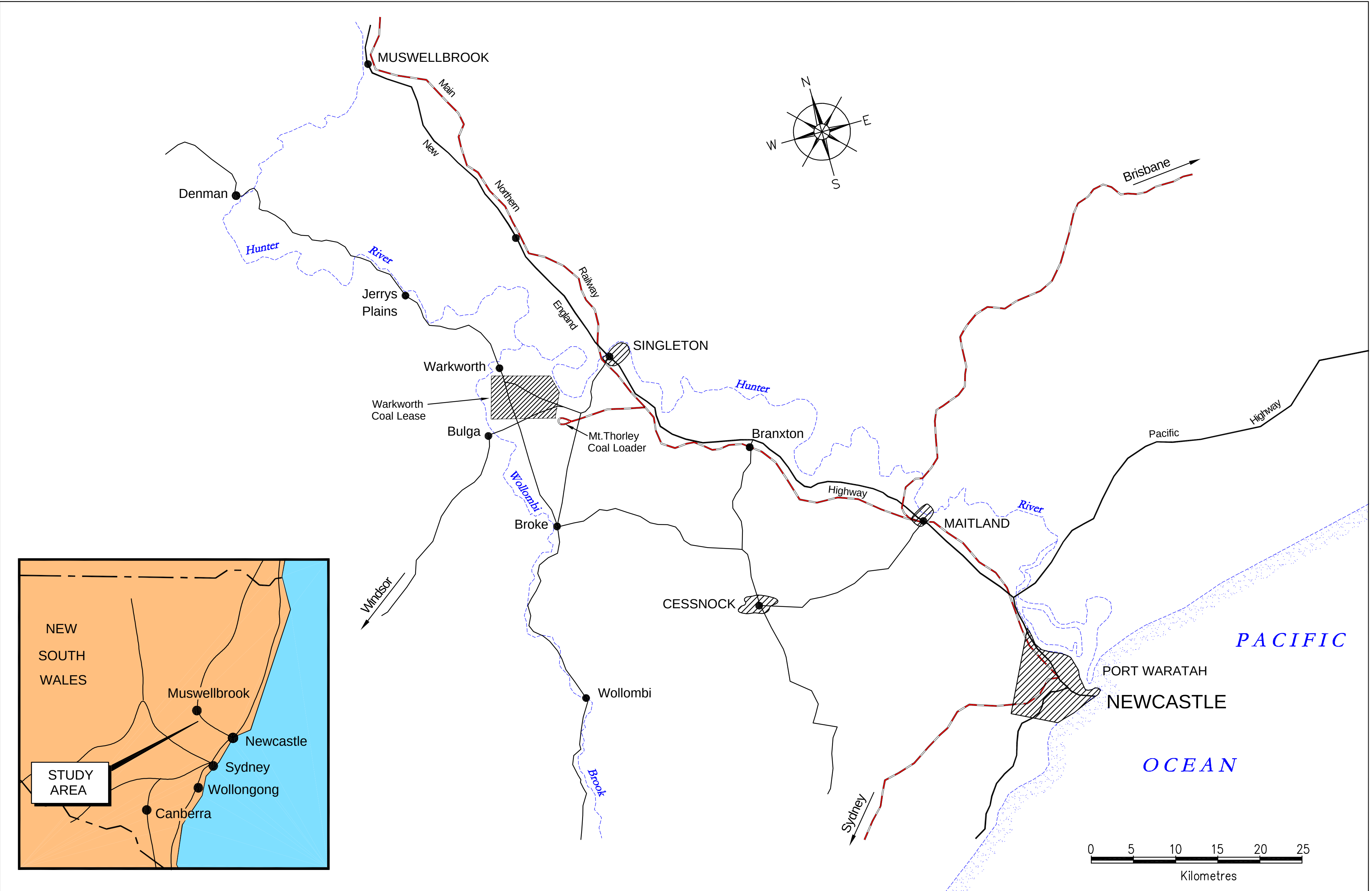
1.2 Location and Access

The Warkworth Mine site is located within the Hunter Valley of New South Wales between Singleton and Bulga (*Figure 1*). Access to the mine is via a private road, 12km along the Putty Road from Singleton.

1.3 Regional Setting

The study area, lies to the west of the current mining operation. Wallaby Scrub Road forms the western limit of the study area (*Figure 2*).

The region is underlain by rich coal resources and several coal mines operate nearby, supplying both domestic and export markets. Cheshunt Mine Lease adjoins the northern boundary, Wambo Mine is located to the west and Mount Thorley Operations lies to the south. The area lies south of the Hunter River.



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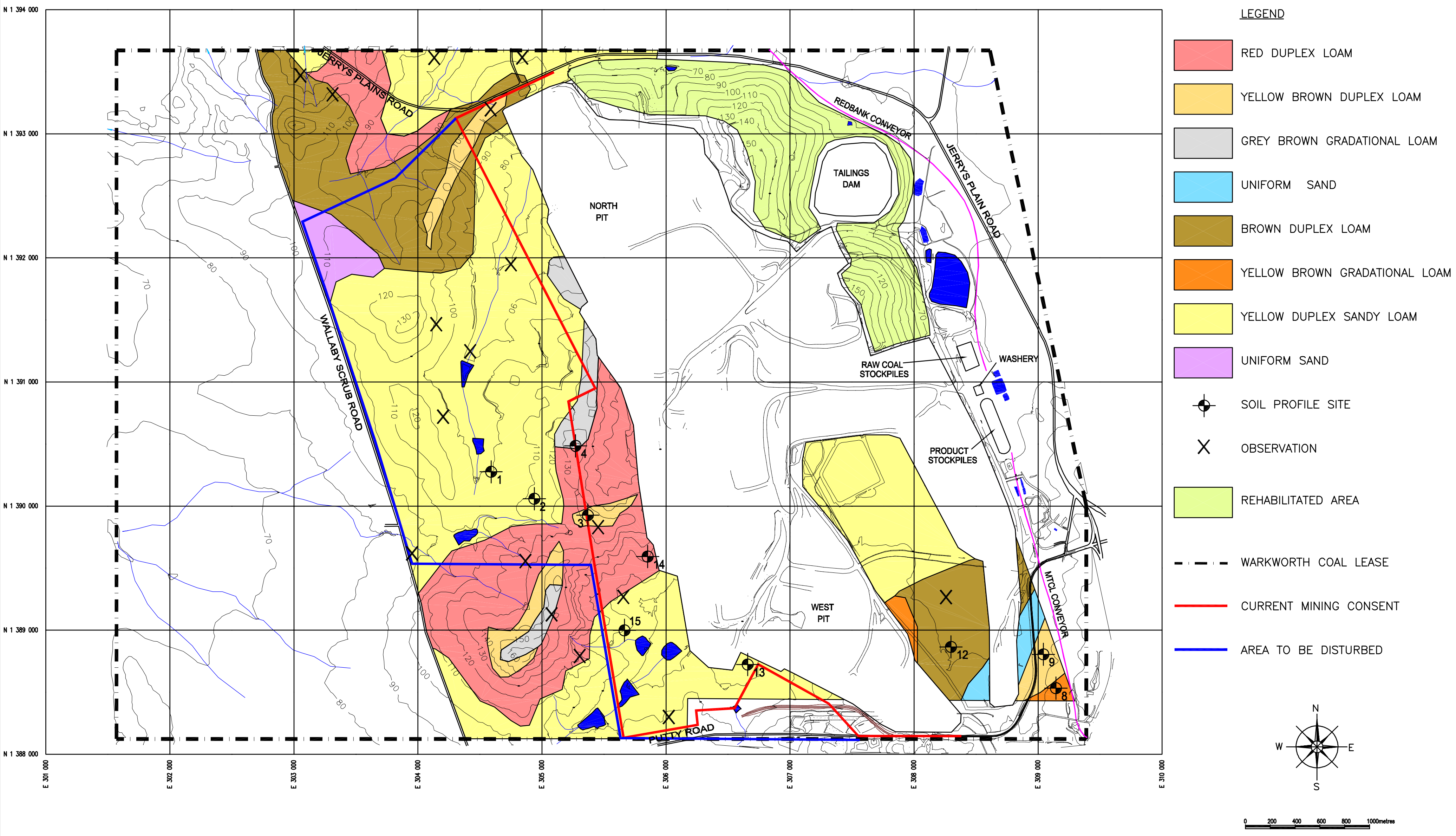
LOCATION PLAN

FIGURE 1



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SOIL UNITS

FIGURE 2

2.0 DESCRIPTION OF STUDY AREA

2.1 Geology

Rock outcrop in the soil survey area is sparse. Elsewhere the soil thickness varies from 0.5m on the hill crests to more than 1.2m on the lower slopes.

The rocks underlying the study area belong to the Jerrys Plains Subgroup of the Wittingham Coal Measures which are of Late Permian age. The coal measures comprise a fluvial sequence of conglomerate, sandstone, siltstone, claystone, tuff and coal seams. Sandstone and conglomerate units show considerable lateral and vertical variation.

Conglomerate contains rounded volcanic pebbles, generally 5 to 40 mm in size, but occasionally up to cobble size. Sandstone is predominantly lithic with a clay cement, and is a fairly strong rock when fresh. Siltstone, claystone and tuff are considerably weaker and will weather rapidly on exposure to air. Subsoils reflect the variation in the underlying rock types: sandy mottled clays have developed on coarse sandstone and lighter clays have developed on the finer grained sediments. Ironstone concretions, formed as a result of weathering and the action of groundwater, are commonly exposed on eroded land surfaces.

The rocks have been folded resulting in westerly dips of up the 35 degrees on the southern side of the study area and 5 degrees on the western side.

The non calcareous sands recorded in the north western part of the study area are windblown sands of Cainozoic age.

2.2 Landforms

Most of the study area is characterised by gently sloping lowlands with widely spaced broad, shallow valleys and slopes less than 5%. The remaining topography features are closely spaced, small, shallow valleys with slopes generally less than 10% but occasionally steeper (between 10% and 20%).

The coal lease is divided by a central ridge, trending north and attaining a maximum elevation of 165m AHD.

The sandstone Wollombi escarpment together with the alluvial terraces of the Hunter River and Wollombi Brook are the dominant landform features of the surrounding area.

2.3 Vegetation

Native timber has been predominantly cleared from the study area. Remaining stands of timber are dominated by Grey Box (*Eucalyptus moluccana*), Narrow-leaved Red Ironbark (*Eucalyptus crebra*) and Bull Oak (*Casuarina leuhmanii*). Black Pine (*Callitris endlicheri*) forms a major component of some stands, particularly over the ridges and undulating rises.

Rough-barked Apple (*Angophora floribunda*) and various shrubs particularly Coast Banksia (*Banksia intergrifolia*) and Lightwood (*Acacia implexa*) occur on the sand deposits. Native ground cover consists of Braken (*Pteridium esculentum*), Daphne Heath (*Brachylonia daphnoides*) and Guinea-flower (*Hibbertia aspera*).

3.0 METHODOLOGY

3.1 Soil Survey

3.1.1 Introduction

The soil survey was undertaken to fulfill the requirements of Planning NSW, the Department of Mineral Resources (DMR) and the Department of Land and Water Conservation (DLWC). The broad objective of the survey is to qualify the reserves of suitable topdressing material to assist planning of future rehabilitation operations.

3.1.2 Mapping

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

(i) **Aerial photographs and topographic maps**

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

(ii) **Previous soil surveys**

A survey of the Warkworth Coal Lease was published in 1975 by Foskett at a scale of 1 : 25,000. The survey encompassed the study area.

During 1991, Kovac and Lawrie completed a soil survey of all areas contained in the Singleton 1 : 250,000 Sheet. The Warkworth lease area was included in the soil survey.

A soil and land capability survey of the study area was conducted by HLA-Envirosciences Pty Ltd in 1994. The survey was conducted at a scale of 1 : 25,000.

(iii) **Stratified observations**

Upon drafting of mapping units, soil profile exposures were visually assessed to ascertain potential mapping units.

3.1.3 Profiling

During the 1994 HLA-Envirosciences survey a total of 15 soil profile exposures were assessed at selected sites to enable soil profile descriptions to be made. The exposure locations were chosen to provide representative profiles of the soil types encountered over the study area. The layers were generally distinguished on the basis of changes in texture and/or colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994).

Soil observations were made by GSS to confirm soil units and boundaries between different soils.

3.1.4 Field Assessment

Soil layers at each profile site were assessed according to a procedure devised by Elliot & Veness (1981) for the recognition of suitable topdressing materials. The system is described in ***Appendix 1***.

3.1.5 Laboratory Testing

A number of samples were taken from exposed soil profiles during the 1994 HLA-Envirosciences survey. The samples were subsequently analysed for the following parameters:

- Particle Size Analysis
- Dispersion Percentage
- Emerson Aggregate Test
- pH
- Electrical Conductivity

A description of the significance of each test and typical values for each soil characteristic are included in ***Appendix 2***.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material which is suitable for stripping and re-use for the rehabilitation of disturbed areas.

3.2 Land Capability Survey

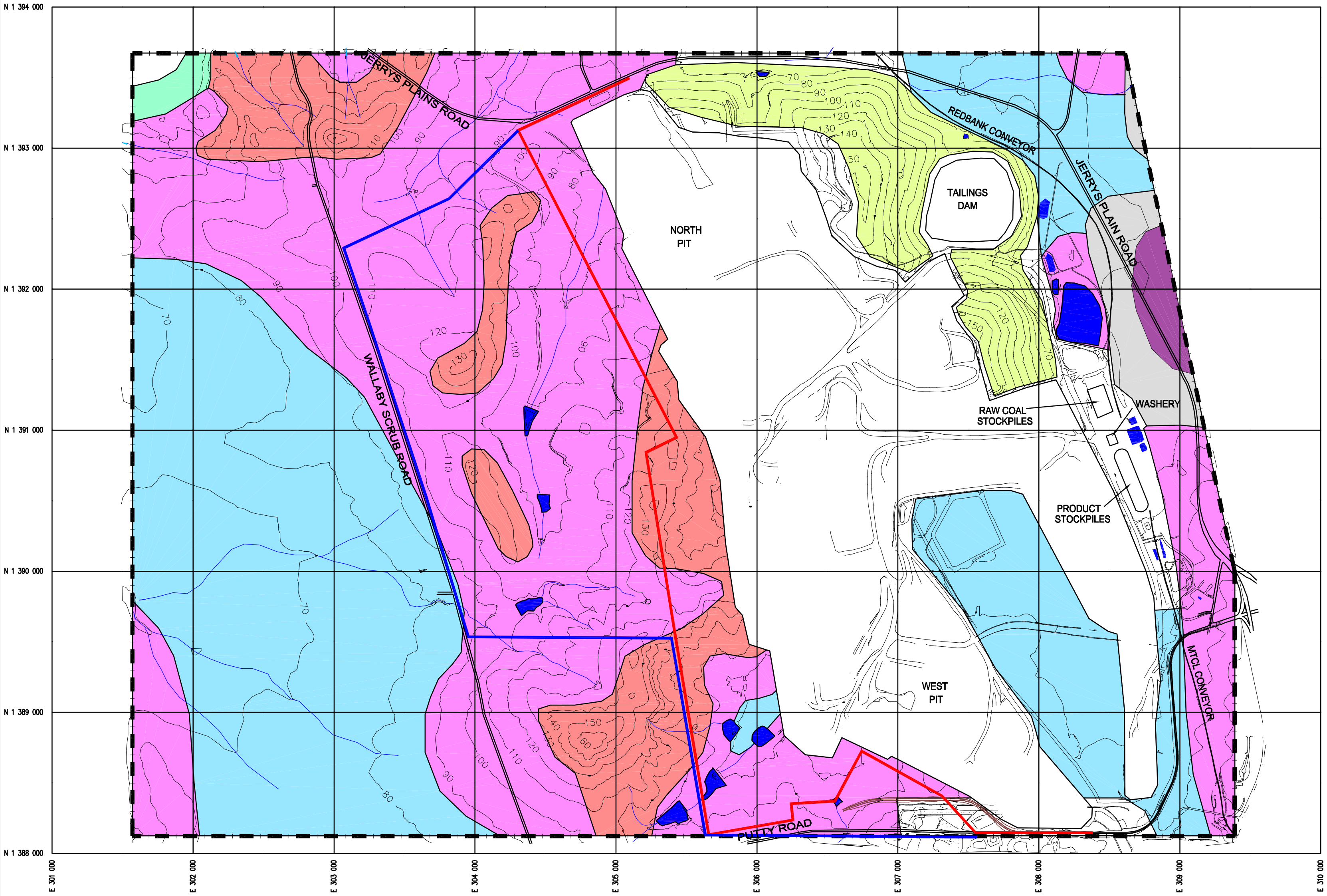
The land capability survey was conducted according to the DLWC rural land capability assessment system. The system consists of eight classes which classifies land on the basis of an increasing soil erosion hazard and decreasing versatility of use. It recognizes the following three types of land uses:

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

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

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

A summary table specifying the required soil conservation practices for each of the relevant classes is included in *Figure 3.*



LEGEND

LAND CLASSIFICATION AND SOIL CONSERVATION PRACTICES			
SUITABLE FOR REGULAR CULTIVATION		I	No Special soil conservation works or practices.
		II	Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotation.
		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.
SUITABLE GRAZING		IV	Soil conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or re-establishment of permanent pasture.
		V	Structural soil conservation works such as absorption banks, diversion banks and contour ripping, together with the practices as in Class IV.
		VI	Soil conservation practices including limitation of stock, broadcasting of seed and fertiliser, prevention of fire and destruction of vermin. May include some isolated structural works.

REHABILITATED AREA

WARKWORTH COAL LEASE

CURRENT MINING CONSENT

AREA TO BE DISTURBED

N
W E
S

0 200 400 600 800 1000metres

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LAND CAPABILITY

FIGURE 3

4.0 RESULTS

4.1 Soils

4.1.1 General

The majority of the survey area is encompassed by the "Branxton" and "Jerrys Plains" Soil Landscapes (Kovac and Lawrie, 1991).

Soil unit classifications for the 1994 HLA-Envirosciences and 2002 GSS surveys were based on the Northcote (1979) classification system.

The following soil units were identified within the study area:

- Red Duplex Loam
- Yellow Brown Duplex Loam
- Grey Brown Gradational Loam
- Brown Duplex Loam
- Yellow Duplex Sandy Loam
- Uniform Sand

The distribution of these soils is illustrated in *Figure 2*.

The red duplex loam dominates the central ridge area that occurs in the southeastern corner of the study area. The soil unit covers approximately 7% of the total study area. The soil is characterised by a dark brown loamy surface horizon which grades to a reddish brown medium clay.

The yellow brown duplex loam is located on all the ridge area and encompasses only 2% of the study area. The brown loam surface horizon grades to a yellowish brown mottled light clay.

The grey brown gradational loam occurs on top of the central ridge area. The unit covers approximately 1% of the study area and is characterised by a brownish black loam which grades to a greyish brown sandy clay loam and eventually into a sandy clay.

The brown duplex loam occurs in the north of the study area and to the west of Sandy Hollow Creek. The unit covers approximately 14% of the study area. A brown loam surface horizon grades to a grey brown sandy clay and eventually to a mottled light medium clay.

The yellow duplex sandy loam dominates the site and encompasses 72% of the study area. The soil occurs on the Doctor's Creek flats and adjacent footslopes together with the western footslopes and sideslopes of the Sandy Hollow Creek catchment. The unit consists of a dark brown sandy loam surface horizon which grades to a brown sandy clay loam and eventually to a yellowish brown light clay.

The uniform sand is located in an isolated area on the northwestern boundary of the study area and forms approximately 4% of the study area. The unit features a deep uniform sand grading to a sandy loam.

4.1.2 Profile Descriptions

The following profile descriptions are characteristics of their respective soil unit.

SOIL UNIT: YELLOW DUPLEX SANDY LOAM		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.08	Dark brown (10 YR 3/3) sandy loam. A subplastic, non sticky, crumbly soil exhibiting weak pedality, with 20 – 50 mm subangular blocky porous peds, containing less than 2% subrounded 6 – 20 mm stones. The soil contains many roots.
2	0.08 – 0.30	Greyish yellow brown (10 YR 4/2)) sandy clay. A plastic, sticky, moderately strong clay with weak pedality as above and less then 2% dispersed rounded 6 – 20 mm stones. This horizon contains few roots.
3	0.30 – 0.40	Greyish brown (7.5 YR 6/2) loamy sand. A subplastic non sticky, moderately strong, crumbly soil with an apedal structure. The soil contains less than 2% stones and few roots.
4	0.40 - >1.15	Dull yellowish brown (10 YR 5/4) sandy clay. A plastic, moderately sticky, strong, apedal clay. The clay contains 2 – 10% dispersed 6 – 20 mm stones. This horizon contains no roots.

SOIL UNIT: RED DUPLEX LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0.00 – 0.06	Brown (10 YR 4/6) loam. A subplastic, slightly sticky, crumbly soil exhibiting weak pedality with 20 – 50 mm earthy subangular blocky peds. The soil contains very few 20 – 60 mm stones and many roots.
2	0.06 – 0.20	Dull brown (7.5 YR 5/4) sandy clay loam. A subplastic, weak crumbly apedal soil with no stones. Roots are common.
3	0.20 – 0.60	Bright reddish brown (5 YR 5/8) light medium clay. A plastic, slightly sticky, moderately strong, apedal clay with less than 2% dispersed 20 – 60 mm stones.
4	0.60 - >1.40	Weathered fine grained grey sandstone.

SOIL UNIT: GREY BROWN GRADATIONAL LOAM		
LAYER	DEPTH (m)	DESCRIPTION
1	0.00 – 0.08	Brownish black (5 YR 2/2) loam. A weak, crumbly subplastic soil with weakly developed 10 – 20 mm subangular blocky peds and less than 2% subrounded dispersed 6 – 20 mm stones. The soil contains many roots.
2	0.08 – 0.32	Greyish brown (7.5 YR 6/2) sandy clay loam. A plastic, moderately strong apedal clay loam containing 20 – 50% subrounded stratified unweathered stones, up to 60 mm across. This horizon is bleached at the base and grades into the underlaying clay.
3	0.32 – 0.56	Brownish grey (7.5 YR 5/1) sandy clay. A plastic, moderately strong, apedal clay with up to 50% 2 – 6 mm subangular sedimentary stones. This layer contains few roots. The lower boundary is diffuse.
4	0.56 – > 1.30	Weathered fine graded sandstone, orange mottled with grey.

SOIL UNIT: YELLOW BROWN DUPLEX LOAM		
LAYER	DEPTH (m)	DESCRIPTION
1	0.00 – 0.11	Brown (7.5 YR 4/4) sandy clay loam. A weak plastic, slightly sticky soil with weakly developed subangular blocky peds 50 – 100 mm across, containing 2 – 10% subrounded 20 – 50 mm stones. This layer contains many roots.
2	0.11 – 0.70	Mottled light clay, yellowish brown (10 YR 5/6) with greyish yellow brown (10 YR 6/2) mottles. A plastic, slightly sticky, moderately strong apedal clay containing 2 – 10% of subrounded 6 – 20 mm stones. Roots common.
3	0.70 – 0.90	Bright yellowish brown (2.5 YR 6/8) sandy clay. A subplastic, slightly sticky, crumbly apedal soil containing up to 50% stratified, rounded stones, up to 200 mm in diameter. The boundary to the underlying soil is sharp. This horizon contains few roots.
4	0.90 - > 1.15	Greyish brown (7.5 YR 6/2) clayey sand. A slightly sticky, subplastic, moderately strong apedal clay with 2 – 10% dispersed 2 – 6 mm stones and no roots.

SOIL UNIT: BROWN DUPLEX LOAM		
LAYER	DEPTH (m)	DESCRIPTION
1	0.00 – 0.10	Brownish black (7.5 YR 3/2) loam. A weak, crumbly, slightly sticky loam with weakly developed 10 – 20 mm subangular blocky, earthy peds, less than 2% stones and many roots.
2	0.10 – 0.20	Greyish brown (7..5 YR 6/2) clayey sand. A weak, subplastic, slightly sticky soil with 10 – 20 mm subangular blocky peds and 2 – 10% subrounded 20 – 60 mm stones.

SOIL UNIT: BROWN DUPLEX LOAM		
LAYER	DEPTH (m)	DESCRIPTION
3	0.20 – 0.45	Greyish brown (7.5 YR 5/2) sandy clay. A plastic, moderately sticky, moderately strong apedal clay with 2 – 10% subrounded 20 – 60 mm fresh stones.
4	0.45 – 0.65	Mottled light medium clay, greyish yellow brown (10 YR 6/6) with 30% bright yellowish brown (10 YR 6/6) mottles. This horizon grades to the weathered rock below.
5	0.65 - > 0.90	Weathered medium grained sandstone.

4.1.3 Laboratory Testing

All soil samples taken during the 1994 HLA-Envirosciences survey were analysed by the DLWC Soil and Water Testing Laboratory at Scone, NSW. All soil analytical results are provided in *Table 1*.

TABLE 1
LABORATORY TEST RESULTS

Sample */ Depth (cm)		Particle Size Analysis					D (%)	EAT	pH	EC (dS/m)
		Clay	Silt	Fine Sand	Coarse Sand	Gravel				
1	20 – 30	23	12	35	16	14	97	2(2)	6.2	0.17
6	1 – 10	7	14	36	33	10	60	3(1)	5.8	0.02
6	10 – 30	5	8	20	18	49	89	3(1)	6.2	0.06
8	0 – 10	22	15	24	34	5	74	3(2)	5.9	0.05
9	10 – 20	16	20	29	14	21	97	2(2)	6.4	0.07
10	0 – 10	13	14	41	28	4	74	3(1)	7.3	0.06
10	10 – 20	33	13	31	21	2	81	2(2)	6.8	0.23
10	20 – 30	29	15	31	24	1	91	2(2)	7.2	0.32
13	0 – 10	9	10	23	19	39	57	3(1)	5.6	0.06
13	10 – 20	6	7	14	14	59	87	2(1)	6.0	0.04
13	20 – 30	30	8	17	20	25	93	2(3)	6.1	0.14
13	30 – 40	36	11	22	22	9	93	2(3)	5.7	0.42
14	0 – 10	36	42	16	4	2	51	3(3)	6.4	0.08
15	1 – 10	17	18	49	14	2	54	3(1)	5.8	0.04

8 = Soil Profile Site D% = Dispersion Percentage
EAT = Emmerson Aggregate Test EC = Electrical Conductivity

4.2 Land Capability

The survey area contains two classes of land capability; Class V and Class IV land. These areas are not suitable for cultivation owing to considerable biophysical limitations such as fine textured shallow soils and relatively steep slopes. The recommended soil conservation practices for these land classifications include structural soil conservation works (Class V land) and pasture improvement, low stocking rates, fire prevention and vermin control (Class VI land).

Figure 3 shows the pre-mining land capability classification of the study area.

5.0 TOPDRESSING SUITABILITY

Details of the soil test results (refer *Table 1*) were used in conjunction with the field assessment (refer **Appendix 1**) to determine the depth or thickness of soil materials which are suitable for stripping and re-use for the rehabilitation of disturbed areas.

Structural and textural properties of soils within the study area are the most significant limiting factors for determination of topdressing suitability.

The surface and initial sub-surface horizons are structurally weak and are considered marginally suitable for stripping, stockpiling and re-spreading as a topdressing material for reshaped overburden. Limited stripping potential (0.1m) is available on the majority of ridge and upper-slope areas. The combination of fine texture and structural weakness (high ped disruption rating) of sub-surface horizons translates to these materials being unsuitable as topdressing media.

Whilst most of the material identified for topdressing purposes is of satisfactory quality, all materials within the study area are relatively dispersible and will require amelioration. The soils are erodible and are prone to surface sealing and structural decline following exposure. To promote successful germination and plant growth, the use of gypsum immediately prior to sowing is highly recommended.

The survey revealed that most soils within the study area can be stripped to at least 0.1 m for topdressing of disturbed areas. Some areas can be stripped to a depth of 0.2 m to yield soil of suitable quality.

Individual volumes of available topdressing material for each recommended stripping depth are illustrated in *Table 2*.

TABLE 2

TOPDRESSING AVAILABILTY

Stripping Depth (m)	Area (ha)	Volume (m^3)
0.1	492	492,000
0.2	45	90,000
TOTAL	537	582,000

Allowing for a 10% handling loss, some 524,000 m^3 of suitable topdressing is available within the area to be disturbed. Therefore, topdressing may be placed on the post-mining landform at a theoretical average depth of 0.1m. At other Hunter Valley mines a topdressing depth of 0.1m has been found to be adequate for healthy pasture establishment on rehabilitated spoil material.

The depth of respread topdressing material is not critical for tree establishment.

6.0 REFERENCES

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APPENDIX 1

FIELD ASSESSMENT PROCEDURE

FIELD ASSESSMENT PROCEDURE

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

Structure Grade

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

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

Consistence - Shearing Test

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

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

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

Consistence - Disruptive Test

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

Mottling

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

Macrostructure

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

Texture

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

Root Density and Root Pattern

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

Field Exposure Indicators

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

APPENDIX 2

SOIL INFORMATION

TEST SIGNIFICANCE AND TYPICAL VALUES

Particle Size Analysis

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

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

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

Emerson Aggregate Test

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

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

The following subdivisions within Emerson classes may be applied:

(1) slight milkiness, immediately adjacent to the aggregate
(2) obvious milkiness, less than 50% of the aggregate affected
(3) obvious milkiness, more than 50% of the aggregate affected

(4) total dispersion, leaving only sand grains.

Salinity

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

0 to 1	very low salinity, effects on plants mostly negligible.
1 to 2	low salinity, only yields of very sensitive crops are restricted.
greater than 2	saline soils, yields of many crops restricted.

pH

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

LABORATORY TEST METHODS

Particle Size Analysis

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

Emerson Aggregate Test

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

EC

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

pH

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