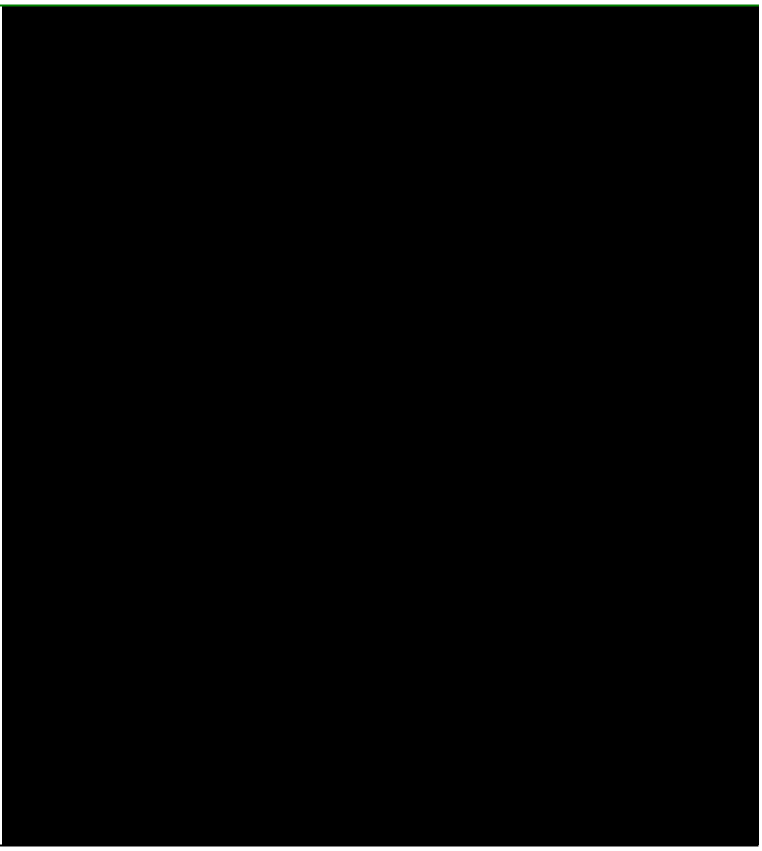
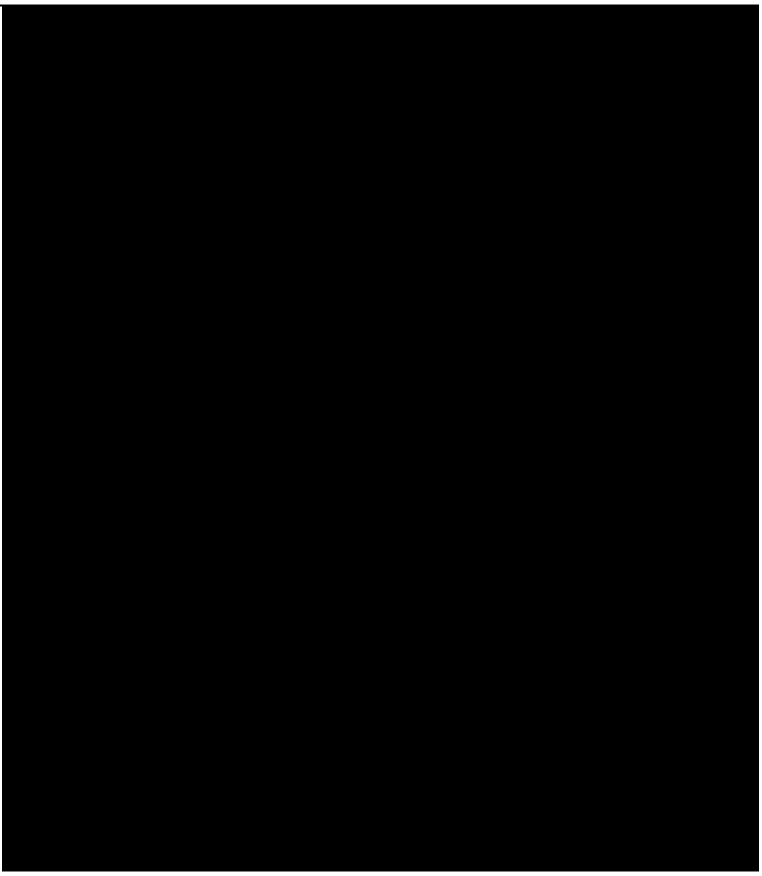


Soil and Regolith Attributes for CRA/RFA Model Resolution

Upper North-east and Lower North-east CRA Regions

A project undertaken as part of the NSW Comprehensive Regional Assessments

August 1999



SOIL AND REGOLITH ATTRIBUTES FOR CRA/RFA MODEL RESOLUTION

UPPER NORTH-EAST AND LOWER NORTH-EAST CRA REGIONS

NSW Department of Land and Water Conservation, NSW State Forests, NSW National Parks and Wildlife Service and Bureau of Rural Sciences (Canberra)

A project undertaken for
the Joint Commonwealth NSW Regional Forest Agreement Steering Committee
as part of the
NSW Comprehensive Regional Assessments.
Project number NA 31/EH.

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The project has been overseen and the methodology has been developed through the Environment and Heritage Technical Committee which includes representatives from the New South Wales and Commonwealth Governments and stakeholder groups.

We would like to thank the following Department of Land and Water Conservation staff who contributed to this project including soil surveyors, Dave Morand, Linda Henderson, Casey Murphy, Sally McInnes-Clarke, Michael Eddie, Dacre King, Robert Banks and Mitch Tulau, who, with the help of the technical assistants Stephen Camper, Fletcher Townsend and Stuart Naylor, undertook the soil landscape survey and provided soil attribute data for the project. Thanks also to Andrew Rawson and Andrea Francis who undertook mapping of the Cowarral 1:100 000 sheet, provided algorithms for use in assessing soil attributes and designed the CRA soil data card. Thanks to Alex McGaw and Katie Nixon who assisted with the input and compilation of data for thousands of CRA data cards in the NSW Soil Data System; Greg Chapman for program management, Dave Morand who provided technical supervision of the project; John Gillooly who produced the maps and figures in this report; Andrew McPherson who spent many hours checking the data sets and maps and Casey Murphy who compiled this report.

Other contributors to the project include: Antti Roppola (Bureau of Rural Sciences, Canberra) who provided his extensive spatial analyst skills to produce the final maps; and Peter Hesp (National Parks and Wildlife Service, Hurstville) who supervised the scanning of the soil landscape maps.

CONTENTS

The NSW Department of Land and Water Conservation, NSW State Forests, NSW National Parks and Wildlife Service and Bureau of Rural Sciences (Canberra) have jointly contributed to providing soil landscape coverage to produce soil attribute themes for both the upper-north east and lower north-east CRA regions.

Starting in late 1997 with successful completion in August 1999, this project provides soil attribute data on essential inputs for many modelling projects within the NSW CRA/RFA process (e.g., individual plant and animal species distributions, extent and pre-European distribution of vegetation communities, and site quality and associated fertility of timber resources).

Complete coverage of both upper-north east and lower north-east CRA regions of soil landscapes and associated soil attribute themes of soil fertility, effective rooting depth and estimated available water-holding capacity have been generated to assist in CRA vegetation modelling. The coverage is supplied on compact disc. Additionally, 1625 profiles were described as part of this project and are available on the NSW SALIS at DLWC (Parramatta).

The NSW Department of Land and Water Conservation is currently undertaking an upgrading of the soil landscape coverage and compilation of an associated ACCESS database (to store soil landscape information) for all non-published areas. It is anticipated that the updated coverage and database will be available by the end of 2001.

1.PROJECT SUMMARY

This report describes a project undertaken as part of the comprehensive regional assessments of forests in New South Wales. The comprehensive regional assessments (CRA's) provide the scientific basis on which the State and Commonwealth Governments will sign regional forest agreements (RFA's) for major forest areas of New South Wales. These agreements will determine the future of these forests, providing a balance between conservation and ecologically sustainable use of forest resources.

Project objective(s)

Mapped soil attributes including depth, fertility, and estimated plant available water-holding capacity were considered to be fundamental, essential and urgently required inputs to many modelling projects within the NSW CRA/RFA process (e.g., modelling of individual plant and animal species distributions, modelling of extant and pre-European distribution of vegetation communities, and modelling of site quality and associated wood resource attributes).

Prior to this project, soils information was incomplete or non-existent for many areas within the upper north-east and lower north-east CRA regions. The project area was defined by all lands east of the New England Highway. The project objective was to expand the existing soil landscape coverage of soil attributes where little or no data was available and to develop a mapped coverage of soil attributes across the upper north-east and lower north-east CRA regions to assist with CRA vegetation modelling. This included:

- development of suitable algorithms and site criteria for collection and ranking of relevant parameters including fertility, soil depth and soil water-holding capacity;
- fitting of specific soil attributes to the existing soil landscape framework;
- extension of the soil and landscape map framework over the remainder of the area;
- potential for greater resolution of soil attributes by making provision for allocation of soil sub-landscapes that can be linked to digital elevation-derived models for outputs at scales of 1:25 000.

Methods

Soil landscape coverage for the area was provided from 13 existing published and draft Department of Land and Water Conservation (DLWC) soil landscape maps and the undertaking of extensive reconnaissance level soil landscape mapping by nine soil surveyors and three technical assistants for the remaining 21 x 1:100 000 sheets.

Useful data sets including colour air photos, geological and existing soil landscape information were collected and reviewed. State Forests supplied 1:100 000 scale base sheets showing geology, cadastre, contour and thematic mapper images. Provisional soil landscape boundaries were drawn onto the base sheets or onto 1:100 000 topographic sheets using geological boundaries and the interpretation of both colour aerial photography and thematic mapper images. Free soil survey techniques were used to describe 1625 soil profiles, which were recorded on specifically designed CRA soil observation cards. Soil landscape boundaries were revised during field work. Approximately two weeks of field work was undertaken for each 1:100 000 map sheet. Soil data cards were collated and entered into the NSW Soil and Land Information System (SALIS). Algorithms were created to assess specific soil attributes (soil fertility, soil depth, effective rooting depth, drainage and estimated plant available water-holding capacity) from soil profile information and existing soil landscape reports for each soil sub-landscape. These were entered into Excel tables. Field maps were traced and along with the soil attribute tables, sent to National Parks and Wildlife Service (NPWS) for scanning on a rolling delivery basis due to time constraints.

Soil attributes were then linked to the mapped coverage by Bureau of Rural Sciences (BRS) (Canberra). Map boundaries and soil attribute values were checked by DLWC soil survey staff and corrections undertaken by BRS.

Key results and products

Complete coverage of both upper-north east and lower north-east CRA regions of soil landscapes and associated soil attribute themes including soil fertility, effective rooting depth and estimated available water-holding capacity have been generated to assist in CRA vegetation modelling. The coverage is supplied on compact disc. Additionally, 1625 profiles were described as part of this project and are available on the NSW SALIS at DLWC (Parramatta).

1.0 INTRODUCTION

1.1 BACKGROUND

The Comprehensive Regional Assessment Unit (CRA) of National Parks and Wildlife Service (NPWS) approached the Department of Land and Water Conservation (DLWC) in June 1997 as to the availability of soil information to assist with vegetation modelling across CRA Regions. Various outputs from the modelling process were expected to provide base information for the Regional Forestry Assessment (RFA). Mapped soil attributes were required as inputs to a number of modelling projects including individual flora and fauna distributions, extent of pre1750 vegetation communities, and site quality and associated wood resource attributes.

Prior to this project, the only soil/regolith information available was impartial 1:100 000 and 1:250 000 scale soil landscape coverage and 1:250 000 geological coverage. None of these maps provided a complete, accurate medium to high resolution of soil attributes necessary for vegetation modelling purposes. In particular, the distribution of soil attributes such as soil fertility, soil drainage, effective rooting depths and plant available water-holding capacity was required for vegetation modelling. To meet the CRA deadlines soil attribute data had to be provided by the end of January 1998 for upper-north east, and by end of August 1998 for the lower north-east CRA regions. Considering the tight time frames and limited budget for the CRA project, the only way to provide complete detailed coverage of these attributes was by using soil landscape mapping and linking it to digital elevation modelling.

Predictive modelling of soil attributes has been shown to be a cost-effective means of improving the resolution and coverage of soil attribute mapping within the narrow CRA timeframe. The approach is based on work undertaken by McKenzie and Austin (1993); Moore *et al.* (1993); and Gessler *et al.* (1995), which involved the modelling of soil attributes recorded at field survey sites within each mapped parent material, climatic and topographic class (or soil landscape if available) in relation to fine-scaled terrain and climate variables derived from digital elevation models.

To provide soil attributes that could be used in the predictive modelling process, DLWC was to review and assess existing published and draft soil landscape maps and reports and also undertake a reconnaissance level soil landscape survey over the remaining area. Provision was made for soil attributes to be linked to more detailed digital terrain models, such as the compound topographic index (CTI) for outputs at higher resolution (to 1:25 000) for use in the RFA modelling process.

The original proposal included laboratory testing for soil properties and provided for a reasonable level of field work, but was rejected as being too costly. A revised project was submitted and approved with no soil testing and a substantially reduced level of field work and checking.

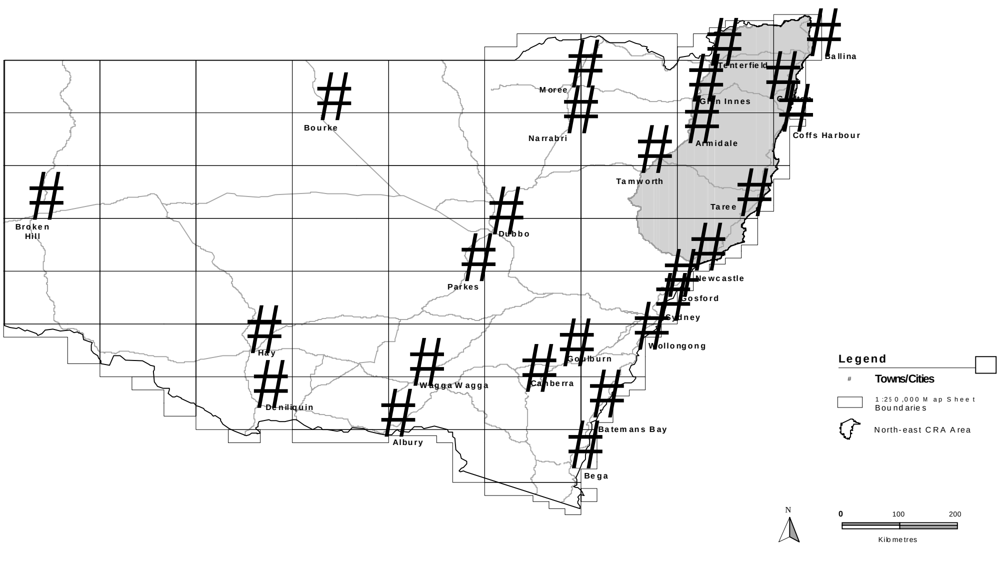
A Steering committee guided the process. It included representatives of State Forests, DLWC, NPWS, and BRS.

2.0 METHODOLOGY

2.1 SCOPE OF PROJECT

The project required DLWC to undertake the assessment of soil fertility, soil drainage, soil depth, effective tree rooting depth, and estimated soil available water-holding capacity attributes, through soil landscape mapping for both the upper north-east and lower north-east CRA areas. The study area consisted of lands east and north of the New England Highway (see Figure 2a). This data was required as a seamless coverage for further refinement of soil attributes at resolutions approaching 1:25 000 scale through the generation of soil sub-landscapes via digital modelling by NPWS.

FIGURE 2A: LOCATION OF UPPER NORTH-EAST AND LOWER NORTH-EAST CRA PROJECT AREA



Existing digital coverage and soil landscape information was available for 12 published and draft 1:100 000 scale soil landscape maps, and one 1: 250 000 scale published soil landscape map (Table 2a). Reconnaissance level 1:100 000 scale soil landscape mapping was undertaken for the remaining 47 000 km^2 (21 x 1:100 000 maps sheets). The data source diagram (Figure

2b) shows the distribution of draft and published sheets as well as where new reconnaissance level soil landscape mapping was undertaken for this project.

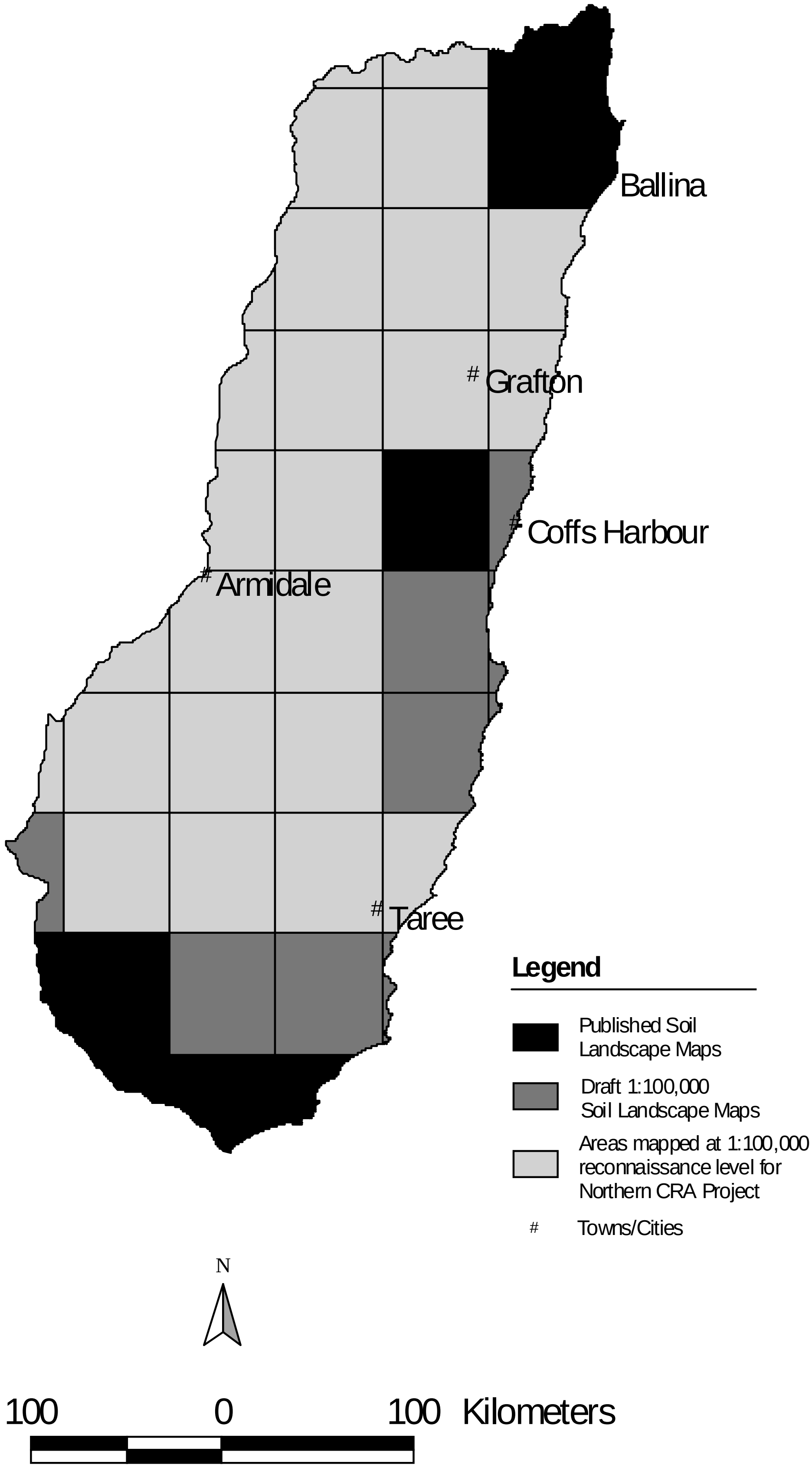
TABLE 2A: LIST OF PUBLISHED AND NEAR DRAFT MAPS AND REPORTS USED IN THE PROJECT

Soil landscape sheet	Publication status at time of project	Reference
Murwillumbah-Tweed Heads 1:100 000 sheets	Published	D.T. Morand 1996
Coffs Harbour 1:100 000 sheet	Draft	H.B. Milford (in press)
Kempsey 1:100 000 sheet	Draft	G.A. Atkinson (in press)
Lismore-Ballina 1:100 000 sheets	Published	D.T.Morand 1994
Dorrigo 1:100 000 sheet	Published	H.B. Milford 1996
Port Stephens 1:100 000 sheet	Published	C.L. Murphy 1995
Newcastle 1:100 000 sheet	Published	L.E. Henderson 1995
Singleton 1:250 000 sheet	Published	M. Kovac and J.W Lawrie 1990
Dungog 1:100 000 sheet	Draft	L.E. Henderson (in press)
Bulahdelah 1:100 000 sheet	Draft	C.L Murphy (in prep)
Tamworth 1:100 000 sheet	Draft	R.G. Banks (in prep)
Macksville-Nambucca 1:100 000 sheets	Draft	M. Eddie (in prep)
Murrurundi 1:100 000 sheet	Draft	S.K McInnes-Clarke (in prep)

Soil landscapes are defined as '*areas of land that have recognisable and specifiable topographies and soils, that are capable of presentation on maps, and can be described by concise statements'* (Northcote 1978). The mapping of landscape properties can be used to distinguish mappable areas of soils because similar causal factors are involved in the formation of both landscapes and soils. Through remote sensing interpretation of landscape features and the description of soils in the field, a soil landscapes model can be built that can predict the distribution and occurrence of different soil types within each landscape. Different soil types have different soil attribute properties and these can often be linked to digital elevation-based models for higher resolution.

Note: This mapping is only at a reconnaissance level and should be used only as a guide to the distribution of specific soil attributes identified for the purposes of this project.

FIGURE 2B: SOIL LANDSCAPE MAPPING DATA SOURCE DIAGRAM



2.2 SETTING GOALS AND RESPONSIBILITIES

Prior to project approval, several meetings were held at DLWC offices in Parramatta for all persons on the steering committee. These meetings included consideration of the project strategy and contents of the proposal, roles, etc. It was decided that DLWC would have the main carriage of the project, with State Forests supplying special base maps and NPWS being responsible for GIS requirements. Each of the parties involved were happy with the outcomes of the project proposal.

A meeting was held in September 1997 at BRS in Canberra between scientists from DLWC, CSIRO, State Forests and BRS where an agreement was reached on methodology for the estimation of the soil parameters - fertility, plant available water-holding capacity and rooting depth.

A further meeting was held in December 1997 to brief soil surveyors and discuss technical aspects of the project including map unit descriptions and spreadsheet formats by DLWC soil survey, NPWS and BRS.

Further internal DLWC technical meetings were held to discuss methodologies, timeframes and outputs required.

2.2.3 PROJECT TASKS

To undertake such an extremely large soil landscape mapping and soil attribute assessment project within the tight CRA timeframe, a number of tasks were implemented to ensure the project followed an orderly path to achieve its goals. Soil surveyors were allocated unmapped 1:100 000 map sheet areas. One month of soil surveyor time was allocated to each map sheet, which included five working days for remote sensing and air photo interpretation, 10 working days for field work and field data collection, and five days for providing map unit descriptions, calculating required soil attribute parameters and producing a tagged 1:100 000 scale field sheet.

2.3.1 Task 1 - Review and acquire existing data

The first task undertaken was to search for and review all existing information that would assist in undertaking the project. This included the acquisition of:

- relevant published soil landscape maps and reports with digital coverage
- 1:250 000 geological maps and RACAC geological maps and associated information
- 1:25 000 scale colour aerial photographs for Aerial Photograph Interpretation
- 1:100 000 scale topographic maps
- 1:100 000 scale base maps from State Forest GIS (Pennant Hills) with cadastre information, contours, geology and satellite Landsat TM washout.

2.3.2 Task 2 - Methodology for calculation of soil attributes

The second task was to develop a methodology for assessing the soil attributes required for vegetation modelling. The following outlines the methodology used to assess soil attributes within every soil sub-landscape (partition of the soil landscape) for both existing soil landscape information and new reconnaissance soil landscape mapping.

Modified Fertility Class
Five soil fertility classes (see Table 2b) were originally derived, based on the *Great Soil Group* classification (Stace *et al*. 1968) as outlined in *Soils of New South Wales--Their Characterisation, Classification and Conservation* (Charman 1978). A class of "1" indicates soil of very low fertility, while a class of "5" indicates high fertility. ***Modified soil fertility classes*** were evaluated based on this table and raised or lowered due to positive or negative soil fertility attributes present. For example, a soil sub-landscape such as a crest with a stony, shallow Red Podzolic Soil has a fertility class of 3 (see Table 2), but this classification can be downgraded to a modified fertility class of 2 due to the stoniness and shallowness of the soil profile. Thus the modified fertility class of this soil is 2. Conversely, a soil's modified fertility class may be improved if the soil had positive soil fertility properties such as good depth, good drainage and high organic matter content in the topsoil.

TABLE 2B: FERTILITY CLASSES OF GREAT SOIL GROUPS (AFTER CHARMAN 1978)

Great Soil Group	Fertility Class	Great Soil Group	Fertility Class
Solonchak	1	Non-calcic Brown Soils	4
Alluvial Soil	5	Chocolate Soil	4
Lithosol	1	Brown Earth	3
Calcareous Sand	1	Calcareous Red Earth	2
Siliceous Sand	1	Red Earth	3
Earthy Sand	1	Yellow Earth	2
Grey-brown Calcareous S	1	Terra Rossa Soil	3
Red Calcareous Soil	1	Euchrozem	4
Desert Loam	1	Xanthozem	3
Red and Brown Hardpan S	1	Krasnozem	4
Grey Clay	3	Grey-brown Podzolic Soil	2
Brown Clay	3	Red Podzolic Soil	3
Red Clay	3	Yellow Podzolic Soil	2
Black Earth	5	Brown Podzolic Soil	3
Rendzina	3	Lateritic Podzolic Soil	1
Chernozem	5	Gleyed Podzolic Soil	3
Prairie Soil	5	Podzol	2
Wiesenboden	3	Humus Podzol	2
Solonetz	2	Peaty Podzol	2
Solodized Solonetz	2	Alpine Humus	3
Solodic Soil	2	Humic Gley	2
Soloth (Solod)	2	Neutral Peat	2
Solonized Brown Soil	2	Alkaline Peat	2
Red-brown Earth	4	Acid Peat	1

Drainage
Five drainage classes were defined, based on the classes recorded on the NSW SALIS soil data cards (Abraham and Abraham 1992). They are:

1. very poorly drained
2. poorly drained
3. imperfectly drained
4. moderately well-drained
5. well-drained

Effective Rooting Depth (ERD)
This is an estimate of the soil and substrate available for tree roots to penetrate and is an important factor in the calculation of estimated plant available water-holding capacity (EPAWC). Where the parent material was not fractured, or where an impeding layer for tree roots exists (e.g., pan or rock), then an estimate of ERD was undertaken on the average depth in the soils and regolith which tree roots are likely to penetrate. This is the effective rooting depth. Where the parent material is fractured, tree roots will be able to penetrate both the solum and, to some extent, weathered parent material. To calculate the ERD:

estimate the size, depth, and number of fractures in the parent material and estimate an **average** depth that roots will be able to penetrate;
add this to the depth of the solum; and
subtract the Fragment Amount volume (see below) from the final calculation to get the effective rooting depth.

Example:
The soil depth is **1.2 m**, fragment amount is **10%**. The substrate is *fractured*, so roots will penetrate the substrate. The depth of the substrate to which the roots will penetrate is estimated to be **2.5 metres,** but only **20%** of the substrate volume is available (i.e., cracks etc.). What is the Effective Rooting Depth?

ERD = soil depth + (substrate volume available to roots % x root penetration into substrate) - (fragment amount % x soil depth)

ERD = 1.2 m + (20% x 2.5 m) - (10% x 1.2 m) = 1.58 metres

Estimated Plant Available Water-holding Capacity (EPAWC)
This is an estimation of a soils capacity to store water for use by plants. It is based on methodology outlined by Greacen and Williams (1983), with reference to work undertaken by Salter, Berry and Williams (1966); and Salter and Williams (1963, 1965, 1967, 1969), which outlines the strong relationship between soil texture and available water-holding capacity. This has been modified to improve the values by 20% for soils with very fine structure or with very high organic matter content. The original data set used by Greacen and Williams was based on agricultural soils and did not take into account strongly and finely structured forest soils.

The EPAWC of a soil profile is calculated by multiplying the soil texture EPAWC (Table 2c) by the soil structure factor (1.2 for finely structured soils, otherwise it is 1), which is multiplied by the horizon thickness in metres. This is repeated for each horizon inside the estimated rooting depth. The EPAWC for the soil profile is the sum of EPAWC calculated for all layers.

TABLE 2C: PLANT AVAILABLE WATER CAPACITY (PAWC) VALUES FOR TEXTURE GRADES (MODIFIED FROM SALTER & WILLIAMS 1967, 1969; GRACEN & WILLIAMS 1983; AND HAZELTON & MURPHY (1992)

TEXTURE	PAWC (millimeters of water stored per metre of soil)	TEXTURE	PAWC (millimeters of water stored per metre of soil)
sand	150	heavy clay loam	180
coarse sand	80	clay loam, coarse sandy	170
fine sand	200	clay loam, sandy	175
loamy sand	160	light clay loam, sandy	175
loamy coarse sand	108	heavy clay loam, sandy	175
loamy fine sand	217	clay loam, coarse sandy	170
clayey sand	150	light clay loam, coarse sandy	170
light clayey sand	150	heavy clay loam, coarse sandy	170
heavy clayey sand	150	clay loam, fine sandy	190
clayey coarse sand	80	light clay loam, fine sandy	190
light clayey coarse sand	80	heavy clay loam,fine sandy	190
heavy clayey coarse sand	80	silty clay loam	190
clayey fine sand	215	light silty clay loam	190
light clayey fine sand	215	heavy silty clay loam	190
heavy clayey fine sand	215	light silty clay loam, fine sandy	195
sandy loam	180	sandy clay	140
light sandy loam	180	sandy light clay	140
heavy sandy loam	180	sandy light-medium clay	140
coarse sandy loam	125	sandy medium clay	140
light coarse sandy loam	125	sandy medium-heavy clay	140
heavy coarse sandy loam	125	sandy heavy clay	140
fine sandy loam	192	coarse sandy clay	130
light fine sandy loam	192	coarse sandy light clay	130
heavy fine sandy loam	192	coarse sandy light-medium clay	130
loam	180	coarse sandy medium clay	130
loam, fine sandy	185	coarse sandy medium-heavy clay	130
silty loam	200	coarse sandy heavy clay	130
light silty loam	200	fine sandy clay	150
heavy silty loam	200	fine sandy light clay	150
sandy clay loam	150	fine sandy light-medium clay	150
light sandy clay loam	150	fine sandy medium clay	150
light-medium sandy clay loam	150	fine sandy medium-heavy clay	150
medium sandy clay loam	150	fine sandy heavy clay	150
heavy sandy clay loam	150	silty clay	183
coarse sandy clay loam	140	silty light clay	183

light coarse sandy clay loam	140	silty light-medium clay	183
light-medium sandy clay loam, coarse sandy	140	silty medium clay	183
medium sandy clay loam, coarse sandy	140	silty medium-heavy clay	183
heavy coarse sandy clay loam	140	silty heavy clay	183
fine sandy clay loam	180	clay	180
light fine sandy clay loam	180	light clay	180
heavy fine sandy clay loam	180	light-medium clay	180
clay loam	180	medium clay	180
light clay loam	180	medium-heavy clay	180
medium-heavy clay loam	180	heavy clay	180

2.3.3 Task 3 - Remote Sensing Interpretation

Where soil landscape mapping was non-existent (about 25 000 km^2 for the upper north-east; about 22 000 km^2 for lower north-east), interpretation of 1:25 000 scale colour aerial photographs, 1:100 000 scale Landsat TM imagery and geological information was undertaken to enable provisional soil landscape boundaries to be identified and placed onto 1:100 000 topographic field sheets. Each new soil landscape was given a number (tag) within each map sheet. A summary of each soil landscape was recorded prior to field work.

2.3.4 Task 4 - Field assessment of soils

Provisional soil landscape boundaries were checked in the field and soil landscape point information recorded on specially designed CRA observation soil data cards (see Appendix 1 for example) which can be readily scanned into the NSW SALIS. These CRA cards were designed especially to meet the requirements of this project and included information on substrate fracturing, effective soil rooting depth, and convergent and divergent drainage attributes, which are useful for vegetation modelling. Table 2d shows a listing of the soil attributes recorded at each soil profile observation site. Many other casual observations were also made and recorded on field sheets and in note books.

Mapping was conducted at a technical standard consistent with national agreements and standards developed under the Australian Collaborative Land Evaluation Program (ACLEP) by DLWC Soil Survey Unit team of trained and qualified soil surveyors. Soil and land descriptions follow the guidelines of the *Soil and Land Survey Field Handbook* (Macdonald *et. al* 1990). Soil and land data collection used a combination of integrated and free soil survey and is a synthesis of methods outlined in *Australian Soil and Land Survey Handbook: Guidelines to Conducting Surveys* (Gunn *et. al* 1988).

TABLE 2D: CRA SITE ATTRIBUTES RECORDED

Parameter field	Soil Attribute
Landform	site and slope morphology, element convergent/divergent slope run-on contributing area
Topography	slope gradient aspect
Lithology	solum parent material substrate degree of fracturing substrate strength

	weathering and alteration
	rock outcrop
Soil	A horizon
	solum
	depth to impeding layer
	rooting depth
	layer colour
	layer soil texture
	stone volume
	layer soil structure
	[1]layer grade of structure
	layer fabric
	erosion hazard
	ground cover
	surface condition
	Australian Soil Classification
	Great Soil Group Classification
Vegetation	community
	growth forms
	upper stratum height
Hydrology	profile drainage/waterlogging
	mottling
	depth to watertable
	runon/runoff
	permeability

2.3.5 Task 5 Collation of soil attribute information, scanning of maps and linking coverage to dataset

CRA soil profile cards were checked by soil surveyors and sent to the NSW SALIS for scanning and compiled into Excel spreadsheets to assist with calculation of soil attributes.

Soil attribute tables (Table 2e)[1] were then compiled from draft and published soil landscape reports, and from the new reconnaissance CRA soil landscape mapping. These soil attribute tables contained information on soil landscape code, the soil sub-landscape (partition of a soil landscape based on Compound Topographic Index (CTI)), estimated soil depth, stoniness, estimated soil rooting depth (ERD), modified soil fertility, soil drainage and estimated plant available water-holding capacity (EPAWC). The 1:100 000 scale field sheets were traced onto stable base maps at Parramatta by Technical Officers and sent to NPWS Hurstville for scanning by a contractor. As a rolling stock of soil landscape maps were required by NPWS for scanning, it was not possible to edge match all map sheets prior to them being sent to NPWS. Major discrepancies on the scanned maps were identified and corrected by DLWC soil survey staff.

TABLE 2E: SOIL ATTRIBUTE TABLE SENT TO NPWS FOR LINKING TO THE MAP COVERAGE

Mapsheet Name:									
Mapsheet No:									

[1] Initially complex soil landscape summary sheets were provided to NPWS who requested that the information be reduced and presented in a more simple tabular format for linking to the coverage. This was undertaken for all soil landscape units.

Landscape	Soil sub-landscape	Unique sub-landscape grouping	%CTI	Soil Depth (m)	ERD (m)	EPAWC (mm)	Drainage	Fertility	Notes

Digital coverage of published data was also sent to NPWS. Although the maps and soil attribute tables were sent within the CRA timeframe, NPWS did not link the datasets in time for the first set of modelling of both upper north-east and lower north-east CRA areas.

BRS in Canberra, requiring the soil attribute information for softwood plantation planning, provided a spatial analyst for linking speadsheet data with the soil landscape map coverage. BRS also developed a Compound Topographic Index (CTI) which could be linked to soil sub-landscape level soil attributes to provide more detailed soil information coverage than the soil landscape maps alone.

2.3.6 Task 6 - Checking map coverage and soil attribute data

Extensive time was invested by key soil survey staff and BRS in edge matching of map sheet boundaries, amalgamation of similar soil landscape units, and a review of soil attribute values. Final map coverages were produced by BRS for fertility, effective rooting depth, soil profile depth and estimated available water-holding capacity. These maps were visually checked by the Soils Quality Officer and project supervision staff, and major anomalies corrected.

Due to the constraints of time and resources (especially GIS), some minor inconsistencies in the coverage may occur, but these will not be an issue for use of the data at a regional planning level.

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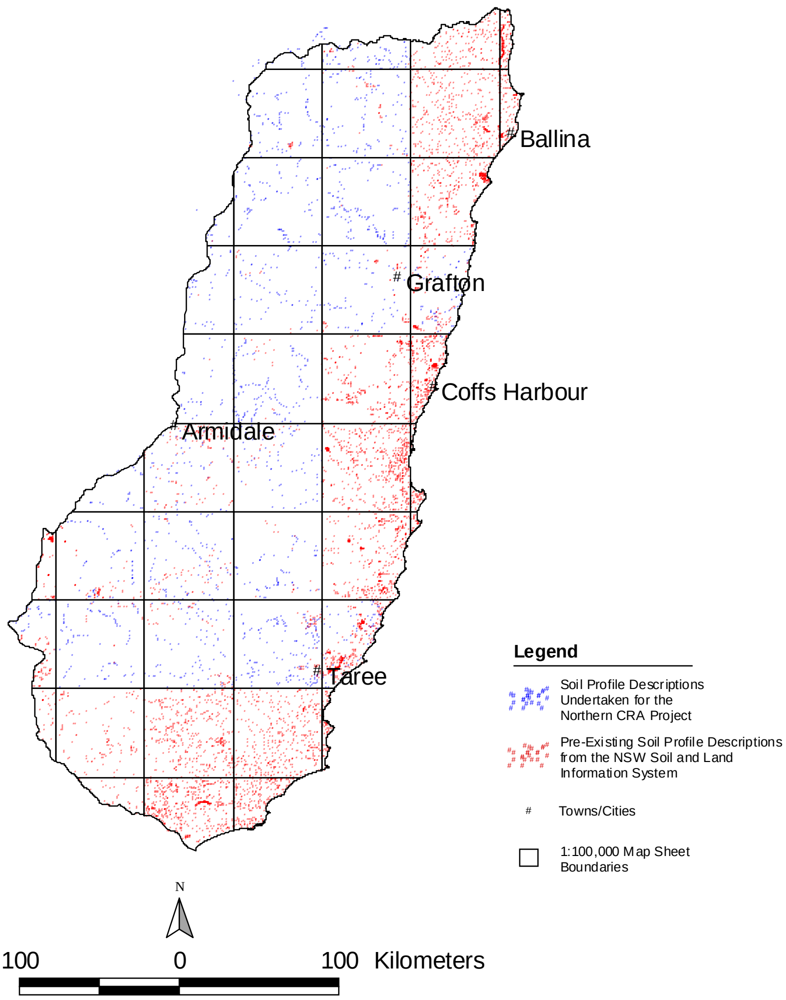
3.OUTPUTS

3.1 SOIL PROFILE INFORMATION

One thousand six hundred twenty five (1625) profiles were described as part of new soil landscape mapping of both upper north-east and lower north-east CRA regions for the parameters listed in table 4. The data is held in the NSW SALIS.

The map below (Figure 3a) shows the distribution of soil profile description sites for both newly mapped areas and existing soil landscape coverage. Soil profile descriptions are available by contacting SALIS information officers at DLWC, Parramatta.

FIGURE 3A: MAP OF SOIL PROFILE DATA POINTS WITHIN UPPER AND LOWER CRA REGIONS



3.2 SOIL LANDSCAPE COVERAGE

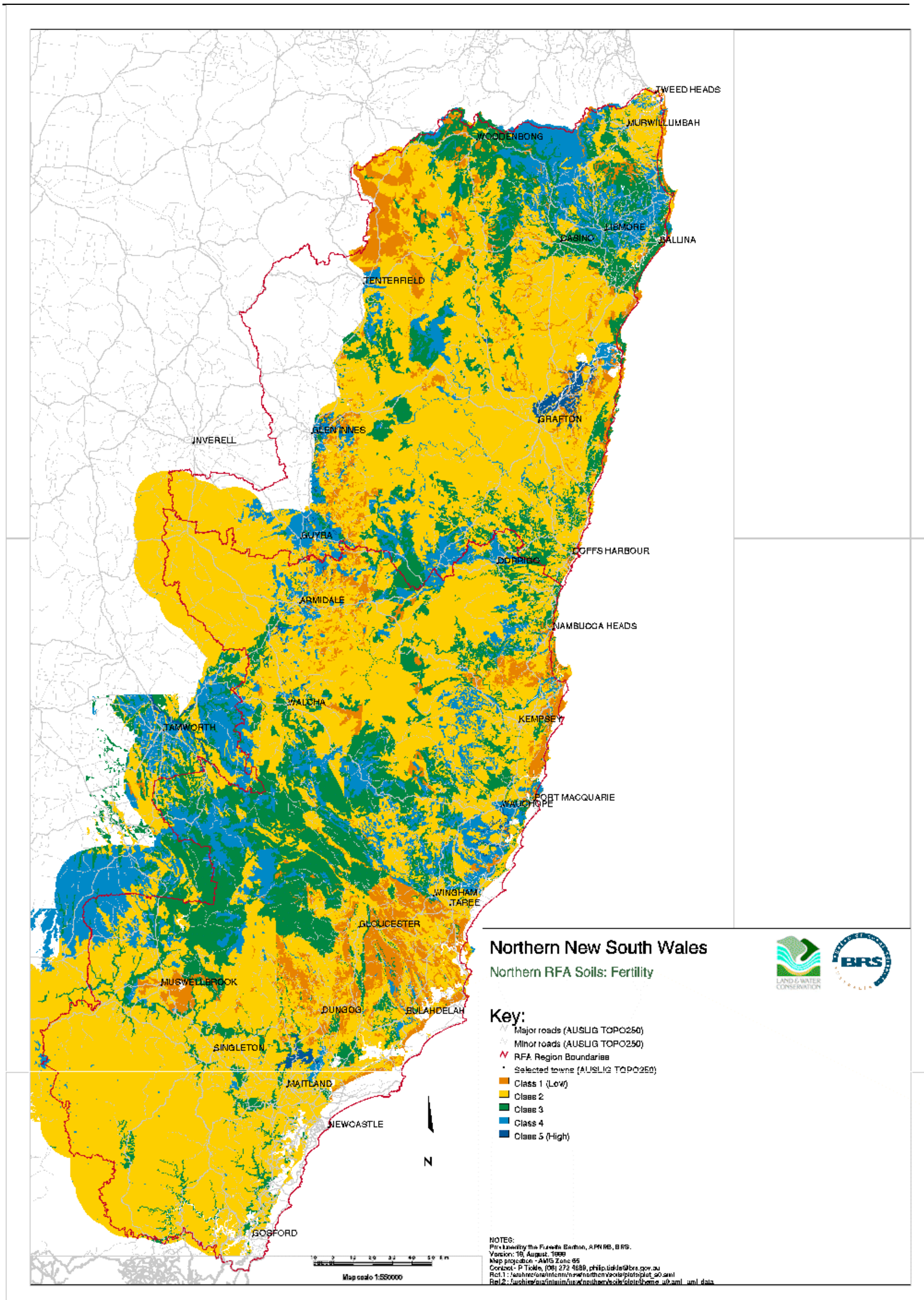
A complete coverage of 1:100 000 scale soil landscape mapping was undertaken with the assistance of BRS. It is provided on the attached CD. Soil landscapes have been compiled from existing draft and published soil landscapes and from the undertaking of reconnaissance level 1:100 000 scale soil landscape mapping for this project.

3.2 SOIL ATTRIBUTE THEMES

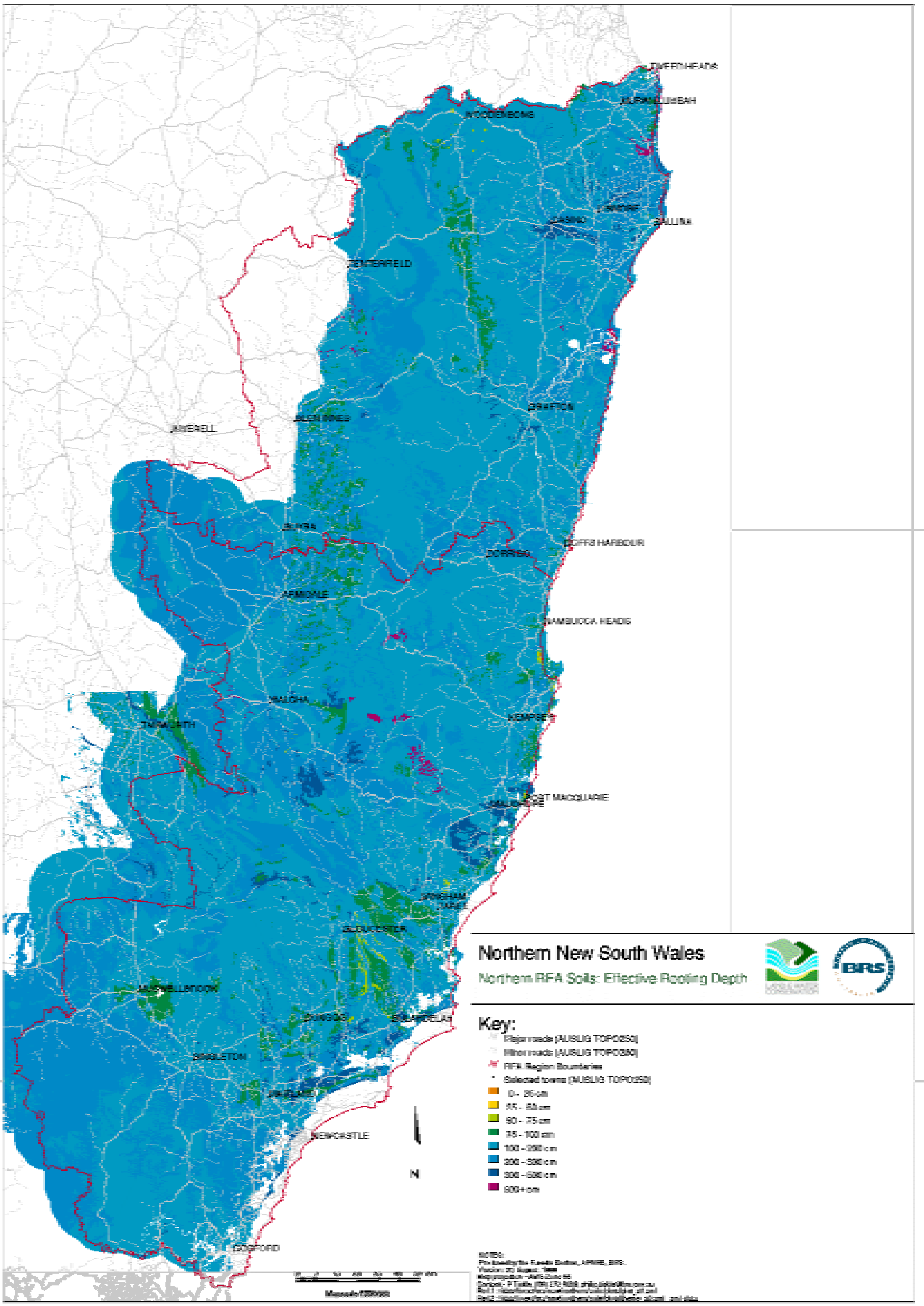
Coverage of the three most important soil attributes for vegetation modelling, modified soil fertility (Map 3a), soil profile depth (Map 3b), effective rooting depth (Map 3c) and estimated plant available water-holding capacity (Map 3d) were produced by BRS GIS using DLWC information and are based on the assessment of both published soil landscape information and the new CRA soil landscape survey. Additional soil attribute information on stoniness, soil depth and soil drainage are also available from this coverage. These coverages are available on CD as Arc shape files from RACD and from BRS. The maps presented below are scaled-down versions of the three attribute maps for reference purposes.

Map 3a – Modified Fertility, Map 3b – Soil Profile Depth, Map 3c – Effective Rooting Depth, Map 3d – Estimated Plant Available Water-holding Capacity.

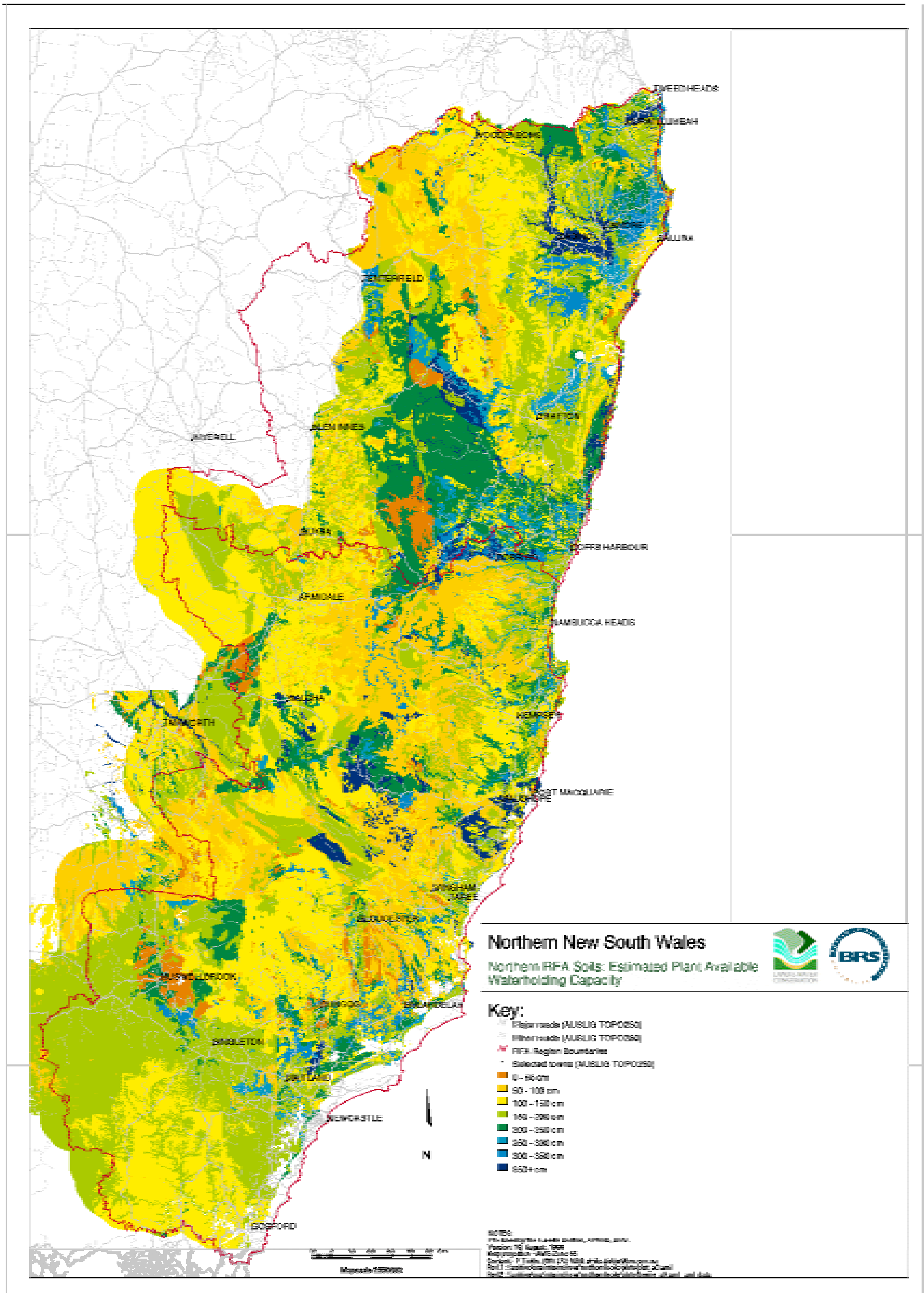
MAP 3A: MAP OF MODIFIED FERTILITY



MAP 3C: MAP OF EFFECTIVE ROOTING DEPTH



MAP 3D: MAP OF ESTIMATED PLANT AVAILABLE WATER-HOLDING CAPACITY (EPAWC)



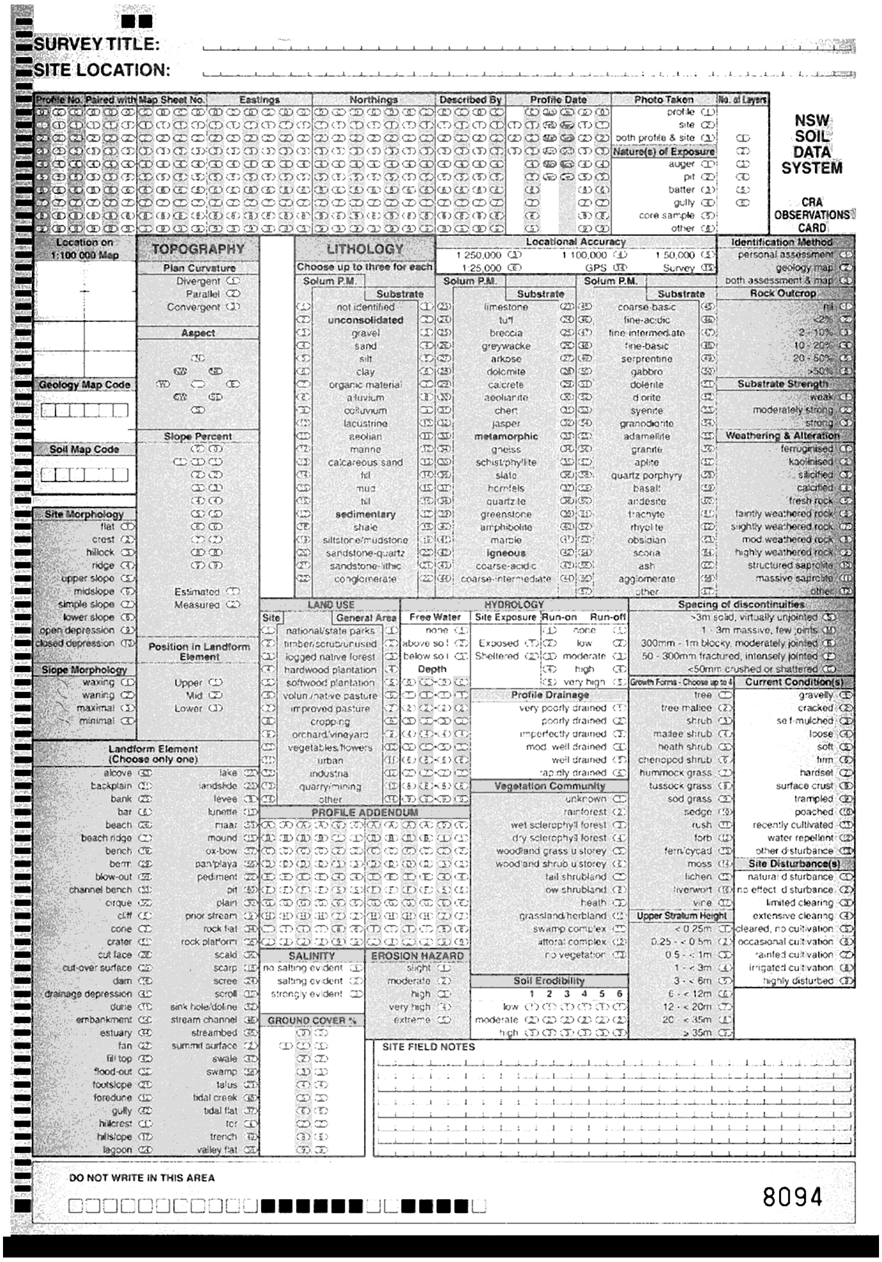
3.3 USE OF DATA

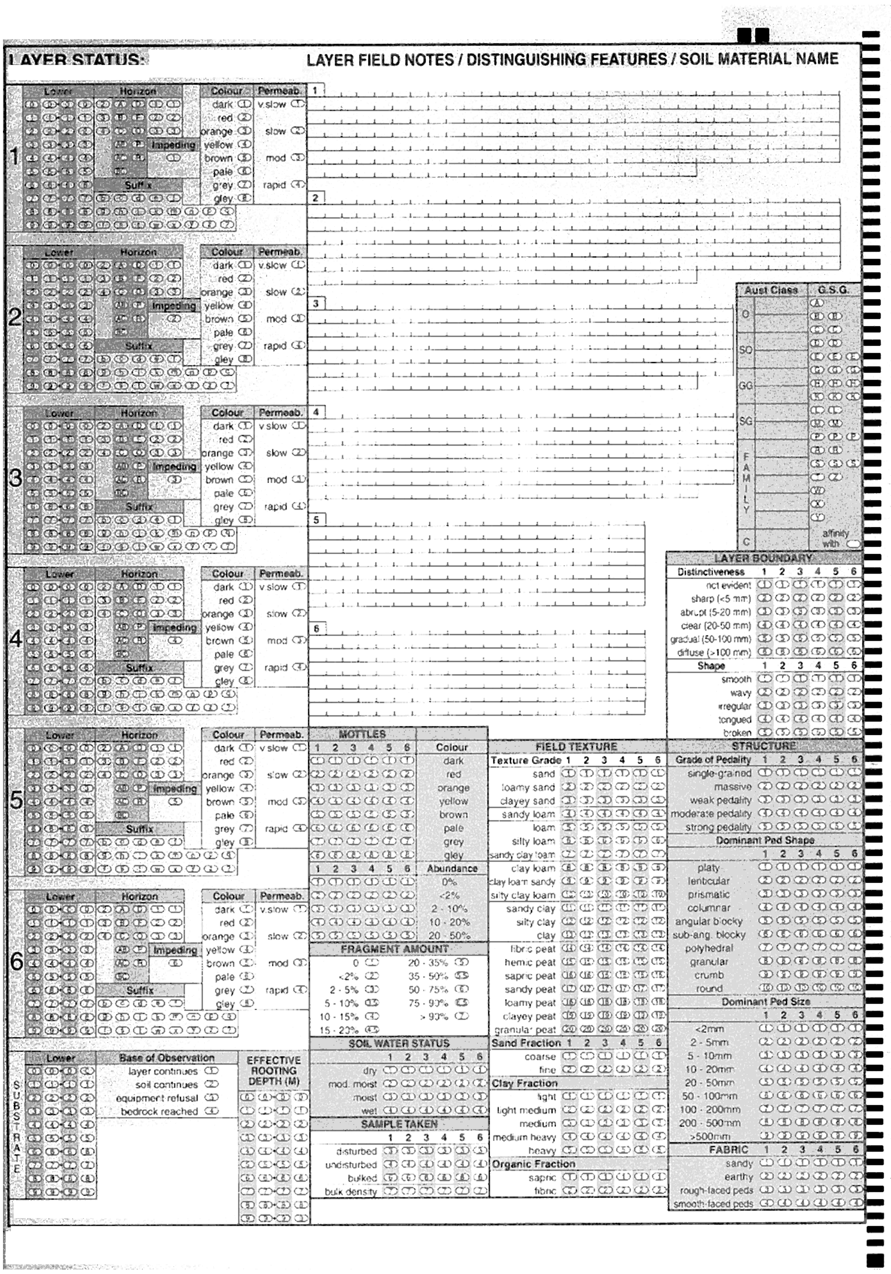
These maps and attribute tables provide a guide to the distribution and assessment of the soil attributes of fertility, effective rooting depth and estimated plant available water-holding capacity. They were undertaken at a reconnaissance level over a short time period and should be used only for broad regional vegetation modelling purposes. Enhanced resolution of these soil attributes can be gained through linkage with digital elevation models. This will be undertaken by BRS if required for modelling purposes. The soil attribute themes will assist in the modelling of :

- biodiversity assessment
- pre-1750s and current forest community modelling
- fauna modelling
- rare flora species modelling
- centres of endemicity
- response to disturbance
- plantation potential on cleared private land, and
- industry development opportunities (e.g., intensification).

The maps should be used only at 1:100 000 scale or smaller and should not be used for any other purposes than those specified in this project without the written permission of both the NSW Department of Land and Water Conservation.

APPENDIX 1 EXAMPLE OF CRA SOIL PROFILE OBSERVATION CARD


SURVEY TITLE:
SITE LOCATION:
Profile No. Paired with Map Sheet No. Eastings Northings Described By Profile Date Photo Taken No. of Layers
profile / site / both profile & site
Nature(s) of Exposure: auger / pit / batter / gully / core sample / other
NSW SOIL DATA SYSTEM
CRA OBSERVATIONS CARD
Location on 1:100 000 Map
TOPOGRAPHY
Plan Curvature: Divergent / Parallel / Convergent
Aspect
Geology Map Code
Slope Percent
Soil Map Code
Estimated / Measured
Site Morphology: flat / crest / hillock / ridge / upper slope / midslope / simple slope / lower slope / open depression / closed depression
Position in Landform Element: Upper / Mid / Lower
Slope Morphology: waxing / waning / maximal / minimal
Landform Element (Choose only one)
alcove / backplain / bank / bar / beach / beach ridge / bench / berm / blow-out / channel bench / cirque / cliff / cone / crater / cut face / cut-over surface / dam / drainage depression / dune / embankment / estuary / fan / fill top / flood-out / footslope / foredune / gully / hillcrest / hillslope / lagoon
lake / landslide / levee / lunette / maar / mound / ox-bow / pan/playa / pediment / pit / plain / prior stream / rock flat / rock platform / scald / scarp / scree / scroll / sink hole/doline / stream channel / streambed / summit surface / swale / swamp / talus / tidal creek / tidal flat / tor / trench / valley flat
LITHOLOGY
Choose up to three for each
Solum P.M. / Substrate
not identified / unconsolidated / gravel / sand / silt / clay / organic material / alluvium / colluvium / lacustrine / aeolian / marine / calcareous sand / fill / mud / till / sedimentary / shale / siltstone/mudstone / sandstone-quartz / sandstone-lithic / conglomerate
limestone / tuff / breccia / greywacke / arkose / dolomite / calcrete / aeolianite / chert / jasper / metamorphic / gneiss / schist/phyllite / slate / hornfels / quartzite / greenstone / amphibolite / marble / igneous / coarse-acidic / coarse-intermediate
coarse-basic / fine-acidic / fine-intermediate / fine-basic / serpentine / gabbro / dolerite / diorite / syenite / granodiorite / adamellite / granite / aplite / quartz porphyry / basalt / andesite / trachyte / rhyolite / obsidian / scoria / ash / agglomerate / other
Locational Accuracy: 1:250,000 / 1:100,000 / 1:50,000 / 1:25,000 / GPS / Survey
Identification Method: personal assessment / geology map / both assessment & map
Rock Outcrop: nil / <2% / 2 - 10% / 10 - 20% / 20 - 50% / >50%
Substrate Strength: weak / moderately strong / strong
Weathering & Alteration: ferruginised / kaolinised / silicified / calcified / fresh rock / faintly weathered rock / slightly weathered rock / mod.weathered rock / highly weathered rock / structured saprolite / massive saprolite / other
LAND USE
Site / General Area
national/state parks / timber/scrub/unused / logged native forest / hardwood plantation / softwood plantation / volun./native pasture / improved pasture / cropping / orchard/vineyard / vegetables/flowers / urban / industrial / quarry/mining / other
HYDROLOGY
Free Water: none / above soil / below soil / Depth
Site Exposure: Exposed / Sheltered
Run-on / Run-off: none / low / moderate / high / very high
Spacing of discontinuities: >3m solid, virtually unjointed / 1 - 3m massive, few joints / 300mm - 1m blocky, moderately jointed / 50 - 300mm fractured, intensely jointed / <50mm crushed or shattered
Profile Drainage: very poorly drained / poorly drained / imperfectly drained / mod. well drained / well drained / rapidly drained
Vegetation Community: unknown / rainforest / wet sclerophyll forest / dry sclerophyll forest / woodland grass understorey / woodland shrub understorey / tall shrubland / low shrubland / heath / grassland/herbland / swamp complex / littoral complex / no vegetation
Growth Forms - Choose up to 4: tree / tree mallee / shrub / mallee shrub / heath shrub / chenopod shrub / hummock grass / tussock grass / sod grass / sedge / rush / forb / fern/cycad / moss / lichen / liverwort / vine
Upper Stratum Height: < 0.25m / 0.25 - < 0.5m / 0.5 - < 1m / 1 - < 3m / 3 - < 6m / 6 - < 12m / 12 - < 20m / 20 - < 35m / ≥ 35m
Current Condition(s): gravelly / cracked / self-mulched / loose / soft / firm / hardset / surface crust / trampled / poached / recently cultivated / water repellent / other disturbance
Site Disturbance(s): natural disturbance / no effect disturbance / limited clearing / extensive clearing / cleared, no cultivation / occasional cultivation / rainfed cultivation / irrigated cultivation / highly disturbed
PROFILE ADDENDUM
SALINITY: no salting evident / salting evident / strongly evident
EROSION HAZARD: slight / moderate / high / very high / extreme
Soil Erodibility: 1 2 3 4 5 6 / low / moderate / high
GROUND COVER %
SITE FIELD NOTES
DO NOT WRITE IN THIS AREA
8094


LAYER STATUS:

LAYER FIELD NOTES / DISTINGUISHING FEATURES / SOIL MATERIAL NAME

Lower | Horizon | Colour | Permeab.

Impeding | Suffix

dark | red | orange | yellow | brown | pale | grey | gley

v.slow | slow | mod | rapid

Aust Class | G.S.G.

O | SO | GG | SG | FAMILY | C | affinity with

LAYER BOUNDARY

Distinctiveness 1 2 3 4 5 6

not evident | sharp (<5 mm) | abrupt (5-20 mm) | clear (20-50 mm) | gradual (50-100 mm) | diffuse (>100 mm)

Shape 1 2 3 4 5 6

smooth | wavy | irregular | tongued | broken

MOTTLES 1 2 3 4 5 6 | Colour

dark | red | orange | yellow | brown | pale | grey | gley

1 2 3 4 5 6 | Abundance

0% | <2% | 2 - 10% | 10 - 20% | 20 - 50%

FRAGMENT AMOUNT

0 | <2% | 2 - 5% | 5 - 10% | 10 - 15% | 15 - 20% | 20 - 35% | 35 - 50% | 50 - 75% | 75 - 90% | > 90%

SOIL WATER STATUS 1 2 3 4 5 6

dry | mod. moist | moist | wet

SAMPLE TAKEN 1 2 3 4 5 6

disturbed | undisturbed | bulked | bulk density

FIELD TEXTURE

Texture Grade 1 2 3 4 5 6

sand | loamy sand | clayey sand | sandy loam | loam | silty loam | sandy clay loam | clay loam | clay loam sandy | silty clay loam | sandy clay | silty clay | clay | fibric peat | hemic peat | sapric peat | sandy peat | loamy peat | clayey peat | granular peat

Sand Fraction 1 2 3 4 5 6

coarse | fine

Clay Fraction

light | light medium | medium | medium heavy | heavy

Organic Fraction

sapric | fibric

STRUCTURE

Grade of Pedality 1 2 3 4 5 6

single-grained | massive | weak pedality | moderate pedality | strong pedality

Dominant Ped Shape 1 2 3 4 5 6

platy | lenticular | prismatic | columnar | angular blocky | sub-ang. blocky | polyhedral | granular | crumb | round

Dominant Ped Size 1 2 3 4 5 6

<2mm | 2 - 5mm | 5 - 10mm | 10 - 20mm | 20 - 50mm | 50 - 100mm | 100 - 200mm | 200 - 500mm | >500mm

FABRIC 1 2 3 4 5 6

sandy | earthy | rough-faced peds | smooth-faced peds

SUBSTRATE

Lower | Base of Observation

layer continues | soil continues | equipment refusal | bedrock reached

EFFECTIVE ROOTING DEPTH (M)

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